OPTIONS méditerranéennes

Innovation for Sustainability in Sheep and Goats

Edited by:
R. Ruiz, A. López-Francos, L. López Marco

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SERIES A: Mediterranean Seminars
2019 – Number 123

CIHEAM

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Centre International de Hautes Etudes Agronomiques Méditerranéennes

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Innovation for Sustainability in Sheep and Goats

Editors: R. Ruiz, A. López-Francos, L. López Marco

Proceedings of the 2nd Joint Seminar of the Subnetworks on Nutrition and on Production Systems of the FAO-CIHEAM Network for Research and Development in Sheep and Goats, jointly organised by the Department of Animal Production of Neiker-Tecnalia (the Basque Institute for Agricultural Research and Development) and the Mediterranean Agronomic Institute of Zaragoza (IAMZ-CIHEAM), with the collaboration of the H2020 Project iSAGE (Innovation for Sustainable Sheep and Goat Production in Europe, GA no. 679302), the Food and Agriculture Organization of the United Nations (FAO, Subregional Office for North Africa) and the Department for Economic Development and Infrastructures of the Basque Government, and with the support of the Municipality of Vitoria-Gasteiz, the Diputación Foral de Alava and the Idiazabal Denomination of Origin.

Vitoria-Gasteiz (Spain), 3-5 October 2017

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OPTIONS méditerranéennes

Head of publication: Plácido Plaza

2019 Series A: Mediterranean Seminars Number 123

Centre International de Hautes Etudes Agronomiques Méditerranéennes
International Centre for Advanced Mediterranean Agronomic Studies

L'édition technique, la maquette et la mise en page de ce numéro d'Options Méditerranéennes ont été réalisées par l'Atelier d'Édition de l'IAM de Zaragoza (CIHEAM)

Technical editing, layout and formatting of this edition of Options Méditerranéennes was carried out by the Editorial Board of MAI Zaragoza (CIHEAM)

Crédits des photos de couverture / *Cover photo credits:*
Mikel Arrazola (Repositorio fotográfico abierto del Gobierno Vasco)

Tirage / *Copy number:* 300 ex.
Printer: INO Reproducciones, S.A.
Pol. Malpica, calle E, 32-39
(INBISA II, Nave 35)
50016 Zaragoza-Spain
Dep. Legal: Z-2893-91

Fiche bibliographique / *Cataloguing data:*

Innovation for Sustainability in Sheep and Goats. R. Ruiz, A. López-Francos, L. López Marco (eds). Zaragoza: CIHEAM/NEIKER 2019, 490 p. (*Options Méditerranéennes,* Series A: Mediterranean Seminars, No. 123)

Catalogue des numéros d'Options Méditerranéennes sur / *Catalogue of Options Méditerranéennes issues on:*
www.ciheam.org/publications

ISSN: 1016-121-X – ISBN: 978-2-85352-590-9

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Foreword

Sheep and goat farming systems face a harsh present and an uncertain future, apparently compromised by a general lack of competitiveness stemming from poor technical and economic results, but also due to severe social and environmental challenges. The society, although unaware of the origin of this reality, is already suffering some of its impacts, with huge areas of many territories being progressively abandoned from human activity and the overwhelming consequences of forest fires of unknown proportions to date (as in Portugal and Greece in recent years).

Therefore, innovative solutions are needed to make the sheep and goat value chain more efficient, profitable and sustainable, but also more appealing for society, particularly to guarantee generational turnover for farms. Such innovations should be aimed at improving production techniques, labour organisation, equipment and infrastructures and developing collective programmes for selection or health campaigns. Innovation should also contribute to strengthening social forms of organisation such as product quality schemes or communal areas management. Also, innovative feeding strategies coupled with precision flock management practices that reduce gaps in production and adjust to the environmental challenges, hold promise to tackle the above mentioned objectives.

This publication compiles the contributions presented at the joint Seminar of the FAO-CIHEAM Sub-Networks on Production Systems and Nutrition on Sheep and Goats, held in Vitoria-Gasteiz, Spain, in October 2017. The Seminar was co-organised between the Department of Animal Production of Neiker-Tecnalia (the Basque Institute for Agricultural Research and Development) and the Mediterranean Agronomic Institute of Zaragoza (IAMZ-CIHEAM), with collaboration of the H2020 Project iSAGE – Innovation for Sustainable Sheep and Goat Production in Europe. The organisers wish to acknowledge the financial support received from the Department for Economic Development and Infrastructures of the Basque Government, the Municipality of Vitoria-Gasteiz, and the Diputación Foral de Alava.

The objective of the Seminar was to encourage participation and interaction among scientists and technicians working in the sheep and goat industry. Finally, 113 researchers and technicians attended the seminar, contributing a total of 40 oral presentations and 49 posters.

The meeting was organised around conferences from several invited speakers in the following sessions:

- Innovation's conceptual and practical framework. Application to the agro-food sector;
- Innovations to adapt sheep and goat feeding and production systems and industry to new societal demands;
- Precision farming and other technical innovations for increasing efficiency in sheep and goats;
- Success stories of innovations in the sheep and goat industry, with special focus on increasing consumption and adding value to products.

In addition, we had the opportunity to visit the experimental flock of Latxa dairy sheep of Neiker, on the Agri-Food Campus of Arkaute, and some examples of the R+D activities conducted on grazing management and innovative feeding practices within a circular bioeconomy approach. The insemination centre of Ardiekin was also visited, as well as one of the traditional areas of mountain pastures, where mixed grazing takes place during most of the summer and autumn.

The celebration of the seminar in the Basque Country offered an unbeatable opportunity to sincerely thank, honour and pay a deserved tribute to our dear colleague and friend Dr Dunixi Gabiña in his

homeland for a long career in favour of the development of small ruminants, as we did in the social dinner. Duni has devoted most of his professional career to IAMZ-CIHEAM where, among many other activities, he contributed to the creation and promotion of the FAO-CIHEAM Network on Sheep and Goats; however, his early years were linked to the start of the breeding scheme of the Latxa and Carranzana breeds in the Basque Country, where he was Director of R+D in the Department of Agriculture of the Basque Government. We wish Duni a long, healthy, active and happy retirement.

The organisers would like to thank all the persons and institutions that have been involved in the meeting: direct participants (authors, reviewers and chairs), technical staff of Neiker and IAMZ, funding and hosting institutions, and those collaborating in the technical visit to the campus of Arkaute, Ardiekin and to the mountain pastures of Entzia. We sincerely hope that the exchange of information at the seminar will provide the basis for further collaborations and joint research projects, and definitively contribute to the development of more sustainable sheep and goat farming systems.

During the process of editing these proceedings, we received the sad news of the death of Dr François Bocquier. Dr Bocquier participated in several activities of the Network in the past, and on the occasion of the Seminar in Vitoria-Gasteiz he delighted us with a very inspiring presentation on precision farming in small ruminants. With an extense background in animal science, he was a researcher of amazing creativity, and firmly committed to the development of small ruminant farming, in addition to being a pleasant, easy-going person, with a great sense of humour. May these proceedings serve to honour the memory of our deeply appreciated colleague Dr. François Bocquier, and to send our warmest support to his family and friends, who, like all of us, will miss him for sure.

Roberto Ruiz, Antonio López-Francos and Lucía López Marco
On behalf of the Scientific and Organising Committees

Session 1

Innovation's conceptual and practical framework

Impact de la conduite en lots d'alimentation de brebis laitières Basco-Béarnaises en début de traite sur la production et la composition chimique du lait

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Résumé. Les troupeaux de brebis laitières sont généralement conduits en lots de traite unique avec un niveau de concentrés identique pour toutes les brebis. La mise en lots, physiques ou virtuels, au moyen des distributeurs automatiques de concentrés (DAC) permet d'ajuster les niveaux de concentrés aux productions individuelles. Les effets de ces conduites alimentaires sur les productions laitières, la composition chimique et l'ingestion volontaire de fourrage n'ont pas été évalués à ce jour. Quatre lots de 44 brebis basco béarnaises en début de traite ont été générés à l'issue d'un contrôle laitier initial, de manière à comparer, durant 6 semaines, intra-lots à forte ou faible production, l'effet de l'ajustement ou non du concentré en fonction du niveau laitier. Cet ajustement des concentrés a des effets tangibles sur la production laitière, la composition chimique des laits, et sur l'ingestion volontaire de fourrages. Ces effets sont cohérents avec les connaissances antérieures. Dans les conditions de l'essai, la stratégie d'ajustement, comparée à la conduite en lot unique, s'est traduite par un gain de production laitière de 5.5%, une meilleure ingestion des fourrages (+5.8%), et une homogénéisation des variations d'état corporel.

Mots-clés. Brebis laitière – Alimentation en lots – Production laitière – Composition du lait – Ingestion.

Impact of group feeding management of Basco-Bearnais dairy ewes in early milking period on milk production and milk

Abstract. *Dairy sheep herds are usually conducted in single groups with the same level of concentrates for all ewes. Physical or virtual feeding groups, supplemented through individual concentrate feeder allows adjusting concentrate levels to individual production. Until now, we do not know the effect of such management on milk production and composition and voluntary forage intake. Four groups of 44 Basco-Bearnaise ewes in early milking period were constituted and balanced according to their milk yield, so as to compare during 6 weeks, intra-lots with high or low production, the effect of the adjustment or not of the concentrates. This adjustment of concentrates has tangible effects on dairy production, chemical composition of milks, and on the voluntary forage intake. These effects are consistent with previous knowledge. Under the test conditions, the adjustment strategy, compared to single group, resulted in a 5.5% increase in dairy production, better forage intake (+5.8%), and homogenization of changes in body condition.*

Keywords. *Idairy sheep – Feeding strategy – Milk yield – Milk composition – Intake.*

I – Introduction

Les brebis laitières en lactation sont traditionnellement alimentées de manière uniforme, indépendamment de leur niveau de production. Les éleveurs et les techniciens mettent en œuvre des stratégies d'apports issues de recommandations techniques propres à chaque bassin de production et basée sur le système d'alimentation INRA (UFL, PDI, UEM). Ces recommandations ont été affinées progressivement et réajustées à partir d'enquêtes sur les pratiques alimentaires (Arranz, sources personnelles, Esvan, 2010) réalisées au sein des services d'encadrement technique de chaque bassin de production.

L'incitation à réaliser des lots d'alimentation a débouché durant les années 2000 sur la constitution de 2 lots, un lot de traite principal et un lot de brebis arrivant tardivement à la traite (antenaises, lot des jeunes et brebis tardives). Contrairement à l'élevage des vaches laitières, la différenciation des apports de concentrés via des distributeurs automatiques de concentrés (DAC) (proposés sur le marché) est restée marginale jusqu'en 2010. C'est l'obligation d'identification électronique qui a été le déclencheur d'un réel développement des DAC en salle de traite, porté par 2 équipementiers du bassin de Roquefort.

Ce développement technologique ouvrait de nouvelles perspectives pour l'alimentation des animaux et pour concevoir une alimentation ajustée aux « besoins » individuels. Les éleveurs se sont rapidement saisis de ces nouveaux outils, à coûts marginaux limités, permettant d'ajuster les apports sans accroître le travail d'astreinte. Dans une première évaluation des stratégies d'alimentation au DAC en 2012 (source personnelle non publiée), nous avions identifié 3 grandes stratégies d'ajustement des concentrés :

- une stratégie dite redistributive, la réduction des apports de concentré aux moins bonnes laitières étant réaffecté aux meilleures laitières
- une stratégie économe, avec réduction des apports aux moins bonnes laitières et en maintenant les apports des plus productrices
- une stratégie dite sécurisée avec seulement un ajustement des concentrés pour les meilleures laitières.

Dans la pratique, ces stratégies peuvent être mise en œuvre avec 2 ou plusieurs lots, avec des ajustements intégraux ou partiels. Ces nouvelles conduites en lot suscitent plusieurs interrogations :

- quelle sera la conséquence d'une variation du niveau d'apport de concentré sur l'ingestion volontaire de fourrages, et donc quelles sont les taux de substitution concentré/fourrages ?
- ces différenciations sont-elles au service de stratégies redistributrives, sécurisées ou au contraire sources d'économie?
- faut-il maximiser la valorisation des fourrages ou les fonctions productrices, ou des fonctions économiques en intégrant les coûts des fourrages et des concentrés ?

Dans le cadre du projet CASDAR AUTELO portant entre autre sur l'autonomie alimentaire, un essai a été conduit à la ferme du lycée agricole d'Oloron Soeix dans les Pyrénées Atlantiques (France) avec des brebis de race Basco-béarnaise.

Cet essai visait à comparer une alimentation traditionnelle en un seul lot de production à une alimentation en lots de production dont le niveau d'apport de concentré était ajusté au niveau laitier pour évaluer l'impact de ces conduites sur la production laitière (quantité de lait et composition chimique) et sur l'ingestion volontaire de fourrages.

II – Matériel et méthodes

Sur la campagne 2015-2016, deux lots de 88 brebis adultes de race Basco-béarnaise ont été constitués selon le niveau de production (bas :B ; haut :H). Chaque lot a été subdivisé en 2 sous lots identiques (même structure de production) de 44 brebis avec appariement sur les productions laitières initiales, l'âge, la date de mise-bas, la taille de la portée, et un contrôle des index laitiers (production et taux). Les deux sous lots recevaient soit une quantité unique de concentrés (témoin, **T**) quel que soit le niveau de production, soit une quantité ajustée (expérimental, **E**) au niveau moyen du sous lot (B ou H). Les données initiales à la mise en lot sont présentées dans le Tableau 1.

L'essai s'est déroulé sur 6 semaines, dont une période pré expérimentale de 14 jours pour mettre en lot et ajuster progressivement les concentrés aux niveaux fixés.

Tableau 1. Données de mises en lot pour les 4 lots (moyennes ± *écart types*)

Lot	Effectif	Date mise-bas	Taille de la portée	Production laitière (l/j/b)	Index lait	Numéro lactation
BT	44	8/11 ± 10	1,36 ± 0,49	2,00 ± 0,32	101 ± 155	4,11 ± 1,8
BE	44	7/11 ± 10	1,36 ± 0,49	2,01 ± 0,28	90 ± 152	4,07 ± 1,7
HT	44	7/11 ± 10	1,48 ± 0,51	2,69 ± 0,25	228 ± 116	3,36 ± 1,1
HE	44	8/11 ± 10	1,48 ± 0,51	2,69 ± 0,23	218 ± 125	3,50 ± 1,2

BT = lot témoin et niveau de production laitière bas ; BE = lot expérimental et niveau de production laitière bas ; HT = lot témoin et niveau de production laitière haut ; HE = lot expérimental et niveau de production laitière haut.

Les 4 sous lots étaient alimentés avec des niveaux de concentrés décrits dans le Tableau 2. Les apports étaient calculés pour couvrir 116% des besoins énergétiques stricts (2,37 et 2,87 UFL respectivement pour les lots B et H) et 135% des besoins en PDI (284 et 385 g PDI pour les lots B et H), ce qui correspond aux recommandations en usage pour la race et les niveaux laitiers mesurés. Les quantités de concentrés ont été réajustées en cours d'essai (29/01) pour s'ajuster à l'évolution des productions laitières en conservant restant sur les mêmes niveaux de couverture des besoins (périodes P1 et P2).La ration de base était constituée d'un mélange de foin de graminée 1ère et 2ème coupe et de foin de luzerne acheté (Tableau 2).

Tableau 2. Valeurs alimentaires des aliments et quantités de matière sèche ingérées individuelle (QIMS) pour les 4 lots

Aliments consommés	Composition (g/kg brut)			QIMS Période 1				QIMS Période 2			
	UFL	CB	MAT	HE	BE	HT	BT	HE	BE	HT	BT
Foin de graminée 2ème coupe	0,68	214	141	1,16	1,22	1,19	1,05	1,46	1,5	1,4	1,21
Foin de luzerne	0,54	296	141	1,02	1,06	1,08	1,01	0,96	1	0,96	0,9
Foin de graminée 1ère coupe	0,57	265	105	0,12	0,12	0,12	0,12	0,08	0,08	0,08	0,08
Pulpe de betterave	0,91	173	80	0,22	0,22	0,22	0,22	0,11	0,11	0,11	0,11
Maïs grain	1,07	23	82	0,5	0,25	0,4	0,4	0,45	0,15	0,35	0,35
Aliment azoté du commerce	0,93	110	400	0,4	0,2	0,3	0,3	0,3	0,1	0,2	0,2

BT = lot témoin et niveau de production laitière bas ; BE = lot expérimental et niveau de production laitière bas ; HT = lot témoin et niveau de production laitière haut ; HE = lot expérimental et niveau de production laitière haut.

Les productions laitières individuelles (PL) étaient mesurées toutes les 2 semaines, avec les mesures individuelles de lait suivantes : taux butyreux (TB) et protéique (TP), urée et comptage des cellules somatiques (CCS). Les productions laitières standardisées (PLS) sont calculées à partir de la formule proposée par Bocquier (Bocquier, 1993) :

PLS = PL x (0,0071 x TB + 0,0043 x TP + 0,2224). Les animaux ont été pesés et leur état corporel (NEC) noté en début d'essai puis toutes les deux semaines.Les consommations de fourrages ont été mesurées 3 fois par semaine, en pesant les quantités offertes et les refus quotidiens pour chaque sous lot.

Les températures (minimum et maximum) ont été relevées quotidiennement. Les tests statistiques sont effectués avec le logiciel SAS (analyses de variance, procédure GLM) sur les variables de productions laitières, de composition chimique et de NEC entre lots 2 à 2. Les résultats sont traités au niveau des lots.La conduite dite traditionnelle (lots HT+BT) et la conduite redistributive (lots HE+BE) sont ensuite mises en comparaison.

III – Résultats

1. Production et composition chimique du lait

Au sein des lots H et B, l'ajout ou la diminution de concentré se traduit par une variation de la production laitière (Tableau 3), significatif pour les lots H, mais seulement en tendance pour les lots BL. Le TB (Tableau 3) varie aussi et de manière significative pour les lots H et BL aux contrôles 2,3 et 4.

Le TP (Tableau 3) est souvent plus élevé pour les lots B, et intra-lot pour les niveaux de concentrés plus élevés. Les teneurs en urée varient peu, et se situent à des niveaux conformes aux valeurs observées dans les élevages du bassin de production sans sortie au pâturage. Elles sont significativement plus élevées pour le lot HE.

Tableau 3. Moyennes et *écarts-types* des productions laitières journalières (PL en litres/brebis/jour) et de la composition chimique (TB et TP en g/l ; urée en mg/l) aux différents contrôles

Lot	PL1	PL2	PL3	PL4	PL5	Urée1	Urée2	Urée3	Urée4	Urée5
HE	2,692	2,283	2,289	1,706	1,478	398	454	428	432	371
	0,235	*0,315*	*0,351*	*0,271*	*0,293*	*32*	*33*	*27*	*26*	*42*
BE	2,011	1,530	1,572	1,181	1,094	394	419	398	421	405
	0,277	*0,296*	*0,319*	*0,225*	*0,217*	*30*	*30*	*25*	*24*	*38*
HT	2,694	1,991	1,956	1,395	1,340	394	424	377	419	405
	0,245	*0,344*	*0,272*	*0,260*	*0,259*	*30*	*38*	*23*	*27*	*42*
BT	1,997	1,719	1,678	1,193	1,142	387	433	394	433	397
	0,315	*0,329*	*0,303*	*0,212*	*0,230*	*33*	*34*	*23*	*26*	*34*
H		***	***	***	*		**	***	*	**
B		*								
Lot	**TB1**	**TB2**	**TB3**	**TB4**	**TB5**	**TP1**	**TP2**	**TP3**	**TP4**	**TP5**
HE	55,3	58,1	58,4	64,3	69,8	44,0	46,4	48,6	51,3	57,3
	6,9	*5,7*	*6,2*	*7,9*	*9,0*	*3,2*	*3,5*	*4,2*	*5,1*	*5,8*
BE	55,6	64,2	67,4	72,0	72,4	45,9	48,3	49,1	52,7	56,8
	6,4	*6,8*	*6,4*	*6,9*	*6,1*	*3,0*	*3,4*	*3,4*	*4,6*	*4,3*
HT	54,7	59,9	62,3	66,5	70,1	44,2	45,8	47,9	51,6	56,7
	7,6	*7,6*	*8,0*	*7,4*	*8,7*	*2,9*	*3,4*	*3,3*	*4,2*	*5,7*
BT	58,3	60,2	64,1	69,9	74,5	46,3	49,5	51,0	54,2	59,1
	6,4	*6,2*	*7,9*	*7,8*	*8,6*	*3,4*	*3,9*	*4,7*	*5,5*	*7,0*
H		***	***	***						
B		***	*	*				*		

Niveau de signification : * =P<0,05 ; ** = P<0,01 ; *** = P<0,01.

2. Etats corporels et poids

Les lots sont assez homogènes en poids (Tableau 4), avec peu d'évolution dans le temps. Les NEC (Tableau 4) restent plus élevées pour les lots à faible production (B), avec des évolutions comparables entre la première et la dernière notation : les écarts entre les lots H et les lots B sont significatifs aux 4 séries de notations, ainsi que les écarts entre les lots BT et BE aux 3 premières notes.

Tableau 4. Notes d'état corporel (NEC) et poids (PDS, kg) des animaux aux différentes mesures (moyennes et *écarts types*)

	NEC1	NEC2	NEC3	NEC4	PDS1	PDS2	PDS3	PDS4
BT	2,23	2,40	2,37	2,60	65,4	66,6	65,3	67,0
	0,19	*0,22*	*0,23*	*0,35*	*6,3*	*6,5*	*6,9*	*6,9*
BE	2,07	2,24	2,20	2,51	65,6	67,0	65,6	67,1
	0,23	*0,30*	*0,25*	*0,31*	*6,8*	*7,2*	*6,6*	*7,1*
HT	1,89	2,03	2,22	2,35	63,8	64,8	64,5	65,6
	0,25	*0,29*	*0,27*	*0,28*	*5,2*	*5,2*	*5,1*	*6,2*
HE	1,78	1,97	2,13	2,20	67,2	67,5	66,6	68,0
	0,30	*0,22*	*0,26*	*0,26*	*5,0*	*5,4*	*5,6*	*6,0*

3. Quantités ingérées de fourrages

Les quantités ingérées de matière sèche (QIMS) de fourrages peuvent varier de manière assez importante d'un jour à l'autre, avec des écarts importants d'une semaine à l'autre (Tableau 5).

Tableau 5. Quantités ingérées de matière sèche (QIMS) des fourrages

Périodes	**Période 1**			**Période 2**		
Semaines	1	2	3	4	5	6
QIMS (kg/j/b)	2,05	2,25	2,01	2,30	2,14	2,19

La variation des quantités ingérées de concentré (MSC) entraîne une modification des QIMS de fourrages durant les 6 semaines : -48g/j pour +174g/j de MSC (lots H) et +290g/j pour -240g/j de MSC (Tableau 6).

Tableau 6. Quantités ingérées de matière sèche (kg/j/b) de fourrage (QIMS-F), de concentré (QIMS-C) et totale (QIMS-T) au cours des 2 périodes (p1, p2) pour les 4 lots

	HE	HT	BT	BE	4 lots
QIMS-F-p1	2,109	2,171	1,933	2,208	2,105
QIMS-F-p2	2,175	2,210	1,973	2,277	2,159
QIMS-C-p1	0,974	0,800	0,800	0,583	0,790
QIMS-C-p2	0,748	0,574	0,574	0,313	0,552
QIMS-TI-p1	3,083	2,971	2,733	2,791	2,895
QIMS-T-p2	2,923	2,785	2,547	2,590	2,711

IV – Discussion

L'ajustement des apports de concentré à la production laitière des brebis a des effets significatifs sur la production laitière et sur le TB voire le TP, ce qui est conforme aux effets attendus (positifs pour la PL et le TP, négatif pour le TB) tels qu'ils sont décrits dans la bibliographie des différentes espèces animales traites. La modulation des apports de concentré se traduit par une substitution entre le fourrage et le concentré : l'accroissement du niveau de concentré provoque une réduction de l'ingestion volontaire defourrage. Cette substitution est beaucoup plus marquée pour les brebis des lots B que pour celles des lots H, ce qui pourrait provenir du protocole d'ajustement (différenciation à partir d'une ration unique plus proche du niveau H). La diminution de l'apport de concentré en cours d'essai se traduit elle aussi par une substitution marginale très élevée (+284g de MS de fourrage pour -237 g de MS de concentré) entre la semaine qui précède et celle qui suit le réajustement, avec un effet dépressif sur la production laitière. Les protocoles d'allotement ou de réallotement en cours de lactation ont des effets à prendre en compte lors de l'utilisation des DAC. Les NEC des lots B sont légèrement plus élevées que pour les lots H, mais les niveaux de concentrés n'ont pas eu d'effet sur l'évolution des NEC, ce qui est cohérent avec les taux de couverture de l'énergie calculés au moment des contrôles.

La comparaison entre la conduite traditionnelle (lots HT et BT) et la conduite redistributive (lots HE et BE) entraîne une légère et non significative augmentation moyenne de la production laitière (+5,5%) durant la période d'essai (42 jours), et seulement de 3,3% de la production laitière standardisées, avec des TB et TP légèrement inférieurs.Ces productions sont obtenues avec un accroissement de l'ingestion volontaire de fourrage (+5,8%), et une légère réduction du concentré (-4,7%), soit une augmentation de la MSI de 3,2%.

Le gain laitier reste limité, mais ne fait pas apparaître un réel intérêt à réduire les concentrés : l'intérêt économique dépend alors du différentiel de prix entre les coûts de production.

Les recommandations, fixées à 116 et 135% des besoins respectifs en énergie et en azote semblent satisfaisantes si on considère à la fois les niveaux de réserves corporelles (estimées par la NEC), les taux de couverture de l'énergie, ou les teneurs en urée (413 mg/l). Ces dernières sont plutôt assez faibles en regard des références publiées (Bocquier, 2001) ou des résultats des analyses interprofessionnelles (non publiées).

V – Conclusions

Cet essai confirme, dans les conditions d'élevage du troupeau expérimental de la ferme du lycée agricole d'Oloron (race, alimentation en intérieur) que l'alimentation en lot, en modulant les concentrés avec un DAC, permet d'accroître légèrement la production laitière et l'ingestion de fourrages. Il permet de réguler les apports en fonction des besoins des animaux, et donc de contrôler l'engraissement durant la lactation, ce qui permet aussi de pouvoir réaliser durant la période de lutte un flushing efficace pour toutes les brebis. De tels essais doivent être répliqués dans d'autres conditions d'élevage (alimentation à l'herbe) et sur d'autres types génétiques. L'importance des substitutions fourrage concentrés invite à poursuivre ces essais en intégrant les effets de la qualité des fourrages sur les substitutions générées lors de l'utilisation des DAC.

Remerciements

Le projet AUTELO, porté par le Comité National Brebis Laitières, a bénéficié d'un financement du compte d'affectation spéciale « développement agricole et rural » (CASDAR) du Ministère de l'Agriculture, de l'Agroalimentaire et de la Forêt. Les auteurs souhaitent remercier le personnel de la ferme du lycée agricole d'Oloron pour le suivi et l'entretien des animaux.

Encart DAC :

Les DAC commercialisés permettent d'ajuster les concentrés en salle de traite. Le chariot distributeur est généralement constitué de 2 cellules permettant de distribuer 2 aliments, le plus souvent un concentré énergétique et un concentré azoté, pour distribuer un mélange des 2 aliments à des quantités paramétrables. La quantité globale de concentré est ajustable entre 50 g (dose d'appel) et 550 à 600 g maximum par jour pour des animaux de format limité (55 à 60 kg de poids vif par animal), soit un maximum de 275 à 300 g par traite. Le logiciel du DAC est alimenté avec les données de contrôle laitier par une application permettant de mettre en lot les brebis présentes, sur les données de production laitière au contrôle laitier, mais aussi en intégrant l'âge des animaux et les dates de mises-bas (stades de lactation).

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Geroko, un outil de simulation pour évaluer les performances économiques, environnementales et climatiques des exploitations agropastorales des Pyrénées occidentales

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Résumé. Les politiques publiques, en réponse aux attentes sociétales, visent à réorienter l'agriculture vers des modèles de production basés sur l'agro-écologie. Comment donner du sens aux principes de l'agro-écologie, appréhender les effets de l'élevage sur les changements climatiques et comment expliciter les compromis (économie-environnement-climat) que doivent faire les agriculteurs dans leurs choix stratégiques ?

L'outil « Geroko » a été conçu dans le cadre d'un programme national mené avec les AOP fromagères des Alpes et du Massif Central, visant à décrire et quantifier les services éco-systémiques (SES) rendus par les exploitations laitières en regard aux objectifs d'autonomie alimentaire des exploitations. Il s'appuie sur la qualification des surfaces fourragères à partir de typologies régionales de prairies articulant des indicateurs de production et de services écosystémiques. L'outil a été testé et mis en œuvre chez 44 éleveurs recrutés sur des préoccupations spécifiques. En amont des simulations, les diagnostics initiaux ont permis de montrer les relations entre indicateurs de services, et de mettre en évidence un gradient de services entre les exploitations de montagne les plus contraintes et des exploitations de piémont et de coteaux. Les indicateurs de services environnementaux sont opposés aux variables d'intensification ou de productivité, l'autonomie alimentaire s'avérant indépendante de ces variables et liée à des stratégies individuelles.

Mots-clés. Systèmes d'élevage – Agropastoralisme – Services écosystémiques – Autonomie alimentaire.

Geroko, a simulation tool to evaluate the economic, environmental and climatic performances of agropastoral farms in the Western Pyrenees

Abstract. *Public policies, in response to societal demand, aim to reorient agriculture towards production models based on agro-ecology. The question is how togive meaning to the principles of agro-ecology, to understand the effects of livestock on climate change and how to explain the trade-offs (economy-environment-climate) that farmers make in their strategic choices?*

The "Geroko" tool was designed as part of a French national program with the Alpine and Massif Central cheese PDOs to describe and quantify the ecosystem services provided by dairy farms in relation to objectives of farm autonomy (feed self sufficiency). It is based on the qualification of forage areas based on regional typologies of grasslands that link production indicators and ecosystem services. The tool was tested and implemented in 44 breeders recruited on specific concerns. Upstream of the simulations, the initial diagnoses showed the relationships between service indicators and highlighted a service gradient between the most constrained mountain farms and the piedmont and hill farms. Indicators of environmental services are opposed to intensification or productivity variables, food self-sufficiency being independent of these variables and linked to individual strategies.

Keywords. *Livestock systems – Agropastoralism – Eco-systemic services – Feed self sufficiency.*

I – Introduction

Les modèles de production agricoles sont aujourd'hui mis en tension et fragilisés, à la fois immergés dans une économie mondialisée, et sous le regard de plus en plus pressant de la société civile et des consommateurs. Les filières sous Appellation d'Origine Protégée (AOP), qui peuvent paraître mieux armées pour répondre à ces nouveaux enjeux, sont paradoxalement désarmées face à la multiplicité des injonctions environnementales : développement durable, agro-écologie, services éco-systémiques, bien être animal, et récemment lutte contre les changements climatiques. Ces concepts apparaissent trop lointains et théoriques pour les acteurs des filières (éleveurs, transformateurs, organisations techniques et économiques), et perçus qu'à travers les applications des politiques publiques et des aides qui s'y rattachent.

En 2013, les filières AOP fromagères de montagne (Alpes du Nord, Massif Central, Pyrénées) ont conçu un programme de recherche développement ATOUS : « Vers une Approche Territoriale de l'autonomie fourragère et des Services rendus par les systèmes fourragers à dominante herbagère en production fromagère AOP de montagne » qui vise à décrire et quantifier les services écosystémiques (SES) rendus par les exploitations laitières, et à s'interroger sur des objectifs de conciliation entre la recherche d'autonomie et le maintien ou le renforcement des SES. Cette question est abordée en s'appuyant sur des groupes d'éleveurs issus d'une dizaine de petits territoires dans les trois massifs montagneux, à partir d'enquêtes sur les fonctionnements des systèmes fourragers, de manière à objectiver les liens entre les niveaux de services rendus et les fonctionnements des systèmes fourragers des exploitations et au-delà des petits territoires considérés. Autour d'enjeux inter-massif communs, et d'un cadre méthodologique co-construit, chaque zone géographique a mobilisé des moyens et outils spécifiques, tels que les typologies de prairies (Michaud, 2013), et des logiciels ou tableur d'approche des systèmes d'exploitation (incluant les systèmes fourragers) des exploitations tels que « Diam » (Farruggia, 2012), « Dialog » (Theau, 2013).

Dans cet article, nous présentons la démarche mise en œuvre dans les Pyrénées, le choix des groupes et des préoccupations traitées, et, à l'issue de sa mise au point, les premiers retours sur l'utilisation d'un outil d'analyse et de simulation des systèmes d'élevage « Geroko » conçu pour des exploitations agropastorales et poly-élevages.

II – Objectifs et prise en compte des préoccupations des éleveurs

La mise au point de l'outil d'accompagnement des éleveurs, « Geroko », doit permettrede simuler des évolutions de système de production, dans le contexte d'élevage agropastoraux à dominante ovins lait des Pyrénées basco-béarnaise, qui intègreraient en intégrant les SES et l'impact climatique. Plus concrètement, l'outil doit répondre aux préoccupations exprimées initialement par les éleveurs, autour de trois questionnements précis :

- Evolution du cahier des charges de l'AOP Ossau Iraty : quel serait l'impact économique de l'application de la nouvelle mesure du cahier des charges de l'appellation d'origine relative à la suppression des fourrages fermentés ? Quelles conséquences sur les systèmes fourragers et vis-à-vis des autres mesures des cahiers des charges AOP ?
- Mise en œuvre des documents d'objectifs Natura 2000 et de l'éco-conditionnalité de la PAC : quelles mesures agri-environnementales et climatiques (MAEC) mettre en œuvre pour des producteurs concernés ?
- Conduite des prairies : quelles pratiques de gestion des prairies pour maintenir et renforcer les services rendus ?

La mise en œuvre du dispositif de test de « Geroko » a été associée à l'élaboration de la typologie des prairies basco-béarnaises (Arranz, 2017). La volonté de sensibiliser les éleveurs et les organisations techniques à la diversité de services et à leur importance dans le fonctionnement des

écosystèmes agropastoraux était un objectif majeur, y compris pour aider à donner du sens et du contenu aux nouveaux modèles d'agro-écologie, aux évolutions des politiques publiques, aux demandes de la société civile.

III – Méthodologie des services éco-systémiques

Nous avons mobilisé le cadre d'analyse des services éco-systémiques (SES) issu de l'évaluation pour le millénaire (MEA, 2005), ainsi que la catégorisation générale des services (travaux du CREDOC : Maresca, 2011), puis appliqué au secteur agricole (Amiaud,2012) et de manière spécifique aux appellations fromagères du Massif central (Carrère, 2012). Dans le cadre du programme ATOUS, 14 services (support, approvisionnement, régulation et culturels) ont été retenus et déclinés dans chaque massif (Carrère, 2015). Ces services sont exprimés à l'échelle de la parcelle, de manière à générer des indicateurs à l'échelle des exploitations, principalement de manière additive pour les indicateurs liées aux surfaces. Une des originalités de cette approche en zones d'AOP fromagères est de produire des indicateurs du potentiel de qualité des produits qui ont été proposés en 2012 lors de l'élaboration de la typologie multifonctionnelle des prairies du Massif Central (Carrère, 2012).

D'autres indicateurs de services liés aux productions animales, sont calculés à partir des données sur les troupeaux : production laitière et de viande, émission de gaz à effet de serre (GES).Dans chaque massif, les indicateurs de service s'appuient sur les typologies de prairies régionales des Alpes (Fleury, 1988), d'Auvergne (Hulin, 2011) et des Pyrénées basco-béarnaises (Arranz, 2017) qui permettent d'affecter à chaque type de prairie des valeurs de service (Michaud, 2013).

IV – Geroko, un outil de diagnostic et de simulation de systèmes d'élevage

Le tableur « Geroko » permet, à l'échelle de l'exploitation, de produire des indicateurs de performances technico-économiques, environnementales et climatiques, mais surtout de simuler des évolutions de systèmes de production en faisant varier ces indicateurs.

Le diagnostic initial est réalisé sur exploitation, la visite permet de quantifier les surfaces par type de prairies ou de milieux, et de générer des indices moyens à l'échelle de l'exploitation.

L'outil repose sur des équations d'estimation des besoins et des ingestions de matière sèche (MS) par animal et par an, en fonction du format des animaux (espèces et races) et des niveaux de production laitière, pour les différents ateliers d'herbivores. Les séjours hors exploitation (estive, mise en pension) sont pris en compte, et la part d'herbe pâturée est calculée par atelier par différence entre les besoins et les stocks consommés. Le paramétrage des besoins MS des brebis laitières en fonction de leur format et de leur niveau de production est basé sur 3 séries d'enquêtes alimentation (années 2008, 2012,2016 non publiées) menées au sein des élevages en contrôle laitier et ayant permis de mettre au point les outils d'évaluation des besoins. Le paramétrage des besoins des bovins est effectué par le technicien. Les indices d'émission des GES (méthane entérique, protoxyde d'azote, gaz carbonique) sont eux aussi calculés à partir de la MS ingérée, en considérant que celle-ci constitue le principal facteur de variation des postes d'émission majeurs : méthane entérique (55%), rejets d'azote (20%), achats d'aliments (CDPB, « Climagri : stratégie climat énergie pour le Pays Basque », 2014). La digestibilité de la Matière organique varie peu, et pour le protoxyde d'azote N2O que la densité azotée des aliments ingérés est elle aussi assez stable (avec des entrées d'azote minéral faibles). Le poste d'émission de CO2 est indexé sur le niveau des achats, poste majeur identifié lors de la mise en oeuvre de Climagri en Pays Basque. Il s'agit bien, à travers ces postes d'émission de GES, de pouvoir expliquer de manière simple l'origine des émissions et comment elles vont varier.

Les simulations permettent de faire varier, indépendamment ou simultanément, les ateliers animaux et les surfaces fourragères, y compris les prix unitaires des aliments, les coûts de production des aliments, et les prix d'achat des produits. Ces changements vont entraîner des variations de marge brute, ainsi que des indicateurs techniques, de services éco-systémiques et climatiques. De manière inter-active avec l'éleveur, plusieurs hypothèses ont pu être testées lors des entretiens.

Le tableur a ainsi été testé et utilisé chez 44 éleveurs participant au programme, permettant de tester l'opérationnalité de l'outil et de répondre aux demandes exprimées en amont par les groupes d'éleveurs. Les diagnostics initiaux, sont seuls présentés ici bien que des états post-simulations et les variations liées à ces simulations aient été ensuite réalisés.

V – Mise en œuvre de l'outil et résultats

Les 44 éleveurs testé étaient issus de 5 groupes d'animation rattachés à différents territoires, parfois très hétérogènes,: les sédentaires non transhumants avec des cultures et des prairies temporaires (coteaux), les exploitations de montagne avec transhumance et SAU constituée de prairies permanentes ou parcours, et les exploitations intermédiaires non rattachables aux 2 groupes précédents.

L'analyse porte sur une centaine de variables de structure, de fonctionnement et d'indicateurs de services. Pour rendre compte de la démarche et des relations observées entre services, 14 variables ont été retenues : nombre d'UGB sur l'exploitation (UGB avec valeur d'équivalence de 0,15 pour les chèvres et les brebis), dont effectif de brebis (Ovins), surface agricole utile (SAU en ha), dont surface en cultures (Cult en ha), production laitière moyenne par brebis (PL en litre par brebis et par an), Chargement (UGB/ha), production valorisée des prairies (tMS/ha), pourcentage d'herbe valorisée par la pâture (%pature), autonomie alimentaire en fourrages et concentrés (AA en pourcentage) de l'exploitation, participation d'espèces mellifères aux surfaces fourragères (meli), potentiel aromatique des surfaces fourragères (Arome), indice de stockage de carbone des surfaces fourragères (StockC), émission de méthane par les ovins (14kg/an/brebis standardisée à 760 kg MSI)(CH4ovin en kg) et par litre de lait (CH4/l en g).

Le tableau 1 récapitule les niveaux moyens et les écart types observés pour les différentes variables sélectionnées.

Tableau 1. Variables de structure et de services : moyennes et écarts type par groupe

Groupes	N	UGB	Ovin	SAU ha	Cult ha	PL	UGB /ha	tMS /ha	% pat	AA %	Meli	Arome	Stock C	CH4 ovin	CH4 /l
Montagne	15	47.2	219	24.8	0.0	139	1.49	3.82	50.5	62.9	19.2	0.83	0.73	2678	106
		27.0	*112*	*11.8*		*62*	*0.52*	*1.18*	*9.1*	*14.2*	*1.9*	*0.07*	*0.10*	*1515*	*52*
Intermédiaire	12	72.9	322	43.6	48.8	35.5	0.69	4.22	43.8	71.8	17.2	0.7	0.61	4158	73
		26.3	*66*	*14.8*	*3.5*	*40.4*	*0.26*	*1.26*	*17.6*	*15.4*	*2.3*	*0.09*	*0.14*	*1020*	*15*
Coteaux	14	99.6	439	53.9	5.9	211	1.93	5.81	32.0	71.9	15.1	0.47	0.46	5631	62
		28.3	*150*	*16.1*	*3.5*	*29*	*0.60*	*1.02*	*11.3*	*7.7*	*1.9*	*0.14*	*0.14*	*1977*	*7*
3 groupes	41	72.6	324	40.2	3.0	177	1.66	4.78	42.2	68.6	17.2	0.67	0.60	4119	81
		34.7	*147*	*18.7*	*3.7*	*55*	*0.52*	*1.41*	*14.8*	*0.132*	*2.6*	*0.19*	*0.17*	*1984*	*37*

Nous observons des gradients de taille (UGB, ovins, SAU), productivité des animaux (PL) et des surfaces fourragères (tMS/ha) décroissants entre la zone de coteaux et celle de montagne, et au contraire des gradients croissants pour les services environnementaux (aromes, mellifères, stockage carbone) entre les exploitations de coteaux et celles de type montagne. La matrice de

corrélation de l'ensemble des variables fait ressortir des relations positives et hautement significatives entre variables de taille et de productivité, mais opposées aux variables de services environnementaux. Paradoxalement, l'autonomie n'est corrélée significativement qu'avec la taille de l'exploitation, mais pas avec les autres variables. Les variables d'émission de méthane par atelier et par litre de lait sont opposées (de manière hautement significative. Les variables de productivité et de taille sont corrélées positivement aux émissions totales de l'atelier ovin, mais négativement aux émissions par litre de lait.

VI – Discussion

L'interprétation proposée à partir d'un nombre restreint de variables n'est pas surprenante, et reste cohérente avec l'analyse menée sur un plus grand nombre de variables, telles que les indicateurs construits à partir de la typologie fonctionnelle des graminées, l'importance des légumineuses, les types de surfaces fourragères, la diversité des espèces, les achats d'aliments, l'excrétion d'azote organique.

Alors que la plupart des variables sont bien corrélées entre elles, l'autonomie alimentaire reste relativement indépendante des autres variables. L'agrandissement des exploitations et l'intensification des surfaces fourragères s'accompagnent d'une augmentation de la productivité animale (par la taille et les niveaux de production laitière par brebis), et donc sans réduction des achats, sans gain d'autonomie. La recherche d'autonomie, parfois réelle, résulte de décisions individuelles indépendantes des structures et des contraintes d'exploitation (pentes et limites de mécanisation) (Arranz, 2015).

Les méthodes d'évaluation des bilans carbone sont exprimées en Kg de CO2 par litre de lait. L'indicateur d'excrétion de méthane par litre de lait (CH4/l), corrélé positivement aux variables de productivité animale, et négativement à l'indicateur à l'échelle de l'atelier ovin (CH4ovin), ainsi qu'aux variables de services environnementaux. Cette opposition suppose, en termes de stratégie de production, de rechercher des compromis entre les différents services.

L'approche au niveau des 3 groupes d'exploitations suggère que ces compromis et ces équilibres diffèrent d'une zone géographique à l'autre, et doivent se raisonner en regard des contraintes propres à chaque exploitation. Dans le contexte géographique des Pyrénées basco-béarnaises et de son piémont, la diversité des situations et des niveaux de handicap naturel produit des « bouquets de services » différenciés : cette diversité constitue une réelle valeur ajoutée pour le territoire de la zone AOP, en lui conférant des capacités d'adaptation et de résilience aux aléas climatiques et économiques.

VII – Conclusion

La majorité des éleveurs a été intéressée à la démarche qui associe un diagnostic sur site et la valorisation de données économiques, en produisant des états de services de production, environnementaux et climatiques : les indicateurs proposés permettent de renouveler et d'enrichir le regard des éleveurs et des techniciens sur leur exploitation, sur l'impact de leurs pratiques. La commande initiale vis à vis du cahier des charges de l'AOP (interdiction des ensilages en période de production à partir février 2018) a été honorée, avec des simulations chez 12 éleveurs. Nous avons aussi simulés des changements sur les ateliers animaux, effectifs ou niveau de productivité laitière, chez 8 d'entre eux, des modifications de gestion des surfaces fourragères ont aussi été proposées.

A l'issue de ces tests, la méthode à été proposée à des élèves de classes de BTS, en travail de groupe, ou pour des rapports de stage en exploitations, ainsi que des conversions en agriculture biologique. Elle demande néanmoins une réelle compréhension des systèmes de production et des connaissances sur l'alimentation des ruminants et sur les systèmes fourragers.

Remerciements

Ces travaux ont été réalisés dans le cadre d'un programme CASDAR financé par le ministère de l'agriculture, et a bénéficié de l'appui du Conseil Régional d'Aquitaine. Nous remercions chaleureusement les 44 éleveurs qui ont collaborés à ces travaux.

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Revisiting particle kinetics in the rumen: comminution, digestion and passage functions as affected by diet type

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Abstract. Six Rasa Aragonesa wethers were fed lucerne hay either chopped at 5 cm (diet C) or ground (2 mm) and pelleted (diet P) in a cross-over design. Access to the diets was restricted to 4 hours, and fractional outflow rates from the rumen of liquid- (Co-EDTA) and solid-phase (Cr and Yb) markers, and digestion kinetics of different particle sizes (0.5-1 mm, 1-2 mm, 2-4 mm and 4-8 mm) were studied. Samples of rumen content were obtained at different times throughout the day to estimate rumen pools of different particle sizes, and dilution rates of transit markers and rumen volume. Feeding behaviour of the animals was also recorded. Dry matter intake was lower (P<0.001) in animals fed diet C than P (1206 *vs.* 1733 g/day) which on the other hand spent more time eating (218 *vs.* 94 min/day, or 182 *vs.* 55 min/kg dry matter intake-DMI; P<0.001) and ruminating (283 *vs.* 182 min/kg DMI; P<0.05). Potential degradability of different particle sizes did not change across diet types whereas fractional degradation rate decreased (P < 0.01) as particle size increased. The mean particle size of rumen digesta was higher with diet C (P < 0.05) whereas the rate at which particles larger than 1.2 mm reduced due to chewing during eating was higher with diet P than C, but the effectiveness of rumination in reducing particle size of rumen digesta was higher with diet C. The higher intakes in animals fed diet P could be explained by variations in rumen volume, rates of digestion and a higher rate of outflow of small particles pulled out with the liquid phase.

Keywords. Degradation – Feeding behaviour – Particle size – Transit.

Revoir la cinétique des particules dans le rumen : diminution de la taille de particule, digestion et passage affectés par le type de régime

Résumé. *Six moutons castrés de race Rasa Aragonesa ont été alimentés avec une ration á base de foin de luzerne soit haché á 5 cm (régime C) ou bien broyé (2 mm) et granulé (régime P) dans un modèle croisé. L'accès aux rations a été restreint á 4 heures, et le taux de passage fractionnaire des marqueurs de la phase liquide (Co-EDTA) et solide (Cr and Yb) de rumen, et la cinétique de la digestion de différentes tailles de particules (0,5-1 mm, 1-2 mm, 2-4 mm et 4 -8 mm) ont été étudiés. Des échantillons de contenu ruminal ont été obtenus à différents moments tout au long de la journée pour estimer les différentes tailles de particules de pools de rumen, et la dilution des marqueurs de transit et le volume du rumen. Le comportement alimentaire des animaux a été également enregistré. L'ingestion de la matière sèche a été plus élevée (P <0.001) chez les moutons alimentés par la ration P en comparaison á ceux alimentés par la ration C (1733 vs. 1206 g/jour) qui ont au contraire passé moins de temps à manger (94 vs. 218 min/jour, ou 55 vs. 182 min/kg de matière sèche ingérée-MSI, P <0,001) et á ruminer (182 vs. 283 min / kg MSI, P <0,05). La dégradabilité potentielle des différentes tailles des particules n'a pas été changée pour les différents types de régime, alors que le taux de dégradation fractionnelle a été diminué (P <0,01) lorsque la taille des particules a été augmentée. La taille moyenne des particules du digesta de rumen a été plus élevée avec le régime C (P <0,05) alors que le taux auquel des particules de plus de 1,2 mm ont été diminués dû á la mastication pendant la consommation a été plus élevée avec le régime P par rapport au régime C, mais l'efficacité de la rumination dans la réduction de la taille des particules du digesta de rumen a été plus élevée avec le régime C. L'ingestion plus élevée chez les animaux nourris avec le régime alimentaire P pourrait s'expliquer par des variations du volume de rumen, le taux de digestion et le taux élevé de passage des petites particules qu'ont été retirées avec la phase liquide.*

Mots-clés. *Dégradation – Comportement alimentaire – Taille des particules – Passage.*

I – Introduction

The amount of a determined feedstuff that can be ingested by a determined animal will depend on both the intrinsic properties of the former (chemical composition and organoleptic characteristics; Minson, 1982) as well as on the intake capacity of the latter (Weston, 1982), and the interaction between those two factors with the environment (Mertens, 1987). Although intake by ruminants can be driven by metabolic or physical signals (Baile and Forbes, 1974; Dulphy and Faverdin, 1987), it seems sufficiently proven that in animals fed low-quality roughages the limiting factor is rumen fill (Conrad *et al*., 1964; Montgomery and Baumgardt, 1965). This rumen fill is in turn related to the rate and amount of intake, and to the rate and amount of digesta flow out of the rumen.

Rate and amount of intake is highly variable (Dulphy and Faverdin, 1987) depending mainly on pattern of intake but also on chemical and physical characteristics of the diet, level of feeding, animal species and physiological state, and environmental conditions. In turn, rate and amount of digesta flow out of the rumen will be determined by digestion and passage. Digestion is the result of comminution through chewing during eating and rumination (Pond *et al*., 1987), and subsequent microbial degradation (Hanna *et al*., 1973), whereas passage refers to the flow of undigested feed residues from one compartment to the next (Warner, 1981).

Classical reviews (Hungate, 1966; Kotb and Luckey, 1972; Warner, 1981; Ellis *et al*., 1988) have pointed out that the study of transit kinetics is not easy, and require an exact knowledge of the amount of the undigestible fraction present in a determined compartment, as well as its rate of incorporation and release, and the assumption that the potentially digestible fractions will show the same kinetic behaviour, or the use of reference substances generally known as markers, which theoretically behave in the same way as the fraction to which they are supposed to be attached. The use of these substances is based on the assumption that rumen volume remains constant, and that inflows to and outflows from the compartment are homogeneous, continuous and equivalent (Faichney, 1975; Ellis et *al*., 1984), although it is known that these ideal conditions are rarely accomplished. The structure of the rumen digesta does not allow an instantaneous and homogeneous mixing of its liquid and solid phases hence different markers with distinct physical-chemical characteristics are needed.

Regardless the methodological aspects, both intraruminal and extraruminal elements affect transit kinetics. Among the latter, dietary (chemical composition, form of presentation) and animal (genetics, age, physiological state) factors, as well as the interaction between them (level of feeding) or with the environment are the most important. Among intraruminal factors, particle size and shape are supposed to be the most limiting factors of digesta passage out of the rumen (Poppi *et al*., 1980; Ulyatt *et al*., 1986) but there is generally a lack of information about how diet type and feeding conditions affect these variables. On the other hand, the relationships between particle size and digestion and passage kinetics are not sufficiently clear as it is not the effect of rumen digesta particle size on marker dilution kinetics in the rumen. Despite that, the number of papers published in this subject in the last two decades appears negligible.

On these grounds, the aim of the present experiment was to study the daily evolution of digesta particle size in the rumen and its relationship with feeding behaviour, digesta load, and digestion and transit kinetics in sheep fed lucerne hay either chopped or ground and pelleted.

II – Materials and methods

In a changeover design, lucerne hay either chopped at 5 cm (diet C) or ground (2 mm) and pelleted (diet P) was offered to six individually-housed Rasa Aragonesa wethers (four years old and with an average live weight of 48.9 ± 1.58 kg at the beginning of the experiment) fitted with a rumen cannula (5.3 mm I.D.). Access to the diets was restricted to 4 hours to allow for daily variations in rumen volume, and fractional outflow rates from the rumen of liquid- (Co-EDTA) and solid-phase (Cr-mordanted and Yb-labelled feeds) markers, and *in situ* degradation kinetics of different particle sizes (0.5-1 mm, 1-2 mm, 2-4 mm and 4-8 mm, obtained by grinding different samples of the lucerne hay through the higher-size meshes, and then sieving through both the higher- and the smaller-size sieves) were studied. Transit markers were introduced via cannula just before feeding (09:00 h). Samples of rumen content were obtained at different times throughout the day to estimate rumen pools of different particle sizes, and dilution rates of transit markers and rumen volume. Feeding behaviour of the animals was also recorded by visual observation.

All results were subjected to a one-way analysis of variance. Differences between treatment means were identified by the least significant difference (LSD). Statistical analysis was performed using the SAS statistical package (version 8.01).

III – Results and discussion

Dry matter intake was lower (P<0.001) in animals fed diet C than P (1733 *vs.* 1206 g/day) which also spent more time eating (218 *vs.* 94 min/day, or 182 *vs.* 55 min/kg dry matter intake-DMI; P<0.001) and ruminating (283 *vs.* 182 min/kg DMI; P<0.05) (Table 1). Potential degradability of different particle sizes did not change across diet types (P > 0.05) whereas fractional degradation rate decreased (P < 0.01) as particle size increased (Table 2). The mean particle size of rumen digesta was higher with diet C (0.89 *vs*. 0.39 mm; P < 0.05) whereas the rate at which particles larger than 1.2 mm reduced due to chewing during eating was higher with diet P than C, but the effectiveness of rumination in reducing particle size of rumen digesta was higher with diet C (Table 3). The higher intakes in animals fed diet P could be explained by variations in rumen volume, rates of digestion and a higher rate of outflow of small particles pulled out with the liquid phase.

Table 1. Dry matter intake (DMI), and times spent chewing during eating and ruminating by wethers fed lucerne hay either chopped at 5 cm (diet C) or ground (2 mm) and pelleted (diet P). Access to the feed was restricted to 4 hours

	Diet C	Diet P	RSD	*P*
DMI (g/day)	1206	1733	39.1	< 0.001
Eating				
min/kg dry matter intake	182	55	7.5	< 0.001
min/day	218	94	10.7	< 0.001
Ruminating				
min/kg dry matter intake	283	182	43.3	< 0.05
min/day	344	318	69.5	> 0.05

RSD: residual standard deviation of the mean of the analysis of variance.
P: probability of the differences.

Table 2. Degradation characteristics (*a* represents the soluble fraction, *b* the insoluble but potentially degradable fraction, and *c* the fractional rate of degradation) of different particle size populations in the rumen of wethers fed lucerne hay either chopped at 5 cm (diet C) or ground (2 mm) and pelleted (diet P). Access to the feed was restricted to 4 hours

	Particle size (mm)	Diet C	Diet P	RSD	*P*
a (%)	0.5-1.0	15.77	17.61	4.780	> 0.05
	1.0-2.0	14.02	17.92	1.541	< 0.01
	2.0-4.0	15.91	16.61	1.559	> 0.05
	4.0-8.0	13.28	15.60	2.360	> 0.05
b (%)	0.5-1.0	41.21	38.43	4.214	> 0.05
	1.0-2.0	43.46	38.96	1.256	< 0.001
	2.0-4.0	40.10	39.21	1.922	> 0.05
	4.0-8.0	40.28	38.65	2.809	> 0.05
c (h^{-1})	0.5-1.0	0.114	0.093	0.0201	> 0.05
	1.0-2.0	0.121	0.086	0.0110	< 0.001
	2.0-4.0	0.087	0.084	0.0143	> 0.05
	4.0-8.0	0.105	0.071	0.0063	< 0.001

RSD: residual standard deviation of the mean of the analysis of variance.
P: probability of the differences.

Table 3. Rate of reduction of digesta particles below a size of 1.2 mm (g/h and%) during eating and ruminating in wethers fed lucerne hay either chopped at 5 cm (diet C) or ground (2 mm) and pelleted (diet P). Access to the feed was restricted to 4 hours

	Diet C	Diet P	RSD	*P*
Chewing during eating				
g/hour	159	294	39.6	< 0.001
%	67.8	91.4	3.74	< 0.001
Ruminating				
g/hour	48.6	9.4	6.69	< 0.001
%	23.8	6.0	3.41	< 0.001

RSD: residual standard deviation of the mean of the analysis of variance.
P: probability of the differences.

IV – Conclusions

Reducing the particle size of lucerne hay increases its intake, and this is related to changes in feeding behaviour, rumen volume, rate of degradation of feed particles in the rumen, and behaviour of different particles which can show a liquid-like (small particles) or a solid-like (large particles) rate of outflow from the compartment.

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Environmental implications of different production systems in a Sardinian dairy sheep farm

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Abstract. Sardinia (Italy) plays a relevant role on EU sheep milk production. As well as in others Mediterranean regions, contrasting dairy sheep farming systems coexist in Sardinia and an effective renovation process is needed in order to contrast the deep structural crisis. Eco-innovation of production processes and the valorisation of pasture-based livestock systems can be a key strategy to improve the farms competitiveness and to promote the typical Mediterranean dairy sheep products in a green way. For this purpose, research studies are needed in order to assess the environmental implications of Mediterranean sheep systems with a holistic and site-specific approach. The main objective of this study was to compare the environmental performances of two contrasting sheep milk production systems, by using a Life Cycle Assessment (LCA) approach. The LCA was carried out in a farm where, along ten years, a conversion from arable and irrigated crops to native and artificial pastures and a reduction of total mineral fertilizers supply occurred. The effects of the conversion on the environmental impacts were analyzed both using 1 kg of Fat and Protein Corrected Milk (FPCM) and 1 ha of surface as functional units. The LCA study highlighted that the change from a semi-intensive to a semi-extensive production system had a different effect on the environmental impacts depending on the utilized functional unit.

Keywords. Dairy sheep – Environmental impacts – Life Cycle Assessment – Functional unit.

Implications environnementales de différents systèmes de production dans une ferme de moutons laitiers de Sardaigne

Résumé. *La Sardaigne (Italie) joue un rôle important dans la production de lait de brebis de l'UE. Ainsi que dans d'autres régions méditerranéennes, des systèmes agricoles contrastés de brebis laitières coexistent en Sardaigne et un processus de rénovation efficace est nécessaire pour contrecarrer la crise structurelle profonde. L'éco-innovation des processus de production et la valorisation des systèmes d'élevage à base de pâturage peut être une stratégie clé pour améliorer la compétitivité des exploitations agricoles et pour promouvoir les produits de brebis laitières typiques de la Méditerranée. A cet effet, des recherches sont nécessaires afin d'évaluer les conséquences environnementales des systèmes méditerranéens de brebis laitières avec une approche holistique et spécifique par site. L'objectif principal de cette étude était de comparer les performances environnementales de deux systèmes contrastés de production de lait de brebis, en utilisant une approche d'évaluation du cycle de vie (ACV). L'ACV a été réalisée dans une ferme où, au cours de dix années, ont eu lieu une conversion pour passer des cultures arables et irriguées aux pâturages naturels et artificiels et une réduction de l'apport total d'engrais minéraux. Les effets de la conversion sur les impacts environnementaux ont été analysés en utilisant 1 kg de lait corrigé pour la matière grasse et les protéines (FPCM) et 1 ha de surface en unités fonctionnelles. L'étude ACV a mis en évidence que le passage d'un système de production semi-intensif à un système semi-extensif a eu un effet différent sur les impacts environnementaux en fonction de l'unité fonctionnelle utilisée.*

Mots-clés. *Brebis laitieres – Impacts environnementaux – Analyse du cycle de vie – Unité fonctionnelle.*

I – Introduction

Dairy sheep farms play a key-role in marginal rural areas of Europe, where extensive farming systems often represent the only tool for supporting local micro-economies (Porqueddu *et al*., 2017). Sardinia (Italy) is one of the leading regions for the sheep milk production: 3.2 million ewes provide a per capita annual production of about 200 kg of sheep milk per inhabitants. Geographical location of farms, specific market conditions and others external factors such as public incentive policies facilitated the development of contrasting dairy sheep farming systems, with differences in input utilization, land use and intensification level. Intensive production systems occurred especially in lowlands, where irrigated crops like maize (for silage), lucerne and hybrid forage sorghum are spread, in order to increase forage productivity. More recently, many farmers tried to reduce production's costs, through the extensification of the production system, reducing the use of concentrates, agrochemicals, agricultural machines, etc. (Porqueddu, 2008). There is not clear scientific evidence showing that extensive systems, at least at farm scale, are really preferable to more intensive one from an environmental point of view. This work is intended to serve to fill this knowledge gap, investigating with a Life Cycle Assessment (LCA) approach if and how the adoption of a low input production system may result in an effective variation of environmental impacts at farm level. In particular, the main scope of this study was to compare the environmental impacts of two contrasting sheep milk production systems carried out in the same farm in different years, considering whether 1 kg of Fat and Protein Corrected Milk (FPCM) and 1 ha of Utilized Agricultural Area (UAA) as functional units.

II – Material and methods

1. Characteristics of the two production systems

The case study was a dairy sheep farm located in Osilo (40°45'11" N and 8°38'43" E, elevation 364 m a.s.l) (Province of Sassari), North-western Sardinia. In the period 2001-2011, the farm changed its forage production system that can be assumed as "semi-intensive" and "semi-extensive" in 2001 and 2011, respectively. In 2001, the farm was characterized by a foraging system based on cereal crops (wheat and barley grain), annual forage crops (ryegrass/oat mixture, mainly) and irrigated maize for silage, and milk production was entirely sold to the dairy industry. From 2008 to 2011, the farm management changed the production strategy, destining the whole farm milk production to the on-farm manufacturing of "Pecorino di Osilo" cheese and, moreover, largely utilizing natural and artificial pastures as feed resources, valorising the role of native legumes-grasses mixtures and adopting low-input farming practices (minimum tillage, reduced use of fertilizers, etc.). Table 1 describes the characteristics of the two production systems.

2. *LCA methodological issues*

The LCA study was conducted adopting a "from cradle to gate" approach and using 1 kg of FPCM and 1 ha of UAA as functional units. The system boundaries included all inputs and outputs related to sheep milk production, and their impact allocation was performed on economic value basis. All data were organized into a Life Cycle Inventory (LCI), the process that quantifies energy and raw material requirements, atmospheric and waterborne emissions, solid wastes and other releases for the entire life cycle of a product. In summary, the LCA analysis included the amount of fodder crops and pastures consumed by flocks, after crosschecking forage production and nutritional needs based on gender, age, weight, physiological stage and production level of animals (Vagnoni *et al.,* 2015). In addition, enteric methane emissions were quantified using a detailed approach (IPCC Tier 2/3) based on Vermorel *et al*. (2008) and considering the total metabolizable energy ingested with the specific animal category diet. In order to consider a wide range of impact categories, IPCC (IPCC, 2013) evaluation method was utilized for the Carbon Footprint (CF) estimates, expressed in kg of CO2-equivalents. LCA calculation was made using LCA software SimaPro 8.1.1 (PRé Consultants, 2016).

Table 1. Main characteristics of the two different production systems adopted to the same farm in 2001 and 2011

	2001	2011
Heads (number)	340	320
Stocking rate (ewes ha^{-1})	4.6	4.6
Milk total annual production (kg)	104,234	82,214
Milk pro-capite annual production (kg ewe^{-1} year^{-1})	307	257
Feed Unit for Lactation, UFL (UFL ewe^{-1} year^{-1})	478	387
Pastures – grazing area (ha)	3	52
Arable land – cereals and annual forage crops (ha)	70	18
Total utilized agricultural area (ha)	73	70
Concentrate feed annual consumption (t)	105	98
Mineral N-fertilizing (kg ha^{-1})	72	8
Mineral P2O5-fertilizing (kg ha^{-1})	110	29
Irrigated maize (ha)	7	0
Irrigated lucerne (ha)	0	2.7
Milk destination	Cheese industry	On-farm cheese manufacture
Power source	Diesel generator	Electricity

III – Results and discussion

The CF of 1 kg of FPCM was quite similar in 2001 and 2011 production systems, with values equal to 2.99 and 3.25 kg CO2-eq, respectively (Figure 1a and 1b). This result seems to agree with some findings reported in literature (Gerber *et al*., 2013), where more intensive systems had a lower environmental impact per kg of product than extensive one. When the environmental impact assessment was performed using as functional unit 1 ha of UAA, the CF of the two productive systems showed relevant differences, confirming the strict positive relationship between the environmental impact of farms and the intensity level in the inputs. The 2001 productive system had the largest value of CF (5,500 kg of CO2-eq for 1 ha of UAA). On 2011, extensification led to a reduction of around 30% of the CF, relative to 1 ha of UAA (Figures 1c and 1d). The analysis conducted using 1 ha of UAA as functional unit showed that the extensive dairy farm, with a high surface area for natural pasture, has much lower environmental impacts than the more intensive production system. In this case, it appears more evident that there is a link between intensive farming, with a consequent greater consumption of inputs, and a greater environmental impact. The contribution analysis illustrates the main processes that contributed to total CF of each production system. For both functional units, “enteric methane emissions” was the most relevant process, representing 50 and 57% of the total GHG emissions, respectively for 2001 and 2011. Summarizing the percentage contributions to total CF of each feed production process, we obtained the same value for the two production systems (around 26%), with a predominant influence of purchased feed (soybean meal, protein pea and cereals grain) with respect to on-farm feed production. This suggested that the increase of the locally produced feed supply may represent a step ahead towards a more eco-sustainable sheep farming system. The percentage contributions of the other processes reflected, in general, the contrasting technological context and farm management strategy, which characterized the two farming systems, such as power source (diesel generator in 2001 and public electricity in 2011), fertiliser use and agricultural machineries supply.

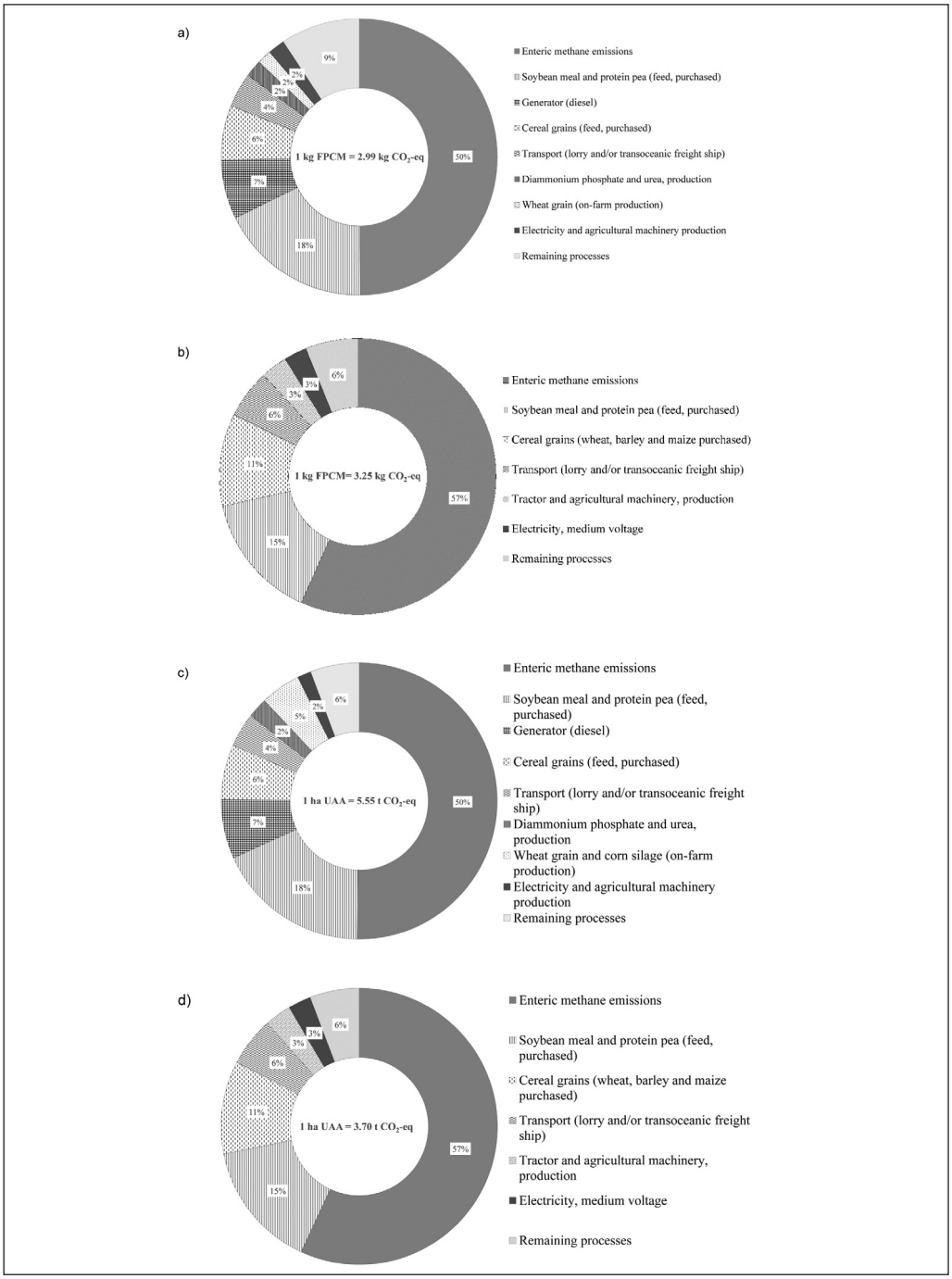

Fig. 1. Percentage contribution of processes to the total GHG emissions, for the 2001 and 2011 production systems using IPCC evaluation method and 1 kg of FCPM (a and b) and 1 Ha UAA (c and d) as functional units. The process category "Remaining processes" includes all the processes with a percentage contribution lower than 0.25% for both production systems.

IV – Conclusions

In this work, LCA approach was used for comparing dairy sheep production systems and for identifying the hotspots to improve their environmental performances. The LCA conducted with two different functional units (1 kg of Fat Protein Corrected Milk and 1 ha of Utilized Agricultural Area) led to a more objective evaluation of the environmental performances of the two productive systems, taking into account both the economic dimension and the environmental role of dairy farming systems. As functional unit, 1 Ha of UAA seems to be more descriptive and effective than 1 kg of FPCM, when LCA analysis is aimed at describing the effect of land use on the environmental performances of extensive dairy systems.

Acknowledgements

The research was funded by the Project SheeptoShip LIFE15 CCM/IT/000123 “Looking far an eco-sustainable sheep supply chain: environmental benefits and implications”.

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Innovation and multi-actor cross-border cooperation in central Pyrenees to improve sustainability of local sheep breeds: PIRINNOVI project

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Abstract. Sheep farming of local breeds in the Pyrenean region is of major significance from an economic, social and environmental viewpoint. However, this activity is in continuous recession. Common problems are found in both sides of the border, in France and in Spain: its scarce profitability and a lack of generational renewal, due in part to the lack of innovation linked to its particular geographic isolation. The PIRINNOVI project aims at establishing a network for acquisition, exchange and transfer of field knowledge but also research methodologies to improve sheep farming sustainability by the way of management and reproductive genetics. Common indicators for sustainability are being designed to perform technical-economic, social and environmental studies. Regardless of breed, increasing efficiency is a key factor to improve sustainability of sheep production. Thus, PIRINNOVI focuses on common reproductive problems like the low efficiency of selection schemes for prolificacy and maternal effects on growing lambs. For this purpose, artificial insemination protocol review, automatization of lamb weight recording, next-generation sequencing (NGS) and other genomic technologies based on SNP arrays are being used in both countries. The opinion of farmers, technicians and other users of the Pyrenean territory on these innovations and their implications for the continuity of this activity are also studied and taken into account for the future.

Keywords. Efficiency – Genetics – Indicators – Ovine – Reproduction.

L'innovation et la coopération transfrontalière multi-acteurs dans les Pyrénées centrales pour améliorer la durabilité des races de brebis locales

Résumé. *L'élevage ovin de races locales dans la région pyrénéenne revêt une importance majeure en termes économique, social et environnemental. Toutefois, cette activité est en récession. Les mêmes problèmes se retrouvent des deux côtés de la frontière, en France et en Espagne: son manque de rentabilité et le déficit de renouvellement des générations, qui résultent en partie du manque d'innovation lié à son isolement géographique. Le projet PIRINNOVI vise à établir un réseau pour l'acquisition, l'échange et le transfert sur le terrain de connaissances, mais également développer des méthodologies de recherche afin d'améliorer la durabilité de l'élevage*

ovin par une meilleure gestion et amélioration génétique de la reproduction. Des indicateurs communs pour le développement durable ont été déterminés pour réaliser des études technico-économiques, sociales et environnementales. Quelle que soit la race, améliorer l'efficacité est un facteur clé pour améliorer la durabilité de l'élevage ovin. Ainsi, PIRINNOVI s'attache à étudier les problèmes observés en reproduction comme la faible efficacité des schémas de sélection sur la prolificité et les aptitudes maternelles. Ainsi, l'examen du protocole d'insémination artificielle, de l'automatisation de la pesée des agneaux, le séquençage de nouvelle génération (NGS) et d'autres technologies génomiques basées sur des marqueurs SNP sont utilisés dans les deux pays. L'opinion des éleveurs, des techniciens et d'autres utilisateurs du territoire pyrénéen sur ces innovations et leurs implications pour la continuité de l'activité est sollicitée et étudiée pour une prise en compte à l'avenir.

Mots-clés. *Efficacité – Génétique – Indicateurs – Ovin –Reproduction.*

I – Introduction and objectives

Sheep farming is largely present on both sides of the Pyrenean border and represents a great economic, social and environmental potential for the territory. It provides an alternative for employment in rural areas, and using local breeds, it represents a unique genetic and cultural heritage. However, the steady decline in economic profitability of these activities, due in part to the lack of innovation linked to its geographic isolation, is threatening its sustainability and with it, the survival of some breeds. It affects more particularly local meat breeds, well adapted to the territory but often less productive. PIRINNOVI project includes a total area of 117,000 km², including the following territories in France: Pyrénées-Atlantiques, Hautes-Pyrénées, Haute-Garonne, Ariège, Pyrénées-Orientales; and Spain: Navarra, Huesca and Zaragoza. In this area, there are around 1,337,000* sheep animals belonging to a total of 18 local breeds, some of them in danger of extinction. In France, this concerns Tarasconnaise (152,100 ewes), Aure et Campans (9,000 ewes), Barégeoise (4,000 ewes), Castillonaise (3,000 ewes), Montagne Noire (2,000 ewes), Rouge du Rousillon (4,000 ewes), Lourdaise (400 ewes), Basco-Béarnaise (80,000 ewes), Manech Tête Noire (120,000 ewes), Manech Tête Rousse (270,000 ewes), and Lacaune meat sheep. In Spain, the project focuses on Ansotana (6,391), Churra Tensina (10,452), Xisqueta (19,700), Roya Bilbilitana (19,207), Maellana (7,200), Rasa Aragonesa (380,638) and Navarra (87,591). Multi-actor cooperation is guaranteed by the participation of 7 R&D agencies, 8 livestock associations and 4 agricultural cooperatives. The objective of PIRINNOVI is to establish a forum for acquisition and exchange of knowledge and research methodologies in the field of sheep management and reproductive genetics. This is achieved by the transfer of skills and technologies to local breed flocks of the Pyrenean region, to improve their efficiency, sustainability and visibility for society. The project is divided into five tasks, including sustainability and genetic axes.

II – Technical actions

1. Sustainability axis

In order to improve the productive efficiency of meat sheep farms, it is necessary to have relevant and reliable technical and economic information. This facilitates further decision-making, not only for farmers and technicians, but also for Administrations, companies and the sector in general. Nevertheless, it is absolutely necessary to go beyond the economic sustainability, and also to study the social and environmental context. In PIRINNOVI, common indicators for economic, social and environmental sustainability are designed for most breeds of the project, valid for both sides of the border. This information, as well as the innovations raised on the project, will be shared with different actors within the territory, to get their acceptance and opinion.

2. Genetic axis

A. Maternal ability

Common work is carried out to improve maternal abilities and prolificacy linked to major genes, due to their major impact on farm profitability. Selecting for maternal abilities will lead to obtain ewes with good maternal care behaviour and sufficient milk to rear their lambs. While more interesting for prolific flocks, it would also be worth for all kind of flocks irrespective of their prolificacy. Selecting ewes for maternal abilities is carried out by assessing the average daily gain of their progeny during the pre-weaning stage, during which lambs' growth depends mostly on their mother's dairy value and maternal behaviour. In practice, lambs are to be weighted twice before weaning, typically at birth and at weaning. While selection for maternal abilities is well stablished in France (with a single weighing at 30 days of age), it is currently starting in Spain. In this sense, a maternal capacity selection criterion in the Rasa Aragonesa breed is being included since 2015 by UPRA-Grupo Pastores within its selection program for prolificacy. In the framework of PIRINNOVI, two other Spanish breeds (Navarra and Ansotana) have started to implement maternal abilities selection programs. One of the bottlenecks for implementing such programs is the unwillingness of farmers to weigh lambs, record weights and keep and transmit weighing records. In order to increase the efficiency of the breeding schemes, activities focus on three main points:

– Electronic identification and weight recording in lambs

Two systems combining electronic identification, already mandatory in France, and automatization are being setting up. In Navarra and Rasa Aragonesa breeds, a "self-weighing" system has been designed to record static weights at about 30 days of age. In this system, lambs are weighed and identified through HD-RFID ear tags when approaching a feeder with attracting supplemental feeds. Image recognition software discards wrong measurements. A prototype has been developed and is currently tested in the Navarra breed. In Ansotana breed, a system consisting in a corridor with manual door opening and a crane implemented with HD-RFID and automatic weight recording is also being tested.

– Artificial insemination

Artificial insemination (AI) is an essential tool for the connection of flocks, the diffusion of genetic progress and to limit the increase of inbreeding. On the French side of the border, apart from the Lacaune breed for which AI is largely used, AI is performed in the 3 local dairy breeds of the Pyrenees Atlantiques region: Manech Tête Noire, Manech Tête Rousse and Basco-Bearnaise (82,550 AI in 2015)**. However in these latter breeds, fertility problems are recurrent, with an average fertility of 55.8% (2016), which threaten the selection schemes. In the meat sheep context, these problems led to the almost total drop up of AI in the Tarasconnaise breed, passing from 4,000 AI/year (1990) to 483 AI in 2015*, which weakens the breed selection scheme. In the Spanish side, AI is applied in the developed local breeds, Navarra and Rasa Aragonesa. The large variability of fertility results, with means of 52.2% in Rasa Aragonesa and 67.4% in Navarra (2015), progressively discourages breeders from using AI (12,232 *vs.* 6,195 AI in 2006 and 2015, respectively, total in both breeds)**. In the endangered sheep breeds exploited on both sides of the Pyrenees in more extensive regimes, the AI is not used or anecdotally, as in Ansotana or Roya Bilbilitana breeds in Spain. Whatever the breed, the fertility of AI has not been improved over the last 10 years, with a great variability between breeds, years and farms. This constitutes an obstacle for the development

* Information provided by breed associations.

** Compte rendu annuel sur l'insémination artificielle ovine-Campagne 2015. L'Institut de l'Elevage (Ed.).

of the technique and therefore, for the progress of the breeding programs. PIRINNOVI project aims at improving the fertility results and the dissemination of AI in local sheep livestock. The activity will be developed at three levels: 1) Individualized analysis through surveys of AI results and ultrasound gestation diagnosis to elucidate the causes of fertility problems and final advice for farmers, 2) AI development in endangered breeds aiming at working on maternal abilities, and 3) Physiological studies on ovarian cyclicity in breeds that do not have this information.

– Genomics

The limited use of AI in the Pyrenean area is an obstacle to the progress of the breeding schemes for maternal abilities in meat sheep. In PIRINNOVI, genomic technologies based on SNP arrays are being used in both countries. In Spain, it is planned to design a common multibreed paternity test valid for all the Pyrenean breeds involved in the project. In France, the real impact of an improved paternity knowledge on the precision of genetic evaluations will be evaluated in a French pilot breed (Tarasconnaise) using an already designed paternity SNP array (developed for French sheep breeds).

B. Prolificacy

Prolificacy, defined as the number of lambs per lambing ewe, is a very interesting trait that has been selected for several decades in meat sheep. It is under a polygenic genetic determinism with very low heritability, so that a small effect and a very slow genetic progress are usually achieved. However, in some sheep breeds of the Pyrenean area considerable genetic improvements have been observed over very short periods of time, revealing the great effect of polymorphisms in major genes affecting prolificacy. In Spain, it is the case of the prolific *FecX*^{R} allele in *BMP15* gene on chromosome X (Martínez-Royo *et al*., 2008). It is segregating in Rasa Aragonesa, and has been introgressed in the Navarra breed, leading to an increase of +0.35 lambs per heterozygous lambing ewe (Lahoz *et al*., 2011). In France, the prolific *FecL*^{L} allele, on chromosome 11, segregates in the Lacaune breed, with an effect on the production of +0.47 lambs per heterozygous lambing ewe (Martin et al., 2014). Techno-economic studies show the main influence of prolificacy major gene on flock profitability (+21 extra € /ewe/year; Pardos *et al*., 2010). For these reasons, the frequency of these polymorphisms in flocks was increased up by dedicated breeding schemes (27.9% and close to 10% for heterozigous *FecL*^{L} and *FecX*^{R} ewes, respectively; Martin *et al*., 2014; UPRA 2017*). Although management programs for these genes have been developed in both countries, little is known about the pleiotropic effect of both polymorphisms, and more particularly of the *FecL*^{L}, on age at puberty, fertility, seasonality, or possible interaction with hormonal treatments. It is expected that the correct management of naturally prolific sheep on farms could, in many cases, reduce the use of hormonal treatments by presenting naturally higher prolificacy and fertility. The PIRINNOVI project aims at 1) studying the pleiotropic effect of the *FecL*^{L} prolific allele in French Lacaune and *FecX*^{R} in Spanish Rasa Aragonesa, 2) discovering, using high density SNP array and whole genome sequencing, new prolific alleles among prolific Lacaune and Rasa Aragonesa ewes non-carrier of *FecL*^{L} or *FecX*^{R}, and 3) identifying the possible presence of already known prolific allele worldwide (using the paternity SNP array tool) in the rest of Spanish and French endangered breeds that share the Pyrenean territory, either for their correct management or for elimination.

Acknowledgments

PIRINNOVI-EFA103/15 project is co-financed by FEDER within the POCTEFA framework. The authors thank R. Castillo (ARANA) and J. Holtz (IDELE) for their work on the development of a new automatic lamb weighing recording system, as well as farmers and other technical and research staff of the involved organisms for their helpful work.

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L'intérêt de dispositifs d'apprentissage organisationnels pour s'adapter à un contexte de changement
Exemples en élevage laitier et en coopérative laitière

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Résumé. En partant des principes et des concepts de l'innovation et de l'apprentissage organisationnel, nous montrons dans cette communication l'intérêt de mettre en place des dispositifs de pilotage stratégique permettant aux acteurs de s'adapter chemin faisant à un contexte agri alimentaire en évolution (mutations des marchés, des attentes des consommateurs, de la société sur les façons de produire, de l'environnement,…). Pour s'adapter – et tirer parti – de ces changements, les éleveurs et les filières doivent pouvoir faire évoluer leur organisation : avoir une lecture des changements de situation, raisonner la façon d'adapter en conséquences les règles et le fonctionnement du système, établir de nouvelles normes et valeurs au sein de l'organisation. Nous mettrons ici l'accent sur l'intérêt des concepts d'apprentissage organisationnel et d'objets intermédiaire pour mettre en place un dispositif et des outils permettant aux acteurs de suivre les changements de les analyser et de penser en cohérence une évolution de leur organisation. Nous prendrons deux exemples. L'un concerne l'autonomie fourragère en élevage. L'autre la gestion de la saisonnalité de la collecte laitière d'une coopérative.

Mots-clés. Innovation – Flexibilité – Systèmes d'élevage – Apprentissage organisationnel.

The interest of devices for organizational learning to be resilient in a rapid change context in agri-food systems. Examples from dairy farming and cheese cooperative

Abstract : *From principles and concepts of innovation and organizational learning, we will analyse in this communication the interest to implement strategic steering devices allowing the actors to adapt in the course of action to evolving context of agri food systems. This include changes in markets, consumers habits, concernment of society about livestock farming practices, environmental changes. To adapt and take advantage of these changes, the players in the agri-food sectors and farmers have to reshape accordingly their organizations. Being resilient in the face of a situation of change is a real problem that requires both the flexibility to change and robustness to define rules that fit the organization. Here, we will focus on the interest to set up a device and tools, such as the logs, allowing the actors to follow changes to analyze and think an evolution of their organization accordingly. We wiil take as examples questions about foraging autonomy at farm level on one hand and on the other hand the management of saisonality of deliveries for a dairy cooperative.*

Keywords. *Innovation – Flexibility – Livestock farming system – Organizational learning.*

I – Un contexte de changement

Le secteur agricole fait l'objet de profondes et rapides mutations. Citons les mutations dans les marchés, avec la mondialisation croissante des échanges, l'évolution des attentes des consommateurs et la multiplication des circuits de proximité, l'interrogation de la société sur les façons de produire, ou encore les mutations de l'environnement qui impactent la disponibilité des ressources. Les éleveurs et les acteurs du monde agricole sont dans une situation d'incertitude quant à l'avenir. Dans ce contexte, l'objectif à atteindre n'est pas donné. Il peut évoluer d'une période sur l'autre, d'un contexte à l'autre. Pour renforcer leur durabilité l'élevage et ses filières doivent être en mesure de suivre ces transformations afin d'ajuster au mieux leurs objectifs, leur stratégie, leurs itinéraires

techniques et leurs pratiques. Cela appelle à de nouvelles postures de la part des acteurs des chaines de valeur (Cheriet F., 2016), comme de l'encadrement de l'agriculture (chercheurs ou conseillers). L'objectif de ce texte est de mettre en discussion l'intérêt, pour le zootechnicien, de mobiliser certains concepts de sciences de gestion pour accompagner au mieux les changements des systèmes d'élevage. Après avoir rappelé les distinctions entre invention et innovation, nous présentons les concepts d'apprentissage organisationnel, d'objet intermédiaire et de dispositif. Nous prendrons deux exemples. L'un concerne des changements de conduite du calendrier de pâturage pour amélioration l'autonomie fourragère d'un élevage. L'autre concerne la gestion de la saisonnalité de la collecte laitière d'une coopérative.

II – Invention et innovation

L'invention est une découverte. Elle peut être due au hasard ou être le produit d'un cheminement créatif. Elle peut être un produit, une méthode, un procédé. Pour devenir une innovation, l'invention doit s'insérer durablement dans le fonctionnement d'un système. Un aliment nouveau peut être une invention. Pour passer au stade de l'innovation il devra être réapproprié par l'éleveur qui va l'essayer, observer le résultat en tirer ses conclusions, modifier en conséquence ses façons de faire et ses règles de conduite. Ce n'est qu'avec la mise en place de nouvelles combinaisons productives, cohérentes au regard des ressources de l'exploitation et de la stratégie de l'éleveur que l'invention sera une innovation. On peut cependant voir un certain paradoxe entre le fait d'établir de nouvelles règles pour intégrer l'innovation dans le processus de changement et le fait qu'à l'extrême ces règles verrouillent l'organisation la rendant ainsi hermétique à des évolutions futures. Si nous partons du principe qu'une exploitation – ou une entreprise – pour être durable doit pouvoir évoluer au bon moment, il faut pouvoir lier organisation et innovation, *c'est à dire s'apercevoir d'un changement, en tirer parti, de manière à permettre à l'organisation de s'adapter à une situation en évolution*. Dans cet objectif nous soulignons l'intérêt de trois concepts de sciences de gestion.

III – Trois concepts utiles à l'innovation

1. La notion d'apprentissage organisationnel

L'apprentissage organisationnel est processus d'acquisition et d'élaboration de connaissance à partir de l'action (Argeris, 1995). Les auteurs définissent deux types d'apprentissage : i) en simple boucle, dans lequel il y a un ajustement de pratique pour améliorer une opération, ou pour agir sur un résultat, sans changer de normes, de valeur, de stratégie ; ii) en double boucle dans lequel l'acteur modifie ses valeurs et ajuste en conséquence ses pratiques. *Dans les deux cas, il y a itération entre l'action et l'analyse de cette action. L'acteur ajuste chemin faisant ses pratiques (simple boucle) ou ses valeurs et ses pratiques (double boucle) à partir du moment où il peut tirer des enseignements de ses actions, les mettre en lien avec un résultat*. A partir de cette notion nous pouvons, en tant que zootechniciens, accompagner les transformations des pratiques ou des systèmes d'élevage en travaillant avec l'éleveur sur la façon de prendre du recul sur ses pratiques et de suivre les évolutions pour en tirer des enseignements.

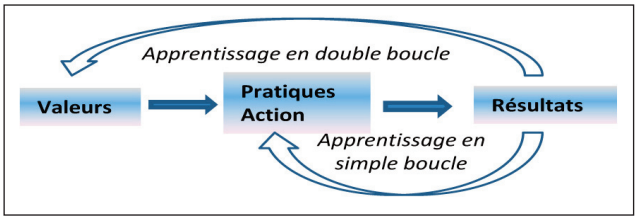

Fig. 1. Apprentissage en simple et double bouche.

2. La notion d'objet intermédiaire pour accompagner un processus réflexif

Vinck (1999), Jeantet (1998) montrent le rôle d'objets intermédiaires dans les processus de conception innovante (Meynard *et al.*, 2006). Ce sont des « objets produits ou utilisés au cours du processus de conception, traces et support de l'action de concevoir». De type croquis, images ou écrits, ces objets sont peu chargés intellectuellement pour faciliter l'investigation empirique. Ils sont facilement intelligibles pour être manipulés, modifiés. Ils ont un lien direct avec les activités. Ils ont des sens multiples et peuvent appartenir à plusieurs métiers. Ils peuvent être mobilisés à diverses étapes du processus d'innovation et peuvent donc avoir diverses fonctions : formalisation, traduction, médiation, … Un dessin du territoire ou d'allotement, une courbe de collecte peuvent être utilisés comme des objets intermédiaires.

3. La notion de dispositif

Le dispositif est un ensemble de lieux, d'outils, de groupes de travail, de moment de réflexion, organisés dans le temps de manière à faciliter et à gérer l'analyse de l'action, l'évolution des façons de voir ou encore des coordinations. Le dispositif est conçu pour ménager des itérations de l'action – ou d'une représentation de l'action – vers l'analyse de la situation. Le dispositif doit être conçu de manière à faciliter le cheminement des acteurs d'une situation perçue par eux comme insatisfaisante vers l'identification de pistes d'action. Des objets intermédiaires peuvent être mobilisés à diverses étapes du dispositif. Ce cheminement doit renforcer la capacité des acteurs à maitriser des transformations de leur système d'élevage, c'est-à-dire un processus d'innovation à partir d'une suite d'ajustements pas à pas.

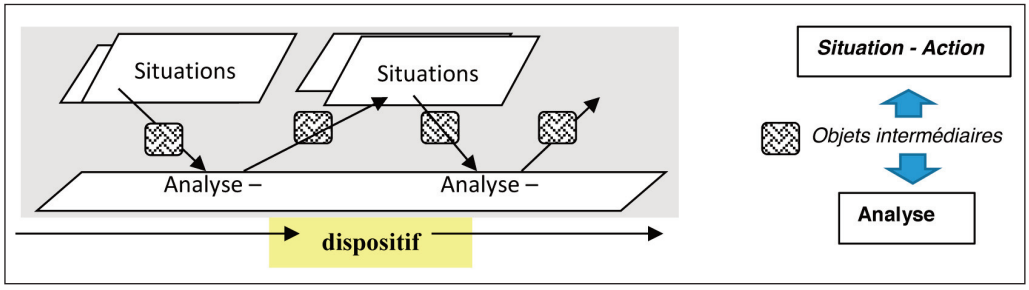

Fig. 2. Des pratiques comme objet intermédiaire pour accompagner la réflexion ?

IV – En quoi ces concepts peuvent-ils concerner le zootechnicien ?

Les chercheurs zootechniciens ou le conseiller d'élevage peut avoir un rôle particulier dans l'accompagnement du processus d'innovation que ce soit à l'échelle d'une pratique (ex introduction d'un nouvel aliment), de l'exploitation (ex : évolution de la conduite du troupeau), ou d'une coopérative (ex laiterie). Il peut aider l'acteur à la formalisation de la situation et des pratiques, en lien avec les résultats, à l'identification de ce qui pose problème, à l'imagination de pistes d'action. Il peut aider à la mise en place d'un dispositif sur le temps long permettant à l'acteur d'apprendre chemin faisant de ses actions et d'en tirer des enseignements. Cependant, rappelons que pour tirer des enseignements, l'acteur doit lui-même faire ce cheminement de l'action vers l'analyse de l'action vers l'identification de nouvelles règles. Lui proposer une analyse clé en main conduirait à la difficulté rencontrée dans maints travaux de recherche : celle de la faible « adoption » des innovations. Comme les travaux des gestionnaires cités ci avant ou ceux d'anthropologues (Darré, 1994), l'indiquent : on n'adopte pas une innovation sans se la réapproprier dans un cheminement

réflexif qui doit être réalisé par l'acteur lui-même. Ce processus réflexif peut être accompagné par un chercheur ou un conseiller. Les démarches de modélisation d'accompagnement (Bousquel *et al.*, 2002), ou encore des démarches comme celle du « Rami fourrager » (Martin *et al.*, 2012) encourageant une réflexion collective sur l'adaptation de la gestion du territoire, rejoignent ces principes. Nous développons ci-après deux exemples : celui de l'accompagnement de l'éleveur dans des changements de pratiques en vue d'améliorer l'autonomie fourragère et celui de la gestion de la saisonnalité de la collecte laitière d'une entreprise.

1. Exemple en élevage : raisonner l'utilisation du pâturage pour améliorer l'autonomie fourragère

Pour des questions de réduction des charges d'alimentation ou d'ancrage au terroir l'augmentation de l'autonomie fourragère est un enjeu important pour les éleveurs, que ce soit en situation intensive ou pastorale. Une des piste d'action pour réduire les intrants consiste à mieux valoriser le territoire disponible, pour la production de foin et le pâturage. Cela implique souvent des réorganisations de l'utilisation du territoire : i) choix d'affectation des surfaces à la fauche ou à la pâture, ii) choix des espèces implantées sur les surfaces cultivables et des rotations, iii) façon de combiner les ressources pâturées dans le calendrier de pâturage pour valoriser la diversité des espaces. Pour accompagner l'éleveur dans l'ajustement chemin faisant de sa conduite du troupeau un dispositif peut être mis en place. En suivant les principes de l'apprentissage organisationnel, la démarche de terrain peut reposer sur 3 étapes co-construites avec l'éleveur :

- représenter les pratiques sur des supports graphiques ;
- établir un diagnostic, identifier les points clés et les points problématiques, estimer les risques ;
- Imaginer des pistes d'action, tester un nouveau mode d'organisation pour réduire ces risques (ex : des réorganisations de pâturage, compatibles avec le fonctionnement de l'élevage)…

Il s'agit d'abord de comprendre la façon dont l'éleveur structure son territoire. Dans l'exemple de la figure 3, l'éleveur constitue des entités d'utilisation, qu'il dénomme de façon précise. Ces unités d'utilisation, sont définies par l'usage de l'éleveur. Elles ne correspondent pas forcément à des caractéristiques agronomiques, ni à des parcelles cadastrales. Leurs périodes d'utilisation peuvent être représentées sur un calendrier de pâturage.

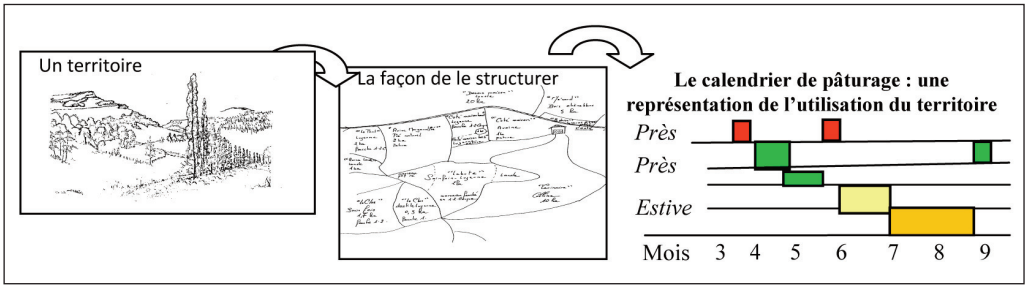

Fig. 3. De la description du territoire au calendrier de pâturage.

A partir de cette base calendaire, le pâturage peut être mis en relation avec les pratiques de conduite (reproduction, alimentation, pathologie…), ou avec l'évolution de la production du troupeau. Ainsi par exemple le lait trait, indicateur de l'éleveur, peut être représenté (figure 4). Mis en regard du calendrier de pâturage ou d'alimentation, il constitue une aide au diagnostic technique pour identifier les périodes qui posent problème. Des réorganisations de pâturage peuvent être envisagées. D'an-

née en année, l'éleveur renforce ses connaissances sur son élevage et ses parcelles et améliore la conduite du troupeau et la gestion de son territoire. Cette démarche de diagnostic est itérative, de l'action vers l'analyse. La représentation graphique du déroulement de la conduite du troupeau et de l'utilisation du pâturage joue le rôle d'un objet intermédiaire facilitant l'échange entre le technicien et l'éleveur et aidant à la prise de recul de l'éleveur lui-même (Napoléone *et al.*, 2011).

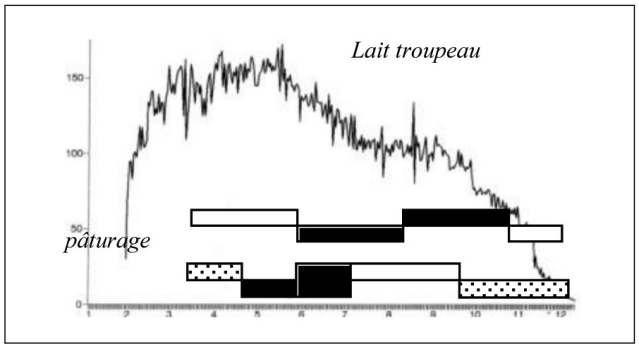

Fig. 4. Evolution de la production du troupeau et calendrier de pâturage.

2. Exemple d'accompagnement en coopérative pour gérer la saisonnalité de la collecte laitière

En coopérative laitière la gestion de la saisonnalité de la collecte est une difficulté pour ajuster la saisonnalité de la collecte à celle des ventes. Cette question concerne différents acteurs, impliqués à divers niveaux dans la coopérative : les éleveurs qui fournissent le lait, les gestionnaires de la coopérative, voir les clients auprès desquels la coopérative vend ses produits. Un des enjeux pour trouver des pistes d'action durables est d'aider les acteurs à formuler les difficultés rencontrées pour ajuster la saisonnalité de la collecte à celle des ventes et à trouver des pistes d'actions adéquates. Là aussi un dispositif peut être mis en place. La courbe de collecte de la coopérative peut être utilisée comme un objet intermédiaire, facilitant l'expression par les gestionnaires de leur difficultés d'ajustement (par ex comment maintenir le lait collecter jusqu'en aout pour fournir tel marché…). Elle peut être mise en relation avec les circuits commerciaux, leurs évolutions, les produits pour travailler sur des marges de manœuvre concernant l'aval. Elle peut aussi être mise en relation avec l'amont, les livraisons des élevages pour travailler, avec les éleveurs, sur des pistes d'action concernant l'amont. Développons cette partie qui s'adresse plus précisément aux zootechniciens. Le dispositif pourrait ménager plusieurs étapes. Par exemple formaliser la diversité des systèmes d'élevage. Pour cela la courbe de livraison de chaque élevage peut être représentée et être mise en relation avec les modes de conduite de chaque éleveur (on rejoint là l'exemple précédent). Cette représentation peut aider à l'identification de proximités entre élevage ayant des caractéristiques fonctionnelles proches (par ex ceux mettant bas au printemps et pouvant par le pâturage tenir leur lait jusqu'en été, ou au contraire ceux étant dessaisonnés pouvant livrer en hiver mais taris en été.). Cela permet aussi de mettre en évidence des différences et des complémentarités entre systèmes d'élevage au regard de la saisonnalité de la collecte (figure 5). La formulation en commun de la question à traiter puis des complémentarités et des rôles que peuvent jouer ces divers systèmes d'élevage permet ensuite à chaque éleveur de travailler sur son exploitation pour améliorer ses pratiques en tenant compte de cet objectif commun. In fine, un dispositif de coordination entre acteur peut se mettre en place. Il peut au fil du temps permettre d'ajuster autant que nécessaire les orientations et les pistes d'action à l'échelle collective et individuelle (Napoléone et Chia, 2010).

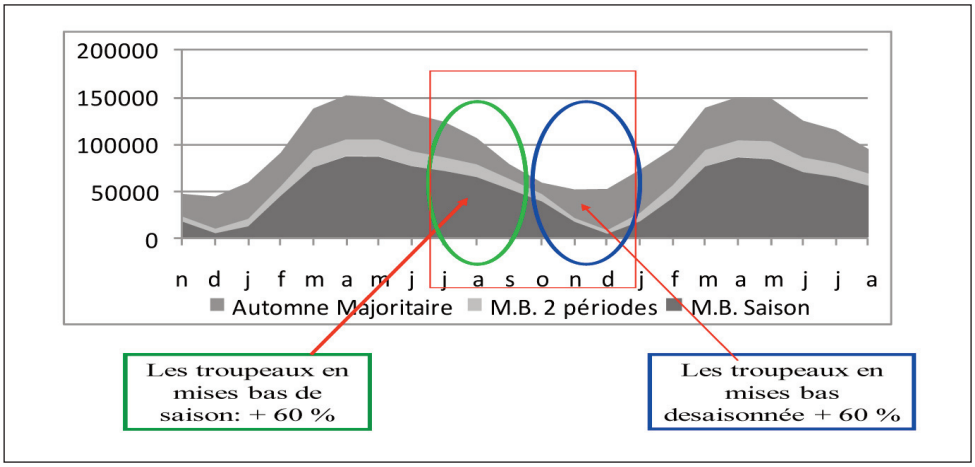

Fig. 5. La collecte laitière d'une coopérative et des complémentarités entre systèmes d'élevage.

V – Conclusions

Nous avons présenté l'intérêt d'une démarche empirique, qui s'appuie sur des concepts de sciences de gestion, tournés vers l'action, pour favoriser un processus réflexif individuel ou collectif auprès des éleveurs ou des filières. Le zootechnicien qui manipule ces concepts augmente ses moyens de travailler avec les éleveurs sur les processus d'innovation et de transformation des systèmes d'élevage. Tout comme nous le disions en début de texte, une invention aussi géniale qu'elle soit, (un produit, une variété, un mode de conduite, etc) ne deviendra une ressource pour l'éleveur que si elle s'intègre dans son système d'élevage et son processus de pilotage. Un dispositif d'apprentissage organisationnel constitue donc un cadre pour renforcer la capacité des acteurs à maitriser les transformations adéquates de leur système d'élevage. Si des moyens de capitalisation des connaissances sont mis en place avec les acteurs, on peut imaginer qu'il y ait une « rationalisation simultanée de l'action et des apprentissages » (Amar-Touati et Sardas, 2006). Nous terminons en disant que nous avons présenté là des concepts et des principes pouvant aider à l'accompagnement des transformations. Il ne s'agit pas de recettes et de démarches clé en main. Le zootechnicien choisissant une posture d'accompagnement améliorera lui aussi pas à pas, sa façon de s'y prendre pour construire et ajuster avec les acteurs des dispositifs facilitant l'apprentissage organisationnel.

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Immigrant shepherds in Mediterranean Europe

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Abstract. This paper examines recent evolutions of Mediterranean European Union (EUMed) countries agro-pastoral systems, and the problems faced following territorial polarization and sectoral restructuring the region has undergone in recent decades. In most southern EU regions the growing presence of immigrants have come to counterbalance the decline and ageing of the local rural population and agricultural workforce. The work specifically examines the presence, contribution and role of immigrant shepherds, who reached southern Europe from other pastoral areas in the Mediterranean, coming to provide skilled labor at a relatively low cost. Despite this phenomenon seems to reproduce mobility patterns that have characterized Mediterranean pastoralism in the last century, problems exist in integrating and upgrading such workforce with a view to tackle the generational renewal problems that affect the sector, and the EU countryside more in general. The paper suggests that a proactive attitude is needed to facilitate the scaling up of these workers to more entrepreneurial levels and more in general to enhance their long-term integration into the sector – with view to ensure their contribution to the future of pastoralism in the region.

Keywords. Pastoralism – Migrations – Shepherding – Small ruminants.

Bergers immigrés en Europe méditerranéenne

Résumé. *Cet article examine les évolutions récentes des systèmes agro-pastoraux de l'UE méditerranéenne (EUMed), et les problèmes qui se posent à eux suite à la polarisation territoriale et à la restructuration sectorielle qu'a subies la région lors des dernières décennies. Dans la plupart des régions du Sud de l'UE, la présence croissante d'immigrés vient à contrebalancer le déclin et le vieillissement de la population rurale locale et de la main-d'œuvre agricole. Ce travail examine de façon spécifique la présence, la contribution et le rôle des bergers immigrés, qui sont venus au Sud de l'Europe à partir d'autres zones pastorales de la Méditerranée, fournissant ainsi une main-d'œuvre qualifiée à un coût relativement faible. Malgré le fait que ce phénomène semble reproduire les modes de mobilité qui ont caractérisé le pastoralisme méditerranéen lors du siècle dernier, il subsiste des problèmes liés à l'intégration et la mise à niveau de cette main-d'œuvre afin de faire face aux problèmes de relève générationnelle qui touchent le secteur, et de façon plus générale les campagnes de l'UE. Cet article suggère qu'une attitude proactive est nécessaire pour faciliter la mise à niveau de ces travailleurs et favoriser leur esprit d'entreprise et, de façon plus générale, améliorer leur intégration à long terme dans le secteur – en vue d'assurer leur contribution à l'avenir du pastoralisme dans la région.*

Mots-clés. *Pastoralisme – Migrations – Bergers – Petits ruminants.*

I – Introduction

While the interfaces between agriculture and migrations are becoming increasing visible and relevant in current debates about rural development, existing literature mostly focus on the exploitative incorporation of mostly low-skilled and seasonal migrant agricultural workforce in intensive agricultural systems of high potential areas (King *et al.*, 2000; Pugliese, 2011; Ortiz-Miranda *et al.*, 2013; Gertel and Sippel, 2014; Corrado *et al.*, 2016). These works come at a time when in Europe the debate is between a multifunctional agriculture or its modernization in efficiency and performance terms (Ploeg, 2008; Marsden and Franklin, 2013)[1].

1. EU Marie Curie fellow TRAMed – Transhumances in the Mediterranean, *https://me.eui.eu/michele-nori/research/*

There are as well very specialized, high skilled sectors where immigrant communities play a relevant role. This is **the case of livestock farming**, where the presence of the foreign workforce is increasing, in both quantitative and qualitative terms. With their commitment and know-how immigrant workers allow EUMed livestock productions to remain at a level of global excellence. As an example in case immigrants in Italy play a strategic contribution in the value chains of the Parmesan, the Fontina, and of the Pecorino cheeses – all important components of the 'made in Italy' brand. Although such contributions have been appreciated to an extent for intensive production systems (Lum, 2011; INEA, 2009), extensive livestock farming remains little investigated, despite its multifaceted relevance throughout the Mediterranean.

II – Results and discussion

Agro-ecological marginal lands - mountainous areas, drylands and many island territories – constitute about one third of the territories of the EUMed region. Through mobile livestock that mostly feed on natural grazing, pastoral resource management represents the main livelihood on these lands where other forms of agriculture are unfeasible. Through this system significant proportion of livestock production takes place in the Mediterranean, especially when it comes to small ruminants. Pastoralism provides thus a relevant perspective to look into Mediterranean food production and natural resource management. Extensive grazing is still predominant for meat production, while semi-intensive systems often apply to milk production farms. Overall, despite the lack of precise references, it can be assumed that more than half of the EUMed small ruminants' flocks take advantage of open grazing during a significant period of the year.

Table 1. The sheep sector in EUMed countries (rounded data for 2010)

Pays	Sheep farms	Sheep flock	% meat production	% milk production
Italy	50,000	7,5 millions	35%	65%
Spain	110,000	22 millions	82%	18%
France total				
Fr. mediterranean	*35,000*	*6 millions*	70%	30%
	8,000	1,5 million		
Greece	200,000	9,5 millions	15%	85%
Total EUMed		*40,5 millions*		

Sources: ISTAT, 2010; INE, 2013; Magrama, 2013; CIHEAM, 2011; Thales, 2014 ; Laore, 2013.

The multifunctional character of agro-pastoralism manifests itself through the wide range of goods and services provided alongside with the production of quality food. Apart from economic and ecological aspects, Mediterranean pastoralism plays as well an important socio-cultural and political role, as it contributes the management of public goods, while supporting cultural heritage and territorial identity. These socio-ecosystem services *benefit not only pastoral communities, but also those living in farming areas, urban centres and coastal regions, who all profit from nutritious animal proteins and related value chains as well as from environmental services (*IFAD, 2016).

For these features pastoralism is increasingly estimated in Europe and elsewhere; such societal appreciation is though only limitedly reflected in market pricing and recognized by European policies. This leads to the fact that such increasingly-appreciated practice is decreasingly practiced by European citizens. Although sector data are not always consistent, medium-term trends indicate a decline in numbers with a marked overall reduction of about 30% of the EUMed flock in the last two decades; the size of remaining flock has grown dramatically as a way to adjust cost-benefit ratios. The classic refrain, everywhere, is that "*20 years ago with a flock half size of the present*

one we had a decent life and we could even make savings and investments. Now with a double-sized flock, it is difficult to make ends meet by the end of the year"[2].

One of the reasons for such sector restructuring is to be found in agricultural and trade policies that have contributed transforming not only the agricultural economy, but the rural society as a whole all over the Mediterranean, with little regard for socio-cultural and ecological variables. As elsewhere, the polarization of agricultural development has widened the gap between intensification of agricultural production in the plains and coastal zones and a gradual abandonment of marginal areas (Gertel and Breuer, 2010). For pastoralism, a practice forged to produce in marginal ecosystems, it is obviously difficult to be competitive on parameters defined solely by performances on productivity.

The restructuring of the sector has profoundly changed the size of the enterprises and the nature of the work, marking the separation between the managerial and the field levels. Despite the extensive characterisation of pastoralism, the work of the shepherd is intense and encompasses both physical labour as well as technical and managerial skills - ranging from climatology to botany, animal physiology and health, ethology of predators, etc. (Meuret, 2010). Most of the shepherd's time is spent in harsh settings, with limited access to public services, scarce connectivity and few opportunities for leisure and alternative activities. Continuous mobility and processing of milk add further burdens to daily mansions, while the growing presence of predators and climatic vagaries represent further hardening factors.

Through this restructuring, living conditions of shepherds have hardly improved, while working conditions have intensified, through a significant increase in their tasks and responsibilities. Such restructuring has thus contributed to creating unattractive conditions for the new generations, who have often decided not to follow their fathers' footsteps, and to avoid engaging in a profession with an uncertain perspective. Through these lenses one can understand the crisis of pastoral "vocation" and the relative problems of generational renewal which is affecting this sector.

In order to deal with the scarce availability of human resources, the supply of immigrant workforce has been strategic in many cases. Notwithstanding the important contributions received by the Common agricultural policy (CAP) and whatever the entrepreneurial strategy pursued to cope with and adapt to restructuring (extensification, intensification, diversification, etc.), immigrant shepherds have provided a quite skilled labor force at a relatively low cost for livestock farms operating in EUMed marginal areas. Without foreign workers, many pastoral farms would face today great difficulty in pursuing their activities. The immigrants workforce represents as well a critical asset for young European entrepreneurs who take up this activity (INEA, 2014; Nori and de Marchi, 2015).

Though strange it might seem, the fact that a generational change is accompanied by an ethnic one is nothing new to the region. Mediterranean pastoralism has witnessed in the 19th and 20th century Sardinians colonizing abandoned pasturelands in central Italy, southern Spanish herders moving to graze the Pyrenees, northern Italian shepherds migrating to Provence and Switzerland, the moves of Valachos and Arvanites flock and shepherds throughout Greece and Kurdish shepherds in several regions of Turkey (Lebaudy, 2010; Meloni, 2011; Nori, 2016) (Fig.1). These communities have contributed substantially to keeping pasturelands of destination countries populated, alive and productive. In this regional rationale, it is thus not surprising that most immigrants who work as shepherds come from other parts of the same Mediterranean ecosystem, as mobility and migration are features embedding pastoral systems.

The difficulties faced by immigrants to scale up in socio-economic terms through upgrading from pastoral workforce towards livestock ownership and more entrepreneurial levels provide relevant

2. Refer as well to the working group *www.agricultures-migrations.org/en/* for migrants in intensive agriculture.

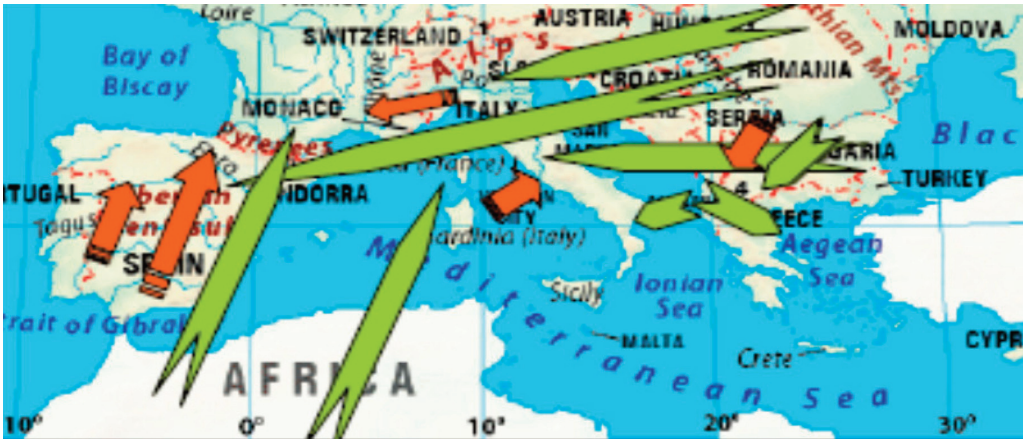

Fig. 1. Trajectories of past (flat botom) and present (arrowed bottom) patterns of shepherds' migrations. Source: TRAMED[3] data elaboration.

constraints to the capacity of the incoming population to contribute to the sustainability of pastoralism in the longer term. Cases where shepherds have graduated to livestock owners are rare exceptions, but represent important opportunities to capitalise upon.

*BOX – **Becoming a pastoral entrepreneur***

Cases exist where foreign shepherds have engaged and succeeded in scaling up to livestock ownership and farm management. For instance, Mario, a Romanian shepherd who has come to Triveneto, Italy ten years ago. Initially, he worked without a contract or insurance. Seven years ago, he got a contract which finally made him eligible for Italian citizenship, which is needed to register as an entrepreneur and to legally own a flock. With his savings, he was able to accumulate a few animals each year, which he kept within the flock of his employer. Recently, he and his employer have been talking about jointly managing a common flock. They plan to share the costs and responsibilities, as well as the profits. With an established business, Mario will be able to bring his wife and children to Italy. Other examples of such socio-economic graduation exist where two immigrants have shared resources and responsibilities or in areas where pasture lands are communal and therefore more easily accessible.

Yet oftentimes, this is a lose-lose situation. Migrant shepherds do not evolve in their socio-economic position while elderly livestock owners do not find people capable of taking over their farms when they retire. And society witnesses the disappearance of flocks, the abandonment of marginal lands, together with the loss of quality products and services.

III – Conclusions

Pastoralism provides a representative case study to analyse the growing interfaces between agriculture and migrations. In this sector migrant shepherds provide a relatively experienced and qualified workforce at relatively low cost, thus importantly contributing to overcome the human resource problem for this activity increasingly recognized as vital to the preservation of our natural and cultural heritage, but decreasingly practised by Europeans.

3. TRAMed interviews: Josetxu Larraz, Fustiñana (Navarra) 4/15; F.lli Costa, Grotte di Castro (Lazio) 6/15.

Enhancing the integration of migrant workers in non-temporary, longer term position into the EU agrarian world provides in such framework an interesting development opportunity for depopulated rural areas as well as for agricultural activities where labour force is scarce. Adequate policy choices and strategic investments are needed to ensure that this phenomenon brings mutual benefits to all stakeholders, so to reflect the Europe 2020 vision for a *smart, sustainable and inclusive development*. The forthcoming CAP mid-term reform should consider these options - as a young and motivated workforce is a key asset for a healthy and vital agriculture and for a resilient rural world.

Sustainable pastoralism will not though be merely the result of subsidies, schemes and incentives, but rather the outcome of a comprehensive, integrated policy framework, including the review of agricultural, trade, migration and labour market polices. The viability of shepherding, the attractiveness of mountainous areas, the profitability of extensive livestock production along with efforts to support integration of foreign shepherds are the key challenges for the future of an ancient activity that is vital for the Mediterranean identity and for the resilience of its territories (Nori, 2015).

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Evaluating dairy sheep systems for conversion to the optimized agroecological model

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Abstract. Interest is growing in promoting sustainable animal production systems because of their healthy relation to the natural environment. Ecological systems stand out, as they pay special attention to preserving natural resources, promoting biodiversity, guaranteeing animal well-being, and obtaining healthy products from raw materials and natural processes. The objective of this study is to evaluate proximity to the agroecological model of dairy sheep systems in Sardinia, Italy. Based on the methodology described by Mena et al (2012) for goat milk systems, a questionnaire was designed for dairyfarms, including 55 variables integrated into 9 indicators. Twenty-two dairy sheep farms were surveyed, all farms with Sarda breed. The results show that farms are close to this agroecological model, necessitating some changes in aspects related to: i) use more sustainable products for the cultivation of forages and grains; ii) improve farm management and data collection and iii) increase the autonomy in products sales.

Keywords. Sarda breed – Sustainability – Index.

I – Introduction

An agroecological production system should comply with the following requirements: contribute to the equilibrium of agricultural systems integrated with the natural environment, contribute to sustainable agriculture development, minimize all types of contamination, respect animal well-being, avoid systematic use of chemically synthesized substances, and renounce the use of genetically modified organisms. According to these requirements, grazing livestock systems, in which feeding is largely based on pasture, could already be functioning close to the agroecological model.In Italy, Greece and in some regions of Spain, in Corsica and French PaysBasque, dairy sheep systems are substantially based on forage direct utilization (Sitzia and Ruiz, 2016). In Sardinia are raised more than 2.5 mil dairy sheep. The animals are commonly fed incultivated or natural pasture and the farming system is strictly linked to the environment.

The objective of this study is to evaluate approximation to the agroecological model of dairy sheep systems in Sardinia (Italy). Furthermore, those aspects which should be improved in order to increase sustainability are analyzed in the light of sustainable animal production and management techniques.

II – Material and methods

Based on the methodology described by Mena et al. (2012) for the conversion of mountain dairy goat systems into ecological systems, a questionnaire for sheep farmers was designed, including 53 binominal variables (yes = 1 or no = 0). Variables (NV) were grouped into nine multi-criteria indicators, as shown in Table 1. Each indicator was assigned a value based on the proportion of positive responses of this indicator's variables, with 100% as the optimum for each indicator. Later, an organic conversion index (OCI) was elaborated using the sum of the ponderation value (PV) for each indicator. In this index each indicator has a different ponderation value, the ponderation value was fixed by organic expert group.

Table 1. Indicators of level of ecological conversion: number of variables integrated into the indicators (NV) and ponderation value (PV)

Indicator	NV	PV (%)	Indicator	NV	PV (%)
Feeding management	6	16	Breeds and reproduction	3	6
Sustainable grassland management	6	14	Animal well-being	11	8
Soil fertilization	5	6	Food safety	4	14
Weed and pest control	6	8	Ecological management	6	16
Prevention and treatments	8	12			

Twenty two dairy sheepfarmers were interviewed in 2016 in Sardinia island, all farms with local Sarda breed.

Statistical analyses were carried out using the program SPSS.20 (2016).A descriptive statistical analysis of each indicator has been conducted (mean and standard deviation).

III – Results and discussion

In Table 2the level of approximation to the agroecological production modelcalculated for each indicator is reported. From these results, it is possible to describe three groups of indicators according to the obtained value: i) 30-50% (Ecological management), ii) 50-70% (Weed and pest control, Prevention and treatments and Soil fertilization) and iii) more than 70% (Feeding management, Animal well-being, Sustainable grassland management, Food safety and Breeds and reproduction).

Table 2. Indicator level of approximation to the agroecological production model (average and standard error) in Sarda dairy system

Indicator	Average (%)	SE	Indicator	Average (%)	SE
Feeding management	72.7	15.9	Breeds and reproduction	90.9	16.7
Sustainable grassland management	84.8	11.4	Animal well-being	79.8	7.9
Soil fertilization	66.4	14.3	Food safety	89.4	15.3
Weed and pest control	50.8	20.2	Ecological management	32.6	18.9
Prevention and treatments	59.7	12.8	**OCI**	**67.2**	7.9

The average value of Weed and pest control (50.8%) and ecological management (32.6 %) indicators resulted equal to or less than 50%, and therefore they require particular attention in order to get toan optimal value to fit the agroecological system requirements.

The Ecological management indicator is the farthest from what would constitute adequate agroecological management, which includes: (i) data recording and technical-economic management, essential to obtain and maintain organic certification, (ii) direct marketing of the products in order to make them available to consumers who value them, and (iii) farmer efforts toward ecological conversion. All farmers surveyed currently sell their milk to large milk cooperatives, none of which has an ecological or sustainable product line.

With respect to “Weed and pest control”, the use of conventional products for treatment is the main problem. Almost none of the farmers use organic products (4% farmers).The others analysed indicators range between 54 and 87 percent of positive situation.

In the case of the indicator “Prevention and treatments “, the use of phytotherapy or homeopathy is not widespread, only 9% of breeders do it. Likewise, they do not use cleaning products allowed by European regulations in organic farming, only the farmers who are in organic production (13.6%farms) do it. For the remaining 6 determinants, the percentage of farmers who meet it is high, ranging between 50 and 95%.

The indicator “Soil fertilization” has a value of 66.4%. Even almost all farmers do an optimal management of farm livestock waste, the low use of fertilizers not registered as ecological and the scarce attention to soil characteristics (farmers who do not do soil analysis) represent the two conditions of the indicator with the lowest score. The rest are above 90%,

The indicators related tofeeding have a score above 70% (Feeding management and Sustainable grassland management). With respect to Feeding management, the situation of the systems is acceptable, mainly due to the fact that the animals pasture daily and the majority of the farms produce hay and more than 60% produce grain to feed their animals. This points out the high level of farm feeding self-sufficiency; in more than 90 % of farms, at least 50% of the dry matter ingested comes from own farm. For the conversion, only it has to change conventional feeding to organic feeding. The very deficient feeding autonomy is reported by Mena et al. (2012) as a principal constraint for the conversion in dairy goat farming system in South of Spain where only few farms produce fibre or/and grain. With respect to Sustainable grassland management, the majority of the farmers perform techniques according to a sustainable management, but they should improve pasture productivity by means improving techniques (sowing, fertilizer...).

Finally, the indicators of Animal welfare, Food safety and Breeds and reproduction have values between 70 and 90%. The tail docking and the short period during which lambs are allowed to nurse from their mother are the aspects that should be modified to improve animal welfare. For the other two indicators the values are close to the optimum.

Table 3 shows the values for three traditional livestock systems in the Mediterranean area: Sarda dairy sheep breed in Italy, Segureña sheep breed specialized in meat production in Spain and Payoya goat for dairy production in Spain. The highest values of the OCI appear in the systems studied in Sardinia and the lowest values in the Payoya goat systems. Payoya farms are located in mountainous areas, where it is difficult to cultivate and the management is general low, although this aspect has improved in recent years. Comparing the two sheep systems, the differences appear mainly in the Sustainable grassland management, Breeds and reproduction and Ecological management. In the Segureña breed systems any improvement of the pasture nor forage cultivation is done, and the majority of the farms use artificial insemination in the reproductive management. Instead, they have a better score in terms of Ecological Management, they make an optimal record of the data of the farm, they sell their lambs to cooperatives and they have made the conversion to ecological.

Table 3. Average for each indicator in three traditional small ruminant systems in Mediterranean area

Indicator	Sarda dairy sheep breed	Segureña meat sheep breed[1]	Payoyadairy goat breed[2]
Feeding management	72.7	81.4	49.6
Sustainable grassland management	84.8	61.0	29.4
Soil fertilization	66.4	56.4	20.5
Weed and pest control	50.8	63.3	79.5
Prevention and treatments	59.7	53.2	38.2
Breeds and reproduction	90.9	64.7	77.9
Animal well-being	79.8	70.7	76.5
Food safety	89.4	70.7	66.2
Ecological management	32.6	61	5.9
OCI	**67.2**	**64.4**	**54.9**

[1] Ruiz *et al*., 2016; [2] Mena *et al*., 2009.

IV – Conclusions

Dairy Sarda breed farmshave a high value of the indicator of approximation to agroecological production model. To achieve thecomplete conversion to agroecological or organic systems, the following changes must be made: i) to use inputs allowed by organic regulations (fertilizers, feed and medicines), ii) to eliminate traditional techniques such as docking lamb'stail, iii) to improve on farm data collectionand iv) to search new circuits of proximity marketing and to diversify cheese and dairy products with the aim to create more sustainable channels that recognise the right valueto organic products.

Compared with other Mediterranean breeding systems, the Sarda dairysystems are better positioned towards conversion, especially in terms of food management and pastureresources.

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Reference indexes of the goat milk price

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Abstract. According to the current EU legislation, all transactions of raw milk that take place in Spain should be registered in a contract. This contract must reflect, among other aspects, the price of milk, which can be fixed or variable. In case of being variable, it must be indicated on the basis of which that price will vary. Conscious of the importance of the reference used, the INLAC (Spanish Inter-professional of Milk) has made available to the sector some price indexes that serve as a reference for the contract. These indexes have been developed by the authors of this paper, which guarantees its transparency and impartiality. Based on interviews taking to traders and experts and using econometric adjustment methods (in which autoregressive techniques are involved), two indexes are proposed, both referring to the price of the total *Useful Dry Matter* content (protein plus fat): Index nº 1, reflecting the variation of market prices, and the Index nº 2 which also incorporates two factors regarding to the international market. A case-study shows a good adjustment between the real evolution of the prices and the behavior of the indexes.

Keywords. Goat – Reference index – Market – Milk price.

Indices de référence du prix du lait de chèvre

Résumé. *Conformément à la législation UE actuellement en vigueur, toutes les transactions concernant le lait cru ayant lieu en Espagne doivent faire l'objet d'un contrat. Dans ce contrat doivent figurer, entre autres, le prix du lait, qui peut être fixe ou variable. En cas de prix variable, il doit être indiqué sur la base de quels éléments ce prix va varier. Conscient de l'importance de la référence utilisée, l'INLAC (Interprofession du Lait en Espagne) a mis à la disposition du secteur quelques indices de prix servant comme référence pour le contrat. Ces indices ont été développés par les auteurs de cet article, ce qui garantit leur transparence et leur impartialité. Basés sur des entretiens auprès d'opérateurs et experts et en utilisant des méthodes économétriques d'ajustement (à l'aide de techniques autorégressives), deux indices sont proposés, tous deux liés au prix de la teneur totale en matière sèche utile (protéine plus matière grasse): l'Index nº 1, reflétant la variation des prix de marché, et l'Index nº 2, qui incorpore aussi deux facteurs liés au marché international. Une étude de cas a montré un bon ajustement entre l'évolution réelle des prix et le comportement des indices.*

Mots-clés. *Chèvre – Indice de référence – Marché – Prix du lait.*

I – Introduction

The current legislation requires that all supplies of raw milk which take place in Spain (from a producer to a processor) should be registered in a contract between both of them, prohibiting the marketing of raw milk which is not registered in the contract.

The contract, which has a minimum duration of one year, shall include, among others things, the duration, volume of milk, methods of collection, methods of payment and, of course, the price to be paid for that supply.

The price of the liter of goat's milk is calculated by multiplying the price of the Useful Dry Extract (sum of the fat content and milk protein) by the useful dry extract grades of the liter of milk.

The price of the useful dry extract, which should be agreed between producer and processor, may be fixed, variable or mixed:

Fixed: When signing the contract, a price for the milk will be set for each monthly payment, which will remain unchanged for the duration of the contract.

Variable: Starting from a base, the price will be calculated month by month based on a series of factors that will be established when signing the contract.

Mixed: including a fixed part and a variable part.

If the prices that are established have a variable component, it will be necessary to establish a reference that, once is applied, allows the calculation of the monthly price during the period of the contract. This reference will be an index with a numeric value. It is important that it is objective and not manipulable. Conscious of the importance of the reference used, the INLAC (Spanish Interprofessional of Milk) has elaborated and published it in its web, an index system for each of the three species: cow, sheep and goat ((http://www.inlac.es/). Goat indexes have been developed by the authors of this paper (Mena *et al*. 2014a, 2014b; Camúñez *et al*. 2016), which guarantees their transparency and impartiality.

The aim of this contribution is to explain how the indexes have been created and which are these indexes.

II – Matherial and methods

Through a questionnaire, the opinion of operators (producers and processors) and experts were collected. The objective of this questionnaire was to know their needs regarding the indexes, as well as to know which were the factors that, in their opinion, could be influencing the monthly variation of milk price.

After reviewing and discussing the factors that could be influencing the Useful Dry Extract of goat's milk price, and taking into account the sector's demands for the inmediacy of the publication and the officiality of the resources, those that were considered relevant where selected. In all, five factors were used (Table 1).

Table 1. Factors constituting the two reference indices for Useful Dry Extract (UDE) price of goat's milk

Factor	Abreviation*	Source
Market price of UDE	PI-UDE-FEGA t-2	FEGA
Price or standard ration for goat	PI-Feeding.SILUM t–1	MAPAMA
Cheese consume at home	QI-cheese consume t-2	MAPAMA
Cheese import	Index-cheese import t-2	DataComex
Milk export	Index-milk export t-2	DataComex

* PI = Price index; QI = Compsumption index
t-1 = data of the previous month; t-2 = data of the two previous months
FEGA : Fondo Español de Garantía Agraria
MAPAMA: Ministerio de Agricultura y Pesca, Alimentación y Medio Ambiente
DataComex: Foreign trade statistics

In order to have an index as up-to-date as possible (for example, the March index is available in April), it was decided to use the factor data corresponding to one or two previous months. That is, the index published in April, which will be used to establish the price of milk sold in the month of March, will have been created with the data of factors corresponding to the previous January or February.

Once the factors were selected, the next step was to establish which weight would have each factor in the index, since not all have the same importance. This was decided taking into account the opinion of the operators, making simulations and comparing the evolution of the index that we are constructing with the price of the ESU in the last former years, looking for the best possible adjustment. The adjustment mechanics used for the construction of a weighted average index were the following:

- Method of Ordinary Least Squares (OLS) and Minimum Squares with Correction of Autocorrelation of type AR (1)
- Autoregressive methods with delays in 1, 2, 3 or 4 periods.
- Data of 4 years (2012, 2013, 2014 and 2015) of 2 operators.

Finally, using the information given by a goat farm in Andalusia, a simulation was carried out in order to compare the variation between the real incomes and the simulated incomes using both indexes.

III – Results and discussion

Although there has been no unanimity in this issue, some of the operators surveyed demand a system of indexes that provide price stability, through mechanisms that reflect the reality of the markets, but that includes factors that prevent sudden price fluctuations. Other operators, however, call for indexes that accurately reflect the evolution of the goat milk market.

Finally, it has been decided to propose two indexes, both referred to the price of the Dry Extract Usefull grade. Index No. 1, which is a reflection of the variation of goat milk market prices, and the Index No. 2 that also includes factors that have been considered to make an influence on the variation of the goat's milk price.

In case of deciding to use the index system, the parties will freely decide which of these indexes best fits their needs, with the possibility of using a combination of both. The two proposed indexes are presented below.

Index 1 = 0'7017× PI-UDE-FEGA t-2 + 0'1885× QI-cheese consume t-2 + 0'1098× PI-Feeding.SILUM t-1

being PI = Price index and QI = Consumption index.

This index, which could be called "simplified", reflects the market trend, although with two months of delay.

Index 2 = 0'3618× PI-UDE-FEGA t-2 + 0'1763× QI-cheese consume t-2 + 0'2123× PI-Feeding.SILUM t–1 + 0'1635× Index-milk export t-2 + 0'0861×Indice- Index-cheese import t-2

being PI = Price index and QI = Compsumption index.

This index also reflects the market trend, but this is tempered by the fact that the PI-UDE-FEGA t-2 factor has less weight, and includes in its formation more factors than the index number one.

Given that the price published by FEGA 82016) is used for the construction of both indexes and that its value depends on the information provided by the different operators, it is necessary to review the price used as the starting point of the series, at least once a year, which must be negotiated between the parties, and must be reflected in the contract.

Figure 1 compares the real monthly income of selling the milk from an Andalusian goat milk farm, with the simulated incomes from using the index number one and the index number two. The real income for the year 2016 was 72432 €, using Index 1, it would have been 71809 € and using the Index 2, it would have been 71027 €, being the differences of -0.87 and -1.98% respectively.

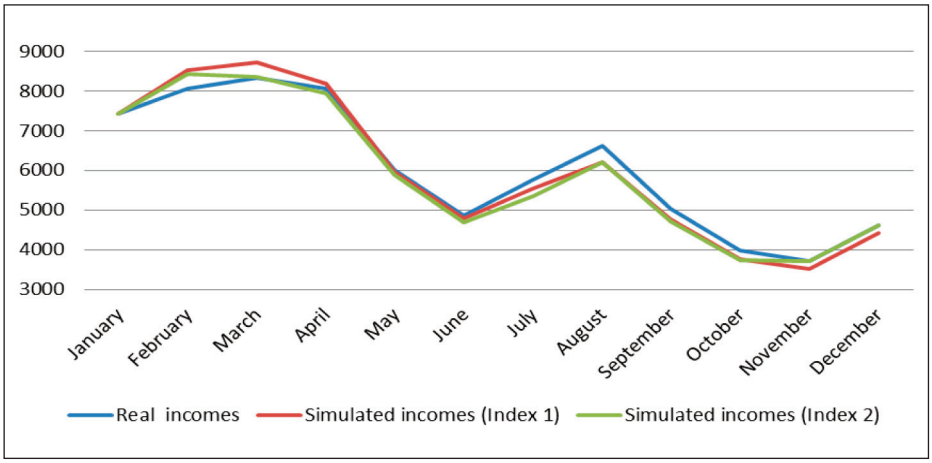

Fig. 1. Comparison of the monthly variation of the milk sale farm incomes (in euros).

As can be seen in the figure, the adjustment between real and simulated variation is very good. Nevertheless, in order to generalize these results, it is necessary to have a significant number of farms.

IV – Conclusions

Two indexes are proposed, both referring to the Useful Dry Extract of goat's milk.

The first one mainly reflects the variation of the price of the Useful Dry Extract of goat's milk in the market, also including a factor related to the price of the ration for the goat and a factor related to the consumption of cheese.

The second includes two more factors, related to the foreign market, removing weight at the Useful Dry Extract of goat's milk market price.

All indexes can be published with a maximum of 2 months of delay.

A simulation performed for the year 2016 indicates a good adjustment between the indexes and the reality of the market. However, a more exhaustive analysis is necessary to conclude.

All this information should serve as a basis for dialogue between the parties, both at the individual negotiation level and at the sectoral level. Indexes should not replace such dialog.

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Towards a pan-European typology of sheep and goat farms: A meta-analysis

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Abstract. The objective of this work was to develop a single pan-European typology of sheep and goat farming systems. Initially a thorough review of all the available literature was undertaken and a total of 45 typological studies were identified. A meta-analysis of these typologies led to the formation of a "broad typology" that specified 13 types of sheep farms and 5 types of goat farms. This typology included types described by their prevailing characteristics such as the level of grazing and intensification, production aims, their environmental impact and awareness and the level of technology uptake at farm level. These types were not discrete and mutually exclusive to all countries, so in a second step they were refined using inputs and knowledge of industry representatives of the sheep/goat sectors across several European countries and Turkey. This process led to the production of the final typology that consisted of five types for sheep farms and five four types for goat farms. Farms of cross-cutting characteristics such as organic, PDO, PGI, pluriactivity etc. were included under these farm types when appropriate.

Keywords. Sheep and goat farming – Production systems – Typology – Meta-analysis.

Vers une typologie pan-européenne des fermes ovines et caprines: une méta-analyse

Résumé. *L'objectif de cette étude était de développer une typologie pan-européenne unique des systèmes d'élevage ovines et caprines. En premier lieu, la littérature associée avec les typologies a été analysée et en total 45 études typologiques ont été identifiées. Une méta-analyse de ces typologies a conduit à la formation d'une "typologie étendue" qui spécifiait 13 types de fermes ovines et 5 types de fermes caprines. Cette typologie comprenait des types décrits par leurs caractéristiques actuelles telles que le niveau d'utilisation de pâturages et d'intensification, les objectifs de production, leur impact et sensibilisation environnementals et leur niveau d'adoption de technologie. Ces types n'étaient pas discrets et mutuellement exclusifs pour tous les pays. Dans l' étape suivant, ces 18 types ont été raffinés à l'aide de connaissances des représentants des secteurs ovins et caprins dans six pays européens et en Turquie. Cette methodologie a conduit à la formation de la typologie finale qui comprenait cinq types pour les élevages de moutons et cinq types pour les élevages de chèvres. Les caractéristiques telles que la production organique, l'AOP, l'IGP, la pluriactivité, etc. ont été incluses dans ces types commes de caractéristiques transversales.*

Mots-clés. *Production ovine et caprine – Systèmes de production – Typologie – Méta-analyse.*

I – Introduction

Uniform policies, interventions and strategies are not appropriate for farmers and production systems, which are characterised by a high level of heterogeneity (Mądry *et al*., 2013). The detection and grouping of homogeneous fractions within these systems can serve as a useful tool to propose better targeted policy measures and strategies (Barrantes *et al*., 2009), achieve improved management practices and higher economic performance (Gelasakis *et al*., 2012) and delve into the interrelations among factors that govern their operation (Milán *et al*., 2011; Riveiro *et al*., 2013).

Typology refers to an established methodology that groups farms with similar features and leads to the formation of clusters (farm types) comprised of relatively homogeneous production units. In livestock production systems, structural and technical characteristics, management and flock size, intensification level, feeding management, socio-economic and environmental attributes, productivity and workforce constitute the main criteria of the typification task (Girard *et al*., 2001).

The objective here was to develop a new common typology for sheep and goat farming systems in seven countries (Greece, UK, Spain, Italy, France, Finland and Turkey) that will represent the diversity of the small ruminant sector across the European Union and Turkey. This typology will allow for consistent farm assessments and comprehensive policy recommendations. It will also help sustainable innovations to be identified and introduced in the existing diverse farm production systems in view of their different challenges and production aims.

II – Methodological approach

The identification of the farm types was based on a meta-analysis that included an extended review of the relevant literature on typologies and information collected though an industry survey. Initially, the profile of the sector in each participating country was described to obtain a general understanding of the sector in each country. The next step involved a review of the existing typological surveys such as scientific papers, studies, reports and official typologies as recognised in each country by Ministries, Institutions, organisations, etc. An on-line survey was also addressed to 17 sheep and/or goat industry organizations in the EU and Turkey with the aim to deduce additional information about existing farm types of sheep and goat systems that prevail in each country, ensuring a bottom-up approach in the identification of farm types. A meta-analysis of the existing typological surveys resulted in a tentative list of farm types (i.e. a “broad” typology), which was presented for further discussion at a workshop in the Mediterranean Agronomic Institute of Zaragoza, Spain. The workshop was attended by delegates from research and industry organizations and following group discussions, participants agreed on a final typology, where the number of the proposed farm types was further reduced and specific and mutually exclusive farm types were established.

III – Results and discussion

1. Tentative list of farm types: “Broad Typology”

The identification of farm types in this extended and tentative “broad” typology was mainly based on indicators frequently used in the literature or those identified through the online survey. These indicators were: i) intensification of the production system, ii) farm location iii) farm size, iv) grazing management practices, v) dependency on external feed inputs, vi) milk or meat production and vii) on-farm processing. Indicators of national/regional importance, such as product characteristics (PDO and PGI products; organic production), active environmental role or farm pluriactivity were also taken into consideration.

A. Description of sheep production systems

1. Farms with confined kept sheep and great dependence on purchased feed: Intensive dairy sheep farms that feed exclusively on purchased concentrates and forage (no arable land) and in which animals have zero or very limited access to pasture. Relatively large farms with modern infrastructure and high investments, often applying technologically advanced production practices.

2. Farms with confined kept sheep and provision of home-grown feed: Intensive dairy sheep farms that depend mostly on concentrates and forage produced on-farm, but in which animals have

very limited access to pasture. Those are usually large farms with modern infrastructure and high investments that cultivate relatively large areas of arable land.

3. Semi-extensive dairy farms: Semi-extensive dairy sheep farms with traditional infrastructure and low investments. Feeding is mainly based on grazing, which is supplemented with forage and concentrates produced on-farm.

4. Dual purpose farms: Dual-purpose refers to intensive or semi-intensive sheep farms, where milk is more important economically than meat (e.g. 70:30 in most Greek farms) or another product, such as wool in the UK. They use relatively new technology but with low levels of innovation.

5. Traditionally managed farms: Traditional both in terms of management and organisation with sheep mostly grazing on natural grasslands. Although they can be found in many areas, they are more typical of mountainous areas and less favoured areas (LFAs).

6. Low input meat farms: Semi-extensive meat producing sheep farms with low stocking rates. Found in mountainous areas and LFAs, or lowlands with low quality of rangelands. One of their basic characteristics is the low level of organisation in reproduction practices.

7. Medium input meat farms: Semi-intensive specialised fattening sheep farms. Management focuses on intensifying lamb meat or on heavy carcass sales.

8. High input meat farms: Intensive fattening sheep farms with high stocking rates and large flocks. Mostly located in lowland areas (most commonly in France and Finland) with low grazing and high reliance on, usually home-grown, forage and concentrates. These farms use heavy breeds bred for meat traits, focusing on heavy carcasses rather than prolificacy.

9. Cheese producing farms: Semi-intensive farms manufacturing cheese on-farm. They graze good quality feed, covering their nutritional needs by more than 50%. Mostly situated in highland areas or LFAs. More common in France (local breeds utilising mountain pastures).

10. Pluriactive farms: Sheep farms engaging in at least one economic activity other than sheep production. Their other key characteristic is their family character, with labour being predominantly supplied by family members, including for other off-farm incomes and on-farm activities. They are found all over Europe.

11. PDO specialist farms: Small farms with low competitiveness in “industrial” markets but with important environmental, social, economic and cultural roles. These farms usually produce location-specific products that they rely on for survival and are managed according to the standards of their PDO products.

12. Organic/eco farms: Environment-friendly and/or organic small/medium sheep farms. Commonly, these farms rear local breeds (e.g. in Turkey).

13. Intensive organic/eco farms: Large organic sheep farms with an entrepreneurial orientation. Farms specialise mostly in milk production, or are dual-purpose.

B. Description of goat production systems

1. Traditional meat production farms: Extensive and semi-extensive systems, situated mainly in LFAs and featuring local breeds, which usually achieve low milk yields. Farms are characterised by low investment in facilities and machinery and use family labour. In most cases these farms survive because of their important environmental role in specific regions.

2. Pastoral dual purpose farms: Low-input farms where animals mainly graze throughout the year. These low-input farms generally have poor facilities, although most of them have adopted mechanical milking and supplemental feeding. These farms can be transhumant.

3. Pastoral dairy farms: Semi-extensive farms that rear local breeds specialized in dairy production. Supplementary feeding contributes more than grazing. Milk yields are higher than in dual purpose systems and the farms are characterised by high investments.

4. Confined dairy farms: Large intensive farms applying advanced technology. Characterised by high milk yields and require high inputs. Mostly depend on concentrates and forage and less on grazing.

5. Cheese making farms: These are intensive and semi-intensive farms located in France. These specialised small farms depend heavily on grazing.

2. Final Typology

This initial list of farm types (the 'Broad' typology) was elaborated with the participation of research and industry organizations from all countries involved. It was apparent that a consistent definition on the terms "intensive" and "extensive" was necessary to be used across all countries. Based both on farm practices and literature, the distinction between "extensive" and "intensive" farm types was based on the level of input of purchased feedstuffs, complemented with information about stocking rate and/or grazing duration if needed. The outcome of this process, which represents the final 'narrow' typology, included ten farm types in total (5 for sheep and 4 for goats; the third farm type does not exist for goats) that are mutually exclusive and of importance in analysing the European sheep and goat sector:

i) Intensive dairy farms (e.g. high input of purchased feedstuff)
ii) Semi-intensive or extensive dairy farms (e.g. normally pasture fed animals)
iii) Intensive meat farms (e.g. high input of purchased feedstuff)
iv) Semi-intensive or extensive meat farms (e.g. normally pasture fed animals)
v) Dual-purpose farms (farms where the farmer sees value in 2 or more different products e.g. meat and wool, meat and dairy).

IV – Conclusions

The most common approach for the classification of diverse farming systems is the statistical (quantitative) method, which, however, requires large quantities of farm-level data and it is a complicated and time-consuming exercise. In this study, a qualitative approach was developed to define a pan-European typology of sheep and goat farms based on a meta-analysis of typological surveys. This approach produced 9 final farm types and each one of these types also accounted for a broad range of sub-types of farms, with differences in their size, economic and environmental role, production systems, farming practices and local/regional/national and intra-national importance. In addition, these types vary as to their relevance in innovation adoption, but also as to their needs in specific types of innovation. This final typology constitutes a basis for the description of the multiple sheep and goat systems in the continent and may serve as an important tool in addressing common problems and challenges without adversely affecting the uniqueness of European production systems.

Aknowledgements

This work was carried out in the framework of the iSAGE project (Innovation for Sustainable Sheep and Goat Production in Europe), funded by the the European Union's Horizon 2020 research and innovation programme under grant agreement No 679302.

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Session 2 (N)

Innovations to adapt sheep and goat feeding and production systems and industry to new societal demands

Nutrition

Nutritional approaches to improve the fatty acid profile of milk fat in sheep and goats

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Abstract. Sheep and goat milk are sources of bioactive compounds with health-promoting properties. The demand for sheep and goat milk has grown worldwide over the years, because of both the increased request for cheese and other traditional dairy products, and the success of sheep and goat milk as component of infant formulas, drinking milk and nutraceutical product. Animal feeding is one of the main factors affecting the quality of fat in sheep and goat milk and, therefore, in the derived dairy products. In particular, nutrition can readily alter milk fat concentration and fatty acid (FA) profile. This review compared the effects of sheep and goats feeding strategies on milk fat composition, with focus on FA with potential healthy properties, such as conjugated linoleic acid (CLA) and polyunsaturated fatty acids (PUFA) of the omega3 family. The nutritional strategies to design the FA profile of sheep and goat dairy products based on grazing and use of vegetable oils and the different nutritional responses of the two species are reviewed and discussed.

Keywords. Dairy sheep and goats – Milk fatty acid composition – Nutrition – CLA – Omega-3 – Alpha linolenic acid – Odd and branched chain fatty acids.

Approches nutritionnelles pour améliorer le profil en acides gras de la matière grasse du lait chez les ovins et caprins

Résumé. *Le lait des ovins et caprins est une source de composés bioactifs possédant des propriétés favorables à la santé. La demande de lait de brebis et de chèvres a augmenté à l'échelle mondiale au fil des années, en raison à la fois de la plus grande consommation de fromage et autres produits laitiers traditionnels, et du succès du lait ovin et caprin comme composante de formulations pour nouveaux-nés, de lait à boire et de produits nutraceutiques. L'alimentation animale est l'un des principaux facteurs qui influencent la qualité de la matière grasse du lait des ovins et caprins et, par conséquent, des produits laitiers dérivés. En particulier, la nutrition peut facilement altérer la concentration de matière grasse et le profil en acides gras (AC). Cette révision a comparé les effets des stratégies d'alimentation des ovins et caprins sur la composition de la matière grasse du lait, en se focalisant sur les AC ayant des propriétés potentielles de santé, tels que l'acide linoléique conjugué (CLA) et les acides gras poly-insaturés (PUFA) de la famille oméga3. Dans cet article sont examinées et discutées les stratégies nutritionnelles visant à moduler le profil en AC des produits laitiers des ovins et caprins en se basant sur le pâturage et l'utilisation d'huiles végétales, ainsi que les différentes réponses nutritionnelles de ces deux espèces.*

Mots-clés. *Brebis et chèvres laitières – Composition en acides gras du lait – Nutrition – CLA – Omega-3 – Acide alpha-linolénique – Acides gras ramifiés impairs.*

I – Introduction

In Mediterranean countries, sheep milk is primarily used for the production of cheese, whereas goat milk is also largely used to produce yogurt and drinking milk. Goat and sheep milk is also suitable for formula and follow-on formula for infants (Directive 2006/141/EC) who cannot use breast milk (Grant *et al*., 2005). In New Zealand, infant formulas for babies from birth until three years of age have been developed and their production is markedly increasing.

Milk and dairy products of small ruminants have a high nutritional value and are a considerable source of high-quality dietary proteins and fats. For the latter, there is an increasing research finalized to improve its nutritional quality by enhancing the content of fatty acids (**FA**) putatively associated with benefits on human health, such as branched-chain fatty acids (**BCFA**), ruminant trans-fatty acids (**R-TFA**), especially cis9, trans11-conjugated linoleic acid (c9,t11**CLA**) also known as rumenic acid (**RA**) and trans11-18:1 vaccenic acid (**VA**), and α-linolenic acid (C18:3n3; **ALA**). More details on these effects are reported in next section. The high concentration of these types of FA in milk and dairy products of small ruminants, usually higher than that found in cow milk, is of particular interest (Prandini *et al*., 2011; Lobos-Ortega *et al*., 2012).

Dietary regimen can greatly affect the amount of these biologically active molecules in sheep and goat milk fat (Chilliard *et al*., 2003; Nudda *et al*., 2014; Ferlay *et al*., 2017). Several studies highlighted the positive and marked role of pasture-rich diets in enhancing the concentration of healthy FA in goats (Tudisco *et al*., 2010; Nudda *et al*., 2007; Tsiplakou *et al*., 2006) and sheep (Nudda *et al*., 2014). Another strategy to increase the concentration of beneficial FA in milk is to supplement the diet of dairy sheep (Nudda *et al*., 2014) and goats (Chilliard *et al*., 2003; Nudda *et al*., 2006; 2008; 2013) with sources of unsaturated plant lipids. In addition, an interaction effect between alpha-s1-casein gene polymorphism and diet on goat milk FA composition has also been reported (Valenti *et al*., 2010; Chilliard *et al*., 2013).

Due to the importance of the feeding regimen of milk FA, this review provides the following: a) a specific update on the studies regarding feeding strategies able to modify the healthy FA content in sheep and goat milk and dairy products, with focus on the use of pasture and vegetable oil sources, and b) an evaluation of the differences between sheep and goats regarding the ability of feeding strategies to modify their milk FA composition.

II – Beneficial effects of fatty acids

Dairy products are the major source of RA and VA, although small amounts of RA isomers can be endogenously synthesized in humans (Adlof *et al*., 2000). RA and VA originate from the incomplete biohydrogenation of **PUFA** by microorganisms in the rumen (Kepler *et al*., 1966), and VA is also the main precursor of CLA in the mammary gland, by the action of D9 desaturase. Several animal and human cell line studies found that CLA, especially the isomer c9t11 CLA (RA), exerts many biological effects (Yang *et al*., 2015; Ferlay *et al*., 2017). Positive biological effects have also been ascribed to VA (Jacome-Sosa *et al*., 2016; Krogager *et al*., 2015). Moreover, RA has acquired significant relevance because of the encouraging positive results obtained by using dairy products, naturally rich in this FA, in human trials. In healthy subjects, the intake of 200 grams per week of a sheep cheese naturally enriched with VA and RA (3.26 and 1.56 g/100 lipids, respectively),when compared with a regular cheese (0.4 VA and 0.19 RA g/100 lipids, respectively), for ten weeks reduced significantly inflammatory substances, such as interleukin-6, interleukin-8 and tumour necrosis factor-alfa, and improved some hemorheological parameters(Sofi *et al*., 2010). In hypercholesterolemic subjects, the intake of sheep cheese naturally enriched with RA and ALA unexpectedly decreased the plasma concentrations of the endocannabinoid anandamide by 40% and the LDL-cholesterol level by 7% (Pintus *et al*., 2013), compared to the intake of a control cheese. Milk is also a source of n-3 FA, with ALA being the most abundant in dairy products. Research in humans and laboratory animals reported beneficial effects of ALA in the prevention of cardiovascular (Del Gobbo *et al*., 2016; Barbeau *et al*., 2017; Ganguly *et al*., 2017) and other (Yamagishi *et al*., 2017) diseases. Several biological effects of RA against enteropathy (Bergamo *et al*., 2016), atherosclerosy (Bachmair *et al*., 2012), cancer (Wang *et al*., 2013; Lu *et al*., 2015), and inflammations (Mollica *et al*., 2014; Penedo *et al*., 2013) have been evidenced in multiple observational studies in animals and in *in vitro* experiments. Ruminant products are also an important source of BCFA, FA with at least one methyl branch along the carbon chain (Ran-Ressler *et al*., 2014), which

were associated with increased expression of anti-inflammatory cytokines in an animal model (Ran-Ressler *et al*., 2014). In ruminant products, there are also odd-chain FA (**OCFA**), of which the pentadecanoic (15:0) and heptadecanoic (17:0) acids have generated interest among scientists recently because of their inverse association with risk of type 2 diabetes and cardio-vascular diseases in humans (Pfeuffer and Jaudszus, 2016).

III – Dietary effects on healthy fatty acids in sheep and goat milk

1. Effect of pasture and forage-based diets

Fresh pasture is an excellent source of ALA and is one of the most effective feeds in shifting milk FA composition towards a healthy spectrum in sheep (Albenzio *et al*., 2016; Nudda *et al*., 2014) and goats (D'Urso *et al*., 2008; Renna *et al*., 2012). In particular, fresh grass grazed directly or cut and supplemented in the diet has a marked effect on VA and RA content in milk fat, maybe because green forage has a high content of ALA, which is partly biohydrogenated into VA in the rumen and partially converted into RA in the mammary tissue by the action of delta-9 desaturase. Differences between these species in responses to pasture-based diets have been hypothesized, because the RA content is normally higher in sheep milk than in goat and cow milk on pasture (Jahreis *et al*., 1999). A survey that evaluated the FA profile of sheep and goat cheese produced during the year (Nudda *et al*., 2008) evidenced that the content of RA in goat cheese was lower than that observed in sheep milk and did not change significantly during the months of production, whereas the content of RA in sheep cheese was the highest in March and April in correspondence of the highest pasture availability and quality (Fig. 1).

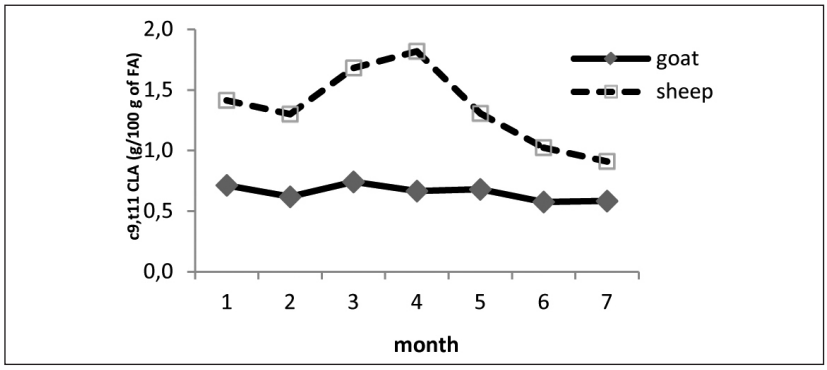

Fig. 1. Temporal evolution of c9,t11 CLA in ovine and caprine cheese produced in Sardinia from January (Month 1) to July (Month 7) (from Nudda *et al*., 2008).

The seasonal evolution of RA in milk and cheese of goats (Nudda *et al*., 2007) and sheep (Nudda *et al*., 2005), sampled from March to June in different processing plants located in Sardinia (Italy; Fig. 2), clearly evidenced a different pattern of this FA concentration between the two species. A pattern similar to that reported in Figure 1 has been observed in a survey carried out by Tsiplakou *et al*. (2006) from January to June, under semi-extensive sheep/goat farming systems in Greece. Data of these two species are difficult to compare due to the different experimental conditions in which the surveys were carried out. However, our experiment (Nudda *et al*., 2003) with goats and sheep maintained in the same environmental conditions and fed the same mixed pasture of *Trifolium* sp. and *Lolium* sp. confirmed that the RA content was significantly higher in ewes than goats (+230%) in April, when the diet was composed mainly by pasture ($P<0.01$).

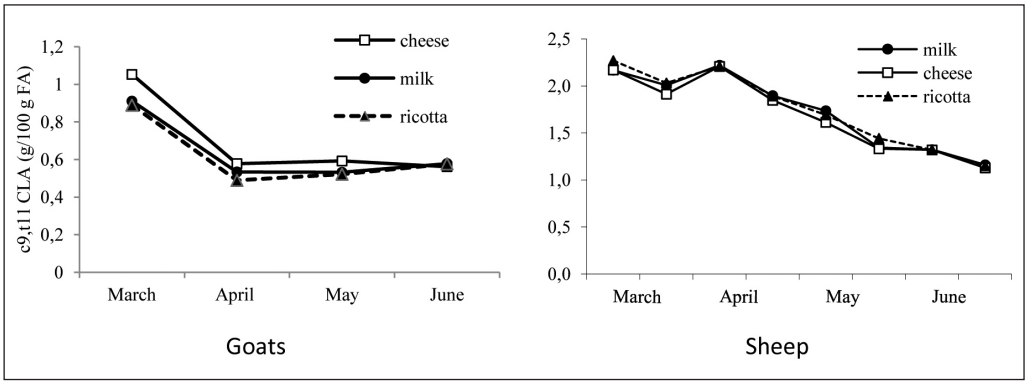

Fig. 2. Seasonal evolution of rumenic acid (c9,t11 CLA, mg/100 mg FA) in milk, cheese and ricotta of goats (adapted from Nudda *et al*., 2007) and sheep (adapted from Nudda *et al*., 2005).

This species difference was markedly reduced in May, when pasture availability and quality decreased and the proportion of concentrate in the diet increased (Fig. 3). The lack of change in RA content between April and May in goat milk is difficult to explain.

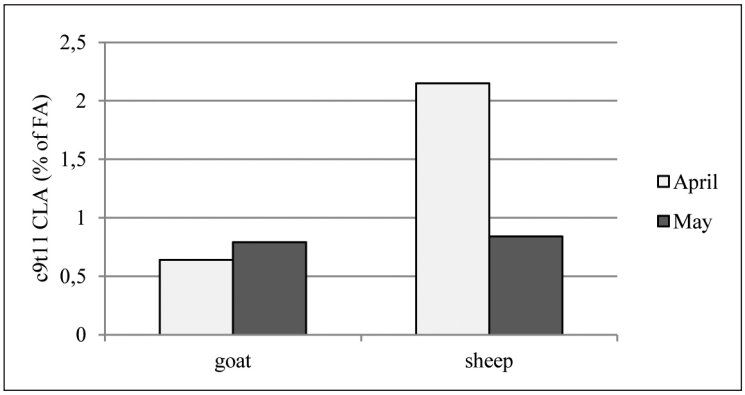

Fig. 3. c9,t11 CLA content of caprine and sheep milk fat, with both species grazing the same pasture during April (high pasture availability) and May (dry pasture). Data from Nudda *et al*. (2003).

Differences between sheep and goats could be related to differences in feeding behavior (e.g. total intake, selectivity and timing) during grazing. Interestingly, in two different studies, as pasture intake increased, the content of RA increased both in sheep (de Renobales *et al*., 2012) and goats (Renna *et al*., 2012), but the extent of the response was higher in sheep than goats. Therefore, daily pasture intake explained only partially the increase in CLA content in milk. Addis *et al*. (2005) observed that PUFA level in milk was higher in ewes grazing pure legumes and grass-legume mixtures than in those grazing pure grass pastures. This could be a consequence of the higher content of PUFA in legumes compared to grasses (Cabiddu *et al*., 2005) with an obviously higher daily intake of PUFA. This indirectly suggests that a possible mechanism explaining the lower RA content in milk of goats fed on pasture is their aversion to legumes, which are richer in CLA precursors. Indeed, goats had a markedly lower preference for legumes compared to grasses when fed on pasture (Fedele *et al*., 1993) and showed an aversion to legume flavor and a preference for

grass flavor in short-term cafeteria trials (De Rosa *et al*., 2002). Other possible mechanisms that could explain the species differences in milk RA are related to the fact that goats have more frequent and smaller meals compared to sheep (Abijaoudé *et al*., 2000) and thus possibly a more regular pattern in rumen pH and feed outflow and more complete rumen bio-hydrogenation of dietary unsaturated FA. The two mechanisms we hypothesized above have not been demonstrated and certainly need solid experimental evidence to be confirmed.

2. Effects of vegetable oil supplementation

The supplementation of vegetable oils to the diet of dairy sheep and goats is a valuable tool to enhance dietary energy content and can influence the FA composition of milk fat. This feeding strategy is particularly useful when the diet has a low content of unsaturated FA, e.g., when hay or silage is the main forage source. The amount of RA in sheep and goat milk is mainly affected by the amount, type and physical form of fat added to the diet (Albenzio *et al*., 2016; Chilliard *et al*., 2003; Gómez-Cortés *et al*., 2011; Shi *et al*., 2015). Linseed, soybeans, safflower, sunflower, and rapeseed are the main lipid supplements used to increase the content of RA and unsaturated FA in milk (Albenzio *et al*., 2016; Nudda *et al*., 2014; Sanz Sampelayo *et al*., 2007;). Linseed is the most widely used supplement to improve the content of the healthy FA in the milk of both species, being very rich in ALA. The average extent of the increase in RA and VA using linseed is greater, on average, for sheep than goats (Table 1). The opposite pattern is observed in ALA concentration, which is greater in goat milk than in sheep milk. The reasons for these different responses between sheep and goats have not been deeply investigated, but, based on the different response of milk FA composition to this lipid source, it seems that in goats the ALA biohydrogenation process occurs very slowly, compared to sheep, leading to higher ALA rumen outflow towards the mammary gland.

The effect of dietary supplementation of soybean oil and sunflower oil in sheep and goats is reported in Table 2. The concentrations of VA and RA increased with sunflower and soybean oil supplementation in both species. The average increment of these FA was the greatest for sunflower oil in goats (+258% for CLA, +223% for VA), and for soybean oil in sheep (+350% for CLA, +596% for VA)(Table 2). The reasons for this species difference are unclear, given the similar FA composition of these two oil sources. The greater increase in VA and RA for sunflower oil than soybean oil has also been recently evidenced in rumen fluid in an *in vitro* study (Roy *et al*., 2017). However, inter-species differences in responses to lipid supplements could be related to an interaction between basal diet composition and PUFA in the diet, which are important determinants of the extent of ruminal biohydrogenation and the formation of specific biohydrogenation intermediate products that could affect affects the expression of lipogenic genes involved in FA uptake (LPL), de novo synthesis (ACACA and FASN) and delta-9 desaturation (SCD1) in mammary tissue (Bernard *et al*., 2009; Chilliard *et al*., 2014). As said before, goats tend to have more frequent and smaller meals compared to sheep (Abijaoudé *et al*., 2000) and thus, possibly, a more regular pattern of rumen pH and feed outflow. However, dairy goats are usually fed diets with much higher doses of concentrates and starch than dairy sheep and this can lead to marked modifications of the rumen environment. To clarify this issue, specific experiments in which the same basal diets and supplementations are given to the two species should be designed.

Other lipid sources, such as as safflawer (Shi *et al*., 2015), pomegranate (Emami *et al*., 2016) and marine oils (Sanz Samnpelayo *et al*., 2007), are effective in increasing milk CLA content in goats and sheep (Albenzio *et al*., 2016; Nudda *et al*., 2014). Moreover, the dietary inclusion of lipid sources in combination with tannins could be another practical tool for increasing the unsaturated FA content in milk of goats (Abo-Donia *et al*., 2017) and sheep (Buccioni *et al*., 2015, 2017).

Table 1. Effects of dietary linseed supplementation on the fatty acid profile of sheep and goat milk. Effects are expressed as the differences in percentage (%) of change between fat-supplemented group and non-supplemented control group

	Dose	Form	c9,t11 CLA	C18:1 t11	C18:2n6	C18:3 n3	Reference
goats	200 g/d	EL	60	87	3	99	Nudda *et al*., 2006
	160 g/d	EL	112	148	13	132	Nudda *et al*., 2008
	200 g/d	EL (+pasture)	54	100	1	145	Nudda *et al*., 2013
	25g/kgDM	Oil	100	26	12	98	Emami *et al*., 2016
	360+40g/d	EL	103	187	5	288	Bernard *et al*., 2016
	3.4% DMI	oil	133	190	0	325	Chilliard *et al*., 2003
	55-61 g/d	oil	256	399	-29	137	Bernard *et al*., 2009
SHEEP							
	210 g/d	EL	50	67	52	100	Zhang *et al*., 2006a
	200 g/d	EL	213	294	11	153	Correddu *et al*., 2016
	100 g/d	EL (+pasture)	28	42	245	48	Cabiddu *et al.,* 2017
	63 g/d	oil	308	447	-12	106	Bodas *et al*., 2010
	41 g/d	oil	90	367	9	122	Zhang *et al*., 2006b
	210 g/d	EL	198	207	0	250	Mele *et al*., 2011

EL = extruded linseed; FO = fish oil; DMI = dry matter intake.

Table 2. Effects of dietary soybean and sunflower fat supplementation on the fatty acid profile of sheep and goat milk. Effects are expressed as the differences in percentage (%) of change between fat-supplemented group and non-supplemented control group

	Form	c9,t11 CLA	C18:1 t11	C18:2 n6	C18:3 n3	Reference
goats	SO	199	214	14	-10	Bouattour *et al*., 2008
	SO+FO	609	466	34	13	Tsiplakou and Zervas, 2013
	SW	-33	-10	-50	-25	Chilliard *et al*., 2003
	SUN	283	290	55	25	Chilliard *et al*., 2003
	SUN-oil	590	792	31	-47	Ollier *et al*., 2009
	SUN-oil	384	562	13	-33	Bernard *et al*., 2009
SHEEP						
	SO	316	809	15	-38	Mele *et al*., 2006
	SO	562	736	59	2	Bodas *et al*., 2010
	SO	171	242	13	-23	Gómez-Cortés *et al*., 2011
	SUN-seeds	130	67	78	56	Zhang *et al*., 2006b
	SUN-oil	138	195	6	-12	Maia *et al*., 2011
	SUN-oil	11	36	12	31	Castro *et al*., 2009

SO = boybean oil; SW = whole soybean; SUN = sunflower.

IV – Conclusions

Based on the literature, it appears that the FA composition of the milk of sheep and goats can be largely modified and improved by feeding, with an increase in the concentration of beneficial FA. This modification can be induced both on pasture-fed and indoor-fed sheep and goats. Sheep seem to respond to the utilization of pasture with a larger increase in beneficial FA compared to goats, possibly because of the higher preference for legumes of the former. The utilization of vegetable oils as dietary supplements, in sheep and goats fed basal diets made of hay or silage, can also positively change the FA composition of milk. The responses to supplementation with various types of vegetable oils differ substantially between the two small ruminant species, with higher production of beneficial FA when linseed or soybean oil are used in sheep, and when sunflower oil is used in goats. It is not

clear if these differences depend on intrinsic species differences (e.g. feeding behavior or metabolism) or by the type of diets most commonly used in the two species. Clearly, more research is needed to determine all the factors affecting the extent and type of FA change in sheep and goat milk.

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In vitro study of the effect of combinations of cereals and sugar beet pulp on pH and gas production pattern in concentrate or forage-based diets for ruminants

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Abstract. The nature of the dietary carbohydrate fraction may affect fermentative conditions and performance, depending on rumen environment. Three mixtures (1:1 maize:barley, MB, and maize:sugarbeet pulp at either 1:1, MP, or 3:1, 3MP) were incubated in an *in vitro* semi-continuous culture system, using inoculum from lambs receiving a concentrate (CI) or a forage (FI) diet (three 24h series for each inoculum). Medium pH was poorly buffered from 0 to 6h, and allowed to rise around 6.5 from 8h onwards. With CI, minimum incubation pH was reached after 6h, being higher (P<0.05) with MP than with MB and 3MP from then (6.06, 5.97 and 5.95 at 6h, respectively) to 20h (6.78, 6.67 and 6.67). Gas production was highest for MB at 2h and from 6 to 16h, and lowest with 3MP from 2 to 8h, and with MP from 20h onwards (P<0.05), whereas no differences (P>0.05) were recorded neither between MB and 3MP at 20 and 24h, nor between MP and 3MP from 10 to 16h. With FI, pH was lower with MB than with 3MP at 6h (6.33 vs. 6.39, P<0.05), and maintained lowest onwards (P<0.05) with MB. The volume of gas from 3MP was lowest (P<0.05) up to 4h, and lower with 3MP than with MB from 6h onwards (P<0.05), whereas differences between MB and MP were only recorded after 24h. In both concentrate and forage environments, MP maintains a more stable pH pattern while fermentation was not noticeably depressed compared to higher starch proportions mixtures (MB and 3MP).

Keywords. Carbohydrate mixtures – Incubation pH – *In vitro* gas production – Semi-continuous culture system.

Étude* in vitro *de l'effet des combinaisons des céréales et de pulpe de betterave sur le pH et la production de gaz avec des rations à base de concentrés ou à base de fourrage pour les ruminants

Résumé. *La nature des glucides alimentaire peut affecter les conditions et les performances de fermentation, selon l'environnement du rumen. Trois mélanges (1:1 maïs:orge, MB, et maïs:pulpe de betterave soit 1:1, MP, ou 3:1, 3MP) ont été incubés dans un system* in vitro *de culture semi-continue, en utilisant un inoculum provenant d'agneaux recevant une ration á base de concentré (CI) ou une ration á base de fourrage (FI) (trois séries de 24h pour chaque inoculum). Le pH de milieu d'incubation a été faiblement tamponné de 0 à 6h, et il a été tamponné autour de 6.5 à partir de 8h. Avec CI, Le pH minimum d'incubation a été atteint après 6h, à partir de là le pH a été supérieur (P<0.05) avec MP qu'avec MB et 3MP (6.06, 5.97 et 5.95 à 6h, respectivement) jusqu'á 20h (6.78, 6.67 et 6.67). La production de gaz enregistrée avec MB a été supérieure á 2h et de 6 á 16h, et inférieure par rapport à 3MP de 2 á 8h, et avec MP á partir de 20h (P<0.05). Tandis que des différences de production de gaz n'ont pas été enregistrées (P>0,05) ni entre MB et 3MP á 20 et 24h, ni entre MP et 3MP du 10 á 16h. Avec FI, le pH a été inférieur avec MB qu'avec 3MP á 6h (6.33 vs. 6.39, P<0.05), et il a été maintenu inférieur (P<0.05) jusqu'à la fin d'incubation avec MB. Le volume de gaz enregistré par 3MP a été inférieur (P<0.05) á partir de 4h, et inférieur avec 3MP qu'avec MB á partir de 6h (P<0.05), tandis que des différences entre MB et MP ont été enregistrées seulement après 24h. Dans les deux cas, avec CI ou avec FI, MP maintient plus stable le pH du milieu, en revanche sa fermentation n'a pas été sensiblement baissée par rapport aux deux autres mélanges avec des proportions plus élevées d'amidon (MB et 3MP).*

Mots-clés. *Mélanges de glucides – pH d'incubation – Production de gaz* in vitro *– Système semi-continu de culture* in vitro.

I – Introduction

The fattening diets fed to lambs in Southern Europe are characterised by a high rate of cereal grains as the main carbohydrates sources. However, using such feeds promotes a high rate and extent of rumen microbial fermentation that are usually associated with digestive disorders such as rumen acidosis (Nagaraja and Titgemeyer, 2007). If an excessive degradation rate of starch is promoted, the risk of ruminal acidosis may increase (Svihus *et al*. 2005), and thus the impact on rumen environment is associated with the nature of dietary starch. Van Barneveld (1999) reported that the fermentation of cereal grains depends on the differences in starch structure from one plant species to another. Despite the amount of starch is higher with corn than barley, the rate of starch fermentation is higher with the latter (Sauvant and Michalet-Doreau, 1988). On the other hand, Calsamiglia *et al*. (2012) proposed that acidosis may be caused by the combined effects of pH and changes in the microbial profile related to the type of diet. The risk of acidosis can be minimized giving adequate amounts of structural carbohydrates, which may avoid a ruminal overload of volatile fatty acids (VFA) and lactate, increasing at the time chewing activity and the flow of salivary buffers. Sauvant *et al*. (1999) conclude that, to avoid the risk of acidosis, diets should contain no more than 25% starch and about 30-40% neutral detergent fibre (NDF) on DM basis. In this regard, several agro-industrial by-products, such as sugarbeet pulp which have a considerable proportion of easily-fermentable hemicelluloses and pectin, are used in ruminants nutrition, rendering high amount of energy when fermented in the rumen (Nocek and Tamminga, 1991). With them, the rumen pH can be maintained because of its own buffering capacity. However, the objective of intensive feedlots is to achieve maximum intake and efficiency of use of energy preserving at the same time a healthy rumen environment.

This work aims to assess the synergistic and antagonistic effects of three mixtures of carbohydrate sources such as maize and barley grain, as sources of starch, and sugarbeet pulp as source of highly fermentable fibre, on *in vitro* fermentation parameters.

II – Material and methods

Three carbohydrate feeds were studied as substrates of incubation, two cereals (barley, var. Gustav and maize grain Dekalb 6667YG), and one by-product (sugarbeet pulp). Substrates were milled through a sieve of 1 mm and used as components of three mixtures, 1:1 maize:barley (MB) and 1:1 and 3:1 maize:sugarbeet pulp (MP and 3MP). Two sets of incubation series were arranged, according to the nature of the inoculum (forage inoculum, FI, and concentrated inoculum, CI), to compare *in vitro* fermentation of substrate mixtures. The rumen fluid was obtained from six lambs weaned abruptly at 7 weeks ± 8 days and fed *ad libitum* afterwards in groups of three with alfalfa hay (FI) for 45 days or with concentrate and barley straw (CI) for 35 days. Then, animals were slaughtered, their rumen contents were individually filtered through a cheesecloth and dispensed into tubes that were frozen in nitrogen liquid and stored at -80 ºC (Prates *et al*., 2010). Before incubation, frozen inocula were thawed in a 39 ºC water bath for 1-2 min. For each inoculum, 3 *in vitro* incubation series of 24 h were carried out, with two bottles per mixture in each series. The fermentation kinetics of experimental feeds were determined by the *in vitro* incubation system of Fondevila and Pérez-Espés (2008), modified by Prates *et al*. (2010). Sealed nylon bags (45um pore size) containing 800 mg of substrates mixtures were incubated in each 125 ml Erlenmeyer flasks, that were filled with 80 ml of incubation solution consisting of 0.20 rumen inoculum and 0.80 of an incubation mixture made up with a macromineral solution, a reduction solution and a buffer solution in which the concentration of bicarbonate ions was buffered to get a pH 5.5 from 0 to 6 h incubation, and a pH 6.5 from 8 to 24 h incubation (Amanzougarene and Fondevila, 2017). The incubation solution was prepared under a CO2 atmosphere, and bottles were maintained at 39 ºC in a water bath throughout the incubation. The pressure of gas produced in each bottle was recorded at 2, 4, 6, 8, 10, 12, 16, 20, and 24 h, and gas volume was expressed per unit of incubated organic matter (OM). Immediately after each gas measurement, fixed volumes of incubation media were extracted by suction

through the filter port, and the exact volume was replaced with incubation solution without rumen inoculum that was maintained anaerobically at 39 ºC. The rate of the liquid phase turnover was adjusted to approximately 6.5ml/h, by replacing liquid media with incubation solution, according to this schedule: 13 ml every 2 h from 0 to 12 h of incubation, and 26 ml every 4 h from 12 to 24 h. Extracted media was used for pH measurement, and then stored for other purposes.

Results for each inoculum were analysed separately by ANOVA using the Statistix 10 software package (Analytical Software, 2010). Each bottle was considered as the experimental unit and the series as a block. The differences were considered significant when $P<0.05$, and a trend for significance was considered when $0.05£P<0.10$. The Tukey test ($P<0.05$) was used for the multiple comparison between means.

III – Results and discussion

1. Pattern of incubation pH

At the start of incubation series, the mean inoculum pH was 6.44 ± 0.12 and 7.01 ± 0.20 for CI and FI, respectively (n=3). When CI was used (Fig. 1a), no differences among mixtures were recorded from 0 to 4h ($P>0.05$), but at 6h the minimum pH was reached, that was highest with MP ($P<0.05$) than MB and 3MP. From 8h, the medium pH increased ($P<0.01$) until reaching the maximum at 20h (6.78, 6.67, 6.67, respectively), maintaining the same treatment differences, and then pH tended to fell ($P=0.081$) at 24h, but no differences between mixtures were recorded ($P>0.05$). When mixtures were incubated with FI (Fig. 1b), no pH differences were recorded among mixtures in the first 4h ($P>0.05$), but at 6h it was lower with MB than with 3MP ($P<0.05$). From 8h onwards, the pH recorded with MP and 3MP was higher than MB ($P<0.05$), not existing differences among the treatments including sugarbeet pulp. For all treatments, the minimum incubation pH was reached after 8h, and then pH for all substrates increased from 10 to 20h, maintaining the lowest values with MB ($P<0.05$), and dropping again at 24h.

Buffer concentration in the incubation media was adjusted to allow for a drop of pH during the first 6h, thus allowing for expression of acidification properties of substrate mixtures in poorly-buffered conditions; afterwards, buffer concentration was increased to simulate pH increase during the low intake daily period in intensive fed ruminants. Such conditions were supported by the minimum medium pH reached at 6 and 8h for CI and FI, respectively, and the maximum pH reached at 20h incubation. However, the extent of pH drop was apparently higher with CI than FI, suggesting that the magnitude of fermentation was higher with CI, as it has been recently demonstrated (Broudiscou *et al*., 2014). When comparing substrate mixtures, the treatment with barley (MB) showed lower incubation pH than those including sugarbeet pulp (MP and 3MP), mainly with CI, because of the higher acidification capacity of barley than maize and the higher acidification capacity of cereal grains than fibrous sources. In fact, the high proportion of starch in 3MP rendered a more acid environment compared with MP considering that the buffering capacity did not greatly differ between maize and sugarbeet pulp (Amanzougarene *et al*., 2017). It is assumed that inclusion of high levels of cereal based concentrates decreases rumen pH (Fondevila *et al*., 1994; Carro *et al*., 2000), as well as the self-buffering capacity of sugarbeet pulp can be expected.

2. *In vitro* gas production

During the whole incubation period, differences ($P<0.001$) in the *in vitro* gas production between the different mixtures were recorded with CI (Fig. 2a). The volume of gas recorded was highest with MB at 2h and from 6 to 16h ($P<0.05$), whereas it was lowest with 3MP from 2 to 8h and with MP from 20h onwards ($P<0.05$). No differences ($P>0.05$) were recorded between MP and 3MP from

10 to 16h, nor between MB and 3MP at 20 and 24h. With FI (Fig. 2b), differences between substrate mixtures on gas production were recorded throughout all the incubation period (P<0.05), the volume of gas recorded by 3MP being lowest (P<0.05) up to 4h, and lower with 3MP than with MB from 6h onwards (P<0.05), whereas differences between MB and MP were only recorded after 24h.

Although not contrasted statistically, the extent of gas production was greater with CI than FI, as it can be expected from results in medium pH. This can be explained by the fact that microorganism of the former inoculum should be better adapted than those from a fibrous diet for the fermentation of this kind of substrates (Amanzougarene *et al*., 2017). Among mixtures, MB recorded a higher volume of gas production than MP and 3MP in both inocula. Comparison between MB and 3MP in CI is determined by the faster rate of fermentation of barley respect to maize, which can be due to the floury starch of barley (Chevalier, 2001), effect that is balanced at later stages of fermentation (at 20 and 24h). However, the lower gas production in 3MP when FI was used can be attributed to the low capacity of microbiota induced by a forage diet for fermenting maize vitreous starch (Amanzougarene *et al*., 2017). Differences in gas production comparing MP to MB and 3MP were of minor magnitude, and even disappear at later stages of incubation mainly with FI probably due to scarce differences between utilisation of slowly fermentable maize starch and rapidly fibre fermentable of sugarbeet pulp.

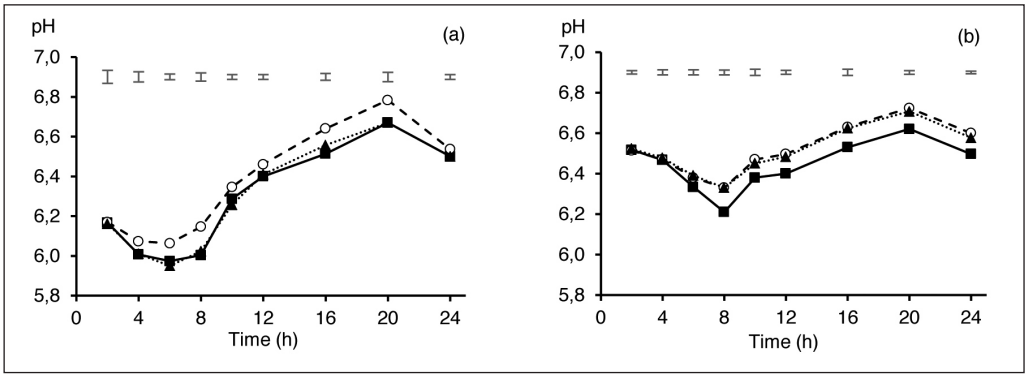

Fig. 1. Pattern of incubation pH from MB; ■, MP; ○, and 3MP; ▲, when incubated *in vitro* with inoculum from a concentrate diet (CI, Fig. 1a) or from a forage diet (FI, Fig. 1b). Upper bars show standard error of means.

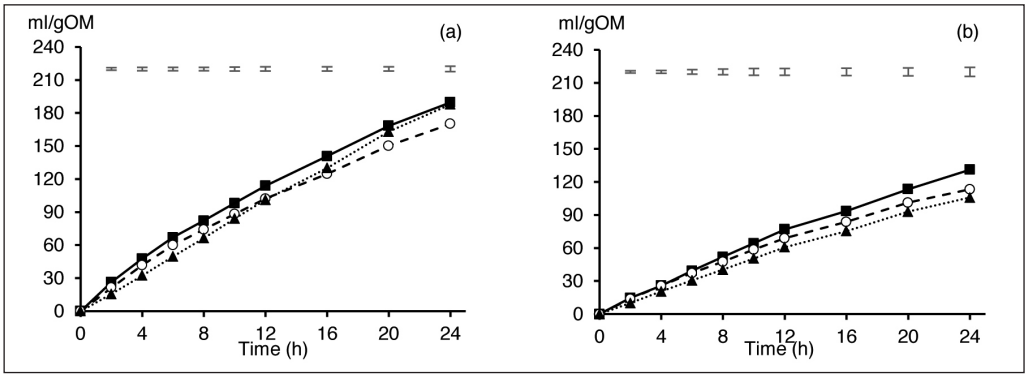

Fig. 2. Pattern of incubation pH from MB; ■, MP; ○, and 3MP; ▲, when incubated *in vitro* with inoculum from a concentrate diet (CI, Fig. 2a) or from a forage diet (FI, Fig. 2b). Upper bars show standard error of means.

IV – Conclusions

In both concentrate and forage environments, inclusion of 50% fibrous source (MP) maintained a more stable pH pattern whereas fermentation was not noticeably depressed compared to higher starch proportion mixtures like 3MP (75 % cereal; 25% sugarbeet pulp), or even a high starch substrate such as MB (100% cereal). From the results obtained, it can be concluded that combine cereal with by-products, as sugarbeet pulp, can promote positive effects on ruminal fermentation due to synergic or antagonist interactions between diet components.

Acknowledgements

This work was supported by the Spanish Government through the MINECO project AGL 2013-46820, with the participation of the Department of Industry and Innovation of the Government of Aragón, and the European Social Fund. S. Yuste was supported by a FPU fellowship from the Ministerio de Educación, Cultura y Deporte (Government of Spain). There were no conflicts of interests.

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Effet de l'incorporation de la pulpe sèche de betterave dans la ration des agneaux sur les performances de croissance, les caractéristiques de la carcasse et la qualité de la viande

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Résumé. L'objectif de ce travail est d'évaluer l'effet de différents niveaux d'incorporation de la pulpe sèche de betterave (PSB) dans la ration des agneaux en phase d'engraissement sur les performances de croissance, les caractéristiques de la carcasse et la qualité de la viande. Trente six agneaux mâles, issus du croisement D'man*Boujaad, âgés de 12 à 15 semaines et d'un poids moyen initial de 23 ± 1,82 kg ont été divisés aléatoirement en trois lots homogènes de 12 têtes chacun. Trois régimes alimentaires ont été utilisés contenant du foin de luzerne (30%), de tourteau de tournesol (10%) et un mélange avec différentes proportions de PSB et d'orge :0%PSB et 60% orge (T0%), 30% PSB et 30% orge (T30%), 60% PSB et 0% orge (T60%). Durant l'essai, qui a duré 68 jours précédé d'une période d'adaptation de 10 jours, les quantités ingérées ont été déterminées et les animaux ont été pesés au début et à la fin de l'essai. A la fin de l'essai, tous les animaux ont été sacrifiés. Le rendement carcasse, le poids du rumen plein et vide, le pH ruminal, le dépôt de gras (gras mésentérique et pélvio-rénal), le pH de la viande à 0 et 24h post-mortem et la couleur de la viande au niveau du muscle *Longissimus dorsi* ont été déterminés. Le remplacement de l'orge par la PSB n'a pas affecté significativement le rendement carcasse, le pH de la viande à 0 et 24h post-mortem, le dépôt de gras, a et b (P> 0,05), alors qu'il a affecté significativement le gain moyen quotidien, le pH ruminal et L (P <0,05). Le gain quotidien moyen des agneaux de T30% (245,5 g/j) a été supérieur à ceux de T0 (192,9 g/j) et de T60% (199,4 g/j). Les agneaux de T0 avaient une valeur de pH ruminale inférieure (6,62) que celles de T30% (6,84) et T60% (7,19). Le paramètre L était plus élevé chez T0 (32,7) et T60% (33,3) que T30% (30,5).

Mots-clés. Pulpe sèche de betterave – Ovin – Engraissement – Carcasse – Viande.

Effect of the proportion of dry beet pulp in the diet on lamb fattening performance, carcass characteristics and meat quality

Abstract. *The objective of this work was to evaluate the effect of the incorporation of different levels of PSB in the diet on lamb fattening performance, carcass characteristics and meat quality. Thirty six Moroccan synthetic breed lambs "Dman*Boujaad" (20.2 ± 1.82 kg initial body weight) were randomly assigned to three homogenous groups of twelve each. Lambs received a diet containing alfalfa hay (30%), sunflower meal (10%) and mixed concentrate with different proportions of dry pelleted beet pulp (DBP) and barley: 0% DBP and 60% barley (T0%), 30% DBP and 30% barley (T30%) and 60% DBP and 0% barley (T60%). The fattening trial was lasted for 68 days after 10-day of adaptation period and lambs were weighed at the beginning and at the end of the trial. At the end of the trial all the lambs were slaughtered, the carcass dressing percentage, ruminal pH, pH of meat at 0 and 24h postmortem, fat deposition (mesenteric and pelvic fat) and instrumental color (L, a, b) of Longissimus dorsi muscle were determined. The proportion DBP did not affect the carcass dressing percentage, pH of meat at 0 and 24h postmortem, fat deposition (mesenteric and pelvic fat), a and b (P> 0.05), whereas it affected significantly the average daily gain, ruminal pH and L (P< 0.05). The average daily gain of lambs of T30% (245.5 g/d) was higher than T0 (192.9 g/d) and T60% (199.4 g/d). Lambs of T0 had lower ruminal pH value (6.62) than those of T30% (6.84) and T60% (7.19). The parameter L was higher in T0 (32.7) and T60% (33.3) than T30% (30.5).*

Keywords. *Dry beet Pulpe – Lamb – Fattening – Carcass – Meat.*

I – Introduction

Les systèmes traditionnels d'engraissement des ovins reposent sur l'administration à volonté de la paille des céréales comme aliment grossier et des aliments concentrés constitués essentiellement de céréales riches en amidon. Ce dernier est très rapidement fermenté dans le rumen et lorsqu'il est consommé en grandes quantités, peut provoquer une acidose chez les animaux (Owens *et al*., 1998). Pour remédier à ce problème, le remplacement d'une partie des céréales dans la ration par des aliments riches en fibres soluble, tels que la Pulpe Sèche de Betterave (PSB) peut aider à atténuer le problème de l'acidose et influencer positivement sur le bien-être animal (Fernández, 2007). L'objectif de ce travail était d'étudier l'effet de l'incorporation de la pulpe sèche de betterave à différents niveaux dans la ration pour l'engraissement des agneaux sur les performances de croissance, les caractéristiques de la carcasse et la qualité de la viande.

I – Matériels et méthodes

Trente-six agneaux mâles issus du croisement D'man*Boujaad âgés de 12 à 15 semaines et d'un poids moyen initial de 20,2 ± 1,82 kg ont été utilisés pour mener ce travail. Les animaux ont été distribués à trois lots homogènes de 12 individus chacun. Ils recevaient trois régimes alimentaires (T0% : 0%PSB et 60% orge, T30% : 30% PSB et 30% orge, et T60% : 60% PSB et 0% orge). Dans le premier régime alimentaire, l'orge est utilisée comme l'unique source d'énergie, alors que dans les deux régimes l'orge a été remplacée partiellement ou totalement par la PSB. Les trois régimes alimentaires contenaient 30% de foin de luzerne broyée et 10% de tourteau de tournesol (Tableau1). Les animaux disposaient à volonté de l'eau propre et des blocs à lécher de CMV. La durée d'engraissement était de 68 jours. Au cours de l'essai, les quantités ingerees et les performances de croissance (évolution de poids) ont été contrôlés. A la fin de l'essai, tous les animaux ont été sacrifiés et le poids du rumen plein et vide, le pH ruminal, le rendement carcasse, le dépôt de gras (gras mésentérique et pélvio-rénal) ont été enregistrés. En outre, la couleur de la viande a été évaluée au niveau du muscle *Longissimus dorsi*.

Les données ont été analysées en utilisant l'ANOVA selon le modèle statistique ci-dessous. Le poids initial a été introduit comme covariable.

$$Y_{ij} = \mu + a_i + e_{ij}$$

Y_{ij} = performance de l'animal (i) recevant le régime (j) ; μ = moyenne générale; a_i = effet du régime alimentaire ; e_{ij} = l'erreur résiduelle.

Tableau 1. Composition (%MS) et composition chimique (%) des régimes alimentaires utilisés

	Régimes		
Composition	**T0% de PDB**	**T30%**	**T40%**
Luzerne (%)	30	30	30
Orge (%)	60	30	0
PSB (%)	0	30	60
TTS (%)	10	10	10
Composition chimique			
MS	90,7	91,0	91,3
MO	95,6	95,2	94,9
MM	4,4	4,8	5,1
PB	14,3	13,8	13,4
NDF	46,8	47,9	49,1
ADF	20,9	26,6	32,2
ADL	4,5	5,7	7,0

PSB: pulpe sèche de betterave, TTS: Tourteau de tournesol, MS: Matière sèche, MO: Matière organique, MM: Matière minérale, PB: Protéine brute, NDF: Neutral detergent fibers, ADF: Acid detergent fibers, ADL: Acid detergent lignin.

II – Résultats et discussion

1. Performance de croissance et charge alimentaire

Le tableau 2 présente les résultats obtenus sur les performances de production, les charges alimentaires et le coût de production. Les résultats montre que les animaux du régime T30% ont réalisé les performances de croissance les plus élevées 36,9 kg et 245,5 g/j respectivement pour le poids final et le GMQ, alors que pour les deux autres régimes les performances enregistrées sont de 33,3 et 33,7 kg pour le poids final et 192,9 et 199,4 g/j respectivement pour T0% et T60%. L'analyse de la variance a montré que le remplacement de l'orge par le PSB à raison de 30% a affecté significativement (P< ???) le poids final et le GMQ. Toutefois, Fernández *et al*., (2007) ont rapporté que l'inclusion de la PSB affecte négativement le GMQ, alors que Richardson *et al*., (2003) n'ont signalé aucun effet significatif sur le GMQ suite à l'incorporation de la PSB dans la ration pour engraissement des agneaux.

Pour l'indice de consommation, les animaux du régime T30% ont consommé moins d'aliment soit 4,76 kg MS contre 5,5 et 5,17 kg MS respectivement pour T0% et T60%. Ce résultat peut être explique par le fait que la substitution de l'orge par le PSB augmente la digestibilité de la matière organique (Richardson *et al*., 2003).

Quant aux charge alimentaires, la valeur la plus faible est enregistrée chez T30% soit 16 dh/kg de gain contre 18 et 17,5 dh respectivement chez T0% et T60%. Les résultats montrent que l'introduction de la PSB dans la ration à des niveaux adéquats pour l'engraissement des ovins améliore l'utilisation digestive de la ration.

Tableau 2. Poids initial et final (kg), gain moyen quotidien (g/j) Ingestion (kg MS /tête/j), indice de consommation (IC), coût du régime (dh/kg MS) et la charge alimentaire (dh/kg de gain) (n = 12)

Paramètres	Régime alimentaire			ESM	P
	T0%	T30%	T60%		
Poids initial kg	20,6 ± 1,83	20,44 ± 2,3	19,8 ± 2,57	–	–
Poids final kg	33,3^{b}	36,9^{a}	33,7^{b}	0,80	0,0062
GMQ g/j	192,9^{b}	245,5^{a}	199,4^{b}	11,78	0,0062
Indice de Consommation (kg MS/kg de GMQ)	5,50	4,76	5,17	–	–
Coût régime (dh/kg MS)	3,27	3,35	3,39	–	–
Charge alimentaire (dh/kg gain)	18	16	17,5	–	–

T0% : ration contenant 0% de PSB, T30% : ration contenant 30% de PSB, T60% **:** ration contenant 60% de PSB, ESM : Erreur standard de la moyenne ; ^{a,b,c} Les valeurs de la même ligne ayant la même lettre ne diffèrent pas significativement.

2. Caractéristique de la carcasse et qualité de la viande

Le tableau 3 regroupe les résultats des caractéristiques de la carcasse et du rumen (poids plein et vide, pH). Pour ces dernières, le remplacement de l'orge par le PSB a affecté significativement le poids du rumen vide ; la valeur la plus élevée est enregistrée chez les animaux recevant le régime T30% (0,67 kg). Il a également affecté significativement le pH. Le plus acide est enregistré chez les animaux dont l'orge constitue l'unique source énergétique dans la ration (T0%). Ces résultats peuvent être expliqués par le fait que l'administration de la PSB, aliment riche en acide oxalique dans la ration, conduit à une altération de l'environnement ruminal y compris le microbiote ruminal (Belenguer *et al*., 2013).

Pour les caractéristiques de la carcasse, l'inclusion de la PSB n'a affecté significativement ni le rendement carcasse ni le pH de la viande. Toutefois, la chute de pH après 24 heures de l'abattage était

plus importante chez les animaux dont la ration contenait 30% de la PSB ce qui peut améliorer d'avantage la conservation de la viande. Pour le dépôt de gras (gras mésentérique et gras pévio-rénal), le remplacement de l'orge par le PSB n'a pas affecté ce paramètre. Cependant, les animaux qui ont reçu la PSB comme la seule source d'énergie ont déposé moins de gras. Pour la couleur de la viande, l'introduction de la PSB dans la ration n'a affecté significativement que la clarté (L). La viande provenait des animaux recevaient 30% du PSB dans la ration était un peu plus sombre.

Les résultats obtenus pour les caractéristiques de la carcasse concordent avec ceux rapportés par Richardson *et al*., (2003) et Fernández *et al*., (2007). Ces derniers ont rapporté que l'inclusion de la PSB dans la ration des agneaux n'affecte ni les caractéristiques de la carcasse ni la couleur de la viande.

Tableau 3. Rumen plein et vide (kg), pH ruminal, pH de la viande, dépôt adipeux et couleur de la viande (n =1 2)

Paramètres	Régime alimentaire			ESM	P
	T0%	T30%	T60%		
Rumen plein (kg)	3,11	3,44	3,40	0,158	0,1780
Rumen vide (kg)	0,58^{b}	0,67^{a}	0,58^{b}	0,025	0,0329
pH Ruminal	6,62^{c}	6,84^{b}	7,19^{a}	0,062	<,0001
pH0 (0 heure post-mortem)	6,49	6,58	6,53	0,052	0,4343
pH24 (24 heures post-mortem)	5,93	5,78	5,82	0,051	0,1250
Gras pelvio-rénal	0,31	0,32	0,25	0,030	0,1766
Rendement carcasse froide	48,1	47,9	47,8	0,40	0,8789
Gras mésentérique	0,46	0,56	0,44	0,040	0,0565
L	32,7^{a}	30,5^{b}	33,3^{a}	0,52	0,0015
a	55,9	55,6	56,4	0,37	0,0600
b	26,6	26,1	27,3	0,7	0,4702

T0% : ration contenant 0% de PSB, T30% : ration contenant 30% de PSB, T60% : ration contenant 60% de PSB, ESM : Erreur standard de la moyenne ; ^{a,b,c} Les valeurs de la même ligne ayant la même lettre ne diffèrent pas significativement.

III – Conclusion

L'incorporation de la pupe sèche de betterave jusqu'à un niveau de 30% dans la ration des agneaux d'engraissement a amélioré les performances de production et probablement peut favoriser les conditions de fermentation ruminale sans que les caractéristiques de la carcasse et la couleur de la viande soient affectées. Ces résultats, donc nous permettent de recommander une utilisation de la PSB dans la ration des agneaux d'engraissement à raison de 30% afin d'améliorer les performances de production.

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Effet du niveau d'incorporation d'ensilage de maïs dans l'alimentation des agneaux sur les performances d'engraissement et les caractéristiques de la carcasse

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Résumé. L'ensilage de maïs (EM) est un aliment qui a été réservé exclusivement au départ pour l'alimentation des bovins laitiers durant les périodes où il y a une faible offre en fourrage vert mais suite à la succession des années de sécheresse, les éleveurs ovins se trouvent dans l'obligation d'introduire cette ressource fourragère en alimentation de leurs animaux. L'objectif de ce travail est d'évaluer l'introduction de l'EM à différents niveaux en alimentation des ovins d'engraissement sur les performances d'engraissement, et les caractéristiques de la carcasse. 36 agneaux D'man*Boujaâd, âgés d'environ 4 mois, ont été répartis en quatre lots homogènes qui ont été affectés aléatoirement à quatre régimes alimentaires : T0(0%EM), T1(15%EM), T2(30%EM) et T3(45%EM). Durant la période de l'engraissement (75 jours), nous avons contrôlé quotidiennement l'ingestion. Des pesées ont été effectuées au début et à la fin de l'expérimentation, et tous les 7 jours pour le premier mois et tous les15 jours pour le reste de l'essai. A la fin de l'essai, 7 agneaux de chaque lot, choisis aléatoirement, ont été sacrifiés. Le rendement carcasse, le dépôt adipeux (gras mésentérique et gras de rognon) ont été enregistrés. Le traitement a affecté significativement la croissance des animaux, les GMQ étaient de 217,9, 172,3, 160,2 et 168,2 g/j respectivement pour les régimes T0, T1, T2 et T3. L'indice de consommation et le coût alimentaire ont été significativement affectés par le traitement (P<0,05), étant de 5,72, 6,29, 7,45 et 6,17 kg MS/kg PV pour l'indice de consommation et 17,53, 18,61, 21,30 et 17,02 dhs/kg PV pour le coût alimentaire respectivement pour les régimes T0, T1, T2 et T3. Le rendement de carcasse et le dépôt adipeux n'ont pas été significativement affectés par le traitement (P>0,05).

Mots-clés. Ensilage de maïs – Ovins – Croissance – Coût – Carcasse – Dépôts adipeux.

Effect of increasing level of maize silage in the diet on lambs fattening performance and carcass characteristics

Abstract. *The aim of this study was to determine the effect of increasing levels of Maize silage in fattening diets for lambs their production performance and carcass characteristics. Thirty six Moroccan crossbred lambs of "Dman*Boujaad" (21.9 ± 0.74 kg initial live weight (LW)) were divided into four homogenous groups of nine each. Diets consisted of a control containing no silage T0(EM0%), diets with T1 (EM15%), T2 (EM30%) and T3 (EM45%) maize silage (DM basis) in the ration. During the fattening trial, which lasted for 75 days, the feed intake was determined and lambs were weighed at the beginning and at the end of the trial and fortnightly. At the end of the experiment seven lambs per group were slaughtered to determine carcass dressing percentage and fat deposition (mesenteric and pelvic fat). The level of maize silage in the diet affected significantly the fattening performance, feed conversion ratio and feeding cost (P<0.05). The average daily gain of lambs was 217.9, 172.3, 160.2 and 168.2 g/d respectively, for T0, T1,T2 and T3. The feed conversion ratio (kg DMI/kg LW) was 5.72, 6.29, 7.45 and 6.17 respectively, for EM0%, EM15%, EM30% and EM45%. The feeding cost (Moroccan dirham (Mdh)/ kg LW) was 17.53, 18.61, 21.30 and 17.02 respectively, for T0, T1,T2 and T3. The carcass dressing percentage and fat deposition were not affected by the inclusion of maize silage (P> 0.05). The study showed that the 45% maize silage can be included in the fattening diets of Moroccan crossbred lambs without negatively affecting feeding cost and carcass characteristics.*

Keywords. *Maize silage – Lambs – Fattening performance – Carcass.*

I – Introduction

Les changements climatiques que le Maroc a connus dans les dernières années ont conduit à une hausse du prix des matières premières utilisées en alimentation des ovins et par conséquent à des changements importants dans l'alimentation des troupeaux. Les éleveurs se sont trouvés dans l'obligation d'introduire d'autres ressources fourragères, notamment celles produites localement, pour satisfaire aux besoins de leurs animaux et pour diminuer le coût de production. L'ensilage de maïs est un aliment qui a été réservé exclusivement au départ pour l'alimentation des bovins laitiers durant les périodes où il y a une faible offre en fourrage vert, mais suite à la succession des années de sécheresse, les éleveurs ont d'introduit cette ressource fourragère dans l'alimentation de leurs troupeaux ovins afin de répondre à leurs besoins d'une part et de baisser le coût de production d'autre part. L'objectif de ce travail est d'évaluer l'effet de l'introduction de l'ensilage de maïs sur les performances de croissance, les caractéristiques de la carcasse et la qualité de la viande.

I – Matériels et méthodes

1. Animaux et aliments

Trente-six agneaux, âgés d'environ 4 mois, issus du croisement entre la race Boujâad et la race D'man (deux races marocaines) ont été utilisés pour cet essai d'engraissement qui a duré 75 jours. La répartition des agneaux a été faite sur la base de leur poids de manière à avoir des lots homogènes. Ainsi, quatre lots de neuf agneaux chacun ont été constitués qui sont affectés par la suite d'une manière aléatoire aux 4 régimes alimentaires : T0(0%EM), T1(15%EM), T2(30%EM) et T3(45%EM), avec un pourcentage d'incorporation de l'ensilage de maïs dans la ration de 0%, 15%, 30% et 45% (en matière sèche) respectivement. La composition des régimes alimentaires utilisés est présentée au tableau 1.

Un bloc à lécher de 10 kg a également été mis à la disposition des agneaux de chaque lot.

Tableau 1. Composition des régimes alimentaires (%MS)

Composition	Régime			
	0%EM(%)	15%EM(%)	30%EM(%)	45%EM(%)
EM	0	15	30	45
FLB	28	13	9	9
ORGE	38	38	28	14
MAÏS	9	9	9	9
TTS	25	25	24	24
Composition chimique				
MS	90,4	91,1	91,6	92,0
MO	95,2	95,8	95,7	95,4
MM	4,8	4,2	4,3	4,6
PB	16,5	15,3	14,3	13,8
NDF	45,0	46,2	48,0	50,2
ADF	24,3	22,4	23,4	25,8
ADL	6,0	5,3	5,2	5,4

EM : ensilage de maïs ; FLB : foin de luzerne broyé ; TTS: Tourteau de tournesol, MS: Matière sèche, MO: Matière organique, MM: Matière minérale, PB: Proteine brute, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, ADL: Acid detergent lignin.

2. Contrôles effectués

A. Niveau d'ingestion

Chaque jour, les rations ont été préparées, à l'aide d'une balance électronique. La détermination des quantités ingérées (quantité distribuée – quantité refusée) a été effectuée quotidiennement, à travers la pesée du refus chaque jour au matin afin d'ajuster la quantité à distribuer, en tolérant un niveau de refus de 10%.

B. Evolution de poids

Des pesées ont été effectuées au début et à la fin de l'expérimentation, tous les 7 jours pour le premier mois et tous les15 jours pour le reste de l'essai. Les pesées ont été effectuées le matin avant la distribution des aliments à l'aide d'une balance électronique d'une capacité de 120 kg et une incertitude de 10 g.

C. Mesures à l'abattage

A la fin de l'essai, 7 agneaux de chaque lot ont été choisis aléatoirement et acheminés à la salle d'attente de l'abattoir pour être abattus après une diète hydrique de 18 heures. Avant l'abattage les agneaux ont été pesés. Par la suite, les animaux ont été abattus, dépouillés et éviscérés.

Après avoir enregistré le poids des carcasses chaudes, ces dernières ont été déposées dans la chambre froide à une température de 4°C pendant 24 h, afin de calculer le rendement en carcasse froide. Après 24 h dans la chambre froide, les nous avons mesuré le poids de carcasse froide et le poids dugras mésentérique et du gras pélvio-rénal.

L'analyse des donnés a été faite par analyse de variance (procédure GLM du logiciel SAS (version 9)) en utilisant le modèle statistique ci-dessous :

$$Y_{ij} = \mu + a_i + e_{ij}$$

Avec : Y_{ij} : Performance de l'animal j recevant le régime i ; μ : Moyenne générale ; a_i : Effet du régime alimentaire ; e_{ij} : Erreur standard de la moyenne.

II – Résultats et discussion

1. Evolution des poids et des gains moyens quotidiens des agneaux

Les résultats sont présentés dans le tableau 2. Pour l'évolution de poids vif, les agneaux ayant reçu le régime 0% EM ont atteint le poids le plus élevé à 75 jours (37,6 kg). En effet, nous remarquons que le poids réalisé par les agneaux recevant le régime T1 élevé d'environ un kilogramme de poids vif par rapport aux autres régimes T2 et T3. Il n'y a pas eu d'effet significatif du traitement sur l'évolution du poids vifs des agneaux. Toutefois, nous avons observé une tendance à un effet du traitementpour le poids des agneaux à 30 jours (P = 0,0753) et à 75 jours (P = 0,0729). Cette tendancepeut être expliquée par la qualité de l'ensilage de maïs utilisé dans cette étude, notammentdans la teneur en matière sèche élevée (40% MS), qui a pulimiter la l'ingestion.

Quant aux GMQ, au cours de la période (0-30j), les agneaux ont atteint des GMQ de 265,4, 191,6, 206,9 et 170,8 g/j respectivement pour les régimes T0, T1, T2 et T3. Alors que durant la période (30-75j), les valeurs enregistrées sont de 186,3, 156,5, 144,4 et 166,5 g/j respectivement pour les quatre régimes. En outre, les gains moyens totaux étaient de 217,9, 172,3, 160,2 et 168,2 g/j respectivement pour les régimes T0, T1, T2 et T3 (Tableau 2). Les GMQ sont inférieurs à ceux rapportés par Benbati *et al*. (2014 et 2015) en utilisant les grignons d'olives en engraissement des agneaux.

Keady *et al*. (2013) ont obtenu des gains moyens quotidiens de 111, 123 et 161 g/j avec trois niveaux de concentré 0,2, 0,5 et 0,8 kg/j et un ensilage de 25% de matière sèche distribué ad libitum. Alors qu'ils ont obtenu des gains moyens quotidiens de 72, 112 et 155 g/j avec un ensilage de maïs à 19% MS avec les mêmes niveaux de concentré.

L traitement expérimental a affecté le GMQ au cours des périodes 0-30 jours (P = 0,0036), et 0-75 j (P = 0,0037). Toutefois, il n'y a pas eu d'effet significatif du traitement expérimental au cours de la période 30-75 j avec une diminution des GMQ pour tous les régimes. Cette diminutionpeut être expliquée par a qualité de l'EM qui a baissé l'ingestion journalière des agneaux.

Tableau 2. Evolution du poids vif et des GMQ moyens des agneaux en fonction du régime alimentaire

Paramètres étudiés	Régime alimentaire				SEM	P
	0%EM	15%EM	30%EM	45%EM		
PV initial	22,7	22,0	21,3	21,8	0,81	0,6869
PV à 30 jrs	29,7	27,0	27,1	26,5	0,91	0,0753
PV final	37,6	34,6	33,4	33,5	1,26	0,0729
GMQ						
0-30 j	265,4^{a}	191,6^{b}	206,9^{b}	170,8^{b}	17,30	0,0036
30-75 j	186,3	156,5	144,4	166,5	15,97	0.3226
0-75 j	217,9^{a}	172,3^{b}	160,2^{b}	168,2^{b}	11,15	0,0037

PV : poids vif; EM : Ensilage de maïs GMQ : gain moyen quotidien (gramme/jour); SEM : Erreur standard de la moyenne.

2. Indice de consommation, coût alimentaire, rendement carcasse et poids des dépôts adipeux

Pour l'indice de consommation, les agneaux recevant le régime T3 ont ingéré moins de matière sèche quel lesagneaux des autres lots, cela peut être expliqué par l'effet du facteur limitant qui est l'ensilage de maïs (tableau 3). L'indice de consommation était de 5,72, 6,29, 7,45 et 6,17 kg de matière sèche par kg de poids vif respectivement pour T0, T1, T2 et T3. Il y a eu un effet du traitement experimental sur l'indice de consommation (P = 0,0274) et le coût alimentaire (P = 0,0524).

Alors que, le coût alimentaire pour produire un kilogramme de poids vif était de 17,53, 18,61, 21,30 et 17,02 dhs respectivement pour les régimes 0% EM, 15%EM, 30%EM et 45%EM.

Pour les rendements carcasse, il n'y a pas eu d'effet significatif du traitement expérimental. Quant au dépôts adipeux, il n'y a pas eu d'effet du traitement expérimental sur le poids du gras mésentérique (P = 0,97) et du gras pélvio-rénal (P = 0,99).

Tableau 3. Indice de consommation; coût alimentaire; rendements carcasse chaude et froide; poids de gras mésentérique et gras pélvio-rénal

Paramètres étudiés	Régime alimentaire				SEM	P
	0%EM	15%EM	30%EM	45%EM		
IC (kg MSI/ kg GMQ)	5,72^{b}	6,29^{b}	7,45^{a}	6,17^{b}	0,40	0,0274
CA (dh/kg PV)	17,53^{b}	18,61^{ab}	21,30^{a}	17,02^{b}	1,17	0,0524
RCC (%)	50,6	50,6	50,8	50,4	0,64	0,9760
RCF (%)	49,2	49,3	49,3	49,1	0,70	0,9955
GM (kg)	0,49	0,51	0,46	0,49	0,0797	0,9755
GR (kg)	0,34	0,35	0,29	0,33	0,0514	0,9955

EM : Ensilage de maïs; IC : indice consommation; CA : coût alimentaire; RCC : Rendement en carcasse chaude; RCF : Rendement en carcasse froide; GM : poids de gras mésentérique; GR : poids de gras pélvio-rénal; SEM : Erreur standard de la moyenne; a,b : sur la même ligne, les valeurs portant la même lettre ne diffèrent pas significativement; dh : monnaie nationale (1€ = ± 11.,5 dh).

III – Conclusion

L'incorporation de l'ensilage de maïs dans la ration des agneaux à l'engraissement a affecté négativement les performances de croissance et n'a pas permis de réduire le coût alimentaire. Toutefois, la répétition de cet essai dans d'autres conditions et sur des animaux de différents stades physiologiques est très importante pour confirmer les résultats obtenus et faire sortir des recommandations pratiques sur l'utilisation de l'ensilage de maïs en alimentation des ovins.

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Chemical composition and essential oil antimicrobial activity of four grazed plants growing wild in northeastern Tunisia

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Abstract. The aim of this work was to study the chemical composition and the antibacterial activity of essential oils of *Rosmarinus officinalis; Thymus vulgaris; Myrtus communis; Artemisia herba-alba* from northeastern Tunisia (Zaghouan). Leaves and twigs from these species were collected in spring and the essential oils (EO) were extracted by hydrodistillation and then analysed using GC/MS. The antibacterial activity was studied by diffusion in agar against four strains: *Staphylococcus aureus* ATCC29213; *Staphylococcus aureus* 6816; *Listeria monocytogenes* ATCC19195 and *Escherichia coli* ATCC35218.

Results showed that *Rosmarinus officinalis* EO are characterized by the presence of 1,8-cineole (39.0%) as chemotype. The *Thymus vulgaris* EO are composed mainly of thymol (60.0%). The *Myrtus communis* EO are composed of 29.5% α-Pinene, 20.4% limonene and 11.5% linalool. *Artemisia herba-alba* EO are mainly composed of thujone (42%) and camphor (17.5%).

Rosmarinus officinalis EO did not show any activity at 1/100 dilution. Whereas at this level *Myrtus communis* showed anti-bacterial activity only against *Escherichia coli.* The cited concentration for *Artemisia herba-alba* was sufficient to inhibit the growth of all strains, except *Listeria monocytogenes*. *T. vulgaris* EO showed the highest anti-bacterial effect against all the tested bacteria. This bioactivity is mainly because these EO are rich in thymol, known for its effectiveness against the microbial agents.

It was concluded that the studied species have an important antibacterial activity that can be tested to modulate ruminant fermentation in order to improve the efficiency of digestion and reduce the production of greenhouse gases.

Keywords: Essential oils – *Rosmarinus officinalis – Thymus vulgaris – Myrtus communis – Artemisia herba-alba* – Antimicrobial activity.

Composition chimique et l'activité antibactérienne de l'huile essentielle de quatre plantes sauvages broutées par les ruminants dans le nord-est de la Tunisie

Résumé. *Le but de ce travail était d'étudier la composition chimique et la activité antibactérienne des huiles essentielles de* Rosmarinus officinalis ; Thymus vulgaris ; Myrtus communis ; Artemisia herba-alba *du Nord-Tunisie (Zaghouan). Les feuilles et les brindilles de ces espèces ont été collecté au printemps et HE ont été extraites par hydrodistillation, puis analysées par GC/MS. L'activité antimicrobienne a été réalisée par diffusion dans un milieu gélose contre quatre souches* Staphylococcus aureus *ATCC29213 ;* Staphylococcus aureus *6816 ;* Listeria monocytogene *ATCC19195 and* Echerichia coli *ATCC35218.*

Les résultats ont montré que les huiles essentielles de Rosmarinus officinalis sont caractérisées par la présence de 1,8-cinéol (39,0%) en tant que composants chimiques principaux. Les huiles essentielles de Thymus vulgaris *sont composées principalement de thymol (60,0%). Les huiles essentielles de* Myrtus communis *étaient composées principalement de 29,5% α-pinène, limonène 20,4% et 11,5% linalol alors qu'*Artemisia herba-alba *sont principalement composées de thujone (42%) et le camphre (17,5%).*

Les huiles essentielles de Rosmarinus officinalis *n'a pas montré une activité à la dilution 1 / 100. Par contre, à ce niveau,* Myrtus communis *a une activité antibactérienne seulement contre* Escherichia coli. *Pour* Artemisia herba-alba *la concentration citée était suffisante pour inhiber la croissance de toutes les souches, à l'exception de* Listeria monocytogene. Pour les huiles essentielles de *T. vulgaris*, *elles montré le plus grand effet antibactérien contre toutes les bactéries testées. Cette bioactivité est principalement due à leur richesse en thymol, connu pour son efficacité contre les agents microbiens.*

Il a été conclu que les espèces étudiées ont une activité antibactérienne importante qui peut être testé pour moduler la fermentation des ruminants afin d'améliorer l'efficacité de la digestion et de réduire la production de gaz à effet de serre.

Mots-clés. *Huiles essentielles* – Rosmarinus officinalis – Thymus vulgaris – Myrtus communis – Artemisia herba-alba – *Activité antibactérienne.*

I – Introduction

Since ancient times, the essential oils (EO) obtained from the aromatic species have been used in food, pharmaceuticals and cosmetics thanks to their antimicrobial and antioxidant properties. Many researchers have reported EO as potential alternative antimicrobials (Solórzano-Santos & Miranda-Novales, 2012). These biological activities are directly correlated with the presence of bioactive volatile components (Mahmoud & Croteau, 2002). The aim of this work is to characterize the chemical composition of the essential oils obtained from *Rosmarinus officinalis, Thymus vulgaris, Myrtus communis, Artemisia herba-alba* and to study their antimicrobial activity against 4 strains: *Staphylococcus aureus* ATCC29213; *Staphylococcus aureus* 6816; *Listeria monocytogenes* ATCC19195 and *Escherichia coli* ATCC35218.

II – Material and methods

1. Plant material

For the studied plants: *Rosmarinus officinalis; Thymus vulgaris; Myrtus communis; Artemisia herba-alba,* leaves and thin twigs (less than 4 mm in diameter) were collected from the region of Zaghouan (North of Tunisia, semi-arid) in spring 2011. The plant material was left to dry at ambient temperature for 7 days before extracting EO.

2. Essential oil extraction

Extraction of the essential oils was carried out by hydrodistillation. For each plant, three distillations were carried out by boiling 1 kg of dried plant material for 1 hour. The EO were stored at 0° C in the dark before conducting the analyses.

3. Chromatography analysis

The GC/MS analysis was performed on an HP 7890 mass spectrometer (Agilent technologies, Palo Alto, California, USA), using an HP-5MS capillary column (30 m, 0.25 mm coated with 5% phenyl methyl silox, 0.25 lm film thickness). Oven temperature was programmed to rise from 50 to 240 °C at a rate of 5 °C/min. The carrier gas was He with a flow rate of 1.2 ml/min and a split ratio of 60:1. The volatile components were identified by comparing their retention indices (RI) relative to (C8-C22) n-alkanes with those of the literature or with those of compounds available in the authors' laboratory. In addition, their

recorded mass spectra was matched with those stored in the Wiley/NBS mass spectral library of the GC/MS data system and other published mass spectra (Adams, 2001). The percentage composition was determined by peak area normalization. Analyses were performed in triplicate.

4. Microbiological procedure

For the studied species, the EO, which are non-miscible with water, were emulsified in a 0.2% agar solution (Remmal *et al*., 1993, Satrani *et al*., 2001) in order to obtain a homogeneous distribution of the EO in the medium and maximize the microbe / EO contact. 13.5 mL of sterilized autoclaved TSA (Tryptic Soy Agar) medium was placed in test tubes and heated for 12 min at 121°C then cooled to 45°C, when 1.5 mL of Agar solution diluted to the final concentrations: 1/100, 1/250, 1/500, 1/1000, 1/2000, 1/3000 and 1/5000 (v / v) was added aseptically. After stirring, the solution was inoculated using a calibrated platinum loop to ensure the same volume of inoculum at 37°C for 24 h. Analyses were performed in triplicate.

III – Results and discussion

1. Chemical composition of essential oils

The ten most abundant EO compounds and their classification are listed in Table 1. For rosemary, the main compound was 1,8-cineole: 39%. Several other studies have mentioned 1,8-cineole as chemotype (Celiktas *et al*., 2007, Wang *et al*., 2008). Hussain *et al*. (2010) reported very similar values of major compounds with an increase in camphor depending on borneol. Moreover, variation in the chemical composition of rosemary EO (3 rosemary chemotypes) has been reported according to the geographical origin (Lahlou and Barrada, 2003, Zaouali *et al*., 2013). The 1,8-cineole rosemary contains more than 40% of this chemotype, characteristic of Tunisia, Morocco, Italy, France, Turkey, Greece and Yugoslavia (Pintore *et al*., 2002). Rosemary with camphor-borneol chemotype is characteristic of Spain and the α-Pinene-verbenone rosemary is characteristic of Algeria and Corsica (Guazzi *et al*., 2001).

As for *thymus vulgaris*, we mentioned a thymol chemotype (60%) with the presence of β-cymene (7.6%) and γ-terpinene (7.6%). Several thyme chemotypes have been mentioned. In several cases, the reported chemotype is thymol with major anti-infectious properties (Ivanovic *et al*., 2011, Stojkovic *et al*., 2013, Nikolic *et al*., 2014). However, other chemotypes are also cited. Carvacrol *Thymus vulgaris* (Imelouane *et al*., 2006), linalool *thymus vulgaris* (Jukic *et al*., 2003), α-terpineol *thymus vulgaris* (Imelouane *et al*., 2006) and o-cymene and β-cymene *Thymus vulgaris (*Klaric *et al*., 2007, Guerra-Boone *et al*., 2015).

Concerning *Artemisia herba-alba*, thujones, which gives the specific odour and taste to white sagebrush (Mohsen *et al*., 2009), are present at 42% (30.1% β-thujone and 11.9% α-thujone). For sagebrush grown in southern Tunisia, Mghiri *et al*. (2010) identified 4 chemotypes of EO: β-thuyone (58%); α-thuyone: 49.3%; α-thujone (24.1%) and β-thujone (24.3%) and 1,8-cineole (18.4%), β-thujone (14.1%), camphor (8%) and α-thujone (10.7%).

For *Myrtus communis*, we mentioned the α-pinene chemotype (29.5%) with high amounts of limonene (20.4%); linalool (11.5%) and linalyl acetate (10.0%). The most reported Tunisian myrtle chemotype is α-pinene. According to Aidi-Wannes *et al*. (2010), the α-pinene content during the vegetative cycle of *Myrtus communis* ranges from 28.3 to 58%. The other major compounds are 1,8-cineol (12.7-30.7%), linalool (2.4-21.5%) and limonene (0.1-13.3%).

Table 1. The EO main compounds

Rosmarinus officinalis	*Thymus vulgaris*	*Myrtus communis*	*Artemisia herba-alba*
α-pinene: 39.0%	thymol: 60%	α-pinene: 29.5%	α-thujone: 30.1%
borneol: 9.8%	β-cymene: 7.6%	limonene: 20.4%	camphor: 17.5%
α-pinene: 9.0%	γ-terpinene: 7.6%	linalool: 11.5%	α-thujone: 11.9%
camphor: 8.4%	β-caryophyllene:2.8%	linalyl acetate: 10.0%	1,8 cineol:7.6%
β -pinene: 7.7%	β-linalool: 2.7%	geranyl acetate: 5.6%	chrysanthenone: 5.3%
camphene: 4.2%	α-terpinene: 2.1%	1,8 cineol: 2.3%	camphene: 4.9%
borneol acetate: 3.5%	β-cymene: 1.8%	p-cymene: 1.4%	endo-borneol: 3.9%
α-terpineol: 3.4%	α-thujone : 1.8%	α-humulene1.4%	sabinyl acetate: 1.5%
β-caryophyllene: 2.0%	α-pinene: 1.7%	α-terpineol: 1.3%	α-pinene:1.1%
β-cymene: 1.7%	α-silinene : 1.5%	neryl acetate: 1.1%	γ-terpinene:1.1%

2. Antimicrobial activity of essential oils

Table 2 presents the essential oil antibacterial activity of *Rosmarinus officinalis; Thymus vulgaris; Myrtus communis* and *Artemisia herba-alba. Thymus vulgaris* (thymol: 60%) exerted the strongest activity against the tested strains. A concentration level of 1/2000 was sufficient to inhibit all strains. Other reports mentioned the strong activity of thymol against *Escherichia coli* O157:H7 (Friedman *et al*., 2002; Mathela *et al*., 2010, Abu-Darwish *et al*., 2012), *Listeria monocytogenes* (Friedman *et al*., 2002, Al-Mariri *et al*., 2013, Mith *et al*. 2014) and *Staphylococcus aureus* (Rota *et al*. 2007, Palaniappan & Holley, 2010). EO from *Artemisia herba-alba* (thujone: 42%) showed moderate activity. At 1/100 concentration, only *Listeria monocytogenes* was sensitive to *Artemisia herba-alba* derived EO and was inhibited at 1/250. Similar results were obtained by Mghiri *et al*., (2010) for *Staphylococcus aureus* ATCC 25923, and *Escherichia coli* ATCC 35218.2010. EO from *Rosmarinus officinalis* (1.8-cineol: 39%) and *M. communis*, showed the weakest activity. At 1/100 level, all strains were inhibited except *Escherichia coli* which was inhibited at 1/250 by *M. communis* EO. Similar results were obtained for *Thymus algeriensis* whose main EO compounds are α-pinene (20,5%), β-pinene (8,02%) and limonene (4,85%) reported for their weak activity (Chalchat *et al*., 2000).

Table 2. EO antibacterial activity

	Dilution				Dilution				Dilution	Dilution	Dilution	Dilution	Dilution
	1/100	1/100	1/100	1/100	1/250	1/250	1/250	1/250	1/500	1/1000	1/2000	1/3000	1/5000
	RO	TV	MC	AHA	RO	TV	MC	AHA	TV	TV	TV	TV	TV
Staphylococcus aureus ATCC29213	+	–	+	–	+	–	+	+	–	–	–	+	+
Staphylococcus aureus 6816	+	–	+	–	+	–	+	+	–	–	–	+	+
Listeria monocytogenes ATCC19195	+	–	+	+	+	–	+	+	–	–	–	+	+
Escherichia coli ATCC35218	+	–	–	–	+	–	+	+	–	–	–	+	+

RO: Rosmarinus officinalis; TV: Thymus vulgaris; MC: Myrtus communis; AHA: Artemisia herba-alba. – : inhibition, + : development.

IV – Conclusion

The EO chemotypes were 1,8-cineol (39,0%), thymol (60,0%), α-pinene (29,5%) and thujone (42%) for rosemary, thyme, myrtle and sagebrush, respectively. In addition, *T. vulgaris* EO showed the highest anti-bacterial effect against all the tested bacteria. This bioactivity is mainly because these EOs are rich in thymol, known for its effectiveness against microbial agents. *Artemisia herba-alba* has shown a moderate activity, whereas *Rosmarinus officinalis* and *Myrtus communis* EO has shown the weakest activity against the tested strains. It was concluded that the studied species have antibacterial activity that can be tested to modulate the ruminant fermentation in order to improve the efficiency of digestion and reduce the production of greenhouse gases.

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Potential of essential oils from natural populations of *Pistacia lentiscus t*o modify *in vitro* ruminal fermentation in sheep

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Abstract. In order to evaluate the effect of *Pistacia lentiscus* essential oils (EOs) on *in vitro* rumen fermentation in sheep, leaves and twigs were collected from the Eastern Region of Tunisia (Zaghouan) in spring. The EOs were extracted by hydrodistillation and analyzed using GC/MS. Increasing doses of EOs (0 ; 5 ; 10 ; 20 ; 40 ; 80 ; 120 µL/0.5 g DM of substrate) were tested with a ration composed of ray-grass hay and concentrate (50:50 on DM basis) in inoculum according to the technique of Menke and Steingass (1988). Rumen liquor was sampled from three adult Barbarine sheep (Averaged age and body weight: 18 months and 38 kg, respectively) receiving a ration composed of 70% of oat hay and 30% of commercial concentrate. For each dose of EOs, three syringes were reserved to determine true organic matter degradability (TOMD) and two syringes were incubated for subsequent ammonia-N (NH_3-N) analyses. Short chain fatty acid (SC-FA) concentration and partitioning factor (PF) were calculated. Results showed that *Pistacia lentiscus* EOs were composed of monoterpene Hydrocarbons (73%), associated to 16.7 % of α-pinene; 15.9% of sabinene; 12% of cis-ocimène and 11.6% of ϒ-terpinene. After 24 h of fermentation, gas production (GP) decreased (P<0.001) with the increase of EOs doses (i.e. 70.6, 82.9, 51.5 and 46.1 mL/0.5 DM, respectively for doses 20, 40, 80 and 120 µL). The same trend (P<0.0001) was observed for the estimated SC-FA concentrations. Ammonia-N concentration increased (P<0.0001) at 20 µL and reached 151.7 mg/L, and then decreased to 97.2 mg/L at 120 µL of EOs. Concerning TOMD, a trend of decrease (P < 0.0001) was noted when adding EOs and the lowest value was observed at 5 µL of EO. PF values are quite among doses 5,10 and 20 µL (averaged: 3.2), it increased significantly for 40, 80, 120 µL (4.9, 8.5, 10.9 mg/mL respectively). It was concluded that *Pistacia lentiscus* EOs could be envisaged as a potential additive to manipulate rumen fermentation in the optic of improving feed feeding efficiency in ruminant.

Keywords. Essential oil – *Pistacia lentiscus* – *In vitro* Fermentation – Sheep.

Potentiel des huiles essentielles de populations naturelles de* Pistacia lentiscus *pour modifier la fermentation ruminal* in vitro *chez le mouton

Résumé. *Afin d'évaluer l'effet des huiles essentielles de* Pistacia lentiscus *(HE) sur la fermentation ruminale* in vitro *chez les moutons, des feuilles et des brindilles de la plante ont été collectées dans la région de Zaghouan (Nord de la Tunisie, semi-aride) au printemps. Les HE ont été extraites par hydrodistillation et analysées à l'aide de GC / MS. Des doses croissantes d'HE (0; 5; 10; 20; 40; 80; 120 µL / 0,5 g de substrat) ont été testées avec une ration composée de foin de ray-grass et de concentré (50:50% sur la base de MS) dans l'inoculum selon la technique de Menke et Steingass (1988). Le jus rumen a été échantillonné à partir de 3 béliers de race Barbarine (Age moyen et poids vif, respectivement, 18 mois et 38 kg) recevant une ration composée de 70 foin d'avoine et 30% de concentré commercial. Pour chaque dose d'HE, 3 seringues ont été réservées pour déterminer la dégradation vraie de la matière organique (TOMD) et 2 seringues ont été réservées pour analyser l'ammoniac (NH_3-N). La concentration en acides gras à chaîne courte (SC-FA) et le facteur de partage (PF) ont été calculés. Les résultats ont montré que les HE de Pistacia lentiscus étaient principalement composés d'hydrocarbure monoterpène (73%), associé à 16,7% d'α-pinène ; 15,9% de sabinène ; 12% de cis-ocimène et 11,6% d'Y-terpinène. Après 24 h de fermentation, la production de gaz (GP) a diminué (P<0,0001) de 20 à 120 µL de doses (c.-à-d. 70,6, 82,9, 51,5 et 46,1 ml, avec les doses, respectivement, 20, 40, 80 et 120 µL). La même tendance (P <0,001) a été observée pour les concentrations de SC-FA calculées. La concentration d'ammoniac a augmenté de manière significative (P <0,0001) à 20 µL et a atteint 151,7 mg / L, puis a*

atteint 97,2 mg / L avec la dose 120 µL d'HE. Une diminution (P <0,0001) du TOMD a été notée après ajout d'HE sachant que la valeur la plus basse a été observée avec la dose 5 µL d'HE. Les valeurs des facteurs de fractionnement sont presque similaires pour les doses 5,10 et 20 µL (moyenne: 3.2). Le PF a augmenté de manière significative avec les doses 40, 80, 120 µL (4.9, 8.5, 10.9 mg / mL respectivement). On a conclu que l'HE de Pistacia lentiscus *pourrait être envisagé comme un additif potentiel pour manipuler la fermentation au niveau du rumen dans l'optique d'améliorer l'efficacité de l'alimentation animale chez les ruminants.*

Mots-clés. *Huile essentielle* – Pistacia lentiscus – *Fermentation* in vitro – *Mouton.*

I – Introduction

Recently, an increasing concern about synthetic antioxidants safety and efficacy has generated interest in the more efficient use of sources of natural antioxidants and biologically active compounds. The essential oils (EOs) extracted from aromatic and medicinal plants has attracted a great deal of researchers' interest due to their natural antioxidants and biologically active compounds explored in food, pharmaceutical and cosmetic (Hammer *et al*., 1999; Burt, 2004; Bakkali *et al*., 2008; Calo *et al*., 2015). In this context, many EOs have been tested as natural antibiotics growth promoters that can upgrade animal performance without emergence of antimicrobial resistance in humans (Newbold *et al*., 2004; Calsamiglia *et al*., 2007; Patra *et al*., 2014; Roy *et al*., 2014). However, there is only a small number of reports available in the literature, studying the *Pistacia lentiscus* L. effect on rumen fermentation, digestion and products quality.

Pistacia lentiscus L., from the Anacardiaceae family, is a Mediterranean dense bush with a strong characteristic aroma and green leaves (Zrira *et al*., 2003). Since antiquity, its aerial part has been used in the treatment of hypertension and possesses stimulant and diuretic properties (Bentley and Trimen, 1980 in Gardeli *et al*. 2008). This woody species is used browsed by sheep and goats as source of forage. Even though, the effects of the EOs on digestion and production performance of ruminants is not well documented. Therefore, the aim of the current study was to evaluate the effect of increasing doses of *Pistacia lentiscus* EO, on in vitro fermentation parameters in sheep.

II – Material and methods

1. Plant material and essential oils extraction

Pistacia lentiscus leaves and thin twigs (of less than 4 mm of diameter) were collected in spring 2011 from a bushland located in the region of Zaghouan (North of Tunisia, semi-arid). After air-drying of this plant material for 7 days, the EOs were extracted by hydro-distillation. The extracted amount of EOs was stored at until analyzed and used in the vitro trial.

2. Diets and animals

A simulated diet was composed of 50% of ray-grass hay and 50% of commercial ovine concentrate on dry matter (DM) basis, ground and mixed through a 1 mm screen. The chemical composition of diet's ingredients is presented in Table 1.

For the *in vitro* fermentation trial, we used two rumen-cannulated Barbarine rams (averaged age and body weight: 32 months and 45 kg). They were housed in individual pens and received twice per day 70 g $kg^{-1}BW^{0.75}$ of a diet composed of 70% oat-vetch hay and 30% barley grains on dry matter (DM) basis.

Table 1. Chemical composition of feeds (%DM)

	DM (%)	Ash	CP	NDF	ADF	ADL
Pistacia lentiscus leaves and twigs	92.1	2.9	9.02	43.5	32.1	9.6
Concentrate	94.1	6.6	16.1	30.8	6.2	5.1
Ray-grass hay	81.6	12.5	11.3	62.7	34.1	7.2

3. Measurements and calculations

The GC/MS identification of the EOs profile was made by corresponding their recorded mass spectra with those stored in the Wiley/NBS mass spectral library of the GC/MS data system in addition to other published mass spectra (Adams, 2004). The percentage composition was determined depending on peak area normalization without using correction factors.

We investigated the increasing doses of identified Pistacia EOs (0, 5, 10, 20, 40, 80 and 120 µL) on fermentation parameters. The *in vitro* gas production was measured on three 100 ml-glass syringes in two incubation runs as described by Menke and Steingass (1988). For each syringe containing 0.5 g of the simulated diet, we added to the corresponding dose of EOs and the ruminal liquid and buffer solution (1:1) and then we incubated them at 39°C. Gas production was measured after 2, 4, 6, 8, 10, 12 and 24 h of incubation.

Gas production was determinated by using the non-linear model of France et *al*. (2000):

$GP = b*(1- e^{-k(t-L)})$ where: GP = Gas production at time t (ml), b = asymptotic gas production (ml), k = fractional fermentation rate (h^{-1}) and L = lag time (h).

The concentration of short chain fatty acids was estimated as described by Getachew et *al*. (2000) on the basis of the gas production at 24 h incubation:

SCFA (mM/syringe) = 0.0239 GP – 0.0601

At the end of the incubation, the pH fluid samples was measured and the liquid was used to determine the truly organic matter degradation (TOMD) and to calculate the partitioning factor (PF) as described by Blümmel et *al*. (1997):

PF (mg/ml) = TOMD (mg) /gas volume produced at 24 h (mL).

4. Chemical analysis

Samples of the extracted EOs were injected in the GC/MS (HP-5MS capillary column) for the determination of their profile. Oven temperature was programmed to rise from 50 to 240 °C at a rate of 5°C/minutes. The used carrier gas was He with a flow rate of 1.2 mL/minutes and a split ratio of 60:1. The experimental feeds were analyzed for their contents in dry matter (DM), ash and crude protein (CP) contents (AOAC, 1984). Cell wall fractions (NDF, ADF and ADL) were analyzed as described by Van Soest et *al.* (1991).

5. Statistical analysis

The data was analysed by The General Linear Model procedure (GLM) of SAS (2009) with the option of LS MEANS multiple ranges. This model has included the effects of dose, incubation and interaction.

III – Results and discussion

1. Essential oils composition

The ten most abundant Pistacia EOs compounds and their classification are listed in Table 2. They represent 84.41% of EOs composition.

Table 2. Main compounds of *Pistacia lentiscus*

Compounds	Chemical classification	%
α-pinene	Monoterpene hydrocarbons	16,7
sabinene	Monoterpene hydrocarbons	15,9
cis-ocimene	Monoterpene hydrocarbons	11,9
ϒ-terpinene	Monoterpene hydrocarbons	11,6
germacrene D	Sesquiterpene hydrocarbons	6,1
α-phellandrene	Monoterpene hydrocarbons	4,6
α-terpinene	Monoterpene hydrocarbons	3,8
δ-cadinene	Sesquiterpene hydrocarbons	3,8
β-caryophyllene	Sesquiterpene hydrocarbons	3,5
α-terpinolene	Monoterpene hydrocarbons	1,9

In total, Pistacia EOs presented 68 identified compounds characterised by a high amount of monoterpene hydrocarbons (73%). The most presented compounds are l'α-pinene (16.7 %); sabinene (15.9 %), cis-ocimene (12 %), ϒ-terpinene (11.6%).

As it was reported by several authors, (Douissa *et al*., 2005, Barra *et al*., 2007, Gardeli *et al*., 2008), we found that the chemotype in *Pistacia lentiscus*, is α-pinene (16.7 %). However, other results reported that the highest compounds are limonene in Italy (Castola *et al*., 2000) and limonene, α-terpineol, β–caryophyllene and β-myrcene in Morocco (Zrira *et al*., 2003; Said *et al*., 2011).

2. Rumen fermentation parameters

Data reflecting the effect of increasing levels of *Pistacia lentiscus* EOs on gas production parameters are reported in Table 3. After 24 h of fermentation, results showed that GP did not change ($P<0.001$) for 5 and 10 μL doses. Doses of 20 μL and beyond had decreasing GP (70.6, 62.9, 51.5 and 46.1, respectively for doses 20, 40, 80 and 120 μL).

To the best of our knowledge, this is the first work that investigated Pistacia EOs effect on fermentation parameters. However, a study conducted on *Myrtus communis* for which chemotype is also α-pinene (29%) showed that GP decreased ($P<0.0001$) from 10 to 120 μL doses (i.e. 93.4, 84.3, 70.3, 35.3 and 25.3 ml, respectively for 10, 20, 40, 80 and 120 μL) (Bettaieb *et al*., 2016). This GP decrease can be explained by the antibacterial effect of EOs against rumen bacteria (Kim et *al.,* 1995).

Our study showed that the final pH value was higher than the blank (i.e. incubated inoculum without substrate) for all doses of Pistacia EOs. It was maximum at 40 μL (6.57) and similar at 5, 10, 20, 40, 80, and 120 μL (averaged: 6.49) ($P<0.0001$). The increase in final pH was associated with a significant reduction in SCFA production, due to a decrease of diet fermentation (Castillejos et *al*., 2006).

The concentration of SC-FA was not affected with EOs doses of 5 and 10 μL (averaged:41.4 mg/L) but decreased with the other levels: 20, 40, 80, and 120 μL (35.3, 21.4, 12.3 and 4.6 mg/L respectively). The same trend was observed by Moujahed et *al.* (2013) for *Rosmarinus officinalis* EOs. Ammonia-N concentration increased ($P<0.0001$) with the administration of 20, 40, 80, and 120 μL (151.7, 135.2, 115.6 and 97.2 mg/L respectively). Ammonia N reduction (from 30 to 50%) was observed by Busquet *et al*. (2006) for carvacrol, carvone, eugenol, oregano, and cinnamon EOs.

Table 3. Effects of increasing doses of *Pistacia lentiscus* EOs on the *in vitro* rumen fermentation parameters

Dose (µL/50 mL)	0	5	10	20	40	80	120	SEM
GP 24 (mL/0.5 mg DM) ***	96.4^{a}	96.1^{a}	91.6^{a}	70.6^{b}	62.9^{c}	51.5^{d}	46.1^{e}	16.55
pH ****	6.20^{b}	6.49^{ab}	6.48^{ab}	6.45^{ab}	6.57^{a}	6.54^{ab}	6.48^{ab}	0.110
SC-FA (mg/L) ****	41.1^{a}	41.6^{a}	41.3^{a}	35.3^{b}	21.4^{c}	12.3^{d}	4.6^{e}	0.55
N-NH_3 (mg/L) ****	179.2^{a}	171.8^{a}	169.3^{a}	151.7^{b}	135.2^{c}	115.6^{d}	97.2^{e}	1.79

a, b, c, d, e Values with different letters in the same line are statistically different, *** P<0.001, **** P<0.0001, SEM: Standard error of the mean.

4. Microbial activity

The effects of Pistacia EOs on TDOM and PF is shown in Table 4. At low doses (0, 10 and 20 µL), the TDOM did not change (averaged 60.4%). Higher doses of EOs (40, 80 and 120 µL) decreased (P<0.0001) TDOM by 49.8, 46.0, and 44.0 % respectively. Other results on the EOs of *Eucalyptus camaldelensis* reported a decrease of TOMD with the increasing doses of EOs (from 25 to 125 µL of EOs). This decrease was not significant (Sallam et *al*. 2009)..

The partitioning factor (PF), which represent the fermentation of nutrients into gas, SCFA and microbial mass, had substantially changed with the increasing levels of EOs. Almost constant for 5,10 and 20 µL (averaged: 3.2), it increased significantly for 40, 80, 120 µL (4.9, 8.5, 10.9 mg/mL respectively).

Table 4. Effects of increasing doses of EOs from *Pistacia lentiscus* on TDOM and PF

Dose (µL/50 mL)	0	5	10	20	40	80	120	SEM
TDOM (%) ****	60.1^{a}	61.4^{a}	59.5^{a}	55.0^{b}	49.8^{c}	46.0^{c}	44.0^{d}	0.008
PF (mg/mL) **	2.7^{d}	3.2^{d}	3.0^{d}	3.4^{d}	4.9^{c}	8.5^{b}	10.9^{a}	0.444

a, b, c, d values with different letters in the same line are statistically different, **** P<0.0001, ** P <0.01, SEM: Standard error of the mean.

IV – Conclusion

Our results showed that the administration of increasing doses of Pistacia EOs resulted in a significant decrease in gas production and short chain fatty acid during the in vitro fermentation. In addition, we found that for high doses of Pistacia EOs, the partitioning factor was improved. It was concluded that the Pistacia EOs could be considered as a potential modulator of rumen fermentation and feed efficiency in ruminants. In vivo studies should be emphasized to study the response of sheep to Pistacia EOs.

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In vitro fermentation of diets including agroindustrial by-products in batch cultures of ruminal microorganisms from goats

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Abstract. In the last years, there has been an increasing interest in the use of alternative feeds, such as agroindustrial by-products, in ruminants feeding. The aim of the present work was to study the effects of including variable amounts of different by-products (tomato fruits, citrus pulp, brewer´s grains and brewer´s yeast), previously processed and dried, in the concentrate of dairy goats on *in vitro* ruminal fermentation. Six concentrates were formulated and mixed with alfalfa hay in 1:1 proportion before being fermented *in vitro* using batch cultures of mixed rumen microorganisms from goats. The kinetics of gas production was evaluated in 72-h incubations and the fermentation variables were determined after 24 h incubation. Gas production data were adjusted to the exponential model $y = A [1 – e^{(-c•t)}]$. There were no differences among diets either on pH (P = 0.091) or molar proportions (P = 0.613 to 0.999) of individual volatile fatty acids (VFA), but total VFA production was greater (P < 0.005) and the amount of CH_4 was lower (P < 0.001) in five of the diets including by-products compared with the control diet. The inclusion of by-products resulted in greater values of gas production and gas production rate (P < 0.004 and 0.001, respectively) in four of the diets. The results of this study indicate that by-products from tomato and citrus juice and beer industry could be included in ruminant's diets, promoting better ruminal fermentation pattern and reducing the environmental impact of animal production. The potential of agro-industrial by-products to substitute conventional ingredients in small ruminant diets should be further investigated.

Keywords. Batch Cultures – Concentrate – By-products – Methane Production – Ruminal Fermentation.

Fermentation* in vitro *de régimes comprenant des sous-produits agroindustriels dans des cultures de microorganismes du rumen de chèvres

Résumé *- Au cours des dernières années on a constaté intérêt croissant pour l'utilisation d'aliments alternatifs tels que les sous-produits agro-industriels, dans l'alimentation des ruminants. Le but du présent travail était d'étudier les effets de l'inclusion d'un mélange de sous-produits (fruits de tomate, pulpe d'agrumes, grains et levure de bière), préalablement transformés et séchés dans des fours solaires à convection, dans le concentré des chèvres laitières sur la fermentation ruminale* in vitro. *Six concentrés ont été formulés et mélangés avec du foin de luzerne en proportion 1: 1 avant d'être fermentés in vitro en utilisant des cultures de micro-organismes provenant du rumen de chèvres. La cinétique de la production de gaz a été évaluée sur la base d'incubations de 72 heures et les variables de fermentation ont été déterminées après 24 h d'incubation. Les données de production de gaz ont été ajustées au modèle exponentiel suivant: $y = A [1 – e^{(-c • t)}]$. Il n'y avait pas de différence entre les régimes ni sur le pH (P = 0.091) ni sur les proportions molaires (P = 0,613 - 0,999) des acides gras volatils individuels (VFA), mais la production totale d'acides gras voltails (AGV) était plus élevée (P < 0,005) et la quantité de CH_4 était plus faible (P < 0,001) dans cinq des régimes incluant les sous-produits par rapport au régime témoin. L'inclusion de sous-produits a entraîné des valeurs plus élevées de la production de gaz (P = 0,004) et des taux de production de gaz (P = 0,001) dans quatre des régimes alimentaires. Les résultats de cette étude indiquent que les sous-produits de l'industrie de la tomate, du jus d'agrumes et de la bière pourraient être inclus dans les régimes alimentaires des ruminants, en ameliorant la fermentation du rumen et en reduisant l'impact environnemental de la production animale. Le potentiel des sous-produits agro-industriels de substituer les ingrédients classiques dans les régimes de petits ruminants devrait être étudié plus en profondeur.*

Mots-clés. *Cultures de Micororganismes Ruminales – Concentré – Sous-produits – Production de Méthane – Fermentation Ruminale.*

I – Introduction

Goat production systems are increasingly changing to intensive models, in which feeding is based on concentrates mainly composed of cereals and other expensive ingredients. The use of agroindustrial by-products in goats feeding could reduce production cost (Ben-Salem and Znaidi, 2008) without altering yield and animal products quality, and some by-products may decrease methane emissions (Molina-Alcaide *et al*., 2010; Romero-Huelva *et al*., 2012). However, a wide range of by-products is available and nutritive evaluation is necessary prior to their use in goats feeding. The aim of the present work was to study the effects of including variable amounts of different by-products (tomato fruits, citrus pulp, brewer´s grain and brewer´s yeast) in the concentrate of diets formulated for dairy goats on their *in vitro* ruminal fermentation.

II – Materials and methods

1. By-products, experimental diets and animals

All by-products were provided by the company Aspero S.A. (Sevilla, Spain). Tomato fruits were cut and dried at 65ºC in a convection oven under controlled conditions. The other by-products were citrus pulp, brewer´s grain and brewer´s yeast and were also dried at 65ºC. Seven experimental diets were formulated based on alfalfa hay and concentrate in a 50:50 ratio. The control concentrate was a commercial one and was composed of corn, wheat bran, sunflower meal, soya hulls, sorghum, soya meal, wheat, calcium carbonate, sugar beet molasses, sepiolite, palm soap, sodium chloride and vitamin-mineral mixture in proportions of 250, 210, 120, 100, 100, 108, 52, 10, 10, 10, 12, 6 and 12 g per kg of concentrate (fresh matter basis). Six experimental concentrates were formulated by replacing 62.5 g of corn with 62.5 g of tomato fruits (T1); 94 g of corn with 94 g of tomato fruits (T2), 125 g of corn with 125 g of tomato fruits (T3); 125 g of corn, 25 g of wheat bran and 25 g of sunflower meal with 125 g of tomato fruits and 50 g of citrus pulp (T3C); 125 g of corn, 25 g of wheat bran and 60 g of sunflower meal with 125 g of tomato fruits, 50 g citrus pulp and 35 g of brewer's grains (T3CB); 125 g of corn, 25 g of wheat bran, 60 g of sunflower meal and 25 g of soya flour with 125 g of tomato fruits, 50 g of citrus pulp, 35 g of brewer's grains and 25 g of brewer's yeast (T3CBY). Chemical composition of experimental diets is given in Table 1. Diets ingredients (alfalfa hay and concentrates) were ground (1 mm) before incubation in batch cultures.

Table 1. Chemical composition (g/kg dry matter, unless other stated) and estimated price (€/ton) of the experimental diets

	Diets						
	Control	**T1**	**T2**	**T3**	**T3C**	**T3CB**	**T3CBY**
Dry matter, g/kg fresh	925	913	912	908	914	903	911
Organic matter	860	835	835	831	836	822	839
Crude protein	176	174	181	174	163	180	168
Neutral detergent fibre	404	422	426	423	410	394	416
Acid detergent fibre	252	254	262	263	262	251	260
Acid detergent lignin	46.9	49.6	50.2	50.8	48.0	47.5	47.7
Ether extract	23.2	23.6	23.4	23.1	23.2	25.9	26.0
Gross energy, MJ/kg dry matter	154	154	154	153	152	153	156
Price, €/ton	219	211	208	204	199	198	194

Three adult dry non-pregnant rumen-fistulated Murciano-Granadina goats fed alfalfa hay at maintenance energy requirements were used as rumen contents' donors for the *in vitro* incubations. An-

imals were cared and handled in accordance with the Spanish guidelines for experimental animal protection (Royal Decree 53/2013) in line with the European Convention for the Protection of Vertebrates used for Experimental and other Scientific Purposes (2012/707/UE). All procedures were approved by the Ethic Committee for Animal Experimentation of the Spanish Research Council and the Junta de Andalucía (approval numbers 24/05/2016/091 and 22/06/2016/115, respectively).

2. *In vitro* incubations

Three 72-h *in vitro* incubation runs were conducted, and four bottles per diet and four blanks (bottles without substrate) were used in each run. Rumen contents were collected from the three goats before the morning feeding, pooled and immediately taken to the laboratory into thermal flasks. Rumen contents were strained through four layers of cheesecloth and mixed with a buffer solution (Goering and van Soest, 1970) in a 1:4 ratio (vol / vol) at 39°C under continuous flushing with CO_2. Samples (0.5 g) of each substrate were carefully weighed into 120-ml bottles, and 60 ml of the buffered rumen fluid were anaerobically added into each bottle. Bottles were then capped and incubated at 39º C. In two of the four bottles for each diet and two blanks, pressure and gas volume were measured at 2, 4, 6, 8, 12, 24, 48 and 72 h of incubation. In the remaining two bottles for each diet, the gas produced after 24 h and a gas sample (about 5 ml) was taken for analysis of methane. Bottles were then uncapped, the pH was measured immediately *(*Crison Basic 20 pH-meter*,* Crisson Instruments, Barcelona. Spain) and 2 ml of bottles contents were added to 2 ml of deproteinising solution (20 g of metaphosphoric acid and 0.6 g of crotonic acid per litre) for volatile fatty acid (VFA) determination. Chemical composition of diets was determined following the procedures of the AOAC (2005). Analysis of methane and VFA were carried out by gas chromatography as described by Molina-Alcaide *et al*. (2017).

3. Calculations and statistical analyses

The gas produced in batch cultures was adjusted to the exponential model: $y = A (1 - e^{(-c * t)})$, where A is the asymptotic gas production (ml), *c* is the fractional rate of gas production (h^{-1}), and t is the time of gas measurement (h). The average gas production rate (AGPR; mL gas/h) is defined as the average gas production rate between the start of the incubation and was calculated as AGPR = A *c* / [2 (ln2 + *c*)]. Data were analysed by ANOVA considering the diet as a fixed effect and incubation run as a random effect. When a significant effect of diet was found, post hoc comparison of means was made using the Tukey test. Differences were considered significant at $P < 0.05$, and $P < 0.10$ values were declared as trend and discussed. The SPSS for Windows (version 19.0. 2010; SPSS Inc., Chicago, IL, USA) was used for statistical analysis.

III – Results and discussion

The inclusion of by-products in the diets did not show any significant effect ($P = 0.091$) on final pH values (Table 2). There were differences ($P = 0.005$) among diets in VFA production, values being higher for the diets including by-products compared with the control one. On the contrary, both molar proportions of individual VFA and acetate/propionate ratio were not affected ($P = 0.613$ to 0.999) by the incubated diet. Methane production was lower ($P < 0.001$) for diets T3, T3C, T3CB and T3CBY compared with the control diet, but diet T1 showed higher ($P < 0.001$) methane production than the control. Although all diets containing 94 (T2) or 125 g of tomato fruit per kg (T3, T3C, T3CB and T3CBY) reduced significantly methane production compared with the control diet, the lowest values for methane production were observed for the T3C diet, with a 22% reduction. In addition, all diets including tomato fruits, with the exception of T1, reduced the methane/VFA ratios compared with the control, which shows higher fermentation efficiency, as methane represents an energy loss and VFA are the main source of energy and precursors for the host animal. These

results would indicate an antimethanogenic effect of tomato fruits and confirm previous results from our group in dairy goats fed diets containing tomato fruits (Romero-Huelva and Molina-Alcaide, 2013). However, the reduction in methane emissions found with diets including by-products were not accompanied by increased propionate proportions, which suggests that other metabolic pathways could have acted as hydrogen sinks. The observed differences among diets in methane production may rely upon differences in their chemical composition, or could be even derived from the presence in the by-products of plant secondary compounds (polyphenols, tannins, saponins, etc.), which could act as natural safe antimethanogenic compounds, alternative to chemical ones, as suggested by Patra and Saxena (2010). These compounds may have an effect on the ruminal microbiota, mainly on archaea and protozoa communities, although it is still unknown which genera or species of archaea are most involved in ruminal methane production (Morgavi *et al*., 2010).

Table 2. Average values of pH, total volatile fatty acids (VFA), molar proportions of individual VFA, acetate to propionate ratio, methane production and methane/VFA ratio after 24 h incubation of concentrates in batch cultures

	Diets								
	Control	**T1**	**T2**	**T3**	**T3C**	**T3CB**	**T3CBY**	**SEM**	**P-value**
pH	6.70	6.71	6.69	6.69	6.68	6.71	6.68	0.002	0.091
Total VFA, mmol	2.51^{a}	2.63^{b}	2.69^{bc}	2.69^{bc}	2.68^{bc}	2.73^{c}	2.75^{c}	0.023	0.005
VFA, mol/100 mol									
Acetate	64.8	65.5	64.3	65.3	66.0	64.8	65.4	0.141	0.822
Propionate	21.5	21.7	22.7	22.2	21.7	22.3	22.2	0.379	0.999
Isobutyrate	1.19	1.12	1.12	1.10	1.05	1.08	1.04	0.019	0.979
Butyrate	9.54	8.96	9.15	8.87	8.68	9.16	8.82	0.245	0.999
Isovalerate	1.63	1.49	1.49	1.41	1.34	1.38	1.27	0.050	0.991
Valerate	1.34	1.27	1.28	1.21	1.18	1.23	1.19	0.012	0.613
Acetate/propionate	3.08	3.05	2.89	2.99	3.09	2.95	3.01	0.057	0.999
Methane, mL/g incubated DM	42.3^{d}	45.7^{e}	35.7^{ab}	37.7^{bc}	33.1^{a}	37.2^{bc}	38.7^{c}	0.633	<0.001
Methane/AGV, mL/mmol	7.80^{b}	7.96^{b}	6.05^{a}	6.37^{a}	5.63^{a}	6.11^{a}	6.37^{a}	0.254	0.017

As shown in Table 3, the inclusion of by-products in the concentrate resulted in higher ($P < 0.05$) values of asymptotic gas production for all experimental diets compared with the control diet. In addition, T3, T3C, T3CB and T3CBY diets showed greater ($P < 0.05$) gas production rates than the control, T1 and T2 diets. There were also differences ($P < 0.001$) among diets in AGPR values, with all diets excepting T2 having greater ($P < 0.05$) values than the control one. The greater gas production values observed for the diets including by-products are consistent with the increased VFA production detected for these diets in the 24-h incubations. The results suggest that the diets including by-products were more extensively fermented, which might be due to a better supply of nutrients to the ruminal microbiota as a consequence of a better synchronization between nitrogen and energy degradation by ruminal microorganisms (Bach *et al*., 2005). Other factors such as energy and nitrogen quality of the diet could influence nitrogen and energy utilization (NRC, 2001). Moreover, some of these diets promoted better fermentation patterns, as indicated by the reduced methane production and methane/VFA ratios.

The combination of tomato fruits, citrus pulp and either brewer's grains (T3CB concentrate) or brewer's yeast (T3CBY concentrate) resulted in the greatest AGPR values, thus indicating a more rapid fermentation. Moreover, these diets also had the lowest cost (198 and 194 €/ton, respectively), being 9.6 and 11.4% lower than that of the control concentrate. These by-products also allowed higher replacement levels of conventional ingredients and lead to lower methane emissions, which has strong environmental implications in a world with an exponential growing population.

Table 3. Average values of gas production parameters after 72 h incubation of experimental diets in batch cultures

	Diets								
	Control	T1	T2	T3	T3C	T3CB	T3CBY	SEM	P-value
Gas produced, mL	338^{a}	343^{ab}	346^{bc}	350cd	352^{d}	364^{e}	362^{e}	1.364	<0.001
A, ml	118^{a}	121^{b}	121^{b}	121^{b}	123^{cd}	125^{d}	124^{d}	0.679	0.004
c, h^{-1}	0.079^{a}	0.081^{a}	0.087^{a}	0.096^{b}	0.098^{b}	0.102^{b}	0.103^{b}	0.003	0.001
AGPR (ml / g dry matter)[1]	6.71^{a}	7.09^{ab}	7.56^{b}	8.33^{c}	8.69^{cd}	9.14^{d}	9.23^{d}	0.273	<0.001

[1] Average gas production rate, calculated as AGPR = A *c* / [2 (ln 2 + c)].

IV – Conclusions

The replacement of conventional ingredients in a diet for lactating goats with a mixture of tomato fruits, citrus pulp, brewer's grain and brewer's yeast resulted in increased *in vitro* fermentation extension and rates. Moreover, the use of by-products in dairy goats could contribute to minimize the negative environmental impact associated with methane emissions from ruminants and to increase the farm profitability as a consequence of reduced feeding costs.

Acknowledgements

Funding was provided by projects RECUPERA (Project Programme 2020, 315/14; CSIC, Ministerio de Economía y Competitividad), P12-AGR-587 (funded by the Junta de Andalucia) and AGL2016-75322-C2-1-R (funded by the Spanish MINECO). Thanks to J. Fernandez and L. Arbesú for technical assistance. Thanks to the ASPERO, SA (Sevilla, Spain) and IFS (Mérida, Spain) for providing us with by-products and conventional ingredients.

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Influence of particle size of crude olive cake on *in vitro* ruminal fermentation and gas production kinectics

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Abstract. By-products of olive oil industry can be used in ruminants feeding, but their nutritive value can be affected by the processing method. The aim of this research was to estimate in vitro the nutritive value of four samples of crude olive cake (COC) with different particle size obtained during the drying process from the same trommel at different stages of the screening procedure. Particles size was greater than 3 mm (COC3), 2 mm (COC2) and 1 mm (COC1) or smaller than 1 mm (COC0). Alfalfa hay and barley straw were included in the study for comparative purposes. Chemical composition was analysed in all samples. Gas production kinetics was determined in 144-h in vitro incubations with sheep rumen fluid as inoculum, and fermentation parameters and in vitro dry matter digestibility (IVDMD) were analysed after 24 h of incubation. COC3 and COC0 samples had lower contents of neutral detergent fibre (NDF; 415 and 391 g/kg DM), but greater crude protein (96.6 and 114 g/kg DM) and ether extract (220 and 242 g/kg DM) contents, than COC2 and COC3 (627 and 624; 42.4 and 48.7; 102 and 124 g/kg DM, respectively). IVDMD of COC samples ranged from 39.4 to 58.7%, and was lower than that for alfalfa hay (67.5%) for all samples, but greater than that for barley straw (42.4%) for COC0 and COC3 samples. COC3 and COC0 samples had greater (P<0.05) potential gas production (103 and 66.2 ml/g DM, respectively) and total volatile fatty acids production (608 and 600 µmol, respectively) than COC2 and COC1, but values were lower than those for alfalfa hay (202 ml/g DM and 1023 µmol, respectively) and barley straw (198 ml/g DM and 733 µmol). The results indicate that decreasing particle size to <1 mm increased the fermentation potential of COC, but its nutritive value was still slightly lower than that of barley straw. The similar quality observed for COC3 and COC0 samples was attributed to the high sugar content of COC3 samples.

Keywords. Olive cake – Particle size – Chemical composition – Gas production – Ruminal fermentation.

Influence de la taille des particules des grignons d'olive sur la fermentation ruminal et la cinétique de production de gaz

Résumé. *Les sous-produits de l'industrie de l'huile d'olive pourraient être utilisés pour l'alimentation des animaux ruminants, mais sa valeur nutritive peut être affectée par la méthode utilisée pour obtenir ces sous-produits. L'objectif de ce travail a été d'estimer in vitro la valeur nutritive pour des animaux ruminants de quatre échantillons de grignon d'olive (COC) avec différente taille de particules obtenues du même trommel en différents moments du processus de tamisage. La taille des particules était plus grande que 3 mm (COC3), 2 mm (COC2), 1 mm (COC1) et plus Petite que 1 mm (COC0). Foin de luzerne et paille d'orge ont aussi été utilisés pour comparer. La cinétique de la production de gaz a été déterminée en une incubation in vitro (144 heures) avec en utilisant du fluide du rumen de brebis comme inoculum. Les paramètres de la fermentation et la digestibilité de la matière sèche in vitro (IVDMD) ont été analysées 24 heures après que l'incubation a été commencée. Les échantillons COC3 et COC1 avaient moins de fibre au détergent neutre (NDF ; 415 et 381 g/kg DM), mais plus des matières azotées totales (96,9 et 114 g/kg DM), et de gras (220 et 242 g/kg DM), que COC2 et COC3 (627 et 624, 42,4 et 48,7, 102 et 124 g /kg DM, respectivement). Les valeurs d'IVDMD des échantillons de COC varié entre 39.4 et 58.7%, étaient plus petite que la valeur du foin de luzerne 67,5%) pour tous les échantillons, mais plus grandes que la valeur de la paille d'orge (42,4%) pour COC0 et COC3. Les échantillons COC3 and COC0 avaient plus (P<0,05) de production potentiel de gaz (103 et 66,2 ml/g DM, respecti-*

vement) et plus des acides gras volatiles (VFA) (608 et 600 µmol, respectivement) que les échantillons COC2 et COC1, mais les valeurs étaient plus petites que les valeurs du foin de luzerne (202 ml/g DM et 1023 µmol, respectivement) et de la paille d'orge (198 ml/g DM and 733 µmol). Les résultats montraient que la réduction de la taille des particules à <1mm augmente la fermentation potentiel, mais la valeur nutritive était encore plus petite que celle de la paille d'orge. La qualité similaire observée pour les échantillons COC3 et COC0 a été attribué à la forte teneur en sucres de l'échantillon COC3.

Mots-clés. *Grignons d'olive – Taille des particules – Production de gaz – Composition chimique – Fermentation ruminal.*

I – Introduction

Olive oil extraction generates several by-products that can be used in animal feeding, especially the cakes and pomaces obtained in the extraction process, but their characteristics and nutritive value depend markedly on the processing method (Feedipedia, 2017). The main product is the "alperujo", which is stored in open ponds until processing, frequently over a period of several months. Alperujo is dried and olive stones are separated from the pulp by a process of screening. This process consists of placing the alperujo in a trommel (a cylinder of perforated metal, open at both ends and with a slight incline), that rotates classifying the material by their particle size (Savage *et al*., 2005). The screening for stones removal produces COC with different particle sizes, and may influence the nutritional quality of COC. The objective of this study was to analyse the influence of particle size of COC on their chemical composition, in vitro ruminal fermentation and gas production kinetics.

II – Material and methods

Four samples of crude olive cake (COC) obtained from the same trommel at different stages of the screening process were used in this study. Samples had different particle size: bigger than 3 (COC3), 2 (COC2) and 1 mm (COC1), or smaller than 1 mm (COC0). Chemical composition was analysed according to the AOAC (2000). Neutral detergent fibre (NDF), acid detergent fibre (ADF) and lignin analyses were carried out as described by Van Soest *et al*. (1991).

Substrates were fermented in vitro to determine gas production kinetics and ruminal fermentation parameters. One sample of alfalfa hay and barley straw were also incubated for comparative purposes. Samples (200 mg of dry matter (DM)) of each substrate were weighed into 60-mL bottles. Ruminal fluid was obtained from four rumen-cannulated Lacaune sheep (64.7 ± 2.10 kg body weight) fed grass hay and concentrate in 2:1 proportion twice daily. Sheep were managed according to the protocols approved by the Institutional Animal Care and Use Committee of the Technical University of Madrid and had free access to water over the trial. Ruminal contents of each sheep were obtained immediately before the morning feeding, strained through four layers of cheesecloth and mixed with the buffer solution of Goering and Van Soest (1970; no trypticase added) in a proportion 1:4 (vol/vol) at 39ºC under continuous flushing with CO2. Bottles were prewarmed (39ºC) prior to the addition of 20 ml of buffered rumen fluid, capped and incubated at 39ºC.. Two incubation runs were performed. In the first incubation run, gas production was measured at 3, 6, 9, 12, 18, 24, 36, 48, 72, 96 and 120 h using a pressure transducer (Widereager Wide Range Pressure Meter, Sper Scientific LTD, Scottsdale, AZ, USA) and a calibrated syringe, and the gas produced at each measurement time was released. Bottles without sample (blanks) were incubated to correct for endogenous gas production. In the second run, bottles were incubated for 24 h, gas production was measured as described before and a gas sample (10 ml) was stored in a vacuum tube for CH4 analysis. Bottles were then uncapped and samples for volatile fatty acid (VFA) and NH3-N analyses were taken as described by Martínez *et al*. (2010). Procedures for CH4, VFA and NH3-N analyses have

been also described by Martínez *et al*. (2010). The amount of OM apparently fermented (OMAF) in each bottle was estimated from VFA production as described by Demeyer (1991).

In vitro DM digestibility (IVDMD) was determined by weighting 300 mg of substrate in polyester bags (30 µm pore size; Ankom Corp #57, Ankom Technology Corp., Fairport, NY, USA) which were incubated with buffered ruminal fluid in an Ankom Daisy II incubator (Ankom Technology Corp, Fairport, NY, USA) at 39ºC under continuous rotation. After 24 h, bags were washed with cold water, dried at 60ºC for 48 h and weighted to calculate the IVDMD. Three bags were used for each substrate.

Gas production data were fitted with time using the exponential model: $gas = A\ (1 - e^{-(-c\ (t - lag))})$, where A is the asymptotic gas production (mL), c is the fractional rate of gas production (h-1), lag is the initial delay in the onset of gas production (h) and t is the gas measurement time. The parameters A, c and lag were estimated by an iterative least squares procedure using the NLIN procedure of SAS (version 9.2; SAS Inst. Inc., Cary, NC, USA). The average gas production rate (AGPR; mL gas/h) was calculated as AGPR = *A c* / [2 (ln2 + c *lag*)]. Data were analysed as a mixed model using the PROC MIXED of SAS. The effect of substrate was considered fixed and that of the inoculum as random. Significance was declared at $P < 0.05$, and comparison of means was performed by the Tukey test.

III – Results and discussion

Content of crude protein (CP), NDF, ADF, lignin and ether extract in COC samples ranged from 42.4 to 114, 391 to 627, 273 to 408, 122 to150, and 102 to 242 g/kg DM, respectively (Table 1). These values are in the range of those reported by others for COC samples from different sources (Molina-Alcaide *et al*., 2003; Molina-Alcaide and Yáñez-Ruiz, 2008), with the exception of EE content, which was greater in our samples. The high amount of CP bound to the ADF in the COC samples (11 to 43% of total CP) indicated a low N availability, as previously reported for COC (Molina-Alcaide and Yáñez-Ruiz, 2003). The IVDMD of COC samples ranged from 39.4 to 58.7%, and was lower than that for alfalfa hay (67.5%) for all samples, but greater than that for barley straw (42.4%) for COC0 and COC3 samples.

Table 1. Chemical composition (g/Kg dry matter) and in vitro dry matter digestibility (IVDMD) of crude olive cake (COC) samples with different particle size and two forages

	COC3	COC2	COC1	COC0	Alfalfa hay	Straw
Crude protein (CP)	96.6	42.4	48.7	114	194	55.6
Neutral detergent fibre (NDF)	415	627	624	391	394	697
Acid detergent fibre (ADF)	298	408	418	273	215	388
Lignin	122	148	163	150	45.0	38.8
Crude protein bound to the ADF	29.4	10.7	12.7	42.5	66.2	19.2
Ether extract	220	102	124	242	47.2	28.5
IVDMD (%)	58.7	39.4	40.9	49.4	67.5	42.4

As shown in Table 2, COC3 had the greatest ($P<0.05$) asymptotic gas production (A) and COC2 and CO1 had the lowest values. The higher gas production values observed in COC3 would indicate a more extensive fermentation, as cumulative gas production is directly related with the amount of organic matter fermented (Menke *et al*., 1979). In contrast, there were no differences ($P\geq0.146$) among COC samples for c and lag parameters. COC3 also showed a greater value ($P<0.05$) of AGPR compared with the other samples. Cumulative gas production over the first 24 h of incubation was greater for COC3 and COC0 than that for barley straw, but COC2 and COC1 showed similar values to straw (Figure 1). Gas production for all COC samples was lower than that for alfalfa hay at all sampling times.

Table 2. Gas production parameters of crude olive cake (COC) samples with different particle size and two forages (n = 4)[1]

Substrate[1]	A	c	*lag*	AGPR
COC3	103[c]	0.0558	0.40	3.98[b]
COC2	29.1[a]	0.0801	2.08	1.37[a]
COC1	30.7[a]	0.0813	1.76	1.54[a]
COC0	66.2[b]	0.0531	1.21	2.35[a]
sem[2]	2.14	0.01002	0.230	0.230
P =	<0.001	0.146	0.242	<0.001
Forages				
Alfalfa hay	202	0.0442	1.82	5.73
Barley straw	198	0.0303	15.4	2.57

[a-c] Means in the same row with different superscript differ (P<0.05).

[1] A: potential gas production; c: fractional rate of gas production; Lag: time until the production of gas begins; AGPR: gas production rate until it has reached half of the A value.

[2] sem: standard error of the mean.

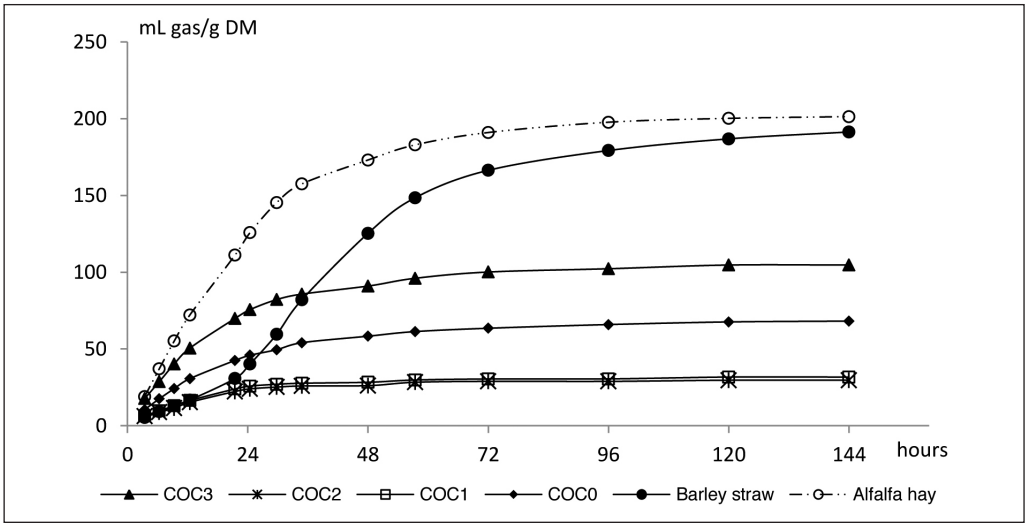

Fig. 1. ***In vitro*** **cumulative gas production of crude olive cake (COC) samples with different particle size and two forages.**

The results of the 24 h in vitro fermentations (Table 3) were in well agreement with those observed for gas production kinetics. Both COC3 and COC0 produced more (P<0.05) total VFA, acetate, propionate and CH4 than COC2 and COC1, resulting in greater (P<0.05) amount of OMAF. In contrast, there were no differences (P>0.05) among COC in NH3 concentrations, which may be due to the use of a N-enriched buffer solution. The greater fermentation of COC0 may be explained by its lower stone content, as stones are low fermentable. The high fermentation observed in COC3 may have been due to a high sugar content, as this sample contained small green-coloured balls which were identified as caramelized sugars (Bacha, personal communication). Both VFA and CH4 production were lower in all COC samples than in the two tested forages, indicating that COC samples were less fermented.

Table 3. ***In vitro*** **fermentation parameters after 24 h incubation of crude olive cake (COC) samples with different particle size and two forages with buffered ruminal fluid from sheep (n = 4)[1]**

Substrate	CH_4 (µmol)	NH_3-N (mg/L)	Total VFA (µmol)	(µmol) Ac	Pr	Bt	Minor VFA	Ac/Pr (mol/mol)	OMAF (mg)
COC3	190[b]	348	628[b]	352[b]	141[b]	90.2[b]	45.5[b]	2.59[a]	54.5[b]
COC2	144[a]	382	406[a]	226[a]	73.4[a]	65.8[a]	41.0[a]	3.15[b]	34.9[a]
COC1	155[a]	366	451[a]	249[a]	83.5[a]	73.4[ab]	45.4[b]	3.07[b]	38.8[a]
COC0	187[b]	349	600[b]	338[b]	131[b]	84.3[ab]	47.3[b]	2.68[a]	51.6[b]
sem2	6.10	11.2	14.5	7.50	4.85	4.47	3.62	0.052	1.44
P =	<0.001	0.167	<0.001	<0.001	<0.001	0.016	0.007	<0.001	<0.001
Forages									
Alfalfa hay	315	423	1023	625	216	116	55.4	3.03	87.0
Barley straw	250	372	733	463	131	92.2	56.8	3.66	63.0

[a-c] Means in the same row with different superscript differ (P<0.05).

[1] Minor VFA are calculated as the sum of isobutyrate, isovalerate, valerate and caproate. The amount of organic matter apparently fermented (OMAF) was calculated from VFA production as described by Demeyer (1991).

[2] sem: standard error of the mean.

IV – Conclusions

Olive cake samples differing in particle size showed marked differences in chemical composition and in vitro ruminal fermentation parameters, with samples having more than 3 mm or less than 1 mm showing the highest fermentability. Crude olive cake could be used in ruminant diets replacing fibrous feeds with low nutritional value, but due to its high fat content olive cake would also contribute to increase the energy level of the diet.

Acknowledgments

This work was supported by the Spanish Ministry of Economy and Competitiveness (Projects AGL2016-75322-C2-1-R, AGL2016-75322-C2-2-R and AGL2014-56653-C3-1-R) and the Junta de Andalucía (Project P12-AGR-587). We gratefully thank Dr. Fernando Bacha for providing the crude olive cake samples.

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Chemical composition and *in vitro* rumen fermentation of crude olive cake and olive extracts

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Abstract. The aim of this study was to assess the nutritive value for ruminants of five samples of crude olive cake (COC) and two commercial olive extracts (Prolivols^{TM} and Hytaolive^{TM}). Alfalfa hay (AH) and barley straw (BS) were also evaluated for comparative purposes. Chemical composition was analysed in all samples. Gas production kinetic was determined in 144-h *in vitro* incubations with sheep rumen fluid, whereas fermentation parameters and *in vitro* dry matter digestibility (IVDMD) were analysed after 24 h of incubation. Crude protein, neutral detergent fibre (NDF), acid detergent fibre (ADF) and ether extract content of COC ranged from 65.2 to 105, 374 to 448, 269 to 316, and 145 to 267 g/kg dry matter (DM), respectively. The high amount of nitrogen bound to the ADF in the COC samples (25 to 45% of total N) indicated low N availability, and the lignin/NDF ratios were high (0.272 to 0.401). The IVDMD values of COC (47.9 to 60.8%) were lower than that for AH (67.5%), but greater than that for BS (42.4%). Potential gas production values of COC samples (60.3 to 103 ml/g DM) were lower (P<0.05) than those for olive fruits extracts, AH and BS (values > 170 ml/g DM). There were no differences (P>0.05) among COC samples in total volatile fatty acid (VFA) production after 24h of incubation, and values were similar to those of BS, but lower (P<0.05) than those measured for the two commercial extracts and AH. The COC could be used in ruminant diets replacing low-quality feeds such as BS, but due to its high ether extract content it could be also used in dairy animals to increase the content of unsaturated fatty acids in animal products.

Keywords. Olive cake – Olive extracts – Chemical composition - Gas production – Ruminal fermentation.

Composition chimique et fermentation ruminal* in vitro *des grignos d'olive et des extraits d'olive

Résumé. *L'objectif de ce travail a été d'estimer la valeur nutritive pour des animaux ruminants de cinq échantillons de grignon d'olive (COC) et deux extraits commerciaux (Prolivols^{TM} and Hytaolive^{TM}). Foin de luzerne (AH) et paille d'orge (BS) ont aussi été utilisés pour comparer. La cinétique de la production de gaz a été déterminée en incubant* in vitro *pendant 144 heures avec fluide du rumen de brebis. Les paramètres de la fermentation et la digestibilité de la matière sèche* in vitro *(IVDMD) ont été analysées 24 heures après que l'incubation a été commencée. Le contenu en matières azotées totales, fibre au détergent neutre (NDF), fibre au détergent acide (ADF) et gras des échantillons de COC varié entre 65,2 et 105, 374 et 448, 269 et 315 et 145 et 267 g/kg matière sèche (DM), respectivement. La grande quantité d'azote lié à l'ADF dans les échantillons de COC (25 à 45% des matières azotées totales) montre une faible disponibilité de l'azote ; le rapport lignine/NDF était haut (0,272 à 0,401). Les valeurs pour l'IVDMD des échantillons de COC (47,9 à 60,8%) étaient plus petites que la valeur pour l'AH (67,5%), mais plus grande que la valeur pour BS (42,4%). Les valeurs pour la production potentiel de gaz des échantillons de COC (60,3 à 103 ml/g DM) étaient plus petite (P<0,05) que les valeurs des extraits commerciaux, et celles pour AH et BS (valeurs > 170ml/g DM). Il n'y avait aucune différence (P > 0,05) entre les échantillons de COC pour la production des acides gras volatiles (VFA) totales, etant les valeurs similaires à la valeur pour BS, mais ils étaient plus petites (P<0,05) que les valeurs des extraits commerciaux et l'AH. Le COC pourrait être utilisé pour l'alimentation des animaux ruminants remplaçant des aliments fibreux, comme la BS, mais grâce à sa forte teneur en gras le COC pourrait être aussi utilisé pour l'alimentation des animaux laitiers á fin d'améliorer le contenu d'acides gras insaturés chez les produits d'origine animale.*

Mots-clés. *Grignon d'olive – Extraits d'olive – Production de gaz – Composition chimique – Fermentation ruminal.*

I – Introduction

Spain is the largest producer of olive oil in the world, and as a consequence produces a large volume of by-products causing serious environmental problems. A waste product with high moisture and pollution potential, called “alperujo”, is generated in the two-phases extraction procedure currently used by the oil industry (Molina and Yáñez-Rúiz, 2008). “Alperujo” is stored in ponds until further processing, which consists in removing olive stones and drying the residue off. The result of this process is a by-product called crude olive cake (COC) that could be used for ruminants feeding. Olives are rich in polyphenolic compounds and only a small part of them are extracted with the oil, most of polyphenols remaining in the waste products (Rodis *et al.,* 2000). Several extracts rich in polyphenols are commercially available and some studies have shown that adding olive extracts during meat processing delayed the oxidation process and increased the shelf-life of meat (Muíño *et al*., 2017). However, to our best knowledge there is no information on the ruminal degradation of these products when they are included in the feed. The objective of this study was to assess the chemical composition and *in vitro* ruminal fermentation of five different samples of COC and two commercial olive extracts.

II – Material and methods

Five samples of COC, obtained at different “almazaras”, and two commercial extracts (Prolivols™ and Hytaolive™) obtained from olives by physical extraction processes were used in this study. According to the manufacturer, Prolivols™ contains 35% of total polyphenols (particularly hydroxytyrosol and tyrosol), and Hytaolive™ has a high level of hydroxytyrosol. In addition, two forages widely used in ruminants feeding (alfalfa hay and barley straw) were included for comparative purposes. All substrates were grounded to 1 mm and their chemical composition was analysed according to the AOAC (1999). Neutral (NDF) and acid (ADF) detergent fibre and lignin were analysed according to Van Soest *et al*. (1991).

Substrates were fermented *in vitro* to determine gas production kinetics and ruminal fermentation parameters. Samples (200 mg of dry matter (DM)) of each substrate were weighed into 60-mL bottles. Ruminal fluid was obtained from four rumen-cannulated Lacaune sheep (64.7 ± 2.10 kg body weight) fed grass hay and concentrate in 2:1 proportion twice daily. Sheep were managed according to the protocols approved by the Institutional Animal Care and Use Committee of the Technical University of Madrid and had free access to water over the trial. Ruminal contents of each sheep were obtained immediately before the morning feeding and strained through four layers of cheesecloth. Fluid of each sheep was mixed with the buffer solution of Goering and Van Soest (1970; no trypticase added) in a proportion 1:4 (vol/vol) at 39ºC under continuous flushing with CO_2. Bottles were prewarmed (39ºC) prior to the addition of 20 ml of buffered rumen fluid, sealed with rubber stoppers and aluminium caps and incubated at 39ºC. Bottles without sample (blanks) were added to correct for endogenous gas production. Two incubations runs were performed. In the first run, gas production were measured at 3, 6, 9, 12, 18, 24, 36, 48, 72, 96 and 144 h using a pressure transducer (Widereager Wide Range Pressure Meter, Sper Scientific LTD, Scottsdale, AZ, USA) and a calibrated syringe, releasing the gas produced at each measurement time. In the second run, bottles were incubated for 24 h, gas production was measured as described before and a gas sample (10 ml) was stored in a vacuum tube for CH_4 analysis before taking samples for volatile fatty acid (VFA) and NH_3-N analyses as described by Martínez *et al*. (2010). Procedures for CH_4, VFA and NH_3-N analyses have been also described by Martínez *et al*. (2010). The amount of OM apparently fermented (OMAF) in each bottle was estimated from VFA production as described by Demeyer (1991).

In vitro DM digestibility (IVDMD) was determined by weighting 300 mg of substrate in polyester bags (30 µm pore size; Ankom Corp #57, Ankom Technology Corp., Fairport, NY, USA) which were incubated with buffered ruminal fluid in an Ankom Daisy II incubator (Ankom Technology Corp, Fairport,

NY, USA) at 39ºC under continuous rotation. After 24 h, bags were washed with cold water and dried at 60ºC for 48 h and weighted to calculate the IVDMD. Three bags were used for each substrate.

Gas production data were fitted with time using the exponential model: gas = $A\ (1 - e^{-(-c\ (t - lag))})$, where *A* is the asymptotic gas production (mL), *c* is the fractional rate of gas production (h^{-1}), *lag* is the initial delay in the onset of gas production (h) and t is the gas measurement time. The parameters *A*, *c* and *lag* were estimated by an iterative least squares procedure using the NLIN procedure of SAS (version 9.2; SAS Inst. Inc., Cary, NC, USA). The average gas production rate (AGPR; mL gas/h) was calculated as AGPR = $A\ c\ /\ [2\ (\ln 2 + c\ lag)]$. Data were analysed as a mixed model using the PROC MIXED of SAS. The effect of substrate was considered fixed and that of the inoculum as random. Significance was declared at $P < 0.05$, and comparison of means was performed by the Tukey test.

III – Results and discussion

Content of crude protein (CP), NDF, ADF, lignin and ether extract in COC samples ranged from 65.2 to 105, 274 to 448, 269 to 316, 122 to150, and 145 to 267 g/kg DM, respectively (Table 1). These values are in the range of those reported by others for COC of different sources (Molina-Alcaide *et al*., 2003; Molina-Alcaide and Yáñez-Ruiz, 2008).

Table 1. Chemical composition (g/kg dry matter) and *in vitro* dry matter digestibility (IVDMD) of crude olive cake (COC) samples, olive extracts (Prolivols and Hytaolive) and forages

Item[1]	COC1	COC2	COC3	COC4	COC5	Prolivols[2]	Hytaolive[2]	Alfalfa hay	Barley straw
CP	66.7	65.2	92.2	90.0	105	100	3.51	194	55.6
NDF	423	448	422	374	414	–	–	394	697
ADF	283	302	287	269	316	–	–	215	388
Lignin	123	122	144	150	150	–	–	45.0	38.8
CP-ADF	21.8	16.3	29.4	34.6	47.7	–	–	66.2	19.2
Ether extract	187	177	203	145	267	78.7	121	47.2	28.5
IVDMD (%)	59.3	60.8	60.6	54.5	47.9	–	–	67.5	42.4

[1] CP: crude protein; NDF: neutral detergent fibre; ADF: acid detergent fibre.

[2] Due to the small particle size of these samples, some analyses could not be performed.

The high amount of CP bound to the ADF in the COC samples (25 to 45% of total CP) indicated low N availability, as previously reported (Molina-Alcaide and Yáñez-Ruiz, 2003). The IVDMD of COC samples (47.9 - 60.8%) was lower compared with alfalfa hay (67.5%) but greater than that of barley straw (42.4%). Due to the small particle size of the commercial extracts, fibre analyses could not be performed. Crude protein content in Prolivols was about 3 times greater than that in Hytaolive, but its ether extract was lower (78.7 *vs.* 121 g/kg DM).

Accumulated gas production was greater ($P<0.05$) for both olive extracts than for COC samples (Figure 1 and Table 2). The high gas production values observed for the two olive extracts would indicate an extensive fermentation in the rumen, as cumulative gas production is directly related with the amount of organic matter fermented (Menke *et al*., 1979). The high VFA production (Table 3) observed for Hytaolive also suports this hypothesis. The COC1 had greater ($P<0.05$) A values than the rest of COC, but there were no differences ($P>0.05$) among COC samples either in lag or AGPR values. There were no differences ($P>0.05$) among COC samples either in VFA and CH_4 production or NH_3-N concentrations, but COC4 showed greater ($P<0.05$) acetate:propionate ratios than the rest of COC samples (Table 3).

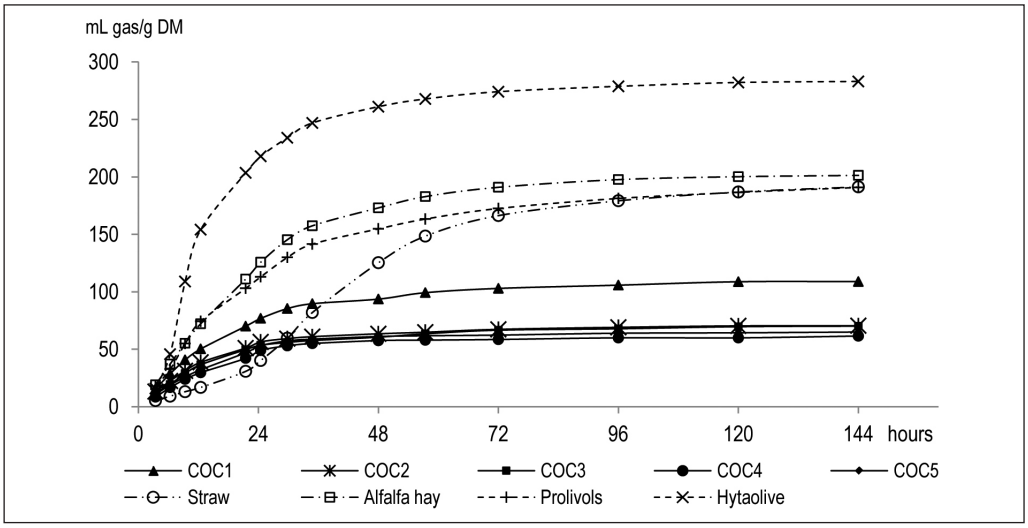

Fig. 1. ***In vitro*** **cumulative gas production of crude olive cake (COC) samples, olive extracts (Prolivols and Hytaolive) and forages.**

Table 2. Gas production parameters of crude olive cake (COC) samples, olive extracts (Prolivols and Hytaolive) and forages (n = 4)[1]

Substrate[1]	A	c	*lag*	AGPR
COC1	103[b]	0.0533[ab]	1.29[a]	3.68[a]
COC2	68.4[a]	0.0695[c]	0.68[a]	3.24[a]
COC3	67.7[a]	0.0617[bc]	0.47[a]	2.90[a]
COC4	60.3[a]	0.0694[bc]	1.61[ab]	2.60[a]
COC5	64.3[a]	0.0678[bc]	0.94[a]	2.90[a]
Prolivols	187[c]	0.0402[a]	0.96[a]	5.19[b]
Hytaolive	277[d]	0.0740[c]	3.04[b]	11.2[c]
sem[2]	4.21	0.00346	0.325	0.252
P =	<0.001	<0.001	<0.001	<0.001
Forages				
Alfalfa hay	202	0.0442	1.82	5.73
Barley straw	198	0.0303	15.4	2.57

[a-d] For COC and olive extracts, means in the same column with different superscript differ (P<0.05).

[1] A: potential gas production; *c*: fractional rate of gas production; *Lag*: time until the production of gas begins; AGPR: gas production rate until it has reached half of the A value.

[2] sem: standard error of the mean.

All COC samples had greater cumulative gas production values over the first 24 h of incubation compared with barley straw (Figure 1), which is consistent with the greater *lag* values of barley straw (15.4 h) compared with COC samples (0.47 to 1.61 h). However, CH_4 and VFA production values were numerically lower for COC (ranging from 173 to 199 µmol and from 604 to 688 µmol, respectively) than those for barley straw (250 and 733 µmol, respectively). Hytaolive produced more total VFA and CH_4 and had a greater amount of OMAF (P<0.05) than all COC samples and Prolivols (Table 3), which is consistent with the greater values of *A*, *c* and AGPR observed for Hytaolive compared with the rest of the samples tested.

Table 3. ***In vitro*** **fermentation parameters after 24 h incubation of crude olive cake (COC) samples, olive extracts and forages with buffered ruminal fluid from sheep (n = 4)[1]**

Substrate	CH_4 (µmol)	NH_3-N (mg/L)	Volatile fatty acid (VFA; µmol)					Ac/Pr (mol/mol)	OMAF (mg)
			Total	Ac	Pr	Bt	Minor VFA		
COC1	199^{a}	304^{b}	687^{a}	382^{a}	161^{a}	103^{a}	41.3^{ab}	2.46^{b}	60.6^{a}
COC2	177^{a}	337^{b}	610^{a}	328^{a}	140^{a}	95.5^{a}	45.5^{b}	2.41^{b}	53.4^{a}
COC3	173^{a}	351^{b}	604^{a}	327^{a}	137^{a}	93.5^{a}	47.1^{b}	2.46^{b}	52.7^{a}
COC4	186^{a}	364^{b}	608^{a}	344^{a}	130^{a}	88.8^{a}	45.2^{ab}	2.72^{c}	52.8^{a}
COC5	181^{a}	339^{b}	688^{a}	370^{a}	161^{a}	105^{a}	52.0^{b}	2.34^{b}	60.0^{a}
Prolivols	210^{a}	249^{a}	672^{a}	355^{a}	161^{a}	126^{a}	30.0^{a}	2.30^{b}	62.2^{a}
Hytaolive	287^{b}	218^{a}	1268^{b}	566^{b}	427^{b}	234^{b}	41.8^{ab}	1.41^{a}	118^{b}
Sem[2]	10.7	15.2	38.6	20.6	24.3	15.1	3.26	0.066	3.09
P =	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.006	<0.001	<0.001
Forages									
Alfalfa hay	315	423	1023	625	216	116	55.4	3.03	87.0
Barley straw	250	372	733	463	131	92.2	56.8	3.66	63.0

$^{a-c}$ Means in the same row with different superscript differ (P<0.05).

[1] Ac: acetate; Pr: propionate; Bt: butyrate; Minor VFA are calculated as the sum of isobutyrate, isovalerate, valerate and caproate. The amount of organic matter apparently fermented (OMAF) was calculated from VFA production as described by Demeyer (1991).

[2] sem: standard error of the mean.

IV – Conclusions

Crude olive cake samples showed some variations in chemical composition, especially in CP content, but only negligible differences in their *in vitro* fermentation. Fermentation pattern of COC was similar to that of barley straw, but COC showed greater fermentation rates. Crude olive cake could be used in ruminant diets replacing fibrous feeds with low nutritional value, being an interesting alternative due to their high content in unsaturated fatty acids, which may improve the quality of animal products. The two commercial olive extracts tested in this study presented different ruminal fermentation patterns.

Acknowledgments

This work was supported by the Spanish Ministry of Economy and Competitiveness (Projects AGL2016-75322-C2-1-R, AGL2016-75322-C2-2-R and AGL2014-56653-C3-1-R) and the Junta de Andalucía (Project P12AGR-587). We gratefully thank Dr. Fernando Bacha for providing the crude olive cake samples.

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Feed restriction in early life modifies the colonic epimural bacterial community and feed efficiency traits during the fattening period of merino lambs

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Abstract. Bacteria firmly attached to the gastrointestinal epithelium during early life show a significant impact on nutrient processing, immune-stimulation, health and feed efficiency traits during the entire life of lambs. Thus, the aim of the present study was to describe the changes in the colonic epimural bacterial community of fattening lambs promoted by different levels of nutrition during the suckling phase trying to shed some light on the underlying mechanisms behind different feed efficiency traits. Twenty four merino lambs (average LBW 4.81 ± 0.256 kg) were used, twelve of them (*ad libitum*, ADL) being kept permanently with the dams whereas the other group (restricted, RES) was separated periodically from the dams and milk restricted. After weaning all the animals were penned individually, offered the same complete pelleted diet at a restricted level (35 g/kg LBW to ensure no differences of dry matter intake) and slaughtered with a target body weight of 27 kg. During the fattening period, lower gain:feed ratio (0.320 vs. 0.261, $P < 0.001$) was observed for the RES group. Additionally, an increment of *Prevotella sp.* was detected in the colonic epimural bacterial community of RES, whereas *Proteobacteria* was decreased. However, the colonic gene expression of toll-like receptors and cytokines (ΔCq), immunohistochemistry parameters (counts of lymphocytes T, B) and IgA levels (pg IgA/µg total protein) were not modified. In conclusion, the level of nutrition during the suckling phase promoted changes in feed efficiency traits and colonic epimural bacterial community that were not related to the immune response at this level.

Keywords. Feed efficiency – Lambs – Colon – Microbiota – Immunity.

Le niveau de nutrition des agneaux d'allaitement modifie la communauté bactérienne epimurale du colon et les traits d'efficacité alimentaire lors de l'engraissement

Résumé. *Les bactéries fermement attachées à l'épithélium gastro-intestinal au début de la vie montrent un impact significatif sur l´utilisation des nutriments, de stimulation immunitaire, de santé et d'efficacité alimentaire pendant toute la vie des agneaux. L'objectif de la présente étude était de décrire les changements dans la communauté bactérienne epimurale du colon d'agneaux d'engraissement promu par différents niveaux de nutrition pendant la phase d'allaitement en essayant de clarifier les mécanismes sous-jacents derrière différents traits d'efficacité alimentaire. Vingt-quatre agneaux mérinos (moyenne LBW 4,81 ± 0,256 kg) ont été utilisés, douze d'entre eux (ad libitum, ADL) étant maintenus en permanence avec les mères tandis que l'autre groupe (restreint, RES) a été séparé périodiquement des mères. Après le sevrage, tous les animaux ont été hébergés individuellement, ont reçu la même ration complète à un niveau restreint (35 g/kg LBW pour éviter toute différence de matière sèche ingérée) et abattu avec un poids corporel moyen de 27 kg. Les agneaux du groupe RES ont montré un taux de conversion inférieur à ceux du groupe ADL (0,32 contre 0,261, P<0,001). En plus, on a détecté une augmentation de* Prevotella sp. *dans la communauté bactérienne epimurale du colon des agneaux du groupe RES, alors que les protéobactéries ont diminué. Cependant, l'expression génique des récepteurs Toll-like et des cytokines (ΔCq) du colon, les paramètres d'immunohistochimie (comptage de lymphocytes T, B) et IgA (pg IgA / µg de protéines totales) n'ont pas été modifiés. En conclusion, le niveau de nutrition pendant la phase d'allaitement a favorisé les changements dans les traits d'efficacité d´alimentation et la communauté bactérienne épimurale du colon qui n'étaient pas liés à la réponse immunitaire à ce niveau.*

Mots-clés. *Efficacité d´alimentation – Agneaux – Colon – Microbiota – Immunité.*

I – Introduction

The Animal Task Force White Paper (2013) has identified improving animal feed efficiency and understanding of the interactions between nutrition, microbiome and immunity in the gut as priorities of research under the Horizon2020 strategy.

The epithelium of the gastrointestinal tract (GIT) is involved in a major part of the immune system and it is well-known that colonization of gut mucosal surfaces can be modulated by nutritional interventions during early life (Taschuk and Griebel, 2012). Moreover, once established, microbiota firmly attached to the GIT mucosa (epimural) seems to be more stable than that associated with GIT contents (Petri *et al*., 2013). Thus, manipulating epimural bacterial community in the first stages of life by nutritional management could promote long-term effects on immune response and/or the efficiency of utilization of nutrients along the whole life of the animals.

The aim of the present study was to assess whether bacterial colonization of colon mucosa is modified by the level of nutrition during the suckling period of merino lambs, hence promoting long-term effects on feed efficiency traits and colonic immune parameters during the fattening period.

II – Material and methods

Twenty four male merino lambs were used in the experiment. The lambs were stratified on the basis of live body weight at birth (average LBW 4.81 ± 0.256 kg), and then assigned randomly to one of two experimental treatments (n=12 per dietary treatment) during the suckling phase. The first group (*ad libitum*, ADL) was kept permanently with the dams, whereas the other (restricted, RES) was separated from the sheep from 9 to 18 h (dams were milked at 17 h and injected with oxytocin to remove alveolar milk). When lambs reached 13.5 kg of LBW they were weaned progressively until they weighed 15 kg. Then, all the animals were penned individually and offered the same complete pelleted diet (CPD) at a restricted level (35 g/kg LBW each day) to avoid differences in dry matter intake (DMI). After a fattening period of at least 50 days, all the animals were slaughtered with a target LBW of 27 kg. Colon tissue samples were collected for microbiological analysis (stored at -80 ºC during 48 h, then freeze-died), gene expression (RNAlater Invitrogen, Lithuania; stored at -80 ºC), IgA quantification (stored at -20 ºC) and immunohistochemistry examination (fixed by immersion in 10% buffered formalin for one week).

The luminal part of the freeze-died colon samples was scraped and microbial DNA purification was performed with the Ultra-Deep Microbiome Prep kit (Molzym, Life Sciences). Samples of microbial DNA were used as templates for T-RFLP analysis according to Andrés *et al*. (2016), but using MspI as restriction enzyme.

Total RNA was extracted from samples and reversed transcribed using QuantiTect Reverse Transcription Kit (Qiagen, Hilden, Germany). The RNA was used as template for qRT-PCR analysis to evaluate the expression of genes encoding 10 bovine toll-like receptors (TLRs), β-defensin and PGLYRP1 in the epithelium using the gene specific primer pairs relative to β-actin expression.

IgA was quantified in colonic mucosa according to the procedure described by Ahmed *et al*. (2015), using a Genorise ELISA IgA kit (Genorise Scientific, Devon-Berwyn, Pensilvania).

Immunohistochemical labelling of T (polyclonal anti-CD3 antibody; Dako, Milan) and B cells (CD20 antigen, ThermoFisher, Madrid) was carried out with cross sections of the colonic wall samples. Quantification was performed in ten random fields within the lamina propria with final magnification of 40×, using image analysis software (ImageJ v1.6.0_14, National Institutes of Health – NIH, USA).

Data were analyzed using GLM procedure (one-way analysis of variance) of SAS (SAS Institute Inc., Cary, NC), with the milk intake level as the only source of variation. Significance was declared at $P < 0.05$. Those data corresponding to T-RFLP were analyzed by principal component analysis (PCA).

III – Results and discussion

Gastrointestinal mucosa is colonized after birth by pioneer microbes and colonization may be manipulated by early feeding management. Once epimural bacterial population is established, it may deeply impact health, feed efficiency and immune response in later stages of life (Taschuk and Griebel, 2012; Petri *et al*., 2013).

The group that was milk restricted showed a lower gain:feed ratio during the fattening period (0.320 vs. 0.261, P<0.001), being DMI similar for both groups (603 vs. 607 g/day, P>0005). Consequently, RES lambs lasted more time during this period (62 vs. 74 days, P<0.001) to reach the intended body weight of slaughter (27 kg of LBW).

Moreover, the different level of milk intake during the suckling period might explain the clusters observed for the ADL and RES groups when the relative height of terminal restriction fragments (TRF) was analyzed by PCA. An increase of genus *Prevotella* (TRF 99 pb; 0.26% vs 1.17% in the ADL and RES lambs, respectively, P=0.052) and a lower abundance of phylum *Proteobacteria* (TRF 140 pb, 11.17% vs 1.89%, P=0.003; and TRF 152 pb, 2.19% vs. 0.47%, P=0.008) were observed in the colonic mucosa of RES lambs when compared to the ADL group. In accordance with these results, *Prevotella* is a genus commonly found in the large intestine which has been reported in greater abundance in the ruminal liquid of inefficient (high Residual Feed Intake, RFI +) bulls (McCann *et al*., 2014) and within the colon content from steers differing in feed efficiency traits (Myer *et al*., 2015). In addition, *Proteobacteria* is a prevalent phylum in the GIT involved in nutrient digestion that has been previously described in lower relative abundance in the jejunum of low efficient steers (Myer *et al*., 2016).

Nevertheless, the colonic mRNA expression of TLRs and cytokines, number of lymphocytes T and B infiltrated in the lamina propria, and IgA levels were not affected by the different suckling regime (P > 0.005) (Table 1). Thus, the aformentioned changes in the colonic epimural bacterial community between RES and ADL lambs did not seem to promote significant differences in the inmmune parameters analyzed at this level.

Table 1. Toll-like receptors (TLRs) mRNA expression, IgA concentration in colonic mucosa and infiltrating lymphocyte counts in colonic lamina propria of fattening lambs being fed *ad libitum* (ADL) or restricted (RES) during the suckling period

	ADL	RES	RSD	P-value
TLR (ΔCq)				
TLR_1	12.5	12.2	2.03	0.792
TLR_2	20.9	19.2	4.97	0.540
TLR_3	13.1	13.6	2.11	0.681
TLR_4	10.7	10.4	1.73	0.763
TLR_5	21.3	20.8	3.04	0.784
TLR_6	10.1	9.82	2.02	0.789
TLR_7	14.3	14.3	2.68	0.992
TLR_8	10.7	11.1	1.94	0.676
TLR_9	15.5	15.9	1.27	0.522
TLR_{10}	14.9	15.6	2.18	0.562
IgA (pg IgA/µg total protein)	27.6	26.6	2.36	0.394
Lymphocytes (number per field 40×)				
B^+	3.50	3.84	1.272	0.522
T^+	138	159	33.34	0.181

[1] Cq = quantification cycle. ΔCq = Cq (TLR) – Cq (*β*-actin). A smaller ΔCq value represents higher mRNA abundance level.

IV – Conclusions

The results of the present study suggest that early feed restriction during the suckling phase of merino lambs affected feed efficiency and promoted differences in the establishment of the colonic epimural bacterial community, with increased relative abundance of genus *Prevotella* and decreased presence of phylum *Proteobacteria* in milk restricted lambs. However, these modifications could not be associated with differences at local immune response.

Acknowledgements

Financial support was received from the Spanish Ministry of Economy, Industry and Competitiveness (MINECO, AGL2014-54124R) and CSIC (Proyecto Intramural Especial; Project 201540E084).

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Diet supplementation with a high dose of stearic acid to alleviate fish oil-induced milk fat depression in lactating ewes

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Abstract. Despite the benefits of using marine lipid supplements in dairy ewe diets to modulate milk fatty acid (FA) composition, this strategy causes milk fat depression (MFD), which precludes its use under farm conditions. This MFD is attributed to an impaired capacity of the mammary gland to achieve an adequate melting point for milk fat secretion. This alteration of fluidity has been linked to a shortage of available ruminal 18:0 caused by the consumption of marine lipids. However, in a previous study, we were not able to prevent the effects of fish oil supplementation through concomitant dietary addition of stearic acid (2% DM). Yet, before ruling out a mechanism based on milk fat fluidity, we decided to try with a higher dose of 18:0. Thus, this assay was conducted with 12 lactating ewes divided in 3 treatments that lasted for 4 weeks: a total mixed ration without lipid supplementation (control) or supplemented with 20 g/kg DM of fish oil alone (FO) or in combination with 40g/kg DM of 18:0 (FOSA-4). As expected, FO supplementation modified milk FA composition towards a healthier profile for consumers but, at the same time, reduced milk fat concentration. This MFD was not alleviated by the dietary addition of 4% 18:0 (FOSA-4). Depression of milk fat is discussed in relation to milk FA composition, particularly to the concentration of main metabolites responsible for changes in the melting point and fluidity of fat (i.e., 18:0 and *cis*-9 18:1).

Keywords. Fat fluidity – Fatty acid composition – Marine lipid – Ruminant nutrition – Sheep.

Supplémentation du régime avec une dose élevée d'acide stéarique pour pallier la chute du taux butyreux du lait induite par l'huile de poisson chez des brebis laitières

Résumé. *Malgré les avantages de l'introduction des huiles marines dans les régimes des brebis laitières pour moduler la composition en acides gras (AG) du lait, cette stratégie provoque une chute du taux butyreux (connu sous le nom de «* milk fat depression *» ; MFD). Ce MFD est attribué à une altération de la capacité de la glande mammaire d'atteindre un point de fusion adéquat pour sécréter des matières grasses du lait. Cette modification de la fluidité a été liée à une faible disponibilité de l'acide grasl 18:0 au niveau du rumen, causée par l'ingestion des lipides marins. Cependant, dans une étude antérieure, nous n'avons pas réussi à pallier les effets de la supplémentation du régime avec de l'huile de poisson par l'addition simultanée d'acide stéarique (2% de la matière sèche ; MS). Pourtant, avant d'exclure un mécanisme basé sur la fluidité des matières grasses du lait, nous avons décidé d'essayer avec une dose plus élevée de 18:0. Ainsi, cet essai a été effectué avec 12 brebis en lactation divisées en 3 traitements de 4 semaines de duration: une ration mixte complète sans supplémentation lipidique (témoin) ou supplémentée avec 20 g/kg MS d'huile de poisson seule (FO) ou en combinaison avec 40 g/kg MS du 18:0(FOSA-4). Comme prévu, le régime FO a modifié la composition en AG du lait vers un profil plus sain pour les consommateurs, mais, en même temps, il a induit une diminution de la teneur en matières grasses du lait. Cette MFD n'a pas été atténuée par l'addition du 4% 18:0 (FOSA-4). La chute du taux butyreux du lait est discutée par rapport à la composition en AG du lait, en particulier à la concentration des principaux métabolites responsables des modifications du point de fusion et de la fluidité du gras du lait (i.e., 18:0 et* cis*-9 18:1).*

Mots-clés. *Fluidité des matières grasses – Composition en acides gras – Nutrition des ruminants – Mouton.*

I – Introduction

Despite the benefits of including marine lipids in dairy ewe diets to modulate milk fatty acid (FA) composition towards a healthier profile for consumers, this strategy causes milk fat depression (MFD; Shingfield *et al.*, 2010; Carreño *et al.*, 2016; Toral *et al.*, 2017), which precludes its use under farm conditions.

Several theories explaining the origin of MFD have been proposed and subsequently found inadequate or incomplete (Bauman and Griinari, 2001; Shingfield and Griinari, 2007). The Biohydrogenation (BH) theory proposed by Bauman and Griinari (2001) establishes that MFD relates to an inhibition of mammary lipogenesis by specific BH intermediates that are produced under certain feeding conditions that alter rumen function. A second theory trying to explain more specifically the marine lipid-induced MFD suggests that a shortage of 18:0 for *cis*-9 18:1 synthesis in the mammary gland, would have a negative impact on the maintenance of milk fat fluidity and, consequently, on the rate of milk fat secretion, causing this syndrome (Chilliard *et al.*, 2007; Shingfield and Griinari, 2007).

However, in a previous dedicated study with lactating ewes (Toral *et al.*, 2016), we had to reject the hypothesis that the negative effects of fish oil supplementation (2% DM) would be prevented through concomitant addition of stearic acid (SA; 2% DM) to the diet. Although reductions in milk 18:0 and *cis*-9 18:1 concentration were partially reversed, supplementation with stearic acid did not prove useful to alleviate MFD. Yet, before ruling out a mechanism based on decreased ruminal production of 18:0 and subsequent alterations of milk fat fluidity, we decided to conduct this new assay with a higher dose of 18:0 (namely, 4% DM).

II – Material and methods

Twelve lactating Assaf ewes (79.0 ± 2.94 kg of body weight; 83.4 ± 2.65 days in milk at the beginning of the assay) were allocated to one of 3 groups (n = 4) balanced for milk production and composition, body weight, and days in milk. Dietary treatments consisted of a total mixed ration (TMR) containing no additional lipid (control) or 2% DM of fish oil (Afampes 121 DHA; Afamsa, Mos, Spain) alone (FO) or in combination (FOSA-4) with 4% DM of 18:0 (Edenor C18 98-100; Oleo Solutions, York, UK). The TMR was formulated (g/kg) from dehydrated alfalfa hay (400), whole maize (180) and barley (130) grains, soybean meal (150), beet pulp (70), molasses (50), and mineral and vitamin supplements (20) and was fed to the ewes for 27 days. Before that, all animals received the control TMR during 3 weeks. Diets were offered *ad libitum* twice daily, at about 9:30 and 18:30 h and clean drinking water was always available. Ewes were milked at approx. 9 and 18 h in a 1 × 10 stall milking parlor (DeLaval, Madrid, Spain).

On days 25, 26 and 27, milk yield was recorded and individual milk samples were collected and composited according to morning and evening milk yield. One aliquot of composite milk was preserved with bronopol and stored at 4°C until analyzed for fat concentration by infrared spectrophotometry (ISO 9622:1999). Another aliquot was untreated and stored at " 30°C until FA composition determinations.

Lipid in 1 mL of milk was extracted and converted to FA methyl esters (FAME) by base catalyzed transesterification (Shingfield *et al.*, 2003). The total FAME profile was determined using a gas chromatograph (Agilent 7890A GC System, Santa Clara, USA) equipped with a flame-ionization detector and a 100-m fused silica capillary column (CP-SIL 88, Varian Iberica, Madrid, Spain). Total FAME profile was determined using the temperature gradient program described in Shingfield *et al.* (2003). Isomers of 18:1 were further resolved in a separate analysis under isothermal conditions at 170°C (Shingfield *et al*., 2003). As outlined previously (e.g., Toral *et al.*, 2016), peaks were identified based on retention time comparisons with commercial standard FAME mixtures and ref-

erence samples for which the FA composition was determined based on GC analysis of FAME and GC-MS analysis of corresponding 4,4-dimethyloxazoline derivatives.

All data were evaluated by one-way ANOVA using the MIXED procedure of SAS (version 9.4; SAS Institute Inc., Cary, NC, USA) with a model that included the fixed effect of treatment. Means were separated through the 'pdiff' option of the 'lsmeans' statement. Differences were declared significant at $P<0.05$.

III – Results and discussion

As expected, supplementation with FO modulated milk FA composition towards a profile potentially healthier for the consumer (Table 1; Chilliard *et al*., 2007). For instance, it increased the concentration of *cis*-9 *trans*-11 CLA, very long chain n-3 FA (e.g., EPA, DPA y DHA) or total polyunsaturated FA (PUFA). These changes were not only observed for FO alone, but also for FOSA-4 and agree with previous reports (Carreño *et al.*, 2016; Toral *et al.*, 2016).

At the same time, following the experiment design, diet supplementation with FO caused MFD (Carreño *et al.*, 2016; Toral *et al.*, 2017), which was characterized by a significant lower milk fat concentration in ewes on this treatment compared to those on the control. Fat production (g/day) was not significantly reduced due to the numerical (although not statistically significant) higher milk production in these animals. Very similar results were observed in ewes fed the FOSA-4 diet, showing that addition of 4% SA was not able to reverse the effect of FO. In fact, when compared to the control, decreases in milk fat concentration reached 19% in FO and 27% in FOSA-4.

TThe FO-induced MFD has been linked to a shortage of available 18:0, caused by the inhibition of the last step of ruminal BH and, consequently, a lower mammary endogenous synthesis of *cis*-9 18:1. This latter FA has a low melting point that contributes to maintain milk fat melting point below body temperature and ensure milk fat fluidity and secretion (Chilliard *et al.*, 2007; Shingfield *et al.*, 2010). In this assay, the decrease in *cis*-9 18:1 proportion due to FO was not completely reverted by FOSA-4 but its value (11.28%) was relatively close to that of the control (12.53%). However, the concentration of 18:0 fell more severely with FO (1.36%) and was still much lower in FOSA-4 (5.42%) than in control (7.18%).

The reasons underlying the lack of response to dietary 18:0 are still uncertain but may be related to the effects of a high dose of SA: a low digestibility of this FA (Boerman *et al.*, 2017) or alterations of rumen metabolism, as suggested, for example, by large increments in *trans*-10 18:1. Poor mammary uptake might also be involved (Enjalbert *et al.*, 1998). In any event, mechanisms linked to milk fat fluidity cannot be completely ruled out because this study, as well as most others, was conducted on milk fat that was successfully secreted but triacylglycerols with high melting point might accumulate in mammary epithelial cells and inhibit lipogenesis (Toral *et al.*, 2016).

As previously suspected (Toral *et al.*, 2016), results point again to the BH theory, with a significant contribution of some FA produced in the rumen to MFD. In line with this, some potentially antilipogenic FA (e.g., *trans*-10 18:1, *trans*-9 *cis*-11 CLA, and *trans*-10 *cis*-15 18:2; Shingfield and Griinari, 2007; Alves and Bessa, 2014) were remarkably increased in both FO and FOSA-4.

Table 1. Milk yield, fat concentration and yield, and composition of selected FA in milk in dairy ewes fed a total mixed ration without lipid supplementation (Control) or supplemented with 2% DM of fish oil alone (FO) or in combination with 4% of 18:0 (FOSA-4)

	Diet				
	Control	FO	FOSA-4	s.e.d.	*P*-value
Milk yield (g/d)	2133	2559	2548	378.3	0.4696
Fat (%)	5.99[a]	4.84[b]	4.35[b]	0.411	0.0089
Fat yield (g/d)	126.6	121.4	109.7	13.32	0.4624
Milk FA composition (g/100 g FA)					
18:0	7.18[a]	1.36[c]	5.42[b]	0.461	<.0001
cis-9 18:1	12.53[a]	5.91[c]	11.28[b]	0.479	<.0001
trans-10 18:1	0.36[c]	3.12[b]	5.48[a]	0.984	0.0019
trans-11 18:1	0.84[b]	3.78[a]	1.96[b]	0.663	0.0052
cis-9 *trans*-11 CLA	0.47[b]	1.88[a]	1.02[b]	0.311	0.0046
trans-9 *cis*-11 CLA	0.016[b]	0.075[a]	0.097[a]	0.0149	0.0012
trans-10 *cis*-12 CLA	0.006[b]	0.006[b]	0.010[a]	0.0013	0.0178
trans-11 *cis*-15 + *trans*-10 *cis*-15 18:2	0.04[b]	0.44[a]	0.49[a]	0.057	<.0001
20:5n-3 (EPA)	0.05[b]	0.37[a]	0.42[a]	0.048	<.0001
22:5n-3 (DPA)	0.09[b]	0.39[a]	0.47[a]	0.059	0.0003
22:6n-3 (DHA)	0.03[b]	1.10[a]	1.37[a]	0.173	<.0001
Total PUFA	5.10[b]	9.26[a]	9.03[a]	0.595	<.0001

s.e.d. = standard error of the difference.

[a-c] Different superscripts within a row indicate differences at $P<0.05$.

IV – Conclusion

Addition of stearic acid to the diet of lactating ewes (4% DM) was not able to alleviate the milk fat depression caused by the concomitant supplementation with fish oil (2% DM; strategy used to improve milk fatty acid profile). This lack of effect does not allow to accept the hypothesis suggesting that fish oil-induced MFD is mainly explained by decreased ruminal production of 18:0 and subsequent problems of milk fat fluidity.

Acknowledgments

P.G. Toral received a *Ramón y Cajal* contract from the Spanish Ministry of Economy, Industry and Competitiveness.

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Feeding behaviour, intake, apparent digestibility and plasma metabolites of Latxa dairy ewes as affected by cold-pressed oilseed cakes and sainfoin

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Abstract. The hypothesis tested was that the tanniferous forage sainfoin, given as hay, has an advantage over a typical fescue in dairy ewes with respect to intake, ruminal fermentation and ingestive behaviour when cold pressed oilseed cakes rich in crude fat are formulated in the concentrate. A lactation trial was carried out with 72 blackfaced Latxa dairy ewes at early lactation in a 2 x 3 factorial arrangement involving two forages (fescue and sainfoin hay) and 3 experimental concentrates. Concentrates were formulated to contain cold-pressed rapeseed cake, cold-preseed sunflower cake or palm as fat sources and to provide equal amounts of crude protein fat and energy. No interactions between concentrate and forage were observed. None of the measured traits was affected by concentrate. However, feeding sainfoin increased forage eating time (356 vs. 279 min/d, P<0.001), reduced rumination time (325 vs. 422 min/d, P<0.001), increased forage dry matter intake (1.84 vs. 0.99 kg/d, P<0.001), apparent organic matter digestibility (613 vs. 580 g/kg, P = 0.011) and IGF-1 plasma concentration (110.7 vs. 98.6 ng/ml, P = 0.014). In conclusion, cold pressed oilseed cakes can be used as feedstuffs regardless of the forage used.

Keywords. Tannins – Rapeseed – Sunflower.

Comportement alimentaire, ingestion, digestibilité apparente et métabolites plasmiques des brebis laitières Latxa affectées par les tourteaux d'oléagineux pressés à froid et le sainfoin

Résumé. *L'hypothèse testée était que le sainfoin, donné comme du foin, a un avantage sur une fétuque chez les brebis laitières par rapport à la ingestion, la fermentation ruminal et au comportement ingestif lorsque des tourteax d'oléagineux pressés à froid riche en graisse brute sont formulés dans le concentré. Un essai de lactation a été mené avec 72 brebis laitières au début de l'allaitement dans un arrangement factoriel 2 x 3 impliquant deux fourrages (fétuque et sainfoin) et 3 concentrés expérimentaux. Les concentrés ont été formulés pour contenir tourteau de colza, tournesol ou palme comme sources de graisse, et pour fournir des quantités égales de graisse, de protéines brutes et d'énergie. Aucune interaction entre le concentré et le fourrage n'a été observée. Aucun des caractères mesurés n'a été affecté par le concentré. Cependant, sainfoin a augmenté le temps d'ingestion (356 vs. 279 min/d, P<0.001), a réduit le temps de rumination* (325 vs. 422 min/d, P<0.001), *a augmenté l'ingestion de fourrage* (1.84 vs. 0.99 kg/d, P<0.001), la digestibilité *apparente (613 vs. 580 g/kg, P = 0.011), la concentration plasmatique d'IGF-1 (110.7 vs. 98.6 ng/ml, P = 0.014). En conclusion, les tourteaux d'oléagineux pressés à froid peuvent être utilisés comme aliments pour LES animaux quel que soit le fourrage utilisé.*

Mots-clés. *Tanin – Colza – Tournesol.*

I – Introduction

Cold-pressed oilseed cake (CPOC) is a cheap by-product of oil-manufacturing. It is widespread in the European area and it can be obtained on-farm after simple mechanical extraction of the oil from the seeds. CPOC has been shown to have higher crude fat content than those of conventional solvent and expeller meals (up to 230 g kg^{-1} compared to 30 and 100 g kg^{-1}, respectively,

Benhissi *et al*., 2014) which make it an attractive energetic feedstuff for livestock. Sainfoin (*Onobrychis viciifolia*) is a temperate forage legume which has a moderate to high content of condensed tannins (Scharenberg *et al*., 2007). Condensed tannins are known to alter rumen microflora activity, inhibiting the last step of rumen biohydrogenation (Vasta *et al*., 2009). The hypothesis tested was that sainfoin, given as hay, has an advantage over a typical fescue in dairy ewes with respect to intake ruminal fermentation and ingestive behaviour when cold pressed oilseed cakes rich in crude fat are formulated in the concentrate.

II – Material and methods

The experiment was carried out in accordance with Spanish Royal Decree 53/2013 for the protection of animals used for experimental and other scientific purposes.

1. Animals and experimental diets

The trial was carried out at the Neiker-Tecnalia experiment station. A lactation trial utilized 72 black-faced Latxa dairy ewes at early lactation in a 2 x 3 factorial arrangement involving two forages (fescue and sainfoin hay) and 3 experimental concentrates. Concentrates were formulated to contain cold-pressed rapeseed cake (RPS), cold-preseed sunflower cake (SUN) or palm (CTR) as fat sources. Concentrates were formulated to provide equal amounts of crude protein (CP), energy and fat. Ingredients of experimental concentrates and forages are shown in Table 1. Ewes were divided into 6 equilibrated groups of 12 ewes each, according to milk yield (2094 ± 520 ml) and days in milk (15 ± 8 d postpartum). The experimental concentrates were offered in individual feeders in the milking parlour as two equal meals (450 g DM) during the morning and evening milkings. Tall fescue (*Festuca arundinacea*) hay or sainfoin hay was group fed *ad libitum* in a feed bunk and water. The quantity of offered fescue or sainfoin hay was based on morning bunk readings, and the amount of feed offered was adjusted daily to allow 10% refusals. The experimental period lasted for 56 d, of which the first 7 d were for covariate determinations, the following 7 d were for treatment adaptation to experimental concentrates, and the last 42 d for measurements and samplings.

2. Measurements and samplings

Quantities of concentrate offered and refused were recorded 7 d/wk on an individual basis throughout the experiment. Individual forage hay dry matter intake (DMI) and diet organic matter apparent digestibility (OMD) were estimated using two markers. Acid insoluble ash (AIA) was used as an internal marker and chromium sesquioxide (Cr_2O_3) as an external. Beginning on d 29 ewes received, during 10 days, twice daily, at 07.30 h and 18.00 h, one gram of Cr2O3, stored in gelatin capsules, and placed directly in the esophagus with an esophageal tube.

Animal behaviour data were recorded for 48-hr observations beginning on d 39 and finishing on 41. The measurement period commenced at 9:20 am and the ewes were kept under observation by one observer. Eating, ruminating, and other activities of the 72 animals were recorded. The actual behavioral observations were recorded at 10-min intervals. The total time spent in a given behaviour was calculated on the assumption that the animal observed in a particular behaviour pattern remained in that pattern until the next observation. Behaviour activities were averaged by ewe.

Blood samples (10 mL) were collected on d 55, 2 h after morning milk feeding via jugular venipuncture into plain vacutainers without anticoagulants (Becton & Dickinson USA). Once collected, blood samples were centrifuged (2800 × g for 10 min at 4°C), and plasma was recovered and frozen at -20°C for non esterified fatty acids (NEFA**)**, blood urea nitrogen (BUN) and IGF-1.

Table 1. Ingredients and chemical composition (g kg^{-1} DM) of experimental concentrates (CTR: control; SUN: sunflower; RPS: rapeseed), sainfoin (SAIN) and fescue (FES) hay

Item	Concentrate			Hay	
	CTR	SUN	RPS	SAIN	FES
Ingredients					
Cold pressed rapeseed cake	0	0	400		
Cold pressed sunflower cake	0	560	0		
Soybean meal	150	0	0		
Barley	160	150	360		
Corn	180	210	100		
Oats	200	0	0		
Molasses	50	50	50		
DDGs	150	0	60		
Hydrogenated palm fat	80	0	0		
Vitamin-mineral premix*	30	30	30		
Chemical composition					
Dry matter	904	902	901	897	905
Organic matter	847	833	862	903	919
Crude protein	185	180	180	139	117
Neutral detergent fibre	201	286	196	375	594
Acid detergent fibre	53	200	123	254	285
Fat	107	108	109	18	19
Starch	338	267	302	43	0
UF	1.1	1.1	1.1		

CON: concentrate, FOR: forage, CTR: control, SUN: sunflower, RPS: rapeseed, FES: fescue hay, SAIN: sainfoin hay,*Vitamin and mineral premix contained per kg of DM: 2500 IU of vitamin A, 400 mg of vitamin D, 2.5 IU of vitamin E, 4.9 mg of Zn, 4.05 mg of Mn and 0.1 mg of Se (Calseaphos, Saint Malo, France).

3. Statistical analyses

Each dairy ewe was considered as the experimental unit. Total, hay and concentrate DMI, OMD, plasma concentrations and milk fatty acid profile (n = 72) were analysed using the GLM procedure. The statistical model included fixed effects of concentrate (CON), forage (FOR), their interaction and the initial record measured at week 0 (covariate). Ingestive behaviour was analysed using the previous statistical model but without including a covariate. Least squares means for treatments are reported. Treatment means were separated using a Tukey test.

III – Results and discussion

Concentrate affected neither DMI nor OMD of the diet, but forage significantly affected these traits. In this sense, SAIN increased total DMI (2.75 vs. 1.90 kg, P<0.001), forage DMI (fDMI) (1.84 vs. 0.99 kg, P<0.001) and OMD (613 vs. 580 g kg-1, P<0.001) compared to FES.

Feeding behaviour data can be seen on Table 5. No interactions between concentrate and forage were observed for any of these traits. Concentrate did not affect feeding behaviour. However, feeding SAIN increased forage eating time (356 *vs.* 279 min day^{-1}, P<0.001), while reduced rumination time (325 *vs.* 422 min day^{-1}, P<0.001) compared to FES.

Mean effects on plasma metabolites can be seen on Table 4. No interactions between concentrate and forage were observed for any of these traits. Similarly, plasma metabolites were not affected by concentrate or forage except for IGF-1 concentrations that were increased with SAIN (110.7 *vs.* 98.6 ng mL^{-1}, P = 0.014) compared to FES.

The increased OMD and changes observed in feeding behaviour in animals fed SAIN, with an increased forage eating time and a reduced rumination time could also explain increases observed in DMI. Our results agree with those of some authors who have reported no detrimental effect of SAIN on OMD (Theodoridou *et al*., 2010). Moreover, higher DMI and OMD could lead to increased energy available for microbial protein synthesis. The Higher IGF-1 plasma concentration observed with SAIN agrees with the latter, since protein is a crucial nutritional factor to regulate hepatic IGF-1 expression and secretion (Wan *et al*., 2017).

Table 2. Mean effects of feeding concentrate (CTR, SUN, RPS) and forage (FES, SAIN) on milk productive performance, intake, apparent digestibility (OMD) and plasma metabolites of lactating ewes

Item	FES			SAIN			SEM	P-value		
	CTR	SUN	RPS	CTR	SUN	RPS		CON	FOR	CONx FOR
Feeding behaviour (min day^{-1})										
Forage intake	284	253	278	344	350	356	9.6	0.072	<0.001	0.441
Rumination	397	422	450	280	359	337	20.9	0.167	<0.001	0.653
Chewing	710	706	773	654	738	735	26.1	0.202	0.536	0.498
Laying	730	734	667	786	702	705	26.2	0.203	0.528	0.510
Intake (kg day^{-1})										
DMI	1.86	1.83	2.00	2.70	2.74	2.80	0.360	0.386	<0.001	0.851
fDMI	0.96	0.92	1.11	1.79	1.83	1.90	0.360	0.347	<0.001	0.851
OMD (g kg^{-1})	583.5	584.7	572.8	602.7	590.7	645.5	52.7	0.347	0.011	0.075
Plasma metabolites										
IGF-1 (ng mL^{-1})	100.3	95.3	100.1	114.3	119.2	98.7	3.62	0.304	0.014	0.099
NEFA (mmol L^{-1})	0.216	0.247	0.228	0.215	0.225	0.223	0.007	0.197	0.294	0.583
BUN (mg dL^{-1})	19.8	20.3	19.6	22.8	19.4	17.8	1.32	0.464	0.961	0.504

CON: concentrate, FOR: forage, CTR: control, SUN: sunflower, RPS: rapeseed, FES: fescue hay, SAIN: sainfoin hay, DMI: dry matter intake, fDMI: forage DMI, IGF-1: insulin growth factor 1, NEFA: non-esterified fatty acids, BUN: blood urea nitrogen, SEM: standard error of the mean.

IV – Conclusions

Our data show that CPOCs nor SAIN had a detrimental effect on digestibility, intake or feeding behaviour. As a consequence, cold pressed oilseed cakes can be used as feedstuffs regardless of the forage used.

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Production performance and milk fatty acid profile as affected by cold-pressed oilseed cakes and sainfoin in Latxa dairy ewes

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Abstract. A lactation study utilizing 72 dairy ewes was performed to determine effects of cold-pressed oilseed cakes (CPOC), including cold-pressed sunflower cake and cold-pressed rapeseed cake, and their interaction with tanniferous sainfoin hay, on production performance and milk fatty acid profile. A 2 x 3 factorial arrangement involving two forages (fescue and sainfoin hay) and 3 experimental concentrates was used. Concentrates were formulated to contain cold-pressed rapeseed cake (RPS), cold-preseed sunflower cake (SUN) or palm (CTR) as fat sources and to provide equal amounts of crude protein fat and energy. SUN reduced milk total saturated fatty acids (SFA) compared to CTR with both non-tanniferous (FES) and tanniferous (SAIN) forages, while RPS only reduced SFA with SAIN. Polyunsaturated fatty acids were increased with SUN and RPS and SAIN. SUN increased n6:n3 ratio compared to CTR (+54%) and RPS (+62%) and SAIN reduced this ratio compared to FES (-27%). Concentrate did not affect milk production. In conclusion, healthier milk can be obtained with CPOCs. Nevertheless the forage used in the ration seems to be of great importance.

Keywords. Tannins – Rapeseed – Sunflower.

La production et le profil d'acide gras du lait affecté par les tourteaux d'oléagineux pressés à froid et le sainfoin

Résumé. *Un essai de lactation a été mené avec 72 brebis laitières au début de l'allaitement dans un arrangement factoriel 2 x 3 impliquant deux fourrages (fétuque et sainfoin) et 3 concentrés expérimentaux. Les concentrés ont été formulés pour contenir tourteau de colza, tournesol ou palme comme sources de graisse, et pour fournir des quantités égales de graisse, de protéines brutes et d'énergie. Le tournesol a réduit les acides gras saturés par rapport au CTR avec des fourrages non tannifères (FES) et tannifères (SAIN), alors que le colza n'a réduit que le SFA avec le SAIN. Les acides gras polyinsaturés ont été augmentés avec SUN et RPS et SAIN. Le tournesol a augmenté le ratio n6: n3 par rapport à CTR (+54%) et RPS (+ 62%) et SAIN a réduit ce rapport par rapport au FES (-27%). Le concentré n'a pas affecté la production laitière. En conclusion, un lait plus sain peut être obtenu avec les CPOC. Néanmoins, le fourrage utilisé dans la ration semble être d'une grande importance.*

Mots-clés. *Tanin – Colza – Tournesol.*

I – Introduction

For over half a century, the concept of healthy eating has been synonymous with reducing fat. A low saturated fat diet remained at the heart of public nutritional recommendation for decreasing low-density lipoprotein, blood cholesterol and lowering the consequent risk of coronary heart disease. Within this context, it is not surprising that sheep milk, containing up to 76% of the total fatty acid (FA) as saturated, has been widely perceived to be detrimental to human health.

Therefore, in these last years a significant research effort has been directed towards modifying milk fat composition in order to increase the concentration of FA with positive effects in human health. In this context, numerous studies have shown that the diet is the most important factor influenc-

ing this trait. New ways of supplementary feeding, searching for synergies between feed components, might help to respond to these challenges.

Cold-pressed oilseed cake (CPOC) is a cheap by-product of oil-manufacturing. It is widespread in the European area and it can be obtained on-farm after simple mechanical extraction of the oil from the seeds. CPOC has been shown to have higher crude fat content than those of conventional solvent and expeller meals (up to 230 g kg^{-1} compared to 30 and 100 g kg^{-1}, respectively, Amores *et al*., 2014) which make it an attractive energetic feedstuff for livestock. Sainfoin (*Onobrychis vicifolia*) is a temperate forage legume which has a moderate to high content of condensed tannins (Theodoridou *et al*., 2010). Condensed tannins are known to alter rumen microflora activity, inhibiting the last step of rumen biohydrogenation (Vasta *et al*., 2009).

Therefore, we hypothesize first that feeding ewes on concentrates rich in UFA has an advantage over the typical saturated FA-rich concentrate that contain palm fat, in modifying milk FA profile towards a healthier product. Second, we also hypothesize that tanniferous sainfoin hay may reduce ruminal BH of UFA, modifying to higher degree milk FA profile.

II – Material and methods

The experiment was carried out in accordance with Spanish Royal Decree 53/2013 for the protection of animals used for experimental and other scientific purposes.

1. Animals and experimental diets

The trial was carried out at the Neiker-Tecnalia experiment station. A lactation trial utilized 72 black-faced Latxa dairy ewes at early lactation in a 2 x 3 factorial arrangement involving two forages (fescue and sainfoin hay) and 3 experimental concentrates. Concentrates were formulated to contain cold-pressed rapeseed cake (RPS), cold-preseed sunflower cake (SUN) or palm (CTR) as fat sources. Concentrates were formulated to provide equal amounts of crude protein (CP), energy and fat. Ingredients of experimental concentrates and forages are shown in Table 1.

Table 1. Ingredients and chemical composition (g kg^{-1} DM) of experimental concentrates

Item	Concentrate		
	CTR	SUN	RPS
Ingredients			
Cold pressed rapeseed cake	0	0	400
Cold pressed sunflower cake	0	560	0
Soybean meal	150	0	0
Barley	160	150	360
Corn	180	210	100
Oats	200	0	0
Molasses	50	50	50
DDGs	150	0	60
Hydrogenated palm fat	80	0	0
Vitamin-mineral premix*	30	30	30

CTR: control, SUN: sunflower, RPS: rapeseed, *Vitamin and mineral premix contained per kg of DM: 2500 IU of vitamin A, 400 mg of vitamin D, 2.5 IU of vitamin E, 4.9 mg of Zn, 4.05 mg of Mn and 0.1 mg of Se (Calseaphos, Saint Malo, France).

Ewes were divided into 6 equilibrated groups of 12 ewes each, according to milk yield (2094 ± 520 ml) and days in milk (15 ± 8 d postpartum). The experimental concentrates were offered in individual feeders in the milking parlour as two equal meals (450 g DM) during the morning and evening milkings. Tall fescue (*Festuca arundinacea*) hay or sainfoin hay was group fed *ad libitum* in a feed bunk and water.

2. Measurements and samplings

The experimental period lasted for 56 d, of which the first 7 d were for covariate determinations; the following 7 d were for treatment adaptation to experimental concentrates, and the last 42 d for measurements and samplings. Ewes were milked daily at 0730 and 1800 h, and milk yield was recorded individually 7 d wk^{-1}. On d-18, 25, 31, 40 and 44, an individual sample of milk was taken and stored with potassium bichromate (0.3 g L^{-1}) at 4ºC for fat, protein, and lactose analysis. On d-54, individual milk samples were collected and a composite sample per animal (am and pm milkings) was stored and preserved at -20ºC for FA composition analysis.

3. Statistical analyses

Data (n=72) was analysed using the GLM procedure. The statistical model included fixed effects of CON, FOR, their interaction and the initial record measured at week 0 (covariate). Milk production treatment means were separated using a Tukey test and for milk FA profile Bonferroni adjustment was used.

III – Results and discussion

Mean effects on milk productive performance and fatty acid profile can be seen on Table 2.

Table 2. Mean effects of feeding concentrate and forage on milk productive performance and fatty acid profile

Item	FES			SAIN			SEM	P-value		
	CTR	SUN	RPS	CTR	SUN	RPS		CON	FOR	CONx FOR
Yield (g day^{-1})										
Milk	1911	2085	1998	2300	2413	2421	93.1	0.581	0.001	0.945
6.5% FCM	1794	1763	1865	2109	2200	2025	91.5	0.912	<0.001	0.317
Fat	116	114	122	144	144	131	4.6	0.895	<0.001	0.257
Protein	82	86	90	98	107	101	2.7	0.213	<0.001	0.510
Lactose	98	100	104	115	123	118	3.3	0.572	<0.001	0.682
Milk composition (g kg^{-1})										
Fat	61.6	59.6	61.4	64.4	59.6	57.5	1.11	0.064	0.786	0.140
Protein	42.8	43.7	44.3	43.5	45.5	44.6	0.32	0.006	0.025	0.269
Lactose	51.2	51.1	50.6	51.0	51.8	51.8	0.19	0.413	0.018	0.734
Milk fatty acid profile (g kg-1 FA)										
∑ SFA	664.2^{a}	567.3^{b}	633.3^{a}	715.3^{a}	627.9^{b}	627.8^{b}	25.06	<0.001	<0.001	0.006
∑ MUFA	297.1^{b}	341.5^{a}	314.1^{ab}	233.1^{b}	255.4^{b}	299.0^{a}	22.21	<0.001	<0.001	0.002
∑ c MUFA	260.0	267.3	257.0	187.4^{b}	192.4^{b}	229.5^{a}	20.03	0.066	<0.001	0.010
∑ t MUFA	37.1^{c}	74.2^{a}	57.1^{b}	45.7^{b}	63.0^{ab}	69.4^{a}	9.74	<0.001	0.328	0.013
∑ PUFA	32.6	83.4	44.9	47.5	111.4	68.3	6.95	<0.001	<0.001	0.083
∑ CLA	7.5^{b}	18.7^{a}	9.1^{b}	6.9^{b}	12.1^{a}	10.1^{ab}	2.22	<0.001	0.009	<0.001
n6:n3	2.85	5.99	2.14	1.83	4.10	1.77	0.9035	<0.001	0.001	0.139

CON: concentrate, FOR: forage, CTR: control, SUN: sunflower, RPS: rapeseed, FES: fescue hay, SAIN: sainfoin hay, 6.5%FCM: fat corrected milk, SEM: standard error of the mean.

The lack of detrimental effects on animal production parameters or milk yield due to CPOCs supplementation agrees with other studies (Amores *et al*., 2014). The higher forage eating time concomitant with a reduced rumination time, increased DMI and OMD in animals fed SAIN (Garcia-Rodriguez *et al*., 2017) could have led to increased energy available for microbial protein synthesis and milk production. Higher IGF-1 plasma concentration observed with SAIN (Garcia-Rodriguez *et al*., 2017) agrees with the latter, since protein is a crucial nutritional factor to regulate hepatic IGF-1 expression and secretion (Wan *et al*., 2017) and IGF-1 stimulates milk production (Cohick 1998).

Nutritional strategies that reduce ruminal BH of dietary PUFA and MUFA could be the key to improve milk quality with respect to human requirements. In this sense, the results of this study indicate that the potential of feeding CPOCs for increasing the content of naturally occurring bioactive FA in milk and thus, for enhancing health or reducing the risk of disease, depends on the forage used in the offered diet. In this sense, it could be advisable the use of a tanniferous forage when RPS was fed in order to increase UFA. Previous works have emphasized that tanniferous SAIN exert a general inhibition of biohydrogentation (Toral *et al*., 2016) and focused on the last step, leading to a more unsaturated profile of milk. Our results support this hypothesis when RPS is fed. However, the effect of SAIN impairing biohydrogentation was not easily observed with SUN. In this sense, SUN reduced SFA and increased CLA compared to CTR with both forages. These results suggest that main changes in milk FA profile with a diet supplemented with sunflower oil and tannin extracts were more likely explained by the presence of sunflower oil than by tannins.

IV – Conclusions

In conclusion, healthier milk can be obtained with CPOCs. Nevertheless the forage used in the ration seems to be of great importance.

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Curd sensory properties as affected by feeding dairy ewes with cold-pressed oilseed cakes and sainfoin

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Abstract. A lactation study utilizing 72 dairy ewes was performed to determine effects of cold-pressed oilseed cakes, including cold-pressed sunflower cake and cold-pressed rapeseed cake, and their interaction with tanniferous sainfoin hay, on curd sensory properties. A 2 x 3 factorial arrangement involving two forages (tall fescue and sainfoin hay) and 3 experimental concentrates was used. Concentrates were formulated to contain cold-pressed rapeseed cake, cold-preseed sunflower cake or palm as fat sources and to provide equal amounts of crude protein fat and energy. Concentrate type did not affected acceptance traits. Non-significant differences were found between forages in terms of overall acceptability, odour, texture or flavour, but curd appearance was improved when the forage was sainfoin (6.9 *vs.* 6.4, P=0.011) compared to fescue.

Keywords. Tannins – Rapeseed – Sunflower.

Effet d'une distribution de tourteaux d'oléagineux pressés à froid et de sainfoin aux brebis laitières sur les propriétés sensorielles du fromage blanc

Résumé. *Un essai a été mené avec 72 brebis laitières en début de lactation dans un schéma factoriel 2 x 3 impliquant deux fourrages (fétuque et sainfoin) et 3 concentrés expérimentaux. Les concentrés ont été formulés pour contenir du tourteau de colza, de tournesol ou de palme comme sources de lipides, et pour fournir des quantités égales de lipides, de protéines brutes et d'énergie. Le type de concentré n'a pas affecté l'intensité d'acceptation du fromage. Des différences non significatives ont été trouvées entre les fourrages en termes d'acceptabilité globale, d'odeur, de texture ou de saveur, mais l'aspect du fromage blanc a été amélioré avec le sainfoin par rapport à la fétuque.*

Mots-clés. *Tanin – Colza – Tournesol.*

I – Introduction

Cold-pressed oilseed cake (CPOC) is a cheap by-product of oil-manufacturing. It is widespread in the European area and it can be obtained on-farm after simple mechanical extraction of the oil from the seeds. CPOC has been shown to have higher crude fat content than those of conventional solvent and expeller meals (up to 230 g kg^{-1} compared to 30 and 100 g kg^{-1}, respectively, Benhissi *et al*., 2014) which make it an attractive energetic feedstuff for livestock. Sainfoin (*Onobrychis viciifolia*) is a temperate forage legume which has a moderate to high content of condensed tannins (Scharenberg *et al*., 2007). Condensed tannins are known to alter rumen microflora activity, inhibiting the last step of rumen biohydrogenation (Vasta *et al*., 2009). Any alteration in milk composition and quality must be accompanied with the concomitant sensory acceptance of milk or dairy products. In fact, during the past thirty years companies have recognized the consumer as the key driver for product success. For today's consumers, the primary consideration for selecting and eating a food commodity is the product's palatability or eating quality. With this regard the effects of CPOCs on dairy product´s eating quality to our knowledge is still unknown. Therefore, the objective of the current study was to ensure that feeding strategy CPOC does not compromise curd sensory acceptance.

II – Material and methods

The experiment was carried out in accordance with Spanish Royal Decree 53/2013 for the protection of animals used for experimental and other scientific purposes.

1. Animals and experimental diets

The trial was carried out at the Neiker-Tecnalia experimental station. We used 72 blackfaced Latxa dairy ewes at early lactation in a 2 x 3 factorial arrangement involving two forages (fescue and sainfoin hay) and 3 experimental concentrates. Concentrates were formulated to contain cold-pressed rapeseed cake (RPS), cold-preseed sunflower cake (SUN) or palm (CTR) as fat sources. Concentrates were formulated to provide equal amounts of crude protein (CP), energy and fat. Ingredients of experimental concentrates and forages are shown in Table 1. Ewes were divided into 6 equilibrated groups of 12 ewes each, according to milk yield (2094 ± 520 ml) and days in milk (15 ± 8 d postpartum). The experimental concentrates were offered in individual feeders in the milking parlour as two equal meals (450 g DM) during the morning and evening milkings. Tall fescue (*Festuca arundinacea*) hay or sainfoin hay was group fed *ad libitum* in a feed bunk and water.

Table 1. Ingredients and chemical composition (g kg^{-1} DM) of experimental concentrates

Ingredients	Concentrate		
	CTR	SUN	RPS
Cold pressed rapeseed cake	0	0	400
Cold pressed sunflower cake	0	560	0
Soybean meal	150	0	0
Barley	160	150	360
Corn	180	210	100
Oats	200	0	0
Molasses	50	50	50
DDGs	150	0	60
Hydrogenated palm fat	80	0	0
Vitamin-mineral premix*	30	30	30

CTR: control, SUN: sunflower, RPS: rapeseed, *Vitamin and mineral premix contained per kg of DM: 2500 IU of vitamin A, 400 mg of vitamin D, 2.5 IU of vitamin E, 4.9 mg of Zn, 4.05 mg of Mn and 0.1 mg of Se (Calseaphos, Saint Malo, France).

2. Curd sensory acceptance test

On d-35 of the experimental period, a composite milk sample (7 L) from each treatment was collected into stainless steel milk cans. Raw milk was pasteurized at 72°C for 20 s using a continuous plate heat exchanger (ATA tecnología alimentaria, Irun, Spain). Pasteurized milk samples were dispensed in individual 125 mL containers, coagulated at 35ºC by calf rennet (Laboratorios Arroyo, Santander, Spain), and conserved covered at 4ºC.

The curd acceptance test was carried out using a non-trained sensory panel, composed of 26 women and 34 men, regular consumers of curds, using a 10-point line scale, with 1 being the lowest and 10 representing the highest intensity, for the attributes of appearance, flavour, odour, texture and overall acceptability. A balanced incomplete block design was used to assign 4 tempered curd samples to each panellist.

3. Statistical analyses

Sensorial data (n=60) were analysed using the GLM procedure. The statistical model included fixed effects of concentrate (CON), forage (FOR) and their interaction. Least squares means for treatments are reported. Treatment means were compared using a Tukey test.

III – Results and discussion

Mean effects on curd acceptance traits can be seen on Table 2. No interactions between concentrate type and forage type were observed for any of the evaluated traits. Concentrate did not affect acceptance traits. Non-significant differences were found between forages in terms of overall acceptability, odour, texture or flavour, but curd appearance was improved when the forage was SAIN (6.9 *vs.* 6.4, P=0.011) compared to FES.

Table 2. Effects of concentrate (CTR, SUN, RPS) and forage (FES, SAIN) type on curd acceptance

Item	FES			SAIN				P-value		
	CTR	SUN	RPS	CTR	SUN	RPS	SEM	CON	FOR	CONx FOR
Overall acceptability	6.3	6.4	6.4	6.4	6.6	6.6	0.56	0.762	0.363	0.766
Appearance	6.6	6.4	6.4	6.8	6.8	7.1	0.49	0.985	0.011	0.319
Odour	5.9	5.6	5.9	5.7	5.7	5.7	0.29	0.672	0.555	0.735
Texture	6.5	6.5	6.4	6.2	6.5	6.8	0.6	0.676	0.943	0.424
Flavour	6.1	5.8	6.3	6.2	6.3	6.3	0.23	0.812	0.456	0.508

CON: concentrate, FOR: forage, CTR: control, SUN: sunflower, RPS: rapeseed, FES: fescue hay, SAIN: sainfoin hay.

Feeding diets rich in fat such those used in the current trial could lead to dietary products more susceptible to oxidation, and as a consequence could also have negative consequences from a consumer´s point of view. It is, therefore, important to ensure that the final product (milk or dairy products) still has a pleasant taste and is free of off-flavours. The results observed in the current trial are in agreement with Lightfield *et al*. (1993) who observed that cheese made from milk obtained supplementing diets with sunflower contained higher concentrations of UFA while maintaining acceptable flavour.

IV – Conclusions

The current study demonstrated that the effects of CPOCs or SAIN on the sensory properties and acceptance of curd were limited.

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Effet du niveau proteique de la ration des chevreaux sur la croissance et les caracteristiques de la carcasse

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Résumé. Quarante chevreaux de la population saharienne marocaine (14,2 ± 1,38 kg PV initial) ont été utilisés pour évaluer l'effet du niveau de protéine brute (PB) de la ration sur les performances de croissance et les caractéristiques de la carcasse. L'essai s'est déroulé en deux phases. Pendant la première phase (un mois), les chevreaux ont été divisés aléatoirement en deux groupes de 10 mâles et 10 femelles chacun et ils ont reçu une ration avec deux niveaux protéiques (17,6% ; T_1 et 16,1% ; T_2) à base de foin de luzerne (16,5% PB) et un concentré (18 et 16% PB) tandis que pendant la 2ème phase (deux mois), chaque groupe formé en phase 1 à été également divisé en deux sous-groupes de 5 mâles et 5 femelles chacun et ils ont reçu une ration avec deux niveaux de protéines (14,5%; T_3 et 13%; T_4) à base de foin de luzerne (16,5%PB) et un concentré (14 et 12% PB). Les chevreaux ont été pesés au début et à la fin de l'essai, ainsi que tous les 15 jours. A la fin de l'essai, les chevreaux ont été abattus et le rendement, l'état d'engraissement (échelle 1-5) et la conformation (SEUROP) de la carcasse ont été déterminés. Le niveau protéique n'a affecté ni la croissance ni les caractéristiques de la carcasse (P> 0.05). Par contre, le sexe a affecté la croissance et les caractéristiques de la carcasse (P <0.05). Le GMQ durant la 1ère et la 2ème phase a été de 124 et 78 g/j, 115 et 74 g/j respectivement pour les mâles et les femelles. Le rendement carcasse et l'état d'engraissement ont été de 55 et 51, 3 et 2,6 respectivement pour les mâles et les femelles.

Mots-clés. Chevreaux – Niveau protéique – Croissance – Carcasse.

Effect of the protein level in the diet on kids' growth and carcass characteristics

Abstract. *Forty Moroccan local kids (14.2 ± 1.38 kg initial body weight) were used to evaluate effects of the diet protein level on the growth performance and carcass characteristics. The trial was carried out into two phases. In the first phase (1 month), kids were randomly divided into two groups of 10 males and 10 females per each and received a diet with two protein levels (17.6%; T_1 and 16.1%; T_2) containing alfalfa hay (16.5% CP) and concentrate supplement (18 and 16% CP), while in the 2nd phase (2 months), each group formed in phase 1 was also divided into two subgroups of 5 males and 5 females per each and received a diet with two protein levels (14.5%; T_3 and 13%; T_4) containing alfalfa hay (16.5% CP) and concentrate supplement (14 and 12% CP). The kids were weighed at the beginning and at the end of the trial, and fortnightly. At the end of the trial, kids were slaughtered and the carcass dressing percentage, fatness (1-5 scale) and conformation (SEUROP) were measured. The level of crude protein of diet did not affect either kids' growth or carcass characteristics (P> 0.05). On the other hand, the sex affected growth performance (during the 1st and 2nd phase) and carcass characteristics (P<0.05). ADG during the 1st period and 2nd period was 124 and 78 g/d, 115 and 74 g/d for males and females, respectively. The dressing percentage and fatness were 55 and 51, 3 and 2.6 for males and females, respectively.*

Keywords. *Kids – Protein level – Growth – Carcass.*

I – Introduction

Au Maroc, l'élevage caprin couvre environ 8% et 4% des productions nationales respectivement en viandes rouges et en lait (MAPM, 2014). Le caprin est très recherché par la qualité de sa viande

moins riche en cholestérol en comparaison avec celle d'ovin. En outre, Il est capable de valoriser les zones défavorables en comparaison avec les autres ruminants domestiques. En période de sécheresse, l'apport alimentaire provenant des ressources pastorales devient insuffisant pour couvrir les besoins d'entretien et de croissance des animaux. De ce fait, les éleveurs sont contraints, soit de vendre une partie de leur cheptel, soit de supplémenter leur troupeaux caprins. Dans la région de Dakhla (sud du Maroc), les chèvres sont élevées principalement pour la production du lait. La catégorie des animaux la plus vendue est constituée essentiellement de jeunes âgés de 6 à 10 mois dont leur alimentation repose principalement sur l'exploitation des parcours et éventuellement une complémentation déséquilibrée en cas de rareté des ressources pastorales et par conséquent leurs performances peuvent être affectées. L'objectif de ce travail est d'évaluer les performances et les caractéristiques de la carcasse des chevreaux recevant des régimes alimentaires avec différents niveaux de protéines.

II – Matériel et méthodes

Quarante chevreaux (20 mâles et 20 femelles) de la population saharienne marocaine, âgés de 90 jours, avec un poids vif initial de 14,7 ± 1,37 et 13,6 ± 1,4 kg respectivement pour les mâles et femelles ont été utilisés pour mener cette étude. L'essai s'est déroulé en deux phases de 90 jours. Durant la première phase (phase de démarrage), qui a duré un mois, les animaux ont été répartis en deux groupes homogènes de 20 têtes chacun (10 mâles et 10 femelles) et ensuite affectés aléatoirement à deux rations alimentaires avec deux niveaux de protéines brutes (PB) (T_1 :17,6% PB et T_2 :16,1% PB). Cette ration est constituée de foin de luzerne (16,5% PB) et d'un concentré avec deux niveaux protéiques 18 et 16% (Tableau 1). Pendant la deuxième phase (phase de finition), qui a dure 60 jours, chaque groupe d'animaux déjà constitué en phase 1 est également divisé en deux sous-groupes de 10 têtes chacun (5 mâles et 5 femelles) et ils ont reçu une ration avec deux niveaux protéiques (T_3 : 14,5% PB et T_4 : 13% PB) à base de foin de luzerne (16,5%PB) et un concentré de teneur en PB de 14 et 12% (Tableau 1). La distribution quotidienne des rations a été effectuée 2 fois/jour, une pendant la matinée (vers 9h) et l'autre à 15h. Les animaux disposaient de l'eau fraiche *ad libitum*.

Tableau 1. Ingrédients (% en MS) et composition chimique des rations utilisées

	rations			
	T_1	T_2	T_3	T_4
Ingrédients (%MS)				
Concentré	75	75	80	80
Foin de luzerne	25	25	20	20
Composition chimique (%)				
Matière sèche	89.7	89.7	90.1	90.9
Matière organique	89,9	89,9	90,0	88,6
Matière minérale	10,1	10,1	10,0	11,4
Protéines brutes	17,6	16,1	14,5	12,9
Neutral detergent fibre (NDF)	33,3	29,7	32,9	37,1
Acid detergent fibre (ADF)	22,5	20,0	22,7	25,0
Acid detergent lignin (ADL)	5,8	6,5	4,3	5,2

T_1: ration contenant 17,6% PB; T_2: ration contenant 16,1% PB; T_3: ration contenant 14,5%PB ; T_4: ration contenant 13% PB.

Les quantités ingérées ont été déterminées quotidiennement. Les animaux ont été pesés au début et à la fin de l'essai, ainsi qu'à des intervalles réguliers de 15 jours. A la fin de l'essai, et après une diète hydrique de 24 heures, les animaux ont été pesés (poids vif vide, PVV) et abattus, et le poids de la carcasse a été immédiatement déterminé (poids de carcasse chaude: PCC) pour calculer le rendement de carcasse chaude (100*PCC/PVV). Par la suite, l'état d'engraissement (échelle de 1 à 5) et la conformation de la carcasse (système SEUROP) ont été mesurés (Cañeque et Sañudo, 2005). L'effet des différents niveaux protéiques de la ration et du sexe sur les performances de croissance les caractéristiques de la carcasse a été analysé le modèle: $Y_{ijk} = \mu + T_i + S_j + T^*S_{ij} + e_{ijk}$ (avec T_i : effet du traitement ; S_j : effet du sexe ; TS_{ij} : Interaction traitement*sexe ; e_{ijk} : erreur résiduelle), tandis que le poids vif initial des chevreaux a été introduit comme covariable dans le modèle. L'effet du niveau protéique de la ration et du sexe de chaque phase a été analysé séparément. La procédure GLM du programme SAS (version 9,01) a été utilisée pour effectuer les analyses statistiques. La signification entre les moyennes a été testée en utilisant le test LSD.

III – Résultats et discussion

1. Performances de croissance

Les performances de croissances des chevreaux pendant la phase 1 et 2 sont présentées respectivement dans les tableaux 2 et 3. L'analyse statistique a montré l'absence d'effet significatif du régime alimentaire sur les performances de croissance (P>0,05), tandis que elles sont affectées par le sexe (P<0,05). Pendant la 1ère phase, une légère supériorité de GMQ est constatée pour les animaux ayant reçu le T_1 par rapport à T_2. Les GMQ obtenus des mâles on été de 138 et 109 g/j pour les régimes T_1 et T_2 alors que ceux des femelles ont été de 83 et 73 g/j pour les mêmes régimes. L'indice de consommation est de 5,2 et 6,3 Kg MS/kg GMQ pour les mâles respectivement pour les régimes T_1 et T_2, tandis que les femelles ont enregistrés des valeurs de l'ordre de 8,3 et 10,1 Kg MS/kg GMQ pour les mêmes régimes. Ces résultats sont conformes à ceux trouvés par Bouchnifa (1996) sur des chevreaux de la race locale «noire de montagne», qui a trouvé l'absence d'effet significatif du régime alimentaire sur l'IC avec des valeurs de 10,5 et 12,1 Kg MS/kg GMQ pour des niveaux de 15 et 11% PB.

Tableau 2. Performances de croissance des agneaux recevant des rations avec différents niveaux de protéines durant la 1ère phase

	T_1		T_2			P		
Paramètres	**M**	**F**	**M**	**F**	**ESM**	**T**	**Sexe**	**T*Sexe**
Poids vif intial (kg)	15,0	13,6	14,5	13,6	–	–	–	–
Poids vif final (kg)	$19,2^a$	$16,1^b$	$17,8^a$	$15,8^b$	0,39	0,136	0,004	0,508
GMQ (g/j)	138^a	83^b	109^a	73^b	7,1	0,114	0,002	0,433
IC (kg MS/kg GMQ)	$5,2^b$	$8,3^a$	$6,3^b$	$10,1^a$	0,78	0,320	0,026	0,838

ESM: Erreur Standard de la Moyenne; GMQ: Gain moyen quotidien; IC : indice de consommation ; T_1: ration avec 17,6% PB; T_2: ration avec 16,1% PB ; ^{a,b} : moyennes avec des lettres distinctes intra-régimes sont significativement différentes (p<0,05).

Pendant la 2ème phase, le poids final des mâles a été nettement supérieur à celui des femelles (25,4 *vs* 20,5 kg). De même, le GMQ des mâles a été supérieur à celui des femelles (115 *vs* 74 g/j). Le meilleur GMQ des (146 g/j) est réalisé par les mâles recevant le régime T_1T_3, tandis que pour les femelles le régime T_1T_4 apparaît le plus convenable avec une moyenne de 96 g/j. L'indice de consommation des femelles (9,1 kg MS/Kg GMQ) est supérieur à celui des mâles (7,2 kg MS/Kg GMQ). Les performances enregistrées durant cette phase sont meilleures à ceux trouvées par

Bouchnifa (1996) et ceux obtenues par Hatendi *et al*. (1992) sur des boucs castrés de la race Matabele avec des valeurs d'IC de 11,4 ; 9,5 et 11,3 kg MS /kg GMQ respectivement pour des pourcentages de protéine de 20, 19 et 15%.

Tableau 3. Poids, gains moyens quotidiens (GMQ, g/j) et indice de consommation (IC, kg MS/Kg GMQ durant la 2ème phase

	T_1T_3		T_1T_4		T_2T_3		T_2T_4		P		
Paramètres	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**T**	**Sexe**	**Sexe*T**
PVi (kg)	19,2	15,7	19,2	15,7	17,9	15,8	17,8	15,8	–	–	–
PVf (kg)	$28,0^a$	$20,5^b$	$24,6^a$	$21,5^b$	$24,0^a$	$19,8^a$	$25,0^a$	$20,4^b$	0,058	0,009	0,003
GMQ (g/j)	146^a	80^b	89	96	103^a	67^b	121^a	75^b	0,070	<0,001	0,012
IC	$5,45^b$	$8,33^a$	$9,13^a$	$7,64^b$	$7,55^b$	$11,36^a$	$6,66^b$	$8,93^a$	0,247	0,045	0,189

ESM: Erreur Standard de la Moyenne; PVi : Poids vif intitial ; PVf : Poids vif final ; T_1T_3 : animaux ayant reçu le régime T_1 (17,6% PB) en phase 1 et T_3 (14,5% PB) en phase 2; T_1T_4 : animaux ayant reçu le régime T_1 (17,6% PB) en phase 1 et T_4 (13% PB) en phase 2 ; T_2T_3 : animaux ayant reçu le régime T_2 (16,1% PB) en phase 1 et T_3 (14,5% PB) en phase 2; T_2T_4 : animaux ayant reçu le régime T_2 (16,1% PB) en phase 1 et T_4 (13% PB) en phase 2 ; ^{a,b} : moyennes avec des lettres distinctes intra-régimes sont significativement différentes (p<0,05).

2. Caractéristiques de la carcasse

Les caractéristiques de la carcasse sont données dans le tableau 4. L'analyse statistique a révélé l'absence d'effet significatif du régime alimentaire sur le rendement carcasse, la conformation et sur l'état d'engraissement (P>0,05). Le rendement carcasse a été de 53,6 ; 52,7; 52,8 et 53,0% respectivement pour les régimes T_1T_3, T_1T_4, T_2T_3 et T_2T_4. Par contre, le sexe a affecté significativement ces paramètres. Le rendement de carcasse chaude des mâles est plus élevé que celui des femelles (55 *vs* 51%). Nos résultats ne s'accordent pas avec le travail de Hatendi *et al*. (1992), d'une part, mené sur des chevreaux de la race Matabele, qui ont trouvé un effet significatif (P<0,05) du régime sur le RCC avec des valeurs de 49,5 ; 55,5 ; 53,3 et 51,7% respectivement pour des taux de 20, 19, 15, 16% de PB et d'autre part, avec l'étude de Bouchnifa (1996) qui a rapporté un effet significatif du régime sur le RCC (P<0,05) avec des valeurs de 58,8 et 56,4% respectivement pour des taux protéiques de 15 et 11%. La conformation de la carcasse des mâles (note U) a été meilleure que celle des femelles (note R). De même pour l'état d'engraissement, la carcasse des mâles est moins grasse (note 2,5) que celle des femelles (note 3). Nos résultats ne s'accordent pas avec ceux rapportés par Hatendi *et al*. (1992), qui ont trouvé un effet significatif du régime (P<0,05) sur l'état d'engraissement avec des valeurs de 2,5; 2,8 ; 2,7 et 3,3 respectivement pour des taux en PB de 20, 19 et 15 et 16%.

Tableau 4. Caractéristiques de la carcasse des animaux recevant des rations avec différents niveaux de protéines

	T_1T_3		T_1T_4		T_2T_3		T_2T_4		P		
Paramètres	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**T**	**Sexe**	**T*Sexe**
RCC (%)	$55,1^a$	$52,1^b$	$55,5^a$	$49,9^b$	$55,1^a$	$50,6^b$	$54,4^a$	$51,6^b$	0,175	<0,05	0,012
NC	4^a	3^b	3,5	3	3	3	3	2,5	0,062	0,023	0,304
NEE	2,5	3	2^b	$3,5^a$	3,5	3	2,5	2,5	0,072	0,024	0,007

ESM: Erreur Standard de la Moyenne; RCC: Rendement de carcasse chaude; NC : Note de conformation ; NEE : Note d'état d'engraissement ;T_1T_3 : animaux ayant reçu le régime T_1 (17,6% PB) en phase 1 et T_3 (14,5% PB) en phase 2; T_1T_4 : animaux ayant reçu le régime T_1 (17,6% PB) en phase 1 et T_4 (13% PB) en phase 2 ; T_2T_3 : animaux ayant reçu le régime T_2 (16,1% PB) en phase 1 et T_3 (14,5% PB) en phase 2; T_2T_4 : animaux ayant reçu le régime T_2 (16,1% PB) en phase 1 et T_4 (13% PB) en phase 2.

^{a,b} : moyennes avec des lettres distinctes intra-régimes sont significativement différentes (p<0,05)

IV – Conclusion

Les résultats de ce travail ont montré que chevreaux durant la phase de démarrage peuvent être alimentés avec le régime T_1 (17,6% PB), tandis que pour la phase finition le régime T_3 (14,5%PB) apparait le meilleur pour les mâles et le régime T_4 (13% PB) pour les femelles. Toutefois, d'autres essais doivent être menés touchant des aspects relatifs aux caractéristiques et la qualité de la viande des chevreaux engraissés pour compléter les résultats de ce travail.

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Effect of drinking high salt water from weaning to adulthood in Barbarine male lambs

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Abstract. Forty adult Barbarine male lambs were used to evaluate the effect of prolonged drinking of saline well waters on growth, ruminal and digestive performances after a period of 4 months of administration. At the weaning day, animals were randomly allocated high salt water (10 g NaCl / 1l of water) or control water (potable fresh water, 0.5g/l). Animals were adapted for experimental conditions before starting the 105-day growth trial. At the end of the growth trial, animals were housed in metabolic cages for total faecal collection during 10 consecutive days. Drinking high salt water did not affect the growth performance. Ony, caudal condition scores increase in S-lambs comparing to C-lambs ($P<0.001$). Moreover, S-lambs decreased their serum triglyceride, cholesterol, glucose, total protein, acid uric and creatinine concentrations ($P<0.01$). Urea and γ-GT concentrations were not affected by water salinity ($P>0.05$).The response of the weaned lambs in water and food intakes, in ruminal fermentation, in digestibility coefficients, in urinary excretions of total purine derivatives, allantoin, xanthine plus hypoxanthine and uric acid as well as in urine outputs and nitrogen balances were similar for both groups independently the water quality used ($P>0.05$).Utilization of such saline water could be used successfully and safely as good quality of water resources without compromising their feedlot performance.

Keywords: High salt water – Lambs – Ruminal fermentation – Digestibility – Nitrogen balance.

I – Introduction

Ram production in Tunisia is essentially carried on under grazing conditions. The use of concentrate supplements to reduce body weight losses during the dry season and to insure more accelerated gains during the rainy season is practically unknown. With the increased demand for meat and the establishment of price differentials for an improved product, ample justification exists to initiate research on the practice of supplementation for animals under grazing conditions and the regulation of concentrate consumption using high salt levels added to water or diet (Ru *et al.,* 2000).The incorporation of salt in the supplement to regulate intake has been demonstrated by some authors to be practical for beef cattle (Kroger and Carroll, 1964) and sheep (Weir and Miller, 1953; Kraidees *et al.,* 1998; Pearce *et al.,* 2008; Sun and Zhou, 2010), while others have observed limitations to this practice (Wilson, 1966; Henze *et al.,* 1994).

Therefore, the objectives of this experiment were to evaluate the effect of drinking 10% high salt water to Barbarine male lambs from weaning to adulthood on body weight gain, body condition scores, food and water intakes, ruminal fermentation, apparent digestibility and nitrogen balance.

II – Materials and methods

On the day of weaning, we randomly selected from the offspring born to ewes drinking a potable, normal salt (0.5% NaCl) water, twenty clinically healthy male lambs, 4-month-old, with an average body live weight 26kg ± 0.5 kg and the dorsal and caudal body scores were 1.5 ± 0.1 kg and 3 ± 0.5 kg respectively. They were randomly divided into two groups with the first group was contin-

ued to drink a potable water (0.5%, C- *lambs*) but the second group was received high-salt water (10% NaCl, S- *lambs*) from the weaning to the adulthood (8-month-old). Animals were individually offered weighed amount of 1 kg of hay daily at 8:00h plus concentrate feed mixture which consisted of 80% soybean, 17.5% triticale and 2.5% CMV. The experiment was approved by the Animal Ethics Committee of The National Institute of Agronomic Research in Tunisia.

Body live weight (BLW) was recorded weekly in order to calculate the body live change (BLC) and average daily gain (ADG). The daily feed intake (DMi and OMi) and water intake calculated for each animal.

Serum triglyceride, cholesterol, glucose, albumin, total protein, uric acid, urea, creatinine and Gamma glutantransferase (γ-GT) contents were determined according to the standard operating procedures.

At the 90th day of experiment (7-months-old), 50 ml of rumen fluid was sampled before feeding, 3 and 6 hours post feeding from each animal for measurement of pH and osmolarity values, ammoniac-N, Na and K ions concentrations and protozoa enumeration and identification.

At the 120th day of experiment (8-months-old), eight representative lambs averaging 29-kg body weight from each treatment group were selected for a metabolic experiment.The lambs were adapted to cages for 7 days, followed by 5 days when feces and urine were collected after excretion and bulked daily for total weight determination in order to assess the apparent digestibility of diets, nitrogen balance and microbial N synthesis as Allantoin, Xanthine plus Hypoxanthine, Acid uric and Purine.

All data were analysed by separately with the PROCMIXED procedure. The statistical model includes watering regimens (C vs S), age of weaned lambs and the interaction between these two fixed variables. All analyses were using the of the statistical analysis systems 9.0 version (SAS, 2004). Differences between means were considered significant when the P-value is below 0.05.

III – Results and discussion

BLW was not affected by water salinity ($P > 0.05$). Similar results were reported by Potter *et al.* (1972), Rasool *et al.* (1996) and Alhadrami *et al.* (2005). The same observation was proved in young sheep or cattle (Walkerden *et al.,* 1976), fattening sheep and cattle (Meyer *et al.,* 1955) and of weaned rats (Coelho *et al.* 2006). The ADG of weaned lambs were not affected by water salinity ($P>0.05$). Similar results were reported by Srivastavam and Sharma (1998) who shown no difference between adult lamb drinking high, low or normal level of salt.

Dorsal condition scores was not affected by water salinity ($P>0.05$). However, caudal condition scores increase high statistically with treatment and age. S-lambs, 8-month-old, had high caudal note than C-lambs ($P<0.001$).

Table 1. Effect of drinking high salt water on Body condition scores of weaned Barbarine male lambs

Parameters	Water type	Post weaning (days) 0	30	60	90	Overall	S.E. Salinity	Age	Interaction
Dorsal Score	F	1.47	1.50	1.44	1.53	1.48	0.02	0.05	0.05
	HS	1.53	1.56	1.56	1.53	1.55			
Caudal Score	F	3.41	3.72	4.09	4.25	3.87	0.08***	0.05***	0.05
	HS	3.63	4.25	4.34	4.56	4.20			

F: fesh water (0.5% NaCl). HS: high salt water (10% NaCl). SE: standard error of means. ***P<0.001.

Serum biochemical indices are illustrated in Table 2. Drinking high salt water decreased the concentration of serum triglycerides, cholesterol glucose, total protein and uric Acid (P<0.05) and increased the concentration of serum Creatinine (P<0.01). Urea and γ-GT concentrations were not affected by water salinity (P>0.05). With increased salt intake from drinking water, the body is exposed to a metabolic stress, resulting in increased energy requirements to maintain the sodium/potassium gradient, which decreased the concentration of glucose (Ahmed *et al.,* 2001) and in increased passage of fluids into the interstitial tissue which decreased the concentration of total protein (Ahmed *et al.,* 2001). However, high salt level did not damage on kidney function and liver enzymes.

Table 2. Effect of drinking high salt water on metabolites blood profiles of weaned Barbarine male lambs

Parameters	Water type	Post weaning (days)				Overall	S.E.		
		30	60	90	120		Salinity	Age	Interaction
Triglyceride	F	18.72	25.90	24.85	26.25	31.43	1.55*	3.13*	4.50*
(mg/dL)	HS	14.62	21.71	21.09	27.71	26.28			
Cholesterol	F	77.48	68.67	54.55	68.85	67.39	4.21*	6.81*	9.31
(mg/dL)	HS	42.86	74.17	40.76	66.64	56.11			
Glucose	F	53.64	43.42	33.98	17.83	42.22	7.13*	11.85***	17.14
(mg/dL)	HS	46.00	42.78	43.75	14.70	36.81			
Total protein (g/l)	F	46.55	52.96	41.04	32.13	43.17	0.98*	1.66***	2.7
(g/l)	HS	41.43	50.34	39.05	28.12	39.73			
Uric Acid	F	0.91	0.94	0.56	0.69	2.02	0.11*	0.19***	0.3
(mg/dL)	HS	0.55	0.69	0.54	0.73	1.45			
Urea (mg/dL)	F	25.00	24.19	24.52	23.45	29.29	1.55	2.75	1.51
	HS	23.12	20.44	20.38	24.14	29.52			
Creatinine	F	22.71	26.06	22.91	31.62	29.70	0.06**	0.14***	0.12
(mg/dL)	HS	25.79	26.89	31.07	38.95	26.80			
γ-glutantransferase	F	0.85	1.64	1.77	0.58	1.21	1.24	2.62***	1.68
(U/L)	HS	1.54	1.81	1.54	0.70	1.40			

F: fesh water (0.5% NaCl). HS: high salt water (10% NaCl). SE: standard error of means. *P<0.05; ***P<0.001.

Average daily food intake, DM intake and MO intake and daily food intake/kg body weight. (Table 3) were similar in the lambs drinking high salt water or potable water (P>0.05) during all the experiment period. Similarly, average daily water intake of S-lambs was similar compared to C-lambs (P>0.05). Also, average daily water intake/kg body weight no affected by drinking high salt water (P>0.05) (Table 3). Kraidees *et al.* (1998) found a linearly increase in water intake with the increase for Na ingested and the increase of kg OM intake.

RumenpH and osmolarity decreased with drinking high salt water (P<0.05). Elam and David (1962) found added sodium chloride tended to decrease the pH. However, ammoniac-N, sodium and potassium concentrations, protozoa quantification and generic composition were not affected by salinity water (P>0.05). The same observations were proved by Kattnig *et al.* (1992) in Holstein steers drinking saline water (2.300 ppm TDS).

The salinity of water did not affect the entire digestibility's parameter. This finding was in accord to the bibliography. The both group treated similarly under the salt stress without any problem for the sheep's health, if clean, soft water is provided at all times. These results indicated that adult lambs accept drinking high salt level (Weir and Miller, 1953).

Concerning nitrogen retention, there were insignificant (P>0.05) variations among treatments where all lambs were in positive nitrogen balance and retained insignificant various amounts of nitrogen. The results are in harmony with those obtained by El- Shaer *et al.* (2001).

Table 3. Effect of drinking high salt water on food and water intakes of weaned Barbarine male lambs

Parameters	Water type	Post weaning (days) 15	30	45	60	75	90	105	Overall	S.E. Salinity	Age	Interaction
g per day	F	847.5	915.1	1039.7	1059.4	1214.6	1351.0	1349.2	1110.9	1.11	2.94***	3.1
	HS	841.9	912.0	1047.7	1058.0	1213.5	1354.0	1351.4	1111.2			
DM intake	F	75.8	87.6	91.9	101.1	117.2	128.0	134.0	105.1	1.31	3.47 ***	3.1
(% DM)	HS	70.0	90.9	92.4	96.5	121.5	120.7	129.8	103.1			
OM intake	F	59.7	47.3	63.0	58.7	59.7	88.6	74.6	64.5	1.66	4.41***	4.26
(% DM)	HS	46.9	48.7	63.9	48.6	51.1	87.8	77.2	60.6			
g per kg W 0.75	F	69	71.3	81.2	81.9	90.5	100.1	97.5	84.5	1.14	3.01***	1.4
	HS	67.8	72.3	82.3	80.8	87.5	97.0	96.5	83.5			
l per day	F	5.63	5.64	5.53	5.88	6.3	6.69	7.94	6.23	0.014	0.04***	0.045
	HS	5.75	5.67	5.57	5.86	6.27	6.67	8.02	6.26			
l per kg W 0.75	F	0.47	0.44	0.43	0.46	0.47	0.5	0.57	0.48	0.006	0.016***	0.009
	HS	0.46	0.45	0.44	0.45	0.45	0.48	0.57	0.47			
l per kg DM	F	6.07	6.17	5.31	5.55	5.19	4.95	5.88	5.59	0.001	0.003***	0.002
intake	HS	0.08	6.22	5.32	5.54	5.17	4.93	5.93	4.74			

F: fesh water (0.5% NaCl). HS: high salt water (10% NaCl). SE: standard error of means. *P<0.05; ***P<0.001.

Table 4. Effect of drinking high salt water on rumen fermentation of adult Barbarine male lambs

Parameters	Water type	Time post feeding (hour) 0	3	6	Overall	S.E. Salinity	time	Interaction
pH	F	5.91	5.78	6.02	5.90	0.50*	0.07	0.10
	HS	5.54	5.78	5.80	5.70			
Osmolarity	F	673.40	448.60	364.60	495.53	19.37**	26.93	31.29
(mosm/kg H2O)	HS	279.20	313.40	272.20	288.26			
NH3-N2+ (mg/dl)	F	8.99	16.08	16.07	13.71	1.93	1.47***	0.73
	HS	7.27	15.40	15.39	12.68			
Na+ (mg/100g)	F	34.44	30.78	27.24	30.82	1.05	1.55	2.36
	HS	33.48	31.20	30.66	31.78			
K+ (mg/100g)	F	34.86	34.68	44.28	37.94	2.82	2.90***	3.02
	HS	31.62	44.94	49.38	41.98			
Protozoa (10^5/ml)	F	34.00	44.00	70.40	49.46	10.67	11.55	9.74
	HS	29.6	35.6	42.00	35.73			
Endiplodium (10^5/ml)	F	25.2	22.00	41.60	29.00	5.71	6.40	6.64
	HS	19.60	21.60	24.80	22.00			
Epidimium (10^5/ml)	F	8.40	20.40	28.40	19.06	5.14	5.65	5.88
	HS	10.00	14.00	17.20	13.73			
Polyplastium (10^5/ml)	F	0.40	1.60	0.40	0.80	0.17***	0.32	0.52
	HS	0.00	0.00	0.00	0.00			

F: fesh water (0.5% NaCl). HS: high salt water (10% NaCl). SE: standard error of means. *P<0.05; **P<0.01; ***P<0.001.

The urine output increased insignificantly (*P*>0.05) in S-lambs comparing to C-lambs. This result was contrary to previous observations (Pierce, 1968; Wilson, 1966) which explicated that the increase of urine output is part of the normal response of the animal in dealing with excessive loads of Na in the body. Nitrogen intake g per day was similar (*P*>0.05) in the two groups without any affect in nitrogen balance in both groups.

Urinary excretions of allantoin, uric acid, xanthine plus hypoxanthine and total purine derivatives were not significantly affected (*P*>0.05) by drinking high salt water. When expressed as proportions

of total purine derivatives, allantoin proportion was increased and xanthine plus hypoxanthine proportion was reduced.

Lambs excreted three times as much as allantoin as xanthine plus hypoxanthine or uric acid. Drinking high salt water decreased slightly the allantoin, xanthine plus hypoxanthine, uric acid and purine excretion but this changes were not significantly different (P>0.05). The lower uric acid excretion of animal compensated quantitatively for the higher allantoin excretion (Liang *et al.*, 1994).

IV – Conclusion

The present results shows that *Barbarine male lambs* can subsist drinking saline water containing 10 g/l of NaCl for a relatively long period (105 days) without exhibiting harmful effects on health or any changes in digestibility, nitrogen balance or microbial system. Adult lambs were adapted to high salt level by some increasing serum concentration and ruminal osmolarity. Further study is required to investigate their responses to other ionic substances dissolved in their drinking water.

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Enrichment of ewe cheese with *Laminaceae* seed oil as a source of omega-3

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Abstract. In this study we evaluated the viability of using oil extracted from *Laminaceae* seeds with a hydraulic press at room temperature as a source of omega-3 enrichment for ewe cheeses. Two concentrations (1.5 and 2.5%; vol/vol) of seed oil prepared as emulsions stabilized with calcium caseinate were assayed in pressed sheep`s milk cheeses, and their physicochemical (fat, protein, dry matter and fattty acids), microbiological (total bacteria, lactic acid bacteria, enterobacteria, yeast and moulds) and organoleptic parameters were evaluated during 32 days of ripening. Sheep's milk coagulation parameters during cheese elaboration were not affected by the incorporation of the oil emulsion. The fortification with the emulsion had a positive impact on the cheese yield, obtaining 2% more in the cheeses containing 2.5% of vegetal oil. Similar results were observed in the fat, dry matter and omega-3 content, which increased proportionally to oil concentration. Moreover, total bacteria and lactic acid bacteria were not inhibited in the cheeses containing the highest oil concentration, confirming the hypothesis that oil addition would not interfere to the normal ripening process. We did not detect the presence of yeast, moulds or enterobacteria in any of the cheeses during ripening. Regarding the sensory analysis, the test "difference from control" showed that no significant differences were observed between the control and the enriched cheeses according to a semi-trained panel of judges.

Keywords. Sheep cheese – Omega-3 – Vegetable oil – *Laminaceae* seeds.

Fromage de lait de brebis enrichi avec de l'huile des graines de* Laminaceae *comme une source d'acides gras oméga-3

Résumé. *Dans cette étude, nous avons évalué la viabilité de l'utilisation de l'huile des graines de Laminaceae, extraite avec une presse hydraulique à température ambiante, pour enrichir le contenu d'acides gras oméga-3 dans un fromage au lait de brebis. Deux concentrations de l'huile (1,5 et 2,5%, vol / vol) ont été préparées sous forme d'émulsion stabilisées avec du caséinate de calcium et ajouté au fromage de brebis à pâte pressée. Les caractéristiques physico-chimiques (matières grasses, protéines, matières sèches et acides gras), microbiologiques (bactéries totales, bactéries lactiques, entérobactéries, levures et moisissures) et les paramètres organoleptiques ont été évalués pendant 32 jours d'affinage. Les paramètres de coagulation du lait de brebis pendant la fabrication du fromage n'ont pas été affectés par l'incorporation de l'émulsion. La fortification avec l'émulsion a eu un impact positif sur le fromage obtenant un rapport fromage/lait 2% plus haut dans les fromages contenant 2,5% de l'huile végétale. Un résultat similaire a été observé pour le contenu en matière grasse, matière sèche et la teneur en oméga-3 qui a augmenté proportionnellement à la concentration de l'huile. Entre autres, la croissance des bactéries totales et des bactéries lactiques n'ont pas été inhibées avec la concentration la plus élevée de l'huile, ce qui confirme l'hypothèse que l'addition de l'huile n'affecte pas l'affinage du fromage de lait de brebis à pâte pressée. La croissance de levure, moisissures et d'entérobactéries n'a pas été détecté dans aucun fromage. En ce qui concerne l'analyse sensorielle, des jurés semi-entrainés n'ont pas trouvé des différences sensorielles dans les fromages enrichis par rapport au fromage témoin selon le test « différence par rapport au contrôle ».*

Mots-clés. *Fromage de brebis – Omega 3 – Huile végétale.*

I – Introduction

In recent years, a wide range of omega-3-enriched dairy products has appeared on the market, due to the fact they provide extensive nutritional benefits for human health. Nevertheless, the main animal sources of unsaturated fatty acids are the oils of fish and shellfish (Ganesan *et al*., 2012). Likewise, the various products enriched with omega-3 are mainly milks or yoghurts, while the offer of cheeses is not frequent, especially for those made with sheep milk and enriched with these fatty acids (Dal Bello *et al*., 2015). In the previous studies that have been carried out in this field, as well as in the development of dairy products enriched with these essential fatty acids, it has been observed that there are hardly any studies on the enrichment of dairy products with vegetable sources such as nuts, seeds and vegetable oils (flaxseed, canola and soybean) that contain α-linolenic acid (ALA C18:3 n3). They have been used as a source of omega-3 (Ganesan *et al*., 2012), but in other foods than dairy. For these reasons, the objective of this work is to study the enrichment of a cheese with omega-3 plant origin (Oil from *Laminaceae* seeds, OLS), made with sheep milk.

II – Material and methods

1. Experimental design

Two different batches of pressed ewe milk cheese were made. Each one consisted in making 3 vats of cheese (30 L) from the same milk tank. These 3 vats included the control vat and 2 vats enriched with oil from *Laminaceae* seeds (1.5 and 2.5% vol/vol, respectively). Ten pieces (~ 0.5 kg) were taken from each vat and ripened for analysing at 8, 16, 24 and 32 d.

2. Preparation of vegetal oil emulsions

Oil was extracted from commercial organic *Laminaceae* seeds (OLS) with mean composition (g/100 g) of fat content of 31.1, protein of 21.2, SFA of 3.8 and omega-3 (α-linolenic acid) of 17.8. OLS was extracted with a hydraulic press (MECAMAQ Model DEVF 80, Spain) at the Vegetal Oil Extraction Pilot Plant of the UCLM (Albacete, Spain). Extraction conditions were performed at room temperature and 20 MPa pressure during 15 min. 0.22 µm-filtered vegetal oil emulsions were prepared according Stratulat *et al*. (2014) containing a dispersion of 70 g of calcium caseinate and 30 g of OLS. Emulsion was homogenised at 40ºC using an Ultra-Turrax T 25 Basic at 17,000 rpm for 2 min. The two OLS concentrations were used for milk enrichment.

3. Cheesemaking, milk and cheese analysis

Cheeses were manufactured at the Dairy Pilot Plant of the UCLM, using Manchega breed ewe milk. Cheese was elaborated according Licón *et al*. (2012) and ripened (8 ± 1°C and 85% RH conditions) during 32 d. Milk gross composition (protein, fat and total solids) was determined with an infrared spectrophotometer MilkoScanTM Minor Type 78100 (Foss Electric, Denmark). Cheeses dry matter and fat content were analysed through a near-infrared analyser FoodScan (Foss Electric). A pH meter Crison GPL 22 (Crison, Spain) was used for pH using a Crison 5232 probe. Fatty acids in lyophilized cheese samples (100 mg) were directly methylated with 2 mL of 0.5 M NaOCH3 at 50°C for 15 min, followed by 1 mL of 5% HCl in methanol at 50°C for 15 min (Bonanno *et al*., 2012). Fatty acid methyl esters (FAMEs) were recovered in hexane (1.5 mL). One microliter of each sample was injected into an Agilent 7820A gas chromatograph equipped with an Agilent 5975 mass spectrometer detector (Agilent Technologies Inc., USA). FAMEs were separated using a 60-m length, 0.25 mm i.d., 0.2 µm capillary column (HP-88; Agilent Technologies Inc., USA), using the following temperature program: 60°C for 2 min, increased at 3°C/min to 220°C and held for 5 min at this temperature, using helium at a flow rate of 1 mL/min (linear velocity of 25.9 cm/s) as the car-

rier gas. A fatty acid methyl ester hexane mix solution (Accustandard, USA) was used to identify and quantify 37 FAMEs. Total aerobic bacteria, lactic acid bacteria, enterobacteria and moulds and yeasts counts were determined according Licón *et al*. (2012). Counts were expressed as log cfu/g.

4. Sensory and statistical analysis

Sensory evaluation consisted of a Difference From Control test (DFC) carried out at 16 d of ripening. Forty-six untrained panelists between 18 and 61 year-old from the UCLM (Albacete, Spain) and familiar with the test format were selected for the study. Twenty-four out of the total were females and 22 were males. The scale used was a verbal and numeric category scale (0: not difference to 5: extremely different). Data obtained in the DFC test were analysed using ANOVA (two-factors, without replication) with samples and judges as factors. The Dunnett's Multiple Comparison Test was used to compare samples with the reference. An ANOVA was performed using the SPSS version 23.0 statistical package (SPSS Inc., Chicago, IL) to determine the effects of OLS concentration and ripening time on each parameter studied ($P < 0.05$). The Tukey test at a significance level of $P < 0.05$ was used to determine differences between means for concentrations and ripening days.

III – Results and discussion

The addition of the OLS emulsion to sheep milk resulted in significant increases ($P < 0.001$) in fat and dry matter (DM) contents (Fig. 1). Milk coagulation parameters during cheese elaboration were not affected by the incorporation of OLS emulsion reaching a pH of 5.3 in similar times (data not shown). A slight increase (2%) in cheese yield when 2.5% OLS emulsions were incorporated to milk was appreciated. Table 1 shows the physicochemical and microbial parameters of the studied cheeses at different ripening stages. There were no significant differences in pH (around 5.2) at any stage of ripening due to OLS addition. The fortification with the emulsion had a positive impact on fat content that increase almost proportionally, with increasing OLS ($P < 0.001$). This increase was observed also in the dry matter. The evolution of these parameters during ripening increased significantly ($P< 0.001$) and was similar for all types of cheeses. Regarding the effect of OLS on omega-3 level the concentration of α-linolenic acid (ALA C18:3n3) also increased proportionally to oil addition being 0.17, 2.8 and 4.31 mg/100 mg of cheese fat for control, 1.5% OLS and 2.5% OLS cheeses, respectively. These results suggest an effective inclusion in the curd of the assayed OLS, as already reported for cheeses fortified with other animal or vegetal omega-3 sources applied as emulsions (Calligaris *et al*., 2015; Stratulat *et al*., 2014).

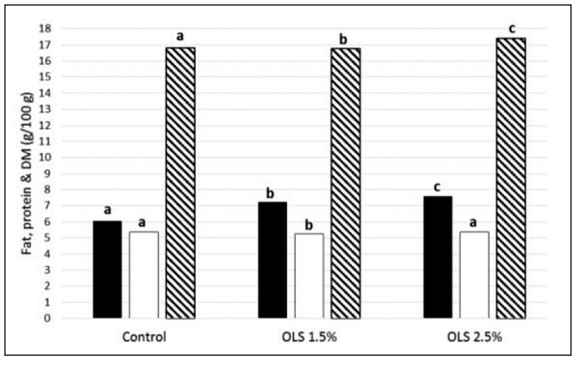

Fig. 1. Effect of OLS addition on milk parameters.
[a-c] Means with different superscripts differ ($P < 0.05$).

No significant differences were found between control and OLS enriched cheeses total bacteria, or lactic acid bacteria (Table 1). There was not growth of yeast and moulds and enterobacteria in none of the cheese during ripening (data not shown). As Bermúdez-Aguirre & Barbosa-Cánovas (2011) and Dal Bello *et al*. (2015) have described for cheeses fortified with different sources of omega-3, the inclusion of the OLS has not negative effects on microbial development during ripening.

Although mean values in the DFC test of samples showed a slight preference for control cheeses (1.5) with respect to the other two (1.8 for 1.5% OLS and 2.12 for 2.5% OLS cheeses), the semi-trained judges did not appreciate significant differences (P > 0.05) between the control and the enriched cheeses. In addition, Bermúdez-Aguirre & Barbosa-Cánovas (2011) reported good scores for cheeses fortified with flaxseed oil. These results demonstrate that fortification levels of up to 2.5% OLS may be applied to pressed sheep`s milk cheeses without negatively affecting shelf-life or consumer acceptation.

Table 1. Effect of OLS addition on cheese parameters (mean ± sd)

		Ripening time (d)				
Parameter	**Cheese**	**8**	**16**	**24**	**32**	***P*-value**
DM	Control	58.50 ± 0.03^{ax}	59.75 ± 0.15^{bx}	61.38 ± 0.34^{cx}	62.32 ± 0.04^{dx}	***
	OLS 1.5%	59.67 ± 0.15^{ay}	60.73 ± 0.41^{by}	62.10 ± 0.07^{cy}	63.65 ± 0.02^{dy}	***
	OLS 2.5%	59.76 ± 0.20^{ay}	61.74 ± 0.08^{bz}	63.07 ± 0.02^{cz}	64.33 ± 0.03^{dz}	***
	P-value[1]	***	***	***	***	
Fat	Control	29.27 ± 0.21^{ax}	29.45 ± 0.03^{ax}	30.02 ± 0.01^{bx}	30.22 ± 0.01^{bx}	***
	OLS 1.5%	30.25 ± 0.03^{ay}	30.76 ± 0.02^{by}	31.28 ± 0.08^{cy}	31.47 ± 0.04^{dy}	***
	OLS 2.5%	31.19 ± 0.05^{az}	31.57 ± 0.03^{bz}	32.22 ± 0.13^{cz}	32.87 ± 0.01^{dz}	***
	P-value	***	***	***	***	
Total bacteria	Control	9.53 ± 0.14	9.40 ± 0.33	9.17 ± 0.08	9.23 ± 0.00	NS
	OLS 1.5%	9.55 ± 0.20^{a}	9.13 ± 0.06^{b}	9.30 ± 0.04^{ab}	9.39 ± 0.16^{ab}	**
	OLS 2.5%	9.47 ± 0.12^{a}	9.07 ± 0.02^{b}	9.19 ± 0.12^{b}	9.23 ± 0.04^{b}	***
	P-value	NS	NS	NS	NS	
Lactic acid bacteria	Control	9.45 ± 0.17^{a}	9.35 ± 0.10^{ab}	9.14 ± 0.09^{bx}	9.32 ± 0.03^{ab}	*
(M17 media)	OLS 1.5%	9.28 ± 0.17^{a}	9.20 ± 0.09^{a}	9.69 ± 0.03^{by}	9.33 ± 0.26^{a}	**
	OLS 2.5%	9.35 ± 0.13	9.28 ± 0.07	9.34 ± 0.19^{x}	9.15 ± 0.15	NS
	P-value	NS	NS	***	NS	

$^{x-z}$ Means within a column with different superscripts differ ($P < 0.05$).

$^{a-d}$ Means within a row with different superscripts differ ($P < 0.05$).

[1] Significance differences are indicated as follows: *$P < 0.05$, **$P < 0.01$ & *** $P< 0.001$.

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Effect of levels of intake on rumen fermentation, digestibility, methane emissions and behaviour

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Abstract. The objective of this experiment was to examine the effect of differing levels of intake on rumen fermentation profile, nutrient digestibility, methane emissions, and feeding behaviour in sheep. Six Aberdale cross Texel ewes (90.2 ± 1.89 kg BW) fitted with rumen fistula were used in a duplicated 3×3 Latin Square with three 21-d experimental periods. Treatments comprised dried grass nuts fed to meet one (1M), 1.5 times (1.5M), or two times (2M) maintenance energy requirements (NRC, 2007). The average daily gain was greater in 2M than 1M ewes. The 1M ewes had a lower VFA concentration than 1.5M and 2M, and a greater acetic-to-propionic ratio than 1.5M. The ammonia concentration was greater in 1.5M than in 2M ewes. Dry and organic matter digestibility per unit of metabolic weight were greater in 1M than 1.5M and 2M ewes. Emissions of methane per unit of DM intake were greater in 1M than 1.5M and 2M ewes. No differences were found in protozoa count, feeding behaviour or haematology. Results show that increased levels of intake have a measureable impact on diet fermentation and digestibility, reducing the acetate-to-propionate ratio, ammonia production, digestibility rate, and methane emissions. These changes could be attributed to the different nutrient fermentation pattern and the higher flow rate from the rumen to the lower digestive tract.

Keywords. Rumen fermentation – Nutrient digestibility – Methane emissions – Feeding behaviour.

Impact de différents niveaux d'ingérés sur la fermentation du rumen, la digestibilité, les émissions de méthane et le comportement

Résumé. *L'objectif de cette étude était d'examiner l'impact de différents niveaux d'ingérés sur le profil de fermentation du rumen, la digestibilité, la production de méthane et les comportements alimentaires chez les moutons. Six brebis croisées Texel-Aberdale (90,2 ± 1,89 kg poids moyen) canulées ont été utilisées dans un carré latin double 3 × 3 de trois périodes expérimentales de 21 jours. Les traitements consistaient en différentes quantités de granulés d'herbe afin de répondre à une fois (1M), 1 fois et demi (1,5M), ou deux fois (2M) aux besoins énergétiques (NRC, 2007). Le gain de poids moyen journalier était plus important chez les brebis 2 M que les 1M. Les brebis 1M avaient une concentration en AGV inférieure aux 1,5 M et 2 M, et un rapport acétique-propionique plus élevé que 1,5 M. La concentration d'ammoniaque était supérieure chez les brebis 1,5M que chez les brebis 2M. La digestibilité des matières sèches et organiques par unité de poids était plus élevée chez les brebis 1M que 1,5M et 2M. La production de méthane par unité de matières sèches ingérées était plus importante chez les brebis 1M. Aucune différence n'a été trouvée sur le nombre de protozoaires, le comportement alimentaire ou les paramètres hématologiques. Ces résultats montrent qu'une augmentation de l'ingéré a un impact quantifiable sur la fermentation et la digestibilité en réduisant le ratio acétate-propionate, la production d'ammoniaque, le taux de digestibilité et la production de méthane. Ces changements pourraient être attribués aux différentes voies de fermentation utilisées et à un transit plus élevé du rumen vers le tractus digestif inférieur.*

Mots-clés. *Fermentation du rumen – Digestibilité – Émissions de methane – Comportement alimentaire.*

I – Introduction

Improving our understanding of tree-animal-soil interactions in upland systems in Wales is a vital component for future sustainable intensification of ruminant livestock systems (MULTI-LAND, 2015). In order to develop a systems-level understanding of management on phenotypic characteristics of grazing animals it is essential to identify and implement new methodologies for accurately estimating for-

age intake by free-ranging ruminants. Existing methodologies, however, are labour intensive and are often associated with large measurement error and low repeatability (Burns *et al*., 1994).

In recent years, alternative methods have been developed that can potentially be used to estimate intake in grazing animals with sufficient accuracy and precision. These include specific biomarkers excreted in urine or in plasma compounds (e.g. nitrogen, sugars, potassium, or vitamins; Fukuwatari and Shibata, 2012), near infrared reflectance spectroscopy of faecal constituents (e.g. fibre fractions; Dixon and Coates, 2015), spot short-term quantification of carbon dioxide and methane (Huhtanen *et al*., 2015), and automatic classification of feeding behaviour using 3-axis accelerometers (Marais *et al*., 2014).

The objectives of this experiment were to evaluate combinations of existing methodologies to estimate intake, and to assess the effects of increasing levels of intake on the rumen microbiome in sheep. Our hypothesis were that intake and digestibility could be estimated individually in grazing animals using a combination of automated methods and biomarkers, and that changes in the level of intake without changes in diet composition have a measureable impact on rumen microbial diversity and composition.

II – Material and methods

1. Animals, housing and experimental design

All animal procedures were carried out according to the Home Office scientific Procedures (Act 1986). Seven Aberdale cross Texel ewes (48 ± 0.1 months of age, and 90.2 ± 1.89 kg BW) fitted with rumen fistula (as described in an earlier experiment; ref.: 101091) were used during 14 weeks from April to July 2016.

Six of the 7 ewes were assigned to one of two groups of 3 animals according to live weight. The remaining ewe was kept as a spare animal in an individual pen with food to cover maintenance requirements. All sheep were moved to the individual pens and fed the experimental diet for 14 d. Thereafter, sheep were used in a replicated 3x3 Latin Square with three 21 d experimental periods. Each period consisted of a 14 d adaptation and 7 d sampling interval. To implement the experimental design, animals in the second group started the experiment 7 d later.

At the beginning of the experiment individual energy requirements were calculated to maintain BW according to the energy evaluation system described by NRC (2007). After the acclimation period, where all sheep were fed at maintenance, animals were allocated to Latin squares according to BW and randomly assigned to experimental treatments. Treatments comprised dried grass nuts fed to meet one (1M), 1.5 times (1.5M), or two times (2M) maintenance energy requirements (NRC, 2007). Allocation of experimental treatments is shown in Table 1.

Table 1. Distribution and permutes of treatments over the experiment

	Period 1	Period 2	Period 3
Animal 1	1M	1.5M	2M
Animal 2	1M	2M	1.5M
Animal 3	1.5M	1M	2M
Animal 4	2M	1M	1.5M
Animal 5	2M	1.5M	1M
Animal 6	1.5M	2M	1M

Treatments comprised dried grass nuts fed to meet one (1M), 1.5 times (1.5M), or two times (2M) maintenance energy requirements (NRC, 2007).

2. Sample collection and analyses

At the beginning of the adaptation period, animals were weighed in two consecutive days to calculate the maintenance requirements. During each of the three experimental periods, sheep were weighed at d 1, 7, 14, and 17 to calculate average daily gain and feed efficiency, and to ensure there were no abrupt changes in BW and that maintenance requirements are being fulfilled.

Feed offered and refusals were recorded daily during the length of the experiment to measure feed intake. Samples of the feed offered were collected weekly for determination of DM by oven drying at 55 ºC for 48 h. A subsample was composited for every experimental period and stored at -20 ºC for later analysis of composition of NDF, ADF, and CP.

A total of 15 mL of blood were taken from jugular venipuncture immediately before feeding and 4 h later during the third day at the digestibility crate (d 17 of each period). One out of the three tubes contained anticoagulant (K3-EDTA), and the sample was kept at 4 ºC until the haematology analysis with the Mythic 18 Vet Haemotology Analyser. The second and third tube contained Lithium Heparin and a clot activator, respectively, and the samples were immediately centrifuged at 2,000 x g for 15 min.

Approximately 100 mL of ruminal content were collected from the ruminal cannula immediately before feeding, and 2 and 4 h after feeding during the third day at the digestibility crate (d 17 of each period). Rumen fluid was filtrated trough 250 µm pore size nylon mesh, and with 50 mL of rumen fluid pH was determined using a pH meter and several sub-samples were taken: 1) 4 mL were transferred into a previously labelled 15 mL falcon tube containing 1 ml 20% V/V orphophosphoric acid with 4 mM 4 ethyl butyric acid for the subsequent analysis of VFA; 2) 1 mL was transferred to a 2 mL eppendorf tube containing 0.25 ml of 25% W/V trichloroacetic acid (TCA) for the analysis of ammonia; and 3) 0.5 mL were transferred to a 1.5 mL eppendorf tube containing 0.5 mL of saline formaldehyde 9.25% in NaCl 0.9% solution and dyed by adding a drop of methylene blue for protozoa count.

The first three days of the sampling week (d 15 to 18) sheep, while sheep were housed individually in metabolic crates, total amount of faeces and urine produced were recorded daily. Urine samples were collected into a container with approximately 100 ml of 10% sulphuric acid in order to maintain the pH below 3 (acidification of the urine prevents bacterial destruction of purine derivatives). A 20% of the faeces and a 10% of the urine were stored in plastic bags and processed accordingly to determine nutrient digestibility, N and energy balances, and purine derivative excretion.

From day 18 to 21 of each experimental period, ewes were housed in methane chambers where methane emissions were quantified. A MGA 3000 series multi gas analyser was used and calibrated and auto zeroing daily using oxygen free nitrogen. Chamber emissions were corrected for background concentrations of methane and for mean gas airflow.

The second day of the sampling week (d 16), from 0 to 6 h after feeding, different measurements were collected to determine individual feeding behaviour: 1) A digital voice recorder (GH609 Digital Voice Recorder) attached to the left side of a head harness captured the bite and chewing sounds of the animal while eating, that were later uploaded into a computer to be processed with an acoustic analysis software; 2) A 3-axis accelerometer (HOBO pendant G data logger) was attached to the right side of a head harness to capture the position and movement of the head while eating, that were later uploaded into a computer to be processed with its specific software to determine magnitude and frequency of the movements; and 3) A video camera recorded the front of the animals to be visualized later and be used as the gold standard for the former behavioural measurements.

3. Statistical analyses

Data were analysed using the MIXED procedure of SAS (University Edition 2.3, SAS Institute, Inc., Cary, NC). Rumen pH, VFA profile, ammonia production, and protozoa count was analysed as repeated measures over the hours after feeding nested within period, considering ewe as the subject with the first-order Autoregressive covariance structure. The model included the square of the Latin Square arrangement, the period, the animal nested within square, the treatment, the hour after feeding, and the interaction treatment x hour as fixed effects. The nutrient digestibility, methane production and average daily gain were calculated once per period, and therefore the model only included the square of the Latin Square arrangement, the period, the animal nested within square, and the treatment as fixed effects, with no repeated measures. For all the statistical analyses, significance was declared at $P < 0.05$ and trends at $0.05 \leq P < 0.10$, using the Tukey multiple comparison test to separate means.

II – Results

The average daily gain was greater (P = 0.01) in 2M than 1M ewes (0.49 vs -0.09 ± 0.079 kg BW/d; Table 2). The 1M ewes had a lower (P < 0.01) VFA concentration than 1.5M and 2M (69.9 vs 101.8 and 111.4 ± 6.99 mM), and a greater (P = 0.04) acetic-to-propionic ratio than 1.5M (2.40 vs 1.97 ± 0.108). The ammonia concentration was greater (P = 0.01) in 1.5M than in 2M ewes (14.14 vs

Table 2. Rumen fermentation profile, nutrients digestibility, methane emissions and growth performance

	Treatment[1]				P-Value[2]		
	1X	1.5X	2X	SEM	Treatment	Hour	Hour*Treatment
Rumen pH	6.25	5.97	6.09	0.089	0.09	<0.01	0.60
Total VFA production, mM	69.9^{b}	101.8^{a}	111.4^{a}	6.99	<0.01	<0.01	0.83
Acetic,%	54.8	53.0	54.8	1.06	0.34	<0.01	0.24
Propionic,%	23.8^{b}	27.5^{a}	25.6^{ab}	0.97	0.04	<0.01	<0.01
Butyric,%	14.5	13.7	14.3	0.68	0.59	0.04	0.55
Valeric,%	1.6	1.5	1.7	0.10	0.28	<0.01	0.63
Branched chain VFA,%	5.2	4.0	3.6	0.43	0.06	<0.01	0.28
Acetic:Propionic ratio	2.4^{a}	2.0^{b}	2.2^{ab}	0.10	0.04	<0.01	0.01
Ammonia, mM	12.2^{ab}	14.1^{a}	8.9^{b}	1.02	0.01	<0.01	0.04
Protozoa count, $\times 10^5$	12.7	21.7	25.9	3.40	0.10	0.04	0.98
Digestibility,%/BW$^{0.75}$							
DM	2.61^{a}	2.47^{b}	2.43^{b}	0.029	0.01	–	–
OM	2.68^{a}	2.55^{b}	2.50^{b}	0.027	0.01	–	–
NDF	2.34	2.20	2.14	0.075	0.20	–	–
ADF	2.27	2.21	2.15	0.081	0.55	–	–
CP	2.53	2.32	2.32	0.066	0.09	–	–
Retained CP,%	1.01	1.03	1.29	0.132	0.26	–	–
Retention rate,%	1.46	1.58	1.98	0.195	0.18	–	–
Methane emissions, g/d	20.1^{b}	25.0^{ab}	30.7^{a}	1.97	0.03	–	–
Kg^{-1} metabolic weight	0.74^{b}	0.88^{ab}	1.10^{a}	0.077	0.04	–	–
Kg^{-1} DMI	18.3^{a}	15.1^{b}	13.5^{b}	0.77	0.01	–	–
ADG, kg BW/d	-0.09^{b}	0.17^{ab}	0.49^{a}	0.079	0.01	–	–

[1] Treatments comprised dried grass nuts fed to meet one (1M), 1.5 times (1.5M), or two times (2M) maintenance energy requirements (NRC, 2007).

[2] Fixed effects were treatment, hour after feeding, and the interaction hour within treatment.

[a, b] Means with different superscripts in the same row are different (P < 0.05).

8.89 ± 1.024 mM). Dry and organic matter digestibility per unit of metabolic weight were greater (P < 0.05) in 1M than 1.5M and 2M ewes (2.61 vs 2.47 and 2.43 ± 0.029%/BW^0.75; 2.68 vs 2.55 and 2.50 ± 0.027%/BW^0.75, respectively). Emissions of methane per unit of DM intake were greater (P < 0.05) in 1M than 1.5M and 2M ewes (18.33 vs 15.08 and 13.53 ± 0.772 g/d x kg DMI). No differences (P > 0.05) were found in protozoa count, feeding behaviour or haematology.

III – Conclusions

Changes in the level of intake, without changing the diet composition, have a measureable impact on rumen fermentation profile, as seen by the greater total VFA production and the lower acetic-to-propionic ratio, DM and OM digestibility, and methane emissions by unit of DMI of x1M ewes compared to x1.5M and x2M. These changes could be attributed to the greater amount of food fermented in the rumen and the higher flow rate from the rumen to the lower digestive tract.

Acknowledgments

The authors acknowledge the financial support provided by the Welsh Government and Higher Education Funding Council for Wales through the Sêr Cymru National Research Network for Low Carbon, Energy and Environment.

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Dietary pomegranate pulp to improve meat fatty acid composition in lambs

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Abstract. The aim of this study was to evaluate the effect of dietary pomegranate pulp (PP) on the intramuscular fatty acid (FA) composition in lambs. Seventeen Comisana lambs were individually stalled, divided into two groups and fed for 44 days: a barley-corn based concentrate diet (CON-8 lambs) or a concentrate diet containing 20% of PP to partially replace barley and corn (POM-9 lambs). The inclusion of PP in the diet produced an overall improvement of the fatty acid composition of LTL. In particular, percentages of C18:1 t11 (0.73 *vs* 1.38, P < 0.001), C18:2 c9t11 (0.35 *vs* 0.94, P < 0.001), C18:3 c9c12c15 (0.37 *vs* 0.51, P < 0.001) and C18:2 c9c12 (5.37 *vs* 7.09, P = 0.035) were higher in the meat of POM group in comparison with CON lambs. All the mentioned FAs are involved in the ruminal metabolism of lipids, suggesting an effect of the bioactive compounds contained in PP on the FA biohydrogenation. In addition, C18:3 c9t11c13 (punicic acid), the peculiar FA of pomegranate seeds, was detected only in the muscle of POM lambs, representing 0.48% of the total fatty acids. The percentage of PUFA was significantly higher in meat from POM group compared to CON. In conclusion, a diet containing 20% of PP increased the proportion of healthy fatty acids in meat without compromising animal growth.

Keywords. Pomegranate – Lamb – Fatty acids – Conjugated fatty acids.

Régime à base de pulpe de grenade pour améliorer la composition en acide gras dans la viande d'agneaux

Résumé. *Le but de cette étude est d'évaluer l'effet sur la composition en acide gras intramusculaire des agneaux exposés à une alimentation basée sur l'utilisation de pulpe de grenade. Dix-sept agneaux d'espèce Comisana ont été séparés dans des box, classés en deux groupes et nourris pour 44 jours : un régime concentré à base d'orge et de maïs (8 agneaux) ou un régime concentré composé à 20% de pulpe de grenade qui remplace, en partie, l'orge et le maïs (9 agneaux). L'inclusion dans le régime de pulpe de grenade a produit, en général, une amélioration de la composition en acide gras du muscle LTL. En particulier, les pourcentages de C18 :1 t11 (0,73 vs 1,38, P < 0,001), C18 :2 c9t11 (0,35 vs 0,94, P < 0,001), C18 :3 c9c12c15 (0,37 vs 0,51, P < 0,001) et C18 :2 c9c12 (5,37 vs 7,09, P = 0,035) ont été plus élevés dans les viandes du groupe alimenté avec la pulpe de grenade (POM) en comparaison avec les agneaux du groupe alimenté avec l'orge et le maïs (CON). Tous les acides gras mentionnés sont impliqués dans le métabolisme des lipides des ruminants ce qui suggère un effet des composants bioactifs contenus dans la pulpe de grenade et dans la bio-hydrogénation des acides gras. En outre, C18 :3 c9t11c13 (acide punicique), acide gras spécifique de la pulpe de grenade ; a été détecté seulement dans le muscle des agneaux POM, représentant' 0,48% du total des acides gras. Les pourcentages de AGPI et AGMI ont considérablement augmenté dans la viande du groupe (POM) par rapport à celle du groupe (CON). En conclusion, un régime contenant 20% de pulpe de grenade a permis d'augmenter la proportion de bons acides gras dans la viande, sans compromettre la croissance des animaux.*

Mots-clés. *Grenade – Agneau – Acides gras – Acides gras combinés.*

I – Introduction

Pomegranate (*Punica granatum* L.) is widely consumed as fresh fruit and juice and is appreciated for its health-promoting potential. In the last years, the increased production of pomegranate juice has led to an increase in the amount of its by-products. Pomegranate pulp (PP) is the residue of pomegranate juice extraction, and consists of peels, membranes, seeds and residual arils. All the components of PP have been reported to contain bioactive compounds in higher proportion than the edible fractions (Goula & Lazarides, 2015). PP contains phenolic compounds such as flavonoids, anthocyanidins, ellagitannins, ellagic acid, punicalagin and gallic acid, which possess antimicrobial, antioxidant, antinflammatory, and antitumoral properties (Viuda-Martos *et al.,* 2010). Pomegranate seeds contain about 12-20% oil (Lansky & Newman, 2007), with punicic acid (C18:3 c9t11c13) accounting for approximately 60-80% of total fatty acids. Punicic acid is one of the few naturally occurring conjugated linolenic acids (CLnA). The CLnA isomers are known to directly exhibit several health benefits that are largely based on animal and *in vitro* studies (Yuan *et al.,* 2014). Furthermore, studies have shown that CLnA isomers can be metabolized into conjugated linoleic acid (CLA) *in vivo* (Tsuzuki *et al.,* 2006) and *in vitro* (Schneider *et al.,* 2013), with the consequent health benefits of CLA. The aim of the present study was to investigate the effects of dietary pomegranate pulp on the intramuscular fatty acid composition of lambs.

II – Materials and methods

Seventeen male Comisana lambs (60 days of age) were individually housed and randomly assigned to one of two dietary treatments. After 8 days of gradual adaptation to the experimental diets, the following diets were offered *ad libitum*: a pelleted diet composed of 20% wheat bran, 20% alfalfa hay, 12% soybean meal, 22.5% barley, 22.5% corn, 1% molasses and 2% mineral premix (CON-8 lambs) and the same diet containing 20% pomegranate pulp (PP) to replace 50% barley and 50% corn (POM-9 lambs). Both diets were isoenergetic and isonitrogenous. Individual intakes and live weight were recorded over the trial. After 36-days of experimental feeding, lambs were slaughtered. The *longissimus thoracis et lumborum* muscle (LTL) was removed, vacuum packed and stored at -80 °C until analysis. Phenolic compounds (Makkar *et al.,* 1993) and fatty acids (Sukhija & Palmquist, 1988) were analysed in the feeds.

Table 1. Phenolic compounds and fatty acids of the experimental diets

Chemical composition	CON	POM
Total phenols†	3.04	18.91
Total tannins†	1.41	16.96
Individual fatty acids,% total fatty acids		
C16:0	14.27	10.90
C18:0	2.27	2.11
C18:1 c9	18.51	13.13
C18:2 c9c12 (LA)	46.35	32.74
C18:3 c9c12c15 (ALA)	5.32	4.01
C18:3 c9t11c13 (PA)	0.00	21.68

† Expressed as gram tannic acid equivalent per kg DM.

The CON diet contained higher levels of C16:0, C18:1c9, C18:2 c9c12 and slightly higher C18:3 c9c12c15 than POM diet. A remarkable amount of C18:3 c9t11c13 (punicic acid, PA) was found only in the POM diet (21.68%; Table 1). The intramuscular fat of LTL sample was extracted (Folch *et al.,* 1957) and fatty acid methyl esters (FAME) were prepared (Christie, 1982). Gas chromatographic analyses was carried out with a GC 8000 Top (Thermo Fisher Scientific Inc.), equipped with

a flame ionization detector (FID) and with a 100-m high-polar fused silica capillary column. Data were analysed using a GLM model to test the effect of the dietary treatment (diet: CON or POM). The individual lamb was considered the experimental unit.

III – Results and discussion

The inclusion of PP in the diet did not affect the performance parameters of lambs: animals in the two treatments had comparable dry matter intake, final body weight and average daily gain (data not shown).

Table 2. Effects of dietary treatment on some selected fatty acid composition of *longissimus thoracis et lumborum* (g/100 g of fatty acids)

	Dietary treatment			
Chemical composition	**CON**	**POM**	**SEM**	**P value**
C18:1 t11 (VA)	0.73	1.38	0.133	0.012
C18:2 c9, c12 (LA)	5.37	7.09	0.409	0.035
C18:2 c9, t11 (RA)	0.35	0.94	0.084	<0.001
C18:3 c9, c12, c15 (ALA)	0.37	0.51	0.022	<0.001
C18:3 c9, t11, c13 (PA)	0.00	0.48	0.062	<0.001
SFA	41.43	41.24	0.770	0.910
MUFA	43.98	41.46	0.532	0.016
PUFA	8.50	12.28	0.827	0.020
OBCFA	3.32	2.12	0.190	<0.001
PUFA n-3	0.86	1.19	0.087	0.062
PUFA n-6	7.27	9.64	0.662	0.080
n-6/n-3	8.51	8.18	0.138	0.244

Despite the greater amounts of linoleic acid (LA, C18:2c9c12) and alpha-linoleic acid (ALA, C18:3 c9c12c15) in CON diet as compared to POM diet, these fatty acids were present in significantly higher concentrations in the muscle of POM fed lambs ($P < 0.05$; Table 2). Considering that in ruminant meat these fatty acids can only be derived from the diet, the results suggest that biohydrogenation was inhibited in the lambs fed POM diet. It has been widely demonstrated that ruminal biohydrogenation may be inhibited by tannins (Vasta & Luciano, 2011), which were abundantly present in POM diet. In fact, there were 6-fold higher total phenols and 12-fold higher total tannins in POM diet in comparison to CON diet (Table 1), which could have exerted inhibitory effects on the microorganisms in the rumen that participate in the biohydrogenation. Furthermore, a higher concentration of OBCFA, which originated from microbial rumen population, in muscle of lambs fed the CON diet in comparison to muscle of lambs fed POM supports our above suggestion. Moreover, the increase of VA in the muscle of POM lambs (1.38%) than in the muscle of CON group (0.73%) could lead to hypothesis that the last step of ruminal BH was mostly inhibited. Similar results were found by Emami *et al.* (2015) using 5-10-15% pomegranate seed pulp in the diets of kids.

The significantly higher amount of rumenic acid (RA) in POM fed lamb muscle (0.94%) as compared to that in CON fed lamb muscle (0.35%), could have been derived from both the isomerization of LA in rumen and from synthesis in the tissues by the action of Δ^9-desaurase on vaccenic acid (VA) (Palmquist*, et al.,* 2004). Moreover, the RA may also be derived from metabolism of PA in liver and small intestine (Tsuzuki *et al.,* 2006). The punicic acid (PA) was detected only in the muscle of POM lambs, likely because it partially escaped from ruminal biohydrogenation. Lastly, it may be supposed that RA may also derive from the direct ruminal BH of PA. Indeed, the saturation of the c13 double bond of PA would directly produce RA.

The inhibition of biohydrogenation has resulted in a greater amount of PUFA (*P = 0.020*) in meat of POM fed lambs (12.28%) than of CON fed lambs (8.50%). Unexpectedly, no effect of the dietary treatment was found for the sum of SFA. If the ruminal BH was inhibited by tannins, the muscle from POM animals would have been expected to possess a lower content of SFA than the CON treatment, which was not the case in the present study (*P = 0.910*). A possible explanation could be that the SFA were produced in greater amount in the rumen of CON lambs than POM animal, but the higher concentration of PUFA in POM muscles had decreased the Δ^9-desaurase activity (Gillis *et al.,* 2004) in lambs fed POM diet than CON group. As a consequence, the major amount of SFA and Δ^9-desaurase activity generated higher level of MUFA in CON muscles compared to POM muscles.

IV – Conclusions

The fatty acid composition of lamb meat could be improved by feeding a diet containing 20% pomegranate pulp, with no adverse effects on animal performances. The presence of pomegranate in the diet resulted in increased concentrations of conjugated linoleic acid (rumenic acid), vaccenic acid, " -linolenic acid and punicic acid in the meat. Specific studies are needed to clarify which specific bioactive components of pomegranate pulp could affect fatty acid metabolism in ruminants. In conclusion, the pomegranate pulp as a low-cost feedstuff source could be used successfully as a replacement for cereal grains in ruminant nutrition.

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Effect of tannins on indoles content and "pastoral" flavor of lamb meat

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Abstract. Skatole and indole derive from the degradation of tryptophan in the digestive tract and are responsible for off-flavors in sheep's meat and fat. Their formation and absorption can be controlled through feeding strategies. Particularly, dietary polyphenols reduce the biodegradation of tryptophan and are claimed to mitigate the "pastoral" flavor of sheep meat. The experiment aimed at evaluating the effect of the polyphenols nature on sensory and chemical characteristics of lamb meat. Fifty-three lambs of 70 days of age were divided in six groups of 7-10 animals each and fed the experimental diets for 75 days. The control group received a diet formulated with barley, bran, dehydrated alfalfa and soybean meal. The remaining groups were fed the control diet with the following integrations: i) 15% cardus, in partial substitution of dehydrated alfalfa; ii) 4% tara tannin extract (hydrolysable tannins – gallic acid), iii) 4% chestnut tannin extract (hydrolysable tannins – ellagic acid), iv) 4% mimosa tannin extract (condensed tannins-profisetinidin) and, v) 4% gambier tannin extract (condensed tannins-catechin). Perirenal fat was extracted in methanol and passed through a Sep-Pak C18 column for analysis of fatty acids profile. Skatole and indole content was quantified using an HPLC system with a fluorescence detector. A trained panel was asked to carry out the Quantitative Descriptive Analysis of sheep meat samples from *longissimus dorsi* muscle as well as an olfactory evaluation of fat samples. Diets rich in hydrolysable tannins significantly reduced "pastoral" flavour of perirenal fat, and at the same time demonstrated greater efficacy, compared to condensed tannins, to contain the accumulation of indole compounds.

Keywords. Cardus – Tara – Chestnut – Mimosa – Gambier.

Effet des tannins sur la teneur en indoles et la flaveur "pastorale" de la viande d'agneau

Résumé. *Scatols et indoles dérivent de la dégradation du tryptophane dans le tractus digestif et sont responsable des goûts désagréables de la viande et de la graisse d'agneau. Leur formation et leur absorption peuvent être contrôlées à travers les stratégies alimentaires. En particulier, les polyphénols de la diète réduisent la biodégradation du tryptophane et sont censés atténuer le goût "pastoral" de la viande ovine. L'expérimentation visait à évaluer l'effet de la nature des polyphénols sur les caractéristiques sensorielles et chimiques de la viande d'agneau. Cinquante-trois agneaux de 70 jours d'âge ont été répartis en six groupes de 7-10 animaux chacun et ont reçu les diètes expérimentales pendant 75 jours. Le groupe témoin recevait une diète formulée avec de l'orge, du son, de la luzerne déshydratée et de la farine de soja. Les autres groupes recevaient la diète témoin avec les composantes suivantes : i) 15% de cardus, en substitution partielle de la luzerne déshydratée; ii) 4% d'extrait de tannins de tara (tannins hydrolysables – acide gallique), iii) 4% d'extrait de tannins de châtaigne (tannins hydrolysables – acide ellagique), iv) 4% d'extrait de tannins de mimosa (tannins condensés – profisetinidine) et, v) 4% d'extrait de tannins de gambier (tannins condensés – catéchine). La graisse périrénale a été extraite dans du méthanol et passée à travers une colonne Sep-Pak C18 pour analyse du profil en acides gras. La teneur en scatols et indoles a été quantifiée en utilisant un système HPLC avec un détecteur de fluorescence. Il avait été demandé à un panel entraîné de faire l'Analyse Descriptive Quantitative des échantillons de viande ovine provenant du muscle longissimus dorsi ainsi qu'une évaluation olfactive des échantillons de gras. Les diètes riches en tannins hydrolysables réduisent significativement la flaveur "pastorale" de la graisse périrénale, et en même temps elles ont montré une plus grande efficacité, en compaison aux tannins condensés, pour limiter l'accumulation de composés d'indoles.*

Mots-clés. *Cardus – Tara – Châtaignier – Mimosa – Gambier.*

I – Introduction

Lamb meat has a characteristic “pastoral” flavor (Schreurs *et al*., 2008) that is often not appreciated by consumers (Sañudo *et al*., 2003). Recently, there is a growing interest in tannin-rich plants' addition to animal diets because they are claimed to mitigate “pastoral” flavor of lamb meat and fat (Vasta and Luciano, 2011). These bioactive compounds, most of which derive from proteins, can interfere with the rumen microbial ecosystem reducing synthesis of molecules that cause off-flavor of lamb meat. “Pastoral” flavor has been attributed to the presence of specific compounds in the meat, particularly indole and skatole (3-methylindole), branched-chain fatty acids (BCFA), phenolic compounds, sulphides, mercaptans and thiols (Schreus *et al*., 2008). Using forages with high content of endogenous tannins or adding exogenous tannins to diets can mitigate “pastoral” flavor because of the formation of tannin-protein complexes in the rumen that prevent enzymatic hydrolysis of proteins and free amino acids availability (Hagerman, 1992).

Tannins' effect depends on different factors as the nature of the tannin, microbial species with which they interfere and protein aminoacidic composition (Patra and Saxena, 2011).

The aim of this study was to check the effect of adding different tannins to the diet on sensory and chemical characteristics of lamb meat.

II – Material and methods

1. Experimental design, animals and diets

Fifty-three lambs of 70 days of age were divided in six groups of 7-10 animals each and fed the experimental diets for 75 days. The control group received a diet formulated with barley, bran, dehydrated alfalfa and soybean meal. Four of the remaining groups were fed the control diet supplemented with a 4% of one of the following commercial tannin extracts: i) tara (hydrolysable tannins – gallic acid – titer purity 53%), ii) chestnut (hydrolysable tannins – ellagic acid – titer purity 75%), iii) mimosa (condensed tannins-profisetinidin – titer purity 65%) and, iv) gambier (condensed tannins- catechin – titer purity 48%). The remaining group received the control diet with 15% cardus in partial substitution of dehydrated alfalfa

2. Sensory panel evaluation

Ten trained panelists, ranging in age between 22 and 55 years, carried out the Quantitative Descriptive Analysis (QDA) of sheep meat samples from *longissimus dorsi* muscle as well as an olfactory evaluation of fat samples. The preliminary sessions were performed to develop a common vocabulary that allowed assessors to use the same terms to describe their perceptions. After that, assessors carried out the sensory evaluation in four replicas, each divided in two sessions. Assessors evaluated 26 descriptors for *longissimus* muscle samples, and six for fat olfactory evaluation. Panellists assigned to each sample and for each sensory attribute a score between 1 (absence of the sensation) and 10 (sensation extremely intense) using a linear scale. Results were collected using software FIZZ v.2.47B (Biosystemes, Couternon, France).

3. Indoles analysis in perirenal fat

Skatole and indole content was measured according to the method of Tuomola et al. (1996). A sample of 2,5 g of fat was homogenized in 10 ml of methanol together with 30 µl of 2-methylindole as internal standard by means of an Ultra Turrax. Homogenate was cooled for 30 min at -20°C and then centrifuged at 4000 rcf for 10 min. The supernatant was filtered through a Sep-Pak C18 column and 2 ml of eluate injected in an HPLC system (Schimadzu LC-20AT-Germany) with a fluorescence detector.

4. Statistical analysis

ANOVA and multivariate analysis (Principal Components Analysis) of sensory data were performed using the statistical software PanelCheck (Nofima Mat & DTU -Informatics and Mathematical Modelling; Norway). The evaluation of the effect of tannins nature on individual descriptors considered both product and assessor effect, assuming the latter as a random factor. ANOVA of chemical data and their correlation with sensory data were carried out using the statistical software SPSS ver.17 (SPSS Inc., Illinois).

III – Results and discussion

Results obtained from sensory evaluation are summarized in Figure 1.

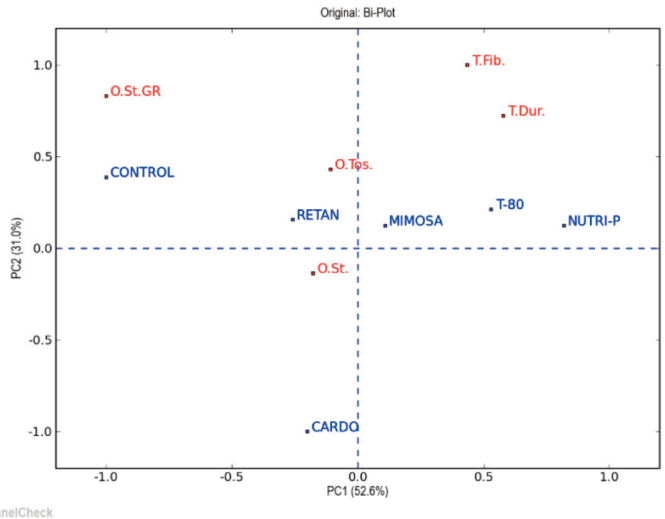

Fig. 1. Map of diets (Control; RETAN = Gambier; Mimosa; Cardus; T-80 = Tara; NUTRI-P = Chestnut) and significant attributes (O.St. GR = fat pastoral flavor; O.St.=meat pastoral flavor; O.Tos. = toasted odor; T.Fib. = meat fibrosity; T.Dur = meat hardness) derived from Principal Components Analysis of lamb meat and fat sensory profiles.

The first two components of the Principal Components Analysis explained 83% of the variability between samples. Except for the diet including cardus, all the others were lined up along the first component, highly related to “pastoral” flavor. Perirenal fat of animals supplemented with chestnut and tara tannins was different from the others because of a lower score related to “pastoral” flavor. The diet including cardus was different from the others because it was lined up along the second component, mainly related to the texture of the meat.

Differences between diets including tannins (excluding control diet and that including cardus) are shown in Fig. 2. Diets including hydrolysable tannins (tara and chestnut) were in opposite quadrants than those including condensed tannins (mimosa and gambier). Along the second component, the diet including mimosa tannins was different than the diet including gambiertannins due to a higher correlation with rancid odor, and a lower correlation with “pastoral” flavor. In the other side, the diet including chestnut tannins was different than that including tara tannins because of a higher correlation with sweet fat odor as well as a lower correlation with meat toasted odor.

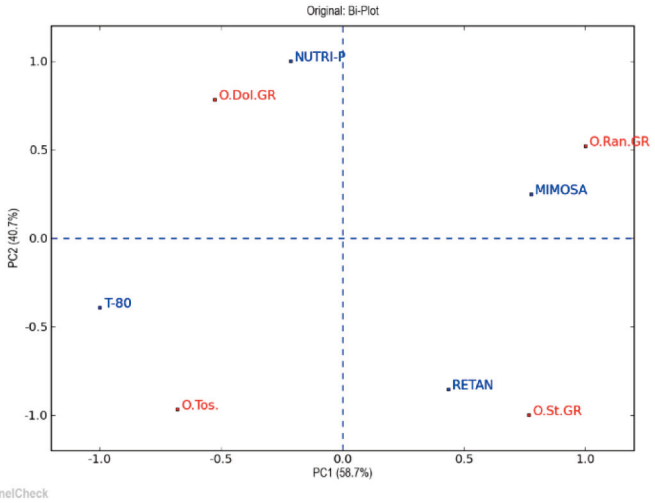

Fig. 2. Map of diets (RETAN = Gambier; Mimosa; T-80 = Tara; NUTRI-P = Chestnut) including tannins, and significant attributes (O.Ran.GR = fat rancid odor; O.Dol.GR. = fat sweet odor; O.St.GR = fat pastoral flavor; O.Tos. = toasted odor) derived from Principal Components Analysis of lamb meat and fat sensory profiles.

Chemical analysis aimed to assess the implication of skatole and indole in the perception of pastoral flavor, and the results are reported in Table 1. Perirenal fat of lambs fed diets including hydrolysable tannins (chestnut and tara) had a lower indole content than that from animals fed diets including condensed tannins (mimosa and gambier).

Table 1. Indole, skatole and total indoles content (ng/g) in lamb perirenal fat

	Control	T-80 (Tara)	Nutri-P (Chestnut)	Mimosa	RETAN (Gambier)	Cardus	DSE	*P*
Indole	25.4[a]	14.1[b]	15.1[b]	27.4[a]	32.0[a]	27.9[a]	2.19	.015
Skatole	9.6	10.4	10.7	11.9	4.7	16.7	2.14	.545
Indoles	35.0	24.5	25.7	39.3	36.8	44.5	3.40	.380

These results are related to “pastoral” flavor score of perirenal fat (Fig. 3). Diets including hydrolysable tannins had a significantly reduced “pastoral” flavor, whereas hydrolysable tannins demonstrated a greater efficacy than condensed tannins in containing indoles’ tissue accumulation, particularly indole.

As reported by Peterson and Reineccius (2003), indole and skatole can confer to animal products floreal and sweet flavor at low concentration, whereas flavor becomes undesirable at high concentration (Young *et al.,* 2003).

Most of the studies reported in the literature consider only plants’ endogenous condensed tannins, which complex structure allows them to be more resistant to ruminal degradation (Piluzza *et al.,* 2014). The results of this research, that compares the use of different tannins, are probably due to different factors that could have modify rumen degradation such as the exogenous origin of tannins and their different purity (from 48% in gambier tannins to 75% in chestnut tannins). All these factors could have changed the relationship between polyphenols availability and the the rate of degradation of proteins in the rumen.

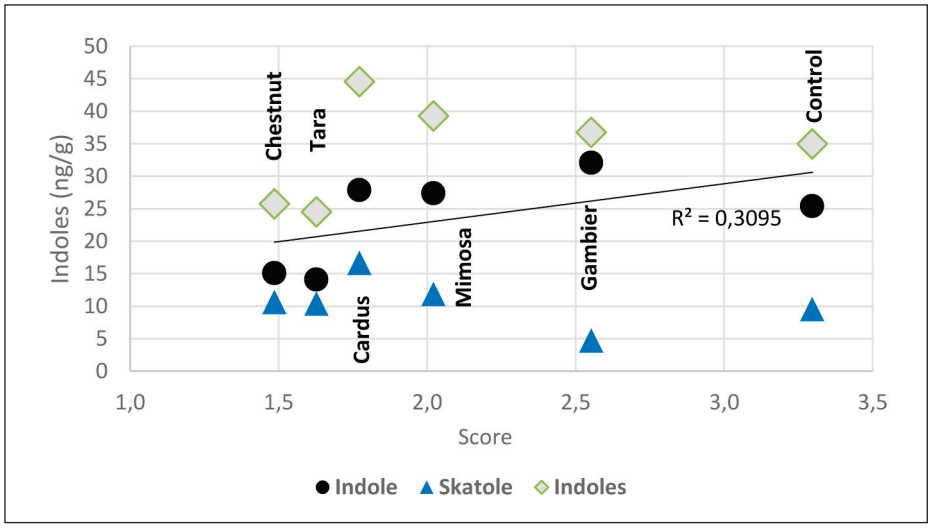

Fig. 3. Relation between "pastoral" flavor (Score) and indoles content in lamb perirenal fat.

IV – Conclusions

Hydrolysable tannins, even though at a low level of inclusion (4%) in the diet, can modify sensory characteristics of lamb meat and fat, particularly reducing "pastoral" flavor. This effect is related to a low content of indoles in the animals' fat.

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Effects on fatty acids profile of milk from transhumant small ruminants related to the floristic composition of mountainous rangelands

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Abstract. The available knowledge regarding the effects of grazed species composition on sheep and goat milk quality in Greece is limited. This study contributes to fill in this gap by presenting the results of a combined study of rangeland floristic composition and milk quality of transhumant flocks. The vegetation cover measured and the species composition and richness were calculated early in summer of 2013 and 2014. At the same period milk samples were taken from the refrigeration tanks where milk is collected before transportation to industries and dairies. Samples were analyzed for the profile of fatty acids, which were divided in six categories (SFA, MUFA, PUFA, CLA, omega-3 and omega-6). The results showed correlations between floristic composition and the concentration of specific fatty acids, some of which are potentially beneficiary for human health.

Keywords. Mountainous rangelands – Extensive production – Grazing – Milk quality.

Effets sur le profil des acides gras du lait provenant de petits ruminants transhumants liés à la composition floristique des pâturages montagneuses: Résultats préliminaires de Grèce

Résumé. *Les effets de la composition des espèces de pâturages sur la qualité du lait de moutons et de chèvres en Grèce n' ont pas reçu attention. Cette étude présente les résultats d'une étude de la composition florale des pâturages et de la qualité du lait des troupeaux transhumants. Des mesures de la couverture végétale et de la production fourragère ont été prises dans les premiers jours de pâturage pendant l'été de 2013 et 2014 et la composition et la richesse des espèces ont été calculées. À la même période, des échantillons de lait ont été prélevés par les réservoirs de réfrigération du lait et ont été analysés pour le profil des acides gras, qui ont été divisés en six catégories (SFA, MUFA, PUFA, CLA, oméga-3 et oméga-6). Les résultats ont révélé des relations entre la diversité floristique et la concentration d'acides gras spécifiques, dont certains sont potentiellement favorables à la santé.*

Mots-clés. *Pâturages montagneuses – Production extensive – Pâturage – Qualité de lait.*

I – Introduction

Greece represents a Mediterranean setting of particular importance in terms of biodiversity. A significant part of the country's Usable Agricultural Areas is characterized as High Nature Value farmland (53%), especially in the mountainous areas of the country, which are the most abundant. Agropastoralism has played a crucial role in the formation and maintenance of unique landscapes with significant biodiversity in these areas, with transhumant sheep and goat flocks being the main grazers. These flocks remain in the highlands for at least four months (May/June – early/late October) and graze in rangelands with considerable ecological and floristic diversity. Recent experimental data have revealed that properly grazed areas are characterized by increased floristic diversity and moderate grazing provides important ecosystem services (Karatassiou *et al*. 2016a).

At the international level there is significant evidence that grazing is reflected in the production of milk of higher quality. Morand-Fehr *et al*. (2007) reported that pasture-based livestock produce milk rich in fat and in micro-components, which are beneficial to human health. Chilliard *et al*. (2003) reported increased Linoleic Conjugated Acid (LCA) concentration in cow milk when animals were fed off fresh grass. Galina *et al*. (2007) found that many of the properties of raw unpasteurized milk were passed to cheese produced in the artisanal way and pointed out differences between cheeses from milk from grazing and milk from indoors feeding. Economic and marketing literature shows that consumers are interested in the consumption of these products, because they require less forage and concentrates and increase animal welfare (Nicholas *et al*., 2014), especially when they are produced from raw milk, which ameliorates their organoleptic characteristics (Colonna *et al*., 2011).

In Greece, research has focused on milk quality of small ruminants fed indoors with various types of feedstuff, for instance by substituting soy meal by legumes (Manousidis *et al*., 2015), or on the differences between various systems of ewe milk production (Tsiplakou *et al*., 2010). Also there has been research on the uses of mountainous grasslands (Hadjigeorgiou *et al*., 2003; Karatassiou *et al*. 2016b) and on their contribution to the economic performance of farms (Ragkos *et al*., 2014), while Manousidis *et al*. (2016) examined the grazing behavior of goats in such settings. However, up to now the available knowledge regarding the effects of grazed species composition on milk quality is limited. This study contributes to fill in this gap by presenting preliminary results of a combined study of rangeland floristic composition and milk quality of transhumant flocks. In particular, the study focuses on grazing in semi-natural mountainous rangelands during summer.

II – Material and methods

The study was undertaken in four different mountainous (summer) rangelands of Northern Greece. The common characteristic of the sampled farms was that they all spend the winter in the lowlands of Thessaly, Central Greece and move towards their summer domiciles in late May. The first area was Samarina-Dotsiko (Mountain Smolikas), which is situated in Grevena (North-Western Greece) and is one of the most important grazing areas for transhumant flocks during summer (52.183 sheep and goats, 128 flocks). The second area is Grammatiko (Mountain Vermio), where actually only 22 flocks rearing 9.161 sheep and goats graze, but used to be an important summer rangeland for transhumant flocks until the 1970s.The third area, Chaliki (Mountain Lakmos), is a small community between Thessaly and Macedonia; the village has a longstanding transhumance tradition and actually 19 farms rearing 9.058 small ruminants, mainly sheep, graze there during summer. The fourth area is Pyrra in Central Greece (Pindos), where the transhumant population has declined considerably (less that 1.900 animals spend the summer there).

In these four areas, plots of 9 - 16 m² were fenced in selected rangelands in order to be protected from grazing. Measurements of the vegetation cover measured and the species composition and richness were calculated in early summer of 2013 and 2014 (Magurran, 2004). At the same period milk samples were taken from the refrigeration tanks where milk is collected before transportation to industries and dairies. Samples were taken in 2013 and 2014 from 23 farms on average 2-3 weeks after the flocks started grazing in summer rangelands. Collected samples were analyzed for the profile of fatty acids, which were divided in six categories: Saturated Fatty Acids (SFA, C4:0, C6:0, C8:0, C10:0, C12:0, C14:0, C15:0, C16:0, C17:0, C18:0, C20:0); Monosaturated Fatty Acids (MUFA, C14:1, C16:1, C18:1, C20:1); Polysaturated Fatty Acids (PUFA, C18:2, C18:3, C20:4, EPA, DHA), Conjugated Linoleic Acid (CLA), ω3 Fatty Acids (C18:3, EPA, DHA); ω6 Fatty Acids (C18:2, C20:4). The fatty acid methyl esters were prepared by trans-esterification with potassium hydroxide according to ISO5509:2000L. The prepared fatty acid methyl esters were analyzed using a HP 5890 (Hewlett –Packard) gas chromatograph equipped with flame ionisation detector and a DB-23 (60 m×0.25 mm × 0.25 μm) column (J & W Scientific, Inc., Folsom, California, USA). A 37 component mixture (Supelco, Bellefonte, Pennsylvania, USA) of fatty acids methyl esters (FAME)

was used as a reference standard. Fatty acids methyl esters were identified by comparing their retention times with the FAME mixture. The results are expressed as percent (%) of the total fatty acids present in the sample.

III – Results and discussion

Table 1 reports the combined results of the species composition and milk quality experiments. The profile of the four areas differs in terms of floristic composition. Rangelands in Grevena exhibited the highest percentage of grasses, followed by other forbs (46% and 38,6% respectively). In Chaliki, no significant differences were found compared to Grevena, except the fact that legumes coverage was 4,5% more. However, different profiles were found in Vermio and Pyrra. In the former area, shrubs covered a significant part (14,4%), other other forbs were the most abundant type of vegetation (43,2%), while grasses were considerably less than in the two previous areas (30,5%). In Pyrra, on the other hand, grasses were the most scarce type of vegetation (18,4%), while legumes accounted for the highest acreage compared to the three other areas (29,4%), and forbs were, for once more, the most abundant (52,1%). The highest species richness was found in Pyrra (22,5 species on average) and Chaliki (20,6 species) followed by Grevena (18,1) and Vermio (16,6). Shrublands exhibited the lowest diversity (1-2 species) and other forbs the highest.

Table 1. Species composition (%), number of species and milk quality components (fatty acids) in the four study areas

	Grevena		Vermio		Chaliki		Pyrra	
	%	No. of species	%	No. of species	%	No. of species	%	No. of species
Functional groups								
Grasses	46,0	6,8	30,5	5,9	44,3	6,0	18,4	5,3
Legumes	14,6	2,9	11,8	2,6	19,1	4,4	29,4	5,7
Other forbs	38,6	8,1	43,2	7,6	36,7	10,1	52,1	11,3
Shrubs	0,8	0,3	14,4	0,5	0,0	0,0	0,0	0,0
Total	100,0	18,1	100,0	16,6	100,0	20,6	100,0	22,5
Fatty acids								
CLA	1,85		1,04		1,95		1,16	
SFA	63,09		65,97		59,67		58,33	
MUFA	29,56		28,54		31,73		35,17	
PUFA	5,49		4,45		6,65		5,34	
Total	100,00		100,00		100,00		100,00	
ω3	1,81		1,45		2,71		1,40	
ω6	3,68		3,00		3,94		3,94	

In the second part of Table 1 the average of the two measurements of fatty acids in the milk samples is reported. The highest CLA concentration was found in Chaliki and Grevena (1,85% and 1,95% respectively), which shows that grasses consumption can be related to higher CLA, which may be beneficial for human health (Whale *et al*., 2004). PUFA are generally higher in cases where animals graze in mountain pastures (Morand-Fehr *et al*., 2006). In this experiment the milk samples in Chaliki were the richest in PUFA followed by the ones in Grevena – i.e. the two areas with highest contribution of grasses – while the lowest was detected for Vermio, where shrublands occupied an important percentage of floristic composition. On the other hand, MUFA were considerably higher in Pyrra, indicating correlations with diets rich in legumes and/or other forbs. SFA were the most abundant types of fatty acids in all cases. The lowest percentage was found in Pyrra and Chaliki, where legumes were more abundan.

The establishment of relationships between grazing material and the quality of raw products has important economic prospects, as mentioned above. Indeed, this would support the standardization of traditional dairy products with high added value, which would improve their competitiveness in markets. Under such a scenario, farmers would probably choose to graze their animals more in order to increase and maintain high quality, even if this would entail less milk yield. Then, integrated management plans would be necessary for mountainous rangelands in order to support more grazing animals without threatening their ecological quality and floristic diversity. Nevertheless, the most important issue behind the economic use of these results is the production of cheese from raw milk. This traditional technique generally allows for the organoleptic characteristics of raw milk to be transmitted to the manufactured product. However, for Greece this is actually under examination, as the legislative framework is very strict regarding cheese-making from unpasteurized milk.

IV – Conclusions

The preliminary results indicate a significant relationship between floristic diversity and the concentration of specific fatty acids, some of which are potentially beneficiary for human health. Differences are found among areas grazed by transhumant flocks during summer. These findings should be carefully analyzed also taking into account the breed of the animals, as it has been reported that Greek autochthonous breeds perform better than imported ones in terms of milk quality, especially in their area of origin.

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Effects of the dose and the administration form of rosemary essential oils on carcass characteristics of lambs

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Abstract. The aim of this experiment was to study the effects of the dose and the administration form of rosemary (*Rosmarinus officinalis* L.) essential oils on lambs' carcass characteristics and meat composition Thirty two Barbarine lambs were allotted to 4 homogeneous groups and fed oat-hay *ad libitum* with 500 g of concentrate. Rosemary essential oils (REO) were orally administrated at a dose of 0.3 and 0.6 ml/day to lambs in O-R1 and O-R2 groups, respectively. Rosemary essential oils were mixed with the concentrate at an equivalent dose of 0.3 ml /day for the Mix-R1 group, while the control group (C) did not receive REO. The administration of REO affected hot carcass weight and, consequently, commercial dressing percentage ($P < 0.05$) being higher for the Mix-R1 group (48 %). The administration of REO slightly ameliorated testicles weight (111 vs. 105 g for REO and C groups, respectively; P?). The administration of 0.3 ml /day of rosemary essential oils may have an important effect on carcass characteristics and meat composition.

Keywords. Rosemary – Lambs – Carcass – Meat.

Effets de la dose et de la forme d'administration d'huiles essentielles de romarin sur les caractéristiques des carcasses d'agneaux

Résumé. *La finalité de cette expérimentation était d'étudier les effets de la dose et de la forme d'administration d'huiles essentielles de romarin (*Rosmarinus officinalis *L.) sur les caractéristiques des carcasses d'agneaux et la composition de la viande. Trente-deux ovins de race Barbarine ont été répartis en lots formant 4 groupes homogènes alimentés de foin d'avoine à volonté avec 500 g de concentré. Les huiles essentielles de romarin (REO) étaient administrées oralement à une dose de 0,3 et 0,6 ml/jour aux agneaux des groupes O-R1 et O-R2, respectivement. Les huiles essentielles de romarin étaient mélangées avec le concentré à une dose équivalente à 0,3 ml/jour pour le groupe Mix-R1, tandis que le groupe témoin (C) ne recevait pas de REO. L'administration de REO affectait le poids à chaud de la carcasse et, par conséquent, le pourcentage de rendement commercial de la carcasse ($P < 0.05$) était plus élevé pour le groupe Mix-R1 (48 %). L'administration de REO améliorait légèrement le poids testiculaire (111 vs. 105 g pour les groupes REO et C, respectivement; P?). L'administration de 0,3 ml/jour de REO pourrait avoir un important effet sur les caractéristiques de la carcasse et la composition de la viande.*

Mots-clés. *Romarin – Agneaux – Carcasse – Viande.*

I – Introduction

Front consumer's increasing demand for healthy and ecological meat products makes the investigation about the possibility of manipulating meat quality through dietary strategies needed. Plant secondary compounds can exert antioxidant activity due to the content of phenolic diterpenes (Aruoma *et al*., 1996). Previous studies demonstrated that rosemary essential oils (REO) can be used as a dietary supplement to improve meat quality and oxidative stability (Nieto *et al*., 2010; O'Grady *et al*., 2006; Smeti *et al*., 2013), although information about the adequate form and dose of REO and their effects on meat composition and carcass characteristics are scarce. On this basis, we were interested in evaluating whether the dose rates and administration form of rosemary (*Rosmarinus officinalis* L.) essential oils could affect lambs' carcass characteristics and meat quality.

II – Material and methods

1. Animals and diets

The experiment was carried out in the National Institute of Agricultural Research of Tunisia (INRAT) and lasted 100 days. The experiment started with a total of 32 Barbarine lambs (32 + 3 kg of BW). Animals were ranked by weight and allotted to 4 homogeneous groups, and received oat-hay *ad libitum* supplemented with 500 g of concentrate. The REO was orally administrated at a dose of 0.3 and 0.6 ml/day to lambs in O-R1 and O-R2 groups, respectively. It was mixed with the concentrate at an equivalent dose of 0.3 ml /day for the Mix-R1 group, while the control group (C) did not receive REO. When reaching 39 + 3 kg of weight, animals were slaughtered after an overnight period without feed but free access to water.

2. Measurements and analysis

Body weight at slaughter (SBW) was recorded. Skin, feet, head, red cut-down (liver, kidneys, spleen, and heart), all fractions of the digestive tract, and the hot carcass (HCW) were weighed. Samples of *Longissimus dorsi* were dried (50 °C), ground (1 mm screen), and stored for subsequent analyses. Dry matter was determined by drying at 80 °C until constant weight. Mineral content was determined by ashing at 600 °C for 8 h. Nitrogen was determined by Kjeldahl method (Crude protein = N×6.25). Meat ether extract was determined by Soxhlet extraction.

3. Statistical analysis

A one-way ANOVA (PROCGLM of SAS (2002)) was used to test the effect of REO incorporation on meat chemical composition, and carcass. The following model was used: $Y= \mu + Di + e$; Y: variable; μ: mean; Di: Diet effect; e: standard residual error. The level of significance was set at 0.05. The following contrasts were used: Contrast 1: Effects of rosemary incorporation form [Mix-R1 group vs. O-R1 + O-R2 groups]; Contrast 2: Effects of rosemary dose [O-R1 vs. O-R2 group]; Contrast 3: Effects of rosemary presence [C vs. O-R1 + O-R2 + Mix-R1 groups].

III – Results and discussion

1. Meat chemical composition

Feeding lambs with REO did not affect ($P > 0.05$) the moisture, protein, ash and fat content of Barbarine lambs' meat (Table 1). These results are in agreement with recent studies of Smeti *et al*. (2013 a) who did not find significant effects of the REO on the meat chemical composition of lambs from the same breed. Similarly, no significant changes in the chemical characteristics of the muscles (moisture, protein, fat, ash) were found between dietary treatments when lambs of different groups were slaughtered at similar BW (Atti and Mahouachi, 2009), which was the case for the current study.

Table 1. Chemical composition of meat

Group	C	Mix-R1	O-R1	O-R2	S.E.M	P	Cst 1	Cst 2	Cst 3
Moisture (g/kg)	73.3	73.9	74.9	74.6	0.97	NS	NS	NS	NS
Protein (g/kg dry matter-DM)	77.7	77.3	77.2	78.1	2.68	NS	NS	NS	NS
Ash (g/kg DM)	4.4	4.4	4.5	4.6	0.01	NS	NS	NS	NS
Fat (g/kg DM)	17.9	18.2	18.3	17.3	2.68	NS	NS	NS	NS

C: control ; Mix-R1 : 0.3 ml/d REO (rosemary essential oils) administered mixed with concentrate ; O-R1: 0.3 ml/d REO administered orally ; and O-R2: 0.6 ml/d REO administered orally. S.E.M: standard error of the mean; NS, P>0.05; Cst 1: Mix-R1 vs. O-R1 + O-R2; Cst 2: O-R1 vs. O-R2; Cst 3: C vs. O-R1 + O-R2 + Mix-R1.

2. Slaughter parameters and non- carcass components

Rosemary administration affected HCW and CDP (commercial dressing percentage) (Table 2: P < 0.05). Both values were higher for the Mix-R1 group (19.4 kg and 48 %, respectively). These differences could be related to the numerical difference in SBW (Atti and Khaldi, 1988; Atti *et al*., 2003), which was higher for lambs from the Mix-R1 group (40.2 kg).

However, no significant differences between groups were recorded for the weight of the different red cut-down (Table 2).

Table 2. Effects of rosemary administration on lambs' slaughter parameters and non-carcass components

	C	Mix-R1	O-R1	O-R2	S.E.M	P	Cst 1	Cst 2	Cst 3
SBW (kg)	39.3	40.2	38.7	39.1	1.20	NS	NS	NS	NS
HCW (kg)	17.8	19.4	17.2	17.4	0.55	*	0.45	NS	**
CDP (%)	45.5	48.2	44.3	44.5	0.76	**	NS	NS	***
Red cut-down (g)	1248	1284	1279	1272	40.3	NS	NS	NS	NS
Testicles (g)	105	108	118	106	9.2	NS	NS	NS	NS

S.E.M: standard error of the mean; NS, P>0.05; *, P<0.05; **<0.01; Cst 1: Mix-R1 vs. O-R1+O-R2; Cst 2: O-R1 vs. O-R2; Cst 3: C vs. O-R1 + O-R2 + Mix-R1; SBW, slaughter body weight; HWC, hot carcass weight; CDP, commercial dressing percentage.

IV – Conclusion

The administration of 0.3 ml /day of rosemary essential oils may have an important interest on carcass parameters of Barbarine lambs.

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Effects of EPA and DHA on *in vitro* ruminal biohydrogenation of 18-carbon fatty acids in sheep

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Abstract. Marine lipid supplements have been used to inhibit the ruminal saturation of *trans*-11 18:1, with the final goal of enhancing *cis*-9 *trans*-11 conjugated linoleic acid (CLA) concentration in milk and meat. This response would be largely explained by the effects of n-3 very long chain polyunsaturated fatty acids (PUFA) on the last step of biohydrogenation (BH). In cows, docosahexaenoic acid (DHA, 22:6n-3) has been suggested to be a stronger inhibitor of *trans*-18:1 hydrogenation than eicosapentaenoic acid (EPA, 20:5n-3), but information about changes in individual 18:1 isomers is very limited, and no reports are available in sheep. This in vitro study was therefore conducted to compare the impact of EPA and DHA on the BH of 18-carbon fatty acids in ovine, using batch cultures of rumen microorganisms and cannulated ewes as inocula donors. The two PUFA were added at a dose of 2% incubated DM and effects were examined after 24 h of incubation. The DHA treatment led to the greatest concentration of *trans*-18:1 in digesta, but this was mainly accounted for by accumulation of metabolites from alternative BH pathways (e.g, *trans*-9, -10, -12 and -15 18:1), while the inhibition of *trans*-11 18:1 saturation was comparable with both PUFA. The saturation of *cis*-18:1 was constrained too, particularly by DHA, whereas EPA seemed to have specific effects on 18:3n-3 metabolism. Changes in oxo-FA concentrations suggested that ruminal hydration (an alternative metabolic pathway to BH) was also affected by PUFA treatments.

Keywords. Ewe – PUFA – Ruminal lipid metabolism – *Trans* fatty acid.

Effets de l'EPA et du DHA sur la biohydrogénation ruminale* in vitro *des acides gras à 18 carbones chez les ovins

Résumé. *Les suppléments lipidiques marins ont été utilisés pour inhiber la saturation ruminale du trans-11 18:1, dans le but final d'améliorer la concentration en acide linoléique conjugué (CLA) cis-9 trans-11 18:2 dans le lait et la viande. Cette réponse s'explique en grande partie par les effets des acides gras polyinsaturés n-3 à très longue chaîne (AGPI) sur la dernière étape de la biohydrogénation (BH). Chez le bovin, l'acide docosahexaénoïque (DHA, 22:6n-3) a été proposé comme un plus fort inhibiteur de l'hydrogénation des trans-18:1 que l'acide eicosapentaénoïque (EPA, 20:5n-3), mais il y a trop peu de données sur les variations des isomères 18:1 individuels et aucune étude n'est disponible chez les ovins. Cet essai in vitro a donc été réalisée pour comparer l'impact de l'EPA et du DHA sur la BH des acides gras à 18 carbones chez des moutons, en utilisant des cultures discontinues de microorganismes du rumen et des brebis canulées comme donneuses d'inoculum. Les deux AGPI ont été ajoutés à une dose de 2% de la matière sèche incubée et les effets ont été examinés après 24 h d'incubation. Le traitement DHA a induit la plus grande concentration en trans-18:1 dans les digesta, mais cela était principalement attribuable à l'accumulation des intermédiares de voies de BH alternatives (p. ex., trans-9, -10, -12 et -15 18: 1), alors que l'inhibition de la saturation du trans-11 18:1 était comparable pour les deux AGPI incubées. La saturation des cis-18:1 était également limitée, en particulier par le DHA, alors que l'EPA semblait avoir des effets spécifiques sur le métabolisme du 18:3n-3. Les changements des concentrations en céto-AG ont suggéré que l'hydratation ruminale (une voie métabolique alternative à la BH) a également été affectée par les traitements avec AGPI.*

Mots-clés. *Brebis – AGPI – Métabolisme ruminal des lipides – Acide gras trans.*

I – Introduction

Marine lipid supplements have been used to inhibit the ruminal saturation of *trans*-11 18:1, with the final goal of enhancing *cis*-9 *trans*-11 conjugated linoleic acid (CLA) concentration in milk and meat (Lee *et al.*, 2005; Toral *et al.*, 2012). This response would be largely explained by the effects of n-3 very long chain polyunsaturated fatty acids (PUFA) on the last step of biohydrogenation (BH). In cows, AbuGhazaleh and Jenkins (2004) suggested that docosahexaenoic acid (DHA, 22:6n-3) could be a stronger inhibitor of *trans*-18:1 hydrogenation than eicosapentaenoic acid (EPA, 20:5n-3), but we are not aware of similar works in sheep. Furthermore, their study did not report changes in *trans*-18:1 profile, although advances in the knowledge of the biological effects of fatty acids (FA) suggest relevant differences between individual isomers (Shingfield *et al.*, 2008; Wang and Proctor, 2013).

Trans-11 18:1, the predominant *trans*-18:1 in milk and meat, is a desirable FA that is desaturated to *cis*-9 *trans*-11 CLA in ruminant and human body tissues (Wang and Proctor, 2013). On the other hand, *trans*-9 and -10 18:1, more abundant isomers in industrial fats, might have potentially negative impact on consumer's health (Shingfield *et al.*, 2008; Wang and Proctor, 2013). In addition, the shift in ruminal BH pathways leading to *trans*-10 18:1 accumulation has been associated with the syndrome of milk fat depression in sheep fed fish oil or marine algae (Toral *et al.*, 2012, 2016). Providing further insight into the influence of specific n-3 PUFA on ruminal *trans*-18:1 profile may then contribute to develop feeding strategies that modulate ewe milk FA composition with the least side effects.

This in vitro study was therefore conducted to compare the impact of EPA and DHA, the major n-3 PUFA in marine lipids, on the BH of 18-carbon fatty acids in ovine.

II – Material and methods

Batch cultures of rumen microorganisms were conducted using 16-mL Hungate tubes and rumen fluid collected from 2 ruminally cannulated ewes fed a total mixed ration (forage:concentrate ratio 50:50). After an adaptation period of 2 weeks, the inocula (collected in three different days, each one corresponding to a replicate) were obtained before the morning feeding and mixed (1:4) with artificial saliva. The ration fed to the animals was used as the substrate for incubation (50 mg/mL of rumen fluid). The two PUFA were dissolved in ethanol 96% and added at a dose of 2% DM just before the incubation started. Only the ethanol was dosed to the control treatment. All vials were incubated under anaerobic conditions for 24 h at 39.5ºC.

At the end of the incubation, the reaction was stopped by placing the tubes into ice-water. They were then stored at -80ºC until FA analysis. The lipids in freeze-dried in vitro ruminal digesta were extracted and converted to FA methyl esters (FAME) by sequential base-acid catalysed transesterification (Toral *et al.*, 2010). Methyl esters were separated and quantified with a gas chromatograph (Agilent 7890A, Santa Clara, CA, USA) equipped with a flame-ionization detector and a 100-m fused silica capillary column (CP-SIL 88, Varian Ibérica S.A., Madrid, Spain). Total FAME profile was determined using a temperature gradient program and then isothermal conditions at 170ºC to further resolve 18:1 isomers (Shingfield *et al.*, 2003). Peaks were identified based on retention time comparisons with commercially available standard FAME mixtures and selected digesta samples for which the FA composition was determined based on GC analysis of FAME and GC-MS analysis of corresponding 4,4-DMOX derivatives (Toral *et al.*, 2010).

Statistical analyses were performed using the MIXED procedure of the SAS software package (version 9.4; SAS Institute Inc., Cary, NC, USA), with a model that included the fixed effect of treatments (control, EPA and DHA), and the random effect of the incubation run. Means were separated through the "pdiff" option of the "lsmeans" statement, and adjusted for multiple comparisons using Bonferroni's method.

III – Results and discussion

The DHA treatment led to the greatest concentration of total *trans*-18:1 in digesta ($P<0.001$), in agreement with earlier results in cows (AbuGhazaleh and Jenkins, 2004). However, this was mainly accounted for by accumulation of metabolites from alternative BH pathways (e.g, *trans*-9, -10, -12 and -15 18:1; $P>0.05$), while the inhibition of *trans*-11 18:1 saturation caused by EPA or DHA was similar ($P>0.10$). This is probably related to the toxicity of each PUFA for particular ruminal bacteria species (Maia *et al.*, 2007), and may have relevant implications due to the different EPA/DHA ratio of marine lipids (e.g., fish oils usually have greater proportions of EPA than DHA-rich algae). The first implication might be that increases in milk and meat *cis*-9 *trans*-11 CLA concentrations would be comparable at the same PUFA dose, as supported by the observed lack of significant variation in ruminal *cis*-9 *trans*-11 CLA ($P>0.10$). Secondly, based on the association between shifts in BH pathways and the low-fat milk syndrome (Kairenius *et al.*, 2015; Toral *et al.*, 2016), it could be expected that supplements rich in DHA (e.g., *Schizochytrium* sp. algae) would have the strongest negative effects on animal performance. In vivo research would be advisable to verify both points.

Table 1. Effect of EPA and DHA on some 18-carbon fatty acid concentration (% of total FA) after 24-h in vitro incubation with rumen inoculum from sheep

	Treatments				
	Control	**EPA**	**DHA**	**s.e.d.[1]**	***P*-value**
18:0	55.799^{a}	39.782^{b}	37.467^{b}	1.7526	<0.001
10-oxo-18:0	0.098^{b}	0.221^{a}	0.149^{ab}	0.0307	0.039
13-oxo-18:0	0.170^{ab}	0.173^{a}	0.126^{b}	0.0114	0.025
cis-9 18:1[2]	1.868^{b}	1.929^{ab}	2.698^{a}	0.2899	0.051
cis-11 18:1	0.254^{b}	0.399^{a}	0.500^{a}	0.0339	0.005
cis-12 18:1	0.170^{b}	0.240^{ab}	0.274^{a}	0.0337	0.054
cis-13 18:1	0.113^{b}	0.112^{b}	0.143^{a}	0.0069	0.017
trans-9 18:1	0.216^{c}	0.472^{b}	0.691^{a}	0.0552	<0.001
trans-10 18:1	0.238^{c}	0.599^{b}	1.025^{a}	0.0357	<0.001
trans-11 18:1	3.927^{b}	5.678^{a}	6.464^{a}	0.4309	0.003
trans-12 18:1	0.472^{c}	1.057^{b}	1.266^{a}	0.0511	<0.001
trans-13 18:1	0.586^{b}	1.434^{a}	1.610^{a}	0.0864	<0.001
trans-15 18:1	0.498^{b}	0.841^{a}	1.003^{a}	0.0310	<0.001
Σ *trans*-18:1	6.326^{c}	10.509^{b}	12.649^{a}	0.5622	<0.001
cis-9 *cis*-12 18:2	1.120^{a}	0.790^{b}	0.838^{ab}	0.0979	0.030
trans-11 *cis*-15 + *trans*-10 *cis*-15 18:2	0.097^{b}	0.492^{a}	0.397^{a}	0.0640	0.008
cis-9 *trans*-11 CLA	0.112	0.130	0.108	0.0134	0.321
trans-10 *cis*-12 CLA	0.028	0.035	0.022	0.0062	0.207
cis-9 *cis*-12 *cis*-15 18:3	0.208	0.126	0.113	0.0337	0.090
trans-9 *trans*-12 *cis*-15 18:3[3]	0.009^{b}	0.099^{a}	0.015^{b}	0.0160	0.002

$^{a-c}$ Within a row, different superscripts indicate significant differences ($P<0.05$) or a trend towards significance (in italics; $P<0.10$) due to the effect of treatment.

[1] s.e.d. = standard error of the difference. [2]Contains *trans*-14 18:1 as a minor component. [3]Coelutes with *cis*-9 *cis*-12 *trans*-15 18:3.

The ruminal BH of *cis*-18:1 was constrained too, consistent with previous investigations in cows and sheep (AbuGhazaleh and Jenkins, 2004; Toral *et al.*, 2012). Increases in *cis*-9, -12 and -13 18:1 accumulation would indicate a more pronounced response to DHA ($P<0.10$). On the contrary, EPA seemed to have specific, yet subtle, effects on 18:3n-3 metabolism, according to variation in minor intermediates (e.g., *trans*-9 *trans*-12 *cis*-15 + *cis*-9 *cis*-12 *trans*-15 18:3; $P<0.01$), although

numerical differences in the major metabolites (i.e., *trans*-11 *cis*-15 + *trans*-10 *cis*-15 18:2) between PUFA treatments did not attain statistical significance ($P>0.10$).

Finally, changes in oxo-FA concentrations (i.e., 10- and 13-oxo-18:0; $P<0.05$) suggested that ruminal hydration (an alternative metabolic pathway to BH) was differently affected by EPA and DHA. Given the limited information about the bioactivity of oxylipids in ruminants (Raphael *et al.*, 2014), the putative link between oxo-FA and milk fat depression (Kairenius *et al.*, 2015; Toral *et al.*, 2016) merits additional investigation.

IV – Conclusion

Sheep diet supplementation with EPA and DHA exerts some different actions on the in vitro ruminal BH of C18 FA (e.g., DHA promotes the accumulation of 18:1 metabolites from alternative BH pathways, such as *trans*-10 18:1, while EPA seems to specifically modify 18:3n-3 metabolism). However, both of them have a similar positive impact on *trans*-11 18:1 concentration, suggesting an equivalent potential to modulate ovine milk and meat FA profiles by improving *cis*-9 *trans*-11 CLA content.

Acknowledgments

This article is dedicated to the memory of Kevin J. Shingfield, a renowned expert in ruminant lipid metabolism and, above all, a good friend of ours. The work was supported by the Spanish Ministry of Economy, Industry and Competitiveness (MEIC; AGL2014-54587-R). P. G. Toral and D. Carreño received *Ramón y Cajal* and FPI contracts from the MEIC. Co-funding by the European Regional Development Fund is also acknowledged.

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Early weaning of kid goats does not compromise rumen microbial colonization and post-weaning digestive capacity

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Abstract. Milk feeding in intensive dairy farming represents a significant cost, which can potentially be reduced if the animal is weaned early. However, an abrupt transition from milk to solid feed may affect animal's growth, appropriate rumen development and future digestive capacity. This experiment was conducted to assess the effect of an early weaning (EW) practice (5 weeks of life) on rumen microbial colonization and post weaning digestive ability against the normal weaning (NW) practice in diary goats farming (7-8 weeks). Twelve new-born kid goats were used and randomly allocated to one of the two experimental groups (n=6). They were provided mothers colostrum for 24 hours and then taken away and fed commercial milk replacer following the manufacturer guidelines. Alfalfa hay and starter concentrate pellets were available from week one after birth. After weaning, animals were kept together until 6 months of life. Then rumen content samples were collected and a digestibility trial was conducted. The weights of kid goats did not differ EW and NW until month six of life and both groups experienced a temporal decline in weight gain during the 7-10 days after weaning (more pronounced in EW). The fermentation pattern and microbial biomass were not different between groups. At month six of life neither the fermentation pattern nor the apparent digestibility differ between groups. Our results suggest that an early weaning strategy is possible and does not compromise the future digestive efficiency of the animal.

Keywords. Rumen development – Weaning – Microbial colonization – Goats.

Le sevrage précoce des chevreaux ne compromet pas la colonisation microbienne et le post-sevrage dans le rumen capacité digestive

Résumé. *L'allaitement dans les systèmes laitiers intensifs représente un coût important, qui peut être réduit par le sevrage précoce. Cependant, une transition brusque vers l'allaitement maternel et les aliments solides peut affecter la croissance animale, le développement approprié du rumen et la capacité digestive à l'avenir. Cette étude a été réalisée pour évaluer l'effet d'une pratique de sevrage précoce (EW, 5 semaines de vie) sur la flore microbienne du rumen et la capacité digestive après le sevrage, en fonction du temps de sevrage habituel (NW, 7-8 semaines) chez les chèvres laitières. Douze chèvres (nouveau-nés) ont été choisies et utilisées aléatoirement pour chaque groupe expérimental (n = 6). Le colostrum de leur mère a été administré à chaque chevreau pendant 24 heures, puis retiré d'eux et fourni du lait commercial reconstitué selon les indications du fabricant. Une luzerne et des granulés concentrés sont fournis librement aux chèvres dès la première semaine de la naissance. Après le sevrage, les animaux ont été maintenus ensemble jusqu'à l'âge de 6 mois, date à laquelle des échantillons de contenu ruminal ont été prélevé et un essai de digestibilité a été mené. Les poids des chevreaux ne diffèrent pas entre EW et NW jusqu'au sixième mois de vie et les deux groupes ont subi une interruption du gain de poids au cours des 7 à 10 jours suivant le sevrage (plus remarquable dans EW). Le schéma de fermentation et de la biomasse microbienne n'était pas différent entre les groupes, à l'exception des champignons, dont la concentration était plus faible chez les chevreaux EW. À six mois de vie, ni le modèle de fermentation ni la digestibilité apparente n'étaient différents entre les deux groupes. Nos résultats suggèrent qu'une stratégie de sevrage précoce est possible sans compromettre l'efficacité digestive de l'animal à l'avenir.*

Mots-clés. *Développement de rumen – Sevrage – Colonisation microbienne – Caprine*

I – Introduction

The intensification of the livestock production systems, especially in dairy production, has transformed the way newborns are reared. Normally the offspring is separated from the dam straight after birth and fed with milk replacer which may compromise development as a result of a lack of appropriate microbial gut inoculation and natural growth promoters present in whole natural milk (Soberon *et al*., 2012). This normally delays the rumen microbial development (Belanche *et al*., 2015) and the liveweight gain and increases the risk of infections by pathogens, which in many cases is addressed in commercial farms by using antimicrobials.

At birth, young ruminants have an undeveloped reticulo-rumen and they function as pre-ruminants fed on milk-based diets that are not digested in the rumen but in the abomasum (Davis and Drackley, 1998). A smooth transition from a pre-ruminant to ruminant animal, with minimal loss in growth, requires the development of the reticulo-rumen and its associated microbial population for efficient utilization of solid and forage-based diets (Heinrichs, 2005).

Development of the rumen is an important physiological challenge for young ruminants (Jiao *et al*., 2015). It entails growth and cellular differentiation of the rumen, and results in a major shift in the pattern of nutrients being delivered to the intestines and liver, and thus the peripheral tissues of the animal (Baldwin *et al*., 2004). The development of the rumen involves three distinct processes (Yáñez-Ruiz *et al*., 2015): Anatomical development (growth in rumen mass and growth of rumen papillae), physiological development (fermentation capacity and enzyme activity, and microbiological colonization. An inadequate development of the rumen will affect nutrient digestion and absorption (Baldwin *et al*., 2004). On the other hand, a complete development of the rumen facilitates digestion of feed components, which provides nutrients for the physiological requirements of the animal. This rumen development is a process that generally occurs following three phases: Pre-ruminant (0-3 weeks); Transitional phase (3-8 weeks) and Rumination (from 8 weeks on) (Lane *et al*., 2002). However the duration of these phases can vary depending on the type of milk feeding system, availability of solid feed or weaning strategy.

Milk feeding of young ruminants in intensive dairy farming represents a significant cost, which can potentially be reduced if the animal is weaned early. However, an abrupt transition from milk to solid feed may affect animal's growth, appropriate rumen development and future digestive capacity. This experiment was conducted to assess the effect of an early weaning (EW) practice (5 weeks of life) on rumen microbial colonization and post weaning digestive ability against the normal weaning (NW) practice in diary goats farming (8 weeks).

II – Materials and methods

Twelve new-born kid goats were used and randomly allocated to one of the experimental groups (n=6): early weaning (EW) practice or normal weaning (NW). All kids were provided mothers colostrum for 24 hours and then moved to a temperature controlled experimental room (23ºC ± 1ºC; 55% HR) and fed commercial milk replacer (Nutral, SA, Madrid, Spain) following the manufacturer guidelines. Milk replacer was provided three times a day during the first 2 weeks and then twice (morning and evening). The volume offered was increased gradually after birth to a maximum of 2 litres (180 g powder/litre). Good quality alfalfa hay and starter concentrate pellets were available from week one after birth.

Weaning was conducted by reducing the concentration of milk replacer gradually during 5 days (20% less every day) to promote solid feed intake.

One group of animal was weaned at week 5 of life (Early Weaning, EW), while the other was weaned at week 8 (Normal Weaning, NW). After weaning, animals from both groups were kept together un-

til 6 months of life, when a digestibility trial was conducted. The digestibility trial comprised total collection of faeces in metabolic cages and motorization of intake during 5 consecutive days. Animals were offered an *ad libitum* diet consisting of 50% alfalfa hay 50% commercial concentrate. Samples of faeces, diet and refusals were kept at -20ºC until analyses of DM, OM, N and NDF were performed.

Rumen contents samples were collected from all animals at 2 times: at weaning (W), one month post-weaning (PW). Rumen samples were collected via oesophageal probe following a previously described protocol (Ramos-Morales *et al*., 2014) and aliquots kept at -20ºC for VFA and molecular analyses. Animals´ weights were recorded weekly before the morning feeding.

Samples of rumen digesta were freeze-dried, genomic DNA was extracted, and DNA was used as a template to quantify the bacterial copy numbers of 16S rRNA gene by real-time PCR as described by Abecia *et al*. (2014). Data were analysed by ANOVA. Differences between means were declared when P-values were below 0.05 and considered as trends when P-values were between 0.05 and 0.10.

III – Results and discussion

There were not statistical differences in the fermentation profile between EW and NW, only tendencies for the proportion of butyric acid and the acetic/propionic ratio (Table 1). Despite the lack of differences between the experimental treatments, the fermentation profile changed clearly from pre to postweaning: acetic acid represented 79-83% of VFA at weaning, while post-weaning propionic acid became more abundant, with a 30% increase. The slight increase in concentration of total VFA from W to PW is consistent with a more developed rumen and the associated increase in solid feed intake (Heinrichs, 2005). However, the concentration at PW is still below the normal values observed in adult goats (Abecia *et al*., 2013). Nevertheless, the fact that values of total VFA concentration are not different between EW and NW groups at W suggests that the functional activity, as anaerobic fermentation, could be ready for a transition from milk to solid feed intake at 5-6 weeks of age. According to Teh *et al*. (1984), goat kids have been successfully weaned at 5 weeks if they were consuming at least 30 g/day of solid feed daily before weaning. The severity of weaning shock is then reduced. Unfortunately, the daily feed intake was not measured in the present experiment, but the lack of differences in the AGV concentration at weaning age may suggest similar solid feed intake in both treatments. An early weaning program also encourages early development of the reticulo-rumen as a result of increased solid feed consumption (Morand-Fehr, 1981). Another strategy is to wean kids by weight (Lu and Potchoiba, 1988) as discussed below.

The concentration of rumen total bacteria at weaning was around the same values observed in adult goats (Figure 1). Previous works have shown that very early in the life of the animal (first week of life) the concentration of bacteria reaches similar levels as in adult ruminants (Abecia *et al*., 2014); however, as the rumen is still growing the total biomass is very low and does not increases substantially until the second-third week of life. Despite the increase in bacterial biomass, the composition in species and functional groups that colonize the rumen will determine the ability to digest plant material, especially in artificially reared ruminants that have not direct inoculation form adult animals as new-borns raised with their mothers do (Abecia *et al*., 2017). Our results show no differences in bacterial concentration between EW and NW animals at weaning, but significantly ($P<0.001$) greater concentration in NW one month after weaning. This could suggest a more active rumen activity, although this is not confirmed neither by the VFA data nor the digestibility data.

Kids´ live weights during the course of the experiment (Figure 2) showed three different stages: i) same linear growth in both groups from birth until weaning, ii) then a slowdown in body weight gain at weaning with a stronger effect on EW group, and compensated growth in EW to catch up with NW at around month 4 of life. Teh *et al*.(1984) indicated that weaning at 8 weeks was optimal for goat kids. Compared with kids weaned at 8 and 10 weeks of age, weaning shock was found to be

Table 1. Effect of weaning time (Early EW, vs. Normal NW) on the fatty acids profile in then rumen of kids at weaning (W) and post-weaning (PW)

		EW	NW	SED	Pvalue
Total VFA (mM)	W	21.1	23.2	2.17	0.104
	PW	23.9	24.9	2.32	0.672
Acetate (%)	W	79.6	83,8	1.76	0.274
	PW	65.1	64.0	2.52	0.827
Propionate (%)	W	18.1	13.6	1.73	0.223
	PW	29.8	29.3	2.50	0.926
Isobutirate (%)	W	n/d	n/d	n/d	n/d
	PW	n/d	0,06	0.036	0.389
Butirate (%)	W	2.26	2.61	0.232	0.484
	PW	4.86	6.03	0.302	0.085
Isovalerate (%)	W	n/d	0.08	0.029	0.198
	PW	n/d	0.18	0.073	0.243
Valerate (%)	W	n/d	n/d	n/d	n/d
	PW	0.18	0.40	0.151	0.488
Acetate/Propionate	W	4.55	7.72	0.842	0.094
	PW	2.49	2.43	0.373	0.941

n/d, no detected.

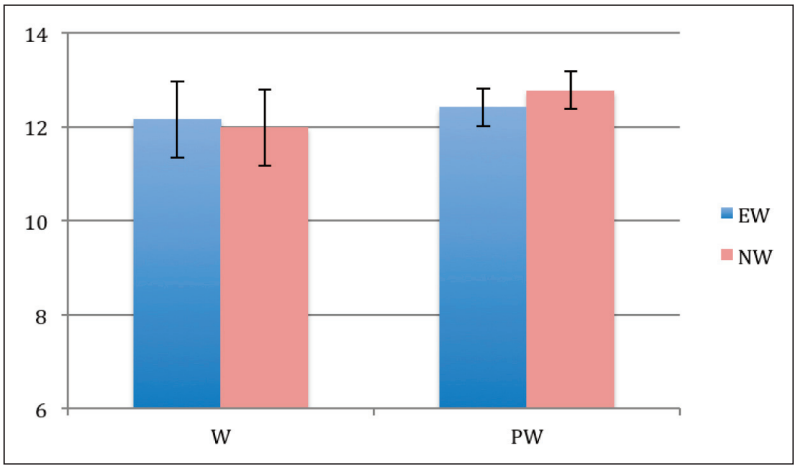

Fig. 1. Effect of weaning time (Early EW, vs. Normal NW) on bacterial abundance (log copy number 16srDNA/g fresh matter) in the rumen of kids sampled at weaning (W) and post-weaning (PW).

more severe and body weight losses were observed in those weaned at 4 and 6 weeks. Kids weaned at 4 weeks showed stunted growth for three consecutive weeks while those weaned at 6 weeks were stunted for two weeks before recovery. In our study goat kids weaned a 5 weeks showed a weaning shock with a delay in the live weight gain during two weeks, while for those weaned at 8 weeks was just one week. However, as observed in this study, subsequent compensatory growth overrode the temporary weight loss. Similar observations were noted when weaning at 4 or 8 weeks of age were compared (Owen and DePaiva, 1980). In agreement with our results similar weight gains after 5 months have been reported for goat kids weaned at 4 and 6 weeks of age (Opstvedt, 1969). What is not clear is whether the slower growth occurring in early-weaned kids affect the develop-

ment of key organs (i.e. mammary gland) that potentially, can compromise milk yield in future lactations of the animal. Different studies conducted in dairy cattle have pointed that greater milk allowance (and subsequent daily growth) in calves results in higher milk yield during first and second lactations (Soberon *et al.*, 2012). This remained to be determined in dairy goats.

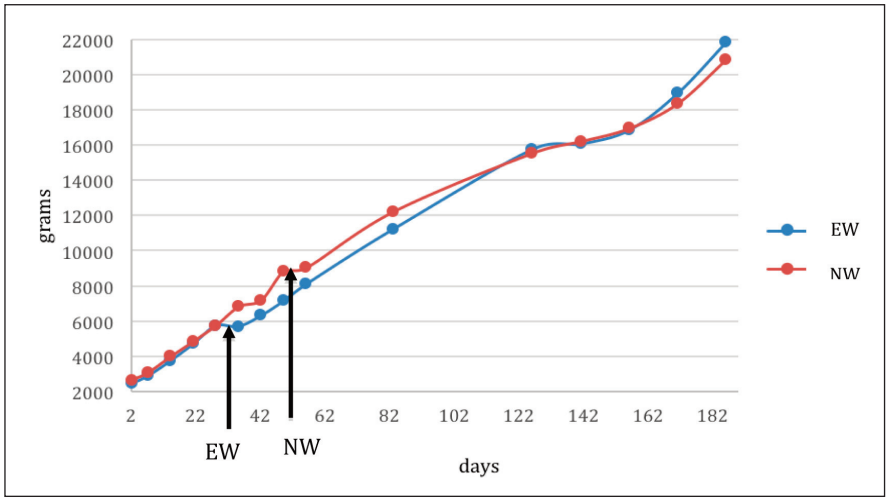

Fig. 2. Live weights of kids during the course of the trial. Arrows indicate weaning time for early weaning (EW) and normal weaning (NW) groups.

Another criteria is weaning animals by weight rather than by age. According to Lu and Potchoiba (1988), kids can be weaned when their body weights reach 2.5 times their birthweight. According to this, the animals in this study could have been weaned at 5.7 to 6.2 kg of body weight, which coincides with the values observed at 5 weeks of age. Compared to weaning by age, weaning shock seems to be less severe in kids weaned by weight (Lu and Potchoiba, 1988), although solid feed consumption is also critical for weaning by weight programs. A consumption of 30 to 50 g of concentrate has been suggested to be sufficient for early weaning (Morand-Fehr, 1981).

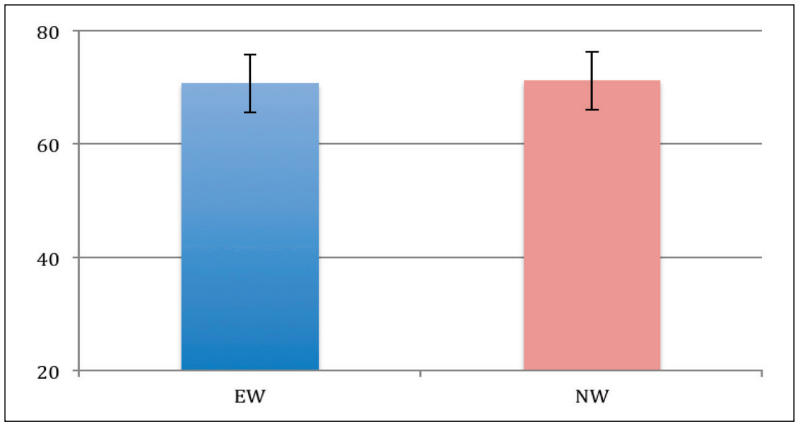

Fig. 3. Effect of weaning time (Early EW, vs. Normal NW) on dry matter apparent digestibility (g/100 g) at 6 months of age.

The total tract apparent digestibility did not differ (P<0.05) between experimental groups. This suggest that for the type of diet used in this study, the differences that could have occurred in the development of the rumen, and the rest of digestive tract, as a result of an early weaning did not compromise the digestive activity. This lack of differences could be explained by the acquisition of a similar rumen development for both experimental groups during the fattening period. Alternatively, EW lambs may have a slightly under-developed rumen function (as noted by the lower bacterial concentration), which could be compensated by a greater feed digestion in the hindgut. Further studies should be conducted to elucidate these hypotheses.

IV – Conclusions

Our results suggest that an early weaning strategy is possible and, although it temporarily slows down the growth of the animal, it does not compromise the future digestive efficiency of the animal. However, the long-term effect on animal productivity associated to the development of key tissues might need to be investigated.

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Session 2 (S)

Innovations to adapt sheep and goat feeding and production systems and industry to new societal demands

Production Systems

Small ruminants in a High Nature Cultural Value agroforestry system. Case studies in sheep research

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Abstract. Sheep and goat systems in south west Spain are "suffering" the same as any other extensive ruminant systems the Mediterranean area. Specifically, sheep farms have been endangered in recent years due to various pressures derived from changes in the consumption patterns and public policy changes. These systems are extremely fragile, as well as having a key role in providing environmental services. In this paper two case studies are presented. The first one is dealing with dairy herds of Merino ewes producing under a PDO scheme. In this case we analyse the farmers' perception of their relationship with the PDO "Torta del Casar", one of the most well-known Cheese PDOs in Spain, focusing on the technical and economic benefits that they obtain from their membership. The second case is related to sheep for meat systems. A sample of 101 sheep farms belonging to a second degree cooperative has been analysed. From this case we can conclude that the integration of farms into cooperatives can improve farm structure and ensure their persistence, due to the provision of additional services to the farmer, the generation of added value and increased price stability. Both cases are examples of successful strategies to improve the level of competitiveness of the productive system and the viability of the farms.

Keywords. Dehesa – Extensive farming – Agroforestry systems – PDO – Cooperativism.

Petits ruminants dans un système d'agroforesterie à forte valeur culturelle. Études de cas en recherche de moutons

Résumé. *Les systèmes de moutons et de chèvres dans le sud-ouest de l'Espagne «souffrent» de même que tous les autres systèmes de ruminants extensifs de la région méditerranéenne. Plus précisément, les exploitations de moutons ont été mises en danger ces dernières années en raison de diverses pressions découlant des changements dans les modes de consommation et les changements de politique publique. Ces systèmes sont extrêmement fragiles, tout en jouant un rôle clé dans la fourniture de services environnementaux. Dans cet article, deux études de cas sont présentées. Le premier concerne les élevages laitiers de brebis Merino produisant dans le cadre d'un programme PDO. Dans ce cas, nous analysons la perception par les agriculteurs de leur relation avec l'AOP "Torta del Casar", l'une des PDO les plus connues du fromage en Espagne, axée sur les avantages techniques et économiques qu'elles obtiennent de leur adhésion. Le deuxième cas concerne les moutons pour les systèmes de viande. Un échantillon de 101 élevages de moutons appartenant à une coopérative de deuxième degré a été analysé. Dans ce cas, nous pouvons conclure que l'intégration des fermes dans les coopératives peut améliorer la structure des exploitations agricoles et assurer leur persistance, grâce à la fourniture de services supplémentaires à l'agriculteur, à la création de valeur ajoutée et à la stabilité des prix accrue. Les deux cas sont des exemples de stratégies réussies pour améliorer le niveau de compétitivité du système productif et la viabilité des fermes.*

Mots-clés. *Dehesa – Agriculture extensive – Systèmes agroforestiers – PDO – Coopérativisme.*

I – Small ruminant systems in south west of Spain

In the southwest of the Iberian Peninsula, small ruminant production is based primarily on an extensive farm system, usually associated with beef cattle and pigs, and located frequently in agroforestry systems known as “Dehesas”. “Dehesas” are High Nature Cultural Value agroforestry system used for livestock range farming characterized by its mix of pasture and evergreen oak stands. It originated from the traditional Mediterranean forest, and indeed human intervention has been fundamental in maintaining the dehesa ecosystem as such, because the use of appropriate cultural practices has conserved the tree stratum, thus avoiding scrub invasion and increasing the system’s efficiency. Mixed-species grazing of beef cattle, sheep, goats and Iberian pigs is often practised to more efficiently utilize grazing resources. The ruminants can make use of the pasture, stubble, and fallow land, while the Iberian pigs in their final phase of fattening for market feed free-range on the pasture, and on mast from the holm oaks principally, but also from gall and cork oaks (Gaspar *et al*., 2007). The main orientation of these systems is to meat production and the sale of animals for intensive fattening (Pulido *et al*., 1999).

In Figure 1 one can see the distribution of agroforestry systems categorized by der Herder *et al*. (2017) in a recent work. As can be seen, throughout the southwest of the Iberian Peninsula there is a large expanse of territory occupied by these agroforestry systems.

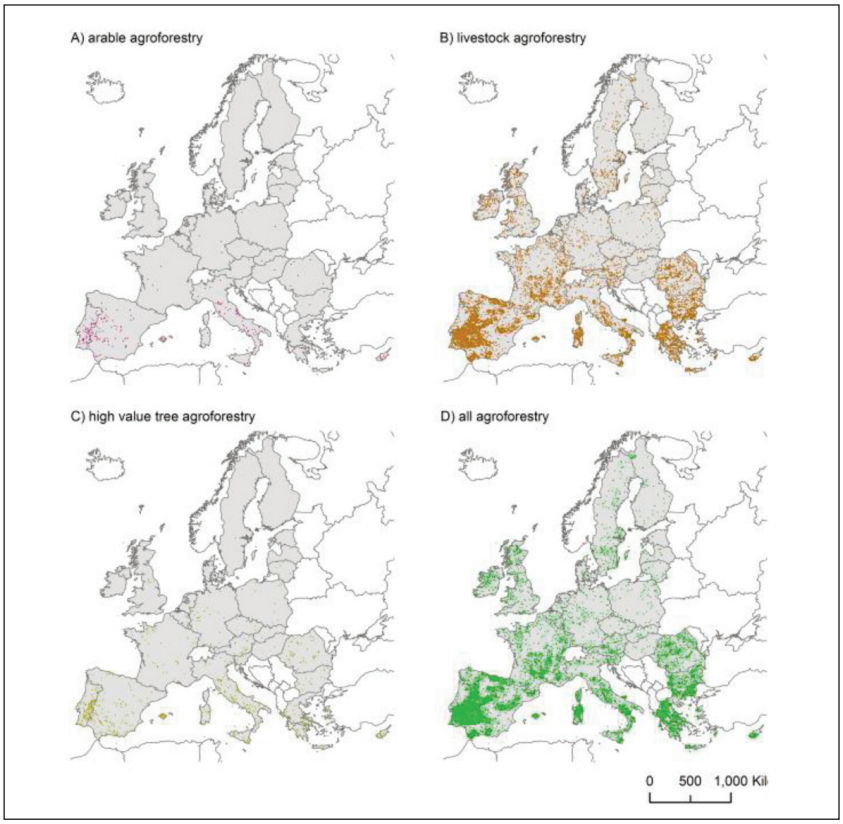

Fig. 1. Distribution of agroforestry in Europe. A) arable agroforestry, B) livestock agroforestry, C) high value tree agroforestry, and D) total extent of agroforestry.
Source: *den Herder et al. (2017).*

In Spain, major census of sheep, are concentrated in the autonomous communities of Extremadura, Castilla-Leon, Castilla-La Mancha, Andalusia and Aragon, representing 78.7 per cent of the national total altogether. In particular, the weight of the sheep in Extremadura is very significant, since it has a census of 3.4 million heads, representing 20.7% of the census at the national level (MAPAMA, 2014). Distribution of sheep and goat cattle in the different regions of Spain can be seen in figures 2 and 3. Largely, the areas with the highest density of small ruminants are also areas occupied by agroforestry systems.

In recent decades, the reduction in the number of farms and animals has been significant. The abandonment of this sheep activity has been of concern for institutions both at European, national or regional level. In particular, in Spain (second largest producer of sheepmeat in EU-28) is worth mentioning that since 2002 the production of lamb meat has been reduced approximately 50% (MAPAMA, 2014).

However, the successive reforms of the CAP and the continuous changes in the market have led to a decrease in the profitability of sheep and goat farms. As a result, there have been changes in the use of the soil, which have failed to materialize in some cases in a production intensification and in other cases in the abandonment of sheep farming activity (Gaspar *et al*., 2008; Gaspar *et al*., 2009; Ripoll-Bosch *et al*., 2012).

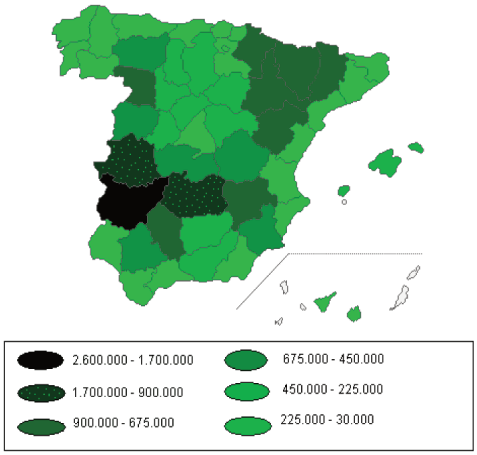

Fig. 2. Geographical distribution of sheep in Spain.
Source: *http://www.mapama.gob.es*

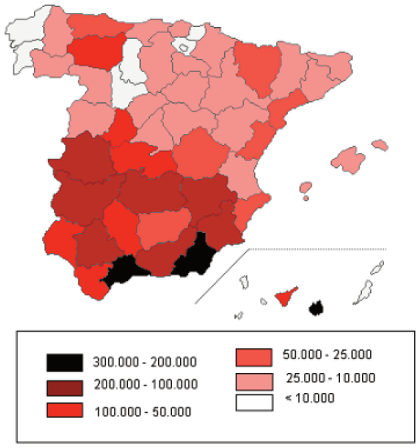

Fig. 3. Geographical distribution of goat in Spain.
Source: *http://www.mapama.gob.es*

In this sense, there is a certain consensus about the fragility of the sheep's meat systems located in Mediterranean regions (De Rancourt *et al*., 2006), Despite the crucial role they play in maintaining environmental and socio-economic disadvantaged areas of Europe (Bernues *et al*., 2011). An example of this role is the contribution of sheep grazing in the fight against climate change through protection against forest fires (Mena *et al*., 2016).

The base of the sheep-farming systems in dehesa agroforestry is the Merino. Because of its hardiness and adaptation to the environment, it is the predominant breed. It has a high capacity to resist extremes of temperature and deficiencies of pasture in both quantity and quality. It also presents rapid bodily recovery when conditions turn favourable. Breeding selection to retain its hardiness, and the use of crosses with meat breeds to improve yields have been the common practice in the dehesas, just as has been the case with cattle.

Dehesa sheep are highly adapted to the energy supply characteristics of the system, so that supplements are minimal compared to other species. Sheep use the grazable pasture resources of autumn and spring, and the agricultural stubble in the summer months. Sheep farms in dehesa systems are basically devoted to meat production, but there are examples where other sheep products are also targeted. Meat production is lamb fattened on the farm, and slaughtered at 3 months and 23-25 kg live weight, depending on resource availability and market demand.

Traditionally, when the Merino sheep was directed towards the production of wool as a main objective, milk only was valued based on the ability of the ewe to grow their lamb. In this sense, the Merino sheep, exploited under grazing conditions with no feed supplement, milk production was very low. The milking was limited to a small number of farms, for a period of 15 - 20 days, after weaning the lambs, for the purpose of obtaining some cheese for family consumption. Yields of 200 gr. per sheep per day were considered to be acceptable (MERAGEM, 2011).

Nowadays, the milking has been extended to a large number of herds, sometimes of great dimensions, although they maintain certain familiar character but which in recent years has transformed into continued, industrial production milking animals throughout the year and applying mechanical milking. In general, the Merino sheep lactation period is divided into two phases; a, 60-day, which corresponds to the period of breeding of the Lamb, and, another, 50 - 70 days, milking-oriented. The average production of milk obtained per sheep per year can be estimated between 30 and 50 litres. The milk obtained by the Merina sheep milking is intended for the manufacture of cheese. In this sense, it has acquired great fame for its high quality, type cheeses: “Serena” “Casar” “Pedroches”, among others, obtained from Merino ewes milk (MERAGEM, 2011).

These production models stand out for their high environmental and socio-economic value. Livestock activity, in this case that we carry out with the sheep, plays a very important role in their maintenance and upkeep. However, currently, the stability of the system is conditioned by the low profitability of the extensive sheep productions, the seasonality of the same and the difficulties of marketing.

II – Participatory research: Problems identified by stakeholders in Dehesa agroforestry systems

Within the framework of the European project called AGFORWARD (*www.agforward.eu*), whose main objective is to promote agroforestry systems in Europe, it is worked to find and test various innovations that can improve agroforestry systems existing at European level. To do this in the early stages of the project was conducted a participatory research process in which a first identified problems which had rangeland and animal systems that settle in it.

One hundred and sixty-nine individual stakeholders were invited for a first meeting. The meeting was envisaged as an open-door day for people interested in the development and conservation of the Iberian dehesa system. The meeting, hold on 30th May 2014 in the Forestry School (University of Extremadura). The degree of participation was very high (> 90 stakeholders) indicating the great awareness of farmers and society in relation to the conservation of the dehesa system. Among the attendees, there were farmers, breeders, foresters, landowners, representatives of their associations (regional and national level), agricultural services companies, extension services, nature-related NGOs, local action groups and policy makers.

Besides of the informative aims, the meeting was stimulated through different techniques of social participation (Ishikawa or fishbone diagrams), to allow joint discussion of the current difficulties and challenges of dehesa and other extensive silvopastoral systems and to compile proposals of innovation. From the discussions consistent proposals of participatory research to evaluate on-farm innovative practices emerged. Participants formed the first nucleus of a Participatory Research and Development Network for the dehesa of SW Spain.

The list of constraints listed in the Ishikawa diagram can be summarized under the following topics:

1. Lack of reliable evaluations of **dehesa profitability**.
2. The sanitary status of dehesa trees. Over-ageing of dehesa trees and lack of tree regeneration.
3. Poor quality of dehesa soils and pasture. **Low productivity and strong seasonality**. Mismatch among pasture resources and **stocking rate**.
4. Livestock health and continuous TB re-infestation through big game.
5. Payment for public **ecosystem services** that presumably are important in the dehesas but that are **not quantified and valued yet.**
6. Lack of governance and communication with **policy** agencies.
7. Lack of adapted policies to multipurpose and seminatural agrosystems such as **extensive wood pastures.**

As it can be seen, a large proportion of the problems identified were that affect animal systems since they are the fundamental pillar by the regime of extensive grazing that occurs there. Thereafter focused on innovations for those animal systems proposal, which though not focus only on the sheep.

A. Demand on innovation new research on animal production

1. The genetic of livestock races is important for selecting the races best adapted to pasture seasonality, docility, browsing behaviour (low preference for young trees) ...
2. Livestock diversification to optimize resources use and market opportunities:
3. Increase the fertility ratios. Semen quality evaluation and breeding males' illnesses.
4. Livestock health with special focus on the tuberculosis re-infestation by wild animal in drinking water points and areas of supplementary fodder provision.
5. Herding schemes
6. Matching stocking rates to forage resources availability and not to subsidies rules.
7. To recover some traditional practices as overnight livestock folding to improve soil and pasture quality.
8. Grazing under the Holistic Management rules (managed fast rotational grazing)
9. Precision grazing by designing calendars for location of facilities (complementary fodder supplementation, water for drink, salt mineral blocks).
10. GPS herding to assist precision grazing, protection of tree regeneration, control of livestock re-infestation by wild animals, monitoring livestock health. While the implementation of GPS to follow and analyse animal's activity is technically solved, the application of negative/positive stimuli to drive animal behaviour is still a big challenge.

III –Case studies in sheep systems research

1. The case of PDO cheese "Torta del Casar"

The sheep sector in Extremadura has been historically oriented towards the production of meat. Milk production has had a marginal importance until the last decade, which has developed a productive infrastructure in some areas of Extremadura region, with a base that is oriented towards the production of artisan cheeses. In this context, producing differentiated through quality marks or Protected Designations of Origin (PDO) could improve the situation of sheep farms, so to en-

sure its continuity and promote rural development in these areas. The PDO Torta del Casar is a case study that demonstrates the usefulness of this strategy. The Torta del Casar is a cheese made with raw milk from merino purebred and crossbred ewes. The geographical area of production and manufacturing is located in the province of Cáceres, in the autonomous community of Extremadura, and within the regions of Los Llanos de Cáceres, Sierra de Fuentes and Montánchez, occupying approximately 400.000 ha.

What is presented in this paper is part of a work that focuses on the analysis of the productive structure of holdings of the PDO "Torta de Casar", assessing the relationship of holdings with the PDO and its future prospects.

A. Methodological process

The research presented analyses sheep farms enrolled in the PDO " Torta de Casar ", located in different municipalities of the province of Cáceres (Spain). The data were obtained directly through a survey of farms´ managers during the months of March and April 2016 and corresponds to a total of 15 of 16 farms that are covered by the PDO "Torta de Casar".

The main purpose was to analyse how farmers valued their relationship with the PDO "Torta del Casar" and what benefits they got from a technical and economic point of view. So, farmers were asked to rank various aspects of their relationship with the PDO, such as the advice and assistance in management that the PDO provides to its members or the benefits perceived by farmers related to farming under the PDO scheme.

Questions were punctuated by farmers using a Likert scale of 1-5 where 1 value corresponds to "very in disagreement", "disagree" value 2, value 3 to "not in disagreement or agreement", the value 4 to "agree" and the value 5 to "very agree" regarding statements presented on the utilities provided by the PDO. Treatment and statistical analysis of data was carried out using SPSS v. 21 statistical package.

B. Assessment of the experience of belonging to the PDO

Figure 4 shows the most common benefits provided to farmers belonging to the PDO. It can be observed that farmers are quite satisfied with respect to the benefits of the PDO especially in aspects related to the breeding of animals, the increase in production and sales volume. We can see that other studies in sheep dairy scanned deeply breeding farms of sheep dairy in order to increase the milk yield of the animals (Ugarte *et al.,* 2002), as well as, the use of reproductive and genetic technologies in the La Mancha dairy sheep system (Rivas*,* 2014).

However, farmers are more neutral when value the benefit in the improvement of the infrastructures. The latter result is expected, since the improvement of facilities is resulting in greater investment in a farm, and for which the PDO cannot contribute, at least economically. Nevertheless, and in order to enhance the denominations and other figures of quality, the perception of certain Community aid, such as those included in the improvement of farm plans, membership could link to any of these quality figures. This could improve the image of them among its partners, encouraging interest in membership and remaining.

When farmers were asked about advice and assistance in management they receive for their membership of the PDO, it was found that some aspects has recieved the least ratings (Figure 5). Respondents are timidly highlight only an improvement in the milk marketing, sales and advice provided by the PDO in animals feeding. However, farmers complain the high price of feed supplied through the associated cooperative and that the POD has not generated support for improvement of farms, as well as veterinary and financial assesment is deficient.

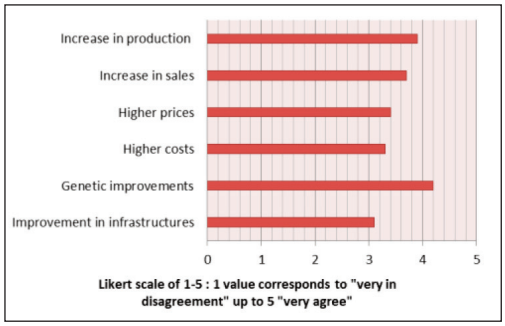

Fig. 4. Benefits of a general nature that PDO Torta del Casar provides to its members.

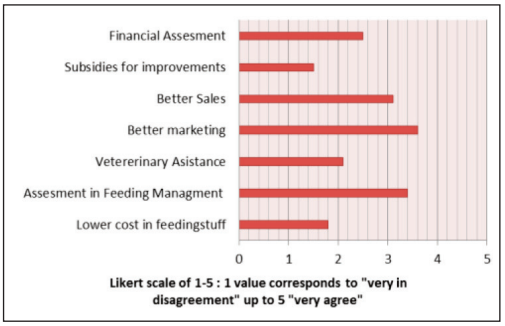

Fig. 5. Valuation of advice and assistance in management that the PDO Torta del Casar provides to its members.

All these aspects will be of extraordinary relevance in assessing the level of competitiveness of the productive system and the viability of their farms, such as in the study of Rivas (2014) in the case of Manchego sheep, or as García *et al*. (2012) who addressed the marketing of milk of sheep like productive alternative.

Finally, the incidence of the PDO on the technical management of farms is given in Figure 6. In terms of the ease of reaching the criteria imposed by the PDO, surveyed farmers are in general quite satisfied. They point to the seasonality of milk production is the main problem in the management of their farms. However, they are reluctant to establish the management of sheep in batches proposed by the PDO, hence they indicated a low level of satisfaction.

As a conclusion, there has been some degree of satisfaction for farmers due to their membership in the PDO, in which they acknowledge its role in the improvement of the general aspects of farms. Respondents are reluctant to establish certain changes in the management of animals involving an annual continuous milk supply for industries. It is clearly visible that they point out shortcomings in financial assessment to undertake reforms and the lack of adequate veterinary advice.

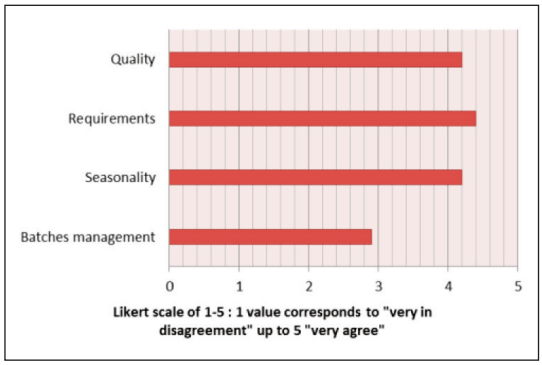

Fig. 6. Assessment of the technical advice provided by the PDO Torta del Casar to its partners.

2. Cooperativism in sheep for meat

In parallel the sheep meat sector is undergoing a transformation, both in the management of their production systems and marketing, to achieve stability of prices throughout the year and the development of new presentations or product formats making it more attractive to the consumer. The aim is that the producers can obtain higher economic returns by improving the management of their holdings and the commercialization of their products. Both levels can be addressed from the integration of farms in a cooperative system that can cope with the current situation and improve their competitiveness (Ruiz *et al*., 2014), assuming that this integration is one of the key aspects for maintenance and viability of the extensive systems (Horrillo *et al*., 2016).

So nowadays the sheep meat sector has been involved in recent years in a very important cooperative integration process. This phenomenon of cooperative concentration has affected heavily the Extremadura sheep sector and has led to now unite the 64.7% of the 2.3 million of sheep meat in cooperative structures, which has led to an increase in profitability (Pozo & Agudo, 2013).

In this context, it is of importance studying both technical and economic characteristics of integrated cooperative sheep farms. It has conducted a comparative analysis of three major cooperative partner for the cooperative of second-degree OVISO.

A. Methodological process

The data used in this study correspond to the analysis of 101 sheep farms of 3 of the most significant cooperative OVISO group (named in this paper Coop1, Coop 2 and Coop 3). OVISO group is a second-degree ' cooperative based in Villanueva de la Serena (Badajoz) integrated today in OVISUR, in what constitutes the largest cooperative group of sheep for meat at European level. OVISO encompasses 17 cooperatives whose members manage a total of 1.3 million sheep (Pozo & Agudo, 2013). OVISO group has experienced tremendous growth since the end of the 1990s to the present, not only in size (passed 3 cooperatives to 17) but also in regards to the introduction of improvements in the value chain, where it has been strengthened the training of farmers, investment in productive infrastructure and the creation of fattening facilities for lambs.

One of the strategies understood by the cooperative as key to future has been the pursuit of collaborations and agreements with other cooperatives in the sector to reach new markets. One example is Ovispain, which is a consortium for export, comprising Oviso, Pastores y Cordesur group. One of the strategies understood by the cooperative as key to future has been the pursuit of collaborations and agreements with other cooperatives in the sector to reach new markets. One example is Ovispain, which is a consortium for export, comprising Oviso, group shepherds and Cordesur. This collaboration has enabled that the exportation has been increased from 4.108 channels in 2005 (only Oviso) to more than 70,000 channels in 2012 (Ovispain). This collaboration is intended to look for alternatives in times of low domestic consumption.

Cooperative farmers have access to the services of the cooperative of second degree in the same conditions. Although technical advice at farm level is similar, technical personnel giving assistance depends on the cooperative's first grade. As for breeds mostly exploited, they are fundamentally Merina racial base females crossed mainly with Ile de France and Berrichon du Cher males.

From the primary information provided by cooperatives, a refined database was created and complemented with secondary sources of information and field work. Information provided by Oviso which mainly limited to technical data of the holdings of the year 2012, being necessary to directly contact each associated cooperative to obtain more specific information from the activity of farmers. It has been found that the availability and use of the information stored by first grade cooperatives is limited, requiring intense collaboration by the technicians for the final preparation of the data base. Treatment and analysis of the information contained in the final database was carried out with the statistical package SPSS, v.22.

B. Characteristics of the studied farms

Table 1 contains information relating to the structural indicators of the farms as well as relevant qualitative information. These parameters allow to identify structural differences based on the main characteristics of the studied farms, i.e. available land, sheep census, ownership of the land and the uses of the land for agricultural purposes. In addition are also reflected differences in predominant breeds in each cooperative.

Table 1. Basic characteristics of the analysed farms

		Coop 1	Coop 2	Coop 3	Total
Number of farms surveyed		33	26	48	101
Total farm land (ha)		360.39	326.56	420.83	379.28
Owned land (ha)		73.09	274.39	219.16	187.53
Agricultural land (ha)		52.45	63.93	112.13	82.01
Number of ewes		779.76	1077.33	858.10	887.3
Number of rams		25.24	43.27	30.44	31.95
Sheep breed in the farm (%)	Merino	50	57.7	6.3	31
	Cross breed	38.5	38.5	91.6	64
	Meat breed	11.5	3.8	2.1	5

C. Analysis of technical parameters of cooperatives

Table 2 shows the mean values of these indicators for each of the analysed cooperatives. One of the most relevant sheep performance indicator is the sheep replacement rate. In this case the values presented three cooperatives seem to conform to the usual requirements of extensive sheep farms, around 15% sheep replacement rate, which covers needs of new breeding ewes. However, the 2 cooperative has significantly higher than mean values. The value of the percentage of replacement of sheep can be taken as a reference when deciding if the exploitation requires a more detailed inspection, since those farms with rates below 13% or above 20% out of the desirable parameters.

TAnother of the problems that sometimes can be found in an extensive sheep farm is the limited reproductive capacity due reduced number of males for mating in the farm (ratio ewes per ram). As can be seen in table 2, there are significant differences between the three cooperatives regarding this aspect; cooperative 2 has the best ratio 26.33 ewes per ram.

Also, the cooperative 2 shows a better reproductive management obtaining higher productivity of lambs (1.22 lambs born per ewe per year). However, when comparing all cooperatives with indicators of reproductive management of other sheep extensive systems, it is observed that these indicators are slightly higher than those observed by Gaspar *et al*. (2007) and Milán *et al*. (2003) which reflects that farms in the cooperative environment are more efficient in these aspects thanks to the technical assistance and advice specific reproductive issues.

In addition to the above, the stocking rate parameter is high for the type of sheep exploitation where recommended values are around 0.3 LU/ha. This greater intensity in the use of pastables resources is common in sheep systems of semi-arid areas and it has been for several decades now, since it has been the most common way to maximize the perception of subsidies during the periods in which they were linked to the number of heads.

Concerning the management of livestock feed, it should be noted that the variations that can be found are closely related to the previously analysed stocking rate parameter. Figure 7 shows average consumption of feedingstuff per adult sheep, which highlights that the cooperatives with lower stocking have lower consumption since they have more resources available to each animal. Fig-

Table 2. Technical indices. Mean. Standard error and significance level (ANOVA) in the farms according to cooperative membership

Technical and economic indicators	Coop 1	Coop 2	Coop 3	Total	SE[1]	Sig.
Stocking rate (LU/ha)	0.48^{ab}	0.49^{a}	0.39^{b}	0.47	0.02	**
Sheep replacement rate (%)	15.44^{ab}	19.63^{a}	14.42^{b}	16.02	0.75	*
Cull ewes (%)	7.71^{a}	10.99^{b}	9.55^{ab}	9.27	0.47	*
Lambs born per ewe per year	1.07	1.22	1.09	1.12	0.03	NS
Ratio ewes per ram	33.62^{a}	26.33^{b}	29.77^{ab}	30.12	0.83	**
Commercial productivity (lamb sold per ewe)	0.87	0.94	0.88	0.89	0.02	NS
Average lamb price (€/lamb sold)	66.58^{ab}	65.56^{a}	67.16^{b}	66.59	0.02	*
Average lamb price per kilogram (€/kg)	3.24	3.24	3.19	3.22	0.01	NS
Average price per cull ewe (€/ewe)	24.88^{a}	25.74^{a}	29.90^{b}	26.87	0.75	*
Wool sold per sheep (kg/ewe)	2.88^{a}	2.27^{b}	4.80^{c}	3.53	0.13	**
Average wool price (€/kg)	1.37^{a}	1.37^{a}	0.77^{b}	1.1	0.03	**
Labour expenses per ewe (€/ewe)	5.99^{a}	19.35^{b}	14.20^{b}	12.92	1.01	**
Veterinary expenses per ewe (€/ewe)	2.71^{a}	4.30^{b}	3.37^{ab}	3.39	0.21	*
Total expenses per ewe (€/ewe)	59.92	59.7	56.55	58.35	2.27	NS
Agricultural subcontracting expenses /total expenses	0.34^{a}	0.04^{b}	0.28^{a}	0.24	0.02	**
Animal feedstuffs expenses /total expenses	0.53^{ab}	0.61^{a}	0.47^{b}	0.52	0.01	*
Labour expenses / Total expenses	0.13^{a}	0.34^{b}	0.29^{b}	0.25	0.02	**
Subsidies perceived per ewe (€/ewe)	38.53	49.04	48.35	45.38	2.13	NS
Total income per ewe (€/ewe)	102.68	117.21	110.11	109.54	2.98	NS
Goss margin per ewe (€/ewe)	42.76^{a}	57.50^{b}	53.56^{ab}	51.19	2.96	*

*p <0.05 y **p<0.01; 1SE: standard sampling error.

Different subscripts in the same row indicate significant differences as *p <0.05 y **<0.01.

ure 8 shows the average consumption of concentrate per fattening lamb where can be seen that there are hardly any differences among cooperatives. This fact is expected because the fattening systems are very similar, all of them in intensive conditions where the second degree cooperative standardizes the live weights the lambs before slaughter.

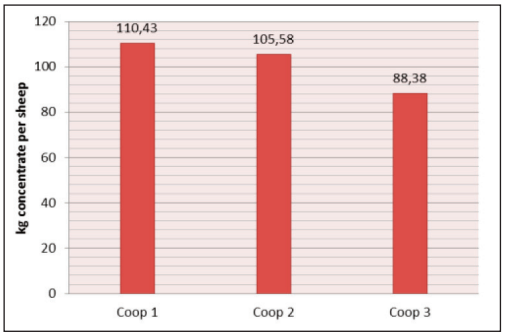

Fig. 7. Average yearly consumption of concentrate per sheep.

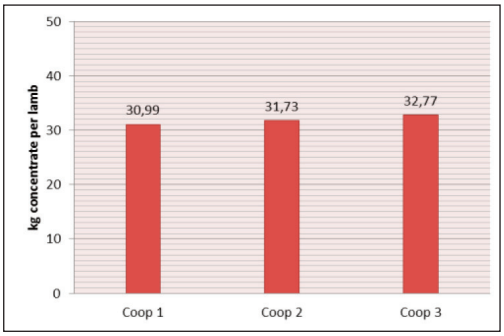

Fig. 8. Average consumption of concentrate per fattening lamb.

D. Analysis of the productive indicators

Regarding the results obtained on commercial productivity of the three analysed cooperatives (table 2), it is observed that the average price of lamb for each cooperative is at very close range. Although the differences are little significant (significant between the 2 and 3), it can be observed that cooperative 2 obtains the lowest price per sold lamb.

These indicators of sale of lambs, although interesting for analysis and comparison among three cooperatives, also serve to study one of the issues that matter most as managers in a farm: business productivity per sheep. The annual commercial productivity per ewe is a normalized variable that indicates the total number of lambs delivered to the cooperative per ewe per year. This is an indicator of great importance to the cooperative, since it expresses the relationship of production among associate and company. Once again the cooperative 2 presents the highest average value (0.94) which indicates that it is the cooperative whose members deliver a greater number of lambs.

If we analyse this indicator "commercial productivity" from the perspective of the cooperative, we can identify different performance of farmers towards the cooperative. This analysis should identify the farmers who are delivering below the standard delivery rate established by the cooperative considered as desirable for such holdings, and study the reasons underlying low rates in order to establish mechanisms to increase these levels.

E. Balance of expenses and income of farms

Indicators of expenses and income can be also observed in table 2. There are significant differences between cooperatives, such as labour expenses per ewe or agricultural subcontracting expenses, which is usually related to the percentage of family labour. Also noteworthy are the more purely economic indicators such as total income per ewe or gross margin per ewe, in which the cooperative 2 stands out with respect to the other two. An explanation for this behaviour may be in the structure of the cooperative 2 farms, which had the largest number of sheep, mostly Merino ewes, and had the highest rate of lambs born and lambs delivered per ewe. The largest stocking doesn't seem to be the main explanation of the profitability of farms, in the light of works such as that of Gaspar *et al*. (2008) who indicated that the factor that seemed to have more relevance was the exploitation of different breeds as a way to more efficiently use of environmental resources.

As a conclusion, it can be said that the comparative study of sheep farms belonging to three cooperatives, integrated into a single entity of second grade, has allowed to identify homogeneous aspects such as the average price per kg of live weight obtained by farmers in each delivered lamb. This fact was predictable since the commercialization of the lambs are made jointly. However aspects differentiated between cooperatives were also found, such as those related to reproductive management and that could be linked to the different technical assessment received from the first degree cooperative.

Although in all analysed cooperatives farms have shown stocking rates higher than those recommended for semi-arid environments, those with minor charges have reflected it in their lower dependence on purchased feedstuff, since they can make better use of the resources generated by the system.

Interesting differences regarding productivity, have appreciated since the cooperative 2 presents substantially higher values. The differences in an important aspect for the cooperative may show an aspect in which relevant improvements could be done. The study of differentiated entities within one cooperative business environment could serve both to establish benchmarking strategies (best holdings became farms for the rest of the cooperative model), as to correct deficiencies, to allow to detect abnormal values or inefficient behaviour.

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Application of random regression model to estimate genetic parameters for average daily gains of Tunisian local kids population

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Abstract. A random regression model was applied to estimate co-variance components and genetic parameters for average daily gains (ADG1 from birth to 30 days, ADG2 from 30 to 60 days, ADG3 from 60 to 120 days, ADG4 from 120 to 150 days and ADG5 from 150 to 180 days). The data comprised13.095 records belonging to 945 local kids (progenies of 22 sires and 285dams) born between 1998 and 2014.The data were first assessed by SPSS Program in order to identify the fixed effects to be included in the model. Year*month, sex*type of birth, dam's class weight were classified as fixed effects and dam's age at kidding as covariate. Random effects included in model were direct additive genetic effect, maternal additive genetic effect, direct permanent environmental effect, maternal permanent environmental effect and residual effect. Direct and maternal heritability estimates of ADG ranged from 0.1 to 0.39 and 0.09 to 0.24, respectively, in which ADG1 had the lowest direct and highest maternal heritability estimates among the other age groups. Estimated co-variance components increased with age for direct effects. A significant maternal effect was found in the pre-weaning stage that decreased in the post-weaning stage. Unlike in breeds raised in favorable conditions, the estimated maternal component of variance was larger than the direct variance in the pre-weaning period, indicating the importance of maternal ability in this breed. A negative correlation was found between direct and maternal additive genetic traits. Estimates of genetic correlations among the traits studied were high and positive with values ranging from 0.06 to 0.98, whereas the magnitude of the phenotypic correlation ranged from 0.05 to 0.83. Heritability estimates indicate that selection for maternal and direct components of ADG is possible in this bred. However, direct components need to be evaluated after weaning for a more efficient selection.

Keywords. Local kids – ADG – Correlations – Heritability – Selection.

Application du modèle de régression aléatoire pour estimer les paramètres génétiques des gains moyens quotidiens des chevreaux de la population tunisienne locale

Résumé. *Un modèle de régression aléatoire a été appliqué pour estimer les composantes de covariance et les paramètres génétiques des gains moyens quotidiens (ADG1 de la naissance à 30 jours, ADG2 de 30 à 60 jours, ADG3 de 60 à 120 jours, ADG4 de 120 à 150 jours et ADG5 de 150 à 180 jours). Les données comprennent 13,095 enregistrements appartenant à 945 chevreaux locaux (progénitures de 22 boucs et 285 chèvres) nés entre 1998 et 2014. Les données ont été évaluées par le programme SPSS afin d'identifier les effets fixes à inclure dans le modèle. Année * mois de naissance, sexe * mode de naissance, classe du poids de la mère à la mise bas ont été classés comme des effets fixes et l'âge de la mère comme co-variable. Les effets aléatoires inclus dans le modèle ont été l'effet génétique additif direct, l'effet génétique additif maternel, l'effet environnemental direct permanent, l'effet environnemental maternel permanent et l'effet résiduel. Les estimations de l'héritabilité directe et maternelle de l'ADG varient de 0,1 à 0,39 et de 0,09 à 0,24 respectivement, dans lesquelles ADG1 avait les estimations d'héritabilité maternelle les plus élevées. Les composantes de covariance estimées ont été augmentées avec l'âge pour les effets directs. Un effet maternel significatif a été trouvé dans le stade de pré-sevrage qui a diminué au stade du post-sevrage. Contrairement aux populations élevées dans des conditions favorables, la composante de la variance maternelle estimée était plus grande que la variance directe au cours de la période de pré-sevrage, indiquant l'importance de la capacité maternelle dans cette population. Une corrélation négative a été trouvée entre les caractères génétiques additifs directs et maternels. Les estimations des corrélations génétiques parmi les phénotypes étudiés étaient élevées et po-*

sitives avec des valeurs allant de 0,06 à 0,98 alors que la corrélation phénotypique varient de 0,05 à 0,83. Les estimations de l'héritabilité indiquent que la sélection pour les composants maternels et directs de l'ADG est possible chez cette population. Cependant, les composants directs doivent être évalués après le sevrage pour une sélection plus efficace.

Mots-clés. *Chevreaux locaux – ADG – Corrélations – Héritabilité – Sélection.*

I – Introduction

Actually, more than 60% of the national caprine herd estimated to 1 500 000 goats were raised in the Tunisian arid area (FAO, 2014). Since centuries, the pastoral breeding mode allows to valorize the rangelands resources by ambulant small ruminant herds under harsh conditions. In southern Tunisia, kids' meat represents about 75% of the local meat production (Najari, 2010). Further, the demand for meat from kids is increasing because of its nutritional quality.

Therefore, body weight and average daily gains are also economically important in breeding objectives that need particular attention in order to improve meat production of the local goat population. One way to improve growth performance is to select the best animals to be used as parents of the next generation. Estimation of heritability for various traits and their correlations with each other are therefore essential for successful selection in a genetic improvement programme.

The study aims to estimate the genetic parameters of kids 'average daily gains at different range of ages, using random regression models.

II – Material and methods

1. Animals and management

All experimental goats were raised in the Arid Areas Institute of Médenine (IRA), in the South-East of Tunisia with an arid continental Mediterranean climate, with irregular and sporadic rains. The season of kidding begins in October and continues until February, with a concentration during November and December. Throughout the study, replacement animals were selected based on weaning weight and physical conformation. Animals grazed in natural pastures during the day. In general, grazing pasture grasses covered about 70% of breeding animals feed requirements. The remaining 30% was covered by a supplementation provided during the mating (600 g/day), the last month of pregnancy and the beginning of lactation (750 g/day). Goats received about 1 kg per day of concentrate mixture. All animals were provided with water allowed twice a day; before and after grazing.

2. Data recording and studied traits

The data used in present study were collected between 1998 and 2014 from a total of 945 kids (531 males and 414 females), the progeny of 19 sires and 284 dams. Out of the 284 dams, 88 had weight records as kids. Since the start of the kidding period and till 180 days of age, kids were weighed once every two or three weeks. Based on the weight records of individual kids, average daily gains were calculated assuming linear growth rate between the appropriate weights. The investigated traits were: ADG1 (from birth to 30 days), ADG2 (from 30 to 60 days), ADG3 (from60 to 90 days), ADG4 (from 90 to 120 days), ADG5 (from 120 to 150days) and ADG6 (from 150 to 180 days).

3. Random regression analysis

Firstly, an ANOVA analyses was carried out for determining the environmental effects and two way interactions that had a significant influence on average daily gains. The analysis of variance showed that dam's age at kidding, dam's weight at kidding, the interaction between sex and birth type and between year and month of kidding were significant. Consequently, those effects were included in the model for those traits. The general model can be represented as follows:

$$y_{ij} = Fij + \sum_{m=0}^{2} \beta_m \phi_m(a_{ij}) + \sum_{m=0}^{2} \alpha_{im} \phi_m(a_{ij})$$

$$+ \sum_{m=0}^{2} \gamma_{im}(a_{ij}) + \sum_{m=0}^{2} \delta_{im} \phi_m(a_{ij}) + \sum_{m=0}^{2} \rho_{im} \phi_m(a_{ij}) + \varepsilon_{ij}$$

Where:

y_{ij} is the j^{th} record from the i^{th} animal ; a_{ij}= standardized age at recording in the [-1,1] interval; =is the m^{th} Legendre polynomial covariates for age at weighing; F_{ij}=is a set of fixed effects including, dam's weight at kidding, the interaction between sex and birth type and between year, month of kidding and dam's age at kidding (as covariate up to quadratic order), β_m=are the fixed regression coefficient to model the population mean; α_{im}, γ_{im}, δ_{im}, ρ_{im} are the random regression coefficients for direct and maternal additive genetic effects, animal and maternal permanent environmental effects, respectively, and ε_{ij}= residual environmental effect related to y_{ij}.

The above statistical model matrix form was as follows:

$$\mathbf{y} = \mathbf{Xb} + \mathbf{Z}_1\mathbf{a}_d + \mathbf{Z}_2\mathbf{a}_m + \mathbf{W}_1\mathbf{p}_d + \mathbf{W}_2\mathbf{p}_m + \boldsymbol{\varepsilon}$$

$$V\begin{bmatrix} \mathbf{a}_d \\ \mathbf{a}_m \\ \mathbf{p}_d \\ \mathbf{p}_m \\ \boldsymbol{\varepsilon} \end{bmatrix} = \begin{bmatrix} \mathbf{K}_{ad} \otimes \mathbf{A}_{gxg} & \mathbf{K}_{ad,am} \otimes \mathbf{A}_{gxg} & \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{K}_{ad,am} \otimes \mathbf{A}_{gxg} & \mathbf{K}_{am} \otimes \mathbf{A}_{gxg} & \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{K}_{pd} \otimes \mathbf{I}_{dxd} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{K}_{pm} \otimes \mathbf{I}_{mxm} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \sigma_e^2 \times \mathbf{I}_{NxN} \end{bmatrix}$$

y = observations vector; **b** = vector of fixed effects ;$\mathbf{a}_d$ = vector of additive genetic direct random coefficients for all animals in the pedigree (g = 1152);$\mathbf{a}_m$ = vector of maternal additive genetic random coefficients for all animals in the pedigree(m = 1152); $\mathbf{p}_d$ = vector of animal permanent environmental coefficients for animals with records (d = 939); $\mathbf{p}_m$ = vector of maternal permanent environmental coefficients for all dams with records (m = 282); **X**,$\mathbf{Z}_1$, $\mathbf{Z}_2$, $\mathbf{W}_1$, and $\mathbf{W}_2$ incidence matrices including Legendre polynomial co-variables; and = vector of residuals; $\mathbf{K}_{ad}$, $\mathbf{K}_{am}$, $\mathbf{K}_{pd}$, $\mathbf{K}_{pm}$ are the (co)variance matrices associated to additive direct and maternal effects and animal and permanent environmental regression coefficients, respectively, and is the matrix of covariance between additive genetic direct and maternal regression coefficients; σ_e^2 is the residual variance; a is the additive numerator relationship matrix and **I** is the identity matrix of differing order depending on the effect associated with it; N =13,095 is the total number of records.

III – Results and discussion

1. Growth

The descriptive statistics for average daily gains are presented in table 1. The overall average daily gains were 85.62, 75.25, 72.67, 50.04, 39.21, and 29.28 respectively for ADG1, ADG2, ADG3, ADG4, ADG5 and ADG6. Kids had a faster growth rate from 60 to 90 days with daily gain 72.67 (g/d) that the average daily gain in kids decreased with the age increase from 150-180 days of age. A similar result was found by Al-Shorepy et *al.,* (2002).

2. Heritability estimation

Direct and maternal heritability estimates for average daily gains at different range of ages are shown in Table2. Direct heritability estimates ranged from 0.1 to 0.39. The highest heritability estimate was found for ADG6 while the lowest heritability was revealed to be for ADG1followed by ADG2. The heritability estimates for ADG4 and ADG5 were approximately the same.

These estimates for average daily gains were in the range of those found by Sharma et *al.,* (2010) in Sirohi kids. However, they were lower than those obtained by Gerstmayr (1988) in Beetal goats. In Teddy goats, a low estimate of heritability 0.10 for post weaning daily gains was reported by Shafiq & Sharif (1996) which was lower than the ones found in the present study. Gowane et *al.,* (2011) reported low heritability estimates of 0.04for daily weight gain at six months in Sirohi goat breed, while Mohammadi et *al.,* (2012) reported that heritability estimates for daily weight gains from three to six months of age was 0.08 in Raeini Cashmere goat.

The low direct heritability estimates may be attributed to the low quality of pastures on which the flock was maintained, resulting in a high environmental variance. Furthermore, since in this case, the average daily gains of local kids could be classified as lowly or moderately heritable traits, performance of animals would be less useful in identifying the individuals with the high genetic merit, and therefore, low genetic progress would be expected through phenotypic selection programmes. Thus, to detect the best animals and to realize a genetic progress, selection should be based on estimates of breeding values, which are based both on phenotype and pedigree information and not on raw performance of kids alone.

Table 1. The characteristics of the data structure for average daily gains of Tunisian local kids population

	Statistical characteristics				
Age groups (days)	**Min.**	**Max.**	**Mean**	**SD**	**CV%**
ADG1 (0-30)	31.02	179.18	85.62	37.71	44.04
ADG2 (30-60)	42	165	75.25	23.46	31.17
ADG3 (60-90)	36.7	156.04	72.67	23.24	31.98
ADG4 (90-120)	40	144.6	50.04	24.52	49.00
ADG5 (120-150)	35.66	111	39.21	14.26	36.36
ADG6 (150-180)	12	85.44	29.28	11.36	38.79

Table 2. Heritability estimates for average daily gains in local kids population

	Age groups (days)					
	ADG1	**ADG2**	**ADG3**	**ADG4**	**ADG5**	**ADG6**
Direct heritability	0.10	0.11	0.15	0.21	0.24	0.39
Maternal heritability	0.24	0.15	0.12	0.11	0.10	0.09

The higher estimate of maternal heritability for ADG1 compared with the estimate for ADG 5 and ADG 6 supports the conclusion of Robinson (1981) that maternal genetic effects generally are important at early age and diminishes with an increasing age. The resultsare in agreement with other literature (Singh,1997; Bata,1989). The deacaying impact of maternaleffects on ADG with increasing agesmay be due to thefact that suckling kids rely mainly on their mother's milk from birth to 30 days, whereas after this age, the importance of milk yieldof dams decreases more rapidly and kids depend more on themselves.

3. Genetic and phenotypic correlations

Estimates of direct genetic correlations between growthtraits at different ages were positive and medium to high, varying from 0.12 between ADG 2 and ADG 6 to 0.98 between ADG 5 and ADG 6. The positivedirect genetic correlations among the studied traits suggest that genetic factors which influence these traits were in similar direction and that selection for any of these traits will bring out a positive response to selection for others. Similar to our estimates, high and positive genetic correlations have been reported by several authorsin various goats breeds (Common African x Alpine (Mourad and Anous, 1991) and Black Bengal goats (Singh, 1997). Consequently, it is logical to suggest that the traits to be included in the goat recording system couldmainly be those measured early in life of the kids, e.g. beforeweaning.

Table 3. Estimates of genetic correlations (below diagonal) and phenotypic correlations (above diagonal) for average daily gains in local kids

	ADG1	ADG2	ADG3	ADG4	ADG5	ADG6
ADG1		0.76	0.51	0.50	0.20	0.17
ADG2	0.94		0.80	0.52	0.10	0.05
ADG3	0.62	0.85		0.70	0.68	0.40
ADG4	0.20	0.52	0.89		0.80	0.61
ADG5	0.06	0.27	0.74	0.96		0.83
ADG6	0.22	0.12	0.62	0.90	0.98	

Phenotypic correlations varied from 0.17 and 0.83.The highest phenotypic correlation (0.83) was recorded between ADG5 and ADG6 and the lowest (0.17) was found between ADG 1and ADG6. The present findings are in agreement with those obtained by Rashidi et *al.,* (2008) in Markhoz goats and Schoemanet *al.,* (1997) in Boer goats.

IV – Conclusions

The low to moderate heritability estimates obtained in this research suggest that selection based on these traits may result in slow to moderate genetic progress for average daily gains. Due to the existence of genetic variation for those traits and generally positive and medium to high genetic correlations among the investigated traits, it can be concluded that improvement of growth traits of local kids seems feasible in selection programmes. Nevertheless, it is recommended to improve the management of flock in order to reduce the environmental variance and to increase heritability estimates, and also to select replacement animals based on their genetic merit but not on their raw performances because without a selection on the genetic merit, smaller genetic improvement will be expected.

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PESagri: A novel payments for ecosystem services framework for targeted agrienvironmental policy

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Abstract. Multifunctional farms and policy makers need to connect agricultural management with the delivery of ecosystem services (ES) to improve policy outcomes and satisfy social demands. Despite the increasing understanding of the complex causal relationships between agricultural practices, biophysical processes and ES delivery, the application of the ES framework to agrienvironmental policy remains very limited. In this context, we developed a reliable and flexible framework of Payments for Ecosystem Services (PES) for the implementation of targeted agrienvironmental measures at the farm level. The PES framework i) focuses on agricultural activity as the main driver of many ES such as biodiversity and landscape conservation; ii) links objectively the real practices at the farm with the provision of relevant ES; iii) uses expert knowledge that allows evaluating and comparing the multiple effects of agricultural practices on ES; iv) reflects the views of all stakeholders involved; and v) constitutes a generic and versatile framework that can be used in diverse agroecological and policy settings. The paper describes the structure and operation of the PES system that is implemented in Excel. We use the case of sheep and mixed sheep-crops systems in the Euro-Mediterranean basin to illustrate the results of the PES application with diverse environmental objectives; for example, a policy targeting the real preferences of society for ES provision by Spanish sheep systems (i.e. wildfire prevention 53.2% of total importance, provision of quality products linked to the territory 20.2%, conservation of biodiversity 18.4%, and conservation of agricultural landscape 8.2%).

Keywords. Agricultural practices – Experts' biophysical assessment – Mixed sheep-crop farming systems – Mediterranean agriculture.

PESagri: Un nouveau cadre pour le paiement des services écosystémiques pour une politique agroenvironnementale ciblée

Résumé. *Les exploitations multifonctionnelles et les décideurs politiques ont besoin d'établir la liaison entre les pratiques agricole et la provision des services écosystémiques (SE) afin d'améliorer la gestion des mesures politiques et de satisfaire les demandes de la société. Malgré de la croissante connaissance qu'il existe sur les complexes relations entre les pratiques agricoles, les processus biophysiques et les SE rendus, l'application d'une approche SE aux politiques agroenvironnementales est encore limité. On a développé un cadre pour le paiement des services écosystémiques (PSE) flexible et fiable pour la mise en œuvre des mesures agro-environnementales au niveau de l'exploitation. Ce system de PSE i) se centre sur l'activité agricole comme la force motrice principale de beaucoup des ES ainsi que la biodiversité et la conservation du paysage, ii) relie les pratiques au niveau de l'exploitation avec la provision des principaux ES, iii) utilise la connaissance d'experts on permettant évaluer et comparer des multiples effets des pratiques sur les ES, iv) reflète des points de vue des parties intéressées et v) constitue an encadrement générique et polyvalent que peut être appliqué sur différents contextes agroécologiques et politiques. Ce travail décrit la structure et le fonctionnement d'un system de PES qui est implémenté en Excel. On utilise les cases de systèmes ovins et mixtes ovins-cultures dans le bassin méditerranéen pour illustrer les résultats obtenues de l'application du system PES avec divers objectifs environnementaux, par exemple, avec des objectifs politiques basées sur les préférences de la société par rapport aux ES rendus pour les systèmes ovins (c.-à-d., prévention des incendies 53,2% de l'importance totale, la provision de produits de qualité liées au territoire 20,2%, conservation de la biodiversité 18,4% et du paysage agraire 8,2%).*

Mots-clés. *Pratiques agricoles – Évaluation biophysique des experts – Systèmes d'exploitation mixtes ovins-cultures – Agriculture méditerranéenne.*

I – Introduction

It is increasingly recognized that agricultural policy should reward the contribution of farmers to the delivery of multiple ecosystem services (ES) to society. Therefore, both farmers and policy makers need improved tools for setting objective environmental targets and fair distribution of subsidies. Payments for ecosystem services (PES) applied to farming constitute a way to achieve this. The importance of land management is acknowledged in the descriptions of all the existing PES, but they do not explicitly include the effect of agricultural management on the provision of ES. This is partially due to the incomplete scientific understanding of the complex causal relationships between management actions, biophysical processes and ES delivery and the lack of homogenized biophysical assessments . In this sense, a better understanding of the agricultural practices that influence trade-offs and synergies among ES would allow the outputs of a range of ES to be envisioned and address a greater integration between agri-environmental schemes to attain a wider and more efficient delivery of ES . In this paper, we present and apply a generic framework of management-based PES (PESagri) for sheep and sheep-crop farming systems.

II – Material and methods

We designed a generic and sound PES framework that links beneficial agricultural practices at farm level with the provision of single or multiple ES (maintenance of agricultural landscapes, biodiversity conservation, wildfires prevention, carbon sequestration and production of quality products linked to the territory). Expert knowledge about links between practices and ES was collected with an on-line Delphi panel. From a list of 66 agricultural practices with potential to deliver public goods in Europe, we selected 36 that were carried out in 10 monitored sheep and mixed sheep-crops farms in Mediterranean mountains and semiarid lowlands in Aragón. Experts had to rate, in two rounds of deliberation, the positive contribution of each agricultural practice to ES using a Likert scale (from 0 none to 5 very high; including the “don’t know” option). The contribution of each agricultural practice to a particular ES was considered as the percentage of the contribution of all agricultural practices to that ES. We assumed that the valuations of the experts reflected the biophysical effect of agricultural practices on ecosystem properties and functions, and on ES delivery, providing a unique and comparable unit of measurement . In this way, the allocation of economic resources (payments to farmers) depends on the agricultural practices carried out at the farm level, where the decisions take place. We also aimed at including different actor involvement (farmers, researchers, society, policy makers) by allowing to customize the agricultural practices and the weight of environmental targets. These characteristics give flexibility to PESagri, which consitutes a usefull tool to address dinamic complex socio-ecological systems. PES agri can be exported to other socio-ecological systems by adapting the variety of agricultural practices, social demands and data availability. We applied PESagri using a socio-cultural and economic prioritization of ES in Mediterranean agro-ecosystems.

III – Results and discussion

1. PESagri framework

Figure 1 depicts the designed framework of PESagri that considers several steps. First, the definition of beneficial agricultural practices taking place at farm level. Second, the link of agricultural practices and a variable number of targeted ES. These links are quantified according to the expert-based assessment, but researchers can define these links in alternative ways according to the type of agro-ecosystem and data available. Third, the establishment of the evironmental targets through diferent combinations of ES (e.g., conservation policy, societal demand). Fourth, the user can define the budget and allocate it according to the targeted ES. If needed, agricultural practices can

be customized, e.g., the group of agricultural practices related to crops and species could be excluded for animal specialized farming systems using only natural pastures. PESagri is implemented in Excel and is fully operational. However, for PESagri to be effective in delivering the desired outcomes, there must be a system of monitoring in place at farm level.

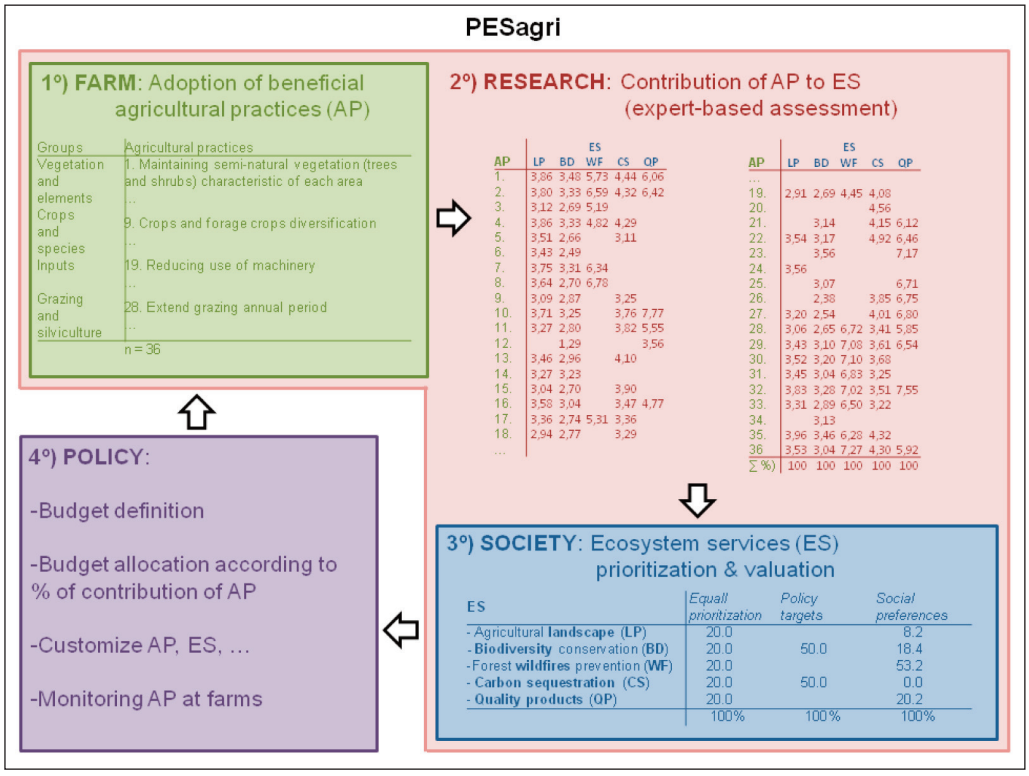

Fig. 1. The PESagri framework.

2. PESagri application to Mediterranean agro-ecosystems

When considering the social prioritization of ES (landscape 8.2%, biodiversity 18.4%, wildfires 53.2% and quality products 20.2%) described by, the agricultural practices that related to the management of grazing and silviculture (with a contribution of 41.79%) had the largest importance (Figure 2), followed by those related to vegetation and other elements (28.17%), mostly due to their contribution to wildfire prevention, highly prioritized by society.

Therefore, despite the relative contribution of agricultural practices to individual ES delivery was rather similar in the expert-based assessment (Figure 1), when considering the ES as prioritized by the public, differences in the importance of diverse agricultural practices were apparent. This resulted in a narrower number of agricultural practices determined by the PESagri, but with more differentiated contribution to each ES (Figure 2).

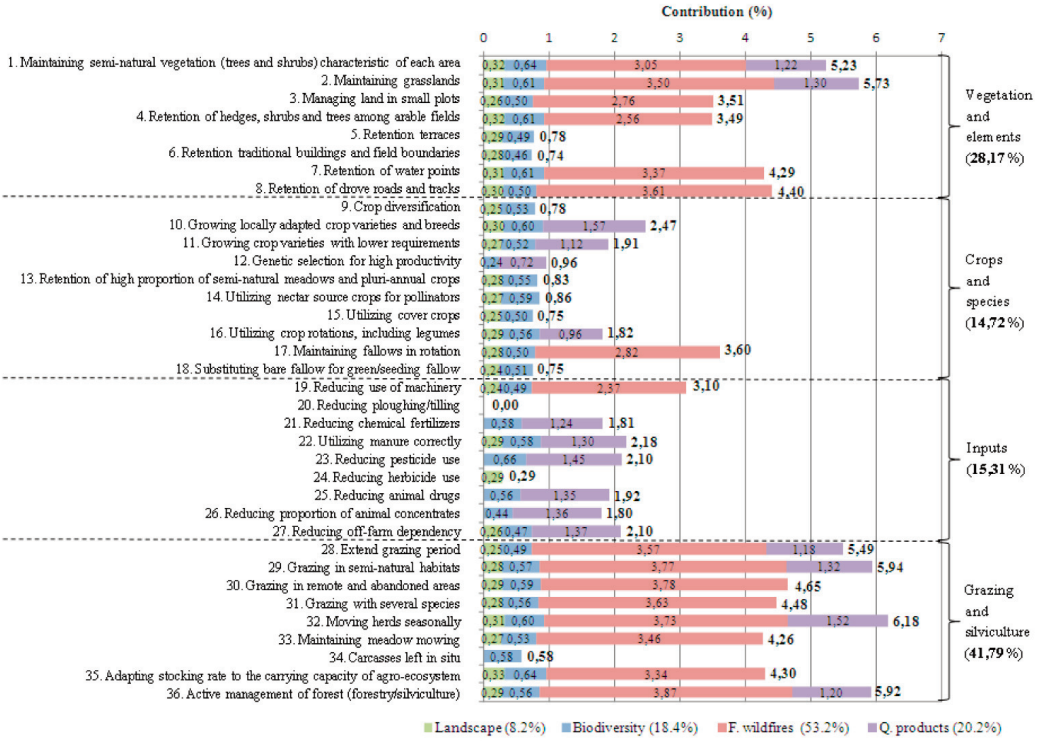

Fig. 2. Contribution of agricultural practices to ES in Mediterranean agro-ecosystems according to societal demand.

IV – Conclusions

PESagri is able to elucidate the contribution of individual agricultural practices to diverse ES and, potentially, reward farmers according to the ES they deliver. The framework is generic, customizable according to particular agro-ecosystems and policy targets, and easy to use. The quantification of the multiple effects of agricultural practices on one or several ES is central in the operation of the PESagri. Promoting particular practices that have a strong influence on a single ES is advisable when this particular ES is the only target. However, by promoting multiple practices with synergic effects on several ES we can deliver ES bundles.

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Progeny-test et facteurs de variation lors de la sélection laitière des brebis dans la population locale (région de Sétif)

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Résumé. Afin de mesurer les performances de production laitière des brebis de population locale dans la région de Sétif et déterminer l'influence des facteurs non génétiques (sexe, mode d'agnelage des agneaux et l'âge de la brebis) sur ces paramètres, un contrôle de performances a été mis en place chez 105 agneaux par la détermination du gain moyen quotidien (GMQ) durant le mois post agnelage. Ce dernier permet d'estimer le potentiel génétique des brebis et des béliers sur le critère de la valeur laitière, à partir de 3 pesées sur agneaux à la naissance, au jour 10 et au jour 30 (J0, J10 et J30 respectivement). Alors que le taux de productivité numérique (TPN) schématise mieux les performances reproductives de la brebis et constitue également le produit de plusieurs autres variables qui sont la fertilité, la fécondité, et le taux de sevrage. Le TP au jour 30 (TP30) est de 0,69 et le taux de mortalité des agneaux à 30j est en moyenne de 11,81%. Les poids à la naissance (PN), au jour 10 (P10) et au jour 30 (P30)sont respectivement de 3,76 ± 1,02 ; 4,86 ± 0,97 et 8,35 ± 1,57 kg, alors que la vitesse de croissance entre la naissance et le jour 10 (GMQ0-10), et entre 10 et 30 jours (GMQ10-30) sont respectivement de 91,80 ± 43,89 et 167,20 ± 61,52. Une analyse de la variance a révélé que les facteurs étudiés n'ont pas eu un effet significatif sur la vitesse de croissance des agneaux, alors que le sexe a eu une influence significative ($p<0,05$) sur le GMQ0-10 avec une préférence pour les agneaux durant les 10 premiers jours après la naissance.

Mots-clés. Performances – Population ovine locale – GMQ – TPN – Sétif.

Progeny-test and factors of variation in dairy sheep selection in the local population (in Setif region)

Abstract. *The main objective of the present research was to determine some non-genetic factors (the sex, the type of birth of the lambs and the age of the ewes) influencing dairy local sheep production in Setif. A total of 105 lambs; were subject to measure of average daily gain at different ages (0, 10 and 30 days). However, other criteria, in particular reproductive efficiency (RE), may be used to explain reproductive performance of ewes and represent the product of several other factors that are fertility, fecundity, and the weaning rate. The results indicated that, the reproductive efficiency at 30 days RE30 was 0.69 and the average rate of mortality from birth to 30 days was 11,81%. The mean bodyweight at the birth was 3.76 ± 1.02kg; 4.86 ± 0.97kg at 10 days of age and 8.35 ± 1.57kg at 30 days of age, the average daily gain estimates for weight at ten days (ADG0-10) and at thirty days (ADG0-30) were 91.80 ± 43.89 and 167.20 ± 61.52 g/d, respectively. The growth rate (ADG) was not affected by age of ewe and birth type. However; the influence of sex on growth performances of lambs during the ten days showed a superiority of males over females ($p<0.05$).*

Keywords. *Performances – Local sheep – ADG – RE – Setif.*

I – Introduction

Le contrôle de performances est l'outil de base de l'amélioration génétique au niveau de chaque race, mais aussi et surtout un outil pour l'éleveur dans le suivi de son troupeau (Migne, 2004). Chez la brebis, la production laitière lors de l'allaitement peut être aussi estimée par la croissance des agneaux, qui reflète mieux la quantité de lait disponible, ingérée et transformée par ces derniers

(Youssao *et al.,* 2008 ; Ben Salem *et al.,* 2009). La production laitière de la brebis africaine est faible. Elle varie entre 30 à 158,70kg/lactation (Bonfoh *et al.,* 1996 ; Gbangboche *et al.,* 2002). De plus, les brebis algériennes ne sont pas traites; leur lait est utilisé seulement pour l'allaitement des agneaux. Notre étude vise à contrôler la production laitière de la brebis et ce à travers l'appréciation du vitesse de croissance GMQ de la naissance à l'âge de 1 mois, et de plus faire une approche du taux de productivité numérique TPN dans le troupeau étudié.

II – Matériels et méthodes

L'étude a été réalisée dans une ferme pilote dans la région de Beni Fouda (hauts plateaux de Sétif). L'effectif analysé concerne 116 brebis mises à la lutte après un traitement de synchronisation des chaleurs. 91 brebis ont mis bas et ont donné 105 naissances, dont le sexe ratio est de 63/42 en faveur des mâles. Un total de 105 agneaux issus de ce troupeau durant la saison d'automne de l'année 2010 ont été identifiés dès la naissance, par des boucles portant le numéro, le sexe, le mode de naissance et le numéro de la mère. Chaque agneau a été pesé à l'aide d'une balance électronique à la naissance, à jour 10 (J10) et à jour 30 (J30). Le taux de mortalité et le taux de productivité à 1 mois ont été déterminés d'après les formules citées par Craplet et Thibier (1980). Les paramètres suivants :Poids à la naissance (PN), vitesse de croissance entre la naissance et le jour 10 GMQ0-10 et vitesse de croissance entre le jour 10 et jour 30 (GMQ10-30) ont fait l'objet d'une analyse de variance à trois facteurs (le mode de naissance, le sexe de l'agneau et le rang d'agnelage).

III. Résultats et discussion

Le taux de productivité (TP30) obtenu dans notre étude est de 0,69 ; il est considéré comme très faible. Ce résultat est inférieur à ceux rapportés par Dekhili et Benkhlif (2005) ; Dekhili et Aggoun (2006) ; Mennani *et al.* (2011) qui sont respectivement de 0,88 ; de 0,94 ± 0,02 et de 1,05 ; ce qui confirme la faible productivité du troupeau étudié. En effet ce dernier doit se rapprocher de 2 (Craplet et Thibier, 1980).

La mortalité des agneaux constitue le principal facteur de baisse de productivité. A un mois d'âge le taux de mortalité est de 11,81%. Il est plus élevé chez les agnelles et chez les naissances doubles (tableau 1).

Les résultats relatifs à la variation des paramètres pondéraux et la croissance des agneaux selon le sexe, le mode de naissance et le rang d'agnelage montrent que le rang d'agnelage n'a aucune influence significative sur les paramètres étudiés (tableau 1).

En effet, les agneaux nés de brebis multipares sont plus lourds (4,0 kg) à la naissance que les agneaux des primipares avec des poids de 3,2 kg, dont nos résultats sont supérieur chez les primipares et presque similaire chez les multipares. Nos résultats sont différents à ceux rapportés par Abassa *et al.* (1992) ; London *et al.* (1994) et Yapi-Gnaoré *et al.* (1997) qui ont prouvé que les agneaux issus du premier et dans une certaine mesure du second agnelage sont généralement plus légers à la naissance que ceux des agnelages suivants, d'où l'importance de l'âge de la mère au premier agnelage sur la croissance de la descendance. cela est confirmé par Dekhili et Mahnane, (2004) qui trouvent une influence significative de l'âge de la mère sur les poids des agneaux de la naissance jusqu'à 30 j.

Le mode de naissance a une influence significative sur le poids à la naissance ($p<0,001$), le poids à 10j ($p<0,01$) et le poids à 30j des agneaux, dont les agneaux uniques sont plus lourds que les agneaux jumeaux), alors que le gain moyen quotidien des ces derniers n'a pas été influencé par ce facteur. Il est évident que l'insuffisance de l'alimentation lactée des portées multiples retarde leur croissance (Gbangboche *et al.,* 2005).

Les agneaux et les agnelles ne présentent pas des poids différents antre eux de la naissance à l'âge de 30j, sauf que la croissance des agneaux est significativement supérieur ($p<0,05$) à celle des agnelles durant les dix premier jours après la naissance (100,91 ± 45,67 vs 77,61 ± 37,31)g/j. Gbangboche *et al.* (2005) indiquent qu'il y a toujours une différence de 1 à 2,5 kg du poids à la naissance selon le sexe.

Tableau 1. Facteurs influençant la croissance des agneaux et le taux de mortalité

		PN	P10	P30	GMQ0-10	GMQ10-30	Mortalité
Sexe	Agneaux	3,8 ± 0,91	5 ± 0,85	8,48 ± 1,54	100,91 ± 45,67	171,33 ± 54,97	11,43%
	Agnelles	3,71 ± 1,17	4,65 ± 1,11	8,10 ± 1,63	77,61 ± 37,31	159,68 ± 72,43	12,38%
	p	ns	ns	ns	*	ns	–
Mode de	Simple	3,96 ± 0,97	5,05 ± 0,93	8,54 ± 1,56	92,74 ± 46,48	171,37 ± 59,23	11,43%
naissance	Double	3,22 ± 0,98	4,30 ± 0,87	7,62 ± 1,46	88,97 ± 35,78	152 ± 69	12,38%
	p	***	**	*	ns	ns	–
Rang d'agnelage	Primipare	3,94 ± 0,92	4,94 ± 0,77	8,05 ± 1,76	88,7 ± 40,77	151,7 ± 80,61	–
	Multipare	3,71 ± 1,05	4,84 ± 1,03	8,45 ± 1,50	92,83 ± 45,12	172,81 ± 52,7	–
	p	ns	ns	ns	ns	ns	–

*** : significatif à 0,001, ** : significatif à 0,01, * : significatif à 0,05, ns : non significatif.

IV. Conclusion

Le contrôle du GMQ permet de trier les mères à béliers et mères à agnelles grâce à leur valeur laitière, pour adapter la conduite des lots selon la croissance des agneaux. De plus la détermination des facteurs qui influencent la viabilité et la croissance des agneaux permettra l'adoption d'une meilleure conduite d'élevage qui réduirait au maximum les effets néfastes de ces derniers. La productivité du troupeau est faible qui est relatif au taux de mortalité et la conduite d'élevage. Le rang d'agnelage et le sexe des agneaux n'ont pas des différences significatifs sur le poids des agneaux (PN, P10, P30) et sur la vitesse de croissance, alors que les agnelles présentent une vitesse de croissance supérieur à celle des agneaux durant les 10 premiers jours après la naissance. Le mode d'agnelage présente une influence significative sur le poids des agneaux dont les agneaux sont lourds que les agnelles avec des vitesses de croissance similaires.

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Effect of doses of eCG and cloprostenol on oestrus and ovulation induction in North Moroccan goats during the anoestrus season

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Abstract. This study was conducted to evaluate the effectiveness of hormonal protocols with different doses of eCG and cloprostenol in induction and synchronization of oestrus in North Moroccan goats. Thirty-two adult goats were divided into four groups adjusted for age and live weight (values??)f. Animals were treated for 11 days with an intravaginal sponge impregnated with 20 mg FGA. Two days before sponge removal, all groups received an intramuscular injection of 300 UI (T1 and T2) or 500UI (T3 and T4) of eCG plus 50 µg of cloprostenol for the T2 and T4 groups. Four fertile bucks were used to detect oestrus 12h after sponge removal and blood samples were collected every 2h from 20 to 60h following sponge removal to determine plasma LH concentrations. Oestrus and LH pic responses were similar in all groups (T1, 100%; T2, 87.5%; T3, 100%; T4, 100%). There were no statistically significant differences (P>0.05) between the groups for the onset of oestrus (26.8 ± 9.4 h, 35.6 ± 8.7 h, 21.5 ± 13h and 23.2 ± 12.7 h respectively for T1, T2, T3 and T4 groups) and preovulatory LH surge after sponge removal (36 ± 13.1 h, 37.4 ± 10.4 h, 27.2 ± 13.4h and 28 ± 9.9 h respectively for T1, T2, T3 and T4 groups). The onset of oestrus and preovulatory LH surge were significantly shorter in groups received 500UI eCG, compared to groups received 300UI (22.32 ± 12.5h vs. 30.6 ± 10h and 27.6 ± 11.4h vs. 36.7 ± 11.5h respectively; p<0.05). Dose of cloprostenol did not affect the induction and synchronization of oestrus and preovulatory LH surge (P>0.05). In conclusion, in hormonal protocols of oestrus and ovulation induction in North Moroccan goats, the utilization of 500UI eCG shortened the onset of oestrus and consequently time to inseminate in North Moroccan goats during anoestrus season. However, the protocol of progestagen treatment with 300UI of eCG can provide for a more efficient program of synchronization. With this protocol AI should be performed later estimated at 53h after sponge removal.

Keywords. Moroccan goat – Anoestrus season – Oestrus synchronization – Hormonal treatment – eCG – LH surge.

Effet de la dose d'eCG et du cloprostenol sur l'induction et la synchronisation d'oestrus et d'ovulation chez la chèvre locale du Nord du Maroc en anoestrus saisonnier

Résumé. *Cette étude a pour objectif d'évaluer l'efficacité d'un protocole hormonal testé avec différentes doses d'eCG et de cloprostenol sur l'induction et la synchronisation d'oestrus chez la chèvre locale du Nord du Maroc. Elle a porté sur 32 chèvres réparties sur 4 groupes homogènes formés en fonction d'âge et du poids corporel. Toutes les chèvres ont été traitées pendant 11j avec des éponges vaginales imprégnées de 20mg de FGA. 2 jours avant le retrait d'éponge, tous les groupes ont reçu une injection intramusculaire de 300UI (T1 et T2) ou 500 UI d'eCG (T3 et T4) avec 50 µg de cloprostenol pour les groupes T2 et T4. 4 boucs fertiles ont été introduits 12h après le retrait d'éponge pour la détection d'oestrus et des prélèvements sanguins ont été effectués chaque 2h à partir de 20h jusqu'à 60h après le retrait d'éponges pour la détermination du pic pré-ovulatoire de la LH. L'induction d'oestrus et de pic pré-ovulatoire de LH a été similaire chez tous les groupes (T1, 100%; T2, 87,5%; T3, 100% et T4, 100%). Aucun effet du traitement hormonal sur le début d'oestrus (26,8 ± 9,4 h, 35,6 ± 8,7 h, 21,5 ± 13h et 23,2 ± 12,7 h respectivement pour T1, T2, T3 et T4) et le délai de pic de LH après le retrait d'éponge (36 ± 13,1 h, 37,4 ± 10,4 h, 27,2 ± 13,4h et 28 ± 9,9 h respectivement pour T1, T2, T3 et T4) n'a été enregistré (p>0,05). Les délais de début d'oestrus et de pic de LH ont été significativement plus réduits chez les chèvres ayant reçues 500UI d'eCG en comapaison avec celles ayant reçues 300UI (22,32 ± 12,5h vs 30,6 ± 10 h et 27,6 ± 11,4h vs 36,7 ± 11,5h respectivement; p<0,05). Aucun effet du cloprostenol sur l'induction et la synchronisation d'oestrus et du pic pré-ovulatoire de LH n'a été enregistré (p>0,05).*

En conclusion, en anoetrus saisonnier, l'utilisation d'eCG à titre de 500UI réduit le délai de début d'oestrus et par conséquent le moment d'IA chez la chèvre locale du Nord du Maroc. De point de vue économique, une dose réduite de 300UI eCG est plus efficiente dans un protocol de synchronisation avec un moment d'IA décalé vers 53h après retrait d'éponge.

Mots-clés. *Chèvre locale – Nord du Maroc – Anoestrus saisonnier – Synchronisation d'oestrus – Traitement hormonal – eCG – Pic de LH.*

I – Introduction

Despite its low productivity, goat farming contributes significantly to the formation of rural population incomes in the North of Morocco (Chentouf *et al*., 2011) and therefore plays an undeniable socio-economic role. In order to improve livestock farms productivity and hence goat producers' income, a genetic improvement program of local goats is requested. The seasonality of reproduction in North Moroccan goats (Chentouf *et al*., 2011) impacts negatively on productivity and consequently on the management of animal products availability (milk and meat). In order to control reproduction and accompany a goat genetic improvement program in this region, the development of hormonal protocols to induce and synchronize oetrus during anoestrus season is necessary. Indeed, no protocol adapted to the local goat is available.

A routine synchronization protocol exists and includes the use of intravaginal progesterone sponges during 11 days combined with eCG and prostaglandin injections 48h prior to sponge removal (Leboeuf *et al*., 2000). This protocol is effective to induce synchronous oestrus and ovulation during both seasons.

The North Moroccan goat has a little size, an average of 37.5 Kg was registered in adult goat (Hilal *et al*., 2013) with an average milk production of 0.5 Kg per day (Elotmani *et al*., 2013), thus the dose of gonadotropins to be used in a progestagen protocol should be determined. Depending on milk production and season of treatment, in French breeds, Loboeuf *et al*. (2000), recommended a dose from 400 to 600 IU of eCG. Also, a dose of 50 µg of cloprostenol is recommended.

The objective of the study is to evaluate the effectiveness of hormonal protocols with different doses of eCG and cloprostenol in induction and synchronisation of oestrus and ovulation in North Moroccan goat.

II – Material and methods

1. Animals and treatments

ThirtyThirty two adult goats, exposed to natural lighting conditions, were used for the study at the experimental station of the INRA Tangier (35°N) during the anoestrus season (April). Before the start of treatment, goats were divided into four groups adjusted for age and body weight. For 11 days, the does in each group were treated with intravaginal sponges impregnated with 20 mg of Fluorogestone acetate (Chronogest CR, Intervet S.A). Two days before sponge removal, all groups received an intramuscular injection of 300 UI (T1 and T2) or 500UI (T3 and T4) of eCG (Synchro-part, Ceva) plus 50 µg of cloprostenol (Estrumate, MSD animal Health) for the T2 and T4 groups.

2. Oestrus detection

From 12h to 60h following the sponge removal does were observed for signs of oestrus with the aid of 4 fertile bucks. Each male was fitted with a marking harness. The onset of oestrus was considered as the moment when the doe showed a harness mark and stood while be mounted by the bucks.

3. Preovulatory LH surge

Blood samples were collected every 2h from 20 to 60h after sponge removal from the jugular vein using 9ml heparinized vacutainer tubes. Plasma was separated by centrifugation (2200 rpm for 20 min) and stored at -20°C until assay. LH concentrations were determined by ELISA using a commercial kit (LH Detect, Repropharm, INRA, France). LH surge was determined following the criteria of (Baird *et al*., 1981).

4. Statistical analysis

The effects of treatment (T1, T2, T3 and T4), the dose of eCG (300 or 500 UI) and necessity of cloprostenol (0, 50 µg) on the onset of oestrus and preovulatory LH surge after sponge removal were analyzed by ANOVA using Proc GLM of SAS 9.0 software.Proportions of females displaying oestrus or LH pic response were compared using chi-square test. Data were presented as mean ± SD, and the level of significance was set at $p< 0.05$.

III – Results and discussion

A summary of data regarding the induction of oestrus and ovulation by different hormonal treatments in the goats are presented in table 1. There were no significant differences ($p>0.05$) in oestrus (96.9%) and preovulatory LH surge (96.9%) responses between treatments. The mean interval from sponge removal to onset of oestrus was not significantly different ($p>0.05$) between treatments (26.8 ± 9.4 h, 35.6 ± 8.7 h, 21.5 ± 13h and 23.2 ± 12.7 h respectively for T1, T2, T3 and T4 groups). Similarly, the interval from sponge removal to preovulatory LH surge did not differ significantly between T1 (36.0 ± 13.1), T2 (37.5 ± 10.4), T3 (27.2 ± 13.4) and T4 (28.0 ± 9.9) groups, respectively.

The present study shows that North Moroccan goat respond adequately to synchronization of oestrus by intravaginal sponges of progestagen treatment. These findings for inducing and synchronizing oestrus and ovulation are in agreement with the others (Freitas *et al*., 1996; Leboeuf *et al*., 2003; Zarazaga *et al*., 2014; Rekik *et al*., 2014). In a previous study, Baril *et al*. (1993) reported an onset of oestrus that start from 24 to 72h after sponge removal. These authors used 45mg FGA. These higher doses of FGA could have promoted an hormonal latency, which could have delayed the onset of oestrus.

Table 1. Influence of hormonal treatments on oestrus and LH pic response and mean interval to onset of oestrus and preovulatory LH surge after sponge removal during the anoestrus season

Treatment groups	Oestrus response (%)	LH pic response (%)	Onset of oestrus after sponge removal (h)	Preovulatory LH surge after sponge removal (h)
T1 (n = 8)	100	100	26.8 ± 9.4	36.0 ± 13.1
T2 (n = 8)	87.5	87.5	35.6 ± 8.7	37.5 ± 10.4
T3 (n = 8)	100	100	21.5 ± 13.0	27.2 ± 13.4
T4 (n = 8)	100	100	23.2 ± 12.7	28.0 ± 9.9
Significance	*NS*	*NS*	*NS*	*NS*

NS: P> 0.05.

Following sponge removal, it was determined that among the groups administered with different doses of eCG, the onset of oestrus (Fig. 1) was shorter in 500UI eCG groups (22.3 ± 12.5h) compared to 300UI eCG groups (30.6 ± 10.0 h; $p<0.05$). Likewise, the mean interval from sponge removal to preovulatory LH surge (Fig. 2) was shorter in 500UI eCG groups (27.6 ± 11.4 h) compared to 300UI eCG groups (36.7 ± 11.5h; $p<0.05$). These results are in agreement with those of Oliv-

era *et al*. (2001), Ali (2007) and Nasroallah and Nemat (2012). As we know, eCG treatment is required to induce oestrus in goats during the anoestrus season (Bosu *et al*., 1978) by the way that it acts like FSH (Follicule Stimulating Hormone) which shortens the interval from progestagen treatment cessation to the onset of oestrus. The injection of a high dose of eCG can stimulate his action on follicular growth by fasting the development, which in turn is caused by a greater production of estrogen (Wildeus, 2000). Consequently, after sponge removal, the times to the onset of oestrus and preovulatory LH surge were shorter in goats synchronized with the high dose of eCG (500UI). Thus, the optimal moment for AI when 500UI of eCG was used is 43h after sponge removal if we estimated an ovulation at 24h after preovulatory LH surge (Fatet *et al*., 2011). In French protocols, cervical inseminations are performed 43h after sponge removal with a time of ovulation estimated as 52h after sponge removal (Leboeuf *et al*., 1998). This report is similar to our findings with a dose of 500UI eCG. With the lower dose of eCG (300UI), preovulatory LH surge was induced at 36.7h after sponge removal. Therefore, insemination can be performed at 53h after sponge removal suggesting an ovulation at 61h after sponge removal.

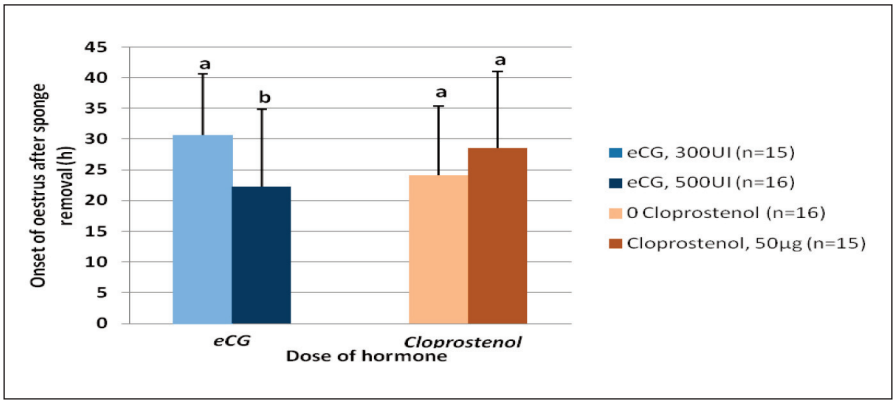

Fig. 1. Effects of doses of eCG and cloprostenol in the time of onset of oestrus after sponge removal in the North Moroccan goats during the anoestrus season.

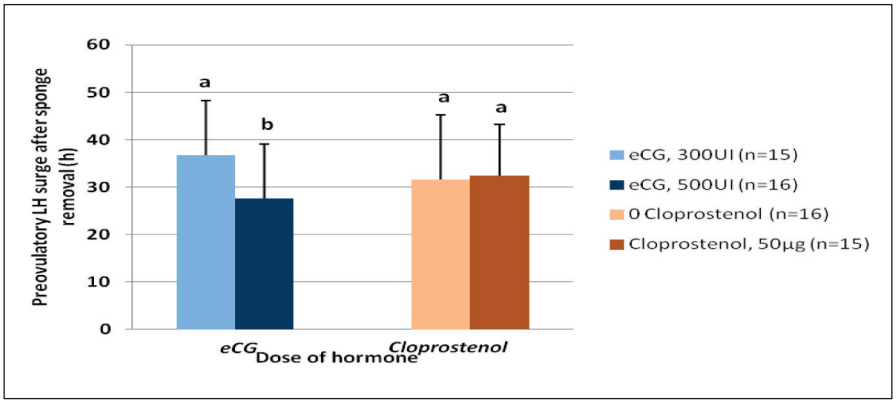

Fig. 2. Effects of doses of eCG and cloprostenol in the time of the preovulatory LH surge after sponge removal in the North Moroccan goats during the anoestrus season.

Dose of cloprostenol did not influence the induction and synchronization of oestrus and preovulatory LH surge in goats (fig. 1 and fig. 2; P>0.05) indicating that as reported by Baril *et al*. (1993) prostaglandine is effective for synchronization only when a persistent corpus luteum is present at the time of treatment. Therefore, it's suitable only for synchronization during the breeding season (Ahmed *et al*., 1998; Greyling and Van der Nest, 2000; Motlomelo *et al*., 2002). Injection of prostaglandin after sponge removal causes a corpus luteum luteolysis and synchronize oestrus in the herd.

IV – Conclusions

The results of this study suggest that in hormonal protocols of oestrus and ovulation induction in North Moroccan goats, the utilization of 500UI eCG shortened the onset of oestrus and consequently time to inseminate in goats during anoestrus season.

Moreover, the protocol of progestagen treatment with 300UI of eCG can provide for a more efficient program of synchronization. With this protocol AI should be performed later at 53h after sponge removal.

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Performances of Barbarine ewes grazing on wheat stubble under conventional and conservation agricultural conditions in a Tunisian semi-arid area

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Abstract. The aim of this work was to study the effect of agricultural practices (Conventional and conservation agriculture: Conv.A and CA respectively) on live weight variation and body condition scoring (BCS) of Barbarine ewes in Tunisian semi-arid conditions. The trial was carried out in the experimental station of INRAT (Region of Zaghouan) in two plots of bread wheat stubble, cultivated respectively according to Conv. A and CA conditions. Each one was dividedinto 3 electrically fenced subplots and each subplot had an area of 1665 m^2 for a stocking rate of 30 ewes/ha.Thirty Barbarine breed ewes (Initial average weight 38 ± 1.86 kg) were divided into 6 homogeneous groups of 5 ewes each (3 groups for each agricultural system: Conv.A and CA). Animals grazed during a period of 45 days. Live Weight (LW), Daily Live Weight Gain (DLWG) were determined 4 times after the start of the experiment (every 10 days) and BCS was determined at the beginning of the experiment and 40 days after. Results showed that Live Weight increased significantly from the first weighing time until the end of the experiment both in Conv. A and CA ($P<0.05$, + 3.94 and 3.85 kg respectively). In the second period, DLWG decreased significantly in CA plot ($P<0.05$, -40.1 g/d), affecting the body weight which decreased but not significantly. Then, the live weight increased in the third period and it was maintained until the end of the experiment with a positive DLWG registered on ewes. The same trends of variation in LW were found in Conv.A and CA. For all the weighing times, no differences in LW and DLWG values between agricultural practices were noted. Results relative to BCS variation showed that no significant differences were observed in lumbar region score between the two investigated agricultural practices in the 2 measurement periods. The variation of tail region score according to agricultural practices at the start and the end of experiment showed that both in Conv. A and CA, the tail region score increased significantly ($P<0.01$; $P<0.0001$, respectively for Conv. A and CA).Statistically, the two investigated agricultural practices (Conv.A and CA) didn't affect the tail region score whatever the measurement time. It was concluded that in these experimental conditions, no differences were found in performances between the two agricultural practices.

Keywords. Ewes – Stubble – Grazing – Conservation agriculture – Performances.

Performances des brebis de race Barbarine pâturant sur chaume de blé sous l'agriculture conventionnelle et l'agriculture de conservation dans la zone semi aride Tunisienne

Résumé. *L'objectif de ce travail était d'étudier l'effet des pratiques agricoles (Agriculture conventionnelle et agriculture de conservation : Conv.A et CA respectivement) sur la variation du poids vif(PV) et la note d'état corporel (NEC) des brebis de race Barbarine dans les conditions semi-arides tunisiennes. L'essai a été mené dans la station expérimentale de l'INRAT (Région de Zaghouan) dans deux parcelles de chaume de blé, cultivées respectivement selon l'agriculture conventionnelle et l'agriculture de conservation. Chaque parcelle était divisée en 3 sous-parcelles électriquement clôturées ayant chacune une superficie de 1665 m^2 pour une charge de 30 brebis / ha. Trente brebis de race Barbarine (Poids Moyen Initial 38 ± 1,86 kg) ont été réparties en 6 groupes homogènes de 5 brebis chacun (3 groupes pour chaque système agricole: Conv.A et CA). Les animaux ont pâturé pendant 45 jours. Le poids vif (PV) et le Gain Moyen Quotidien (GMQ) ont été déterminés 4 fois après le début de l'expérience (tous les 10 jours) et la NEC a été déterminée au début de l'expérience et*

40 jours après. Les résultats ont montré que le poids a augmenté significativement dés le début jusqu'à la fin de l'expérience à la fois dans Conv. A et CA (P <0,05, + 3,94 et 3,85 kg respectivement). Au cours de la deuxième période, le GMQ a diminué de manière significative dans CA (P <0,05, -40,1 g / j), affectant le poids corporel qui a diminué mais non significativement. Ensuite, le poids vif a augmenté dans la troisième période et il a été maintenu jusqu'à la fin de l'expérience avec un GMQ positif enregistré chez les brebis. Les mêmes tendances de variation du poids vif ont été signalées dans les deux types d'agriculture. Pour tous les temps de pesée, aucune différence du PV et du GMQ n'a été enregistrée entre les pratiques agricoles. Les résultats relatifs à la NEC n'ont mentionné aucune différence significative dans le score de la région lombaire entre les deux types d'agriculture dans les deux périodes de mesure. Le score de la région caudale dans Conv.A et CA au début et à la fin de l'expérience a augmenté de façon significative (P <0,01; P <0,0001, respectivement pour Conv. A et CA). Statistiquement, les deux types d'agriculture étudiés (Conv.A et CA) n'ont pas affecté le score de la région caudale quel que soit le temps de mesure. On a conclu que, dans ces conditions expérimentales, aucune différence n'a été enregistrée quant aux performances entre les deux pratiques agricoles.

Mots-clés. *Brebis – Chaume – Pâturage – Agriculture de conservation – Performances.*

I – Introduction

Conservation agriculture (CA) is based on No-Tillage which requires a permanent mulching as a crop residue or a cover crop and an adapted rotation. In Tunisia, the total area cropped under CA context, mainly no-tillage increased from 27 ha in 1999 to nearly 12 000 ha in 2014 (INGC, 2014). Generally, CA relies on three major principles:

(i) Maintenance of a permanent vegetative cover or mulch on the soil surface,

(ii) Minimal soil disturbance,

(iii) Diversified crop rotation.

The integration of crop-livestock under CA holds promise to improve the efficiency and sustainability of production systems, but this is conditioned by good understanding of CA principles and appropriate use of corresponding packages. The farmer can introduce forage crops into the crop rotation, thus extending it and reducing pest problems. Forage species could be used as dual-purpose crops for fodder and soil cover. However, tradeoffs between the use of stubbles for livestock feeding or to cover the soil have to be resolved, particularly in dry lands where fodder potential is low (FAO, 2006).This concept of CA seemed to be apparently incompatible with livestock extensive system and if it is adopted, competition with livestock feeding needs to be optimized. Unfortunately, the crop-livestock interaction in conservation agriculture has rarely been studied and little data are available in the literature to resolve this conflict. The aim of the current study was to evaluate the effect of agricultural practices (Conventional and conservation agriculture: Conv.A and CA respectively) on live weight variation and body condition scoring (BCS) of Barbarine ewes in Tunisian semi-arid conditions.

II – Material and methods

1. Experimental area

The trial was carried out in the experimental station of INRAT (24 km from Tunis, semi-arid: 350 mm of rainfall). During the experimental period, animals grazed on stubble of bread wheat cultivated according to Conv.A and CA. Two plots (last year crop: vetch produced in CA conditions) of 0.5 ha each were respectively reserved to the trial (Previous crop: Vetch; agricultural practice: CA since 3 years). Each one was divided into 3 electrically fenced subplots and each subplot had an area of 1665 m^2 for a stocking rate of 30 ewes/ha. In the 2 plots, bread wheat from the variety AC-

SAD was sowed in the 25thof November 2014 at a density of 160 kg/ha. In CA plot, a treatment by herbicide (glyphosate 180 g of AI equivalent to 3L of commercial product/ha) was applied before sowing. The 2 plots were fertilized using Ammonitrate (150 kg/ha) and Diammonium phosphate (DAP) (100 kg/ha). The *two* plots were weeded with 2.4.D (2 applications). Wheat was harvested on the 12th of June 2014 at a cutting height of about 30 cm. The registered grain yield was of about 1.3 and 1.5 T/ha respectively for Conv.A and CA.

2. Animals

A total of 30 Barbarine ewes (Initial average weight 38 ± 1.86 kg) were selected from the experimental station of Bourbiaa (INRAT) and used for the experiment. They were divided into 6 homogeneous groups of 5 ewes each and received an anthelmintic treatment and were vaccinated against enterotoxaemia. They were housed in collective boxes and marked on, using different colors of painting to be easily identified and separated per treatment and plot before leaving for grazing. They had access to water 3 times a day.

3. Experimental design, sampling and measurements

One main factor was studied: Agriculture practices (Conv.A and CA) and 3 groups of 5 ewes each were reserved for each agricultural practice (3 groups in the correspondent 3 subplots for each agricultural practice). During the experiment, ewes grazed twice a day (from 5 h to 8 h and from 16 h to 18 h or 17h to 19 h) with a total grazing duration of 5 hours per day. The experiment lasted from the 15-07-2014 to the 28-08-2015, with a total duration of about 45 days. To monitor the ewes live weight variation, the animals were weighed early in the morning (5h) before the start of grazing. Live weight and body condition scoring (BCS) were determined 4 times after the start of the experiment (every 10 days). Live weight and daily live weight gain by period (LW and DLWG respectively) were calculated.

4. Statistical analysis

Available data were analyzed according to GLM procedure, using Statistical Analysis System software (SAS, 2002). The model included: Agricultural practices (Conv.A. or CA), period and interactions (animal was considered as co-variable).The Student-Newman-Keuls (SNK) test was used to compare treatment effects. When P-value is below 5%, the treatment effect was considered significant.

III – Results and discussion

1. Ewes' performances

Live weight and DLWG results according to agricultural practices and period are presented in Figures 1 and 2. Live weight increased significantly from the first weighing time until the end of the experiment both in Conv.A and CA ($P<0.05$, + 3.94 and 3.85 kg respectively for Conv.A and CA). In the second period, DLWG decreased significantly in CA plot ($P<0.05$, -40.1 g/d), affecting the body weight which decreased but not significantly. Then, the live weight increased in the third period and it was maintained until the end of the experiment (Figure 1), with a positive DLWG registered on ewes (Figure 2). Figure 2 shows that in the first period in CA, animals registered the highest DLWG (278.6g/d), but the difference with Conv.A animals was not significant, probably due to individual variations. This can be explained by the higher quality of stubble at the beginning of the experiment which is rich of heads, presenting a high source of energy.

The last finding could claim that biomass in plots was not limiting and enough to sustain live weight increase. Results presented in Figure 1 indicated that generally in this feeding system, body con-

dition of animals was preserved and stubble could contribute to safeguard livestock even in absence of supplementation (Moujahed *et al.,* 2015). In this context, Köller (2003) claimed that livestock could be fully integrated into conservation agriculture, when more than 30% of the residues from the previous crop are left on the ground as mulch. Results showed that, the same trends of variation in LW were found in Conv.A and CA. For all the weighing times, no differences in LW and DLWG values between agricultural practices were noted.

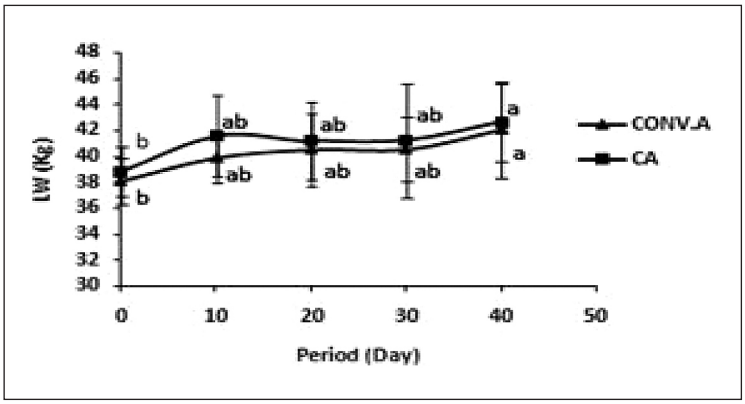

Fig. 1. LW variation depending on agriculture conditions.
a, b: Different letters indicate that the difference between the treatment effects are significantly different (P<0.05).

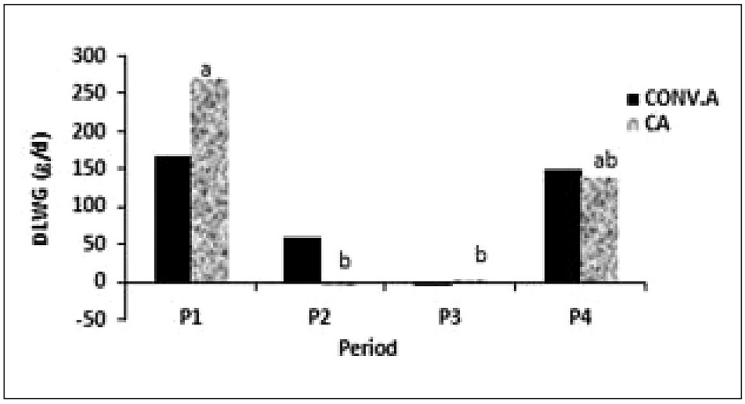

Fig. 2. DLWG variation depending on agriculture conditions.
a, b: Different letters indicate that the difference between the treatment effects are significantly different (P<0.05).

2. Body condition scoring variation according to agricultural practices

A. Lumbar region score

The variation of lumbar region score presented in Table 1showed that at the beginning of the experiment, ewes registered a lumbar region score ranging between 1.45 and 1.5 respectively in Conv.A and CA. At the end of the experiment, ewes presented a score value of about 1.43 in Conv.A

and 1.46 in CA. Results mentioned that no significant differences were observed in lumbar region score between the two investigated agricultural practices in the 2 measurement period. But it's worthy to note that the body state as observed trough the lumbar region was relatively low, but was conserved among the experiment duration, even without supplementation.

Table 1. Lumbar region score variation according to agricultural practices

Period (Day)	0	40	SEM	Significance
CONV.A	1.45	1.43	0.021	NS
CA	1.5	1.46	0.016	NS
SEM	0.043	0.042		
Significance	NS	NS		

SEM: Standard error of the mean.
NS: No Significant effect.

B. Tail region score

The variation of tail region score according to agricultural practices at the start and the end of experiment (Table2) showed that both in Conv. A and CA, the tail region score increased significantly (P<0.01; P<0.0001, respectively for Conv. A and CA). In Conv.A, ewes registered a score value of about 3.6 at the beginning, which increased to attend 4.21 at the end of the experiment. In CA, ewes started the experiment with a tail region score of about 3.53 to attend 4.25 after 40 days. Statistically, the two investigated agricultural practices (Conv.A and CA) didn't affect the tail region score whatever the measurement time.

Table 2. Tail region score variation according to agricultural practices

Period (Day)	0	40	SEM	Significance
CONV.A	3.6^{a}	4.21^{b}	0.064	**
CA	3.53^{a}	4.25^{b}	0.06	***
SEM	0.12	0.096		
Significance	NS	NS		

SEM: Standard error of the mean.
NS: No significant effect.
**: P<0.01; ***: p<0.001.

IV – Conclusions

Under the experimental conditions of the current work, the two investigated agricultural practices (Conv.A and CA) resulted in similar performances of Barbarine ewes. Indeed, for all the weighing times, no differences in LW and DLWG values between agricultural practices were noted. Also, The Body Condition Score was not affected both in Conv.A and CA whatever the measurement time which proves that biomass was available enough to feed animals.

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Adaptation of sheep breeding systems to changes in the Algerian steppe context: Case of the region of M'Sila

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Abstract. The Algerian steppe extends over an area of 20 million hectares (rainfall between 100 and 400 mm/year). It supports a grazed ecosystem whose balance had been found by local populations, in particular through movements of animals (Achaba and Azzaba). But for about half a century, the steppe knew many socio-economic and environmental changes, of which the most notable: (i) the depletion of naturals pastures, as a result of the degradation of the steppe rangelands, (ii) an accelerated demographic growth, which is reflected in an increase in household needs and the necessity to find a satisfactory income for the family, and (iii) economic instability, especially the arrival of imported livestock feed. And despite the upheaval which the steppe knew, the breeders still keep the activity of sheep breeding and herd numbers are constantly increasing. Hence the need for making studies to understandthe dynamics of the breeding systems, very important element in the implementation of development programs. In this study, we are interested in the analysis of the different mechanisms of flexibility and adaptation of sheep breeding in M'Sila region, One of the main wilayas (departments) of the Algerian steppe. We conducted interviews with thirty sheep breeders representing the different breeding systems in the area. After analyzing the results of the undertaken interviews, we noted a wide range of practices of innovations adopted by the breeders facing to the various changes in the socio-economic and environmental contexts, both nationally and locally. Diversification of sources of income, readjustment of tribal rangelands distribution rules, adaptation of animal feeding to the fodder deficit, are all indications that the present study attempts to clarify.

Keywords. Changes – Adaptation – Sheep breeding – Algerian steppe – M'Sila.

Adaptation des systèmes d'élevage ovin aux changements du contexte steppique algérien : Cas de la région de M'Sila

Résumé. *La steppe algérienne s'étend sur une superficie de 20 millions d'hectares (pluviométrie entre 100 et 400 mm/an). Sur la steppe se greffe un écosystème pâturé dont l´équilibre avait été trouvée par les populations locales, notamment grâce à des mouvements pendulaires des animaux (Achaba et Azzaba). Mais depuis environ un demi-siècle, la steppe a connu de nombreux changements socio-économiques et environnementaux, dont les plus remarquables : (i) l'appauvrissement des pâturages naturels suite à la dégradation des parcours steppique, (ii) une croissance démographique accélérée, qui se répercute par une augmentation des besoins des ménages, et la nécessité de trouver un revenu satisfaisant à la famille, (iii) l'instabilité économique surtout pour l´apparition des aliments de bétails importés. Et malgré tout le bouleversement qu'a connu la steppe, les éleveurs maintien toujours l'activité de l'élevage ovin et les effectifs ne cessent de s'augmenter. D'où la nécessité de faire des études pour comprendre les dynamiques des élevages, élément très important dans la mise en œuvre de différents programs de développement. Alors, dans cette étude, on s' est intéressé à l'analyse des différents mécanismes de flexibilité et d'adaptation des élevages ovins dans la région de M'Sila, l'une des principales wilayas (départements) de la steppe algérienne. Pour ce faire, nous avons mené des entretiens auprès de trente éleveurs d'ovins représentant les différents systèmes d'élevage existants dans la région. Après analyse des résultats des suites des enquêtes entreprises, on relève la présence d'une large gamme de pratiques innovantes adoptées par les éleveurs faisant face aux différentes changements socio-économiques et environnementaux, aussi bien à l'échelle nationale que locale. La diversification des sources de revenu, le réajustement des règles tribales de répartition des terres de parcours, l'adaptation de la conduite alimentaire au regard du déficit des fourragers sont autant d'indices que la présente étude tente d'élucider.*

Mots-clés. *Changements – Adaptation – Élevage ovin – Steppe algérienne – M'Sila.*

I – Introduction

In Algeria, the steppe constitutes a vast area which extends between the Tellian Atlas in North and the Saharian Atlas in the South. It covers a total surface of 20 million hectares (8.4% of the Algerian national territory). It is located between the isohyets of 100 and 400 mm and on altitudes from 600 to 1400 m (Aidoud *et al*., 2006). The bioclimatic characteristics of the steppe make it suited for breeding small ruminants, in particular sheep (species best adapted to the steppe context); this space offers 15 million hectares of rangelands (HCDS, 2008), sheltering 17 million ovine heads (MADR, 2014), 62% of the national ovine livestock.

In the steppe, a balanced grazed ecosystem had been found by the local populations, in particular thanks to pendulum movements of animals (Achaba and Azzaba). But for barely a half-century, the steppe has known many socio-economic and political changes. The accelerated population growth, the tendency towards the sedentarisation and the change of type of living of the local population, the increase in the ovine livestock, the increase in the planted surfaces, as well as the climate changes, all these factors combined contributed to the disturbance of the balance of the steppe ecosystem. The emergence of systems of breeding in transition is the result of the changes which underwent the steppe territory.

From there it is timely, and even important to know the dynamics of the existing sheep breeding systems in order to understand the mechanisms of flexibility and adaptation adopted by the stockbreeders to face this new socio-economic and ecological environment.

II – Material and methods

To answer the objectives assigned by this work, we chose the area of M'Sila. This choice is based on animal and pastoral potentialities which the area conceals (1.63 million sheep per 1 million hectares of rangelands) (DSA, 2016). Field interviews to thirty sheep breeders representing various breeding systems were realized.

III – Results and discussion

1. Sheep breeding systems practiced in M'Sila area

The field investigations revealed that according to the rangelands management style, t two great groups of stockbreeders exist: sedentary stockbreeders (16 stockbreeders of the sample) and the semi-sedentary transhumant stockbreeders (14 stockbreeders of the sample), which determines two extensive breeding systems. The sedentary stockbreeders are characterized by the use of the proximity food resources and a concentration around watering points whatever the year is rainy or not.The semi-sedentary transhumant stockbreeders use the proximity food resources when the year is supposed good in the area (rainy), and access to the resources out of the area when the year is bad (drought). This group is generally the stockbreeders who have materials and financial means to carry out long shifting, to benefit sometimes from the Saharan rangelands (practical of azzaba), and sometimes stubbles and fallow of the Tellian highlands (practical of achaba).

Generally, the current sheep breeding steppic systems are characterized by a sedentarisation of the families of the stockbreeders, which leads obviously to a transformation of the herds feeding system, with a passage of the pastoral mode to agro-pastoral (86.66% of the investigated stockbreeders are agro-stockbreeders). As well as a generalization of the food complementation on rangelands, i.e. passage of grass feeding to concentrate feeding as a reply to the continued rarefaction of natural fodder resources.

2. Main changes in steppic area

The agricultural operating system generally is a total of elements in dynamic interaction (Rosnay, 1975). The steppic region knew many changes on several aspects; each modification is at the same time a consequence and a cause in another phenomenon. Some of these changes are at the origin of the appearance of a new behavior adopted like reaction, but which becomes a current practice thereafter.

All in all, in a rather dynamic ecosystem like the steppic ecosystem, it would be very difficult to isolate a unique element responsible for the changes of area, because the whole system is in dynamic interaction and elements are connected each other. Despite of this constraint, we can quote the principal and most outstanding changes in the area:

The degradation of the natural rangelands. It is the most remarkable phenomenon in the whole steppe, and the area of M'Sila remains among the most affected areas. In little time (hardly one half-century) the rangelands have degraded and disappeared to leave space for poor areas or even bare soils. Actually, the rangelands degradation phenomenon is rather complex in its interactions. The sheep are at the same time destructors of the rangelands (overexploitation) and victims of the impoverishment of these natural fodder resources. In the area of M'Sila, 73.45% of the rangelands are supposed degraded (HCDS, 2010). This state of the rangelands directly affects the sheep breeding, very dependent on the spontaneous steppic vegetation. To face this situation, reactions were adopted by the stockbreeders to cover the feeding needs for the animals.

Climatic hazards and drought. The Algerian steppe had been struck by very outstanding and very long periods of dearth which affected negatively the space of the pastures. Indeed, their impact on the natural vegetation (one of the causes of degradation), as well as on the sheep food, is immediate. Nedjraoui and Bedrani (2008) noted a reduction in rainfall of about 18 to 27%, and an increase of the dry season by two months on the steppe region. In parallel, the climatic data of the area of M'Sila show that the dry season is spread out almost over all the year (except two months December and January).

Evolution of the land law and development policy. Since the independence (1962), the public authorities initiated and implemented several development programs in the steppic areas. These policies were marked by discontinuity or even the inadequacy regarding the steppe context. In spite of this failure, some programs gave results on the field, and some even could upset the image of the pastoral steppe (in particular programs of agricultural development). As a whole, these development policies cause an abrupt change in the socio-economic organization of the steppe namely:

(i) Change in the tribal rules of management of steppic space. In other words, passage of a collective exploitation of the rangelands to a race of individual overexploitation (from the collective era to the individual interest);

(ii) Introduction of new agricultural speculations (cereal crops, crops fodder, vegetable crops, arboriculture… etc). However, these last are not always adapted to the conditions of the steppe region.

3. Adaptation mechanisms of the stockbreeders

In front of each constraint, the stockbreeders always seek either to anticipate or to react to keep the exploitation of their herds. Analysis of the results of the investigations shows the diversity of the adopted mechanisms according to the socio-economic status of the stockbreeder. We can classify the various forms of adaptation according to the mobility of the herds (breeding in sedentary mode or semi-sedentary transhumant mode). Nevertheless, we find practices adopted by the stockbreeders of the two modes.

A. Sedentary stockbreeders

This category of stockbreeders is characterized by the exploitation of the different local food resources (maximum 15 km of distance covered/day). This sedentary mode of management is a form of adaptation of stockbreeders. The sedentarisation finds its explanation in the size of the herds of stockbreeders of this category; 81% of the surveyed sedentary stockbreeders (13 stockbreeders) have a herd whose size does not exceed by the 200 heads, a relatively weak number knowing that in this area some stockbreeders have herds exceeding 2000 heads.

Therefore, it is more effective and more profitable for these stockbreeders to keep their herds and to try to adapt its food control according to the availability of fodder in the area. In this objective, the sedentary stockbreeders adopt a series of mechanisms which are summarized mainly in:

The association of the breeding to agriculture. This mechanism has several dimensions; the association of the sheep breeding to the various agricultural crops (cereal, fodder, arboriculture). This practice has a double objective: it ensure food resources for the animals (grass barley, barley in grain, oats, sorghum, stubble, straw, hay, crops residues), and it is seen as a financial margin of security while diversifying the incomes of the stockbreeder. These economic activities are often better independent with the climatic constraints of the steppe area. Developed agriculture is often led by the irrigation. In addition, this practice is used as much by the sedentary stockbreeders as by the semi-sedentary transhumant stockbreeders. In our sample of study, 83.33% of the stockbreeders have farmlands, and 40% have an average surface between 3 and 10 hectares. Moreover, there exists a positive correlation (r = 0.603) between the surface of the farmland and the size of the herd in possession. Barley is the dominant crop (41.40% of the exploited lands). It has a very important place in the economic life in steppic region and it is used for different purposes (grass fodder, concentrated food, straw and stubble).

The sale of animals for purchase of food. This form of economic management is very widespread in the steppic area. In this logic, the animals constitute “a capital on feet”. The hoarding of the sheep livestock is related to the availability of natural fodder, because in the event of impoverishment of the rangelands, the stockbreeders will be in the obligation to buy food complements (often of the barley in grain) to correct the food deficit. However, there is a whole organizational logic in the priority of animal’s category to sell in first. Lambs fattened initially, then weaned lambs (starting from 6 months age), then ewes of reform. The principle is to preserve the maximum the breeding stocks.

The use of the family labor. It is a very widespread practice to decrease the charges, implying various actors; shepherd, guard, farmer, associated farmer or tractor driver. These activities are often tasks entrusted to family members

The multi-activity. Among the mechanisms of security of the income of households is to have another activity except breeding and agriculture. The 23.33% of the surveyed stockbreeders (either 7 stockbreeders) declare practice another economic activity (often civil servant). This employment ensures a stable income and considered much more as in social security of the household members.

B. The semi-sedentarily transhumant stockbreeders

Like the preceding category, the semi-sedentary transhumant stockbreeders adopt this mode of breeding to benefit the maximum from a free or low costs (stubble) resources. For these stockbreeders, the associated costs with transhumance remain always beneficial in fodder (pre-Saharans rangelands, stubble and fallow of the Tellien areas). The stockbreeders of this category have the financial and material means, as well as an enough heads (from 100 to 1960 heads) to justify the practice of transhumance.

To use the local food resources available in good year and to seek other resources except steppic area when the year is bad: a mechanism practiced since the antiquity and which remains still profitable for these stockbreeders.

In addition, among the mechanisms adopted by these stockbreeders, we can quote the most determining points:

Flexibility of displacements. The principle in the movements of herds is "to seek grass where it is found". It is thanks to the ancestral knowledge network with the indigenous stockbreeders and thanks to mobile telephony facilitating the communications a fast transfer of information as for the status of the vegetation and the climatic conditions prevailing in a given region. Displacements become more targeted and more reasoned but especially faster. We can say that we witness a new mode of transhumance which is closely related to the climatic conditions (good or bad year). This new transhumance is characterized by a spatial and temporal flexibility of displacements. In other words, displacements are not done each year, at the same period, towards the same place. The essential is to find food for the animals starting with the local fodder resources, then most distant.

Adaptation of livestock management to new forms of displacement. This is a global reorganization of the zootechnic calendar to be functional with this mode of transhumance (food, reproduction, sale and purchase of the animals and food, and the practice of fattening). It is the boss (generally the father owner) which makes the decisions concerning the management.

Exceptional displacements. In addition to already quoted transhumances, the stockbreeders proceed to realize other exceptional displacements according to the status year to gain a rangeland judged be interesting to exploit.

IV – Conclusions

From this study, we note a large range of adaptation mechanisms adopted by the stockbreeders of the area of M'Sila. These mechanisms are the result of local innovations emanating from the stockbreeders themselves. Indeed, each breeder seeks to solve the problems of his own herd. These mechanisms have certainly advantages, but some showed their limits. On the other hand, in a situation of vulnerability of the current breeding systems to the various climatic and economic hazards, the question of the future of the sheep breeding in steppe area arises urgently with acuity.

From another point of view, the different forms of adopted adaptations constitute real experimental attempts on field and remain very useful for the elaboration of possible management and development programs adapted to local steppic conditions.

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Energy footprint assessment of sheep meat produced under two different farming systems in Tunisia

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Abstract. Energy is a major input for sheep production due to the intensification and mechanization of production technologies. Energy efficiency is one of the key indicators for developing more sustainable agricultural practices. However, the analysis of energy uses in different sheep production systems are scarce. In this context, this study had been set out to measure energy footprint (EF) of sheep meat production in two farming systems in Tunisia; the mixed sheep-cereal farming system (prevailing in Northern Tunisia, mainly the regions of Beja, Jendouba) and the agro-pastoral farming system (prevailing in southern Tunisia mainly the regions of Tataouine and Kebili) where farmers rely on the purchase of livestock feedstuffs from local markets. This study further considers differences in the two production systems to explore the causes of variation of EF in sheep meat production. A total of 80 sheep farms, were investigated, using data on direct (fuel and electricity) and indirect (structures, machinery, feed, fertilizers, pesticides, and seeds) energy inputs. EF was expressed as mega joule (MJ) per unit of live weight (LW). Results show that the average EF of all evaluated farms was 1.58 MJ/ kg of LW. Farms in the North had the highest EF (average 2.18 MJ/ kg of LW) for which energy use is distributed as following: 65% feed production, 15% water pumping for livestock watering and irrigation, 8% animal housing and lighting and 12% for transport. While the lowest EF was obtained in farms located in the south averaging 0.98 MJ/ kg of LW for which the energy use during feed production, water pumping for watering and irrigation, animal housing and lighting and transport were 15, 25, 9 and 51%, respectively. It is concluded that sheep meat production in the agro-pastoral farming system in Southern Tunisia is less energy demanding than in the mixed sheep-cereal farming system in the North of the country. This can be explained by the fact that feed production has the largest share of the total energy used by Northern's farms. This means that efforts should be made to increase the energy efficiency of feed production and to increase feed use efficiency by animals.

Keywords. Energy footprint – Sheep – Mixed cereal-sheep system – Agro-pastoral system.

Évaluation de l'empreinte énergétique de la viande ovine produite sous deux différents systèmes de production en Tunisie

Résumé. *L'énergie est un intrant essentiel dans la production ovine en raison de l'intensification et de la mécanisation des technologies de production. L'efficacité énergétique est l'un des indicateurs clés pour développer des pratiques agricoles plus durable. Cependant, les analyses de l'utilisation énergétique dans différents systèmes d'élevage ovin sont rares. Dans ce contexte, cette étude a été conçue pour mesurer l'empreinte énergétique (EF) de la production de viande ovine dans deux systèmes d'élevage en Tunisie; Le système mixte céréales-élevage (prévalant dans le nord de la Tunisie, principalement les régions de Beja et Jendouba) et le système agro-pastoral (prédominant dans le sud de la Tunisie, principalement Tataouine et Kebili), où les agriculteurs comptent sur l'achat des aliments de bétail au niveau des marchés locaux. Cette étude considère également les différences dans les deux systèmes de production pour explorer les causes de la variation de l'EF dans la production de viande ovine. Au total, 80 exploitations ovines ont été étudiées, en utilisant des données sur les intrants énergétiques directes (carburant et électricité) et indirectes (structures, machines, aliments, engrais, pesticides et graines). EF a été exprimée en mégajoule (MJ) par unité de poids vif (LW). Cette étude montre que la valeur moyenne du EF de la viande ovine est 1.58 MJ / kg LW. Les fermes du Nord avaient la plus élevée EF (valeur moyenne de 2.18 MJ / kg de LW) pour laquelle la consommation d'énergie est distribuée comme suit: 65% de production des aliments, 15% de pompage d'eau pour l'abreuvement des animaux et l'ir-*

rigation, 8% de logement et d'éclairage pour animaux et 12% pour le transport. Cependant, l'EF la plus faible a été obtenue dans les fermes du sud et elle est d'en moyenne 0.98 MJ / kg LW pour laquelle la consommation d'énergie pendant la production des aliments, le pompage d'eau pour l'abreuvement et l'irrigation, le logement des animaux et l'éclairage et le transport étaient de 15, 25, 9 et 51%, respectivement. Il est conclu que la production de viande ovine dans le système agro-pastoral dus le sud Tunisien est moins exigeante en énergie que dans le système mixte céréales- élevage dans le nord du pays. Cela s'explique par le fait que la production des aliments correspond à la partie la plus importante de l'énergie totale utilisée dans les fermes du Nord. Cela signifie que des efforts doivent être faits pour améliorer l'efficacité énergétique de la production des aliments et l'efficacité de l'utilisation des aliments par les animaux.

Mots-clés. *Empreinte énergétique – Ovin – Système mixte céréales-élevage – Système agro-pastoral.*

I – Introduction

The population growth coupled with the rapid economic development place a heavy burden on natural resources through the increasing demand for agricultural products. In addition, the way in which we use natural resources is central to the challenge of improving food security across the world, particularly in developing countries (FAO, 2013; Wanapat *et al*., 2015). The challenge of providing sufficient food for everyone worldwide has never been greater. Livestock products and especially meat rely highly on natural resources and is responsible for high emissions of greenhouse gases (GHG) (Herrero *et al*., 2016). Fossil energy has been identified as a major input of livestock production systems. Furthermore, energy use is expected to increase globally from 46 to 58 percent between 2004 and 2030 (EIA, 2007). Energy footprint (EF) was proposed as a metric to measure the indirect and direct use of energy of a product. Fossil energy is used mainly for the production, transport, storage and processing of feed. Depending on location (climate), season of the year and building facilities, energy is also needed for the control of thermal environment (cooling, heating or ventilation) and for animal waste collection and treatment. Tunisia is one of the countries in the Mediterranean area having very limited energy resources. Small ruminants' production is the main source of income of many households in Tunisia. Therefore, producing more crops and livestock products with less energy has become a challenging demand by the government authorities. Several studies assessed the energy inputs of livestock products (Hartman and Sims, 2006; Meul *et al*., 2007; Thomassen *et al*., 2008; Kraatz, 2012; Pagani *et al*., 2016). However, assessments of EF of sheep meat are scarce. This study aimed to assess and compare the EF of sheep meat produced in Tunisia under two farming systems; the mixed sheep-cereal farming system (prevailing in Northern Tunisia, mainly de regions of Beja, Jendouba) and the agro-pastoral farming system (prevailing in southern Tunisia mainly Tataouine and Kebili). This indicator could help to identify hotspots of energy use and propose strategies to reduce energy consumption in sheep meat production. Additionally, select the more efficient farming system in term of energy use.

II – Methods and data

1. Study area and farming systems description

This study was carried out in two locations with two different production systems (Figure 1). The first location is in northern Tunisia (Beja and Jendouba governorates), and is characterized by an average annual rainfall ranging between 700 and 1200 mm. The average minimum and maximum temperatures are 5°C and 38°C, respectively. In this location, cereal cropping and sheep production are the main activities undertaken by farmers. The second location is in Southern Tunisia (Tataouine and Kebili governorates) characterized by an arid climate with an average annual rain-

fall less than 200 mm and the temperature varies between 15°C and 42°C. The agro-pastoral system is the dominant production system, and people get their incomes from small ruminant's production. This study was based on data from surveys conducted in 80 farms, from where sheep production is an important activity. This survey was also performed to determine diet composition, fodder crops types and energy costs.

Fig. 1. Localization of the surveyed sheep farms in Tunisia.

2. The energy footprint accounting

In this study, a cradle to farm gate perspective was adopted. The system boundary included all direct energy inputs occurring at the farm level (fuels and electricity) and all indirect energy inputs immediately related to purchased animal feeds on the market. Data on direct energy inputs, structures, machinery, materials and feed were collected during field visits. The direct energy uses, which are recurring energy inputs, are those for pumping and operating the farm irrigation system, transport and feed production. For diesel engines, the energy input was calculated as (Khan *et al*., 2009; Pagani *et al*., 2016):

$$Ec = F_c * T_c * C_v * L$$

Where E_c is the energy output of the machine (kW h), F_c the fuel consumption of the machine (l/h), T_c the time consumed in operation (h), C_v the caloric value of the fuel (kW h/l), L is the actual fuel consumption over fuel consumed at rated power. For electric motors, the energy input was calculated by the product of rated power of the electric motor, operation time, and load factor. For operation performed by the contractor where the farmers paid for the energy applied, the energy consumption was

calculated based on data from similar farms, but the charges were ascribed among operations based on the amount the particular farmer paid for a particular operation to the contractor (Khan *et al*., 2009). The energy footprint of sheep expressed on megajoule (MJ) and calculated as following:

$$EF_{sheep} = EF_{feed} + EF_{pumping\ drinking\ and\ irrigation\ water} + EF_{Lighting\ and\ housing} + EF_{transport}$$

III – Results and discussion

This study showed that the typical diet used in the north-located farms raised under the mixed sheep-cereal farming system includes 20 to 30% of concentrate feeds (commercial concentrate, barley and wheat bran). In addition, farmers rely on grazing on natural pasture, fallows and cereal stubbles in summer. Farms in southern Tunisia target sheep production under the agro-pastoral farming systems. Farmers in this region rely mainly on concentrate feeds (40 to 60%) and fodder crops mainly from the north region of Tunisia. Sheep flocks in this arid region are in most cases grazing on degraded rangelands. The energy footprint accounting of sheep meat in the selected farms averaged to 1.58 MJ/ kg of LW. Sheep meat produced on the north had the highest EF (2.18 MJ/kg of LW) compared to that produced in the south (0.98 MJ/kg of LW). This difference could be ascribed to the high use of energy during feed production on the farm scale. Moreover, Figure 2 shows that feed production in the northern farms represents the hotspot in term of energy use. While the transport of animal and feed reveals the highest consumption of energy in the Southern farms. These findings confirm that producing sheep meat under the agro-pastoral system consumes one time less energy than the mixed sheep-cereal farming system. Our study is the first assessing EF of sheep meat. Sheep meat is less intensive in term of energy use than dairy products (Koknaroglu, 2010; Mikkola & Ahokas, 2009). In order to reduce the EF of sheep meat it is suggested to improve the energy use efficiency of feed production in the Northern farms through for example the adoption of conservation agriculture. In the Southern part, Tunisia can invest more to take advantage from the renewable energy since our country has a good potential to produce solar energy which can be used to recompense the wasting of energy in feed transport.

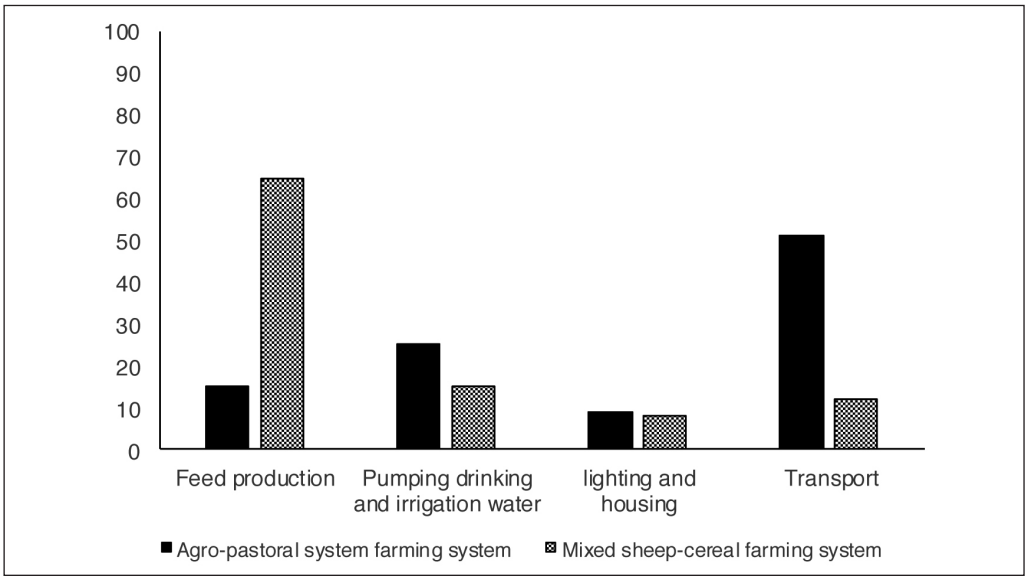

Fig. 2. Percentage of energy use per step of production in the agro-pastoral and the mixed sheep-cereal farming system in Tunisia.

IV – Conclusions

Our study shows that energy footprint is an important indicator for the assessment of energy use in livestock sector. The comparison of sheep farming systems in Northern and Southern Tunisia provides useful insights in terms of energy saving strategies for this sector. Energy efficiency intervention strategies should promote a sustainable agricultural mechanization through the adoption of conservation agriculture to save energy. Therefore, further research should focus on the reduction of farming dependency on fossil fuels through the integration of renewable energy sources in farm scale could lead to a transition to low carbon farms, driven by locally available resources such as biogas energy from manure and solar energy.

Acknowledgments

Authors acknowledge the support of the National Institute of Agricultural Research of Tunisia (INRAT) and the collaboration of the farmers.

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L'élevage respectueux de l'animal, condition de sa durabilité

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Résumé. Aujourd'hui le sort réservé à beaucoup d'animaux d'élevage manque d'humanité. Ceci n'est pas acceptable et ne laisse plus indifférent. Cet état de fait et un manque de transparence général sur les conditions d'élevage mais aussi sur les conditions d'abattage conduit nombre de citoyens à rejeter toutes formes d'élevage et leurs finalités productives. Cependant, il existe aussi par ailleurs, nombre d'autres élevages dans lesquels les animaux sont traités avec considération et respect. Ce papier met en lumière, au sein d'élevages ovins, des pratiques relationnelles peu connues mais respectueuses des animaux, nécessaires à l'acceptabilité sociale et à la durabilité de l'élevage. A partir d'observations et d'enregistrements vidéo des comportements interactifs entre brebis, chiens de conduite et bergers, nous avons identifié, la nature des liens qui existent entre les animaux et les hommes. A partir d'entretiens individuels et collectifs avec les bergers et les éleveurs, nous avons repéré la considération qu'ils portent à leurs animaux. Dans ces élevages, les éleveurs révèlent que le travail partagé avec eux transforme de simples interactions en attachement affectif et contribue au développement du respect qu'ils leur portent tout au long de leur vie. Ceci les amène à créer des conditions dignes d'élevage et à exiger des conditions dignes d'abattage. Ils souhaitent que les animaux dont ils ont pris soin soient respectés jusqu'au bout en particulier en réduisant leur stress avant l'abattage. Ils expliquent que ce n'est qu'à ces conditions qu'ils peuvent assumer la finalité productive de l'élevage, conditions qui sont aussi nécessaires pour que l'élevage soit socialement acceptable.

Mots-clés. Troupeau – Brebis - Chien de conduite – Berger – Eleveur – Conditions d'élevage – Conditions d'abattage.

The respectful animal farming: condition of its sustainability

Abstract. *Today, the fate of many livestock farming is lacking in humanity. This is not acceptable and no longer leave indifferent. A lack of general transparency on the conditions of livestock farming and slaughtering, leads many citizens to reject all forms of livestock farming and their productive purposes. However, there are also many other livestock farming where animals are treated with consideration and respect. This paper highlights, in sheep farming, relational practices little known but respectful of animals, necessary for the social acceptability and the sustainability of livestock farming. From observations and video recordings of interactive behaviours between ewes, shepherd dogs and shepherds, we have identified the nature of the links between animals and humans. From individual and collective interviews with shepherds and farmers, we have noticed the consideration they give to their animals. In these farms, the farmers reveal that the work shared with them transforms simple interactions into affective attachment and contributes to the development of the respect that they carry to them throughout their life. This leads them to create conditions worthy of farming and to demand conditions worthy of slaughtering. They want the animals they have taken care of to be respected to the end, especially by reducing stress before slaughter. They explain that it is only under these conditions that they can assume the productive purpose of their farm. These good conditions are also essential for socially acceptable animal farming.*

Keywords. *Flock – Sheep – Sheep dog – Shepherd – Farmer – Farming conditions – Slaughtering conditions.*

I – Introduction

Les animaux d'élevage ont acquis le statut d'êtres vivants sensibles (Loi n° 2015-177, article 2 du Code Civil), or une grande majorité des conditions de vie et d'abattage qu'on leur impose encore aujourd'hui n'en tiennent pas vraiment compte. Dans ces conditions, les animaux sont surtout utilisés comme des objets de production avec comme objectif premier celui d'optimiser le profit. Ces animaux sont traités avec peu de considération, et parfois même avec mépris, ce qui est largement critiqué par les citoyens qui en ont pris conscience et n'acceptent pas cette situation largement révélée dans les médias. Si le développement de normes de bien-être a permis certaines améliorations matérielles et sanitaires des lieux de vie des animaux, celles-ci restent bien insuffisantes, en particulier en ce qui concerne les relations des animaux avec les humains qui les côtoient quotidiennement. Car des relations entre des êtres vivants, étant pour une grande part du domaine de la sensibilité, ne se déclarent pas à travers des normes, elles se vivent (Porcher, 2003). Paradoxalement, l'existence de ces relations étant tellement évidente pour ces éleveurs qu'ils ne voient pas la nécessité d'en parler. L'absence de cet élément dans leur discours renvoie au public un message d'indifférence des éleveurs par rapport à leurs animaux (Lamine, 2006). Ainsi, la nature et l'importance de ces interactions pour les animaux comme pour les éleveurs sont peu connus et passés sous silence (Porcher, 2011). Pour répondre à cette lacune, nous avons observé et filmé dans 3 élevages des comportements interactifs entre brebis, chiens de conduite et bergers (Vallée, 2013). Pour connaitre le point de vue des bergers et des éleveurs nous les avons interrogés sur leurs pratiques d'élevage et sur les conséquences de leurs relations avec les animaux dans leur métier d'éleveur. Nous avons réalisé des enquêtes individuelles (18 éleveurs ovins, Robine, 2012 ; 32 éleveurs ovins, Gouy, 2013) et collectives (66 éleveurs essentiellement ovins mais aussi bovins, porcins et multi-espèces, Porcher *et al.,* 2014).

II – L'élevage : des relations de travail méconnues entre éleveurs et animaux

L'élevage met en jeu des relations interspécifiques entre éleveurs et animaux. En situation de gardiennage, sont impliqués un berger, un troupeau de brebis et un chien de conduite. Le chien doit suivre ce que fait et veut le berger ; les brebis doivent suivre ce que font et veulent le berger et le chien. Cela nécessite une attention particulière portée par chacun au contexte environnemental d'une part, mais aussi aux actions et aux réactions interactives de chacun, ainsi qu'à la nature de leurs relations.

1. Des relations intersubjectives cognitives et coordonnées

Les observations et l'analyse des films permettent de décrire les comportements interactifs entre brebis, chiens de conduite et bergers et de montrer que ces animaux, comme les humains, investissent leur subjectivité pour mettre en œuvre des actions qui conviennent et coordonner leurs activités (Vallée, 2013).

A. Des actions spécifiques

Le berger, a la responsabilité du troupeau. Il doit le faire manger le mieux possible pour la satisfaction des brebis : il organise le circuit dans le sens de leur biais, il donne une direction au troupeau, choisit les lieux et les limites des zones qu'il fait pâturer, rappelle les brebis qui dépassent les limites, règle la vitesse de déplacement. Si nécessaire, il adresse des commandes à son chien pour qu'il intervienne, contrôle ses interventions. Il doit faire respecter ses ordres.

Le chien aide le berger à contrôler les déplacements, il protège les limites des zones choisies par le berger pouvant être pâturées, rassemble les brebis ou les agneaux qui s'éloignent ou trainent

à l'arrière du troupeau. Le chien comprend ce qui se passe et évalue le contexte dans lequel il travaille et s'engage ; sous certaines conditions, il peut proposer une intervention comme rassembler des brebis pour contenir le troupeau à l'intérieur des limites du pâturage.

Quant au troupeau, il connait la plupart du temps les lieux où il est mené pour pâturer : les brebis connaissent les chemins et les directions qu'elles doivent emprunter. Selon les bergers, *« les brebis, c'est elles qui montrent la route »* car *« elles ont une grande mémoire des lieux »* et *« elles savent aussi où sont les bons endroits »* … et c'est en partie cela que le berger contrôle : ces « bons endroits » repérés par les brebis qu'il empêche ou autorise au pâturage selon la saison et les autres ressources alimentaires dont il dispose.

Les brebis savent ce qu'elles doivent faire, là où elles sont autorisées à pâturer, connaissent et testent les limites imposées par le berger et le chien. Elles trient les espèces qu'elles préfèrent, anticipent un changement de parc et refusent de continuer à prélever de l'herbe sur un pâturage devenu peu appétant. Elles reconnaissent les noms des différents chiens et remarquent leur présence ou leur absence.

La réussite d'un circuit de garde atteste de capacités cognitives réflexives et partagées entre les intervenants et témoigne d'un sens commun donné à leurs activités.

B. Des règles partagées

Les activités des uns et des autres sont régies par des règles qui sont le socle d'une possible coopération. Ces règles mobilisent leurs capacités sensibles et cognitives. Elles sont spécifiques, doivent être apprises, être connues et acceptées par tous. Elles sont la preuve d'une communication interspécifique.

L'attention : berger, brebis et chien doivent être attentifs au contexte environnemental complexe dans lequel se déroule le circuit de garde comme aux actions et aux réactions interactives des uns et des autres. Le chien doit rester vigilant pendant toute la durée du circuit de garde y compris pendant la pause.

L'obéissance : le troupeau, les brebis et le chien doivent suivre les ordres du berger. Les brebis doivent se soumettre aux interventions du chien.

Le positionnement : Le troupeau doit rester dans les limites autorisées. Le chien doit rester à proximité du berger en dehors des moments où il intervient ; il doit canaliser les déplacements du troupeau, contrôler son rassemblement, garder la mémoire des lieux à protéger, savoir se positionner par rapport au troupeau et au berger.

La vitesse : le troupeau et les brebis doivent se déplacer tranquillement. Le chien doit contrôler son allure de course pendant une intervention. Il doit agir vite et juste sans trop d'excitation

La modération : le berger doit rester calme. Le troupeau doit pâturer librement. Le chien doit perturber au minimum l'activité de pâturage du troupeau, garder son self-control avec les brebis, même les plus rebelles, et ne pas mordre.

C. Des initiatives autorisées

Les animaux et les bergers mettent en œuvre ces règles ; elles sont souvent respectées, parfois oubliées, et peuvent aussi être dérogées et mettre en péril la réussite de la garde. Mais il existe des circonstances où le chien déploie son intelligence et où ce qui pourrait paraitre comme une désobéissance n'en est pas une. Par exemple, dans une situation particulière, le chien qui prend l'initiative d'une intervention adéquate, répond et supplée avantageusement à une analyse erronée du berger. Dans d'autres circonstances, le berger laisse des marges de négociation aux ani-

maux : par exemple, le troupeau peut accéder à un changement de lieu de pâturage s'il le demande en bêlant ; le chien peut prendre l'initiative d'une intervention dès lors que le berger lui reconnait son expérience et lui laisse une part d'autonomie. Le chien est alors autorisé à prendre en charge le contrôle d'une situation, indépendamment du berger. C'est par la mobilisation de sa subjectivité que le chien parvient à proposer une intervention adaptée. Dans ce cas, le chien est investi de responsabilité pour une prise en charge partielle du déroulement du circuit de pâturage. Ensemble, berger et chien assurent ainsi une coopération efficace qui engage les animaux et les éleveurs dans une relation qui les intéresse réciproquement.

2. Des relations intersubjectives affectives

La coopération entre un éleveur et ses animaux engage des relations affectives qui s'appuient sur le respect des tempéraments et des compétences particulières de chacun. C'est le cas du berger qui partage son temps avec son troupeau et ses chiens. Il les regarde vivre et les conduit en tenant compte de leurs comportements naturels, de leurs habilités et de leurs prédispositions. Il prend en compte les tempéraments individuels des brebis : il s'appuie sur les plus familières pour rassembler le troupeau, sur les plus dynamiques pour déplacer le troupeau. Il en surveille certaines plus que d'autres : les plus vindicatives, les plus rebelles, celles qui s'éloignent et en entrainent d'autres. Le berger adapte son niveau d'exigence envers chaque chien en fonction de l'intérêt de ce dernier à la garde, de ses compétences liées à son âge, à son expérience, à son tempérament, à ses capacités physiques et mentales. Les enquêtes menées par Lucie Robine (2012) et Gouy (2013) ont permis d'identifier les valeurs relationnelles sous-jacentes à ses relations affectives. Deux d'entre elles sont explicitées par 100% des bergers et éleveurs : celles d'observer les animaux et d'être proche d'eux. Ils expliquent que l'observation a pour but, avant tout, de prendre soin des bêtes pour détecter ou anticiper blessures ou maladies. Etre proche est pour eux, une manière d'apprivoiser les animaux. Une autre valeur importante consiste pour 81% des éleveurs à communiquer avec leurs animaux afin de parvenir à un degré de compréhension mutuelle. Pour cela, 75% d'entre eux disent parler à leurs animaux. Soixante-neuf pour cent expliquent aussi passer du temps avec eux. Selon ces éleveurs, l'absence de temps strictement dédié à l'observation des animaux inhibe la possibilité d'une relation avec leurs animaux alors que le temps de présence partagé est un temps nécessaire à l'acquisition d'une interconnaissance mutuelle et au repérage d'éventuels problèmes. En effet, des indications de mal-être ou de maladies des animaux sont souvent subtiles et indiquées par un comportement inhabituel (Salmona, 1994). Les éleveurs expliquent que prendre le temps de la relation, n'est pas une perte de temps. Le temps passé avec les animaux et l'établissement d'une proximité avec eux sont porteurs de liens déterminants pour le développement de la relation. Enfin, 69% des éleveurs expliquent avoir de la considération pour leurs animaux et 53% avoir de l'empathie. Quarante-sept pour cent disent se sentir impliqués dans un rapport de don et 25% assurent avoir de la reconnaissance pour eux. Cette affectivité repose sur des liens de confiance et de reconnaissance réciproques nécessaires entre l'homme et l'animal pour une collaboration efficace.

A. Des liens de confiance

Les liens de confiance entre les éleveurs et leurs animaux se construisent dans leurs échanges quotidiens empreints du respect de chacun. Ils apprennent –bergers, éleveurs mais aussi animaux– ce qu'ils peuvent attendre ou pas les uns des autres. Ils savent ainsi interpréter divers signaux. Par exemple, les brebis qui reçoivent quotidiennement les soins des bergers et des éleveurs ont appris à les solliciter : quand elles bêlent, ils comprennent qu'il s'agit, selon les circonstances, d'une demande pour recevoir une simple attention ou de l'alimentation, sortir de la bergerie, changer de parc afin d'avoir de l'herbe « neuve ». De la même manière, des brebis marquent leur proximité affective avec leur berger ou leur éleveur en s'approchant d'eux. Au moment des mises-bas, le fait que certaines attendent la présence de l'éleveur pour agneler, atteste de la confiance qu'elles lui portent.

B. Des liens de reconnaissance

Cette confiance, s'instaure du fait des tempéraments des animaux et des hommes qui les élèvent. Non seulement, ces derniers prennent soin d'eux mais souvent leur parlent, leur prêtent attention, leur adresse caresses et friandises**.** L'animal qui se souvient de son soigneur, lui est reconnaissant. De manière similaire, l'éleveur n'est pas indifférent aux compétences de ses animaux. La réussite d'une intervention du chien auprès du troupeau, l'efficacité des brebis dans leur activité de pâturage, la naissance de jolis agneaux sont autant de sujets de satisfaction pour les bergers et les éleveurs comme pour les animaux. Ces plaisirs partagés conduisent les bergers et les éleveurs à exprimer leur affection et leur reconnaissance par des remerciements : félicitations orales, caresses, friandises tiennent lieu d'approbation. Cette reconnaissance est pour le chien un facteur crucial de plaisir et de sens donné à son intervention. Elle lui permet de développer un sentiment d'utilité et de compétence, et de répondre positivement aux ordres du berger. Elle est nécessaire pour sa prise d'autonomie et lui permet, si nécessaire, de prendre de nouvelles initiatives. Elle a une fonction relationnelle : celle d'entretenir des liens et de développer de la considération réciproque.

III – Des pratiques d'élevage et d'abattage responsables

Les éleveurs enquêtés, permettent de caractériser leurs pratiques d'élevage (Robine, 2012, Gouy, 2013), et d'identifier leurs exigences pour l'abattage de leurs animaux (Porcher *et al.,* 2014).

1. Des conditions de vie respectueuses

Ces éleveurs passent beaucoup de temps avec leurs animaux, ils savent qu'ils ne sont pas seulement des objets de production. Ils considèrent que les animaux ont une valeur propre, autre que strictement économique. Ils reconnaissent que leurs animaux engagent leur subjectivité dans des activités cognitives puisqu'ils ne font pas que se soumettre aux consignes de l'éleveur et qu'ils participent avec lui à la réalisation du bon déroulement d'activités quotidiennes. Ils expliquent que ce partage est pour eux un possible accomplissement. Ils reconnaissent également leurs capacités relationnelles et parlent de l'importance des liens qu'ils nouent avec eux. Ces relations construites et entretenues pendant la période d'élevage, s'inscrivent sous le signe du respect et engagent leur responsabilité. Ainsi, ces éleveurs, cherchent à procurer à leurs animaux des conditions de vie respectueuses, les meilleures possibles, et veulent assumer leur devenir vulnérable.

2. Une mort digne

Ces éleveurs ne veulent pas dissimuler la mort des animaux et le but de l'élevage. Mais ils sentent la nécessité de penser la légitimité morale de la mise à mort comme la condition nécessaire de l'élevage, pour l'assumer de manière responsable (Mouret, 2012). Ainsi, ils veulent exercer leur rôle d'éleveur jusqu'au bout en évitant la dégradation des liens qui se sont construits entre eux et leurs animaux et exigent des pratiques respectueuses jusqu'à l'abattage *« Tant que l'animal est en vie, il reste un animal à qui l'on doit respect et considération »* (Porcher *et al.*, 2014). Pour être à la hauteur du respect qui est dû aux animaux et qu'ils soient traités dignement à l'abattage, de repenser les pratiques actuelles d'abattage et d'apprendre à tuer de manière responsable (Haraway, 2010). La principale exigence réclamée par les éleveurs pour améliorer les conditions de mise à mort est d'éviter ou au moins de réduire au maximum le stress des animaux avant la mort. Pour cela, certains souhaitent réaliser la mise à mort de leurs animaux sur leur lieu de vie, ce qu'ils considèrent comme étant la meilleure des solutions. Pour d'autres, le minimum serait d'abattre les animaux au plus près de leur lieu d'élevage, pour réduire les durées de transport et d'attente avant l'étourdissement. Ils veulent également le contrôle systématique de la perte de conscience effective des animaux au moment de l'abattage. Cette dernière condition qui est exigeante car elle de-

mande de prendre le temps nécessaire, s'inscrit dans la volonté des éleveurs de pratiquer la meilleure mort possible, ce qui parait paradoxale pour beaucoup, mais qui symbolise néanmoins la compassion et le respect de l'éleveur pour son animal (Grandin, 1998, Porcher, 2011). Dans cette démarche, certains éleveurs expriment aussi le souhait d'accompagner leurs bêtes jusqu'à la mort et demandent la possibilité d'être présents jusqu'au bout.

3. Le sens du métier d'éleveur

En général, les éleveurs parlent peu de l'importance des liens qu'ils entretiennent avec leurs animaux quand ils décrivent leur activité d'élevage, alors que les observations menées et les éleveurs enquêtés sur cette question montrent que cet aspect apparait comme une richesse essentielle de leur métier. Trente-huit pour cent d'entre eux se considèrent tout autant gestionnaires d'entreprise que motivés par cet aspect affectif de la relation et se sentent responsables des rapports qu'ils entretiennent avec leurs animaux. Ces liens affectifs entre un éleveur et ses animaux, sont l'expression d'un engagement moral fondamental qui donne du sens à leur métier d'éleveur. (Porcher, 2003, 2011, Despret, 2012).

IV – Conclusion

Dans les élevages, on ne peut plus ignorer ni la sensibilité des animaux, ni leurs capacités relationnelles (Bekoff, 2013). Les éleveurs que nous avons rencontrés en tiennent compte. Ils mettent en avant la dimension humaine de leurs élevages. Leurs façons d'être avec les animaux témoignent de l'estime et du respect qu'ils leur portent et sous-tendent certaines des raisons pour lesquelles ils font de l'élevage. Ces éleveurs mettent en place des conditions de vie respectueuses et cherchent des conditions d'abattage les plus respectueuses possibles. Mais ces formes d'élevage ne sont pas majoritaires et sont méconnues des citoyens et des consommateurs. En effet, 33% des français enquêtés en 2016, expriment une inquiétude quant aux conditions de vie des animaux (Etude OCHA-Certop-Credoc, 2016). Ils sont alarmés par la vision inacceptable des conditions d'élevage et d'abattage industriels dans lesquels ces valeurs relationnelles sont négligées et où la primauté est donnée aux performances techniques et économiques. Ainsi, nombre de citoyens et de consommateurs se conforment à l'idée d'abolir l'élevage sans savoir qu'il est possible de faire différemment. Il faut que la différence puisse être faite. Alors que l'engagement moral de ces éleveurs porteurs de valeurs relationnelles, de plaisir partagé avec leur animaux et d'émancipation rejoint les exigences éthiques des consommateurs, il est urgent d'augmenter la visibilité de cette autre façon de faire de l'élevage. De telles pratiques, respectueuses des animaux et des hommes, sont aujourd'hui nécessaires et essentielles à l'acceptabilité sociale et à la durabilité de l'élevage.

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Ethnoveterinary practices in the Tena Valley and Biescas Area (Spanish Pyrenees) for the care of sheep and goats

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Abstract. This study covers traditional healing practices for sheep and goats recorded in the Tena Valley and Biescas Area (Spanish Pyrenees). 30 informants were interviewed and 60 different plant taxa were registered belonging to 35 botanical families, as well as 7 herbal remedies, 1 fungus, 9 elements of animal origin, 9 of mineral origin, 1 of chemical origin and 7 handling practices or other remedies. In total, 149 practices for medicinal, reproductive or production uses in small ruminants were recorded. These traditional practices are very useful for organic farming as alternatives to synthesised medicinal products and as non-conventional feeds, and contribute to maintaining traditional knowledge, which has been passed on from one generation to the next and has been falling into disuse in recent times. Therefore there is an urgent need to record knowledge related to ethnoveterinary practices to conserve them and thus enable the development of new remedies.

Keywords. Ethnobiology – Organic farming – Traditional farming – Indigenous knowledge – Small ruminants – Pastoralism.

Pratiques ethnovétérinaires dans la vallée de Tena et la zone de Biescas (Pyrénées espagnoles) en matière de soins de santé aux ovins et caprins

Résumé. *Cette étude porte sur les pratiques curatives traditionnelles chez les ovins et caprins, rapportées dans la vallée de Tena et la zone de Biescas (Pyrénées espagnoles). Un entretien a été mené auprès de 30 personnes, et 60 taxons végétaux différents ont été répertoriés appartenant à 35 familles botaniques, ainsi que 7 remèdes à base de plantes, 1 provenant de champignons, 9 éléments d'origine animale, 9 d'origine minérale, 1 d'origine chimique et 7 pratiques liées à la gestion ou autres remèdes. Au total, 149 pratiques utilisées en médecine vétérinaire, reproduction ou production chez les petits ruminants ont été constatées. Ces pratiques traditionnelles sont très utiles en élevage biologique comme alternatives aux produits médicaux synthétiques et comme aliments non conventionnels, et contribuent à la préservation des savoirs traditionnels, qui sont transmis de génération en génération et sont tombés en désuétude de nos jours. Par conséquent, il est nécessaire et urgent de documenter ces savoirs liés aux pratiques ethnovétérinaires pour les conserver et permettre ainsi le développement de nouveaux remèdes.*

Mots-clés. *Ethnobiologie – Élevage biologique – Élevage traditionnel – Savoirs locaux – Petits ruminants – Pastoralisme.*

I – Introduction

Ethnoveterinary medicine or popular veterinary medicine is the "interdisciplinary and holistic study of local knowledge associated to practices, skills, beliefs and social structures involved in animal production, in order to apply them to agricultural development projects aiming to improve the population's standard of living and increase their production" (McCorkle, 1995).

According to some studies (McCorkle and Mathias-Mundy, 1992), the integration of ethnoveterinary practices into conventional veterinary medicine could save money, energy and natural resources. Furthermore, according to the current regulations on ecological livestock farming in Europe, (EC) No 889/2008 (EC 2008) "phytotherapeutic and homeopathic products, trace elements (…) shall be used in preference to chemically-synthesised allopathic veterinary treatment or antibiotics, provided that their therapeutic effect is effective for the species of animal, and the condition for which the treatment is intended". Therefore, this type of study is essential to give livestock farmers and technical experts access to this information as it is becoming scarce.

The study area chosen was the Tena Valley and Biescas Area in the Spanish Pyrenees, in the Ordesa-Viñamala Unesco Biosphere Reserve. The local economy has traditionally been based on livestock farming but in the later part of the twentieth century, migration from the area and tourism have decreased farming activities as well as the associated traditional know-how. For this reason it is vital to investigate the knowledge related to ethnoveterinary practices, in order to maintain them and contribute to the development of new remedies.

II – Materials and methods

Information was collected using semi-structured interviews to farmers, shepherds and housewives in the last years. Thirty people over 50 years old were interviewed. Most of the study participants were born in, and reside in the valley. All data, were obtained by means of an informal conversations ith the subjects interviewed accompanied by a survey guide that included pre-determined questions. All 30 interviewees were visited once except one subject who, given his high level of knowledge on the matter, received visits at two different times of the year: winter and spring. The 31 interviews were conducted every other week from February to June 2015.

The data collected was classified according to the pertinent bodies and functions, following the classification in the *The Merck Veterinary Manual: A Handbook of Diagnosis, Therapy, and Disease Prevention and Control for the Veterinarian* (Fraser, 1993), and was divided into the following categories: Blood, lymphatic and cardiovascular systems; digestive system; endocrine system; eye and ear; generalized conditions; immune system; metabolic disorders; musculoskeletal system; nervous system; physical injuries; reproductive system; respiratory system; skin; urinary system; management, rearing and nutrition. Witchcraft has also been added to this classification, as in other research work in ethnoveterinary practices (Gómez, 2011), which have documented preparations of mystic origin aiming to prevent phenomena such as witchcraft, storms, etc. as well as instruments such as a hen's feather used to apply other remedies or *Pinus sylvestris L.* used for marking cattle.

This compilation focuses solely and exclusively on the properties affecting animals and, gathers information not only on preparations made from plants but also on all types of remedy related to animal production and health. It is likewise noteworthy that not only does this study gather information provided by the interviewees and other bibliographical sources but this information is also submitted to scientific study to ascertain their viability or efficacy. Data from Villar *et al*. (1992) is also included as well as the information provided by the interviewees.

III – Results and discussion

As indicated in figure 1, most remedies compiled in this study correspond to plant species (64%), followed by those of mineral and animal origin (each 10%), plant remedies and handling practices (7% each one), and finally chemical origin and fungi species(1% each one).

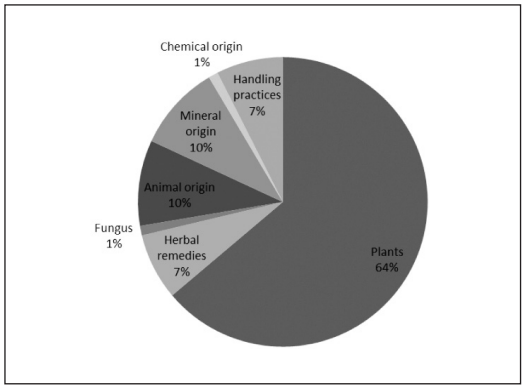

Fig. 1. Distribution of remedies according to origin.

The plant taxa belong to 35 different botanical families. The 6 different species of the Compositae family are those most frequently used in the study area, followed by the 4 different species of Leguminosae (Fig. 2).

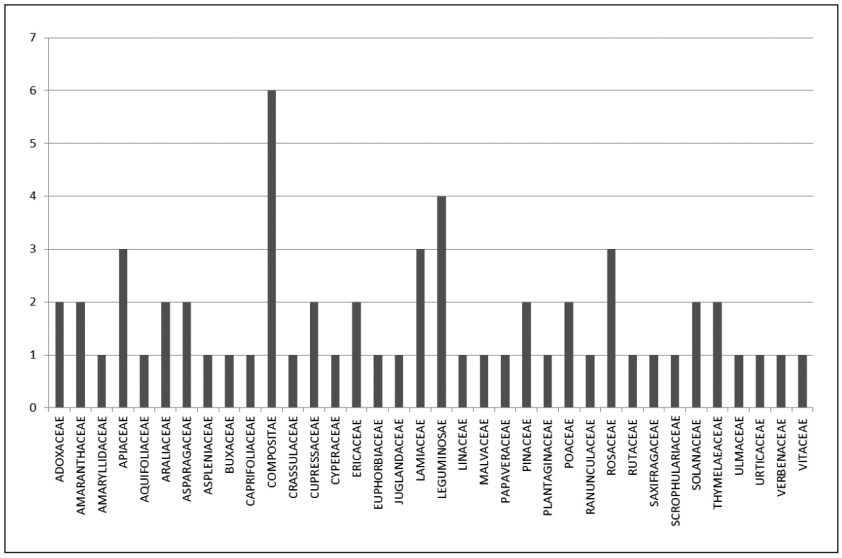

Fig. 2. Number of species according to botanical family.

The most popular plant species is *Sambucus nigra L.*, cited 16 times, used to improve respiratory, digestive and mammary conditions. The same uses have been recorded by different authors (Villar *et al.*, 1992; Navarro, 1994). Copper sulphate (mineral remedy) was also mentioned by 16 subjects as a remedy to heal ruminant hoof wounds.

Concerning remedies of animal origin, cobwebs were most frequently mentioned (4 subjects) as blood thinners. Cobwebs are a widespread therapeutic resource used mainly to treat haemorrhages (González y Vallejo, 2012). There are numerous bibliographical citations for this use in the province of Huesca and in the rest of the Iberian Peninsula (Ullod, 1994; Ibáñez, 2009).

The only fungus that the interviewees were aware of in popular veterinary practice is *Lycoperdon spp*. of the Agaricaceae family, for local haemostatic use. Villar *et al*. (1992) also report use of the fungus to stop bleeding.

The most cited plant remedy is ground carbon, mentioned by 12 subjects and applied to wounds to prevent myiasis.

Zotal® (chemical origin) was very popular against myiasis throughout the study area and according to some subjects it is also used to treat scabies. Other ethnoveterinary studies also mention the widespread use of this product in Cadiz and Huelva (Spain) (Mata *et al*., 2004; Gómez, 2011).

Cuts for bleeding sheep are the most frequently mentioned handling practices (9 subjects) to treat some diseases. In particular, the ear, the conjunctiva of the eye (more effective for type D enterotoxemia), or the tip of the tail (more effective for anthrax). These practices are still followed when the animal shows symptoms of type D enterotoxemia.

On the other hand, the largest number of remedies has been reported for generalized conditions (26 for generalized conditions, 23 for the reproductive system and 22 for the digestive system). As shown in figure 3 different uses have been compiled for some of the remedies, reaching a total of 87 remedies for 149 different uses.

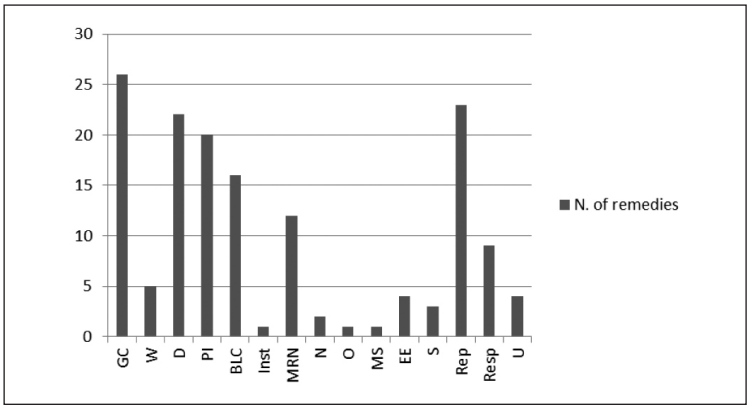

Fig. 3. Number of remedies recorded for each clinical pattern. [The clinical patterns correspond to: generalized conditions (GC), witchcraft (W), digestive system (D), physical injuries (PI), blood, lymphatic and cardiovascular systems (BLC), instrument (inst), management, rearing and nutrition (MRN), nervous system (N), others (O), musculoskeletal system (MS), eye and ear (EE), skin (S), reproductive system (Rep), respiratory system (Resp), urinary system (U)].

IV – Conclusions

This study shows that there is still considerable information related to ethnoveterinary practices, both concerning the number of remedies gathered in the study and in the quality of such practices, however they are also little known and in danger of disappearing forever, as most of the subjects interviewed are advanced in years and these traditions are no longer passed on orally to the younger generations.

A total of 94 elements are used for productive, reproductive or medicinal purposes.

The data recorded in this study is very useful for small ruminant farming, as some of these remedies can be used as alternatives to pharmaceutical products, especially in organic farming. On the other hand, some of the practices reported, such as the use of mastiff dogs to protect the flocks from wolves or bears, are being recovered in some areas of the Iberian Peninsula to prevent attacks on cattle. This goes to show that sometimes innovation means reverting to past practices and therefore measures should be taken to prevent this type of knowledge from disappearing. Likewise, studies are needed to assess and validate the efficacy of these practices.

Acknowledgements

We would like to thank the people living in Biescas and Tena Valley, in particular the farmers, for their availability and contribution to this study.

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The implementation of some regenerative practices to improve the sustainability of latxa dairy sheep system

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Abstract. Land use and grazing management practices have changed during the last decades as a result of intensification. Some of the consequences are directly related to environmental impacts. Under this scenario, the assessment of the effect of different management practices is critical to improve the sustainability of land-based systems. The main objective of the current work was to determine the effect of some regenerative practices on productive and environmental parameters. Two essays were carried out with the experimental flock of Neiker during 2014 and 2015, with two grazing regimes: regenerative (RG) and free (FG). Soil, pasture and livestock samples and data were obtained during springs, and carbon footprint was estimated with data collected monthly before (2013) and after (2014-2015) the regenerative practices were implemented. According to the results, there were no differences on milk parameters (daily milk yield and composition) and livestock parameters (live weight and body condition score) due to grazing management. RG regime resulted in 8% higher amount of particulate organic matter in the soil and 10% greater amounts of harvested herbage. Moreover, the regenerative practices implemented reduced the carbon footprint in 10%. As conclusion, the regenerative practices implemented in the study seemed to be linked with an increase of harvested herbage and a reduction of carbon footprint without compromising livestock productive parameters.

Keywords. Grazing management – Latxa dairy sheep – Regenerative practices – Sustainability.

La mise en place de certaines pratiques régénératives pour améliorer la durabilité du système d'élevage d'ovins laitiers Latxa

Résumé. *L'utilisation des sols et les pratiques de gestion du pâturage ont changé au cours des dernières décennies en raison de l'intensification productive. Quelques conséquences sont directement liées aux impacts environnementaux, comme l'empreinte du carbone. L'évaluation de l'effet de différentes pratiques de management est essentielle pour améliorer la durabilité de ces systèmes. L'objectif principal de ce travail était de déterminer l'effet de certaines pratiques régénératives dans les variables de production et environnementale des brebis laitières. Les essaies pour déterminer l'effet sur les variables de production ont été réalisés au troupeau expérimental de Neiker en 2014 et 2015, avec deux régimes de pâturage: régénératif (RG) et libre (FG). Des données et des échantillons du sol, pâture et brebis ont été prélevés aux printemps. D'autre part, l'empreinte carbone a été estimée avec des données recueillies mensuellement avant (2013) et après (2014-2015), la mise en œuvre des pratiques régénératives dans le troupeau. Selon les résultats, il n'y avait pas de différences dans la production quotidienne du lait, mais le régime R a présenté 8% plus de matière organique particulaire organique et produit une récolte de 10% de plus de fourrage. De plus, les pratiques régénératives ont réduit de 10% l'empreinte du carbone. En conclusion, les pratiques régénératives mises en œuvre dans l'étude semblent liées à une augmentation de la production de fourrage et à une réduction de l'empreinte du carbone sans compromettre les paramètres productifs du troupeau.*

Mots-clés. *Gestion du pâturage – Ovins laitiers latxa – Pratiques régénératives – Durabilité.*

I – Introduction

The sustainability of sheep farming systems depends on a diversity of factors related to the technical viability, economic profitability, environmental impact and social acceptance. Land use and grazing management practices, for example, have changed during the past few decades due to the intensification of many flocks. Some of the consequences of these changes are directly related to environmental impacts. Under these circumstances, it is crucial to design grazing management practices suitable to cope with the existing challenges (Ruiz *et al*., 2009).

Despite permanent pastures have a huge capacity for soil regeneration and carbon fixation (Teague *et al*., 2011), little attention has been devoted to grazing practices, and the beneficial impact on soil has been disregarded. In this line, soil carbon plays a vital role to provide essential ecosystem services, such as soil fertility, climate change regulation, water supplies, biodiversity, etc. Therefore, many farmers require knowledge transfer and advisory to improve the utilisation of grasslands and forage resources, when improving the fertility of soils.

Dairy sheep production from pasture in the Basque Country has been traditionally based on the Latxa breed. LIFE REGEN FARMING (*www.regenfarming.com*) tries to innovate grazing management practices to enhance the potential of grasslands to fix carbon and improve pastures' fertility, productivity and, finally, livestock sustainability. The assessment of the effect of these management practices is critical to improve the efficiency of these land-based systems.

The main objective of the current paper was to determine the effect of two different grazing management regimes on pasture and on dairy sheep production variables during the spring lactation period. Soil, pasture, livestock parameters and carbon footprint were monitored in order to determine the effectiveness and the sustainability of these management practices.

II – Material and methods

Two assays (one per year) were conducted with the experimental flock of NEIKER-Tecnalia during spring lactation period (early April – late June) of 2014 and 2015 to assess the effect of the grazing regime on soil, pasture, livestock parameters and carbon footprint. Sheep were blocked into two homogeneous groups of 60-65 ewes, and randomly assigned to two different grazing regimes: free grazing (FG) or regenerative grazing (RG), under the same annual stocking rate (11 ewes/ha). During the assays the size of the paddocks was 7500 m^2 for FG and the same size divided in 8 plots for RG. Each group accessed for 4-9 hours, April-June respectively, to a similar and botanically seminatural pasture after morning milking. Ewes' diet was complemented indoor with a concentrate and fescue hay.

Grazing data were collected daily on grazing-cards to describe the number of sheep per paddock, time spent at the pasture and the grazing management regime. As a summary of the assays, the RG group of ewes grazed 3 times per each plot during 1-3 days/plot each time depending on pasture offer, milk production and climate. As consequence, each plot had a 24±2 days resting time between grazing periods. The FG group of ewes grazed 4 times each plot during 6-10 days/plot each time with a resting period of 15±3 days between grazing periods.

Data and sample collection started after 2 weeks of treatment adaptation. Referring to soil/pasture, the following measurements were made fortnightly:

– Soil samples (n=9) (10 cm depth) were collected in spring 2014-2015 and were submitted to the laboratory to determine some chemical parameters and particulate organic matter (POM) was estimated in 2015. This latter comprises all soil organic matter particles between 0.053-2mm size (Cambardella and Elliot, 1992), is very unstable and easily decomposable.

– “Grazing herbage mass” (GHM): was estimated by cutting herbage to ground level with scissors in a 0.5 x 0.5 m quadrat per paddock and fortnightly during spring 2014-2015. Herbage samples were dried (60ºC / 48h) and weighed. Biomass data were extrapolated to kg DM/ha/year.
– Grass nutritive composition: GHM dried samples were submitted to the laboratory to determine crude protein (CP), acid-detergent fibre (ADF) and neutral-detergent fibre (NDF) contents.
– “Harvested herbage mass” (HHM, kg DM/ha): the surplus of grass was harvested once during the study period (May 2014-2015) due to the excess of pasture production and HHM was estimated by weighting the bales of hay obtained in each grazing regime paddocks.

Referring to livestock, the following measurements were made:

– Daily milk yield (DMY) per ewe was measured during 3 consecutive days, fortnightly. Daily milk yield was corrected to standard DMY as described by Bocquier and Caja (1993).
– Milk composition: individual milk samples were taken at the same days for analyses of crude fat (CF) and crude protein (CP) content.
– Individual live weight (LW) and body condition score (BCS) as described by Wright and Russel (1984) was determined fortnightly.

Finally, carbon footprint was estimated with the methodology described by Batalla et al. (2015), considering the Intergovernmental Panel on Climate Change (IPCC, 2006) and Carbon Calculator (Bochu *et al*., 2013) tool. Regenerative practices applied during the study period were: an increase of 7% in grazing time, removal of the use of chemical fertilizations, and a reduction of 4% of concentrates for feeding.

Pasture and livestock data were analysed by a generalised linear model (SAS, 2010) considering the following fixed effects: grazing management regime (FG and RG), month (April-June) and their interaction.

III – Results and discussion

The average POM values were 28.0±5.30 and 25.7±1.75 for RG and FG, respectively (Table 1). There was higher POM value in the RG regime, which could be due to the higher resting time of this grazing management which allows soil time to recover and fix carbon as POM. Statistic was not applied due to the low number of samples.

Referring to pasture parameters, there were no significant differences on the average GHM ($P>0.05$) and its nutritive value ($P>0.05$) due to the grazing regime (Table 1). Instead, there were significant differences on GHM due to the week of monitoring, with higher values in April and lower in June ($P=0.01$). The nutritive quality of pasture had the same tendency, with no significant differences ($P>0.05$) on CP and fibres due to the grazing management (see Table 1), and with significant differences due to the week of monitoring. The CP also had higher values ($P<0.01$) during April and mid-May, compared to June, whereas fibres had significantly lower values ($P<0.01$ for ADF, and $P<0.001$ for NDF) at the beginning of the spring compared to the end of the spring.

Referring to HHM, average (2014 and 2015) harvested biomasses were 4890±252.4 kg DM/ha and 4387±460.3 kg DM/ha for RG and FG regimes, respectively. Statistic was not applied due to the low number of samples, but results showed higher HHM for the RG (Table 1). The increase in grass surplus in the RG regime could be due to the higher resting time of the paddocks. This harvested grass could save or reduce the purchase of conserved forage under this grazing regime, and improve the feeding autonomy of farms.

In relation to animal parameters, daily milk yield, standardized daily milk yield and milk fat and protein content were similar (P>0.05) for FG and RG groups (Table 1). Finally, ewes of both groups had similar (P>0.05) LW and BCS. There was a significant reduction in DMY and DMYs, and a significant increase in milk CF content between April and June.

Finally, carbon footprint of latxa dairy sheep production ranged between 2.91 and 3.23±0.419 kg CO_2eq/ kg milk (standardized by CF and CP contents). Moreover, comparing the carbon footprint before (2013) and after the regenerative practices were implemented (2014-2015), these practices reduced by 10% the carbon footprint of milk production activity.

Table 1. Effect of the treatment "grazing regime" (free-FG and regenerative-RG) on pasture and livestock parameters: CP-crude protein of grass, ADF-acid detergent fibre, NDF - neutro detergent fibre, DMY - daily milk yield, DMYs-standarized daily milk yield, CF - crude fat of milk, CP* - crude protein of milk, LW - liveweight, BCS - body condition score

	Variables/ treatment	RG	FG	P value
Soil parameter	POM	28.0 ± 5.30	25.7 ± 1.75	–
Pasture parameters	GHM, kg DM ha^{-1}	1590 ± 234	1591 ± 207	0.99
	CP, g kg DM^{-1}	160 ± 36	161 ± 25	0.26
	ADF, g kg DM^{-1}	250 ± 30	251 ± 30	0.73
	NDF, g kg DM^{-1}	500 ± 90	486 ± 60	0.85
	HHM	4890 ± 252.4	4387 ± 460.3	–
Animal parameters	DMY (mL d^{-1})	1510 ± 420	1533 ± 453	0.99
	DMYs (mL d^{-1})	1320 ± 351	1357 ± 382	0.39
	CF (%)	6.63 ± 0.9	6.50 ± 1.0	0.12
	CP* (%)	4.91 ± 0.7	5.04 ± 0.7	0.39
	LW (kg)	60.0 ± 7.6	59.5 ± 8.8	0.19
	BCS	2.50 ± 0.08	2.37 ± 0.08	0.24
Full system	Carbon footprint (kg CO_2eq/ kg milk)	3.23	2.91	–

IV – Conclusions

In conclusion, the regenerative practices implemented in the study seemed to be linked with an increase in surplus herbage for conservation, and with a reduction of carbon footprint, without compromising livestock productive parameters. These results show that there are opportunities for the sheep farming systems to face the existing challenges and to improve the sustainability of the sector through the introduction of regenerative practices in the management of grazing resources.

Acknowledgments

Authors want to acknowledge the financial support provided by the Basque Government and the EU (LIFE REGEN FARMING-LIFE12 ENV/ES/00232).

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Adaptation of goats feeding systems to the adverse economic conditions by changing the grazing management practices

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Abstract. The economic sustainability of the intensive sheep and goats systems in the Mediterranean region has been compromised by the current economic crisis, which has worsened the impacts of the high costs of purchased feeds and the high dependency on capital. An alternative option to overcome these issues is the extensification of farming systems which provides livestock farmers with the necessary flexibility to adjust their livelihoods according to the external circumstances. Thus, they can modify the grazing system, the daily grazing duration and the supplementation management according to the availability of necessary resources in order to achieve an acceptable level of flock productivity. The purpose of the present study was to investigate the shepherds grazing management practices and the characteristics of the flock's movement in a communal rangeland. For this purpose, the case of a herded goat farm was investigated for three seasons (spring, summer and autumn) throughout two consecutive years during the economic crisis when the cost of feedstuffs increased and the selling price of milk decreased. Collars with GPS devices were placed on adult female goats' neck for four consecutive days during each test period. The GPS data were analysed using GIS tools. According to the results grazing spatial patterns per season were differentiated as the shepherd took into account the cost of supplementation, the forage availability per season and criteria to prevent overgrazing.

Keywords. Extensive systems – Shepherd – Rangeland – Supplementation – GPS tracking.

Adaptation du système d' alimentation des chèvres aux conditions de crise économique en modifiant la gestion du pâturage

Résumé. *La durabilité économique des systèmes intensifs de moutons et de chèvres dans la région méditerranéenne a été compromise par la crise économique actuelle, qui a empiré les impacts des coûts élevés des aliments achetés et de la forte dépendance du capital. Une autre option pour remédier ces problèmes c'est l'extensification des systèmes agricoles qui offre aux éleveurs la flexibilité nécessaire pour ajuster leurs moyens de subsistance selon les circonstances extérieures. Ainsi, ils peuvent modifier le système de pâturage, la durée quotidienne du pâturage et la gestion des suppléments selon la disponibilité des ressources nécessaires afin d'atteindre un niveau acceptable de productivité du troupeau. Le but de la présente étude était d'étudier les pratiques de gestion du pâturage des bergers et les caractéristiques du mouvement du troupeau dans un parcours communal. À cette fin, le cas d'une ferme de chèvres chevronnée a été étudié pendant trois saisons (printemps, été et automne) pendant deux années consécutives de la crise économique lorsque le coût des aliments a augmenté et le prix de vente du lait a diminué. Des colliers avec des dispositifs GPS ont été placés sur le coude des chèvres adultes pendant quatre jours consécutifs au cours de chaque période d'essai. Les données GPS ont été analysées à l'aide d'outils GIS. Selon les résultats, les modèles spatiaux de pâturage par saison ont été différenciés car le berger a pris en compte le coût de la supplémentation, la disponibilité fourragère par saison et les critères pour prévenir le surpâturage.*

Mots-clés. *Système extensif – Berger – Parcours – Supplémentation – GPS.*

I – Introduction

The sustainability of intensive sheep and goats systems in the Mediterranean region is threatened by the current economic crisis, due to their high dependency on capital and the increasing prices of purchased feeds (Ragkos *et al*., 2016). These limitations are less strong in extensive production systems, as in these systems an essential part of feeding requirements are covered by grazing, which reduces feeding costs. Indeed, grazing in extensive pastoral systems provides farmers with the necessary flexibility to adjust their livelihoods according to the external circumstances (Baker and Hoffman, 2006). Shepherds can modify the grazing system, the daily grazing duration and the supplementation management according to the availability of necessary resources in order to achieve an acceptable level of flock productivity (Bonanno *et al*., 2008).

The purpose of the present study was to investigate the shepherds grazing management practices and the characteristics of the flock's movement in a communal rangeland in response to different economic constraints.

II – Materials and methods

The study was conducted in Evros region, Northeastern Greece, during three seasons (spring, summer and autumn) for two consecutive years (2010 and 2011). A flock of 650 Greek local breed goats, which grazed in communal rangeland close to the small village of "Megalo Derio" (41º14´N; 26º01´E, 380 m a.s.l.) was investigated. The production system was the traditional sedentary extensive in which the flock, after the daily grazing, returned to the barn to be housed during the night. Goats were hand-milked twice per day (early morning and late afternoon) during the lactation stage that lasted from early March to late August.

The shepherd led the flock to the rangeland during the grazing period and made decisions about the direction of flock's routes taking into account the forage availability. He also managed the duration of the daily grazing time considering the productive stage of goats as well as the supplementary feeding he wanted to provide. During the study period, the shepherd significantly modified the amounts of supplementary feeds. This decision was based on their price as well as the selling price of the milk. Particularly, the goats received 400g corn grains and 400 g wheat grains per head during the spring and summer of 2010. During the spring of 2011, in addition to the same amounts of corn and wheat grains, the farmer supplied to the goats also 400 g alfalfa hay per head in order to increase their productivity, since milk price was high, but he totally discontinued supplementary feeding during the summer of 2011, because prices of supplementary feeds increased markedly. No additional supplementary feeding was provided to the flock during the autumn (both 2010 and 2011) as the lactation stage had been completed.

In order to study the animals' movement, GPS data loggers were placed on their neck (ten during 2010 and twenty during 2011) during four consecutive days per test period. The devises were set to record the geographical position every 5 sec. The processing of GPS data was performed using Quantum GIS 2.16 software (www.qgis.org). The GPS locations for each animal were converted into trajectories, i.e. the sequence of location points and segments connecting them (Calenge *et al*., 2009).The analysis was performed using only complete individual daily trajectories (n=74 in 2010; n=211 in 2011).The "duration" (h/d) was calculated as the time elapsed between the first and the last position recorded that indicates the total time the collared goats spent daily in the rangeland. The "distance" travelled daily (km/d) was calculated by summing each segment length corrected for the altitudinal gradient between the initial and final position.

The metrics of goats' trajectories (duration and distance) were sorted according to the three seasons of grazing (spring, summer and autumn) of the two years under investigation (2010 and 2011).

The analysis of the effect of the season on the above measurements within each trial year was carried out using one-way ANOVA. Tukey–Kramer HSD test was used to perform the multiple comparisons for all pairs of means. The significance level was set to P< 0.05. The statistical analysis was performed using version 8.0 of the JMP software (SAS Institute Inc, Cary, North Carolina).

III – Results and discussion

The metrics of the goats' trajectories are given in Table 1, and movement paths shown in Fig. 1. During 2010, the duration and the distance of goats' trajectories (2.4 h/d and 3.2 km/d, respectively) were significantly shorter in summer compared to the other seasons. During this period, the goats were in late lactation and their nutritional needs were lower than in spring. The shepherd continued to supply supplementary feds and reduced the time the flock spent in the rangeland. On the contrary, in 2011 the duration and the distance of goats' trajectories were longest in summer of 2011 and shortest in spring (Table 1).

To meet the requirements of the goats in early lactation during spring 2011, the shepherd increased supplementary feeding as respect to spring 2010, keeping the flock in the fenced area 1 (FA1) and providing extra alfalfa hay, which allowed him to reduce the grazing duration. During summer 2011, despite the fact that the goats were still in late lactation, the shepherd stopped providing any supplementary feed. He modified the feeding and the grazing system in order to face the increased prices of the purchased feedstuffs (cereal grains and alfalfa hay) and the sharp decrease of the selling price of milk. He decided to increase the grazing time of the goats in order to meet their nutritional needs by increasing the forage intake, as the forage is the cheapest source for the ruminants' feeding (Molle *et al*., 2004).

Table 1. Metrics describing goats' trajectories in 2010 and 2011. Data show mean ± standard deviation

Year	2010				2011			
Season	**Spring**	**Summer**	**Autumn**	**P-value**	**Spring**	**Summer**	**Autumn**	**P-value**
Tracks (n)	19	24	31		70	74	67	
Duration (h/d)	8.4 ± 0.9^{A}	2.4 ± 0.4^{B}	8.0 ± 0.8^{A}	***	3.3 ± 0.2^{C}	9.8 ± 0.8^{A}	7.9 ± 0.4^{B}	***
Distance (km/d)	10.0 ± 2.7^{B}	3.2 ± 0.5^{C}	13.9 ± 2.2^{A}	***	5.0 ± 0.9^{C}	11.4 ± 1.5^{A}	9.4 ± 1.4^{B}	***

Means in the same row followed by the same letter are not significantly different (P≤ 0.05).***P< 0.001.

In autumn, goats were in the dry period, they did not receive supplementary feeds and their nutritional needs were covered exclusively by grazing. For this reason, the shepherd led the flock to the fenced areas (FA2 in 2010 and FA1 in 2011) far away from the barn (Fig. 1) close to less-grazed areas in order to gain access to better forage resources.

Therefore, the shepherd was able to strongly modify, the movement paths of the flock and their spatial distribution, also by shifting the position of shelters (Jouven *et al*., 2010). In doing so, he took into account not only his experience regarding the seasonal differences in forage availability and quality, but also criteria to prevent overgrazing, as the area was grazed by other flocks (mainly of goats and less of sheep). Similar variations in the characteristics of goats' itineraries and management practices have been reported (Feldt and Schlecht, 2016). Indeed, the balance among the grazing time, the animal need, the type and the amount of the supplementary feeds according to their cost, is common pursuit in the extensive farming systems (De Rancourt *et al*., 2006).

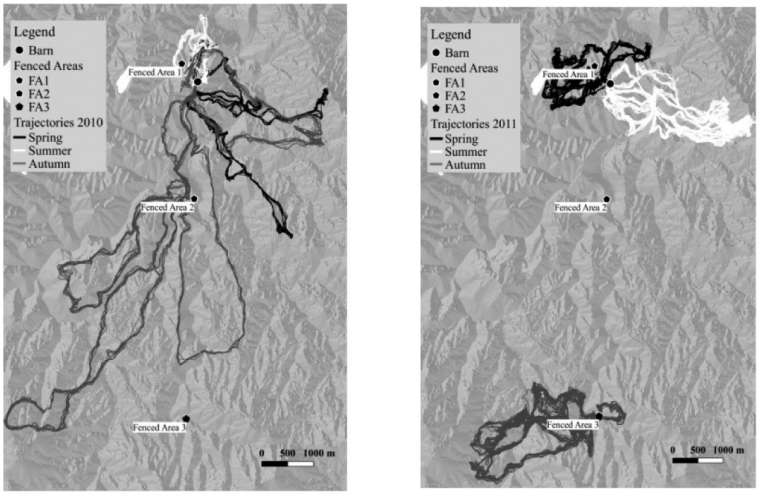

Fig. 1. Goats' trajectories and movement patterns in the study area during 2010 and 2011.

IV – Conclusions

This case study demonstrates that the shepherd and his grazing management practices profoundly affected the characteristics of the goats' itineraries during grazing to respond to the economic constraints dictated by the trade-off between the milk price and the cost of supplementary feeding. When feed costs were high and the milk price low, the shepherd decided to replace supplementary feeds with pasture, by increasing duration and distances of daily grazing, and increasing his working time. The grazing patterns were different in each year and season, reflecting how the shepherd used his experience about forage availability and quality according to the variability of seasonal conditions in order to lead the flock in better feeding resources. This allowed flexibility to adapt feeding and grazing management practices in accordance with adverse economic conditions.

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Sheep dairy and meat products: from urban consumers' perspective to industry innovations

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Abstract. Sheep and goat production in Spain represents 8% of the final livestock production and it holds the second largest sheep population of EU-28. However, it has suffered 15 years of negative evolution of sheep numbers and sheep meat consumption. Conversely, cheese production has increased slowly but steadily during the last decade, with a sharper increase since 2012. These trends respond mainly to changes in consumption habits and consumers preferences which are highly influenced by urban way of life. In this context, four consumers' focus groups were conducted in Madrid aiming to explore urban consumers' awareness, attitudes and preferences towards meat and dairy sheep and goat products. Focus groups session showed that despite their high consumption of cheese, participants had an important lack of knowledge on cheese products. Participants also gave increasing importance to environmental, and animal welfare issues; however, it was globally acknowledged that price continues to be the main driver of sheep products consumption. These and other aspects are discussed in term of its implications for the design of sheep products marketing campaigns and inclusion of new goals in breeding programmes.

Keywords. Sheep products – Urban consumers – Focus groups – Awareness – Cheese.

I – Introduction

Sheep production has a long history in Spain that is reflected in a large variety of native breeds, production systems and products. Nowadays, sheep and goat represents 8% of the final livestock production and it holds the second largest sheep population of EU-28 (2015). However, it has suffered 15 years of negative evolution of sheep numbers and sheep meat consumption, which has dropped from 2.7kg per capita (2006) to 1.7kg (in 2014). Conversely, cheese production has increased slowly but steadily during the last decade, with a sharper increase since 2012. These trends respond mainly to changes in consumer habits and preferences which are highly influenced by urban way of life, food scandals, and the Media. In this context, four consumers' focus groups were conducted in Madrid aiming to explore urban consumers' awareness, attitudes and preferences towards meat and dairy sheep products.

II – Material and methods

Four consumers focus group (FG) sessions were carried out in Madrid in November 2016; two focusing on sheep and goat dairy products and another two on sheep and goat meat products. Focus groups consisted of 8 to 12 participants, who were recruited attending to the following quotas: born between 1951 and 1991, a minimum of 2 participants of the least represented gender, at least 4 and at most 8 full-time or part-time workers, unemployed/students/ housewives/retired, occasional consumers, and regular consumers. For dairy products "regular" consumers were those eating prod-

ucts at least once per week, and "occasional" consumers, several times per year. For sheep/goat meat products "regular" consumers had to eat meat at least once per month, and "occasional" consumers several times per year.

The FG sessions followed a guide of discussion used in several other FGs held in other countries participating in the iSAGE EU project. After a brief introduction about the aim of the FG, participants were asked to choose their three most preferred sheep/goat dairy product, and to list positive characteristics of the chosen product. Then, to guide discussion and foster participation, FG facilitator raised one by one the following questions: i) What kind of sheep/goat dairy/meat products do you purchase or happened to purchase in the past?, ii) If you have a choice of several other types of dairy/meat products (from other types of milk/meat) to choose from, what makes you buy those made from sheep/goat?, iii) What do you like/dislike the most in sheep/goat dairy/meat products?, iv) What would make you increase the share of sheep/goat dairy/meat products that you purchase relative to other dairy/meat products?, and v) If you were developing innovations in sheep/goat dairy/meat production/processing, which would they be? Finally, participants were provided a list of innovations in sheep dairy/meat production/ processing, and were asked to choose the three most and least preferred ones. After completing the task, the results were discussed for participants to explain their choices.

III – Results

1. Dairy products focus groups

Cheese was the most preferred sheep/goat product for two thirds of the participants (Table 1). Their main reason, by far, to consume sheep/goat dairy products is its taste, followed by its preparation features (easiness and versatility). Other less important reasons are related to health and digestion or environmental/natural/biological characteristics.

Table 1. Most preferred sheep/goat dairy product and their main positive characteristics

		Main desirable/positive characteristics						
Most preferred product	**N**	**Organoleptic properties**	**Preparation /cooking features**	**Health (calories)**	**Facilitate digestion**	**Environmental/ natural/ biological**	**Price**	**Others**
Cheese	7	*3.4	1.9	0.3	0.1	0.1	–	0.1.
Goat cheese	6	3.3	1.3	0.5	–	0.2	0.5	0.2
Goat yoghurt	3	3.7	–	1.3	1.0	–	–	–
Goat kefir	1	3.0	–	–	0.0	1.0	–	2.0
Total	17	3.4	1.2	0.5	0.2	0.2	0.2	0.2

* Importance Weight = (3 x number of times the characteristic is ranked 1st + 2 x number of times the characteristic is ranked 2nd + number of times the characteristic is ranked 3rd) / number of participants.

The main issues regarding urban consumers' awareness, attitudes and preferences towards dairy sheep/goat products coming from the FG can be summarized in the following points:

– Cheese is highly consumed and is appreciated due to its versatility and easiness to prepare. However, participants showed a wide lack of knowledge about cheese products, i.e. they could not discriminate between cow, sheep, goat or mix-milk cheeses, and between marketing brands, cheese types, PDO and PGI. Cheese taste is both the main positive and the main negative characteristic of sheep/goat dairy products.

– Price was pointed out as the main driver of cheese purchase. Most of the participants usually buy "mainstream" cheese in the supermarket, based on price and personal preferences. Some participants stated to be more selective when buying high quality cheese. Participants

felt that sheep/goat dairy products are more natural than cow dairy products. Changes in buying habits usually follow marketing campaigns and/or supermarkets marketing strategies. Globally, it is believed that standard dairy cow products are of lower quality but since price is also lower it continues to represent the bulk of the daily basket.

– There is another consumer type (25% of participants) who tries not to buy fresh products in supermarkets. They are worried about environmental, and health properties of products and animal welfare (as most of the participants state to be) and do not mind to pay higher prices for "better" products. They do not like what they call "industrial" products and do not trust supermarkets, however, many of them trust blindly the stores where they usually buy in.
– Globally, all innovations that sound to technology, genetics, any sort of modification of traditional livestock systems or dairy products making processes were rejected. Conversely, all innovations that sound to improve feeding and animal welfare, and reduce the use of antibiotics, were seen positively. It was clearly seen during the discussion that participants´ views about innovations were more based on gut feeling and ethical issues than on informed opinions. Most participants showed a profound ignorance on current livestock production systems. There were some references to food scandals and fake marketing strategies as the cause reason of the lack of trust on livestock production industry.

2. Meat products focus groups

Most meat FG participants choose either chops or legs as their most preferred cut (Table 2). Organoleptic properties were by far the main desirable characteristic. Afterwards, participants chose cooking features and health issues related to having less fat that other cuts, as well as product freshness. Most participants stated that rarely consume kid meat, thus issues raised in the discussion were related to lamb meat.

Table 2. Most preferred sheep/goat meat cuts and their main positive characteristics

		Main desirable/positive characteristics							
Most preferred product	**N**	**Organoleptic properties**	**Preparation /cooking features**	**Health (fat)**	**Freshness**	**Environmental/ natural/ biological**	**Geographic origin**	**Origin (type of store)**	**Other**
Lamb/kid chops	10	*3.9	0.6	0.2	0.3	0.5	–	–	0.4
Leg of lamb/kid	7	2.3	0.9	1.1	0.7	–	0.4	0.6	–
Shoulder of lamb	1	4.0	–	–	–	–	2.0	–	–
Total	18	3.3	0.7	0.6	0.4	0.3	0.3	0.2	0.2

*Importance Weight = (3 x number of times the characteristic is ranked 1st + 2 x number of times the characteristic is 2nd + number of times the characteristic is 3rd)/number of participants.

The main issues raised in dairy FG were also relevant for meat. Specific issues regarding sheep meat were:

– Main stated reason to buy chops was that it is easier to cook than other cuts. There was the general feeling that nowadays people eat a smaller variety of lamb cuts than in the old times. Most participants consume lamb occasionally, usually in restaurants, family gatherings and celebrations. Taste is what participant liked the most of lamb. Conversely, some participants considered that taste of sheep meat was very strong, which lead to not consume it regularly. Smell and fat content were considered the main negative characteristics of lamb meat.
– Participants who moved to Madrid from smallest cities or towns, stated that their buying habits have changed; in Madrid they mostly go to supermarkets due to their lack of time. Many participants prefer to buy lamb at butcher stores and at traditional markets because

they think it is of higher quality and freshness. Whereas some others noted that they buy packaged lamb meat in the supermarket and it is of very good quality.

– Most participants said that they do not care much about meat origin. They believe that farming systems are very similar everywhere and that quality of lamb meat is standard. However, when compared to other livestock species, sheep and goat systems are seen as less industrialized.

IV – Discussion

Focus groups findings are in line with the consumers' habits draw by some wide analysis commissioned by Spanish inter-branch associations (Ikerfel 2013a, 2013b, and 2015). Spain has a strong tradition on cheese production and consumption but a limited cheese culture. Taste is the main criterion for choosing among cheese types. Similarly, the lamb distinctive taste (and fat content) is both its main positive and negative consumption driver. There is a general lack of knowledge on lamb production and cooking recipes. Current urban people cooking habits (fast, easy and healthy) fit with cheese consumption but hamper lamb consumption.

The existing miscommunication between sheep farming sector and urban consumers has to be tackled. Improving consumer knowledge on sheep cheese and lamb production and farming systems is key to transform consumer reluctance to key sector innovations into support. Well-designed TV campaigns are a tool that have proven efficacy in other countries (i.e. Beef+Lamb NZ), but they require large and multi-annual investment programme to realize its potential.

The development of PDO, PGI and ETP labels helped less intensive production systems, traditional systems and local breeds to differentiate their product and fill a market niche. However, our finding showed that many consumers do not really know what those labels mean, and mix them up with commercial brands. Thus, they have become brands and therefore its success might be linked to the capacity of managing it as commercial brands.

Animal welfare, human health and environmental sustainability are concerns for consumers, however price is the main criterion to buy. Similarly, although consumers think that sheep products found in local markets and traditional stores are fresher and most trustable, most of the products are sold in super and hypermarkets, i.e. these large stores had 90% of dairy products market share (Mercasa, 2014). Therefore, although the development and exploration of niche market is of importance, especially for product of outstanding quality, the future of sheep and goat sector will rely on sales on large stores where price is a decisive criterion.

To raise daily consumption, increasing availability at supermarkets and large stores and developing new cuts and product presentation in line with modern urban preferences, is being explored with good results by some Spanish cooperatives (Oviaragón, Pastores) which show a remarkable potential. However, it poses some challenges related to farmers´ organization and industry integration. Again, experiences in this regard of farmer levy organizations in other countries like New Zealand and Australia (i.e. MLA) can be enlightening.

Finally, genetic selection for fat content and fat composition could be also a tool to naturally evolve to a most acceptable product; however, consumers should be taught what genetic selection means and how it could contribute to generate healthier products without any manipulation of the animals' genome.

Acknowledgments

This work was carried out in the framework of the iSAGE project (Innovation for Sustainable Sheep and Goat Production in Europe), funded by the the European Union's Horizon 2020 research and innovation programme under grant agreement No 679302.

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Effect of the presence of neomycin in goat's milk on the making and characteristics of Tronchón cheese

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Abstract. Antibiotic residues in milk and dairy products are a potential problem for public health, and for the dairy industry. This study investigated the effect of the presence of neomycin in goat's milk on the production and characteristics of semi-hard Tronchón cheese. Cheeses were made, in duplicate, from raw goat's milk without antibiotics and with addition of neomycin at the Maximum Residue Limit (1500 μg/kg). Possible changes in the characteristics and the presence of antibiotic residues in the cheeses were evaluated at different time points along ripening (1, 30 and 60 days). Processing time was increased (48 ± 18 min) by the presence of neomycin in milk. Regarding cheeses, lower values of water activity as well as reduced free fatty acids and free amino-acid concentrations were detected in cheeses from milk with the antibiotic, suggesting a minor biochemical activity throughout ripening. Thus, a greater lightness and lower redness value were observed in this type of cheese, also presenting lower springiness. Moreover, high concentrations of neomycin were retained in the cheese and concentrated during ripening, leading to a concentration factor of 4.9, with respect to the initial concentration in the milk, potentially implying a risk to public health.

Keywords. Antibiotic – Neomycin – Goat milk – Cheese.

Effet de la présence de néomycine dans le lait de chèvre sur la fabrication et les caractéristiques du fromage Tronchón

Résumé. *La présence de résidus d'antibiotiques dans les produits laitiers peut constituer un problème pour la santé publique et pour l'industrie laitière. Dans ce travail, nous avons évalué l'effet de la présence de néomycine dans le lait de chèvre sur la fabrication et les caractéristiques du fromage Tronchón. Les fromages ont été fabriqués, en double exemplaire, à partir du lait de chèvre cru sans antibiotiques et avec l'addition de néomycine à la limite maximale de résidu (1500 μg/kg). Nous avons étudié les changements dans les caractéristiques du fromage et la présence de résidus à différentes périodes de maturation (1, 30 et 60 jours). La durée du procédé de fabrication augmentait (48 ± 18 min) sous l'effet de la présence de néomycine dans le lait de chèvre. Concernant les caractéristiques du fromage, nous avons observé une diminution dans les valeurs de l'activité de l'eau ainsi qu'une réduction dans les concentrations d'acides gras libres et d'acides aminés libres dans les fromages avec l'antibiotique, en suggérant une activité biochimique mineure pendant la maturation. Nous avons aussi observé une plus grande légèreté, moins rougeur et une plus faible élasticité dans ce type de fromage. En plus, pendant la maturation, les concentrations de néomycine dans le fromage augmentaient 4,9 fois par rapport à la concentration initiale dans le lait, ce qui pourrait impliquer un risque pour la santé publique.*

Mots-clés. *Antibiotique – Néomycine – Lait de chèvre – Fromage.*

I – Introduction

Goat's milk demand has increased in recent years as it is easier to digest and is an ideal substitute for cow milk in the diet of children, the elderly and people with allergies to cow milk (Haenlein, 2004). Traditionally, goat's milk production was intended for the manufacture of dairy products, especially cheese. In dairy goats, the use of antibiotics to treat mastitis and other animal health con-

ditions is a common practice that might contaminate the milk supply if appropriate measures are not taken. Among antibiotics, the aminoglycosides (gentamicin, neomycin and streptomycin, among others) are usually applied in to treat infectious diseases caused by gram-negative bacteria (Davies and Wright, 1997). The presence of antibiotic residues in milk can affect consumer health, either generating resistance to antibiotics or causing allergies (EFSA, 2016), as well as the production, thus affecting the growth of microorganisms responsible for fermentation or biochemical reactions (Novés *et al.,* 2015). For consumer protection, the European Union (EU Regulation 37/2010), established Maximum Residue Limits (MRLs) in products of animal origin such as milk, but so far, they have not been established for dairy products, such as butter, yogurt or cheese. It has been shown that the presence of antimicrobial residues in milk may result in the retention of varying amounts of these substances in cheese (Adetunji, 2011; Cabizza *et al.,* 2016). Also, the presence of antibiotics might have negative effects on cheese quality parameters. However, related studies are very scarce. Thus, the aim of this study was to analyse the effect of the presence of neomycin, on the production and the characteristics of Tronchón cheeses along ripening.

II – Materials and methods

1. Cheese manufacture

Tronchón cheeses were made at the Universitat Politècnica de València (UPV) pilot plant using raw milk from the experimental flock of Murciano-Granadina goats of UPV. Cheese manufacture was performed in duplicate from goat's milk without antibiotics (control) and with neomycin (N1876, Sigma-Aldrich Química, SA, Madrid, Spain) at an equivalent concentration to the MRL (1,500 µg/kg) in a 50 l vat, following the traditional Tronchón cheese-making procedure. After moulding, the pressed rennet curd was salted and ripened for 60 days.

2. Cheese analysis

The physicochemical, colour and texture properties of the Tronchón cheeses were evaluated at 1, 30 and 60 days of ripening. Cheese composition (moisture, fat, protein and salt content) was determined in duplicate using a FoodScan infrared device (Foss, Foss Iberia, Barcelona). The water activity of samples (aw) was measured in duplicate by using a dew point hygrometer (Decagon Devices Inc., Aqualab 4TE, USA). Regarding pH, a pH-meter with a penetration electrode (Crison Instruments, S.A., Basic 20, Spain) was employed, making 6 measurements per sample. The free amino-acid (FFA) concentration, as indicator of proteolysis in cheeses, was determined by the method reported by Folkertsma and Fox (1992). The free fatty acid (FFA) concentration, as indicator of lipolysis level, was performed following the methodology described by Nuñez *et al.* (1986). The colour of the cheeses was measured using a Minolta spectrocolorimeter, model CM-3600D (Minolta, Japan), considering the coordinates of the CIE colour space L* a* b*, which were obtained by reflectance, with illuminant D65 and the observer 10º. The texture was determined through a texture profile analysis (TPA) using a TA.XT.plus texturometer (Stable Micro Systems, UK). A double compression analysis was performed with a cylindrical probe of 45 mm diameter (P/45), with a deformation percentage of 50% and a holding time of 5 seconds. 9 measurements were made per cheese in cylinders 2 cm in diameter and 1 cm thick. The concentration of residual neomycin in cheeses was analysed in the Laboratory of Public Health of Galicia (Spain), using a High Performance Liquid Chromatography (HPLC-MS-MS) method.

3. Statistical analysis

Data generated by this study were subjected to a two-way analysis of variance (ANOVA), including the effect of antibiotic concentration (0 and 1500 µg/kg) and ripening time (1, 30 and 60 days)

as variation factors. The least significant differences were calculated using the LSD test (least significant difference) and a significance level of α=0.05, using Statgraphics Centurion XVI (version 16.2.04; Statpoint Technologies, Inc. Warrenton, Virginia, VA, USA).

III – Results and discussion

The cheese-making process was moderately affected by the presence of neomycin in goat's milk which inhibit the starter culture activity and increased by 48 ± 18 min the time required to reach the final pH of the cheeses (pH = 5.3) during the pressing stage. Antibiotics affecting kinetic acidification in the manufacture of fermented products have been reported by other authors (Novés *et al.,* 2015; Cabizza *et al.,* 2017). Regarding the characteristics of the cheeses, Table 1 shows the parameters evaluated along with the results of the analysis of variance. As shown in Table 1, a lower water activity ($p<0.001$) as well as shorter concentrations of FFA ($p<0.05$) and FAA ($p<0.01$) were found in the cheeses made from spiked goat's milk, suggesting that the microbial metabolism was also reduced along ripening by the presence of the residual amounts of neomycin in the curd. Thus, the lower degree of biochemical reactions in cheeses with the antibiotic could be related to the higher lightness ($p<0.001$) observed in this type of cheese (Rohm and Jaros, 1997), which also presented a lower redness value ($p<0.05$), especially, in the second month of ripening ($p<0.001$). Regarding texture analysis, the presence of the antibiotic significantly affected the springiness of the cheeses, being lower ($p<0.05$) in cheeses with neomycin. Cohesiveness also declined drastically during the first month of ripening ($p<0.01$) in cheeses made from contaminated milk.

Table 1. Average values of parameters analysed in Tronchón cheese and ANOVA F-ratio for each of the two factors: neomycin concentration (C) and ripening time (T) and their interaction (C*T)

Parameters	Neomycin concentration (µg/kg)			Ripening time (days)				ANOVA F-ratio		
	0	1,500	SE[1]	1	30	60	SE[1]	C	T	C*T
pH	5.29	5.27	0.02	5.36^{b}	5.26^{a}	5.22^{a}	0.02	0.47 ^{ns}	11.02*	3.00 ^{ns}
Moisture (%)	40.27	40.86	0.36	42.81^{c}	40.64^{b}	38.24^{a}	0.44	1.38 ^{ns}	27.29***	0.26 ^{ns}
Fat (%)	32.56	32.11	0.26	31.72^{a}	32.03^{a}	33.25^{b}	0.32	1.47 ^{ns}	6.06 *	0.22 ^{ns}
Protein (%)	22.24	21.79	0.19	20.76^{a}	21.85^{b}	23.45^{c}	0.23	3.02 ^{ns}	37.32***	0.05 ^{ns}
NaCl (%)	1.85	1.87	0.05	1.64^{a}	1.85^{b}	2.09^{c}	0.06	0.07 ^{ns}	11.62***	0.79 ^{ns}
Water activity	0.97^{b}	0.96^{a}	0.00	0.98^{c}	0.97^{b}	0.96^{a}	0.00	26.79***	432.7***	0.39 ^{ns}
FAA[2]	2.76^{b}	2.45^{a}	0.06	0.76^{a}	2.96^{b}	4.09^{c}	0.08	11.84**	426.2***	3.40 ^{ns}
FFA[3]	2.67^{b}	2.34^{a}	0.08	1.64^{a}	2.70^{b}	3.18^{c}	0.10	6.87*	56.28***	3.26 ^{ns}
L*	86.72^{a}	87.66^{b}	0.18	90.69^{c}	86.03^{b}	84.84^{a}	0.22	14.00***	198.9***	0.97 ^{ns}
a*	-1.24^{b}	-1.31^{a}	0.02	-0.32^{c}	-1.57^{b}	-1.93^{a}	0.03	5.19*	962.3***	8.23***
b*	11.83	11.50	0.13	10.74^{a}	12.56^{c}	11.71^{b}	0.16	3.17 ^{ns}	31.57***	1.62 ^{ns}
Hardness (N)	23.36	22.58	0.52	30.28^{b}	19.11^{a}	19.53^{a}	0.63	1.13 ^{ns}	99.5***	0.85 ^{ns}
Adhesiveness (N*s)	-1.01	-1.04	0.03	-0.58^{a}	-1.24^{b}	-1.26^{b}	0.04	0.39 ^{ns}	84.5***	2.16 ^{ns}
Springiness	0.63^{b}	0.60^{a}	0.01	0.82^{c}	0.56^{b}	0.46^{a}	0.01	5.80*	619.1***	2.81 ^{ns}
Cohesiveness	0.43	0.42	0.00	0.68^{c}	0.33^{b}	0.27^{a}	0.00	1.64 ^{ns}	2442***	7.47**
Chewiness (N)	7.92	7.52	0.20	17.00^{c}	3.64^{b}	2.51^{a}	0.25	1.99 ^{ns}	1062***	0.02 ^{ns}

[1] SE: standard error.

[2] FAA: Free amino acids (mg leucine/100 g cheese).

[3] FFA: Free Fatty Acids (meq/100 g milk fat).

a, b, c: Different letters in the same row indicate significant differences ($p< 0.05$); ***$P< 0.001$; **$P< 0.01$; *$P< 0.05$; ns: non-significant.

THPLC analysis indicated a high concentration of neomycin in the cheese at the beginning of maturation which increased along time (day 1: 5,590 ± 14 μg/kg; day 30: 6,420 ± 707 μg/kg; day 60: 7,415 ± 120 μg/kg), due to the loss of moisture occurring during this period (Table 1). Similar amounts of residues were obtained along ripening ($p>0.05$) when antibiotic concentrations are expressed on dry basis. Thus, although neomycin is water soluble (Papich, 2016) results herein indicate that this substance is largely retained in rennet curd and shows high stability under the maturation conditions. In fact, a concentration factor of 4.9 ± 0.1, with respect to the initial concentration of neomicyn in milk, was calculated in Tronchón cheese at the end of ripening. These results agree to those reported by Giraldo *et al.* (2017) when assessing the transfer of antibiotics from goat milk to whey in a laboratory scale study.

IV – Conclusions

The presence of neomycin, at safety level, in goat's milk destined to the manufacture of ripened cheese may affect the development of biochemical processes during maturation leading to organoleptic shortcomings in the final product. Moreover, high concentrations of the antibiotic can be retained in mature cheese, this poses a potential risk for the consumer. It would be convenient to assess the retention mechanisms of this substance and other antibiotics in depth to avoid public health issues.

Acknowledgments

This work is part of the AGL-2013-45147-R funded by the Ministry of Science and Innovation (Madrid. Spain). The authors thank the UPV (Program of Research and Development) for funding the PhD scholarship FPI-2014 attained by P. Quintanilla.

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Chaines de valeur caprines en Algérie
Propositions pour s'adapter aux mutations en vue d'un développement durable

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Résumé. L'élevage caprin en Algérie connaît des mutations profondes ; Il passe progressivement d'un élevage extensif à un élevage orienté au marché afin de s'adapter au nouveau contexte caractérisé par une demande soutenue sur la viande et le lait caprins. Notre étude tente de mettre en évidence la dynamique évolutive des stratégies des acteurs de la filière afin d'identifier les dysfonctionnements et y remédier pour un développement durable. Notre étude montre que l'évolution du contexte socioéconomique du pays (amélioration du pouvoir d'achat, mondialisation des habitudes alimentaires, etc.) a stimulé la demande sur les produits caprins primaires (lait et viande) ou transformés (fromage), pour leur qualité diététique, nutritionnelle et organoleptique. Cette demande est traduite par une augmentation des prix et les acteurs tentent de s'adapter pour saisir cette opportunité. Le système d'élevage se caractérise par le changement de ses pratiques de production, tendant à être plus spécialisé. On assiste également à l'apparition de nouveaux éleveurs laitiers et engraisseurs à la recherche de profit. En parallèle, on note un développement relatif de l'industrie fromagère dans certaines régions. Cependant, malgré ces tentatives, le secteur souffre d'une multitude de contraintes, naturelles, techniques, organisationnelles et économiques affectant un ou plusieurs de ses maillons et acteurs. Notre étude propose des solutions innovantes pour accompagner ces changements; faire appel aux nouvelles approches de l'utilisation des ressources pastorales, produire de nouvelles connaissances sur la génétique de la chèvre locale et la réorganisation du secteur en mettant l'accent sur la cohérence entre acteurs et maillons des filières.

Mots-clés. Chèvre – Algérie – Innovation – Filière.

Goat value chain in Algeria, sustainable development proposals to cope with changes

Abstract. *Goat farming in Algeria is undergoing profound changes; it is gradually shifting from pastoral low input to economic livestock farming in order to adapt to a new context, characterized by a high demand of goat's meat and milk. Our study tries to highlight the evolutionary dynamics of this breeding and the adaptation strategies of the supply chain actors in order to identify dysfunctions and to propose alternatives to ensure sustainable development. Our study shows that the changing socioeconomic context of the country (urbanization, improvement of purchasing power, standardization and emergence of new food habits) has boosted the demand of primary (milk and meat) and processed (cheese) goat products, for their real and supposed dietetic, nutritious and organoleptic qualities. This high demand has led to an increase in products prices, and chain stakeholders try to catch this opportunity. Breeding systems are changing toward a more market oriented system, and new dairy farmers and fatteners are organizing their production systems to own more profit. There is also a starting of a development process of a goat cheese industry in several regions. However, the sector is still suffering from a multitude of natural, technical, organizational and economic constraints affecting one or several stakeholders and chain segments. To accompany these changes, our study propounds innovative solutions: use of new approaches to utilize food resources, produce new knowledge on local goat genetics, and reorganizing the sector, with the emphasis on making more organized and coherent the relationship among the stakeholders and value chain segments.*

Keywords. *Goat - Algeria – Innovation – Chain.*

I – Introduction

Avec un effectif de plus de 5,1 millions de têtes en 2014 (FAO, 2015), l'élevage caprin en Algérie compte parmi les activités agricoles les plus répandues en milieu rural, particulièrement dans les régions marginales. Il permet de valoriser les ressources pastorales, sécuriser le système de production, et compléter les rôles des élevages ovin et bovin (El Aich *et al*., 1995).

Véhiculant l'image de produits sains, la viande et le lait caprins sont de plus en plus recherchés par le consommateur. Ceci s'est répercuté sur les filières caprines qui tentent de répondre à cette demande. Notre étude vise à analyser cette dynamique, en repérer les atouts et les limites et faire des propositions pour en améliorer le fonctionnement dans une optique de durabilité.

II – Les productions caprines entre passé et présent

Outre sa capacité de survie et de production grâce à des ressources pastorales pauvres, et peu ou pas de compléments, le rôle du caprin tient aussi de sa supériorité productive en lait comparativement aux ovins. Il assure souvent la production du lait d'autoconsommation pour les ménages ruraux. Par ailleurs, son infériorité productive en viande peu appréciée jadis, a longtemps plaidé pour un usage orienté à l'autoconsommation ou pour financer les dépenses quotidiennes.

1. Le lait

La production de lait caprin est estimée à plus de 300 000 tonnes soit environ 8% de la production laitière nationale. Elle est assurée en 2014 par plus de 2,7 millions de chèvres (FAO, 2015).

A. Production

Avec une production quotidienne de 1.1 litre, la chèvre locale est considérée comme peu laitière (Mouhous *et al*., 2016), les éleveurs recourent par conséquent aux races européennes, soit pour le croisement (la Saanen et l'Alpine notamment) avec la population locale comme dans la région de Ghardaïa (ITELV, 2003), soit pour l'élevage en race pure comme dans la Kabylie à travers la Sannen notamment, rencontrée dans 77% des élevages (Kadi *et al*., 2013).

La production laitière est généralement pratiquée en système d'élevage extensif mixte lait/viande avec de petits troupeaux de moins de 10 chèvres (Kadi *et al*., 2013 ; Sahraoui *et al*., 2016), généralement associé à un élevage ovin. Cependant, on rencontre en Kabylie des troupeaux importants (> 100 têtes) spécialisées en production laitière (Mouhous *et al*., 2015). Les caprins sont conduits seuls dans ces élevages (ITELV, 2003 ; Mouhous *et al*., 2015).

L'alimentation est exclusivement pastorale dans les élevages extensifs des montagnes de l'Est algérien et de la Kabylie, et la complémentation est exceptionnelle en hiver (;). En revanche dans le système laitier, la complémentation est assurée par des fourrages verts, du concentré ou du foin. Alors qu'en élevage oasien, les animaux s'alimentent essentiellement de paille et de déchets de dattes (ITELV, 2003).

B. Collecte et transformation

Traditionnellement, le lait caprin est autoconsommé ou offert, mais il n'est pas vendu. Il est aussi transformé en fromages (Dj'ben, Bouhazza, Kemmaria…) selon l'environnement naturel et socioculturel et des pratiques locales avec parfois des procédés très particuliers qui peuvent constituer de véritables atouts pour le développement local.

A Ghardaïa, Il existe un circuit de collecte dirigée par un industriel privé. Par ailleurs, dans la région de Tizi-Ouzou, le segment de la collecte est représenté par plusieurs collecteurs qui sont à la base des collecteurs de lait de vache (Mouhous *et al*., 2016). L'absence de collecteurs dans certaines régions oblige les éleveurs à transporter eux-mêmes leurs productions aux unités de transformation ou aux vendeurs de proximité. La collecte est incitée par une subvention de 5 DA* / litre collecté.

C. Commercialisation

Avec un prix de revient de 11 DA (pour les élevages extensifs) (Mouhous *et al*., 2015), le litre de lait est payé 62 DA à l'éleveur, y compris une subvention de 12 DA/litre. En revanche, le lait écoulé dans le marché informel est cédé entre 100 et 200 DA (Mouhous *et al*., 2015 ; Sahraoui *et al*., 2016). Quant au fromage, est vendu dans les centres urbains autour de 1700 DA/kg.

2. La filière viande

La production de viande caprine nationale est estimée par la FAO à plus 19 000 tonnes en 2014 soit environ 4% de la production de viande nationale. Par ailleurs, on assiste depuis 2003 à une augmentation significative estimée à plus 57%, liée à l'augmentation de l'effectif global.

Si la production d'animaux en vue de la production de viande s'effectue durant toute l'année afin d'alimenter la trésorerie quotidienne des ménages, celle-ci se concentre de la fin du printemps à l'automne valorisant ainsi l'offre pastorale en vue de produire une viande plus tendre recherchée par le marché. Par ailleurs, la vente pour la fête religieuse de l'AID EL KEBIR est beaucoup moins importante que celle des ovins (Mouhous *et al*., 2015 ; Sahraoui *et al*., 2016). Les ventes concernent généralement les chevreaux de 6 à 9 mois et les animaux de réforme.

Par le passé, le chevreau était commercialisé dans les marchés proches des lieux de production et destiné aux couches sociales à faible revenu. Les transformations socio-économiques actuelles ont fait qu'il gagne les grands centres urbains et une clientèle plus aisée à la recherche d'une viande plus maigre et 'naturelle' que celle des agneaux, et disposant d'attributs supposés favorables à la santé. Son prix qui ne dépassait pas la moitié de celui de l'agneau il y a moins de 10 ans, a fortement augmenté et le talonne actuellement (1100 vs 1300 DA) (Sahraoui *et al*., 2016).

III – Contraintes éprouvées par les filières caprines locales

Les contraintes auxquelles la filière fait face, résident d'abord dans la lenteur de la réponse des systèmes de production à la demande sur les produits caprins. Les systèmes d'élevage dans leur majorité sont restés extensifs à base de race locale. Les tentatives d'intensification cherchent donc l'intégration des races exotiques. Ceci représente un coût énorme difficilement amortissable pour de petits élevages, pose le problème de leur renouvellement et menace la diversité génétique de la population locale. D'autre part, et avec la prévalence la plus importante parmi toutes les espèces de ruminants, la filière caprine, notamment laitière, fait face au problème de la brucellose.

La faiblesse des maillons de la collecte et de la transformation dans certaines régions constitue un frein à la production et pousse les éleveurs à écouler leur production dans le marché informel, qui se répercute négativement sur la santé du consommateur et l'image des produits caprins à terme.

Quant à la filière viande, elle reste fortement dépendante des fluctuations de l'offre pastorale, interannuelles notamment. Ceci laisse le marché moins pourvu certaines années. Les mauvaises années sont caractérisées par le déstockage des animaux par les producteurs afin de limiter les

* : Dinar Algérien, 1 € = 120 DA.

dépenses liées à l'alimentation à l'auge, ce qui s'accompagne d'une chute des prix. En bonne année au contraire, l'abondance de l'offre pastorale pousse les éleveurs à maintenir leurs animaux afin d'agrandir leurs troupeaux ce qui pousse les prix à la hausse. D'autre part, la forte demande sur la viande caprine a provoqué dans certaines régions l'apparition d'un nouvel acteur dans la filière qui est l'engraisseur. Ces derniers font subir des périodes d'engraissements en stabulation entravée aux animaux en les alimentant aux concentrés composés. Une fois sur le marché, cette viande risque de tromper le consommateur à la recherche de viande « saine » issue des pâturages.

IV – Quelles stratégies pour promouvoir les filières caprines en Algérie?

Pour définir les stratégies, il faut s'interroger sur les moteurs des dynamiques actuelles des filières caprines et sur les possibilités d'intégration des innovations. L'enjeu principal réside dans le développement d'un système d'élevage valorisant les ressources locales et utilisant peu d'intrants pour maintenir son atout principal qui est à la base de l'augmentation de la demande.

La disponibilité des ressources alimentaires locales est de ce fait le principal objet du développement des filières caprines. Plusieurs avis s'accordent que ce n'est pas la chèvre qui est responsable de la dégradation des espaces naturels, mais sa mauvaise utilisation. Une stratégie judicieuse devrait donc l'intégrer dans la gestion de ces espaces. En parallèle, l'initiation d'un programme d'amélioration génétique est primordial pour fournir les élevages en animaux performants. Outre la quantité et la qualité des produits, l'efficience des animaux et leur résistance aux maladies sont à prendre en compte dans un tel programme.

Pour mieux orienter l'utilisation de la subvention de l'état, il faudrait repenser le modèle du soutien à la filière caractérisée par des élevages de taille réduite et situés en régions marginales dans un contexte ou la production et la consommation vont augmenter, par une aide à la maitrise des maladies, l'amélioration du matériel animal et la gestion durable des ressources pastorales. La mise en évidence de la typicité des produits locaux et leur labellisation est une solution judicieuse pour promouvoir leur production et augmenter l'intégration des maillons de la filière et la part de la valeur ajoutée captée par les différents maillons de la filière. Ceci leur permettra éventuellement aussi de conquérir des marchés nouveaux dans les milieux urbains. Les moteurs des dynamiques des filières caprines varient d'une région à une autre ce qui suppose la conception de plusieurs modèles de filière qui aillent de pair avec les potentialités locales.

V – Conclusion

Les mutations subies par les filières caprines sont essentiellement motivées par deux forces : (i) la demande du marché sur les produits caprins pour leur qualité diététique et la mondialisation des habitudes alimentaires (ii) et d'un autre côté, le changement du paradigme des productions agricoles d'une façon générale qui sont de plus en plus tournées vers le productivisme et le profit.

Les trajectoires d'évolution actuelles des filières caprines sont parsemées de plusieurs contraintes dont la "remédiation" passe systématiquement par l'implication de toutes les parties prenantes (État, institutions agricoles, association des éleveurs) à travers la mise en place d'une stratégie cohérente et d'un plan d'action à l'échelle des terroirs.

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Innovation in small ruminants' dairy products in Lebanon: an alternative drying technique for kishk, a traditional fermented milk

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Abstract. The Lebanese dairy sector is a viable and competitive sector. However, local dietary habits and consumer expectations of dairy products are changing, with a strong demand for innovative products with better hygienic and nutritional qualities. Consequently, it is essential to valorize traditional dairy products and improve their hygienic and nutritional quality, in order to increase their competitiveness in the Lebanese market and preserve this culinary heritage. Kishk is a traditional Lebanese fermented product, prepared from yogurt and bulgur allowed to ferment together, shaped into balls and sun-dried. However, the sun drying of kishk requires a large amount of manual labor for homogenous drying, and includes a high risk of microbial and physical contamination exists.Therefore, our study proposes an innovative drying technique (hot air drying at 50 °C for 8 h), and evaluates its effects on the nutritional, physicochemical and sensory properties of Lebanese kishk. Results showed that the structure and rheological behavior of kishk powder were not altered,despite slight differences in chemical composition and particle size. Furthermore, kishk soup resulting from the optimized production seems thicker and consistent than traditional soup, without significant loss of the organoleptic properties of kishk.Our results are promising and show that hot air drying technique can be a great alternative to improve the safety of kishk powder while preserving its nutritional and sensory quality.

Keywords. Kishk – Lebanese – Traditional – Sun drying – Innovative – Hot air drying.

L'innovation dans la filière laitière des petits ruminants au Liban: une technique alternative de séchage du kishk, un lait fermenté traditionnel

Résumé. *La filière laitièreau Liban est un secteur viable et compétitif. Cependant, les habitudes alimentaires locales et les attentes de base des consommateurs vis-à-vis des produits laitiers évoluent, avec une forte demande pour des produits innovants de meilleures qualités hygiéniques et nutritionnelles. A cet effet, il est essentiel de valoriser les produits laitiers traditionnels et d'améliorer leur qualité hygiénique et nutritionnelle, afin d'accroître leur compétitivité sur le marché libanais et de préserver ce patrimoine culinaire. Le kishk est un lait fermenté traditionnel, à base de yaourt et de boulgour laissés fermenter ensemble, avant d'être façonné en boules et séché au soleil.Le kishk est généralement consommé sous forme de soupe après reconstitution de la poudre avec de l'eau bouillante. Cependant, le séchage du kishk au soleil est très laborieux, et induit un risque élevé de contamination microbienne et physique Par conséquent, notre étude propose une technique innovante de séchage (séchage convectif par air chaud à 50°C pendant 8 h) et évalue ses effets sur les propriétés nutritionnelles, physico-chimiques et sensorielles du kishk libanais. Les résultats ont montré que la structure et le comportement rhéologique de la poudre de kishk n'ont pas été altérés, malgré de légères différences au niveau de la composition chimique et la taille des particules. Au niveau rhéologique et sensoriel, la soupe de kishk issue de la production optimisée semble plus épaisse et consistante que la soupe traditionnelle, sans dépréciation notable des qualités organoleptiques du kishk. Nos résultats sont prometteurs et montrent que la technique de séchage à l'air chaud peut être une excellente alternative pour améliorer la sécurité sanitaire de la poudre de kishk tout en préservant sa qualité nutritionnelle et sensorielle*

Mots-clés. *Kishk – Libanais – Traditionnel – Séchage au soleil-innovant – Séchage par air chaud.*

I – Introduction

Kishk powder is a dried fermented milk-cereal mixture, widely consumed in Lebanon. It is traditionally manufactured by mixing yogurt, bulgur and salt. The obtained dough undergoes a fermentation stage lasting up to 6 days and the mixture is kneaded daily. Then, kishk dough is shaped into small balls and sun-dried. Dried kishk is finally milled into a powder and stored (Tamime *et al*., 2000; Tamime and O'Connor, 1995). It is usually consumed in the form of a thick soup after reconstitution with boiling water.However, one of the crucial steps in the traditional production of kishk is sun drying, which requires a large amount of manual labor for homogenous drying. It also includes a high risk of microbial and physical contamination, and affects the final quality of kishk powder (Salameh and Hosri, 2016). Recent studies (Salameh *et al*., 2016; Salameh and Hosri, 2016) characterized this traditional Lebanese fermented product, by determining its chemical compositionand evaluating its hygienic quality. An unacceptable amount of contaminants was reported, which can pose a potential hazard to consumers. Consequently, it is necessary to optimize kishk's manufacturing method, and produce it at industrial scale using modern drying techniques, in order to guarantee a healthy and stable product and to improve its competitiveness in the Lebanese market.Therefore, the objective of this study was to evaluate the effect of hot air drying on the nutritional, physicochemical and sensory properties of Lebanese kishk.

II – Material and methods

1. Kishk production

The ingredients used in kishk preparation (white coarse bulgur, full fat yogurt, strained yogurt and salt), and twenty traditional kishk samples were purchased from local markets in Keserwan, Lebanon. The production method of kishk in laboratory conditions using hot air drying was based on a previous study (Salameh, 2012) . White coarse bulgur (100 g) was mixed with yogurt (300 g) and the resulting mixture was left to ferment in an incubator at 20 - 25 °C for 36 h. Salt was added to the yogurt/bulgur mixture (2 g salt for 100 g bulgur). Strained yogurt (150 g total) was also added in small amounts during 4 days and the mixture was kneaded daily to encourage fermentation. At the end of the fermentation, kishk dough was cut into small balls of 3 - 5 cm diameter, placed into stainless steel trays, and dried in a convection oven at 50 °C for 8 h. The resulting dry product was ground in a mill and sieved through a 1-mm screen. Kishk powder was stored in glass jars at 4 °C until analysis.

2. Chemical analysis

Kishk's composition was determined according to AOAC standard methods (AOAC, 1995). Moisture content was calculated by heating 3 g of each sample to a constant weight in an oven maintained at 105°C. For determination of ash, 3 g of each sample were ashed at 550°C in a furnace until constant weight. Protein was determined by the Kjeldahl method with a conversion factor of 6.25. Fat was obtained by extracting 5 g of each sample in a Soxhlet apparatus using petroleum ether as the extractant.

3. Powder flow properties

The powders flow properties were characterized using the FT4 powder rheometer (Freeman Technology, Worcestershire, UK), through compressibility, permeability, aeration, and shear tests, with the 50 mm geometry. Detailed descriptions of this equipment and its use in powder characterization can be found elsewhere.

4. Sensory evaluation

A panel of 50 subjects, between 20 and 45 years old, evaluated the sensory properties of kishk soups, and gave scores for color, smell, consistency, acidity, bitterness, aftertaste, mouth-feel, and overall acceptability on a scale from 1 to 9. Kishk soups were prepared by mixing and heating 20 g of Kishk powder with 80 mL water with constant stirring until boiling. The samples were labeled randomly with three digit numerical codes. The cooked samples were served to the panelists in ceramic bowls. Water was provided to the panelists to rinse their mouths between samples.

5. Statistical analysis

Data is tested using the SPSS software (version 16.0). Statistical analysis of the results is based on one-way analysis of variance. Statistically significant differences are considered at the level of $p<0.05$.

II – Results and discussion

1. Chemical analysis

Chemical analysis of traditional and hot air dried kishk samples revealed significant differences in protein and fat contents, whereas moisture and ash contents were not significantly affected by the drying method. Fat and protein contents of hot air dried kishk (20.24% and 22.14%, respectively) were higher than those of traditional product (18.15%and 20.25%, respectively). This slight variation may be related to the composition and ratio of ingredients used inkishk formulation. In fact, the composition of kishk powder is strongly dependent on employed ingredients (yogurt, strained yogurt, and bulgur), their ratio, and bulk composition, as well as on the milk type and the fermentation conditions (Erkan *et al*., 2006; Salameh *et al*., 2016; Tamime and O'Connor, 1995).

2. Powder flow properties

The variation of powder flow properties according to normal stress,through compressibility and shear test, is shown in Figure 1. The rheological behavior of hot air dried and traditional kishk powders was not significantly different. Both powder's types exhibited high compressibility values (Figure 1A) (31.08% and 22.44% at 15 kPa, respectively).They also showed high shear strengths (Figure 1B), revealed by their low friction coefficients (<4). Thus, both kishk powders were considered as cohesive materials,with poor flowability and high compressibility, according to the powders classification (Jenike, 1964).

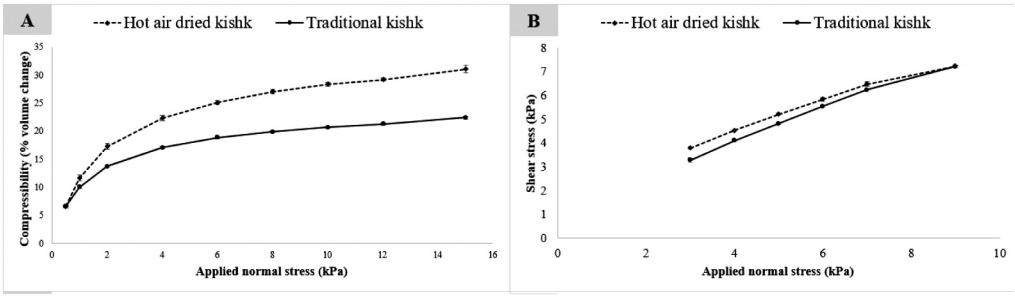

Fig. 1. Variation of kishk flow properties at different applied normal stress (A: powder compressibility test; B: shear test).

In fact, powder flowability is multifactorial: it is not an inherent property of a material, but results from the combined influence of its physicochemical properties (particle size and shape distributions, density, moisture content, composition) and of environmental and processing factors (Prescott and Barnum, 2000). Furthermore, the cohesive character of kishk powder is also related to its broad andbimodal particle size distribution (Salameh *et al.*, 2016). Smaller kishk particles tend to fill the intergranular spaces between larger particles, increasing therefore the contact area between particles and the material compressibility (Bian *et al.*, 2015; Crawford *et al*., 2016).

Besides, hot air dried and traditional kishk powderswere almost insensitive to airflow (Figure 2A) in the tested air velocity range (from 0 to 10 mm/s), as evidenced by their low aeration ratios (1.05, and 1.13 respectively). Both powder's types were physically stable and highly permeable (Figure 2B), due to their large particles of irregular shape, leading to a relatively large porosity, with a pressure drop of 0.39 and 0.24 mbar, respectively.

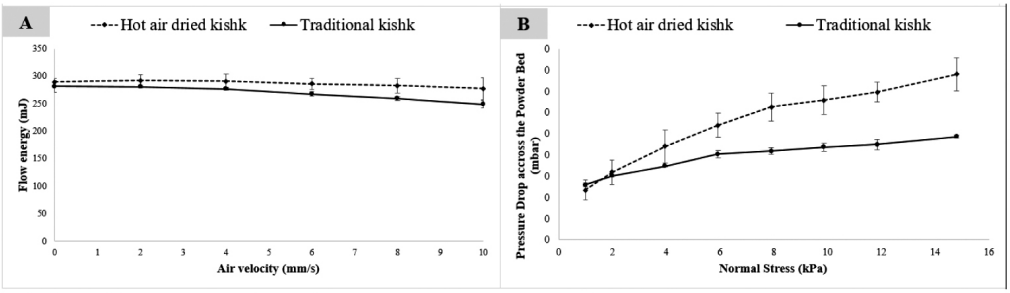

Fig. 2. Variation of kishk flow energy and pressure drop at different applied normal stress and air velocity (A: aeration test; B: permeability test).

3. Sensory evaluation of kishk soup

Evaluating the sensory properties of laboratory-made kishk was essential to evaluate the success of using hot air drying to produce kishk, and to identify the weaknesses to resolve in order to get closer to the traditional product.The average scores given by the jury for traditional and hot air dried kishk soups are presented in Figure 3. The latter was significantly more consistent and thick, with a viscous and sticky mouthfeel ($p < 0.05$), unlike the traditional soup that was more heterogeneous and fluid with the presence of particles in suspension.

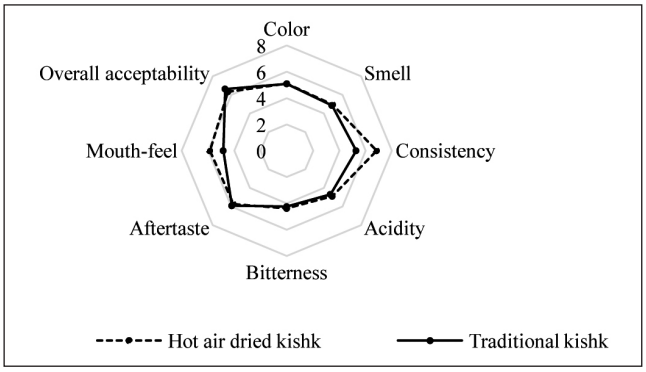

Fig. 3. Sensory properties of traditional and hot air dried kishk.

However, differences in scores for color, smell, acidity, bitterness, aftertaste and overall acceptability were insignificant. Both kishk soups were well appreciated by the evaluation panel, despite a slight preference for the traditional kishk ($p > 0.05$). The acceptability results of laboratory-made kishk are promising; nevertheless they require a better adaptation of the ratio kishk / water to improve the consistency and mouthfeel of kishk soup.

IV – Conclusion

The aim of this research was to assess the effect of hot air drying on the nutritional, physicochemical and sensory properties of Lebanese kishk. Though fat and protein contents of both kishk types were different, their flow behavior was similar, as powder flowability is multidimensional and depends also on particle shape, surface roughness and structure, and size distribution. Despite these differences, both kishk soups were well appreciated by the evaluation panel and received similar scores for acceptability and other sensory attributes. Therefore, our results are promising and show that using hot air drying is suitable for an industrial application, and can be a great alternative of the traditional sun drying method. Nevertheless, the reconstitution ratio of kishk powder (kishk/water) must be controlled in order to improve the consistency and mouth-feel of kishk soup.

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Innovation aspects of Serdaleh, a traditional Lebanese cheese produced from raw extensive goat's milk

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Abstract. Serdaleh is a traditional lactic goat cheese originated in mountainous areas of Lebanon. It is highly recommended for its unique taste and manufacturing technique using jars. Unfortunately, little information is available about this traditional product and its distinctive ripening method, which represents an obstacle for the protection of such authentic and original products. Our study aims to investigate the changes in microbial flora and chemical composition of Serdaleh cheese throughout ripening, and to optimize its manufacturing product by using innovative ripening materials. Serdaleh cheeses were manufactured from raw goat's milk and ripened in terracotta jars or plastic barrels to understand the effect of ripening material on the physico-chemical and microbiological properties of Serdaleh cheeses during 35 days of ripening.

Results showed that the chemical composition of Serdaleh cheese was significantly affected by the ripening period rather than the material used (jars or plastic barrels). Moisture and fat content decreased gradually due to regular whey drainage and fat removal throughout the production period. However, cheeses ripened in jars exhibited a higher moisture loss due to the porous structure of terracotta jars. Microbiological results showed that samples fall within the standards for *Salmonella* spp. and *Staphylococcus aureus*, whereas a high contamination with fecal coliforms was recorded in the samples produced in jars, which can pose a potential hazard to consumers. Our findings represent an opportunity for the Lebanese dairy sector, to adapt artisanal goat cheese production to the new demands of consumers, and ensure its sustainability, specificity and authenticity.

Keywords. Serdaleh – Goat cheese – Ripening material – Terracotta jars – Plastic barrels.

Les aspects innovants dans la production du Serdaleh, un fromage de chèvre libanais

Résumé. *Serdaleh est un fromage lactique de chèvre, originaire des régions montagneuses au Liban. Il est fortement recommandé pour son goût unique et sa technique de fabrication dans des jarres en terre cuite. Malheureusement, il existe peu d'informations sur ce produit traditionnel et sa méthode d'affinage, ce qui représente un obstacle à la protection de ces produits authentiques de terroir. Notre étude vise à étudier les changements dans la flore microbienne et la composition chimique du fromage Serdaleh tout au long de l'affinage, et à optimiser sa production en utilisant des matériaux innovants pour son affinage. Le fromage Serdaleh a été fabriqué à partir du lait de chèvre et affiné dans des jarres en terre cuite ou des barils en plastique, afin de comprendre l'effet du matériau d'affinage sur les propriétés physico-chimiques et microbiologiques du fromage Serdaleh pendant 35 jours d'affinage.*

Les résultats ont montré que la composition chimique du fromage Serdaleh était significativement influencée par la période d'affinage plutôt que par le matériau utilisé (jarres ou barils en plastique). La teneur en humidité et en matières grasses a diminué progressivement en raison du drainage régulier du lactosérum et de l'élimination de la couche superficielle de matières grasses tout au long de la période de production. Cependant, les fromages affinés dans les jarres en terre cuite ont montré une perte en eau plus accentuée en raison de la structure poreuse de ces dernières. Les résultats microbiologiques ont montré que les échantillons sont conformes aux normes concernant la présence de Salmonella spp. et Staphylococcus aureus, alors qu'une contamination élevée par des coliformes fécaux a été décelée dans les échantillons produits dans les jarres, ce qui cause un risque potentiel pour les consommateurs. Nos résultats représentent une opportunité pour le secteur laitier libanais, pour adapter la production artisanale du fromage de chèvre aux nouvelles demandes des consommateurs et en assurer la durabilité, la spécificité et l'authenticité.

Mots-clés. *Serdaleh – Fromage de chèvre – Matériau d'affinage – Jarres en terre cuite – Barils en plastique.*

I – Introduction

Traditional dairy products have always been an important component of Lebanese diet; their production is fundamentally rooted in culinary heritage. Nevertheless, the future of these artisanal products is uncertain and needs considerable scientific efforts to save them from extinction, due to changes in lifestyle, consumer preferences and market challenges. Serdaleh is a traditional lactic goat cheese originated in mountainous areas of Lebanon, more specifically in Chouf region, where extensive farming is still practiced. It is also known as Ambarise or Labnet el-jarra in the Bekaa valley (Hajj Semaan *et al*., 2011). It is traditionally produced to preserve goat milk through the non-milking season for winter consumption. However, studies on Serdaleh cheese are very limited and little information is available about this traditional product, which represents an obstacle for the protection of such authentic products. Serhan and Mattar (2013) studied the physico-chemical and microbiological characteristics of Serdaleh produced in different regions. Serdaleh cheese is highly recommended for its distinctive taste and unique manufacturing technique using terracotta jars. The jars are filled with raw goat milk, and with time, whey will drain through the small hole in the bottom of each jar. Goat milk and salt is added every 7 to 15 days, depending on weather conditions until the jar is completely full and entirely dry. (Hajj Semaan *et al*., 2011; Massaad, 2010).

Recently, some Serdaleh producers are substituting terracotta jars with plastic barrels for economic and practical reasons. However, the effect of using different ripening materials (jars or plastic barrels) on the properties of Serdaleh cheese has not been studied. Consequently, the aim of this research is to study the evolution of physicochemical and microbiological properties of Serdaleh cheese during ripening period, and to investigate the effect of ripening material on these characteristics.

II – Material and methods

1. Serdaleh production

In this study, Serdaleh cheese samples were produced according to a traditional method (Figure 1), using terracotta jars (cheeses J1 and J2) and plastic barrels (cheeses P1 and P2). Terracotta jars were obtained from local producers. The first step is to put raw and salted goat milk in jars and barrels. Coagulation is obtained within 15 days. Two weeks later, the whey is drained through the hole present at the base of the jar (or the barrel). The moldy surface layer is removed, followed by addition of raw goat milk and salt to assist the coagulation of fermented milk. Removal of whey and addition of raw goat milk and salt is done every two weeks. The coagulum is then collected, put in canvas bags to dry for 24 hours. Cheese making was performed in duplicate, and the cheese samples were analyzed during ripening period (Day 6, 20 and 35).

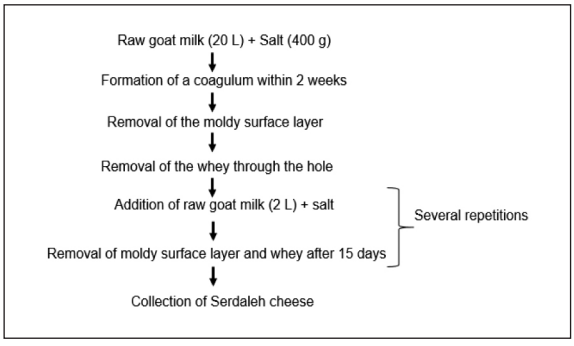

Fig. 1. Flow diagram of Serdaleh production.

2. Chemical analysis

Cheese composition was determined according to AOAC standard methods . Moisture content was calculated by heating 3 g of each sample to a constant weight in an oven maintained at 105 °C. The pH values of cheeses were measured, by homogenizing 10 g of cheese and 10 ml of distilled water, with a pH meter (SI Analytics GmbH, Mainz, Germany). Protein was determined by the Kjeldahl method with a conversion factor of 6.38. For determination of ash, 3 g of each sample were ashed at 550°C in a furnace until constant weight. Fat was obtained by extracting 5 g of each sample in a Soxhlet apparatus using petroleum ether as the extractant.

3. Microbiological analyses

Cheese samples (10 g) were diluted in 90 mL peptone water solution and homogenized in a sterile polyethylene bag using a stomacher 400 circulator lab blender (Thomas Scientific, Swedesboro, USA). Further tenfold serial dilutions ranging from 10^{-2} to 10^{-6} were prepared, and 0.1 mL from the different dilutions were plated onto selective media for enumeration of isolates. All samples were evaluated for total aerobic bacteria (Nutrient Agar at 37 °C for 48 h), fecal coliforms (MacConkey Sorbitol Agar at 37 °C for 48 h), *Staphylococcus aureus* (Mannitol Salt Agar at 37 °C for 36 h), Salmonella spp. (Salmonella Shigella Agar at 37C for 24h), thermophilic cocci (M17 agar at 42 °C for 48 h) and thermophilic *Lactobacillus* (MRS agar at 42 °C for 48 h), respecting the suitable medium and incubation temperatures. All media were purchased from Scharlab S.L. (Barcelona, Spain). Counts were carried out in triplicate.

4. Statistical analysis

Data is tested using the SPSS software (version 16.0). Statistical analysis of the results is based on one-way analysis of variance and t-test. Statistically significant differences are considered at the level of $p<0.05$.

II – Results and discussion

1. Chemical analysis

The changes in chemical composition and pH values of Serdaleh cheeses during ripening are given in Table 1. The initial pH ranged between 4.33 and 4.65, then it decreased significantly during the first 20 d of ripening, in both types of cheese, owing to the production of organic acids by lactic acid bacteria. Moisture contents of all cheeses decreased gradually during ripening period due to regular drainage through the hole, and evaporation of water from the surface of cheese (Arslaner and Bakırcı, 2016). However, moisture loss was observed at higher level in jars because of their porous structure. Similar results were reported by Hayaloglu et al. (2007) where ripening in tulums (goatskin bag) caused more moisture loss than plastic barrels. The ripening material didn't significantly affect protein and fat contents. Nevertheless, protein levels increased significantly throughout the ripening period in all cheese samples, due to the regular addition of milk and to the moisture loss during 35 days. Initial fat levels varied between 13.24 and 14.85; but these values decreased significantly during ripening, due to the repeated elimination of the moldy surface of the coagulum. In fact, the fat tends to float on the upper layer in the barrel or jar. Thus, the removal of the moldy surface layer will induce indirect skimming (Hajj Semaan *et al.,* 2011; Serhan and Mattar, 2013).

Table 1. Chemical composition and pH of Serdaleh cheeses ripened in terracotta jars (J) or plastic barrels (P) during 35 days of ripening

Variable	Days	Cheese			
		J1	J2	P1	P2
pH	J6	4.33 ± 0.15^{a,B}	4.44 ± 0.31^{a,B}	4.77 ± 0.2^{a,B}	4.65 ± 0.13^{a,B}
	J20	3.84 ± 0.26^{a,A}	3.96 ± 0.19^{a,A}	3.65 ± 0.13^{a,A}	3.72 ± 0.12^{a,A}
	J3	53.78 ± 0.09^{a,A}	3.82 ± 0.12^{a,A}	3.63 ± 0.35^{a,A}	3.64 ± 0.27^{a,A}
Moisture (%)	J6	65.07 ± 0.22^{a,B}	64.94 ± 0.26^{a,B}	66.64 ± 0.21^{a,B}	66.82 ± 0.26^{a,B}
	J20	61.58 ± 0.19^{a,A}	61.15 ± 0.22^{a,A}	64.55 ± 0.15^{b,B}	64.76 ± 0.19^{b,B}
	J3	557.64 ± 0.25^{a,A}	57.97 ± 0.2^{a,A}	60.49 ± 0.17^{a,A}	60.48 ± 0.25^{a,A}
Ash (%)	J6	3.27 ± 0.35^{a,A}	3.34 ± 0.39^{a,A}	3.93 ± 0.08^{a,A}	4.05 ± 0.11^{a,A}
	J2	04.78 ± 0.28^{a,B}	4.74 ± 0.25^{a,B}	5.51 ± 0.19^{a,B}	5.65 ± 0.21^{a,B}
	J3	54.24 ± 0.31^{a,B}	4.28 ± 0.24^{a,B}	5.28 ± 0.08^{a,B}	5.35 ± 0.09^{a,B}
Protein (%)	J6	7.55 ± 0.25^{a,A}	7.66 ± 0.36^{a,A}	6.75 ± 0.35^{a,A}	7.2 ± 0.38^{a,A}
	J2	09.73 ± 0.19^{a,B}	10.04 ± 0.42^{a,B}	12.13 ± 0.29^{a,B}	12.25 ± 0.25^{a,B}
	J35	13.24 ± 0.1^{a,C}	13.38 ± 0.34^{a,C}	14.72 ± 0.19^{a,C}	14.85 ± 0.18^{a,C}
Fat (%)	J6	5.64 ± 0.26^{a,C}	5.5 ± 0.17^{a,C}	5.92 ± 0.28^{a,C}	5.84 ± 0.31^{a,C}
	J2	04.8 ± 0.34^{a,B}	4.92 ± 0.22^{a,B}	4.6 ± 0.39^{a,B}	4.54 ± 0.37^{a,B}
	J35	4.2 ± 0.17^{a,A}	4.35 ± 0.19^{a,A}	4.02 ± 0.15^{a,A}	3.9 ± 0.18^{a,A}

Different letters (A, B) within the column across the table show significant differences at $p<0.05$.

Different letters (a, b) within the row across the table show significant differences at $p<0.05$.

P: Serdaleh ripened in plastic; J: Serdaleh ripened in terracotta jars.

2. Microbiological analyses

The counts of different microbial groups investigated during ripening of Serdaleh cheese, in terracotta jars (J1 and J2) or plastic barrels (P1 and P2), are presented in Table 2. At the beginning of the ripening, initial counts of total aerobic bacteria ranged between 6.63 and 7.08 $\log_{10}$ CFU/g, then they decreased significantly in the following 35 days. A similar trend was reported by Hayaloglu *et al.* (2007) on Tulum cheese, and by Jahromi and Jalali (2012) on Iranian jar cheese. This reduction of microbial counts can be attributed to the increase in salt and acid content, and decrease in moisture content during ripening period. None of the cheese samples contained Salmonella spp. or Staphylococcus aureus. As for the presence of fecal coliforms, Serdaleh samples produced in jars showed an unacceptable amount (approximatively 4.5 $\log_{10}$ CFU/g) indicating that contamination occurred throughout the ripening. This might be related to an initial contamination of terracotta jars or workplace prior to Serdaleh production. High coliform numbers are common in raw goat's milk cheeses (El Galiou *et al.*, 2015), and represent a great concern for the dairy industry because of their technological and public health significance.

The highest counts of thermophilic lactic acid bacteria (LAB) were observed at the beginning of ripening, then they decreased significantly during 35 days. The growth of LAB exhibited a similar trend after 1 month of ripening for many Mediterranean cheeses such as Feta (Manolopoulou *et al*., 2003), Tulum (Hayaloglu *et al*., 2007), and Halloumi (Milci *et al*., 2005). Nevertheless, cheese samples ripened in jars exhibited higher numbers of thermophilic LAB than those ripened in goatskin bags after 20 days of ripening. These differences may be related to the porous structure of jars that preserves higher microbial counts.

Table 2. Changes in microbial counts (Log CFU/g) during ripening of Serdaleh cheeses ripened in plastic barrels or terracotta jars

Variable	Days	Cheese			
		J1	J2	P1	P2
Total aerobic bacteria	D6	$6.63 \pm 0.38^{a,B}$	$6.87 \pm 0.31^{a,B}$	$7.08 \pm 0.22^{a,B}$	$6.92 \pm 0.15^{a,B}$
	D20	$6.24 \pm 0.28^{a,B}$	$6.34 \pm 0.23^{a,B}$	$6.66 \pm 0.34^{a,B}$	$6.78 \pm 0.27^{a,B}$
	D35	$5.64 \pm 0.42^{a,A}$	$5.73 \pm 0.45^{a,A}$	$4.65 \pm 0.12^{a,A}$	$4.79 \pm 0.08^{a,A}$
Fecal coliforms	D6	4.5 ± 0.22^{A}	4.7 ± 0.15^{A}	–	–
	D20	4.49 ± 0.31^{A}	4.55 ± 0.26^{A}	–	–
	D35	4.38 ± 0.41^{A}	4.58 ± 0.32^{A}	–	–
Staphylococcus aureus	D6	–	–	–	–
	D20	–	–	–	–
	D35	–	–	–	–
Salmonella spp.	D6	–	–	–	–
	D20	–	–	–	–
	D35	–	–	–	–
Thermophilic cocci	D6	$7.07 \pm 0.18^{a,B}$	$6.99 \pm 0.29^{a,B}$	$6.9 \pm 0.26^{a,B}$	$7 \pm 0.33^{a,B}$
	D20	$6.71 \pm 0.25^{b,B}$	$6.75 \pm 0.35^{b,B}$	$4.67 \pm 0.09^{a,A}$	$4.74 \pm 0.13^{a,A}$
	D35	$5.47 \pm 0.32^{b,A}$	$5.66 \pm 0.45^{b,A}$	$4.4 \pm 0.36^{a,A}$	$4.34 \pm 0.3^{a,A}$
Thermophilic *Lactobacillus*	D6	$6.81 \pm 0.34^{a,B}$	$6.79 \pm 0.29^{a,B}$	$7.18 \pm 0.28^{a,B}$	$7.25 \pm 0.21^{a,B}$
	D20	$6.41 \pm 0.19^{b,B}$	$6.65 \pm 0.26^{b,B}$	$4.29 \pm 0.42^{a,A}$	$4.43 \pm 0.4a^{,A}$
	D35	$5.48 \pm 0.26^{b,A}$	$5.59 \pm 0.28^{b,A}$	$4.19 \pm 0.08^{a,A}$	$4.22 \pm 0.12^{a,A}$

Different letters (A, B) within the column across the table show significant differences at $p<0.05$.

Different letters (a, b) within the row across the table show significant differences at $p<0.05$.

P: Serdaleh ripened in plastic; J: Serdaleh ripened in terracotta jars.

IV – Conclusion

In order to preserve an endangered traditional Lebanese goat cheese and increase its competitiveness, our research aims to assess the effect of ripening material (plastic barrels and terracotta jars) on the physico-chemical and microbiological properties of Serdaleh cheeses during 35 days of ripening. This study is the first approach in Lebanon to investigate the influence of ripening container on Serdaleh cheese.

No significant differences were recorded among Serdaleh samples produced in jars or plastic barrels, except for moisture content. However, the results revealed high contamination with fecal coliforms in Serdaleh produced in jars, which can pose a potential hazard to consumers. Therefore, it is crucial to optimize the manufacturing process using an alternative ripening material, in order to obtain a uniform and safe product. However, the distinctive flavor and local characteristics of Serdaleh cheese must be considered, to avoid losing the product's specificity and authenticity. Thus, further studies are essential to assess the effect of using plastic barrels on the sensory properties and volatile compounds of Serdaleh cheese, in order to maintain Serdaleh peculiarities, while improving its sanitary quality.

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Session 3

Precision farming and other technical innovations for increasing efficiency in sheep and goats

Eye and muzzle temperatures measured using infrared thermography to assess sheep stress during shearing and foot trimming

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Abstract. The aim of this study was to investigate the infrared thermography (IRT) to measure eye (IRTeye) and muzzle (IRTmuz) temperature to assess stress in sheep during shearing and foot-trimming procedures. IRT temperatures were measured on 89 ewes of two breeds (55 Churra da Terra Quente – CTQ - and 34 Ile-de-France – IF). The IRT images were collected before, during and at the end of each procedure. A FLIR infrared camera was used, and IRT images were analyzed using FLIR Tools+ software to determine IRTeye and IRTmuz. All statistical analyses were performed using the JMP software. Data were analyzed considering breed and time of IRT collection as factors. The IRTeye was higher than IRTmuz (37.26 vs. 31.60 ºC, P<0.01, respectively) for both breeds and procedures. The IF ewes show higher temperatures than CTQ for foot-trimming and shearing (37.49 vs. 37.11 ºC, P<0.05; 37.54 vs. 37.13 ºC, P<0.05, respectively). Time of IRT collection presents different values, the lowest (P<0.05) being observed during and the highest before both procedures. In conclusion, IRT was sensitive in obtaining IRTeye and IRTmuz, being a viable indicator of distress and a valuable tool to assess welfare in sheep during shearing and foot trimming.

Keywords. Infrared thermography – Sheep – Stress – Welfare.

Températures des yeux et du museau mesurées à l'aide d'une thermographie infrarouge pour évaluer le stress des moutons pendant la tonte et le taillage des onglons

Résumé. *L'objectif était d'étudier la thermographie infrarouge (IRT) pour mesurer la température des yeux (IRTeye) et du museau (IRTmuz) pour évaluer le stress chez les moutons pendant la tonte et le taillage des onglons. L'IRT a été mesuré sur 89 brebis de deux races (55 Churra da Terra Quente-CTQ et 34 Ile-de-France-IF). L'IRT a été collecté avant, au milieu et à la fin de chaque procédure. Une caméra infrarouge FLIR a été utilisée, et les images IRT ont été analysées avec le logiciel FLIRTools+ pour déterminer IRTeye et IRTmuz. Les analyses statistiques ont été réalisées avec le logiciel JMP. Les données ont été analysées considérant la race et le temps de collecte comme facteurs. L'IRTeye était plus élevé que l'IRTmuz pour les deux races et les deux procédures. Les brebis IF présentent des températures plus élevées que les brebis CTQ pour le taillage des onglons et la tonte (37,49 contre 37,11 ºC, P <0,05; 37,54 contre 37,13 ºC, P <0,05, respectivement). Le temps de la collecte présente différentes valeurs (P <0,05), le plus bas étant observée au milieu et le plus haut avant les deux procédures. En conclusion, l'IRT était sensible à l'obtention d'IRTeye et IRTmuz qui sont indicateurs viables de détresse et un outil précieux pour évaluer le bien-être chez les moutons pendant la tonte et le taillage des onglons.*

Mots-clés. *Thermographie infrarouge – Moutons – Stress – Bien-être.*

I – Introduction

Infrared thermography (IRT) has a wide range of potential applications in studies relating to health and welfare of farm animals (Stewart *et al*., 2005; Mcmanus *et al.*, 2016). These include the measurement of body and eye temperature during management procedures, handling, transport and slaughter (Schaefer *et al.*, 1988; Mcmanus *et al.*, 2016). Some recent reports show the applicability of IRT when measuring physiological stress responses via eye temperature (cattle – Stewart *et al.*, 2008; George *et al.*, 2014; sheep – George *et al.*, 2014 and swine – Weschenfelder *et al.*,

2013). These reports take advantage of some IRT features, namely its portability, the remote reading of temperature, which allows for no physical contact with the animal, and the accuracy of temperature measurement (Speakman and Ward, 1998; Berry *et al.*, 2003). Although the effects of various farm animal management stressors and respective welfare outcomes may be assessed by body and eye temperature, little is known about the applications of IRT to assess shearing and foot-trimming stress of sheep. It is recognized that both procedures are stressors that cause physiological changes and alterations of blood flow patterns, which manifest as changes in body surface temperature (Beausoleil *et al.*, 2004). Moreover, with IRT it is possible to identify changes in eye temperature as a result of a stress-induced physiological response and consequent changes of blood flow patterns (Stubsjøen *et al.*, 2009; Riemer *et al.*, 2016). The aim of this study addresses the question of whether the eye and muzzle temperature variations measured using IRT can assess shearing and foot-trimming stress of sheep.

II – Material and methods

1. Animals, environment and management procedures

The present study observations were conducted on 89 multiparous ewes, ranging in age from three to seven years old, of two different breeds. Fifty-five ewes of the local breed Churra da Terra Quente (CTQ) and 34 of Ile-de-France (IF) breed. The ewes were housed at UTAD - University of Trás-os-Montes and Alto Douro, Vila Real (41 º 17 ‘18:52’’ N 7 º 44’ 31.97’’ W) where the study took place during 3 days in July 2016. The environmental temperature and relative humidity ranged from 21.7 to 24.8 ºC and 48.3 to 52.3%, respectively.

In this study shearing and foot-trimming were elected as stressors to which thermography would be applied to assess thermal measurements and respective physiological mechanisms of stress responses to these management procedures. Over the course of three days all sheep were sheared by one experienced worker. Foot-trimming was performed by two experienced operators with the animals sitting on their rump. To ensure identical levels of stress, each procedure was conducted following a similar routine. Both procedures were conducted in similar housing conditions and protected from sunlight and wind.

2. Thermographic image capture and image analysis

An infrared camera FLIR F4 (FLIR Systems AB, Sweden) was used to collect thermographic images (thermograms) of the eye and muzzle of sheep. Thermograms of the eyes and muzzle were acquired before, during and at the end of shearing and foot-trimming. This camera has a thermal sensitivity of <0.02°C. The FLIR Tools+ software was used to analyze the thermograms. Analysis of the thermograms was undertaken to determine temperature in five points of the eye and muzzle (Figure 1). All ewes were scanned from the same side at a 90° angle and at a distance of 1.0 m.

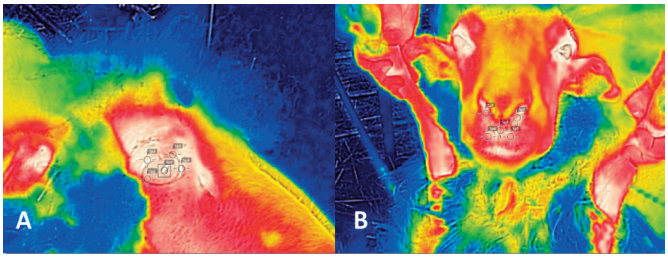

Fig. 1. Examples of eye (A) and muzzle (B) thermograms. Both thermograms show the five points used for temperature determination.

3. Statistical analysis

All statistical analyses were performed using the JMP-SAS software (Version 13, SAS Institute Inc. Cary, NC, USA). Data was analyzed considering breed and time of thermograms capture as factors. The IRT of eye and of muzzle were analyzed separately. Least significant difference Student's t-test was used to compare means.

III – Results and discussion

Table 1. Effects of breed and time (before, during and end of procedure) on IRT eye and muzzle temperature obtained during shearing and foot-trimming procedures

Effect	Eye		Muzzle	
	Shearing	Foot-trimming	Shearing	Foot-trimming
Breed				
CTQ	37.13^{b}	37.11^{b}	31.59^{a}	31.60^{a}
IF	37.54^{a}	37.49^{a}	31.64^{a}	31.59^{a}
Time				
Before	37.77^{a}	37.71^{a}	31.73^{b}	31.75^{a}
During	36.81^{c}	36.83^{c}	31.24^{c}	31.24^{b}
End	37.42^{b}	37.35^{b}	31.88^{a}	31.79^{a}
Probability Breed	<.0001	<.0001	0.334	0.804
Time	<.0001	<.0001	<.0001	<.0001
Breed*Time	<.0001	0.004	0.599	0.389

Temperatures are presented in Celsius (°C). For breed and time, eye and muzzle temperatures during shearing and foot-trimming procedures values with different superscript letters are different (P<0.05).

Breed had a significant effect (P<0.0001) on eye temperature (Table 1.), the IF breed showing the highest values (P<0.05) for both shearing (37.54 vs 37.13°C) and foot-trimming (37.49 vs 37.11°C). On the contrary, effect of breed on muzzle temperature was not significant (P>0.05), with an average value of 31.6°C for shearing and foot-trimming.

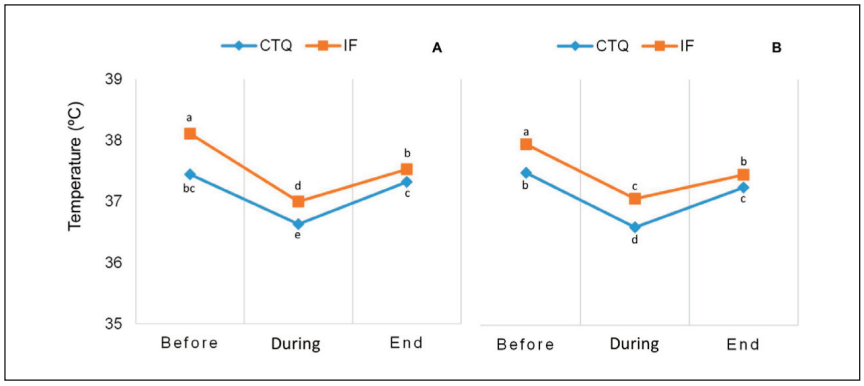

Fig. 2. Eye IRT temperature variation before, during and at the end of shearing (A) and foot-trimming (B) for CTQ and IF sheep. For shearing and foot-trimming and for both breeds markers with different superscript letter are different (P<0.05).

Time only had a significant effect on eye temperature (P<0.0001) for both procedures. Significant differences (P<0.05) were observed before, during and at the end of shearing and foot-trimming for both eye and muzzle. The highest temperature values for eye measurements was observed before, followed by end and during procedure time. However, a different pattern was observed for the muzzle, with higher values for end followed by time before and during the procedure time.

The interaction Breed x Time was only significant (P<0.0001) for eye measurements and this effect is represented on Figure 2.

For both sites, the pattern of variation is similar but more marked variation was observed for shearing measurements on IF breed and for foot-trimming on CTQ breed. Time of IRT collection presents different values, the lowest (P<0.05) being observed during both procedures. Fear and distress have been associated with a drop temperature of peripheral tissues as result of a sympathetically-mediated vasoconstriction response and consequent reduction of blood flow (Herborn *et al.*, 2015). Reduction of IRT temperature measured in the eye has been observed in cattle (Stewart *et al.*, 2008) and sheep (Stubsjøen *et al.*, 2009; George *et al.*, 2014). These studies found that IRT is able to detect small, yet significant, differences in eye temperature which is key to assess a stressful procedure. Our IRT eye temperature results are in agreement with those published in these papers, though those with the IRT muzzle temperature have not been so sensitive in distinguishing small temperature variations.

IV – Conclusions

This study shows that IRT is sensitive to be utilized as a technique for non-invasive remote stress assessment in order to assess animal welfare related with stressful procedures, such as shearing and foot-trimming of sheep.

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Classification of lactation curves on French dairy goats

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Abstract. The objective was to achieve a typology of lactation curves and to analyze the influence of environmental factors on these curves. The data used consists of 2,245,628 monthly test-day records of milk on 213,534 Saanen and Alpine French goats. A principal component analysis (PCA) was performed on milk test-day records with R package fdapace. Three principal components were found: one related to the level of milk production, another to the persistency and a third to the shape in middle lactation. The first principal component was mainly explained by herd effect, milk yield estimated breeding value (EBV), parity and region. The second one was mainly explained by month of kidding, breed, age at kidding, dry period length, gestation stage, somatic cell score (SCS) EBV, and parity. The third one was mainly driven by the month of lactation. A classification was used on PCA lactation scores and 5 clusters were found.

Keywords. Lactation curve – Lactation persistency – Functional clustering – Dairy goat.

Classification des courbes de lactation de chèvres laitières françaises

Résumé. *L'objectif de cette étude était d'obtenir une typologie des courbes de lactation et d'analyser l'influence de facteurs environnementaux sur ces courbes. Les données utilisées consistent en 2 245 628 enregistrements mensuels de la production laitière sur 213 534 chèvres Saanen et Alpines françaises. Une analyse en composantes principales (ACP) a été réalisée sur les productions journalières avec un package R (fdapace). Trois composantes principales ont été trouvées: l'une relative au niveau de la production laitière, l'autre à la persistance et la dernière à la production au milieu de la lactation. La première composante principale a été expliquée principalement par l'effet du troupeau et la valeur génétique pour la production laitière. La seconde a été principalement expliquée par le mois de mise bas, la race et l'âge à la mise bas. La troisième a été principalement influencée par le mois de mise bas. Une classification a été utilisée sur les scores de l'ACP et 5 groupes de courbes ont été identifiés.*

Mots-clés. *Courbe de lactation – Persistance laitière – Classification de courbes – Chèvre laitière.*

I – Introduction

France is one of the world's leading countries in terms of goat milk production thanks to its herds with high genetic potential, composed mainly of two internationally recognized breeds (Alpine and Saanen). This production is carried out by 850,000 goats distributed into: 3,000 farms of 225 goats on average delivering their milk directly to dairies and producing 80% of the French volume, and 2900 farms of 79 goats on average processing part or all of their production (Maigret, 2016). Every 4 to 5 weeks, a technician measures the dairy production of goats called test-day in farms that adhere to the official performance control. All these data are stored in the national database of the Genetic Information Treatment Center (CTIG) of the INRA.

The shape of the lactation curve is of interest for several reasons. First, for the same total production during a lactation, a goat with a "flat" curve is said to be persistent and will have a lower production level at the lactation peak. This is particularly interesting because a high level of production

at the lactation peak can lead to an energy deficit of the goat due to its inability to ingest enough food to compensate for its large production. The goat then draws on its body reserves, which can lead to metabolic and reproductive problems (Gipson et Grossman, 1990). A persistent goat is able to be fed with basic forages and few concentrate (Sölkner et Fuchs, 1987), which is an advantage, in a context of new environmental policy measures. It is known that environmental factors influence the shape of the lactation curve (Gipson et Grossman, 1990). The objective of this study was to achieve a typology of lactation curve forms in the two main French dairy goat breeds (Alpine and Saanen) from a large dataset of milk production records from the French national database and to analyze the influence of different environmental factors on these curves.

II – Material and methods

1. Data

After data selection, measurements consist of 2,245,628 monthly test-day from 319 975 lactations of 213 534 French Saanen and Alpine goats collected between September 2008 and June 2012 in 910 French herds by the French official record program. The weights of morning and evening milk produced were added to calculate the daily milk yield of a goat. Lactations should last between 180 and 350 days to be conserved. Test-day records before the 7th and beyond 300th day of lactation were not considered. Within a lactation, a goat was required to have at least 4 test-day records per lactation with the first one occurring before the 81st day of lactation. Only goats from herds having at least 30 conserved lactations per year were kept. On average, a goat had 7 test-days per lactation and Alpine goats represented 60% of the data.

2. Analysis

All statistical analyses were completed using R software. A Principal Component Analysis (PCA) was performed on milk yield test-days, for each lactation, using the R package fdapace (Dai et al., 2016). This package was appropriated to our dataset: sparse data, irregular measurement stage, irregular number of measurements per lactation. Based on the principal component (PC) scores of the lactations, a cluster analysis was performed using the R package Rmixmod (Langrognet et al., 2016). Rmixmod contains a set of functions to fit a mixture model of multivariate Gaussian or multinomial components to a dataset. The optimal number of clusters was researched between 2 and 5 clusters and the Bayesian Information Criterion (BIC) was used to determine it.

The effects of environmental factors on each principal component of PCA were tested with a linear Gaussian model. The fixed effects considered were: the breed, the French herd region, the parity, the age at kidding for the three first parturitions, the kidding month, the dry-period length before their last kidding, the gestation stage at 300 days after the last parturition, the genetic milk estimated breeding value (EBV) based on total lactation milk yield (kg), the somatic cell score (SCS) EBV (high SCS index are correlated with small SCS), with respectively 2, 3, 8, 5, 12, 5, 7, 4 and 5 levels. For each model, a factor was successively removed in order to study its relative impact on each PC using a Fisher test and the determination coefficient (R^2). Least-square means (LS-means) were calculated for each fixed effect to interpret the correlation between the environmental factor and the PC. The influence of the herd on the PC scores was studied from the residuals of each linear Gaussian model.

III – Results and discussion

1. Principal Component Analysis and Classification

In average, goats produced 31.4 hg of daily milk during 283.4 days for a total milk yield of 964 kg on a lactation. The first 3 components explained 99.5% of the original variance: 81%, 15%, and 3.5% for PC1, PC2, and PC3 respectively. Only these three PC were studied due to the high percentage of variance explained. PC1 represented an indicator of the level of production, PC2 a persistency indicator, and PC3 an indicator of linearity deviation in the middle of lactation. Macciotta et al. (2006) performed a PCA on dairy cow correlation test-days milk yield matrix. They did not used all the lactation stage but they summarized the information by the test-day rang in the lactation. They obtained two PC: the first one representing the total lactation production and the second one the persistency. These results were in accordance with ours.

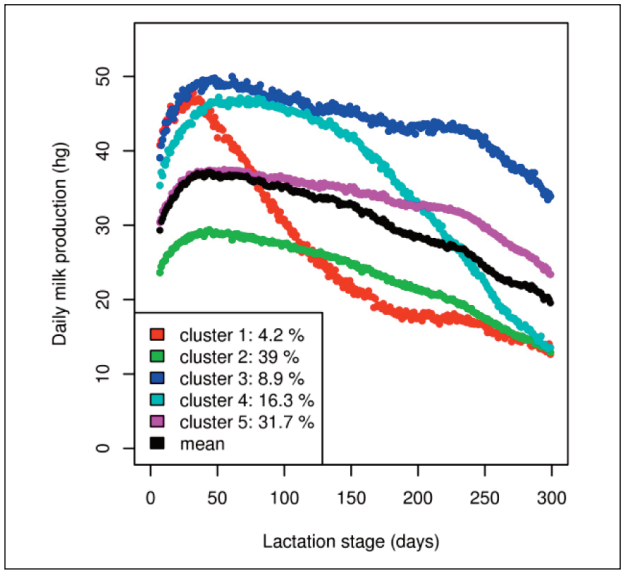

Fig. 1. The average lactation curves for each cluster and the general mean curve (in black) on French dairy goat data. Each point corresponded to the average production of animals in the cluster, and for each cluster, the percentage of lactations was noted.

Five clusters were obtained according to the BIC score. A greater number of clusters was not kept in order to maintain sufficient cluster sizes. Procedures were run several times on the whole dataset and the same clusters were found each time. The averages of daily milk production were plotted according to each cluster number (Figure 1). The cluster 2 was characterized by the lowest total level of milk production and a curve shape similar to the mean curve. The cluster 5 was characterized by a "flat" curve. The mean curves of clusters 1, 3 and 4 (nearly 30% of the data) were very different to the mean curve. Indeed, the cluster 3 had the higher level of milk production and the higher persistency. The cluster 1 had a very marked lactation peak. The cluster 4 was characterized by a "bombed" curve (between the 70th and 200th lactation stage). The mean curves showed a great coherence between two consecutive stages with smooth profiles. The PC3 contributed significantly to the diversity of the shape of curves highlighted and had led to build clusters 1 and 3.

2. Relationship between environmental factors and Principal Components

The milk EBV and the region were the most correlated effects with PC1 with a correlation equal to +0.51.The goats bred in South of France produced less than the goats in North-East which produced less than those in North-West. The breed, the gestation stage, the SCS EBV, the age at kidding, the kidding month and the length of dry period were correlated with PC2. The goats were more persistent when their gestations were less advanced at 300 days after their previous parturition, when they were dried during a short period before their last kidding, when they had a high SCS EBV. Saanen goats were more productive and more persistent than the Alpine goats. The goats which kidded younger had a lower level of milk production but a higher persistency. From the first to the fourth parity, the goats produced in average more milk but their lactations were less persistent at each parturition. After the fourth parity, they produced less and less milk and they were a little bit less persistent than in the fourth lactation. Lactations were less and less persistent when the goats kidded from January to June and were more persistent in the second part of the year. The kidding month was the most linked to the PC3 and presented a great variability with a maximal value in February and a minimum value in August. The effect of the kidding month reflects the effect the evolution of the photoperiod length 120 days later when the bulge of the curve is observed. The influence of herd on residuals of the linear Gaussian models showed important R^2, equal to 0.397, 0.178 and 0.162 for the 1st PC, 2nd PC and 3rd PC respectively. Bouloc (1991) obtained similar results on French goats for the effects of herd, parity, breed, region and age at kidding. The effect of kidding month on persistency had already been highlighted by León et al. (2012) in Murciano-Granadina dairy goats. This effect could be linked to the duration of the day. The effect of the duration of the day on the lactation curve was also found by Delouis et Mirman (1984): an important exposure to artificial light affects the milk yield for all the lactation stage, until +33% in France. Knight and Wilde (1988) showed that the gestation induce a decrease of milk yield comparing to non-gestating goats. Caja et al. (2006) studied the impact of the dry-period length and they found that goats with no dry-period had a smaller peak and less milk during the lactation than goat dried. The relationship between high SCS EBV and the persistent goats did not seem to be known. A hypothesis could be that goats with low SCS genetic level are more able to protect themselves against diseases allowing to maintain a high milk production. EBVs for type traits were studied and no effect on PCs was found. It was not possible to test here the effect of the number of kids whereas Leon et al (2012) showed that this factor affected the amount of milk and the shape of the lactation curve. Analysis with more data on the animal health, alimentation system, weather,… would be interesting to better understand the large effect of the herd.

IV – Conclusions

This study, based on a large number of goats, allowed to characterize different shape of lactation curves and to analyze the influence of environmental factors on each cluster. Three principal components were found: one relating to the level of milk production, another to the persistency and a third to the shape in middle lactation. Five clusters were found with very different lactation curves. This work is a first step to model the lactation curves according to the environmental factors and to propose a genetic evaluation model to study the persistency.

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Using different carbohydrates in prenatal life, growing and mid-lactation can affect lactation persistency in first lactating sheep

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Abstract. Improving milk production by using digestible fiber rich by-products would increase production efficiency and reduce environmental impact of sheep production. We hypothesized that prenatal and early life exposure to either starch from corn grain or highly digestible fiber from beet pulps and soy hulls would affect sheep response to the same feeds in mid-lactation. Two groups of 12 Sarda ewes each were exposed during the last two months of the prenatal life to two different isoproteic diets (one per group) and then fed the same diet during their growing phases and their first pregnancy. The diets were one glucogenic, being rich in starch from corn grains (S; 21% of starch and sugars, DM basis), the other lypogenic, being rich in digestible fiber from soy hulls and beet pulps (F; 9% of starch plus sugars, DM basis). In early lactation (until 54 DIM) all the 24 ewes received the same glucogenic S diet to support the lactation peak. From 55 to 160 days in milk (DIM) the ewes with S and F background, homogeneous per yield and BCS, were split to S or F total mixed rations (with 24%, S, and 13%, F, of starch plus sugars, DM basis), creating 4 groups of 6 ewes each: SS, SF, FS and FF based on the dietary sequence applied between prenatal life and parturition and between mid-lactation to the end of the experiment. Milk yield and composition were measured each 10 days and BCS every two weeks. Milk yield and composition were compared by using the PROC MIXED procedure of SAS for repeated measurements. At 55 DIM, milk production was (mean ± SE) 1.592 ± 0.096 kg/d per ewe and BCS was 2.85 ± 0.15. The S diet provided during early life and until parturition favored the production of fat and protein corrected milk (FPCMY) and a higher persistency on ewes fed the F diet compared to those fed the S diet during their mid lactation (1.483 ± 0.180 vs.1.143 ± 0.198 kg/d for SF vs. SS, respectively; $P<0.05$), whereas ewes with F background had no different milk persistency with both mid-lactating diets (1.269 ± 0.198 vs 1.198 ± 0.180 kg/d for FS and FF, respectively). BCS did not differed among groups at 160 DIM. On ewes exposed to S early in life, the use of F in mid-lactation was significantly associated to higher FPCMY compared to S ewes after 110 DIM ($P=0.05$). The positive effects of the exposure to glucogenic diets in early life suggest to investigate the hormonal and metabolic mechanisms underlying these results.

Keywords. Starch – Digestible fiber – Fetal programming – Dairy.

Influence de l'utilisation de différents hydrates de carbone pendant la vie prénatale, la croissance et la mi-lactation sur la persistance de la lactation chez les brebis en première lactation

Résumé. *L'amélioration de la production de lait en utilisant des sous-produits riches en fibre digestible augmenterait l'efficience de la production et réduirait l'impact environnemental de la production ovine. Notre hypothèse est que l'exposition pendant la vie prénatale et le premier âge à, soit de l'amidon provenant de grains de maïs, soit de la fibre hautement digestible de pulpe de betteraves et d'enveloppes de soja influencerait la réponse des ovins à ces mêmes aliments à la mi-lactation. Deux groupes de 12 brebis sardes chacun ont été exposés pendant les deux derniers mois de vie prénatale à deux régimes isoprotéiques différents (un par groupe) et ont reçu ensuite le même régime pendant leurs phases de croissance et leur première gestation. Les régimes étaient, l'un glucogène, étant riche en amidon provenant de grains de maïs (S; 21% d'amidon et de sucres, sur base MS), l'autre lipogène, étant riche en fibre digestible provenant d'enveloppes de soja et de pulpe de betterave (F; 9% d'amidon et de sucres, sur base MS). Lors des premiers stades de lactation, jusqu'à 54 JEL (jours en lait) les 24 brebis ont toutes reçu le même régime glucogène S pour soutenir le pic de lactation. De 55 à 160 JEL les brebis à alimentation première S et F, homogènes pour le rendement et la note d'état corporel, ont été*

réparties entre les rations totales mélangées S ou F (avec 24%, S, et 13%, F, d'amidon et de sucres, sur base MS), créant ainsi 4 groupes de 6 brebis chacun: SS, SF, FS et FF basés sur la séquence de régime appliquée entre la vie prénatale et le vêlage et entre la mi-lactation jusqu'à la fin de l'expérience. La production de lait et sa composition ont été mesurées tous les 10 jours et la note d'état corporel toutes les deux semaines. La production de lait et sa composition ont été comparées par la procédure PROC MIXED de SAS pour des mesures répétées. À 55 JEL, la production de lait était de (moyenne ± ET) 1,592 ± 0,096 kg/j par brebis et la note d'état corporel était de 2,85 ± 0,15. Le régime S distribué pendant le premier âge et jusqu'au vêlage favorisait la quantité de lait corrigé pour la matière grasse et la protéine (FPCMY) et une plus forte persistance chez les brebis recevant le régime F comparées à celles alimentées au régime S pendant leur mi-lactation (1,483 ± 0,180 vs.1,143 ± 0,198 kg/j pour SF vs. SS, respectivement; P<0,05), tandis que les brebis à alimentation première F ne montraient pas de différences pour la persistance du lait avec les deux régimes de mi-lactation (1,269 ± 0,198 vs 1,198 ± 0,180 kg/j pour FS et FF, respectivement). La note d'état corporel ne différait pas entre groupes à 160 JEL. Sur les brebis recevant S pendant le premier âge, l'utilisation de F à la mi-lactation était significativement reliée à un FPCMY plus élevé en comparaison aux brebis S après 110 JEL (P=0,05). Les effets positifs de l'exposition aux régimes glucogènes lors du premier âge suggèrent que des recherches sont à mener sur les mécanismes hormonaux et métaboliques sous-jacents à ces résultats.

Mots-clés. *Amidon – Fibre digestible – Programmation fœtale – Laitier.*

I – Introduction

Production efficiency in dairy sheep farms can be reached by increasing yearly production levels per head either achieving high lactation peaks and/or high lactation persistency. Improving milk production using digestible fibrous substrates from industrial by products increases efficiency and reduces environmental impact of small ruminant productions. Cannas *et al*., (2002) highlighted that the shape of the lactation curve might be influenced with nutritional strategies. In particular in early lactation, glucogenic diets with high starch contents help to support lactose production and milk yield, then in mid-late lactation, switching to lypogenic diets by substituting the most part of the starch with digestible fiber from sohyhulls or beet pulp help to maintain lactation persistency (Cannas *et al*., 2004). Decreases of glucogenic substrates, from mid to late lactation, should limit the peripheral insulin response reducing the accumulation of body reserves and favoring the nutrient utilization by the mammary gland, which is not sensitive to insulin (Sasaki, 2002). Several authors, using high digestible fiber versus high starch diets in mid lactation, observed increases in milk production and reduction of body reserves deposition (Cannas *et al*., 2004; Lunesu *et al*., 2016; 2017). Furthermore several authors have observed important effects of maternal nutrition on offspring characteristics, including production performances and metabolism. The maternal environmental, moreover the metabolic substrates to which the fetus is exposed during pregnancy, influences epigenetic processes and developmental changes which may have consequences later in life (Poore *et al*., 2014). Prenatal diet can affect body weight, milk yield and milk composition in the subsequent first generation (Blair *et al*., 2010) or reproductive organs and reproduction performances (Rhind *et al*., 2001). Both in humans and small ruminants has been observed that overnutrition or undernutrion during prenatal life can impair the glucose metabolism in adult life (Paliy *et al*., 2014; Husted *et al*., 2008). In previous works studying prenatal lypogenic diets mainly considered the fat content, whereas few studies focused the effect of the type of carbohydrate on the offspring metabolism of dairy ruminants (Poore *et al*., 2014). Following the evidences observed by Cannas *et al*., (2004; 2007) and Lunesu *et al*., (2016) on lactation persistency and also the findings from studies on fetal programming of glucose metabolism this work hypothesized that the exposures to starch or high digestible fiber early in life might affects the sheep response to carbohydrates in adult life.

II – Materials and methods

Twenty-four Sarda ewes that lambed in the same week (± 3 days from the expected date of parturition) were selected from a larger group of animals that were exposed to different carbohydrates from their prenatal life until the first lambing. The 24 sheep were divided in two groups of 12 sheep each that were exposed to two different isoproteic diets (one per group) during the last two moths of prenatal life. In this phase their mothers were kept indoor and the offered diets consisted of a common basis of ryegrass hay and a pelleted concentrate: one glucogenic, being rich in starch and sugars (diet S), the other lypogenic with low starch content (diet F) (Table 1); the glucogenic was formulated with high amounts of corn grains whereas in the lypogenic one the most part of the corn grain was substituted with digestible fiber from soy hulls and beet pulps (Table 1). After birth the lambs were fed with only maternal milk, then from 20 to 60 days of age were gradually weaned with a pelleted starter that was initially composed, for both groups, with a mix of the two prenatal concentrates. After weaning, during the growing phase until the first parturition, the lambs were fed with diets similar to those offered in prenatal life (S and F, respectively) but accounting for the higher protein requirements (Table 1). In early lactation (until 54 DIM) all the 24 ewes received a glucogenic (S) diet based on corn meal, soybean meal, finally chopped ryegrass hay and chopped straw and offered as total mixed ration. The choice of using the same S diet, in early lactation for all groups, assumed that glucogenic substrates in this phase are needed to support metabolic efforts until the lactation peak. From 55 to 160 days in milk (DIM) the ewes with S and F background, homogeneous per yield and BCS, where split to S or F total mixed rations (with 24%, S, and 13%, F, of starch plus sugars, DM basis), creating 4 groups of 6 ewes each: SS, SF, FS and FF based on the dietary sequence applied between prenatal life and parturition and between mid-lactation to the end of the experiment. Milk yield and composition were measured each 10 days, BCS every two weeks and intake every 20 days. Milk production and composition and fat and protein corrected milk yield (FPCMY; Pulina *et al*., 2004) were compared by using the PROC MIXED procedure of SAS for repeated measurements considering as fixed effects the mid-lactation diets (2 levels: S and F for glucogenic and lypogenic diets, respectively) nested within the nutritional background (2 levels: growing and prenatal diets: S and F), and the sheep as random effect.

Table 1. Feeds used for the experimental diets in the last two months of prenatal life (last 75 days of gestation), growing phases (from weaning to first lambing) and lactation (from lambing until 160 days)

Offered feeds	Hay	Prenatal concentrate		Growing concentrate		Lactation total mixed ration*	
Item		Diet S	Diet F	Diet S	Diet F	Diet S	Diet F
Dry matter, % of as fed	90.0	87.5	86.4	86.4	86.4	88.3	88.7
Crude protein, % of DM	11.0	17.6	17.9	20.1	19.1	17.2	16.4
NDF, % of DM	63.1	15.7	32.9	20.2	40.2	41.3	50.2
ADF, % of DM	49.9	6.2	27.9	8.6	27.9	23.4	31.9
ADL, % of DM	3.9	1.2	1.7	0.9	1.7	3.8	4.9
Ether extract, % of DM	1.1	2.9	3.2	2.8	3.0	2.7	2.0
Ashes, % of DM	11.3	8.5	10.3	4.4	5.9	8.4	8.6
NFC, % of DM	26.7	55.3	35.7	52.6	31.8	30.5	22.9
Starch and sugars, % of DM		44.5	15.4	42.3	13.7	23.8	12.8
Forage: concentrate ratio		45/55	45/55	40/60	40/60		

* TMR was fed ad libitum; during milking each ewe received 160 gr/d of DM of pelleted mix (17% of CP, 24% of NDF, 4% of EE and 9% of ashes).

III – Results and discussion

Animal performances at 54 days of lactation before to switch to mid-lactation diets, mean ± SE of milk production was equal to 1.592 ± 0.323 kg/d per ewe, whereas BCS was 2.85 ± 0.15. On average for the first lactation, the nutritional background did not influence significantly the milk production (Table 2). Even though it was observed a significant effect on daily milk yield for the interaction between nutritional background and mid-lactation diet and in particular the diet F favored higher milk yield in animals with glucogenic background ((P<0.001; Table 2). Milk composition was not significantly affected by prenatal diet or mid-lactation diet, except than for lactose content, which resulted very low in the FF group (Table 2). It perhaps indicates heavy shortages of glucose for lactose synthesis in the group FF fed with lypogenic diets after a lypogenic background. It has to be noticed that milk fat and protein contents were also low in respect to the standards of the Sarda breed and it was partially attributed to a negative effect of the small TMR particle sizes on animal rumination. High starch background (S) favored higher FPCMY on ewes fed low starch from 55 to 160 DIM (1.483 vs. 1.231 ± 0.150 kg/d for SF vs. SS, respectively). The shape of the lactation curve of the SF group showed higher FPCMY persistency than SS group (Figure 1). At the opposite, for lypogenic background (F) FPCMY persistency was similar among FS and FF groups (Table 2; Figure 1). On ewes exposed to glucogenic background (S) the use of digestible fiber in mid-lactation was significantly associated to maintain FPCMY after 110 DIM (P<0.05; Figure 1). The observed differences among SS and SF were numerically high, whereas tested statistical significances were quite poor, it was attributed to the high variation among individuals and to the low number of ewes included in each group. FPCMY at 150 DIM was 1.242 ± 0.196 vs. 0.886 ± 0.214 kg/d (P<0.05) for SF vs. SS ewes, and 0.947 ± 0.214 vs. 0.770 ± 0.196 for FA and FF ewes (P>0.20). Differences among BCS were very small and not significant among the experimental groups, BCS at 160 DIM was 3.00, 2.96, 2.94, 3.02 ± 0.10 for SS, SF, FS and FF, respectively.

Table 2. Animal performances in mid and late lactation. Reported values of animal performance and milk composition were calculated as average from 55 days from lambing to end of lactation

Background diets: (prenatal and growing)	Glucogenic, high starch (S)			Lipogenic, high digestible fiber (F)			Statistics		
Mid lactation diet	Starch (SS)	Fiber (SF)	Mean+SE n = 12	Starch (FS)	Fiber (FF)	Mean+SE n = 12	Background (B)[a]	Lactation (L)[a]	Interaction (B X L)[a]
Milk, gr/d	1225	1606	1434 ± 53	1365	1253	1309 ± 57	NS	*	****
Fat, %	6.10	5.96	6,02 ± 0.08	5.91	6,04	6.0 ± 0.09	NS	NS	NS
Protein, %	5.59	5.45	5.51 ± 0.05	5.43	5.69	5.56 ± 0.06	NS	NS	**
Lactose, %	4.75	4.95	4,86 ± 0.04	4.78	4.51	4,65 ± 0.05	****	NS	****
FPCM, gr/d	1231	1483	1376 ± 39	1269	1198	1233 ± 48	**	NS	***

[a] Statistical differences within levels of tested effects were equal to NS = not significant * = P<0.1; ** = P<0.05; *** = P<0.01; **** = P<0.001.

The observed results of this research confirmed that feeding high digestible fiber diets from mid to late lactation favors lactation persistency as exposed In previous studies (Cannas *et al*., 2013; Lunesu *et al*., 2016). In addition this research suggests that ewe response to starch and fiber in terms of milk yield is highly dependent on the nutritional background.

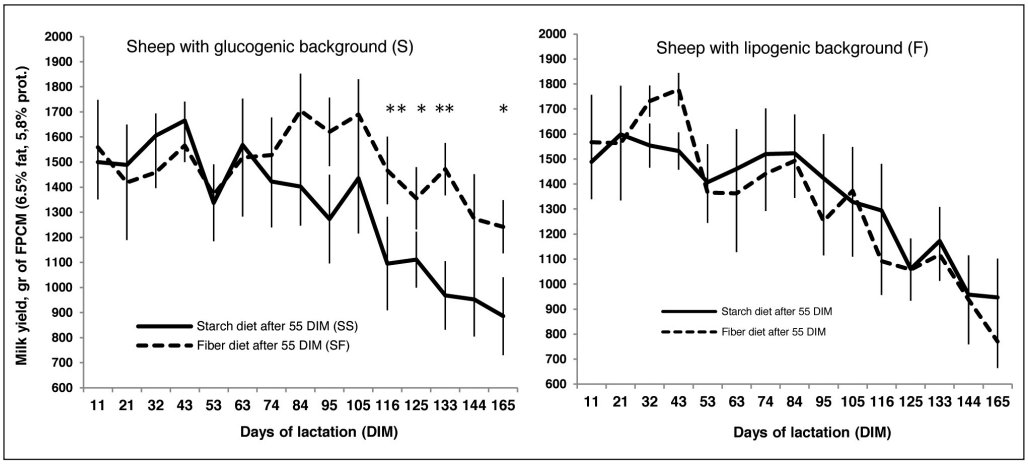

Fig. 1. Production of fat and protein corrected milk (FPCMY) during the first lactation of the experimental ewes. In the first 55 days of lactation all the groups were fed with the glucogenic (S) diet. * and ** indicates that observed FPCMY of the two groups were significantly different for P<0.1 and P<0.05.

IV – Conclusion

The use of glucogenic diets from high starch content or lypogenic diets from high digestible fiber used early in life caused different animal response to amilaceous or fibrous carbohydrates after the first lactation peak. Ewes with glucogenic backgrounds in uterine land growing phases showed higher lactation persistency when the mid lactation diet included low starch and high digestible fiber content. This effect was higher after 110 days of lactation. Otherwise ewes with lypogenic background did not show differences in milk persistency attributable to the dietary carbohydrates used from mid to late lactation. The positive effects obtained with the exposure to glucogenic diets early in life suggest to deeply investigating the hormonal and metabolic mechanisms underlying these results, including insulin sensitivity and energy homeorhesis in mid-lactating dairy sheep.

Aknowledgements

This work was carried out within the project “Permanent effects of starch and fiber supplied during uterine and postnatal life of dairy sheep on gastrointestinal microbiota and energy partitioning between milk production and fat deposition” funded by the Italian Ministry of University and Research (Future in Research Program, 2013).

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Eskardillo: a platform based on individual animal data collection to improve decision making in dairy goat farms

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Abstract. Dairy goat sector is experiencing the intensification process observed in dairy cattle systems consisting on maximizing productivity, efficiency and profitability. To achieve this ambitious goal Cabrandalucía Federation has implemented a new concept of farming based on the use of the 'Eskardillo', a smart phone-based platform which relies on three principles: i) systematic individual data recording (milking control, productivity, genetic value, morphology, phylogeny, prolificacy), ii) big data processing and interpretation and iii) interactive feed back to the farmer to optimize decision making. In this case study twelve farms belonging to the Murciano-Granadina goat breeding association (Caprigran), which implemented the Eskardillo in 2014, were monitored from 2013 to 2016 in terms of genetic value and productivity of individual animals to determine the effectiveness of this platform. The results demonstrated that the implementation of the Eskardillo platform implied a holistic and data-driven management, which aided to optimize the first kidding age, dry period length and culling strategy which helped to minimize "invisible loses" derived from unproductive periods. Eskardillo management also accelerated the genetic progress and milk yield due to a better identification and monitoring of animal productivity. This platform could also provide additional benefits derived from implementing precision feeding practices or sustainability parameters integration. Thus, a more detailed study is required to fully evaluate the impact of Eskardillo platform on farm profitability over the years to come.

Keywords. Dairy goats – Eskardillo – Farm management – Milk production – Precision livestock farming.

Eskardillo: une plateforme basée sur la collecte de données par animal pour améliorer la prise de décision dans les élevages de chèvres laitières

Résumé. *L'industrie de caprin laitier subit une intensification similaire à celle du bovin laitier visant ainsi à maximiser la productivité, l'efficience et la rentabilité. Pour atteindre cet objectif ambitieux, la Fédération Cabrandalucía a élaboré un nouveau concept de gestion du bétail basée sur l'utilisation de 'Eskardillo', une plateforme via smart-phone qui repose sur trois principes: i) la collecte systématique des données individuelles (contrôle laitier, de la productivité, la valeur génétique, la morphologie, la phylogénie, la prolificité); ii) le traitement et l'interprétation des données sur une grande échelle; iii) l'impression interactive de l'éleveur afin d'optimiser la prise de décision. Dans cette étude de cas et dans l'objectif d'évaluer l'efficacité de cette plate-forme, douze fermes appartenant à l'association des éleveurs de race Murciano-Granadina (Caprigran) et qui a d'ailleurs mis en œuvre le Eskardillo en 2014, ont été choisi pour un suivi individuel de valeur génétique et de productivité des animaux et ce, de 2013 à 2016. Cette étude a montré que l'implantation de la plateforme Eskardillo impliquait une gestion holistique et axée sur des données, ce qui a contribué à l'optimisation de l'âge à la première mise-bas, la durée du tarissement et la stratégie de réforme permettant ainsi de minimiser les «pertes invisibles» résultant de périodes improductives. Cette plate-forme pourrait également fournir des avantages supplémentaires découlant de la mise en œuvre des pratiques d'alimentation de précision et de l'intégration des paramètres de durabilité. Ainsi, une étude plus détaillée est nécessaire pour évaluer complètement l'impact de la plate-forme Eskardillo sur la rentabilité agricole au cours des années à venir*

Mots-clés. *Caprin laitier – Eskardillo – Gestion de ferme – Production laitière – Élevage de précision.*

I – Introduction

Livestock production today has to combine several requirements such as food safety, animal welfare, animal health, and environmental and economic sustainability in a wide sense. The consequence is a growing need to monitor many variables during the production process. One alternative consists on using Precision Livestock Farming (PLF) which consists on the use of forward-thinking technologies to optimize the contribution of each individual animal. Through this "individual animal management", the farmer aims to deliver better results in livestock farming in comparison to those which manage the flock as a whole. These results can be quantitative, qualitative or addressing sustainability concerns.

Precision Livestock Farming is made possible by monitoring each individual animal which although sounds futuristic, it has been made during millennia. In olden days when flock sizes were small, farmers could identify animals by name and point out who the parents were and sum up other important morphological and productive characteristics. As a result, they could select those offspring born from the most productive animals. Thus, each animal was approached and managed as an individual given the inherent diversity among them. However, during the last three decades the ruminant livestock sector has experienced a vast intensification and farms have scale up their size and have incorporated highly automated processes for feeding and other tasks which manage the flock as a whole. Farmers generally work with average values per group without taking into consideration each animal particularity and the inter-animal variation is perceived as an impediment to achieve economies of scale. On the contrary PLF is taking advantage of this inter-animal variability to enhance farm productivity. Using modern tools for data collection and information technologies, farmers now can easily measure and monitor numerous attributes of each animal such as age, reproduction, health, pedigree, performance and product quality. Three key aspects are needed to unlock the potential of PLF: 1) Electronic Identification (EID): each animal gets a unique number (equivalent to the ear-tag) which can be read by a handheld "reader". 2) Consistency in the data collection from each animal. 3) A piece of software to instantaneously transmit and process the data on servers and provide the feed-back to the farmer´s terminal. When this platform is available and easy to apply several economic and societal goals could be achieved in terms of higher quantity, quality and food safety, efficient production, sustainability, animal health and well-being, low footprint of livestock and farmer professionalization. However the level of effectiveness of implementing these PLF platforms has not been studied yet.

To date, most of the PLF concepts have been developed for monogastric livestock such as pigs (e.g. improve ventilation in buildings, cough recognition, thermal control, weight estimation, sensor placement robot, precision feeding), poultry (e.g. egg counting and identification, hatching synchronization, carcass inspection) and fish (optimizing sizing and sorting) (Banhazi *et al*., 2012). In ruminants PLF has mainly focused in very specific aspects of dairy cattle such as implementation of automatic milking robots (John *et al*., 2016), oestrus detection (Mottram, 2016) and health prevention (Bull *et al*., 1996). The dairy goat sector is currently experiencing the intensification process observed in dairy cattle however, to our knowledge, very little PLF concepts have been implemented yet. The dairy goat sector has a series of peculiarities such as low net margin per animal, relatively low automatization in feeding and milking systems, absence of dynamic buildings, and frequent utilization of grazing-based systems which limit the implementation of PLF concepts. Thus, a more holistic approach is needed that focuses in the monitoring of individual animals and their performance if PLF-like concepts are to be implemented in the dairy goat sector.

Cabrandalucía Federation (www.cabrandalucia.com) has implemented a new concept of farming based on the use of "Eskardillo", a smart phone-based platform which incorporates PLF-like principles. Thus, the aim of this paper is to monitor 12 case study farms which implemented the Eskardillo in 2014 in order to reveal the effect of this platform on key parameters related with animal productivity and ultimately the farm sustainability.

II – Materials and methods

Eskardillo itself is an Android smartphone-like terminal which incorporates 4 elements: An Electronic Identification reader to identify animals *in situ.* A barcode reader to identify milk tubes for the milk control, blood tubes for genotyping, biopsy tubes for post-mortem analysis or drugs/vaccines used. A digital camera to take pictures for post-mortem certificates. And a mobile-phone SIM card to store data with Wi-Fi connection for data transfer.

However, Eskardillo platform is a broader term which relies on three principles: 1) systematic individual data recording such as milk yield and composition every 4 weeks, genetic value, morphology, phylogeny, prolificacy, etc., 2) big data processing and interpretation and 3) interactive feedback to the farmer to optimize decision making. A management index is calculated for each animal based on its genetic value, morphology and productivity which summarizes the quality of each animal in comparison with the flock average. Thus this management index represents an easy-to-use approach to discern between animals with high potential (which should be inseminated with high merit billy goats) to those with low potential which should be discarded from the farm. Table 1 summarizes the main inputs and outputs in the Eskardillo platform.

Table 1. Summary of the main inputs and outputs required for the Eskardillo platform regarding to individual animals

INPUT	OUTPUT / FEEDBACK TO FARMER
At birth	**At birth**
Date of birth	Genetic value and accuracy
Type of partum (single/tweens/caesarean/miscarriage)	Management index
Provisional ID Ear-tag / Tattoo / Blood tube barcode	Records for future paternity / maternity DNA
Sex	Appropriateness as reproductive female
Mother ID (one or various)	Appropriateness as reproductive male
Father ID (one or various)	Appropriateness as high merit male for insemination centre
During growin	**During growin**
Permanent ID	Updated genetic value for animals to be sold as replacement
Assessment of animals into groups for treatments	Sorting and grouping animals for treatments / measurements
Sanitary records	Updated genetic / sanitary information from animals bought
Movement of animals from farms / slaughtered	Notification of animal movements/treatments to authorities
Slaughtered animal ID	Animal traceability and fulfilment of drug withdraw period
Deaths and reasons	Optimal time for first matting / Artificial Insemination (AI)
During the productive life	**During the productive life**
Morphological evaluation	Updated morphological value and management index
Date lactation begins	Updated days in milking and productivity
Prolificacy	Recording reproductive problems
Number of partum (productive cycles)	Identify top animals for artificial Insemination (AI)Milk yield and quality every 4 weeksIdentify bottom animals for culling
Number of milk controls per lactation	Identify unproductive animals for culling
Total milk yield/quality in certified lactations	Updated genetic valueLactation curveIdentify the optimum moment for AI/matting based on milk yield
Sanitary treatments	Grouping of animals for sanitary treatments and records
Location (pen)	Updated location of animals in the farm
Echography results for pregnancy	Estimated day for delivery or relocation for further AI/matting
Day dry period begins	Updated census of lactating / pregnant + lactating / dry animals
Day and reason of culling / death (ID / biopsy / photo)	Post-mortem analysis and updated census of total animals

In order to evaluate the effectiveness of the Eskardillo platform on the farm productivity, a total of 12 Spanish dairy goat farms were selected based on several aspects:

1. They belong to the same Murciano-Granadina breeding association (CAPRIGRAN), therefore data were collected and processed using the same standards.
2. They implemented the Eskardillo platform in 2014, thus they can be considered as pioneers in this innovation and have available data from 2013 to 2016.
3. They are managed by forward thinking farmers who consistently use the Eskardillo as a key management tool in the farm.
4. They have maintained a similar production system during the course of this study and have not suffered relevant health issues which could comprise data interpretation.

Three data files per farm were generated compiling the key information from two years before (2013) to two year after (2016) the Eskardillo platform was implemented:

The **milk control file** compiles information about each animal (ID, mother ID, father ID), relevant dates (day of birth, day in which each lactation begins, day dry period begins, date of death / culling and reason), reproductive information (number of partum, type of partum, litter size, etc.) and milk yield based on the milk control performed every 4 weeks during the lactation (days on milk, milk yield and composition). Since most dairy goat farms have lactations starting all year around, it was decided to use day in which the lactation finishes as the factor which determines lactation allocation to each natural year.

The **productive ranking file** compiles all those goats which successfully achieved an certified lactation consisting on a minimum 210 days in milking (150 days for primiparous goats) having not missing more than 2 milk controls (1 for primiparous goats).

The **genetic value file** compiles the updated genetic merit of each individual animal each year. This genetic value is calculated based on the productivity (milk yield and quality) of each animal and its relatives. Only those animals present in the farm with a genetic value with accuracy above 50% were considered.

Each farm was considered as experimental unit, thus data from animals belonging to each farm were averaged. Data were analysed by ANOVA considering each year (from 2013 to 2016) as fix factor and each farm as a block. Since the age to the first partum and the dry period length did not follow a normal distribution, data were grouped into intervals and a further ANOVA was performed for each individual interval. Differences among means were compared with the LSD when $P<0.05$, while P values between 0.05 y 0.10 were considered as trends. The impact of the Eskardillo on a given parameter was also expressed as the proportion of the 2016 data with respect to the year the platform was implemented (2014).

III – Results and discussion

(Pleguezuelos *et al*., 2013) described the situation of the Spanish dairy goat sector based on the analysis of 68.352 lactations of a total of 31.859 Murciano-Granadina goats before the Eskardillo implementation. This study revealed the presence of “invisible loses” which are not registered in the farm accountability due to its measurement difficulty. The main drivers of these invisible loses are the unproductive periods in which the animal do not produce such as the first partum age or the dry period, and those periods in which the animal is not able to cover its production cost such as the late lactation stage. Pleguezuelos *et al*., revealed that up to 74% of the dairy goats have a first partum age above the optimum (13-14 months), moreover 42.9% of the animals had it above 17 months which can be considered excessive and thus an unproductive period. Our data (Figure 1) based on

the study of 12 farms revealed a substantial decrease (-24%) in the proportion of animals which have an excessive first partum age (15-16 months) as well as an increase (+49%) in the proportion of animals with an optimum age (13-14 months) resulting on a tendency to decrease the average first partum age (P=0.076). Moreover, these primiparous goats experienced a substantial increase in the milk yield over the total lactation (+13%) and 150d-length certificated lactation (+11%).

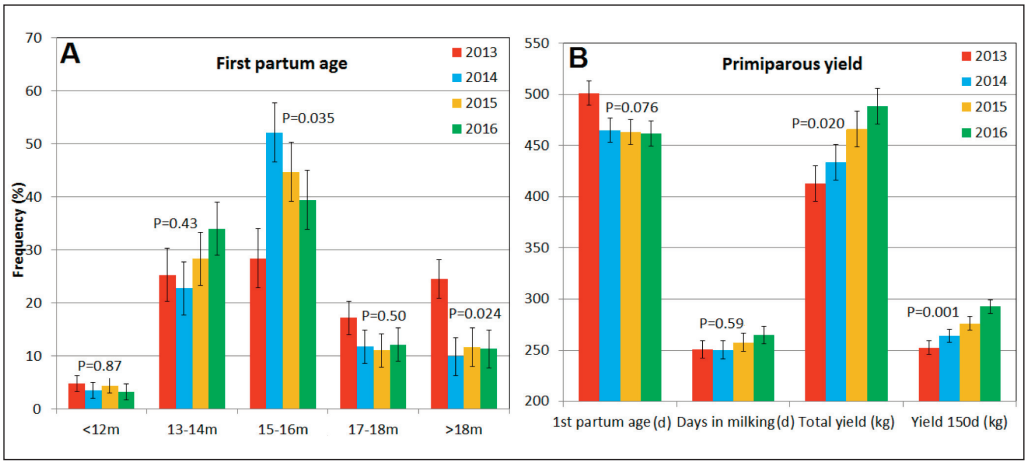

Fig. 1. Frequency distribution of the 1st partum age (A) and milk yield of primiparous goats from 2012 to 2016 (n= 12 farms).

Pleguezuelos *et al*. (2013) also revealed that up to 85% of the dairy goats have a dry period above the optimum length (61d). Moreover 44% of the animals had a dry period length above 91d which can be considered as unproductive period. Our study revealed that the 12 farms evaluated already have a relatively low dry period length in 2012 (81 days), thus a narrow margin for improvement was expected. Nevertheless, Eskardillo implementation promoted a decrease in the proportion of animals with a dry period length above 151 days (-93%), between 121-150d (-79%) and between 91-120d (-15%), with the subsequent improvement (+21%) in the proportion of those between 61-90d, which can be considered as the optimum length (Figure 2). This improvement in the dry period length could be achieved due to the implementation of a well-defined reproductive plan which estimates the optimum moment for the conception according to the milk yield of each individual animal with a target dry-period length equal to 60d (Caja *et al*., 2006). Eskardillo management also led to an increase in the milk yield per total lactation (+10%) and 210d normalized lactation (+7.1%) over the 2 year-course since this platform was implemented.

Eskardillo also allowed to better monitor the productivity of each individual animal resulting on a substantial increase in the number of certificated lactations per year (+33%) since this platform was implemented (Figure 3). These certified lactations showed a similar increase in milk yield than previously described for the total lactations (+9.3%). Several factors could explain this increased productivity such as a strict culling strategy based on identifying unproductive animals as well as the execution of a well-defined genetic selection program as was showed by a substantial increase in the genetic value for milk yield (P=0.003) and milk components such as milk fat (P<0.001), protein (P<0.001) and solids (P=0.008).

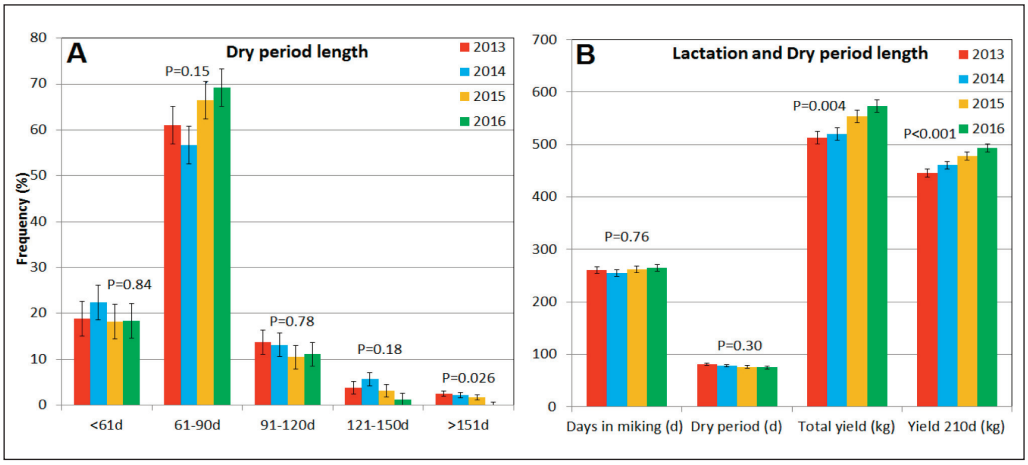

Fig. 2. Frequency distribution of the dry period length (A) and milk yield (B) from 2012 to 2016. (n=12 farms).

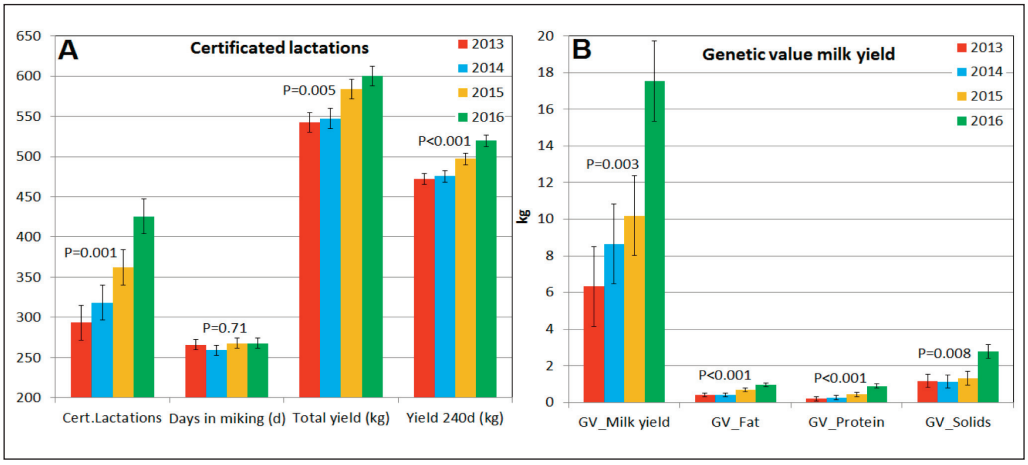

Fig. 2. Number of certified lactations per farm (A) and average genetic value (B) from 2012 to 2016. (*n*=12 farms).

IV – Conclusions

The implementation of the Eskardillo platform implied a holistic and data-driven farm management. This platform helped to optimize the first kidding age, dry period length and culling strategy and thus minimized the "invisible loses" derived from unproductive periods. Eskardillo management also accelerated the genetic progress and milk yield due to a better identification and monitoring of animal productivity. This platform could also provide additional benefits derived from implementing precision feeding practices or integrating sustainability parameters.. Thus, a more detailed study is required to fully evaluate the impact of Eskardillo platform on farm profitability over the years to come.

Acknowledgements

This work was carried out in the framework of the iSAGE project (Innovation for Sustainable Sheep and Goat Production in Europe), funded by the the European Union's Horizon 2020 research and innovation programme under grant agreement No 679302.

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Evaluation of subsidies for rangelands in development of sheep and goat farming

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Abstract. The production of sheep and goat is heavily dependent on grazing for feed needs of livestocks in Turkey. This requires that the yield of fodder has to be increased to the level of meeting the livestocks' needs. For this reason, rangelands are improved and put into service for breeders by government. It is aimed to provide a sustainable fodder yield on these rangelands. The effects of the improvement works on breeders and rangelands should be studied. This research is conducted in 11 villages where the most improvement works are carried out and implemented. The breeders who produce sheep and goat in villages are the population of the study and the sampling volume is determined according to these numbers. The sampling volume is fixed by 89, according to the Stratified Sampling Method. The data obtained are analyzed by Chi-square test and evaluated with regard to the analysis results. According to the study results, the correlation between the breeders' view about finding rangelands improvement works successful and their age, level of education, land size and forage crops production are found statistically significant ($p<0.05$). In respect to sustainability, according to the analysis results; the correlation between the demand for the sustainable rangeland use and the variables of rangelands improvement works, producing forage crops and the low feed cost is found statistically significant ($p<0.05$). According to the analysis and evaluations, it is found that rangelands improvement works carried out in the study field are not successful and sustainable use of rangelands will not be realized in respect to socio-economic factors.

Keywords. Rangeland improvement and management works – Sustainability in rangelands – Rangeland supports – Turkey.

I – Introduction

Even though the rangelands in Turkey have been grazed for centuries, so far any planned management and improvement works have not been carried out. Moreover, they have not been considered as lands where forage crops grow and supply constant feed source for livestocks. That's why, they have been and are being destructively used. This has led to the destruction of the forage crops and loss of yield in the rangelands. The destructive use of rangelands has had a damaging impact not only on livestock breeding and agriculture in Turkey, but also the general economy and the future of Turkey. There are six main reasons why meadows and rangelands in Turkey have been seriously damaged; namely, over grazing, early grazing, drought, uncontrolled grazing, burning and weed invasion. Through the scientific research and test carried out in agriculturally developed continents and countries such as Europe, United States of America, Australia and New Zealand for many years, the main principles that can easily be used in other parts of the world have been established (Ekiz *et al*. 2001). Small livestock production in Turkey highly depends on small family businesses that prefer to graze their livestocks in rangelands. That's why, it is imperative to increase productivity of the forage crops in rangelands. Within this scope, rangelands are given priority when determining the rural improvement policies. It is crucial to render rangelands productive in order to protect the natural resources and the environment in rural areas, increase the

standard of life and foster livestock breeding. Small livestock production in Turkey highly depends on grazing in rangelands, which make it essential to increase the yield of forage crops in the rangelands so much that it meets the demand. Therefore, rangelands are improved and given to the use of breeders through government funding. Rangeland improvement efforts are expected to prevent breeders' immigration from rural areas to cities and increase the standard of life in rural areas. Rangelands in Turkey are fully owned by the state and the right to use them is allocated to multiple villages and municipalities. In addition to this, the rangelands that are in surplus are rented out to either private businesses or corporations breeding livestock.

Sheep and goat production is the cheapest way of livestock breeding in Turkey. Small livestock breeding has an important place in Turkish economy. Sheep and goats supply 24.75% of the overall meat production, 12.35% of milk production, and 63.18% of the leather production in Turkey. Even though Turkey has a remarkable potential for small livestock breeding, it is not properly fulfilled. As it is looked at the historical improvement of sheep and goat production in Turkey, it is seen that it has considerably shrunk since 1980 (Anonymous, 2012). Small livestock breeding is vital in meat, milk, wool, goat's hair and leather production, not to mention the ice cream and textile sectors. Sheep and goat based products are vitally important for human beings' diet. This sector is extremely important in terms of not only the affordability and availability of animal protein, but also communities' balanced diet. Small livestock breeding, which is known to have been one of the sources of income of human beings, has historically had a significant place in agricultural economies and always provides millions of people around the world with employment. Sheep and goats are highly adaptable to poor rangeland and weather conditions. This characteristic is particularly important for developing countries. Sheep and goats that can take best out of rangelands all year round are extremely favorable to Turkey's geographical features. Sheep and goats' high adaptability to poor rangeland conditions helps breeders to turn this disadvantage into a big advantage. Considering its geographical features and large rangelands, Turkey has the potentiality for affordable and quality breeding. The majority of the meadows and rangelands in the country are underproductive and mostly appropriate for small livestock breeding (Anonymous, 2012).

One of the major problems of Turkish agriculture is the insufficient production of quality roughage. Therefore, it is essential to improve the conditions in the meadows and rangelands so as to upgrade breeding and increase the employment in the country. Considering quality roughage deficit in the country and the objectives particularly set for small livestock breeding, rangelands should be hastily improved and given to the use of breeders.

The social, environmental and economic aspects of sustainable improvement have their own important subtopics such as social needs, biological diversity, production and cultural heritage. It would be more appropriate to analyze the interaction among these aspects, instead of examining them independently. At this point, it is strictly necessary to handle this issue as a serious project that not only improves Turkey's limited and non-renewable sources, but also protects them. Therefore, some rangeland improvement works are being carried out in order to optimize the sustainable income flow in small livestock breeding in Turkey. Moreover, breeders are informed about these efforts through publications. Between 1998 and 2016, 1083 projects were carried out in the rangelands as large as 5.065.601 decare and more studies are still being done (Anonymous, 2016). Therefore, it is now essential to analyze the effects of these studies made in the rangelands on their users' point of view. The study of these effects is expected to provide information about the characteristics of the target group that uses the rangelands. To achieve this, in this study, the existing uses of the completely managed and improved rangelands have been analyzed and the effects of these studies on breeders have been determined.

II – Materials and methods

The scope of this study is the villages of 11 provinces that have the highest areas of rangeland improvement works. The statistics regarding the villages was obtained from the Plant Production General Directorate of Ministry of Food, Agriculture and Livestock. The sample unit was the agricultural farms doing small livestock production in those villages. The data were collected through face to face interviews with 89 randomly selected breeders. To analyze the sustainable rangeland use and determine how successful the works are, chi-square test was used. The analysis results are significant at the $p<0.05$ level.

Fig. 1. Photographs in the study area.

III – Results and discussion

The ages of small livestock breeders participating in the study are between 23 and 81, with an average of 50.36. It is found that 77.5% of the breeders are either primary school graduates or have a lower education level. Table 1 displays the socio-economic characteristics of the breeders attending the study, the results regarding the level of achievement and sustainability in the fully improved rangelands. When the table is analyzed, it is seen that 47.4% of the breeders that produce small livestock for the markets find rangeland improvement works unsuccessful, while 52.6% of them think they are successful. 69.7% of the breeders in the same group indicate that the sustainable plant productivity will decrease in time. 69.2% of the breeders who produce only for the consumption of their families state that rangeland improvement efforts are unsuccessful while 30.8% of them think they are victorious. 46.2% of the breeders in the same group state that the sustainable plant productivity in the completely improved rangelands will not last long. On the other hand, 53.8% of them believe that sustainable plant productivity will be consistent. According to the data obtained, the breeders who produce for livestock markets find rangeland improvement works more successful than the breeders producing solely for their families do. One of the main reasons for this could be the fact that the breeders in the former group have participated in the rangeland improvement efforts more.

63.2% of the small livestock breeders state that they have no source of income other than breeding and plant production. Moreover, it is found that 85.4% of the breeders produce for the livestock markets. As for the land size, 55.1% of the breeders have less than 61 decare and 61.8% of them have more than 10 livestock per breeder. It is found that although they have been using rangelands for years, 62.9% of the breeders do not know anything about what pasture law is. Furthermore, this study is expected to shed light to find out what rangelands mean to breeders. The breeders' responses show that 30.4% of them think rangelands are important to prevent erosion, while 59.6% of them state they are crucial for livestock reproduction. In this study, it is also determined to what extent users have an effect on the choice of rangelands improvement works carried out in the research area. According to the results, it is found that 52.8% of the breeders have voluntarily wanted

the improvement works to be made in their villages. It is also found that 44.9% of the breeders had the training on meadows and rangelands before the rangeland improvement works were initiated. In the research area, the amount of roughage grown to ease off the need to graze in rangelands is important, as well. That's why, the breeders were asked whether they produce roughage or not. The results indicate that approximately 50% of the breeders grew fodder crop before the rangelands improvement works. User participation in rangeland improvement works is among the outstanding factors in terms of success, sustainability and preserving rangelands. In the research area, it is found that 73% of the breeders took part in the rangeland improvement works. This study also aims to display the benefits of the improvement works to both the breeders and the rangelands. On breeders' side, rangeland improvement works ensure that livestocks are better fed (58.9%), natural habitat looks much better (44.9%) and fodder crop costs are lower (56.2%). As per the pasture law, the village rangelands that are in surplus could be rented out by Provincial Directorates of Agriculture to be used as rangelands again. The rate of breeders that would like to rent out the rangelands in surplus is found 43.8%. In order to preserve rangelands and organize the improvement works, in accordance with the pasture law, Rangeland Management Unions are being founded. 70.1% of the breeders interviewed state that they are willing to join these unions.

When Table 1 is analysed, it is seen that age and total land size are significant variables in the breeders' views about the success of rangeland improvement works ($P<0.05$). As far as distribution of age is concerned, it is found that the rate of finding improvement works successful is higher among the breeders who are 50 years of age or younger. As for the total land size, the breeders who own 61 decares of land or more have a higher rate of finding improvement works successful. It is seen that the correlation between the view about the importance of rangelands in terms of livestock reproduction and breeders' finding improvement works successful is statistically significant, as well ($P<0.05$). As the rate of breeders thinking that rangelands are important for livestock reproduction increases, the rate of breeders' finding improvement works successful decreases. The correlation between the view about the rangelands helping livestocks feed better and breeders' finding improvement works successful is statistically significant, too ($P<0.05$). The breeders who state that rangelands feed livestocks better have a lower rate of considering rangeland improvement works successful.

As far as the views about sustainability are concerned, the correlation between the view about the importance of rangelands in terms of preventing erosion and the view about the sustainability is statistically significant. ($P<0.05$). The breeders who hold that rangelands are important to prevent erosion have a higher rating of sustainability, compared to the breeders who don't. The correlation between the breeders' demand for rangeland improvement works and the view of sustainability is considered significant statistically, too ($P<0.05$). The breeders demanding improvement works in the rangelands they use have a high opinion of sustainability. Similarly, the breeders who indicate that rangelands make natural habitat look better maintain higher rates for sustainability. The correlation between the view about decrease in fodder crop thanks to rangelands and sustainability is statistically significant, as well. Accordingly, it can be said that the breeders emphasizing that thanks to rangelands, fodder crop consumption has decreased have a higher approval rating of sustainability.

Table 1. Distribution of opinions of breeders on the success and sustainability of rangeland improvement works by socio-economic characteristics

		Rangeland Improvement Works are Successful			Are Rangeland Improvement Works Sustainable?			
Variables		No	Yes	χ^2	No	Yes	χ^2	T
Age	≤50	20 (40.0)	30 (60.0)	**5.09***	29 (58.0)	21 (42.0)	3.51	50 (56.2)
	>50	25 (64.1)	14 (35.9)		30 (76.9)	9 (23.1)		39 (43.8)
Education Level	≤Primary	37 (53.6)	32 (46.4)	1.15	46 (66.7)	23 (33.3)	0.20	69 (77.5)
	≥Secondary	8 (40.0)	12 (60.0)		13 (65.0)	7 (35.0)		20 (22.5)
Non-Agricultural Income Source	Yes	17 (54.8)	14 (45.2)	0.35	21 (67.7)	10 (32.3)	0.05	31 (34.8)
	No	28 (48.3)	30 (51.7)		38 (65.5)	20 (34.5)		58 (63.2)
Total Land Size	≤ 61	34 (69.4)	15 (30.6)	**15.46****	35 (71.4)	14 (28.6)	1.29	49 (55.1)
	>61	11 (27.5)	29 (72.5)		24 (60.0)	16 (40.0)		40 (44.9)
Small Livestock Count	≤10 Animal Unite	13 (38.2)	21 (61.8)	3.34	24 (70.6)	10 (29.4)	0.45	34 (38.2)
	>10 Animal Unite	32 (58.2)	23 (41.8)		35 (63.6)	20 (36.4)		55 (61.8)
Purpose of Breeding	Livestock Market	36 (47.4)	40 (52.6)	2.12	53 (69.7)	23 (30.3)	2.76	76 (85.4)
	Family Consumption	9 (69.2)	4 (30.8)		6 (46.2)	7 (53.8)		13 (14.6)
Aware of Pasture Law	Yes	15 (45.5)	18 (54.5)	0.55	21 (63.6)	12 (36.4)	0.17	33 (37.1)
	No	30 (53.6)	26 (46.4)		38 (67.9)	18 (32.1)		56 (62.9)
Rangelands are Important to Prevent Erosion	Not Important	13 (56.5)	10 (43.5)	1.53	16 (69.6)	7 (30.4)	**12.33****	23 (25.8)
	Quite Important	21 (53.8)	18 (46.2)		32 (82.1)	7 (17.9)		39 (43.8)
	Important	11 (40.7)	16 (59.3)		11 (40.7)	16 (59.3)		27 (30.4)
Rangelands are Important to Reproduce Livestock	Not Important	2 (22.2)	7 (77.8)	**4.63***	5 (55.6)	4 (44.4)	4.08	9 (10.1)
	Quite Important	12 (44.4)	15 (55.6)		22 (81.5)	5 (18.5)		27 (30.3)
	Important	31 (58.5)	22 (41.5)		32 (60.4)	21 (39.6)		53 (59.6)
Demand for Rangeland Improvement Works	Yes	21 (44.7)	26 (55.3)	1.39	25 (53.2)	22 (46.8)	**7.65***	47 (52.8)
	No	24 (57.1)	18 (42.9)		34 (81.0)	8 (19.0)		42 (47.2)
Being Informed on Rangelands	Yes	17 (42.5)	23 (57.5)	1.89	24 (60.0)	16 (40.0)	1.29	40 (44.9)
	No	28 (57.1)	21 (42.9)		35 (71.4)	14 (28.6)		49 (55.1)
Fodder Crop Production	Yes	21 (47.7)	23 (52.3)	0.28	26 (59.1)	18 (40.9)	2.02	44 (49.4)
	No	24 (53.3)	21 (46.7)		33 (73.3)	12 (26.7)		45 (50.6)
Participation in Rangeland Improvement Works	Yes	31 (47.7)	34 (52.3)	0.79	41 (63.1)	24 (36.9)	1.16	65 (73.0)
	No	14 (58.3)	10 (41.7)		18 (75.0)	6 (25.0)		24 (27.0)
Rangelands are Important to feed Livestock	No	22 (41.5)	31 (58.5)	**4.29***	35 (66.0)	18 (34.0)	0.04	53 (41.1)
	Yes	35 (46.1)	41 (53.9)		48 (63.2)	28 (36.8)		76 (58.9)
Rangelands Make Natural Habitat Look Better	No	27 (55.1)	22 (44.9)	0.90	38 (77.6)	11 (22.4)	**6.19***	49 (55.1)
	Yes	18 (45.0)	22 (55.0)		21 (52.5)	19 (47.5)		40 (44.9)
Rangelands Decrease Fodder Crop Costs	No	25 (50.0)	25 (50.0)	0.01	37 (74.0)	13 (26.0)	3.03	50 (56.2)
	Yes	20 (51.3)	19 (48.7)		22 (56.4)	17 (43.6)		39 (43.8)
Renting Out Rangelands in Surplus	Yes	19 (48.7)	20 (51.3)	0.09	25 (64.1)	14 (35.9)	0.15	39 (43.8)
	No	26 (52.0)	24 (48.0)		34 (68.0)	16 (32.0)		50 (56.2)
Willingness to Join Rangelands Management Unions	Yes	30 (47.6)	33 (52.4)	0.75	41 (65.1)	22 (34.9)	0.14	63 (70.1)
	No	15 (57.7)	11 (42.3)		18 (69.2)	8 (30.8)		26 (29.9)
Decrease in Fodder Crop	I don't agree	23 (59.0)	16 (41.0)	1.96	34 (87.2)	5 (12.8)	**13.55****	39 (43.8)
	I agree	22 (44.0)	28 (56.0)		25 (50.0)	25 (50.0)		50 (56.2)
Aware of Grazing Plan	Yes	33 (49.3)	34 (50.7)	0.19	42 (62.7)	25 (37.3)	1.58	67 (75.3)
	No	12 (54.5)	10 (45.5)		17 (77.3)	5 (22.7)		22 (24.7)
Complying with Grazing Plan	Yes	33 (49.3)	34 (50.7)	0.19	42 (62.7)	25 (37.3)	1.58	67 (75.3)
	No	12 (54.5)	10 (45.5)		17 (77.3)	5 (22.7)		22 (24.7)

* P<0.05; ** P<0.01.

IV – Conclusions

It is aimed that plant productivity is sustained in the completely developed rangelands used by breeders. To achieve this, the impact of the breeders on the rangeland improvement works has been evaluated. In this study, the correlations among the socio-economic characteristics of the breeders, their points of view about the state of sustainability of rangeland improvement works and the level of achievement have been analyzed and evaluated. According to the results, it is found that age, land size, the importance of rangelands for livestock reproduction and the view that rangelands feed livestocks better are correlated with the view about achievement in rangeland impro-

vement works. 60% of the breeders under the age of 50 think that rangeland improvement works are a success. This rate is reduced to 35.9% among the breeders who are older than 50 years of age. It is seen that 72.5% of the breeders owning over 61 decares of land find improvement works successful. While 53.9% of the breeders that think rangelands feed livestocks better consider improvement works a success, this rate is 58.5% among other breeders. 59.3% of the breeders who feel that rangelands are important to prevent erosion find improvement works sustainable. 47.5% of the breeders who indicate rangelands make natural habitat look better think that improvement works are sustainable. This rate is reduced to 22.4% among other breeders. The half of the breeders who say that thanks to rangelands, fodder crop consumption has decreased find improvement works sustainable. According to the results, it can be said that the breeders who actively participated in the rangeland improvement works by providing manpower, tools and equipment find improvement works more successful than other breeders surveyed in this study.

As a result, small livestock production in Turkey highly depends on meadows and rangelands. Therefore, they need to be thoroughly improved and turned into more productive source of roughage for livestocks. By intensifying the improvement works and ensuring sustainability, it is highly probable to meet the demand for red meat, enhance small livestock breeding, prevent breeders' immigration to cities and maintain sustainability in livestock breeding in Turkey. That's why, subsidies for rangeland improvement should be continuously paid. According to the results obtained in this study, it is essential to prioritize to increase breeders' participation in the future rangeland improvement works and carry out these works in the areas where the breeders producing livestock for the markets are densely found. If all these objectives are achieved, the success in rangeland improvement works and the level of sustainable rangeland use are expected to considerably improve.

Acknowledgements

This work has been funded by TAGEM (Agricultural Research General Directorate); through Grand TEAD/ 13/A15/P01/005-001.

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Comportement au pâturage des chèvres dans les montagnes du rif marocain par l'utilisation de nouvelles techniques

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Résumé. Le pâturage est associé à des activités quotidiennes significativement différentes de celles des animaux en stabulation, comme le comportement et la distance parcourue. L'évaluation de l'intensité du pâturage est un élément important pour prendre des décisions pour une gestion adéquate des parcours. Cette étude a été menée dans un parcours forestier dans les montagnes du rif marocain (Derdara), exclusivement utilisé par des éleveurs caprins, afin d'évaluer leur mouvement spatio-temporel et leurs activités pendant deux saisons (printemps et été). Huit chèvres ont été équipées de colliers GPS et de « IceTags ». Le temps de pâturage et la distance parcourue ont été estimés à 9 h et 6,9 km par jour au printemps, contre 12 h et 9,2 km en été. La courte durée du pâturage au printemps peut être expliquée par la forte disponibilité fourragère. En été, les chèvres sont fatiguées en raison de la température élevée qui limite leur mouvement en altitude. Au printemps, 62,4% de l'activité animale est consacrée au pâturage et 68,7% en été. Pendant la saison estivale, les chèvres se déplacent plus qu'au printemps (6600 vs 4400 pas/jour), confirmé par les résultats des colliers GPS. La zone de pâturage, l'itinéraire et la distance parcourue par les chèvres varient en fonction de la saison. L'information obtenue sur le comportement des chèvres au pâturage en utilisant de nouvelles techniques, associée à des données quantitatives sur l'apport alimentaire et la production en biomasse, pourrait être utile à l'avenir pour une meilleure gestion du troupeau dans le temps et dans l'espace.

Mots-clés. Pâturage – Comportement – Chèvre – Montagne du rif.

Grazing behaviour of goats in Rif Mountains of Morocco by using new techniques

Abstract. *Grazing is associated with daily activities significantly different from those of animals in confinement, such as grazing behaviour and distance covered. The assessment of grazing intensity is important for making adequate management decisions on rangelands. This study was conducted in a forest rangeland of the Moroccan Rif Mountains (Derdara) exclusively used by goat's herds to assess their spatio-temporal movement and activities during two seasons (spring and summer). Eight goats were fitted by GPS collars and IceTags activity monitors. Grazing time and covered distance were estimated per day at 9 h and 6.9 km in spring vs 12 h and 9.2 in summer. The short duration of grazing during spring compares to summer, can be explained by the high forage supply. In summer, goats are exhausted due to the high temperature which limits their movement in altitude. In spring, 62.4% of animal activity is devoted to grazing, for 68.7% in summer. During the dry seasons goats move more compared to spring (6600 vs 4400 steps per day) which was confirmed by the GPS collars results. Rangeland area, itinerary and covered distance by goats vary depending on the season. The obtained information on the grazing behavior of goats by using new techniques, coupled with quantitative data on feed intake and biomass production of pastoral area, could be useful in future for a better management of herds in time and space.*

Keywords. *Grazing – Behaviour – Goat – Rif mountain.*

I – Introduction

Dans les montagnes du rif marocain, la plupart des élevages caprins sont conduits exclusivement ou partiellement dans des systèmes d'élevage extensif dans lesquels la majorité des nutriments proviennent des parcours. Le pâturage est associé à des activités journalières considérablement différentes de celles des animaux en stabulation, tels que le temps de pâturage et les distances parcourues (Osuji, 1974; Lachica et Aguilera, 2003).

À ce jour, les travaux de recherche se sont principalement concentrés sur l'étude du comportement des chèvres au niveau du laboratoire et par l'observation directe sur le terrain. Bien que du travail considérable soit nécessaire avec des animaux au pâturage, les mesures ont été uniquement faites de jour et avec un observateur dont la présence peut modifier le comportement des animaux (Barroso *et al.,* 2000; Papachristou *et al.,* 2005; El Aich *et al.,* 2007). Actuellement, de nouvelles techniques sont proposées afin de caractériser le comportement des petits ruminants sur parcours et tout au long de la journée. Parmi ces techniques on peut citer : l'utilisation des colliers GPS et des capteurs d'activité comme les « IceTags ».

L'évaluation du comportement des chèvres sur parcours, par l'utilisation des techniques de précision, est une approche technologique nouvelle et prometteuse dans le but d'améliorer les stratégies de gestion et les performances de production des élevages en extensif. Ce travail de recherche vise à évaluer le mouvement spatio-temporel et l'état des activités physiques des chèvres pendant le pâturage, par l'utilisation des colliers GPS et des capteurs IceTags.

II – Matériel and méthodes

L'étude a été réalisée au niveau du parcours forestier de Derdara (35° 28' N 5° 18' O) qui fait partie du domaine forestier de Chefchaouen, situé au nord du Maroc. Ce parcours est caractérisé par une végétation à base de chêne liège et par une strate arbustive dominée principalement par : *Arbutus unedo, Cistus crispus, Cistus monspeliensis, Erica arborea, Lavandula stoeches* et *Mentha pulegium.*

L'étude du comportement des caprins sur parcours a concerné principalement l'évaluation de l'itinéraire, la distance de déplacement et l'état d'activité physique des chèvres durant deux saisons de l'année (printemps et été). Les mesures ont été effectuées dans'un élevage caprin laitier, sur 8 chèvres (race locale), qui présentent les mêmes âge et stade physiologique, durant trois jours de mesure continue pour chaque saison.

Pour déterminer les itinéraires et la distance de déplacement des chèvres sur parcours, on a utilisé 8 colliers GPS, installés au niveau du cou de l'animal. Ces colliers GPS enregistrent l'emplacement des chèvres selon les coordonnées globales, à 5 min intervalle.

Pour mesurer l'état d'activité physique des caprins sur parcours, on a utilisé 8 bracelets « IceTags ». Ce dispositif est fixé à l'une des pattes postérieures de la chèvre. Les données de sortie concernent le nombre des pas, le temps passé debout, couché, ou en action (marche).

Les IceTags ont été utilisés simultanément avec les colliers GPS sur les mêmes chèvres pour les deux saisons de mesure. Une période d'adaptation de 3 jours par saison a été nécessaire pour que les chèvres s'acclimatent aux deux appareils. Pour la synchronisation et la validation des résultats obtenus, deux observateurs sur le terrain ont enregistré les données observées et les paramètres que les appareils ne peuvent enregistrer : heure de début et de fin du pâturage.

III – Résultats et discussion

1. Itinéraire de déplacement et aire de pâturage des chèvres sur parcours

D'après nos observations sur le terrain, la sortie des chèvres vers le pâturage dépend de la saison. Au printemps, le pâturage débute, après la traite du matin, vers 9 h, soit une heure plus tard qu'en période estivale (8 h du matin). La durée journalière du pâturage a été estimée de 8 à 9 h par jour au printemps et de 11 à 12 h en été. Au printemps, le pâturage est continu, tout au long de la journée, avec des périodes de repos très courtes, pendant lesquelles les chèvres ruminent et se reposent à l'ombre. En été, la durée du repos du troupeau est plus longue, elle peut aller jusqu'à 1 h, majoritairement aux alentours de 14 h, lorsque les chèvres s'installent à côté d'un point d'eau (rivière) pour

s'abreuver, ce point d'eau se trouve à 250 m d'altitude, considéré comme étant le point le plus bas du parcours (fig. 1). La courte durée de pâturage au printemps par rapport à l'été, pourrait s'expliquer par la forte disponibilité en espèces pastorales qui sont en pleine saison de pic végétatif, à une époque où les espèces pastorales les plus appétentes sont les plus présentes. Pendant l'été, la végétation pastorale appétente devient de plus en plus rare, à cause du surpâturage, et du fait qu'elle coïncide avec la fin de la saison végétative de la plupart des espèces pastorales, obligeant les éleveurs à rester une durée plus longue sur le parcours pour faire profiter au maximum le troupeau.

Les conditions climatiques favorables de la saison printanière, favorisent le déplacement du troupeau caprin vers d'autres horizons plus hautes au niveau du parcours de Derdara où la végétation est plus appétente et plus abondante. L'été, les caprins sont plus fatigués à cause de la chaleur, ce qui limite leur déplacement en altitude, surtout en milieu de journée (fig. 1)

Au nord du Maroc, le pâturage est constitué en majorité de parcours forestiers qui restent des espaces domaniaux où le pâturage extensif est mal accepté par les autorités locales. La superficie de ces espaces de pâturage reste inconnue et aucune étude n'a permis de les délimiter. A travers l'utilisation des colliers GPS, nous avons pu estimer cette aire de pâturage, au niveau du parcours de Déradera, à 151 ha avec un périmètre de 9,9 km. Cette aire de pâturage varie considérablement en fonction de la saison. Au printemps, il est estimé à 65 ha, avec un itinéraire de déplacement de 6,9 km/jour. En été, l'aire de pâturage est plus importante avec 123 ha et une distance de déplacement journalière de 9,2 km (fig. 2).

Pendant l'été, l'aire de pâturage double et le troupeau se déplace 2,3 km de plus qu'en saison printanière. Ce changement dans le comportement des chèvres sur le parcours peut être expliqué par la faible offre pastorale, pendant la saison sèche, où les chèvres explorent d'autres espaces à la recherche de la végétation appétente.

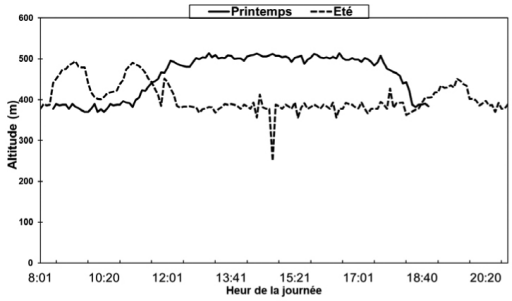

Fig. 1. Altitude de déplacement des chèvres sur le parcours de Derdara.

Fig. 2. Itinéraire de déplacement des chèvres sur le parcours de Derdara.

2. Etude de l'activité physique des chèvres sur parcours

Les résultats obtenus montrent que pendant l'été les chèvres se déplacent plus, ce qui a été confirmé par rapport aux colliers GPS. Au printemps, 62,4% de l'activité de l'animal est consacrée au pâturage, contre 68,7% en été.

Au début du pâturage jusqu'à midi, les chèvres sont plus actives pendant les deux saisons, mais à partir du début de l'après-midi, cette activité commence à changer surtout en été où les chèvres deviennent inactives et ce, à cause de la chaleur. A travers les données récupérées des colliers GPS et des IceTags, plusieurs paramètres influencent le comportement des chèvres sur parcours, à savoir : la température, l'altitude de déplacement et le degré de disponibilité des d'espèces pastorales appétentes. Vers la fin de la journée de la saison estivale, quand la température baisse et la température devient plus fraiche, le troupeau montre une forte activité de pâturage à la recherche de plus d'espèces pastorales à brouter (fig. 3).

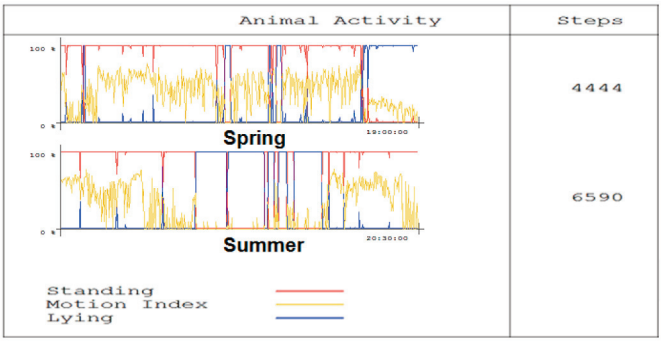

Fig. 3. Activité physique des chèvres sur le parcours de Derdara.

IV – Conclusions

L'utilisation des colliers GPS et des IceTags nous ont permis d'avoir une connaissance plus pointue sur les différentes activités des chèvres et leur déplacement sur un parcours forestier. L'aire de pâturage, qui reste la clé de l'élaboration d'un système de gestion des parcours forestier au Maroc, a été déterminée grâce à l'utilisation des colliers GPS.

Les informations obtenues sur le comportement des caprins pendant le pâturage en utilisant de nouvelles techniques, associées à des données quantitatives sur les prélèvements des caprins et la production en biomasse des pâturages, nous permettra dans l'avenir de mieux gérer le troupeau dans le temps et l'espace.

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Phenotyping intake rate in dairy goats, a repeatable trait which can be measured automatically

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Abstract. In intensive systems, high producing animals are at risk of acidosis due to the high proportion of concentrates in their diet. There is considerable variability between individuals in occurrence and severity of acidosis which is likely related to feeding behaviour. Phenotyping this behaviour could explain some of the variation in digestive efficiency, and therefore in feed efficiency. Feeding behaviour was assessed at three periods (1st and 2nd lactations, 2nd gestation) on thirty-five contemporary goats. The evolution of feed intake during 15 hours after the afternoon allowance was measured individually every 2 min for 3 days. Two phenotypes were calculated: Q90 (quantity of diet consumed during the first 90 minutes post-feeding), P90 (Q90/quantity consumed during 15 hours). Intra-period individual repeatability was very high. The value for one period was highly correlated with that of a preceding one for P90, but poorly for Q90. Given this repeatability, it would be possible to characterise the feeding behaviour of all the goats during their first lactation and, in the following lactations, to restrict feed allowance of those with the highest P90 or Q90 in order to decrease the occurrence of acidosis in the herd, and thereby increase efficiency. These results on the variability of intake rate show that simple criteria to phenotype goats on intake rate can be applied in precision livestock farming systems.

Keywords. Precision livestock farming – Phenotyping – Intake rate – Dairy goats.

Phénotypage de la vitesse d'ingestion des chèvres laitières, une caractéristique utile et répétable qui peut être mesurée automatiquement

***Résumé**. Dans les systèmes intensifs, les animaux hauts producteurs reçoivent une ration riche en aliments concentrés, mais peuvent souffrir d'acidose avec une occurrence et une intensité variables d'un animal à l'autre qui seraient liées au comportement alimentaire. Le phénotypage de ce comportement expliquerait une partie des variations de l'efficacité de la digestion, et donc de l'efficacité alimentaire. Ce comportement a été mesuré à trois périodes (1ère et 2nde lactations, 2nde gestation) sur trente-cinq chèvres contemporaines. L'évolution de l'ingestion pendant les 15 heures suivant la distribution de l'après-midi a été mesurée individuellement toutes les 2 min pendant 3 jours. Deux phénotypes ont été calculés : Q90 (quantité d'aliment ingérée pendant les 90 minutes suivant la distribution), P90 (Q90/quantité ingérée en 15 h).La répétabilité individuelle était très élevée intra-période. La valeur à une période donnée était fortement corrélée à celle de la période précédente pour P90, mais faiblement pour Q90. Ainsi, il serait possible de caractériser le comportement alimentaire de toutes les chèvres pendant leur première lactation et, pour les lactations suivantes, de restreindre la quantité d'aliment distribuée pour celles présentant les plus hauts P90 ou Q90 afin de diminuer l'apparition de l'acidose dans le troupeau, et donc d'augmenter son efficacité. Ces résultats sur la variabilité de la vitesse d'ingestion montrent que des critères simples peuvent être proposés pour phénotyper les chèvres dans le cadre de l'élevage de précision.*

***Mots-clés.** Elevage de précision – Phénotypage – Vitesse d'ingestion – Chèvres laitières.*

I – Introduction

In intensive systems, high producing animals are fed with a high proportion of concentrates in the diet to meet their requirements. With such acidogenic diets, animals often suffer from acidosis with an occurrence and an intensity differing from one animal to another (Brown *et al.*, 2000; Gao and

Oba, 2014). In previous studies, we showed that feeding behaviour is a key factor to explain the inter-individual variation in the evolution of rumen pH, and therefore in the occurrence of acidosis (Desnoyers *et al.*, 2011). The aim of this study was to develop repeatable, pertinent, and easy to measure criteria to evaluate this trait in dairy goats.

II – Material and methods

1. Animals, Design, Diets and Feeding

The present study was carried out according to French legislation on animal experimentation in line with the European Convention for the Protection of Vertebrates used for Experimental and other Scientific Purposes (European Directive 86/609). Protocols were approved by the ethical committee.

Feeding behaviour was assessed at three different periods during their adult life on thirty-five dairy goats born in early 2011:

- Middle of first lactation (spring 2012)
- End of first lactation and middle of second gestation (autumn 2012)
- Middle of second lactation (spring 2013)

Thirteen goats were from Alpine breed and twenty-two from Saanen breed. At each period of measurement they were housed for 12 days, including 9 days of adaptation, in individual pens with automatic measurement of the quantity of feed eaten every two minutes with free access to feed and water (Giger-Reverdin *et al.*, 2012).

They were fed *ad libitum* a complete diet adapted to requirements. On a dry matter basis, its composition was: 20% concentrate, 20% meadow hay, 30% dehydrated Lucerne and 30% pressed sugar beet pulp silage. One third of the diet was delivered after the morning milking (around 7 a.m.) and two thirds after the afternoon milking (around 3 p.m.) according to the intervals between milkings.

Animals were weighed at each experimental period before the afternoon milking. Dry matter content of the diet was measured during each period of measurement

2. Recording of dynamic patterns of intake

The evolution of feed intake during 15 hours after the afternoon allowance was automatically measured by weighing devices fitted under individual feed-troughs with a recording frequency of every 2 minutes on three days in each period. Two phenotypes were automatically calculated and analysed:

- Q90: quantity of diet consumed by 90 minutes post afternoon feed distribution expressed on a dry matter basis per kg of body weight.
- P90: ratio between Q90 and total quantity of feed consumed between the afternoon feed distribution and the next morning milking (consumption in fifteen hours). This is an estimation of the rate of intake during the main eating phase after feed distribution.

3. Statistical analysis

The mean values and standard deviation of P90 and Q90 were calculated per goat at each period. Across animals, the average variability was estimated as the average of the standard deviation of this mean value. It was estimated for each period (n = 35 goats), and for the combined three periods (n = 105 observations).

Between-animal variability per period was estimated by the standard deviation of the individual goat mean value. A variance analysis was performed with all the period combinations.

The correlations between periods were calculated using the individual within-period means.

III – Results and discussion

1. Factors of variation of the phenotypes

A. Evolution between periods and between-goat variability

The mean Q90 value varied from 8.90 to 27.4 g DM/kg BW with a mean value of 16.1 and a standard deviation of 3.63 (n = 105). It was similar between the first two periods (P1 = 14.6 ± 3.36 vs P2 = 14.8 ± 2.83) and significantly higher at the third period (18.8 ± 3.03).

The mean P90 value varied from 0.242 to 0.768, with a mean value of 0.499 and a standard deviation of 0.1115 (n = 105). It was significantly lower for the first period (0.416 ± 0.1055) compared to the others (P2 = 0.524 ± 0.0972 vs P3 = 0.556 ± 0.0796). The between-goat variability decreased as goats get older. The mean value of 0.499 showed that goats ate around half of the total intake of the 15 hours during the first 90 minutes after feed allowance.

The increase in P90 as goats get older is also in agreement with the observations on cows as primiparous cows ate more slowly than multiparous (Beauchemin and Rode, 1994; Neave *et al.*, 2017).

The effect of goat was significant for these two variables (Q90 and P90) which shows a significant between animals variability. This agrees with previous data on goats (Daovy *et al.*, 2008) or on cows (Vasilatos and Wangsness, 1980) suggesting that eating behaviour may be characteristic of individuals.

B. Across animals, average repeatability

The mean standard deviation of the Q90 value/goat/period varied from 0.13 to 4.18 with a mean value of 1.56 (± 0.896). It was the highest during the first period (2.05) but not significantly different for the other two periods (P2 = 1.33 and P3 = 1.29).

The mean standard deviation of the P90 value/goat/period varied from 0.0057 to 0.0941 with a mean value of 0.0422 (± 0.02321). It decreased significantly from the first (0.0520) to the third period (0.0343) with a mean value of 0.0406 for the second period which did not differ from each of the other periods.

The period effect was significant for these two variables, but there was no goat effect. These values show that there is a good repeatability for each goat within a period, and that the behaviour is more repeatable as animals get older.

2. Evolution between periods

The quantity eaten during the 90 first minutes of the first period was highly correlated with that eaten at the second period (r = 0.61, n = 35, P = 0.001) and correlated with that of the third period (r = 0.42, n = 35, P = 0.01). However, the correlation between the quantities eaten at the second and third periods was not significant. For the P90, the highest correlation concerned the first with the third period (r = 0.63, n = 35, P = 0.001). The others were also significant: (P1 and P2, r = 0.54, P = 0.001; P2 and P3, r = 0.38, P = 0.03).

These results meant that the rate of intake (P90) is more repeatable than the Q90 and is a characteristic of the feeding behaviour of the goat.

IV – Conclusion and practical implications

It is possible to derive summary measures to characterise the feeding behaviour of all the goats. This suggests that this could be evaluated during their first lactation (corresponding to the first period of this trial) and, in the following lactations, to restrict the feed allowance of those with the highest P90 or Q90 in order to decrease the risk of acidosis in the herd, and then increase efficiency and welfare (Giger-Reverdin *et al.*, 2013).

Acknowledgments

We gratefully acknowledge Joseph Tessier, Alexandra Eymard, Ophélie Dhumez and the team at the Inra-AgroParisTech UMR 791 Modélisation Systémique Appliquée aux Ruminants (Paris, France) experimental installation for the care of the animals.

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Feeding strategy of Lacaune dairy sheep: dairy ewes fed in groups according to their milk yield

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Résumé. En France, les brebis laitières Lacaune du rayon de Roquefort sont alimentées en groupes avec grande variabilité de niveau de production de lait (MY). Un essai a été conduit en début de stade de lactation (50 j) pendant 100 jours avec trois lots de 54 brebis adultes sur la base de leur MY(l/j) : haut (H, 3,2), moyen (M, 2,7) ou bas (L, 2,2). Chaque lot était divisé en 2 groupes alimentés soit avec le même niveau de concentrés (CH, CM et CL) soit avec un apport ajusté à la MYdu groupe (EH, EM et EL). Toutes les brebis recevaient un mélange de fourrages distribué à volonté. Les quantités ingérées de fourrages n'ont pas été différentes (P>0,05) entre les groupes H et M (2,3 ± 0,17 kg MS), mais celles de CL(2,0 ± 0,17 kg MS) étaient inférieures (P<0,05) à EL(2,2 ± 0,17 kg DM). La variation de poids de EH (59,2 g/j) était supérieure (P<0,01) à celle de CH (33,9 g/j), et non significative (P>0,05) pour les autres groupes de même que pour l'état corporel. Aucun effet n'a été observé (P>0,05) sur la MY, la composition du lait ou les cellules somatiques. Seule la concentration en urée du lait de ELétait inférieure (P<0,001) à celle de CL. Aucun effet n'a été observé sur les paramètres biochimiques sanguins entre les lots E et C. Dans nos conditions, l'ajustement des apports de concentrés n'a ni économisé du concentré ni modifié la production de lait et sa qualité.

Mots-clés. Brebis laitière – Alimentation en lots – Production laitière – Composition du lait – Ingestion.

Feeding strategy of Lacaune dairy sheep: dairy ewes fed in groups according to their milk yield

Abstract. *In France, Lacaune dairy sheep in the Roquefort area are fed in groups with a wide range of milk yields (MY). In order to adapt concentrate levels to MY, a100-dayexperimentwas conducted during the early milking period (50 days in milk) with three batches of 54multiparous ewes constituted according to their MY (L/d): high (H: 3.2), medium (M: 2.7) and low (L: 2.2). Each batch was separated into two groups of 27 ewes, a control group (C) and an experimental group (E), fed either with the same level of concentrate(CH, CM and CL) or with concentratesadjusted to theMY (EH, EM and EL), respectively.All ewes were fed a forage mixturead libitum.The average daily individual forage dry matter intake was not different (P>0.05) between groups EH, CH, EM and CM(2.3 ± 0.17 kg DM),but that of CL(2.0 ± 0.17 kg DM) was lower (P<0.05) than EL (2.2 ± 0.17 kg DM).Body weight gain was higher (P<0.01) for EH (59.2 g/d) than for CH (33.9 g/d), but not for the other groups (P>0.05). Body condition score was not affected (P>0.05) by concentrate level in any of the groups.There was no effect (P>0.05) on MY and milk composition. However,the urea level in the milkwas lower (P<0.001) for ELthan CL.There was no effect on metabolism parameters between batches E and C. In our conditions, adjusting concentrates to the MYneither saved concentrate nor changed total milk yield.*

Keywords. *Dairy sheep – Feeding strategy – Milk yield – Milk composition – Intake.*

I – Introduction

In France, in the Roquefort area during thewinter period, confined dairy sheep are fedin batches with the same ration. This ration is determined at the beginning of the milking period on the basis of the milk yield (MY), fat (FC) and protein (PC) contents expected for the average ewe in the batch. Energy and nitrogen intakes are calculated according to INRA recommendations (Hassoun and

Bocquier, 2010) on the requirements of each average ewe, increased by 15% for energy and 25 to 30% for nitrogen. This strategy makes it possible to cover approximately 80% of the energy needs and 90% of the nitrogen needs of the ewes. However, it tends to overfeed a high proportion of the ewes whose needs are much lower than the average ewe and to underfeed the most productive ones. In this context, the interest in constituting more homogeneous milk yield batches makes it possible to provide a more adapted diet to ewes with different yield levels(Bocquier*et al*., 1995).In addition, the formation of batches strongly reduces the heterogeneity of the intra-batch yield level, with a decrease of 24% for two batches and of 30% for three batches (Bocquier *et al*., 1997). Within the framework of the CASDAR AUTELO project dealing with food self-sufficiency, among other things, we once again studied the effect of batch feeding.

II – Material and methods

The experiment was carried out over 14 weeks in a sheepfold during the winter period (2015-2016) at the farm of the Lycée Agricole de La Cazotte (St. Affrique, France). Two batches(**C**, control; **E**, experimental) of 81 multiparous ewesin second lactation or more were formed on the basis of their milk yield (**MY**) at the first control, fat (**FC**) and protein (**PC**) contents, body weight (BW), body condition score (**BCS**) of the litter size and lactation number. Each batch was subdivided into three groups according to the MY, and balanced two-by-twoon the basis of the preceding criteria: two “low” groups (**CL** and **EL**, MY=2.2 L/d), two“medium” (**CM** and **EM**, MY=2.7 L/d) and two “high” (**CH** and **EH**, MY=3.2 L/d).GroupsL, MandHhof batchCwere fed with the same ration calculated on the basis of the BW,theMYand the average FCandPCof the batch with the aim of covering 115% and 125% of the needs in energy (**UFL**) and in nitrogen (**PDI**) according to the system recommended by INRA (Hassoun and Bocquier, 2010). GroupsL, MandHof batch E were fed with the same aim, but taking the average values (BW, MY, FC, PC) of each group. The forage ration common to the two batches was constituted on the basis of the dry matter (DM) of a mixture ofcorn silage (32%), silage (24%) andwrapping (11%)of Italian ryegrass and of alfalfa hay (33%). This mixture was distributed every morning *ad libitum* with a minimum refusal rate of 15%. The type and quantity of concentrates distributed to each group are presented in Table 1.

Table 1. Quantities (kg DM/d/ewe) of concentrate distributed daily to each group during the two periods

	Period 1				Period 2			
	C (L, M, H)	E L	E M	E H	C (L, M, H)	E L	E M	E H
Barley	0.19	0.14	0.19	0.39	0.15	0.00	0.15	0.30
Fortolis énergie®*	0.69	0.53	0.69	0.74	0.45	0.36	0.45	0.53
Dehydratedalfalfa	0.49	0.35	0.49	0.64	0.37	0.27	0.37	0.64
Total	1.37	1.02	1.37	1.77	0.98	0.62	0.98	1.47

* proteincommercial concentrate.

After 35 d (Period 1, **P1**), the quantities of concentrate were decreased and maintained until the end of the experiment to be adjusted to the observed MY (Period 2, **P2**).TheMY, FC, PC and thesomatic cell count (SSC) were measured at the beginning of the experiment and then every two weeks. The urea level in the milk could only be measured as of the 3rd milk control. The BWand theBCSwere measured every month. The dry matter intake (DMI) of the mixture for each group was measured every week for 3 to 4 days. A sample of each forage was taken every two weeks to determine the DM content and kept for analysis. A blood sample was also taken at the beginning of the experiment and then at the same time as the milk controls in order to determine plasma concentrations of glucose (GLU), insulin (INS), nonesterified fatty acids (NEFA) and beta-hydroxybutyrate (BHB) according to the methods described by Gonzalez-Garcia *et al*. (2015).

All of the data were compared intra-group (CHvs. EH; CMvs. EM; and CLvs. EL), and then inter-batch (Cvs. E). Forage dry matter intake was analyzed with the Mann-Whitneynonparametric U test by comparing intake per period and using average weekly measurements. The average daily gain (ADG) between the last weighing and the first at the beginning of the experiment and the variation of the BCS for the same period were analyzed with the Mann-Whitney nonparametric U test. Biochemical blood parameters (GLU, BHB, NEFA and INS) were analyzed with a one-way ANOVA (group) with repeated measurements (time). The MY, FC andPC contents, urea concentration and total fatty matter (TFM),protein (TP) and urea (TU) were analyzed with a one-way ANOVA (batch) each week. Statistical tests were conducted using STATISTICA software, v10,for Windows (Statsoft 2010, www.statsoft.fr).

III – Results and discussion

For the entire experiment, three ewes (1CH, 1EM and 1EL) were removed because of severe mastitis, and no other health problems were observed for the other animals.

1. Dry matter intake

During the first period (P1), the forage DMIswere not different (P>0.05) for groups EHandCH(2.44 vs. 2.43 kg DM/d/ewe) and EM and CM (2.33 vs. 2.42 kg DM/d/ewe), whereas they tended (P=0.066) to be greater forEL (2.27 kg DM/d/ewe) compared toCL (2.05 kg DM/d/ewe). During P2, the same results were observed for EH and CH (2.10vs. 2.26 kg DM/d/ewe) and EM and CM (2.27 vs. 2.25 kg DM/d/ewe). On the other hand, EL consumed more forage (P<0.01) thanCL (2.19 vs. 1.95 kg DM/d/ewe). No difference (P>0.05) was observed between theHandMgroups of the two batches, nor between EHandEL, whereas theDMIof concentrates was clearly greater in P1 (+ 0.75) and P2 (+ 0.85) forEH. Even if the differences between ELandCLfor the two periods can be explained by the substitution phenomenon since CL consumed more concentrate (+ 0.35 kg DM/d/ewe),it was not observed in the other cases despite greater differences in concentrate intake. These results are in contradiction with those observed by Bocquier *et al*. (1997) that did not reveal the effect of MY level at similar stages of lactation (61 d). Nevertheless, the MY sat the beginning of the experiment were lower (2.02 L/d/ewe) and less than that of theLgroups in our experiment (2.2 L/d/ewe),and the ewes were not separated into batches like here. By comparing the results of the regrouped E and C batches, we obtain results identical to the total intake of those obtained with the intake capacity (IC) equation of Bocquier *et al*. (1997).When the concentrate quantities decreased between P1 and P2 (-0.3 to – 0.4 kg DM/d/ewe), forage intake increased for all of the batches in the week that followed from 0.24 to0.38 kg DM/d/ewe, representing a marginal substitution rate of 0.81 to0.98,comparable to the one previously observed (Bocquier *et al*., 1997).

For the totality of both periods (98 d), the total forage concentrate intake for batches C and E was identical, with1.13 and 1.17 kg DM/d/ewe of concentrates and 2.22 and 2.26 kg DM/d/ewe of forage, respectively, as had been previously reported (Bocquier *et al*., 1995) when constituting only two batches for the same period and lactation time.

2. Milk yield,milk composition, weight and body condition score

The adjustment of the rations at the level of the MY, had no effect on the number of somatic cells in the milk. The intra-group MY did not differ throughout the experiment (P>0.05) (Fig. 1), whereas the MY of the EL group tended to be lower that that of the CL group. After the formation of batches, the MY slightly decreased (0 to 0.19 l/ewe) for all of the groups during Period 1. In contrast, after the decrease in concentrate intake (P2) and despite a week of transition, the drop in MY was greater, with 1.3 L/d/ewe (H groups), 1 L/d/ewe (M groups) and 0.7 to 0.9 L/d/ewe (L groups) in 56 days. Likewise,

the FC and PC were not different (P>0.05) for the H (76 and 59 g/L)and M (76 and 59 g/L) groups, but greater for the EL group compared to CL (81 vs. 78 and 62 vs. 59 g/L) as a result of a lower MY. Urea levels in the milk (UR) at each milk control were not significant (P>0.05) for groups H and M. For the seven controls, they were, on average, 0.50 ± 0.051 and 0.51 ± 0.063 g/L and 0.47 ± 0.061 and 0.49 ± 0.064 g/L, respectively. However, they were always lower (P<0.05) for the EL group with an average of 0.43 ± 0.058 g/L and 0.50 ± 0.061 g/L for CL. These results were confirmed for the quantities of fatty matter, proteins and urea that are not different (P>0.05) intra-group (H, M and L), except for the quantities of urea that are lower (P<0.05) for EL, with average values of 0.71 ± 0.125 g/d compared to 0.91 ± 0.176 g/d for CL. When we estimate the cumulative milk yield for the totality of both periods (98 d) for both batches, it is identical (P>0.05), with 205 and 202 L/ewe for batches C and E, respectively. The FC and the PC were also identical for the entire experiment. These results are consistent with those reported by Bocquier *et al*., (1995) when the animals were separated into two milk yield batches (low and high) over the same period and lactation time.

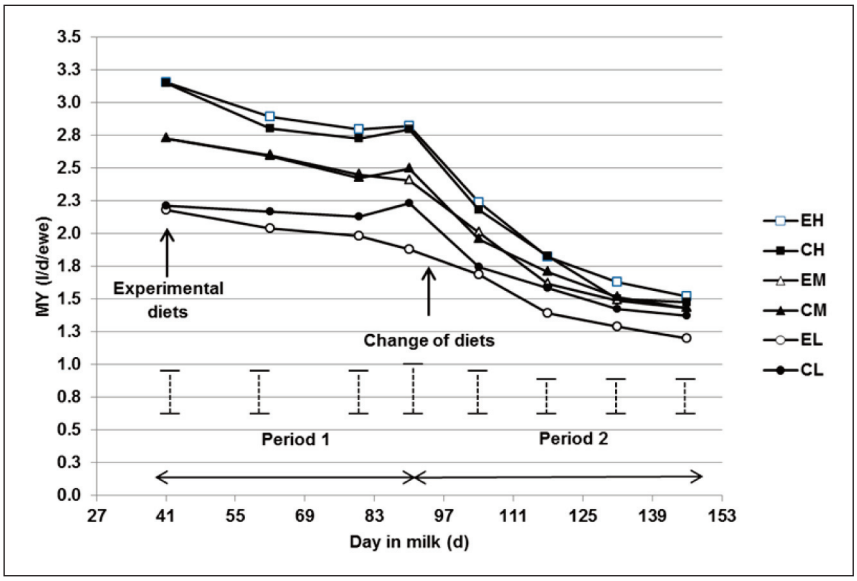

Fig. 1. Milk yield (MY) evolution and standard error (vertical dotted lines) during the two periods.

The ADG was higher (P<0.01) in group EH (59.2 g/d) than in group CH (33.9 g/d), and no difference was observed for groups M and L although the ADG of CL (50.7 g/d) tended to be higher (P=0.11) than that of EL (37.1 g/d). No difference (P>0.05) was observed in the variations of BCS.

3. Biochemical blood parameters

NEFAand GLU levels are not different (P>0.05) between groups or between batches. NEFAlevels are low and comparable to those observed by Gonzalez-Garcia *et al*., (2015) on Lacaune dairy ewes at similar lactation stages when there is no longer any mobilization of body reserves. Consequently, when ewes are fed according to their production level, intake is sufficient to cover their needs in MY, FC and PC. For the EH group, BHB levels were greater (P<0.01) or tended to be than those of the CHgroup as a result of a higher intake of concentrates during the two periods. This can also be seen in the plasma insulin levels that are often higher (P<0.01) for EH compared to TH. In these groups, overfeeding (EH) most likely leads to the accretion of fat in the fatty tissue that is not reflected in the BCS because the method is probably not precise enough.

IV – Conclusions

In the conditions of this experiment with high-quality forage, the adjustment of concentrate intake to the average level of milk yield did not lead to significant changes at the batch level in terms of forage or concentrate intake, milk yield or its composition. Intake adjustment led to a higher weight gain for group EH and a lower one for group EL without affecting the animals' fat cover, whereas the biochemical parameters (insulin, BHB) suggest an accretion of fats in the fatty tissue.As long as the ewes are raised and fed in heterogeneous milk production batches, the equations currently used (Hassoun and Bocquier, 2010) are applicable. On the other hand, if the ewes are to be fed in more homogeneous batches, additional studies should be carried out to better determine substitution phenomena according to MY level and forage quality. An experiment is currently in progress to determine these effects on more homogeneous groups of ewes in terms of milk yield.

Acknowledgments

The authors are grateful to Claire Azam, Laurent Buisson, Jérome Cougoureux, Jean-Luc Ginest and Louise Lefbvre of the Lycée Agricole de La Cazotte for the daily monitoring of the animals, intake, weight and BCS measurements, and blood samples,and to Claude Vacaresse of the Confédération Générale de Roquefort for having organized and overseen milk yield measurements. The authors would also like to thank Zuzanna Holubova for her assistance in preparing plasma samples and biochemical assays.

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Caractérisation des environnements de production et de nouveaux phénotypes pour améliorer la sélection et l'adaptation des ovins et caprins dans des environnements variés

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Résumé. En France, l'évaluation génétique des petits ruminants estime simultanément la valeur génétique des reproducteurs ainsi que les effets d'environnement dont le plus important est l'effet troupeau. Cette évaluation est réalisée dans des environnements variés et mal caractérisés faisant l'hypothèse d'absence d'interaction GxE. Pour tester cette hypothèse et disséquer les composantes des effets troupeaux, les environnements de production seront caractérisés à partir des données collectées en fermes (disponibles dans les systèmes nationaux d'information génétique ou collectées ponctuellement) décrivant les systèmes d'élevages et des données météorologiques. La discrimination des types d'environnements de production établis par la typologie des élevages permettra d'analyser les interactions GxE pour différentes races ovines et caprines en France. Par ailleurs, l'adaptation des petits ruminants à ces environnements variés et changeants implique entre autre leur efficacité d'utilisation des ressources et leur capacité biologique à mobiliser et reconstituer leurs réserves énergétiques sous forme de lipides. Des travaux expérimentaux seront conduits pour étudier les mécanismes biologiques et le déterminisme génétique de la dynamique des réserves corporelles en lien avec l'efficacité alimentaire. Cette approche permettra d'identifier de nouveaux phénotypes pour l'amélioration génétique de la robustesse des petits ruminants.

Mots-clés. Interaction génotype x environnement – Robustesse – Petits ruminants.

Characterizing environment production and exploring new phenotypes to improve genetic selection efficiency and animal adaptation to a variety of environments

Abstract. *The overall sustainability and innovative capacity of the sheep and goat sector in Europe have to be improved to cope with current and future economic, environmental and societal challenges. Innovations in genetic resource management and breeding for sheep and goat populations will be explored in the iSAGE European project (WP5) in order to help the industry to cope with such future challenges. In France, genetic evaluation for small ruminants is performed in a large variability and poorly characterized environments. In this regard, we will consider multi-generation data from existing French breeding programs and experimental field studies. Effects of herd for traits under genetic selection will be investigated in commercial farms in order to better characterize the production environment, particularly using meteorological data but also feeding, breeding system and economic criteria. Such characterization will enable to follow-up trends in animal performances according to weather changes. This work could also contribute to characterize farm typologies to which a set of sustainability indicators will be tested. Then, contrasted environments will be identified and genotype by environment interactions studies will be carried out aiming to improve genetic selection efficiency in a variety of environments. In addition to existing data, we will explore new phenotypes considered as key functional traits for robustness and for which stakeholders are particularly interested. These new phenotypes will be also ex-*

plored in combination with feed efficiency in experimental facilities under contrasted environments or under feed shortage challenges. Genetic and genomic studies will be performed for new phenotypes used to assess individual robustness. The total merit indices will be revisited from the technical and economic point of view in order to evaluate economic weights of each trait in the "breeding goal", for diversified production systems.

Keywords. *GxE interaction – Robustness – Small ruminants.*

I – Introduction

En France, le contexte de sélection des petits ruminants repose sur la sélection des différentes races dans leurs contextes de production. Pour les races locales, elle s'opère dans des milieux parfois difficiles (zones de montagnes) avec une valorisation de l'herbe et des ressources produites par l'exploitation et s'accompagne de règles de production (race, alimentation…) pour les produits bénéficiant de signes officiels de qualité. Pour les races nationales, leurs répartitions sur l'ensemble du territoire contribuent à une diversité de systèmes d'élevage avec parfois un fort contraste météorologique de production (nord/sud, montagne/plaine). Dans un contexte économique tendu (volatilité des prix, coût des intrants, disponibilité de la main d'œuvre…), la demande des éleveurs porte sur la sélection d'animaux adaptés à ces milieux variés et changeants (aléas climatiques) et capables de valoriser les ressources de l'élevage. Cette demande est en adéquation avec les orientations agro-écologiques qui montrent l'importance, en matière de sélection, de la prise en compte de la diversité des profils d'animaux en lien avec la diversité des systèmes (Phocas *et al*. 2017).

Pour apporter des éléments de réponse à ces demandes, l'INRA GenPhySE et l'Institut de l'Elevage réunis au sein de l'Unité Mixte de Technologie Génomique et Génétique des Petits Ruminants ont proposé, dans le cadre du programme européen H2020 iSAGE (www.isage.eu) des approches complémentaires associant des données d'élevage collectées en fermes commerciales et des données expérimentales produites en fermes expérimentales. L'objectif est de contribuer à répondre aux 2 questions suivantes : **1) Y a-t-il des interactions génotype x environnement (GxE) pour les caractères sélectionnés ?** La sélection génétique actuelle fait l'hypothèse d'absence d'interaction GxE : est-ce toujours le cas ? Pour répondre à cette question, les données collectées en fermes permettront de caractériser la diversité des systèmes d'élevages en lien avec les données météorologiques et serviront de support aux études des interactions GxE pour différentes races ovines et caprines. **2) Comment l'animal s'adapte à cet environnement changeant tout en maintenant sa production ?** Il s'agit, aux travers de 2 dispositifs expérimentaux en ovins laitier *et al*laitant, de mieux comprendre les mécanismes d'adaptation et d'identifier de nouveaux phénotypes de la résilience qui pourront ensuite être sélectionnés en fermes. Pour cette approche, le mécanisme clé retenu est l'aptitude au dépôt et/ou à la mobilisation des réserves corporelles en lien avec l'efficacité alimentaire des animaux.

II – Caractérisation des élevages et étude des interactions génotype x environnement

1. Les données de production et effets troupeau

En France, dans les 3 filières de petits ruminants, les évaluations génétiques s'appuient sur des systèmes d'informations dédiés permettant l'enregistrement des données de contrôle de performances, de pedigree et de reproduction depuis de nombreuses années. En ovins allaitants, les performances correspondent aux tailles de portées ainsi qu'aux poids des agneaux à 30 jours afin d'estimer la valeur laitière des mères. En ovins et caprins laitiers, les performances concernent prin-

cipalement la quantité et la qualité du lait. Ces performances enregistrées depuis environ 30 ans permettent l'évaluation génétique des reproducteurs qui sont réalisées, pour ces caractères, à l'aide d'un BLUP modèle animal avec répétabilité. Cette méthode permet d'estimer simultanément la valeur génétique des reproducteurs ainsi que les effets d'environnement dont le plus important est l'effet troupeau. Pour les filières laitières, cet effet « troupeau » se précise jusqu'au numéro de lactation intra-campagne : « troupeau x campagne x numéro de lactation ». Pour les ovins allaitants, l'effet troupeau se précise jusqu'à la période d'agnelage intra-élevage: « troupeau x campagne x période d'agnelage ».

Ces effets troupeaux rassemblent de nombreux effets non identifiés parmi lesquels il y aurait notamment des effets liés aux systèmes d'élevage, à l'alimentation des animaux, à la technicité de l'éleveur, au climat,… Afin de disséquer les différentes composantes des effets troupeaux, il convient de caractériser au mieux ces possibles composantes.

2. Les données de caractérisation des environnements

a. Données météorologiques : En 2010, Vidal *et al*. ont réanalysé avec le système SAFRAN les données météorologiques françaises enregistrées sur les 50 dernières années. Le système SAFRAN consiste en une interpolation des données issues des stations météorologiques sur un maillage dense du territoire (9 892 mailles de 8x8 km). Cette réanalyse a permis de construire une grande base de données contenant pour chaque maille et chaque jour un grand nombre de données météorologiques telles que la température, les humidités relatives et spécifiques, les radiations solaires, l'évapotranspiration etc…

b. Les systèmes d'élevage : Pour les espèces laitières, la mobilisation de données disponibles dans les systèmes nationaux d'information génétique et de données collectées ponctuellement permettent la construction d'une trentaine de variables décrivant les systèmes d'élevage. Ces variables concernent les caractéristiques générales (nombre de femelles, race,...), la situation géographique, la conduite du troupeau, le système alimentaire, le système de valorisation du lait.

A. Analyse des effets de la météo sur les effets élevages : exemple des ovins allaitants

Les variables climatiques peuvent être considérées individuellement ou bien combinées en de nouvelles variables synthétiques telles que le THI (temperature – humidity index) (NRC, 1971) qui peut être calculé à différentes échelles (horaires, quotidiennes…) et cumulé (ACTHI) sur un certain nombre de jours afin de résumer le climat sur cette même période (Santana *et al*., 2015). Pour les brebis allaitantes, nous avons cumulé le THI sur les 30 jours pré-mise-bas (ACTHI-pré) et sur les 30 jours post mise-bas (ACTHI-post). Des analyses préliminaires en race Lacaune viande sur les 10 dernières années tendent à montrer que le THI cumulé (ACTHI-pré ou ACTHI-post) n'aurait pas de lien significatif avec l'effet troupeau à l'échelle de la race, mais qu'il pourrait aussi bien avoir un effet significatif que non-significatif sur l'estimation des effets troupeaux à l'échelle du cheptel (figure 1).

B. Typologie des élevages ovins laitiers et caprins laitiers

L'approche menée en ovins laitiers et caprins laitiers est identique. L'objectif est de constituer une typologie des élevages à partir de l'ensemble des données disponibles : performances, effet « troupeau », valeurs génétiques, données météo, systèmes d'élevage. La première étape consistera à résumer les variables disponibles par élevage à l'aide d'analyses en composantes principales et d'analyses des correspondances multiples. Puis, à l'aide de méthodes de classification, les facteurs principaux (ou composantes principales) seront utilisés pour définir différents groupes d'éleveurs (ou clusters) bien différenciés.

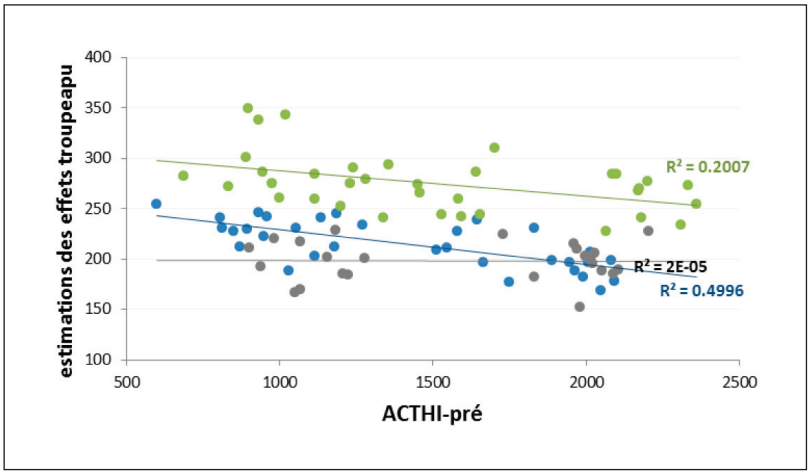

Fig. 1. Effet du THI cumulé durant les 30 jours pré-mise-bas (ACTHI-pré) sur les effets troupeaux estimés durant l'évaluation génétique de la valeur laitière en race Lacaune viande. En bleu, vert et gris sont les résultats obtenus dans trois élevages différents.

3. Interactions Génotype x Environnement

La discrimination des types d'environnements de production établis par la typologie des élevages permettra d'analyser les interactions GXE en ovins laitiers et caprins laitiers en France. Pour cela en fonction de la structure des données et de la description des environnements, nous évaluerons dans les principales races le modèle le plus adapté (multicaractère ou norme de réaction) pour estimer les paramètres génétiques des caractères de production en fonction des environnements.

III – Caractérisation de nouveaux phénotypes d'adaptation

L'adaptation des petits ruminants aux nouvelles contraintes d'élevage repose entre autre sur leur efficacité d'utilisation des ressources impliquant leur efficacité alimentaire et leur capacité biologique à mobiliser et reconstituer leurs réserves énergétiques sous forme de lipides.

La dynamique des réserves corporelles est étudiée chez des brebis allaitantes de race Romane et des brebis laitières de race Lacaune élevées au domaine expérimental INRA de la Fage (Roquefort sur Soulzon). Les brebis allaitantes (350 brebis/280ha) sont élevées en plein air intégral sur des parcours natifs (Causses du Larzac) caractérisés par des terres arides et une végétation steppique. Les brebis sont soumises aux aléas climatiques (été sec et chaud, hiver froid et humide) et aux variations naturelles des ressources alimentaires. Les brebis laitières (600 brebis) sont élevées selon une conduite mixte bergerie et pâturage selon le cahier des charges de l'appellation d'origine protégée Roquefort. Un suivi longitudinal de plusieurs centaines d'animaux couplant des mesures biochimiques (dosages métaboliques et hormonaux dans des échantillons de plasma sanguin), d'imagerie (échographie) et zootechniques (poids vif et notes d'état corporel) permettra de mesurer les variations des réserves corporelles (**RC**) au cours des cycles de production, de la carrière et en réponse à des challenges (environnementaux, nutritionnels…). Le suivi des RC sera réalisé tout au long de deux à trois cycles de production. Le suivi métabolique permettra également de caractériser le bilan énergétique des brebis. Les brebis phénotypées pour la dynamique des RC seront également génotypées pour les marqueurs mono-nucléotidiques (54KSNP). Les mécanismes physiologiques et le déterminisme génétique de la dynamique des RC seront explorés

pour proposer de nouveaux critères de sélection permettant l'amélioration génétique de la robustesse. Les relations entre l'efficacité alimentaire (**EA**) et la dynamique des RC seront étudiées en réalisant le phénotypage décrit ci-dessus chez des ovins allaitants sélectionnés de façon divergente pour l'EA (basse versus haute consommation résiduelle) et en couplant les mesures de RC à des mesures individuelles d'ingestion quotidienne chez les ovins laitiers.

Remerciements

Les auteurs tiennent à remercier les organismes de sélection ovins et caprins, France Conseil Elevage, Météo France, AgroClim, l'agence Bio pour la mise à disposition de données. Ce travail est financé par le projet européen iSAGE (Innovation for Sustainable sheep and goat production in Europe, 2016-2020 ; H2020 contrat nº 679302). Les auteurs remercient vivement Aude Rolland et Audrey Combasteix pour le travail réalisé durant leur stage.

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Feed preference and nutrient digestibility of pelleted or silage form of olive cake as affected by concentrate supplementation

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Abstract. High fiber level of olive cake (OC) is the main limiting factor for its use in animal feeding. Effective industrial-scale destoning process improves its nutritive value but the level of destoned OC (SOC) to be included in the ruminant diets for safe and efficient feeding is yet unclear. Thus, this study was carried out to determine the voluntarily intake of SOC and nutrient digestibility of diet by offering the feed as free-choice. A total of ten, Karya female yearlings were divided into two groups and were fed maize silage-alfalfa hay mix, pellet or silage form of SOC with (Con+) or without concentrate (Con-), as free-choice for 3 weeks. The individual dry matter intake (DMI) was determined for each feedstuff that was offered *ad libitum*. The difference between two groups (with or without concentrate) was compared by independent *t* test. The silage-alfalfa mix, SOC silage and pelleted SOC intake of Con- and Con+ yearlings were 778 and 192; 158 and 56 (P<0.001); and 65 and 40 g/kg DM (*P* =0.06), respectively. The concentrate consumption of Con+ group was 712 g/kg DM. The Con+ yearlings consumed more DM and nutrients, and tended to (P=0.06) grow faster than Con- yearlings. The in vivo apparent DM, organic matter, crude fat, crude protein and non-fiber carbohydrates digestibility were higher in Con+ lambs, while fiber digestibility did not differ (P>0.05) with concentrate supplementation. The results indicated that yearlings had lower preference for SOC as compared to silage-alfalfa mix regardless of the presence of concentrate. The intake of OC was greater in the form of silage than pellet form.

Keywords. Digestibility – Free choice – Intake – Nutritive value – Lamb – Olive cake.

Préférences alimentaires et digestibilité des nutriments des tourteaux d'olive distribués sous forme de pellets ou d'ensilage, influencées par la supplémentation en concentré

Résumé. *Le niveau élevé de fibre dans les tourteaux d'olive (TO) est le principal facteur limitant pour les utiliser en alimentation animale. Un processus effectif de dénoyautage à l'échelle industrielle améliore leur valeur nutritive mais le niveau de tourteaux d'olive dénoyautés (TOD) à incorporer dans les régimes pour ruminants pour les nourrir de façon sûre et efficiente reste encore à définir. Ainsi cette étude a été menée afin de déterminer l'ingestion volontaire de TOD et la digestibilité des nutriments du régime en offrant cet aliment en libre choix. Un total de dix agnelles d'un an de race Karya ont été divisées en deux groupes et ont reçu un mélange d'ensilage de maïs-foin de luzerne, et des TOD sous forme de pellets ou d'ensilage avec (Con+) ou sans concentré (Con-), en libre choix pendant 3 semaines. L'ingestion individuelle de matière sèche (IMS) a été déterminée pour chaque ingrédient qui était offert ad libitum. La différence entre les deux groupes (avec ou sans concentré) a été comparée par t-test indépendant. L'ingestion de mélange ensilage-luzerne, d'ensilage de TOD et de TOD en pellets pour les agnelles Con- et Con+ a été respectivement de 778 et 192; 158 et 56 (P<0,001); et 65 et 40 g/kg MS (P =0,06). La consommation de concentré pour le groupe Con+ était de 712 g/kg MS. Les animaux Con+ consommaient plus de MS et de nutriments, et tendaient à une croissance plus rapide (P=0,06) que les animaux Con-. La digestibilité apparente in vivo de la MS, de la matière organique, de la matière grasse brute, de la protéine brute et des hydrates de carbone non fibreux, a été plus élevée chez les agnelles Con+, tandis que la digestibilité de la fibre n'a pas différé (P>0,05) avec la supplémentation en concentré. Les résultats indiquent que les animaux avaient une moindre préférence pour les TOD en comparaison au mélange ensilage-luzerne indépendamment de la présence de concentré. L'ingestion de TO était plus élevée sous forme d'ensilage que de pellets.*

Mots-clés. *Digestibilité – Libre choix – Ingestion – Valeur nutritive – Agnelle – Tourteau d'olive*.

I – Introduction

In Turkey, livestock production primarily relies on eroded rangelands, agricultural by-products (straw and bran) and to a lesser extent cultivated forages and supplemental grains, where the annual shortage of roughage is estimated to be 15 million tons (TUIK, 2015). Forage supply from rangelands is erratic with high seasonal and annual fluctuations in quality and quantity depending on the management and environmental factors. Feeding cereal grains to animals is costly and being increasingly challenged by the competition between humans and livestock (Hegarty, 2012). Grains can partly be replaced by agro-industrial byproducts in livestock diets without compromising yield and product quality (Ben Salem *et al.* 2014).

Industrial by-products, such as olive cake (OC) can help alleviating the feed gap for ruminants and reduce the feed cost in Mediterranean countries (Ben Salem *et al*. 2014). The OC has been proven to be successfully used both in feedlot and dairy production systems. However, the studies that evaluated the potential of OC in supporting ruminant production have reported inconsequential findings, depending on the nutritive value, inclusion level and substitution level of OC with forage or concentrate in diet, and species and production levels of livestock used in these studies (Abbeddou *et al.* 2015; Cıbık and Keles, 2016; Keles et *al.* 2017). Thus, determination of the voluntarily intake of OC by livestock can help designing successful feeding programs for ruminants.

II – Material and methods

1. Olive cake and feeds

Olive cake was obtained from an olive oil processing plant that performs two-phase oil extraction. Fresh OC was transported to another processing plant where the OC was stoned by using 3.5 mm industrial screen. The stoned olive cake (SOC) was immediately dried with an industrial-scale drier and was either pelleted or directly ensiled into the 120 L drums for a period 6 months without any additives. Four feeds that were compared in the present study as free-choice were; alfalfa-maize silage mix (40:60 in DM basis) as source of roughage, dried SOC, SOC silage and concentrate. Alfalfa hay and maize silage were mixed daily before offering to sheep. The nutritive values of offered feed are presented in Table 1.

Table 1. Nutritive value of feed offered to lambs (g/kg DM)

Feedstuff	OM	EE	CP	NDICP	ADICP	NDF	ADF	ADL	NFC	ME
Roughage	925	21	110	16	10	534	375	100	260	1.7
Concentrate	892	20	149	8	8	201	113	28	522	2.4
SOC silage	965	95	80	71	66	673	528	258	117	1.4
Pelleted SOC	953	94	81	73	67	641	486	214	137	1.6

OM = Organic matter; EE = crude fat, CP = crude protein, NDICP = neutral insoluble N, g/kg in CP; acid insoluble N, g/kg in CP; ADL = acid detergent lignin; NFC = non-fifer carbohydrates; ME = metabolizable energy, Mcal/kg.

2. Free-choice experiment

The feeding experiment was carried out with a total of 10 homogeneous female Karya yearlings with an average initial body weight of 28.7 ± 0,7 kg. Yearlings were randomly divided into two equal groups and each lamb was housed in individual pens (1.2 × 1.7 m) equipped with plastic bucket feeders (20 × 20 × 20 cm). Five of the individual pens had four buckets that contained either alfalfa+maize silage mix, SOC silage, pelleted SOC or concentrate (Con+), while the other five pens equipped with only three buckets containing the same feedstuff except the concentrate (Con-). Year-

lings had *ad libitum* access to fresh water at all times. All test feeds offered daily *ad libitum* after refusal was removed and weighed. The individual free-choice feed consumption of the yearlings was determined daily. The experiment continued for 3 w. Yearlings were weighed at the beginning and end of the experiment following being fasted for 12 h.

The free-choice feed offered and refusals were sampled and simultaneous fecal grab samples from each yearling were taken for 5 d in last w of the experiment. The 5-d individual offered and refusals feed and fecal samples were then equally pooled for each yearling. Nutrients intake of each of the free-choice feeds was calculated by multiplying its intake by its nutritive value for each animal. The daily total nutrients intake of each animal was the sum of individual free-choice nutrients consumption.

3. Analytical procedures

Samples of feeds, refusals and feces were dried to a constant weight in an air" forced oven at 55ºC for 48 h. Dried samples were then ground to pass a 2-mm screen (MF 10 B, IKA werke, USA), and analyzed for DM, ash, ether extract, crude protein (CP), NDICP and ADICP according to AOAC (1990). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were assayed according to the methods described by Van Soest *et al.* (1991) using with Ankom$^{200/220}$ Fiber Analyzer (Ankom Technology, Macedon, NY, USA), and expressed inclusive of residual ash. Lignin was determined by incubation of ADF residues in diluted H_2SO_4 for 3 hours. The ME was calculated according to NRC (2001). NFC was: 100-Ash-CP-EE-NDF. Apparent digestibility of nutrients was determined according to Van Keulen and Young (1977). Intake and apparent digestibility of nutrients of two groups compared by independent *t* test. The preference of form of SOC with or without concentrate were also analyzed 2 x 2 factorial model. Means was separated by Fisher's protected LSD test (SPSS, 2010).

III – Results and discussion

Intake, feed selection, nutrient digestiblity and performance of yearlings are presented in Table 2. Yearlings had greater DMI ($P<0.01$) when concentrate was offered along with the roughage, pelleted SOC and SOC silage but the increased intake was at the expense of reduced forage and pelletted SOC consumption ($P<0.001$). As a result of feed selection, yearlings consumed nearly 50% less fiber fractions but they had more CP, NFC and ME when concentrate was offered as free-choice ($P<0.001$). Because NDF concentration of diet and DMI was negatively correlated (Huhtanen *et al.* 2007) due to the filling effect of rumen (Allen, 2000), Con+ yearlings consumed more DM than Con- yearlings. But Huhtanen (2007) also hyphotesised that DMI is more related to NDF quality rather than its amount in grasses. In the present study, although DM, OM, EE, CP and NFC digestibilty of Con+ yearlings were higher than Con- yearlings (Table 2), both NDF and ADF digestibilites of the consumed feed were similar ($P>0.05$). The results on fiber digestibility and associated DMI in the current study may deviate from the findings of other studies that used conventional diets as the crosslinking effects between lignin and other fiber elements could differ in forage and agricultural by-product. Similar values of LWG and FCR of yearlings could be related to the productivity levels of native yearlings used in this experiment.

The form of the SOC altered the preference of yearlings (Table 3). The SOC silage consumption of the sheep that did not have access to concentrate was the highest ($P<0.001$), but it was similar ($P>0.05$) to peletted SOC when concentrate was offered. This finding suggests that SOC silage is more preferable by sheep than pelleted form of SOC.

Table 2. Intake, feed selection, nutrient digestiblity and performance of yearlings fed free-choice of forage, form of SOC with or without concentrate (in (DM)

	Without concentrate	With concentrate	SEM	P value
DM and feed intake				
Dry matter, g/d	1033	1166	27.4	0,009
Forage, g/kg	778	192	16.1	0.001
Pelleted SOC, g/kg	65	40	8.0	0.001
SOC silage, g/kg	158	56	6.0	0.001
Concentrate, g/kg	–	712	17.7	–
Nutrient intake, g/kg				
Organic matter	933	898	1.1	0.001
Ether extrat	45	35	0.5	0.001
Crude protein	104	142	1.1	0.001
NDIN, in CP	226	111	4.8	0.001
ADIN, in CP	177	90	4.4	0.001
NDF	565	284	7.3	0.001
ADF	410	172	6.5	0.001
NFC	219	437	5.0	0.001
ME, Mcal/Kg	1.8	2.1	0.02	0.001
Digestiblity, g/kg				
Dry matter	521	797	19.0	0.001
Organic matter	567	795	19.2	0.001
Crude fat	763	857	19.1	0.001
Crude protein	416	823	5.9	0.001
NDF	519	496	46.2	0.001
ADF	498	445	52.4	0.001
NFC	724	971	12.9	0.001
Performance				
LWG, g/d	70.0	90.0	6.50	0.063
FCR	14.8	13.4	0.95	0.327

Table 3. Preferance of form of OC by sheep

Form	Concentrate	İntake, g/kg DM
Pelletted SOC	+	40c
Pelletted SOC	-	65b
SOC Silage	+	56bc
SOC Silage	-	158a
SEM		7.088
P value		0.001

IV – Conclusions

The results indicated that the destoned olive cake either in the form of pellet or silage has limited potential use in ruminant diets as compared to high quality forages or grains. The optimum levels of SOC seems to be between 100 and 200 g/kg of diets. The inclusion level of SOC can possibly be higher if fed in silage form.

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The experience of the ANGRA farmers in prolificacy improvement by the BMP15 ovine mutation Fecx^R in Rasa Aragonesa

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Abstract. The FecX^R mutation is a variant of the ovine gene BMP15 involved in the increase of prolificacy. It was found in the breed Rasa Aragonesa, and since 2007, the National Association of Breeders of this sheep (ANGRA) included it in its genetic selection scheme under the denomination "Gene Santa Eulalia" (or GASE). FecX^R provides a sustainable molecular tool to improve productive efficiency avoiding additional treatments. Over 4000 ewes carrying this mutation are nowadays exploited by members of ANGRA. The positive effect of FecX^R on prolificacy is well known, resulting in a clear improvement of incomes and cost effectiveness. This communication reports the results of a satisfaction survey conducted among 18 producers using FecX^R in their flocks. The survey is based up on the farmers' personal perception of different questions regarding the ewes carrying FecX^R. The statistical analysis of data provides several conclusions about practical aspects that, prior to the diffusion of this variant, generated some doubt among producers. In fact, the producers do not observe differences among the FecX^R carrier and wild type ewes as it refers to general management, even if most of them consider that the mutation provides a higher fertility, prolificacy and cost effectiveness. All of them should recommend the use of FecX^R in other flocks in practice. A high degree of satisfaction with the use of FecX^R is therefore observed, confirming the results of the objective analysis of the data actually recorded by the official Control of Productions.

Keywords. FecX^R perception – Ovine farmers – Actual production data.

L'expérience des producteurs ovins associés à ANGRA utilisant la mutation FecX^R de BMP15 chez la race Rasa Aragonesa

Résumé. *La mutation FecX^R est une variante du gène ovine BMP15 impliqué dans l'augmentation de la prolificité. Elle a été trouvée dans la race Rasa Aragonesa, et depuis 2007, l'Association Nationale des éleveurs de ce mouton (ANGRA) l'a incluse dans son programme de sélection génétique sous la dénomination "Gène Santa Eulalia" (ou GASE). FecX^R fournit un outil moléculaire pour améliorer l'efficacité productive en évitant les traitements supplémentaires. Plus de 4 000 brebis portant cette mutation sont aujourd'hui exploitées par des membres d'ANGRA. L'effet positif de FecX^R sur la prolificité est bien connu, ce qui entraîne une nette amélioration des revenus et de la rentabilité. Cette communication rapporte les résultats d'une enquête de satisfaction menée auprès de 18 producteurs utilisant prolificité dans leurs troupeaux. L'enquête est basée sur la perception personnelle des éleveurs à propos de différentes questions concernant les brebis portant la mutation FecX^R. L'analyse statistique des données fournit plusieurs conclusions sur des aspects pratiques qui, avant la diffusion de cette variante, avaient suscité des doutes parmi les producteurs. En fait, les producteurs n'observent pas de différences entre les porteuses de FecX^R et les brebis de type sauvage en ce qui concerne la gestion générale, même si la plupart d'entre eux considèrent que la mutation offre fertilité, prolificité et rentabilité accrues. Tous devraient recommander l'utilisation de FecX^R dans d'autres troupeaux en pratique. Un degré élevé de satisfaction à l'égard de l'utilisation de FecX^R est donc observé, confirmant les résultats de l'analyse objective des données effectivement enregistrées par le contrôle officiel des productions.*

Mots-clés. *Perception FecX^R – Ovins – Données de production réelles.*

I – Introduction

The “Rasa Aragonesa” is an autochthonous Spanish rustic ovine breed devoted to meat production. Its mean prolificacy is 1.3 lambs/birth. In 2007, a variant of the BMP15 locus denominated $FecX^R$ was identified in this breed (Monteagudo *et al*., 2009). As other BMP15 variants known in different breeds, $FecX^R$ increases prolificacy in heterozygous ewes, improving the number of produced lambs and the profit earning capacity of the flocks. Since that year, the Asociación Nacional de Criadores de Ganado Ovino de la Raza Rasa Aragonesa (ANGRA) is including the use of $FecX^R$ in its genetic improvement programme, under the commercial denomination “Gen Santa Eulalia” (GASE). The programme is based up on the identification of the females carrying $FecX^R$ by means of DNA analysis and in a strict mating control, since homozygous $FecX^R$ ewes are sterile. The mating plan design takes into account that BMP15 is linked to the chromosome X. It is also focused to conserve the morphology of the breed by preventing crossing with other ones and to minimize inbreeding increase (Laviña, 2012).

Prior to the beginning of GASE introduction into flocks, several doubts arose among breeders, mainly about the ability of the “Rasa Aragonesa” ewes to nurture two (or even three) lambs and about the productive life expectancy. After a decade of experience, the present communication reports the current perception of the flock managers (López, 2016) and the analysis of the real data compiled on these and other aspects of the use of $FecX^R$. Both (subjective opinions and objective data) are now compared.

II – Material and methods

Among the 20 farms owning the highest amounts of $FecX^R$ carriers, 18 accepted telephone interviews in order to provide information on the present perception of the flock owners. These farms are distributed along the three provinces of the Aragón region.

The poll included 27 questions. Among them, 11 were related to the characteristics of the flock exploitation (staff, management system etc.) while the rest are devoted to obtain the perception of the farmers (comparison of the $FecX^R$ carriers vs. wildtype ewe, workforce requirements, profitability etc.). For most of the questions two or three possible answers are offered (yes or no, equal, more, less, etc), while two may have free answers and six require numerical values.

Besides the answers from the farmers, the ANGRA databases provided the necessary and precise information about the flock size and the proportion of $FecX^R$ ewes. Moreover, the actual production data were obtained from the official Control of Productions in the Genealogy Book of the Rasa Aragonesa breed, managed by ANGRA. Recorded data from 23,645 individuals and 84,583 births have been used to study the following variables: **prolificacy** (number of alive or dead lambs per litter), **parturition interval** (number of days between a delivery and the following one), **proportion of deaths among the ewe**, **single, duplet or multiple birth**, **age at moment of the first delivery and productive life duration**.

Statistical analysis was carried out by means of the software IBM ® SPSS ® version 22, in order to produce descriptions of the variables (mean, standard deviation, range, histograms and different diagrams) and to perform univariate and multivariate analysis. Student’s t and ANOVA were applied to comparisons among means. The interdependence among qualitative variables was studied by chi square test, while Pearson’s correlation was applied in the case of quantitative variables for this purpose (see Petrie and Watson, 1999, for further details). The **productive life span** (difference in months between the last and the first known deliveries for a given ewe) was studied by means of survival analysis; the Breslow test allowed the comparison between the productive life span in both group of ewes.

III – Results and discussion

Table 1 summarises the results obtained in the opinion survey for the qualitative values, indicating the absolute frequencies of each kind of answer Farms using the $FecX^R$ mutation are mainly intergenerational and semi-extensive, with a mean size of 1,033.9 animals and apply high technification reproduction procedures.

Table 1. Results of the opinion survey about qualitative variables

Question	Answers	Count
Is artificial insemination used	yes	17
	no	1
Prolificacy of FecXR ewes	higher	10
	equivalent	8
Productive life span of FecXR ewes	equivalent	10
	shorter	8
Veterinary cares for FecXR ewes	more intensive	1
	equivalent	17
Workforce for FecXR ewes vs. for wildtype ewes	equivalent	18
Profitability of FecXR ewes vs. of wildtype ewes	superior	18
Would you suggest the use of FecXR by other prducers	yes	18
Plans to modify the number of your FecXR ewes?	increase	16
	decrease	1
	maintain	1

Table 2 presents the quantitative data of the farms involved in the survey; it indicates the obtained mean and standard deviation for each variable, besides its maximum and minimum values. The results in both Tables provide an approximation to the characteristics of the farms using the $FecX^R$ variant, besides an extensive view of the producers' perception of $FecX^R$ ewes.

Table 2. Description of the main quantitative variables in the flocks (rd: registered data; op: opinion)

Variable	N	%	Mean	Minimum	Maximum	Standard deviation
Flock size (rd)	18	100	1.033	344	1790	466.906
% of FecXR ewes(rd)	18	100	12.95	2.48	31.4	10.347
Age of flock manager (rd)	18	100	47.72	31	66	9.041
Staff members (rd)	18	100	1.5	1	3	0.588
Ideal % of FecXRewes (op)	13	72,2	57.3	15	100	23.1495

On the other hand, Table 3 shows the actual differences among $FecX^R$ and wildtype ewes according to the recorded data (not subjective opinion); the differences are significant for prolificacy, age at the first delivery and productive life span. Most of the results in this table are similar to those reported by Alabart *et al*. (2016).

Table 3. Comparison of the data recorded for wildtype and ewes

Character	Wild type ewes	FecXR carriers	p
Prolificacy	1.40 ± 0.003	1.75 ± 0.011	<0.005**
Parturition interval	283.31 ± 0.750	277.94 ± 1.512	0.198
Adult ewes mortality	6.36 ± 0.003	5.58 ± 0.004	0.124
Productive life span (months)	64.66 ± 0.328	74.54 ± 2.634	<0.005**

** Significant difference, p<0.01.

Our main conclusions are:

1. Most farmers do not notice clear differences as it refers to day-to-day management (workforce, required equipment, etc.) after introducing FecX^R in their genetic improvement strategies.
2. Besides prolificacy, the fertility index of the FecX^R ewes is perceived to be higher than this of the wildtype sheep.
3. Most of the flock managers do not appreciate a shorter life span in the FecX^R ewes, or different veterinary cares.
4. For most of the farmers, profitability of the FecX^R ewes is higher; as a consequence they are planning an increase of the proportion of this kind of sheep in their flocks. All of them should recommend the introduction of FecX^R in other farms.
5. In all, we can therefore conclude that the producers using the FecX^R mutation are highly satisfied by the obtained results.
6. The objective evaluation of the data actually recorded, confirms the perceptions declared by the flock managers: the FecX^R mutation is a useful tool in the improvement of the Rasa Aragonesa breed productivity, leading to a higher profitability of the flocks.

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Effet de la surface cisternale de la mamelle sur la production laitière totale des brebis Sicilosardes

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Résumé. Ce travail a consisté d'étudier l'influence de la surface cisternale de la mamelle sur la production laitière totale des brebis laitières. L'étude a porté sur un nombre total de 54 brebis Sicilosarde élevées dans la région de Béja au nord de la Tunisie. Au 45ème jours du stade début de lactation, la surface cisternale de la mamelle a été mesurée par un échographe (Noveko) menu d'une sonde linéaire (4 MHz). Les mesures échographiques ont été effectuées 8 heures après la traite du matin. Les résultats ont montré que 28% des brebis (n=15) ont eu de petites surfaces cisternales de leurs mamelles [2 – 6 cm^2[, 50% (n=27) de moyennes surfaces cisternales [6 – 10 cm^2[et 22% (n=12) de grandes surface cisternales [10 – 13,5 cm^2]. La production laitière totale a été plus élevée dans le groupe de brebis ayant de grandes surfaces cisternales par rapport aux autres groupes (120 vs 112 and 105 L; p<0.05).La surface cisternale a été plus élevée chez les multipares par rapport à celle des primipares (8.5 ± 2.5 vs 4.5 ± 1 cm^2; p<0.05). De plus, la production laitière totale a été plus élevée chez les brebis multipares par rapport à celle des brebis primipares (120 ± 24 vs 108 ± 18 L; p<0.1). Les résultats de cette étude suggèrent que la surface cisternale de la mamelle affecte la production totale des brebis Sicilosardes.

Mots-clés. Production laitière – Surface cisternale – Mamelle – Brebis Sicilosarde.

The influence of the cisternal surface of the udder on milk production of Tunisian Sicilo-Sarde sheep

Abstract. *The study aimed to investigate the influence of the cisternal surface of the udder on the total milk production of dairy sheep. Study was undertaken on 54 Tunisian Sicilosarde ewes bred in Beja in the north of Tunisia. The cisternal surface of the sheep udder's has been measured by an ultrasonography (Noveko) using a linear probe (4 MHz) at 45 days of the stage of the beginning lactation. Measurements were performed at 8 hours after the morning milking. Results showed that 28% of ewes (n = 15) had little cisternal surface of udder between [2 – 6 cm^2[, 50% (n = 27) with mean cisternal surface udder between [6 – 10 cm^2[and 22% (n = 12) with great cisternal surface of udder between [10 – 13.5 cm^2]. The total milk production was higher in the class of great cisternal than the mean and little classes (120 vs 112 and 105 L; p<0.05). We found that multiparous ewes had cisternal surface breast higher than the primiparous one (8.5 ± 2.5 vs 4.5 ± 1; p<0.05). The total milk production was higher in the multiparous ewes than the primiparous one (120 ± 24 vs 108 ± 18 L; p<0.1). Our results suggest that the cisternal surface udder influenced the total milk production of Tunisian Sicilo-Sarde dairy sheep.*

Mots-clés. *Milk production – Cisternal surface – Udder – Sicilosarde sheep.*

I – Introduction

L'échographie est une technique utilisée chez la femme depuis longtemps. Ces dernières années, elle s'est développée pour être utilisée pour plusieurs fins chez les animaux d'élevage ; notamment chez la brebis dans l'étude de la morphologie interne de la mamelle (Carretero *et al.*, 1999) et dans la détermination du volume interne ainsi que le périmètre de la citerne de la mamelle (Caja *et al.*,

1999). Cette technique a permis aussi d'établir une relation entre la surface de la citerne de la mamelle et sa production laitière (Rovai *et al.*, 2000).

L'objectif de ce travail a consisté d'étudier l'effet de la surface cisternale de la mamelle sur la production laitière totale chez les brebis laitières élevées en Tunisie.

II – Matériel et méthodes

1. Animaux

L'étude a été réalisée sur 54 brebis Sicilo-Sarde, âgées de 6 ans en moyenne, ayant un état corporel satisfaisant et un poids moyen de 45 kg. Les animaux ont été hébergés dans une ferme au nord ouest de la Tunisie et l'expérience a duré du mois de septembre 2012 au mois de juin 2013.

2. Echographie des mamelles

La morphologie interne des mamelles a été évaluée quotidiennement, 8 heures après la traite du matin et à partir du 45ème jour du début de la lactation (Labussière *et al.*, 1981), à l'aide d'un échographe (amB^{v} NOVEKO, Canada) menu d'une sonde linéaire (Am102) de 4 Mhz. Les mesures échographiques ont été effectuées selon la méthode décrite par Knight *et al.* (1994) et Ayadi *et al.* (2003). Les images échographiques sont transférées à un ordinateur par un logiciel de transmission d'images (Enic2pc, Version 2.1.0.1). Ensuite, le périmètre (cm) et la surface échographiée (cm^2) ont été déterminés par le logiciel Image Tool (Version 3.00).

3. Production laitière

La production laitière totale (L) a été estimée selon l'équation de Fleischmann rapportée par Alayet (2014).

4. Analyses statistiques

Les données ont été traitées par le logiciel SAS (Version 9.0). L'analyse de la variance a été effectuée par la procédure GLM (general linear model). L'étude des corrélations a été effectuée par la procédure CORR. Le seuil de signification a été fixé pour $p < 0,05$.

III – Résultats et discussion

Les résultats ont montré que 28% des brebis ont des petites surfaces cisternales de [2 – 6 cm^2], 50% ont des moyennes surfaces cisternales de [6 – 10 cm^2 [et 22% ont de grandes surfaces cisternales de [10 – 13,5 cm^2] « Fig.1 ». Il est à noter que la moyenne de la surface des petites citernes est de 4,5 ± 1,05 cm^2 et celles des moyennes et grandes citernes sont respectivement de 8 ± 1,09 et 12 ± 0,91 cm^2.

La production laitière totale calculée a été plus élevée dans le groupe des brebis ayant de grandes citernes par rapport à celles des groupes des moyennes et petites citernes « Fig.2 » ($p<0,05$). D'autant plus, les résultats ont montré que la production laitière totale a été corrélée avec la surface cisternale (r=0,88 ; $p<0,01$). Ceci n'est pas en accord avec le résultat rapporté par Ayadi *et al.* (2003) qui a trouvé chez les bovins que la surface des citernes n'est pas liée au potentiel laitier. En revanche, Labussière et Richard (1965) ont indiqué que les animaux ayant de grosses mamelles sont généralement ceux qui produisent plus de lait. D'autre part, Labussière (1966) a mentionné que certaines brebis peuvent retenir le lait dans la partie supérieure de leur mamelle entraînant ainsi l'arrêt de l'activité des cellules sécrétoires.

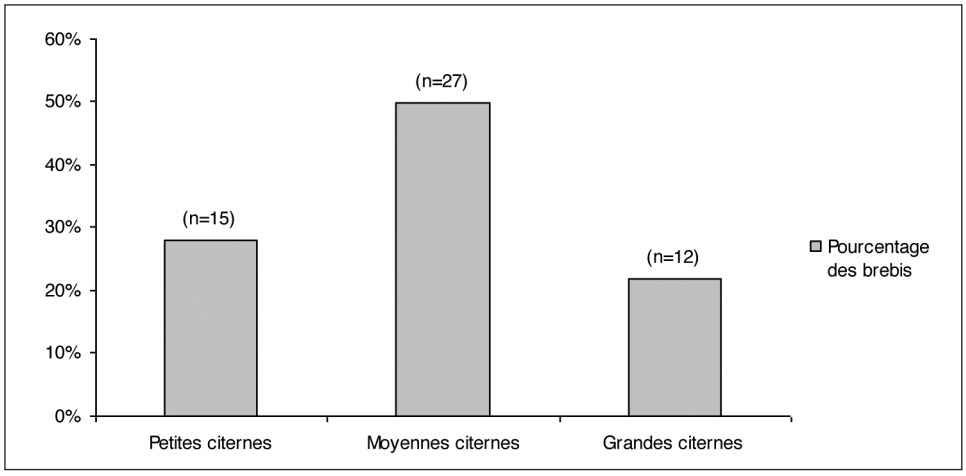

Fig. 1. Répartition des brebis en fonction de leurs surfaces cisternales.

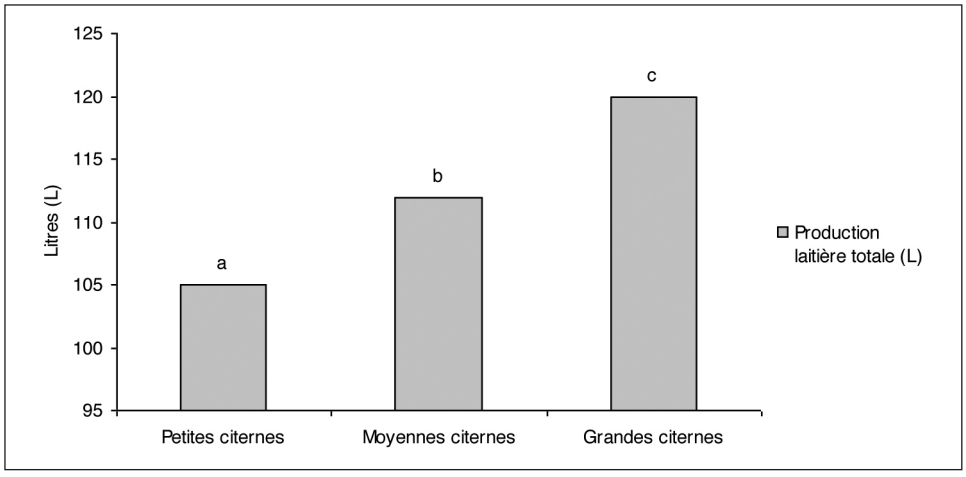

Fig. 2. Variation de la production laitière totale des brebis en fonction des catégories de citernes.

Les résultats ont montré aussi que le périmètre et la surface cisternale des mamelles des brebis multipares ont été plus élevés que ceux des mamelles des brebis primipares ($p<0,05$). De plus, l'analyse des données a montré que la production laitière tend à être plus élevée chez les brebis multipares ($p<0,1$; Tableau 1). L'étude de Rovai *et al.* (2002) a rapporté une corrélation élevée (r=0,9) entre les mesures échographiques des citernes et le numéro de lactation.

Tableau 1. Caractères morphologiques internes chez les primipares et les multipares

	Périmètre mammaire (cm)	Surface cisternale (cm^2)	Production laitière totale (L)
Primipares	$9 \pm 1,8^a$	$4,5 \pm 1,2^a$	$108 \pm 17,5^c$
Multipares	$14,5 \pm 4,5^b$	$8,5 \pm 2,5^b$	120 ± 24^d

a,b : p<0,05 ; c,d : p<0,1.

IV – Conclusion

Les résultats de l'étude ont suggéré que le recours à l'échographie des mamelles de la brebis pourrait nous donner une meilleure estimation de la production laitière puisque cette dernière est liée aux paramètres morphologiques internes.

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Genetic characterization of three genes associated with fertility performance in Egyptian small ruminant breeds

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Abstract. The fertility and reproduction traits enhancement is considered one of the main targets in livestock breeding programs. This work aimed to indentify RFLPs and SNPs variations among three fertility genes in Egyptian small ruminant breeds. RFLP analysis of the amplified fragments at 462-bp from exon 1 of *GDF9* using *Hpa*II endonuclease showed the presence of two genotypes, GG with the nucleotide G at position 209 and AG genotype with a SNP (A/G) at this position**.** The frequencies of GG and AG genotypes as well as G and A alleles were 83.6%, 16.4%, 91.8% and 8.2%, respectively in Egyptian small ruminants. Depending on the presence of the restriction site of *Taq*I endonuclease (T^CGA) at position 100^101 in the 348-bp amplified fragment from exon 5 of *GPR54* gene, the results showed the presence of two alleles, C and T with three genotypes, CC, TT and CT. There was a SNP (C→T) between the two different alleles at position 100. The total frequencies for CC, CT and TT genotypes in all sheep and goat animals were 33.6%, 62.1% and 4.3%, respectively and the frequencies of C and T alleles were 64.6% and 35.4%, respectively. The PCR amplified fragments of 190-bp from *FecB* gene were digested with *Ava*II restriction enzyme and the results showed that all tested animals have the same homozygous non-carrier genotype (++) with uncut 190-bp fragments. The SNP (G→A) at position 160 resulted the destruction of G^GACC restriction site at position 160^161.

Keywords. *GDF9* – *GPR54* – *FecB* – PCR-RFLP – DNA sequencing – Small ruminants.

I – Introduction

The reproduction traits improvement is considered one of the breeding programs targets in small ruminants. Maker assisted selection depending on genetic and DNA markers associated with reproduction traits became the most effective tool for genetic improvement of economically important traits in different livestock (Kolosov *et al*., 2015). The ovulation rate (Hanrahan *et al*., 2004) and litter size (Cao *et al*., 2011) are two important indicators for the fertility and reproduction performances in farm animals especially sheep and goat (Tang *et al*., 2012 and Dinçel *et al*., 2015). The detection of genes associated with fertility and reproduction traits and the identification of their genetic variation effects on these traits phenomena will help in the reproduction enhancement of sheep and goat breeds. Growth differentiation factor 9 (*GDF9*) gene is expressed in the developing oocytes in the ovaries of ruminants (Bodensteiner *et al*., 1999 and 2000) and plays an essential role in ovarian follicular development, ovulation rate and prolificacy in different mammalian species (Chung and Davis, 2012 and Tang *et al*., 2013). *GPR54* is one of the G protein-coupled receptors and the endogenous receptor of *KISS-1* peptide (Chu *et al*., 2012). *GPR54* gene is highly expressed in placenta, pancreas and in brain whereas it expressed at low level in adrenal glands, testes and spleen (Funes *et al*., 2003 and Cao *et al*., 2011). The kisspeptin/GPR54 pathway has an essential role in puberty process and is considered the key for GnRH secretion regulation. This pathway stimulates LH and FSH secretion to initiate the puberty (Kuohung and Kaiser, 2006 and Tena-Sempere, 2006). Many reports focused on the role of the Booroola fecundity (*FecB*) gene in reproductive endocrinology, ovary development, ovulation rate and litter size (EL-Hanafy and El-

Saadani, 2009). This gene increases the ovulation rate and litter size in small ruminants and the identification of the *FecB* mutation is of great interest in the studies of mammalian fertility (Wilson *et al*., 2001). The small ruminants produced about 9.1% of meat production (MoA, 2004) in spite of they are exposed to compromised and marginalized production system in Egypt. Due to the shortage in domesticated meat and milk production, the reproduction improvements of these livestock must have a top priority in any developing plan. Toward this target, the present study aimed to identify the genetic and single nucleotide polymorphisms of three genes associated with fertility and reproduction traits in Egyptian small ruminant breeds.

II – Material and methods

The blood samples were collected from one hundred and forty animals belonging to three sheep breeds, Barki (32 animals), Ossimi (28 animals) and Rahmani (22 animals) in addition to three goat breeds, Baladi (16 animals), Barki (20 animals) and Zaraibi (22 animals). Genomic DNA was extracted from the whole blood according to the method described by Miller *et al*. (1988) with minor modifications. Briefly, blood samples were mixed with cold 2x sucrose-triton and centrifuged at 5000 rpm for 15 min at 4°C. The nuclear pellet was suspended in lysis buffer, sodium dodecyl sulfate and proteinase K and incubated overnight in a shaking water bath at 37°C. Nucleic acids were extracted with saturated NaCl solution. The DNA was picked up and washed in 70% ethanol. The DNA was dissolved in 1X TE buffer. DNA concentration was determined, using Nano Drop1000 Thermo Scientific spectrophotometer, and then diluted to the working concentration of 50 ng/µl, which is suitable for polymerase chain reaction. The DNA fragments from the tested genes were amplified using polymerase chain reaction technique developed by Mullis *et al*. (1986). A PCR cocktail consists of 1.0 µM upper and lower primers (Table 1), 0.2 mM dNTPs and 1.25U of *Taq* polymerase. The cocktail was aliquot into PCR tubes with 100 ng of sheep or goat DNA. The reaction was cycled with the following conditions, initial denaturation for 5 min at 94°C followed by 30 cycles of denaturation at 94°C (1 min), annealing at optimum temperature for each tested gene (1 min) and extension at 72°C (2 min) and the final extension for 10 min at 72°C. The amplification was verified by electrophoresis on 2% agarose gel in 1x TBE buffer using GeneRuler^{TM} 100-bp ladder as a molecular weight marker for confirmation of the length of the PCR products. The gel was stained with ethidium bromide and visualized on UV trans-illuminator. Ten µl of PCR products were digested with 1 ul of FastDigest restriction enzyme specific for each tested gene (Table 1) at 37°C for 5 min. The restriction fragments were subjected to electrophoresis in 2% agarose/ethidium bromide gel (GIBCO, BRL, England) in 1× TBE buffer (0.09 M Tris-boric acid and 0.002 M EDTA). Gels were visualized under UV light and documented in FX Molecular Imager apparatus (BIO-RAD). The PCR products representing detected genotypes of each tested gene were purified and sequenced by Macrogen Incorporation (Seoul, Korea). Sequence analysis and alignment were carried out using NCBI/BLAST/blastn suite. Results of endouclease restriction were carried out using FastPCR.

Table 1. The sequences and information of primers used in this study

Gene	Primer sequences 5'———— -3'	Anneal. temp.	PCR product size	Restriction enzyme	Ref.
GDF9	GAAGACTGGTATGGGGAAATG CCAATCTGCTCCTACACACCT	63°C	462-bp	*Hpa*II	Kolosov *et al.* (2015)
GPR54	ACCTGGCATCCGCGCAGTT CTCAGAGGGGCCCGTCTTGAT	58°C	348-bp	*Taq*I	Cao *et al.* (2011)
FecB	CCA GAG GAC AAT AGC AAA GCA AA CAAGATGTTTTCATGCCTCATCAACAGGTC	60°C	190-bp	*Ava*II	Wilson *et al.* (2001)

III – Results and discussion

1. Growth Differentiation Factor 9 (*GDF9*) gene

The restriction process of the amplified fragments from *GDF9* at 462-bp using *Hpa*II resulted the presence of two different genotypes GG and AG according to the restriction sites (CC^GG) in these fragments, AG genotypes with four fragments at 410-, 254-, 156-bp and 52-bp and GG genotypes with three fragments at 410-, 254-, 156-bp and 52-bp (Fig. 1).

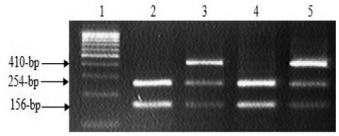

Fig. 1. Electrophoretic pattern after digestion of *GDF9* PCR products with *Hpa*II endonuclease
Lane 1: 100-bp ladder marker
Lanes 2 and 4: GG genotype with 3 digested fragments at 254-156- and 52-bp
Lanes 3 and 5: AG genotype with 4 digested fragments at 410-, 254-, 156- and 52-bp
* The small fragment at 52-bp did not show in the figure.

The total frequencies for GG and AG genotypes were 85.4% and 14.6% in 82 tested sheep animals, 87.5% and 12.5% for Barki, 82.1% and 17.9% for Ossimi and 86.4% and 13.6% for Rahmani, respectively. In 58 goat animals, the frequencies for GG and AG genotypes were 83.6% and 16.4, respectively, for Baladi (81.3% and 18.7%), Barki (85.0% and 15.0%) and for Zaraibi (77.3% and 22.7%), respectively. The total frequencies for GG and AG genotypes as well as G and A alleles in tested small ruminants were 83.6%, 16.4, 91.8% and 8.2%, respectively. The sequence analysis of GG (Fig. 2) and AG (Fig. 3) genotypes showed the appearance of a SNP (G/A) at position 209 in AG genotypes which leads to the presence of four digested fragments at 410-, 254-, 156- and 52-bp in these genotype.

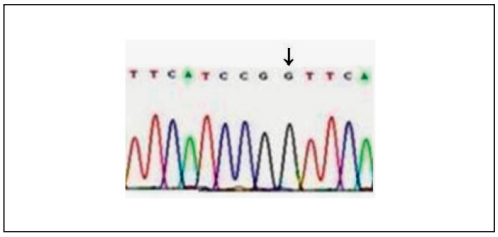

Fig. 2. Genotype GG of *GDF9* with the nucleotide G at position 209.

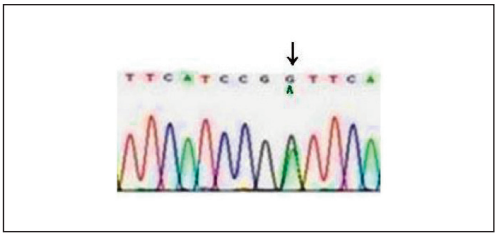

Fig. 3. Genotype AG of *GDF9* with the nucleotide A/G at position 209.

Kolosov *et al*. (2015) determined *GDF9* polymorphism in two Russian sheep breeds-Salskaya and Romanov- using PCR-RFLP technique. They reported the appearance of GG and AG genotypes in exon 1 which was tested in the present study and AA and AG genotypes in exon 4. At exon 1 which is interested in our study, the frequencies of GG and AG genotypes were 90% and 10%, in Salskaya breed and 60.9% and 39.1% in Romanov breed, respectively. This result declared that our sheep breeds is closer genetically to Salskaya than to Romanov breed, as the frequencies of GG and AG genotypes in our sheep breeds were 85.4% and 14.6%, respectively. The PCR amplified fragments from exon 1 of *GDF9* (462-bp) in Iranian Sangsari sheep breed were digested using *Hha*I and the results showed a G to A substitution in *GDF9* locus with allele frequencies for G and A at 80.16% and 19.84%, respectively. The results showed that this Iranian sheep breed possess a rare genotype AA which is not appear in Egyptian or Russian sheep breeds suggesting that

the domestication of sheep breeds may be occurred in Iran and surrounding area of Fertile Crescent. Some reports declared that the sheep animals with GG genotype of *GDF9* possess high fertility than animals with AG genotypes where the animals with AA genotypes are low fertility (Kasiriyan *et al*., 2011). This finding showed that our animals have high fertility rate where most of them possess GG (85.4%) and AG (14.6%) genotypes of *GDF9* with the absence of AA genotype.

2. G Protein-Coupled Receptor 54 (*GPR54*) gene

A fragment of 348-bp from *GPR54* exon 5 was amplified using PCR and the restriction analysis of these fragments using endonuclease *Taq*I declared three genotypes, CC, CT and TT. The appearance of these genotypes resulted from the presence of T^CGA restriction site at position 100^101.

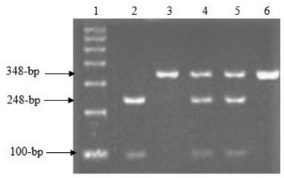

Fig. 4. Electrophoretic pattern after digestion of *GPR54* PCR products with *Taq*I endonuclease
Lane 1: 100-bp ladder marker
Lane 2: TT genotype with 2 digested fragments at 248- and 100-bp
Lanes 3 and 6: CC genotype with undigested fragment at 348-bp
Lanes 4 and 5: CT genotype with 3 digested fragments at 348-, 248- and 100-bp

In sheep breeds, the frequencies of CC, CT and TT genotypes were 31.25%, 62.5% and 6.25% in Barki, 32.1%, 64.3% and 3.6% in Ossimi and 27.3%, 68.2% and 4.5% in Rahmani, respectively with the total frequencies of 30.5%, 64.6% and 4.9% for CC, CT and TT genotypes, respectively. In goat breeds, the frequencies of CC, CT and TT genotypes were 37.5%, 62.5% and 0.0% for Baladi, 35.0%, 60% and 5.0% for Barki and 41.0%, 54.5% and 4.5% for Zaraibi, respectively with total frequencies of 37.9%, 58.6% and 3.5% for CC, CT and TT genotypes, respectively. The total frequencies for CC, CT and TT genotypes in all sheep and goat animals were 33.6%, 62.1% and 4.3%, respectively. The total frequencies for C and T alleles in all tested animals were 64.6% and 35.4%, respectively. The sequence analysis of the two different alleles, C (Fig. 5) and T (Fig. 6), showed the presence of a SNP (C→T) at position 100 in allele T yielding two digested fragments at 248- and 100-bp in this allele.

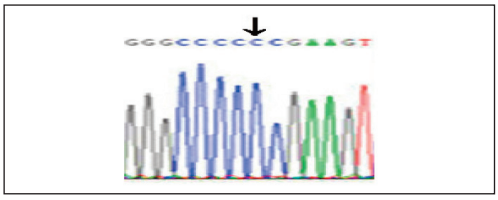

Fig. 5. The nucleotide C at position 100 in allele C of *GPR54* gene.

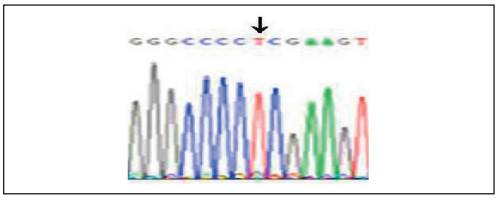

Fig. 6. The nucleotide T at position 100 in allele T of *GPR54* gene.

Tang *et al.* (2012) reported the presence of different mutations in *GPR54* gene in four Chinese sheep breeds, Small Tail Han, Chinese Merino, Hu and Corriedale. In first sheep breed, there are three genotypes AA with frequency of 0.25, AG (0.50) and GG (0.25) with negative effect on the litter size. On the other hand, the frequencies of CC (0.175), CD (0.125) and DD genotypes (0.700) were reported in this breed with positive effect where sheep ewes with genotype CC had lambs more than those with genotype DD or CD. These results declared that allele C of *GPR54* gene may be considered as a candidate marker for improving litter size in sheep.

3. *FecB* gene

A 190-bp fragment from *FecB* gene of sheep and goat was amplified using PCR. The digestion process of these fragments by *Ava*II restriction enzyme revealed the absence of the restriction site (G^GACC) at position 160^161 in tested animals yielding the presence of uncut fragments at 190-bp. This result showed that all tested Egyptian sheep and goats have the same homozygous non-carrier genotype (++) (Fig. 7).

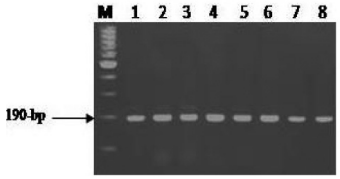

Fig. 7. The electrophoretic pattern obtained after digestion of PCR amplified fragment of *FecB* gene from sheep and goat DNA with *Ava*II restriction enzyme.
Lane M: 100-bp ladder marker
Lanes 1-8: ++ non-carrier homozygous genotype with uncut fragment at 190-bp.

The sequence analysis of the purified PCR products (Fig. 8) representing the detected monomorphic ++ non-carrier genotype showed the presence of a SNP (G→A) at position 160 (Fig. 9) which is responsible for the absence of restriction site (G^GACC) at position 160^161 and consequently the presence of undigested fragments at 190-bp in all tested animals.

CCAGAGGACAATAGCAAAGCAAATTCAGATGGTGAAA
CAGATTGGAAAAGGTCGCTATGGGGAAGTTTGGATGG
GAAAGTGGCGTGGCGAAAAGGTAGCTGTGAAAGTGT
TCTTCACTACAGAGGAGGCCAGCTGGTTCCGAGAGA
CAGAAATATATCAGACCGTGTTGATGAGGCATGAAAA
CATCTTG

Fig. 8. The nucleotide sequence of ++ non-carrier genotype (190-bp). The nucleotide A at position 160.

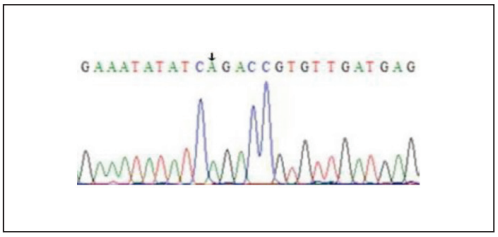

Fig. 9. The nucleotide A in the monomorphic ++ non-carrier genotype.

Two important reproduction parameters with economic importance in small breeding programs are litter size and lamb growth. Souza *et al*. (2003) reported the presence of genetic polymorphism in *BMPR-IB* gene and its association with the *FecB* gene and the high prolificacy in Booroola Merino sheep using PCR-RFLP technique (Souza *et al*., 2001 and Davis *et al*., 2002). The genetic polymorphism in *FecB* gene and its association with some economically important growth parameters was identified by Guan *et al*. (2007). They reported that Hu sheep are homozygous carriers (BB) whereas in Merino prolific meat breed, the three genotypes, BB, B+ and ++ were appeared with different frequencies. In Merino prolific sheep breed, the animals with genotypes BB and B+ have higher mean litter sizes of ewes, the heart girth and chest width than those with genotype ++. The association between *FecB* gene and some reproduction and fertility parameters like reproductive endocrinology, ovary development, litter size, organ development and body mass was reported (Smith *et al*., 1993, Smith *et al*., 1996 and Cognie *et al*., 1998). The effects of *FecB* gene on these parameters are different where it has positive effects on litter size and ovulation rate and negative effects on fetal growth and development and body mass (Wang *et al*., 2003 and Liu *et al*., 2003).

IV – Conclusions

In conclusion, the detection of genes and the identification of their favorable genotypes associated with production and reproduction traits are considered the first step towards the genetic improvements of these economically important traits in different livestock. *GDF9*, *GPR54* and *FecB* genes are considered as three promising markers associated with different fertility trait parameters like ovulation rate, ovarian follicular development, puberty and litter size in small ruminant breeds.

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Innovations in the selection program of the UPRA-Grupo Pastores in Rasa aragonesa sheep breed

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Abstract. The Cooperative Oviaragón-Grupo Pastores carries out since 1994 a selection program for prolificacy in Rasa Aragonesa sheep, with 490,337 ewes at present. Sires of higher estimated breeding values are produced within the scheme by MOET, increasing the performance of this technology through the measurement of plasmatic Anti-Müllerian Hormone (AMH) in ewe embryo donors, an endocrine marker of the ovarian activity. Within this program a natural genetic prolific variant was found in 2007, the *FecX^R* allele of the *BMP15* gene. Its effect on prolificacy leads to an increase of 0.35 lambs/lambing ewe when compared with non-carrier ewes, with an additive effect over the standard hormonal treatments used in farms. Recently, new variants in *MTNR1A* gene associated to reproductive seasonality have been detected in Rasa aragonesa breed. Non-linked SNPs in the promoter and exon 2 have been detected which decrease the length of the non-cycling period (periods with three or more consecutive weekly-sampled progesterone concentrations lower than 0.5 ng/ml from January to August) as much as 30 and 53 days, respectively. In the same way, the allele located in exon 2 was also associated to an increase of 15% of oestrus cycling months (based on oestrus records). Due to their productive interest, a controlled program for the outreach of *FecX^R* and *MTNR1A* alleles has been developed. Finally, a polygenic selection program for maternal capacity is being carried out. The selection program goes on with a combined polygenic selection for prolificacy, maternal capacity and dissemination of *FecX^R* and *MTNR1A* alleles.

Keywords. Ovine – Selection program – Prolificacy – fertility.

Innovations dans le programme de sélection de l'UPRA-Grupo Pastores dans la race Rasa aragonesa

Résumé. *La Coopérative Oviaragón-Grupo Pastores mène depuis 1994 un programme de sélection pour la prolificité sur la race ovine Rasa aragonesa avec donnés enregistrées sur 490337 brebis à l'heure actuelle. Les béliers à tester pour son valeur génétique sont produits par un Programme MOET, étant le rendement de cette technologie augmentée à travers l'analyse de l'Hormone plasmatique Anti-Müllerienne (AMH) dans les brebis donneuses, un marqueur endocrinien de l'activité ovarienne. Dans ce programme une variante génétique naturel prolifique a été découverte en 2007 (*FecX^R*, allèle du gène* BMP15*). Son effet sur la prolificité conduit à une augmentation de 0,35 agneaux/brebis agnelant par rapport aux brebis non-porteuses, ayant un effet additif sur les résultats des traitements hormonaux standard utilisés dans les troupeaux. Récemment, des nouvelles variantes dans le gène* MTNR1A *associé à la saisonnalité de la reproduction ont été détectés dans la race Rasa aragonesa. Des SNPs non liés ont été détectés au promoteur et a l'exon 2 en diminuant la durée du période d'anoestrus jusqu'à 30 et 53 jours, respectivement. (périodes dont les concentrations de progestérone sont inférieures à 0,5 ng/ml au cours de trois semaines consécutives ou plus, de janvier à août). De même, l'allèle situé dans l'exon 2 est également associée à une augmentation de 15% de mois avec manifestation d'œstrus (basé sur la détection de chaleurs). En raison de leur intérêt productif, un programme contrôlé de diffusion de l'allèle* FecX^R *et* MTNR1A *ont été mis au point. Finalement, un programme de sélection polygénique de capacité maternelle est en cours. En conclusion, le programme de sélection continue avec l'association d'une sélection polygénique pour prolificité, capacité maternelle et la diffusion des allèles* FecX^R *et* MTNR1A*.*

Mots-clés. *Ovine – Programme de sélection – Prolificité – Fertilité.*

I – Introduction

Rasa aragonesa is a Mediterranean autochthonous sheep breed from the northeastern Spain, mainly reared in extensive or semiextensive farming systems and oriented to meat production. Improvements in farms efficiency is possible by genetics, nutrition and managementapproaches. In this context, the Cooperative Oviaragon-Grupo Pastores carries out since 1994 a selection program for prolificacy in Rasa aragonesa, with 490,337 ewes at present, since the number of lambs born per lambing ewe is a critical point in the efficiency and viability of these farms (Pardos *et al*., 2008). Artificial Insemination (AI) with fresh semen at 15 ºC is used for the connection of the flocks and diffusion of the genetic improvement (133,000 AI with a mean fertility of 55% since the beginning of the program). Prolificacy is considered a difficult trait because of its low polygenic heritability (h^2 = 0.034; Jurado *et al*., 2008). In Rasa aragonesa, phenotypic prolificacy is 1.37 lambs/birth (16^{th} genetic evaluation made in 2016, unpublished). However, new selection objectives, as maternal ability, or marker-assisted selection based on major genes are being developed to increase the selection efficiency.

In particular, this paper focuses in some results on innovations in the selection program of the UPRA-Grupo Pastores in Rasa aragonesa sheep breed.

II – Multiple ovulation and embryo transfer (MOET)

This selection scheme exploits multiple ovulation and embryo transfer (MOET) to produce ovine embryos with identified sex in combination with *PrnP* genotype determination. In the selection scheme to improve prolificacy in the Rasa aragonesa sheep breed, the males to be tested are produced by a MOET programme, using the ewes of higher genetic value as donors. In the period from 1998 to 2013, a total of 331 flushings have been performed in 213 donor ewes. Ewes were treated with FGA sponges and superovulated with 8.8 mg of oFSH (Ovagen) in eight decreasing doses (2 x 1.32; 4 x 1.1 and 2 x 0.88 mg) at 12h intervals. Since 2008, Ovagen was replaced by Folltropin. Intrauterine insemination ($200x10^6$ spermatozoa/ewe) with fresh semen from selected rams was carried out 51h after sponge withdrawal. A total of 3076 embryos were obtained (2037 morphologically viable), 1551 of which were fresh-transferred to FGA+eCG synchronized recipients (two morulae or blastocysts per recipient). A total of 931 lambs were born (470 males), 226 of which were suitable to be tested (Folch *et al*., 2015). The efficiency of the MOET program has been influenced by many factors, such as the improvement of the techniques, the number of flushings per donor, the genetic value of the donor or the ovulation rate of the recipient. Anti-Müllerian hormone (AMH) has been demonstrated to be a good predictor of the ovarian response to gonadotropins in several mammalian species. We aimed to test its usefulness in the MOET program, where the performance is widely known to be low mainly due to the variable ovarian responses to FSH treatments. Two plasma AMH samples were obtained from each ewe and session at the time of the first FSH injection (T0) and 4 days before (T-4), and were analyzed using the AMH equine ELISA kit (AnshLab, Webster, TX, USA). The AMH concentrations as well as the other MOET-related variables were highly variable between individuals. The AMH at T0 was highly correlated with the total number of corpus luteum (CL) ($r=0.70$; $p<0.05$). In conclusion, plasma AMH concentrations measured before the FSH treatment could be used to predict the ovulatory response of donor ewes, and so to improve the efficiency of MOET programs (Lahoz *et al*., 2015). More data are necessary to assess the individual repeatability as well as the relationship of AMH with other MOET-related variables, in order to establish a reliable protocol to be implemented in farms before selecting and moving the donor ewes. Moreover, selecting at the same time offspring of the preferred sex will make more efficient the MOET selection scheme for increasing prolificacy. In this sense, sex determination in ovine embryos using a duplex PCR has been applied with an efficiency in sex de-

termination of 95 and 98% when more than two and more than three cells were sampled from compact morulae, respectively (Dervishi *et al*., 2008; Dervishi *et al*., 2011). The total time required for the genetic test, was less than 4 h. This rapid sex determination using *AMEL* and *PRNP* genes allows transferring sexed fresh embryos in MOET and IVF (In Vitro Fertilization) programs to make them more efficient.

III – Major genes

In 2007, some descendants of the tested rams showed an uneven increase in prolificacy unexplained by polygenic heredity, leading to the discovery of a new naturally occurring polymorphism in the bone morphogenetic protein 15 (*BMP15*), a fecundity gene with a major effect on ovulation rate (OR) in sheep. The polymorphism (*FecX*^{R} allele) consists of a deletion of 17 bp in the coding region of *BMP15*, located on the X chromosome, which produce an increased in prolificacy in heterozygous (R+) ewes and sterility in homozygous (RR) ewes (Martinez-Royo *et al*., 2008). The *FecX*^{R} mutation, when present in heterozygosity, produces 0.44 extra ovulations in ewe lambs and 0.63 in adult ewes, that lead to an increase in prolificacy of 0.35 lambs per lambing ewe, with no adverse effect on oocyte quality, preovulatory LH surge, fertility after AI or offspring weights at birth (Lahoz *et al*., 2011). The R+ ewes show an increased response to eCG that should be taken into account to avoid too high rates of triplets and higher order births (Lahoz *et al*., 2011). A study was conducted to evaluate the effects of lamb (RR, R+ or ++) and maternal genotypes (R+ or ++) on birth weight, growth and meat quality traits. All lambs were classified within the normal ranges for the "Ternasco de Aragón" commercial category, and no significant differences were observed between the genotype groups. We conclude that birth weight, growth traits, light lamb carcass characteristics and meat quality traits were not affected by the maternal and lamb *FecX*^{R} genotype combinations studied (Roche *et al*., 2012). The use of the *FecX*^{R} allele allows for a very quick increase in prolificacy that results in important economical advantages, meeting the needs of farmers to improve this parameter. However, it is essential to continue with the classical polygenic selection to prevent excessive inbreeding and to improve other productive parameters. In fact, in 2016 the estimated population of R+ ewes was approximately 15,200, showing a clear trend toward increased numbers.

Sheep breeds from the Mediterranean area show reproductive seasonality, mainly regulated by variation in the photoperiod. Maximal reproductive activity is associated with short days, with the highest percentage of ewes exhibiting ovulatory activity from August to March. This reproductive seasonality induces great variation in lamb production and, therefore, in the market price of lamb meat. Hormonal treatments are widely used in some countries to control reproductive activity out of the breeding season, but the increasing demand for hormone-free products leads to search for alternative methods such as the ram effect or the use of genetic markers. In this sense, new variants in *MTNR1A* gene associated to reproductive seasonality have been detected in two different (R+ and ++) populations in the Rasa aragonesa breed. Non-linked SNPs in promoter and exon 2 regions have been detected decreasing the length of non-cycling period (based on weekly individual plasma progesterone levels and defined as the sum of days in anoestrus, considering anoestrus those periods from January to August with three or more consecutive P4 concentrations lower than 0.5 ng/ml) as much as 30 and 53 days, respectively. In the same way, the allele located in exon 2 was also associated to an increase of 15% of oestrus cycling months (defined for each ewe as the rate of months with at least one oestrus record between January and August). The SNP located in exon 2 produces an aminoacid change, while mutations identified in the promoter region could affect binding motifs for some transcription factors. It is important to remark that mutations in the promoter region are age dependent, affecting mainly to young animals. Due to their productive interest, a controlled program for dissemination of *MTNR1A* favorable alleles is currently being developed.

IV – Maternal capacity

Selecting rams with high prolificacy estimated breeding values (EBVs) will increase lamb numbers produced by their female offspring. Then, selecting for improved maternal ability traits will ensure ewes have sufficient milk to rear their lambs, as well as maternal carebehaviour. In this sense, in 2015, a maternal capacity selection criterion in the Oviaragon-Grupo Pastores breeding program has been included, taking into account the lamb birth and weaning weights. For this second weight (weaning) it has been developed an automatic weighting equipment with electronic identification, reducing labour and improving efficiency.

V – Conclusions

A selection programme to increase prolificacy has been carried out in the Spanish sheep breed Rasa aragonesa since 1994, exploiting multiple ovulation and embryo transfer (MOET) to produce males to be tested. This selection led to the detection of a new naturally occurring polymorphism in the BMP15 gene (*FecX*^{R} allele) causing increased prolificacy in heterozygous (R+) and sterility in homozygous (RR) ewes compared with non-carrier (++) ewes, with an additive effect over the standard hormonal treatments used in farms. Recently, *MTNR1A* variants associated to reproductive seasonality have been detected in Rasa aragonesa breed increasing fertility in the non-breeding season. The selection program goes on with a combined polygenic selection for prolificacy, maternal capacity and dissemination of *FecX*^{R} and *MTNR1A* alleles.

Acknowledgments

The authors are thankful to the cooperative UPRA-Grupo Pastores and to the staff of CITA de Aragón for their assistance in sample collection and analysis. These studies were supported by INIA (RTA2006-0140, RTA2013-00041, RTA2015-0090), TRACE (PET-2008-0076), INNPACTO (010000-2010 IPT-33), CDTI (CDTI-IDI-2004-0611, 2007-0880, 2012-0768, 2016-0426), FITE 2016 (I+D PLATEA, A9), Interreg V A -POCTEFA (EFA103/15-PIRINNOVI), and UE-H2020-Call: SFS-01c-2015 (iSAGE) projects and co-financed with FEADER funds.

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Remote sensing for real time estimate of aboveground biomass productivity in mountain pasture

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Abstract. Precision grazing may increase the farm business productivity, through improved pasture and animal management. One of the main issue is to estimate the real productivity of the pasture, in order to program the correct grazing load at each moment of the year. The aim of the study was to verify if the data acquired by the new European satellite system named "Sentinel 2" could be used for estimation of aboveground biomass in a mountain pasture. During 2016 growing season, in a Central Italy mountain pasture (M. Tilia, Rieti), we built nine grazing exclusion fences (12 m x 12 m), including the Sentinel 2 acquisition grid (10 m x 10 m pixel). Inside each plot, we cut grass (5 m^2) once a month for three months. The grass was weighed and analyzed for chemical and physical parameters. At the dates matching with cuts, free-of-charge red and infrared bands were acquired from Sentinel 2 data hub, in order to calculate NDVI (Normalized Difference Vegetation Index). In a GIS environment, we extract NDVI values for each plot. To explore how NDVI relate to biomass, linear regression analyses were performed. NDVI, varying from 0.41 to 0.83, showed strong linear relationships with green biomass (R^2 = 0.6356). A lower relationship was observed between NDVI and dried biomass (R^2 = 0.4678). The model, after being further refined, can be used to spatialise data over vast grazing areas, with high temporal frequency (5-10 days), helping in a more precise planning of livestock grazing.

Keywords. NDVI – Precision grazing – Grassland – Remote sensing.

Remote sensing pour l'estimation en temps réel de la productivité de la biomasse aérienne dans les pâturages de montagne

Résumé. *Le pâturage de précision peut augmenter la productivité des entreprises agricoles, grâce à l'amélioration de la gestion des pâturages et des animaux. L'un des principaux problèmes est d'estimer la productivité réelle du pâturage, afin de programmer la charge des animaux correcte à chaque moment de l'année. Le but de l'étude était de vérifier si les données acquises par le nouveau système européen de satellites appelé "Sentinel 2" pouvaient être utilisées pour l'estimation de la biomasse aérienne dans un pâturage de montagne. Au cours de la saison de croissance 2016, dans un pâturage de montagne de l'Italie centrale (M. Tilia, Rieti), nous avons construit neuf clôtures d'exclusion de pâturage (12 m x 12 m), y compris la grille d'acquisition de Sentinel 2 (10 m x 10 m de pixel). À l'intérieur de chaque parcelle, nous coupons l'herbe (5 m^2) une fois par mois pendant trois mois. L'herbe a été pesée et analysée pour des paramètres chimiques et physiques. Aux dates correspondant aux coupures, les bandes rouges et infrarouges gratuites ont été acquises de Sentinel 2, afin de calculer le NDVI (Normalized Difference Vegetation Index). Avec un software SIG nous avons extrait les valeurs de NDVI pour chaque parcelle. Pour explorer comment NDVI se rapporte à la biomasse, des analyses de régression linéaire ont été. NDVI, variant de 0,41 à 0,83, a montré de fortes relations linéaires avec la biomasse verte (R^2 = 0,6356). Une relation inférieure a été observée entre le NDVI et la biomasse séchée (R^2 = 0,4678). Le modèle, après avoir été affiné, peut être utilisé pour spatialiser les données sur de vastes zones de pâturage, avec une fréquence temporelle élevée (5-10 jours), ce qui aide à une planification plus précise du pâturage.*

Mots-clés. *NDVI – Pâturage de précision – Prairie – Remote sensing.*

I – Introduction

Grasslands are one the most widespread vegetation types all over the World (Latham *et al*., 2014), playing a central role for ruminant nutrition in many countries. Permanent pastures play a key role in climate change (FAO, 2014), regulating the global carbon cycle (Franzluebbers, 2010) acting as carbon sink (Derner and Schuman, 2007), contributes to the maintenance of ecosystem services, including plant and animal biodiversity (Punjabi *et al*., 2013; Primi *et al*., 2015), hydrogeological stability and landscape conservation.

Erroneous livestock management practices, such overgrazing or undergrazing, may leads to grassland degradation, with the risk of losing these benefits. Having accurate and reliable data on the status of pastures is one of the needs for proper grazing load planning. Information concerning sward height, biomass, quality, phenological stage, productivity level, species composition are traditionally acquired with on-field measurement, with intensive efforts and with inappropriate method for large-scale coverage (Ali *et al.*, 2016).

Modeling approaches joined with satellite remote sensing-based techniques permits large scale observation, quantification and prediction at varying temporal and spatial resolutions (Nordberg and Evertson, 2003), allowing a precision farming approach also for grazing livestock (Primi *et al*., 2015). Remote sensing-based studies have demonstrated the potential for grassland monitoring with different approaches, and increasing the spatial and temporal resolution seems to be the future challenge, as well as the communication of the benefits and opportunities to the farming community (Ali *et al*., 2016).

The aim of the study was to verify if the data acquired by the new European satellite system named "Sentinel 2" could be used for estimation of aboveground biomass in a mountain pasture, contributing to the scientific debate on the topic.

II – Material and methods

1. Aboveground grassland productivity

The studies were conducted during the year 2016 growing season (June-September). In a Central Italy mountain pasture (M. Tilia, Rieti, 42°32'56.60"N, 12°32'56.60"E) (Figure 1), we built nine grazing exclusion fences (12 m x 12 m), including the Sentinel 2 acquisition grid (10 m x 10 m pixel). Inside each plot, we cut grass (5 m^2) once a month for three months. The grass was immediately weighed (fresh weight, FW). A quote was taken to the laboratory for chemical analysis.

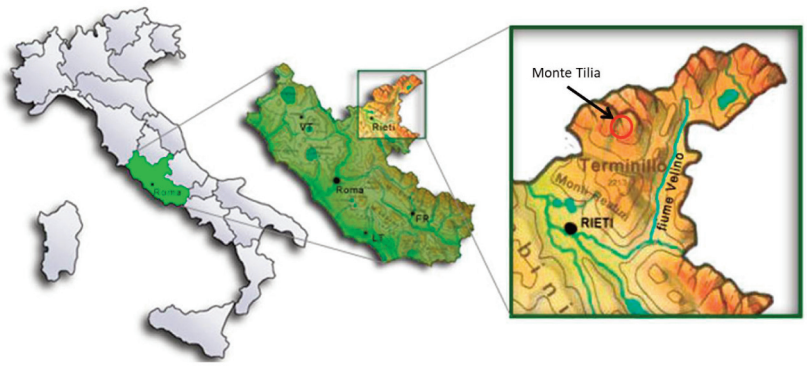

Fig. 1. Study area.

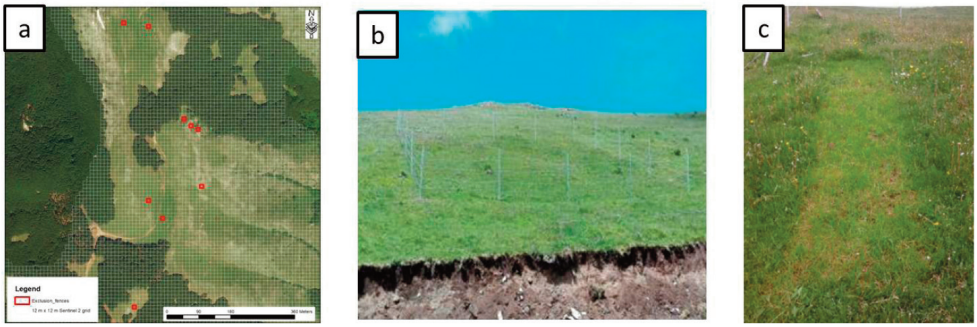

Fig. 2. a) Localization of the 9 exclusion fences over the Sentinel 2 grid; b) example of esclusion fence; c) 5 m^2 grass cutting plot.

2. Chemical analysis

The grass was analyzed for chemical parameters, such as dry matter (DM), crude protein (CP), ether extract (EE), crude fibre (CF) and ash as reported by AOAC (2012) procedures (ID number: 2001.12, 978.04, 920.39, 978.10 and 930.05 for DM, CP, EE, CF and ash respectively). Neutral detergent fibre was assayed with a heat stable amylase and expressed exclusive of residual ash (aNDFom), acid detergent fibre expressed exclusive of residual ash (ADFom) and ash were determined according to AOAC methods 984.13 (A-D), 920.39, 2002.04, 973.18 and 942.05 (AOAC, 2012).

3. Statistics

NDVI was related to field measured biomass (t ha^{-1}) and to the chemical parameters using simple linear regressions. Statistics were performed with Statistica 10 software (StatSoft, Inc., 2011).

III – Results and discussion

The summary statistics of biomass dataset are reported in Tab. 1. NDVI, varying from 0.41 to 0.83, showed a good linear relationships (Y=18.681X-7.1557, R^2=0.64, Standard Error of the Estimate [SEE]=1.59, P<0.001) with green biomass (Fig. 4). As expected, a lower relationship (Y=4.1051X-1.0457, R^2=0.47, SEE 0.49, P<0.001) was observed between NDVI and dried biomass.

Table 3. Summary statistics of measured biomass for the data set

	Mean	Min	Max	Range	Std. Dev.	Coef. Var.
Fresh green biomass (t ha^{-1})	5.04	0.15	22.96	22.81	5.13	101.81
Dry green biomass (t ha^{-1})	1.75	0.12	6.13	6.01	1.48	84.64

Significant correlation at P<0.05 was found between NDVI and ether extract (P=0.045) and NDVI and Acid Detergent Fibre (P=0.017), however with lower coefficient of correlation (R^2= 0.10 and 0.19, respectively).

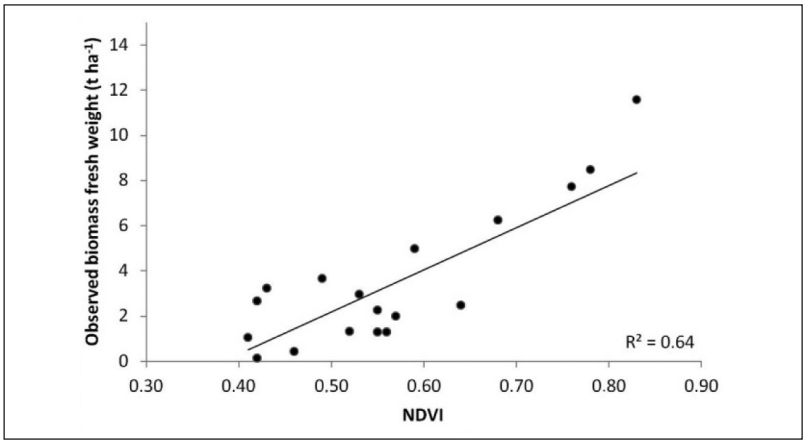

Fig. 3. Linear regression model fitting observed biomass fresh weight *vs*. NDVI.

IV – Conclusions

The simple linear regression model, after being further refined and validated, can be used to spatialise data over vast grazing areas, with high temporal frequency (5-10 days as Sentinel 2 acquisition of images), helping in a more precise planning of livestock grazing. Other vegetation indexes (i.e. REP, SAVI, TSAVI) could be used in order to minimise inaccuracies (e.g., mitigating the effects of atmosphere and background reflectance etc.) or to find some possible relationship with chemical composition (i.e. with the nitrogen content).

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The gaps and environmental challenges for small ruminant production in Turkey

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Abstract. Livestock production aims to sustainability, increasing productivity and producer incomes. In Turkey, largest population of sheep and goat known by adaptation to marginal conditions with low reproductive efficiency, and low milk and wool production In extensive livestock production systems the productivity of meat and milk producing animals is low compared with that of the intensive production systems. There are three general production systems, the sedentary, transhumant and nomadic system. While the nomadic system decline the sedentary system increase and transhumance is still common. Improved genetics is effective in commercial systems, however in marginal environments and extensive livestock systems have interaction effects of the adaptation, production environment and management practices should account for sustainable farming. Breeders prefer cross-breeding and changing their breeds with improved bred to increase productivity (i.e., live weight, milk yield and reproduction). Locally adapted breeds known having lower reproduction, meat and milk production levels' compared to the exotic breeds and their crossbreds. But, integrated approach should be placed on via developed breeding programs. Breed adaptation, conformity with production environment and marketing opportunity are important points for the sustainable production; therefore interrelated effects must determine and take into consideration in the long-term goals. Good management practices, high exploit production environments, and better product quality for marketing which may answer consumer preferences.

Keywords. Sheep – Goat – Adaptation – Production environment – Productivity – Sustainable production.

I – Defining production systems

The management practices and production systems developed by adaptation to the production environment since the domestication. Therefore, livestock production systems differ widely in relation to production environment, species/breeds, degree of intensification, use of resources, local condition, socio-economic condition, cultural/traditional/religion aspects etc. Thus, determination of the production characteristics of the breeds and identification of important features in certain production environment are fundamental steps.

With the arid/semi-arid climate Turkey has large grasslands and steppes that are suitable for sheep and goat breeding. Anatolia's rich geographical and climatic conditions cause high genetic diversity of animal genetic resources (AnGR). In 2017, Turkey has 30.9 million head sheep (47 breeds) and 10.3 million head goat with (18 breeds). The number of purebreds declined and even their populations reached to the threshold of extinction mainly due to the uncontrolled crossbreeding. Therefore, efforts related to the conservation of AnGR have been increased in last two decades. Subsidy policy has been continuing since 2005 for the AnGR which are under the risk of extinction. National Strategy and Action Plan for AnGR Turkey (2015-2010) accepted as priority of developing strategies to sustainable production of AnGR, i.e. breed specific products, niche markets, traditional production systems and long term breed improvement programs via breeder organizations.

For the prior classification, livestock productions have been characterized as extensive, semi-extensive and intensive. A key factor of intensity is input of purchased feedstuffs together with information regarding stocking rate or grazing duration (Gelasakis *et al.*, 2017). Typically, small rumi-

nant systems comprise of small-size flocks that are managed with family labor. Most of the farms are operated as family based enterprises. Herding mostly carried out by household member. Some farms paid their workers as employees (shepherd, management etc.). In accordance with the dependency of natural resources, production systems can classified as land based and landless systems. Commercial-industrialized enterprises can classified as non-family farms. Landless commercial production systems are mainly present in west part of Turkey. And, they characterize using high productive breeds such as Saanen and Shami goat.

For the small ruminant breeding there are three general systems; the sedentary, transhumant and nomadic system (Yalçın B.C., 1986). The nomadic system is dramatically declining. Transhumance is still common but is leaving its place to sedentary system for sheep and goat production because of the social and economic condition (Gürsoy, 2005). Farmers prefer to stay settled and enjoy common development and follow the changing socio economic conditions.

II – Sustainable production

Livestock production aims to sustainability, increasing productivity and producer incomes. Sustainability of sheep and goat breeding concerns about the relationship among production environment (e.g. climate change, soil formation, water cycling, regulation services), social context (increasing demand for livestock product, religion,) and mainly economic dimensions.

The factors that contributed negatively to the small ruminant production in Turkey are many; low genetic potential of the native breeds, inappropriate breeding strategies, decrease in the area covered by pastures, intensification of agriculture and livestock production, demand for high status jobs, support regimes favoring poultry and dairy production, inappropriate market conditions for sheep and goat production. The livestock inventory data show that the number of the animals has decreased since the early 1980s and the number of breeds at risk in Turkey (Yıldırır *et al.*, 2011). For this reason, the conservation and sustainability of farm animal genetic diversity in Turkey is essential for sustainable animal production, rural development and food security.

Traditional small ruminant production is characterized by low inputs and low outputs. The low input–output production system in the sheep and goat production is not satisfied developing economical and social welfare conditions in the rural areas. Because of the complex and diverse nature of the traditional livestock keeping socio-economic factors are more important in order to fully explain the determiners of the production. Do the pastoral livestock breeders always face to low potential and use the unfavorable agricultural areas?

The proportion of household income from livestock sources differentiated in different based livestock production system. Therefore, one way analyze does not fully explains the real production determiners, because of the complex and diverse nature of the traditional livestock keeping. The classification of native AnGR in their original production environment with socio-economic characteristics can also help to market traditional and qualitative products. In Turkey, largest population of sheep and goat known by adaptation to marginal conditions with low reproductive efficiency, and low milk and wool production. Despite a low in milk, reproduction and meat gross output per head fell breeders preferred to continue production because of the socio-cultural factors and livelihoods.

Locally adapted breeds known having lower reproduction, meat and milk production levels' compared to the exotic breeds and their crossbreds Improved breeds and crossbreeds can increase productivity (i.e., live weight, milk yield and reproduction). However, exotic breeds more vulnerable than local breed for the new production environment. An integrated approach should be placed on via developed breeding programs, good management practices and high exploit production environments.

Local species and breeds often have advantages in terms of their ability for adaptive traits, but also disadvantages for productive traits (Anderson, 2003). Studies are required to quantify most of these valuable characteristics and to identify the underlying genetic effects.

In extensive condition the total milk yield per lactating was estimated to be around 50-100 kg for sheep and goats. According to field observations, some breeders prefer low production level for the some of the native breeds. Low production levels could be preferable under the certain circumstances especially for adaptive traits. For example Honamlı goats, knowing high performance, some breeders stated that they intentionally select lower milking performance of goats for the adaptation to the particular marginal production environments and feeding conditions. Thus, the adaptation level should be considered when recommended to certain environment.

Contrarily, indiscriminate cross-breeding reported as top threats for the AnGR in the SoW-AnGR (FAO, 2015). Many farmers prefer cross-breeding their local breeds with exotic breeds to take advantage of the combination of adaptive and productive traits.

On the other hand, some indigenous and locally adapted breeds lost their economic importance and thus becoming endangered. Under the conditions, there is no other choice for these farmers whether cross-breeding or to get support from conservation subsidy. For the conservation of breeds that are threatened of extinction, which factors can be used as an incentive for farmers to sustainable production?

Having breeders associations and coordinate production activities (e.g. provide input, market linkage, genetic selection, performance recording, sire exchange schemes) are crucial especially for the local breed farmers. Breeders associations for sheep and goat are new and the formation need to be progress for the operational real affects in Turkey. Developed countries have successfully used rural development tools. The stakeholders such as breeder organization, cooperatives, university, NGO has taken responsibilities for the sustainable production and rural development.

Marketing services was the most important service among the breeding program activities in priority order for goat keepers (Bett *et al*., 2009). This classification can also help to farmers depending on differences between their socio-economic characteristics. For example, encouraging traditional goat farmers to manufacture protected designation of origin (PGO) dairy products from their own milk may make their farms more viable (Gelasakis *et al*., 2017).

Social and cultural factors have profound effects on sustainability of livestock production systems in particular locations. However, small ruminant productions are probably not well understood. Because of the complex situation of the environment, cultural, social and economic factors, it is often unclear how these factors play out in relation to impacts on livestock breed and production systems. But this conditions changes thanks to projects that focus AnGR.

III – Conclusion

In order to maintain food safety and agricultural production, AnGR and production environments are two basic components of biological diversity. In terms of sustainability, functions of the both component should be well analyzed. Breed adaptation, conformity with production environment and marketing opportunity take into consideration in the long-term goals. Good management practices, high exploit production environments, and better product quality for marketing which may answer consumer preferences.

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Session 4

Success stories of innovations in the sheep and goat industry, with special focus on increasing consumption and adding value to products

Ekiola: Piloter l'alimentation des ovins lait en s'appuyant sur les profils d'acides gras pour mieux soigner les animaux et accroître la valeur santé des produits laitiers fermiers

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Résumé. Le Groupement agricole d'exploitation en commun(GAEC) Elizagaraia (ferme Ekiola) a développé une gamme de produits laitiers diversifiés (pâtes pressées sous AOP Ossau Iraty, pâte molle, yaourt, greuil) fermiers (lait cru) à partir d'un troupeau de brebis mixte (manech tête rousse et tête noire). Il fait vivre 6 personnes. Depuis 10 ans, engagé au sein de l'association Bleu-Blanc-Coeur (BBC), l'alimentation du troupeau a été adaptée de manière à accroître la valeur santé du lait (qualité des acides gras) et la production laitière, par supplémentation en lin, mais aussi en réincorporant des fourrages et aliments favorables à ces objectifs. Le suivi analytique mensuel, mais aussi celui des animaux (notation de l'état corporel) et de la production permettent véritablement de piloter la conduite du troupeau en respectant la Charte BBC. La société de service associée Valorex propose un outil en ligne « Visiolait » basé sur l'interprétation des spectres prochain infrarouge (NIR), avec des indicateurs de qualité des acides gras, d'état physiologique tu troupeau et d'émission de méthane.

Les produits laitiers sont valorisés entre 2,5 et 3 euros par litre de lait, les clients sont de plus en plus sensibles aux allégations nutritionnelles portées par BBC.

Mots-clés. Produits au lait de brebis – Graine de lin – Systèmes d'alimentation – Acides gras du lait.

Ekiola: manage feeding of a milk sheep flock based on the use of milk fatty acid composition to better care for animals and increase the health value of dairy farm-products

Abstract. *The GAEC Elizagaraia (farm Ekiola) has developed a range of diversified raw milk products (pressed cheese under PDO Ossau Iraty, soft cheese, yogurt products, greuil) from a herd of mixed ewes (red-faced and black-faced manech). The GAEC supports 6 units of labour. For the past 10 years, commited within the association "Bleu-Blanc-Coeur" (BBC), the herd management has been adapted to increase the health value of milk (quality of mik fatty acids) and milk production, by supplementation in extruded flaxseed, but also by reincorporating fodder and concentrates favorable to these objectives.*

Monthly analytical Monitoring and also of the herd (body condition) and production allows to manage the herd according to the charter BBC. The associated service company Valorex offers an online tool "Visiolait",based on the interpretation of NIR spectra, with indicators of fatty acid quality, herd physiological status and methane emission.

Dairy products are valued between 2.5 and 3 euros per liter of milk. Clients are increasingly sensitive to nutritional claims developed by BBC.

Key words. *Dairy sheep products – Extruded flaxseed – Feeding system – Milk fatty acid.*

I – Ekiola, un producteur fermier dans une démarche nutritionnelle

Le GAEC Elizagaraia (Gamarthe, France, GPS : 43.201593, -1.143084) est un GAEC familial orienté vers la production fermière de produits à base de lait de brebis. Le troupeau est aujourd'hui constitué de 670 brebis (manech tête rousse en majorité et manech tête noire), dont plus de 500

à la traite (Tableau 1). Un gros effort d'amélioration a été consenti, avec un taux d'insémination de 88,6 % en 2016. La production laitière a été augmentée ces dernières années, en passant de 180 litre/brebis traite à 257 litres. La production laitière (calculée à partir des données de contrôle laitier) est passé de 75 000 litres à 127 000 litres.

Tableau 1. Résultats techniques de l'élevage: effectifs, moyennes de production par campagne de 2007 à 2016

Année	2007	2009	2011	2013	2015	2016
Brebis présentes	**554**	**577**	**619**	**636**	**641**	**671**
Mises-bas	*434*	*441*	*462*	*473*	*492*	*507*
Agnelles de renouvellement	*125*	*146*	*141*	*131*	*144*	*154*
Production par brebis (litres)	***178***	***178***	***181***	***182***	***214***	***257***
Durée de traite (jours)	*170*	*158*	*153*	*167*	*166*	*169*
Volume de lait campagne	***75300***	***76700***	***82500***	***84600***	***103600***	***127300***
Nombre d'agneaux	*547*	*533*	*578*	*669*	*661*	*720*
Fertilité globale	***98,0***	***96,6***	***95,3***	***93,3***	***97,6***	***94,9***
Prolificité globale	*126*	*121*	*125*	*141*	*134*	*142*
Nombre d'IA	**289**	**318**	**333**	**425**	**429**	**473**
Taux d'IA	*65,2*	*69,9*	*68,7*	*83,8*	*85,1*	*88,6*

Source: SIEOL, Centre Départemental de l'Elevage Ovin, Ordiarp.

L'engagement dans l'association Bleu Blanc Cœur (BBC) remonte à plus de 10 ans, en adhérant à la promesse de mieux nourrir le troupeau et de produire un lait à haute valeur nutritionnelle. La démarche a permis progressivement de trouver des règles de conduite et d'alimentation qui portent leurs fruits aujourd'hui.

Le troupeau continu de transhumer, et la production de lait d'estive va pouvoir redémarrer. L'alimentation hivernale repose sur des aliments favorables aux acides gras d'intérêt : foin de luzerne (et foin de vesce), foins de graminées et pâturage, complémentation avec un aliment riche en lin, et une forte limitation du maïs.

Au-delà du suivi de la production laitière, les états corporels sont pris en compte. Le monitoring proposé par Valorex (Visiolait), permet mensuellement un suivi des indicateurs de qualité du lait et de l'état physiologique du troupeau, avec la possibilité de corriger les déséquilibres éventuels. Les problèmes sanitaires (mammites, avortements) sont apparemment limités.

Le lait est transformé principalement en fromage de brebis sous appellation d'origine Ossau Iraty, mais avec des formes de diversification : « tomette » pâte pressée, fromage lactique, mais aussi caillés (« mamia »), greuil (ou breuil), yaourt.

Cette diversification vers des produits frais a nécessité une réorganisation des circuits de vente pour gérer conjointement produits frais et produits à affinage long. La vente directe à la ferme et les marchés restent les principaux canaux de commercialisation.

Le site internet (http://www.fromage-de-brebis.fr/) propose « un panier » de produits qui peuvent être commandés en ligne. Mais il a fallu organiser des formes de commande, de la part des particuliers comme des collectivités. L'engagement nutritionnel BBC a débouché sur des marchés auprès des personnes les plus fragiles, comme des maisons de retraites ou des cliniques. Le greuil, par sa richesse en protéines sériques (et en minéraux) intéresse de plus en plus les nutritionnistes et le monde médical. Les allégations santé mettant en cause les produits au lait de vache sont très favorables aux produits à base de lait de brebis, avec une très bonne perception de la démarche BBC.

Celle-ci permet d'améliorer le niveau de valorisation du lait, entre 2,5 et 3 €/litre. Il semble difficile d'augmenter encore ce niveau dans un contexte aussi concurrentiel que celui des Pyrénées Atlantiques.

Un des enfants du couple d'éleveurs termine ses études dans une École nationale de l'industrie laitière (ENIL) et va rejoindre prochainement le GAEC pour poursuivre la diversification. Le GAEC fait vivre 6 personnes aujourd'hui. un des premiers objectifs est de retrouver une organisation du travail moins chronophage. Une réflexion est en cours pour réaménager les locaux et les équipements (bergerie, saloir) et les render plus fonctionnels.

II – La démarche « Bleu-blanc-cœur »

L'association « Bleu-Blanc-Cœur » (http://www.bleu-blanc-coeur.org) a été créée en 2000 pour promouvoir une meilleure alimentation des animaux, et la production d'aliments de qualité nutritionnelle supérieure pour l'homme. L'association est organisée en filière regroupant des producteurs (500 producteurs adhérents sous la marque), transformateurs, distributeurs, mais aussi des compétences scientifiques en amont et une unité de production d'aliments (Valorex) et d'assistance technique. Elle est aujourd'hui pleinement reconnue par les services de l'Etat (ministère de l'agriculture, de l'environnement et de la santé), et elle commence à se développer en Belgique. Chaque producteur est engagé par une charte, qui fixe des obligations de moyens (plan d'alimentation) et de résultats (analyses, suivi mensuel des analyses)

L'objectif d'amélioration de l'alimentation animale repose en premier lieu sur l'utilisation privilégiée d'aliments riches en oméga 3 (lin, pâture, luzerne) et la réduction des aliments favorables à la production d'acides gras saturés, voire l'interdiction de certaines substance (huile de palme) ainsi qu'aux aliments importés.

Des indices (IT3 : http://www.tradilin.ch/site/index.php/fr/l-association/l-indice-it3) ont été proposés pour calculer l'efficacité des sources d'ω3, chaque aliment étant caractérisé par un indice propre. Le cahier des charges fixe le niveau d'indice à atteindre dans les plans d'alimentation.

Le suivi analytique des acides gras repose pour partie sur des analyses de référence (profils des acides gras par chromatographie en phase gazeuse par un laboratoire agréé), mais aussi le recours aux nouvelles méthodes telles que les spectres infrarouge prochain (NIR) à partir d'une analyse de lait (1 analyse par mois). Au-delà des indicateurs qualitatifs sur les acides gras (part d'acide palmitique, part des ω3), le NIR permet de produire des indicateurs de bon fonctionnement physiologique du troupeau (expression du potentiel laitier, risque acidose, efficacité protéique). Enfin, l'analyse permet aussi de prédire la production de méthane par les animaux. Ainsi Valorex (http://www.valorex.com/), la société service de l'association BBC a développé un expertise propre (et protégée), elle met à disposition des adhérents un outil en ligne intégré de valorisation de l'ensemble des résultats, « Visiolait » (http://www.visiolait.com/description). L'outil permet de situer les résultats de l'élevage vis-à-vis des engagements inscrits dans la Charte. Un volet biodiversité est aussi développé, basé sur la nature des cultures. L'ensemble des résultats alimente un compteur « Eco-nutrition ».

III – De l'analyse à la valorisation des analyses d'acides gras : tables CIQUAL et résultats disponibles

Les résultats d'analyses et le références relatives aux laits de brebis en France sont peu nombreux et difficiles d'accès aux professionnels.

Le CIQUAL (Centre d'information sur la qualité des aliments) a été créé en 1985, à l'initiative conjointe des Pouvoirs Publics et des industries agroalimentaires. Il est chargé de gérer et de valoriser une banque de données sur la composition nutritionnelle des aliments consommés ou produits en France.

Il est rattaché aujourd'hui à l'ANSES (Agence nationale de sécurité sanitaire de l'alimentation, de l'environnement), établissement public assurant *des missions de veille, d'expertise, de recherche et de référence sur la santé humaine, la santé et le bien-être animal ainsi que la santé végétale.*

Chaque produit (https://pro.anses.fr/tableciqual/index.htm) fait l'objet d'une fiche nutritionnelle regroupant les teneurs moyennes en différents constituants (glucides, protéines, lipides et acides gras, vitamines, minéraux…) ainsi que les valeurs énergétiques des aliments. Les données sont toujours proposées pour 100 g d'aliment.

Les tables relatives aux laits et aux fromages de brebis ont été élaborées sur la base, principalement, des résultats de l'étude menée dans les 3 principaux bassins français en 2005 à partir de 55 échantillons de lait (de mélange pour les Pyrénées Atlantiques) et 49 fromages (type Ossau Iraty), soit une ensemble de 2600 analyses. Cette étude a fait l'objet de 2 publications, dont une publique:

- Caractéristiques nutritionnelles du lait de brebis, rapport final du programme réalisé dans le cadre du Comité Lait de Brebis de l'Office de l'Elevage, mai 2008, réalisé par Gilles Lagriffoul,
- Composition fine du lait et du fromage de brebis, document de synthèse réalisé dans le cadre du Comité Lait de Brebis de l'Office de l'Elevage, septembre2008, réalisé par Gilles Lagriffoul (http://cfbourgogne.free.fr/IMG/pdf/compo_fine_lait_fromages_brebis.pdf)

Les valeurs des tables CIQUAL sont présentées sur le Tableau 2.

Tableau 2. Principaux types d'acides gras et ratios issues de differentes analyses (voire texte)

	Office élevage 2008				CIQUAL 2016			Ekiola		Ayhe	LPA	
	Lait de brebis		Fromage type Ossau Iraty		Lait brebis	Fromage brebis Pyrénées	Fromage brebis PP	*Fromage 2016*	*Lait 2013*	Lait 2016	*Lait L1*	*Lait L2*
	g/100g	%AG	g/100g	%AG	g/100g	g/100g	g/100g	%AG	%AG	%AG	%AG	%AG
Matières grasses	*6,97*		*35,35*		6,97	33,6	32,3					
AGS (saturés)	***4,8***	***69,1***	***20,71***	***71,1***	***4,8***	***20,7***	***21,3***	***71,9***	***69,2***	***70,8***	***76,2***	***72,2***
C 16:0 (palmitique)			*7,97*	*22,6*	*1,53*	*7,64*		*22,0*	*21,2*	*24,5*	*26,3*	*24,2*
AGI (insaturés)	***1,9***	***26,9***	***8,9***	***25,1***	***1,9***	***12,0***	***10,6***	***28,2***	***30,8***	***30,7***	***24,2***	***28,0***
AGMI	*1,6*	*22,4*	*7,33*	*20,7*	*1,6*	*10,9*	*9,5*	*22,1*	*24,3*	*24,6*	*20,2*	*23,5*
AGPI	*0,3*	*4,45*	*1,57*	*4,43*	*0,3*	*1,09*	*1,1*	*6,1*	*6,5*	*6,1*	*4,0*	*4,5*
C18 :1 (oléique)	***1,6***		***4,53***	***13,9***	***1,26***	***7,16***		***19,8***	***22,0***	***17,8***	***18,2***	***21,9***
C18 :2 (LA linoléique)	***0,18***	***1,64***	***0,63***	***1,79***	***0,18***	***0,56***		***1,9***	***1,3***	***1,8***	***1,9***	***2,1***
C 18 :3 (ALA alphalin.)	***0,073***		***0,33***	***0,94***	***0,073***	***0,22***		***1,2***	***1,6***	***1,0***	***0,7***	***0,9***
n-6	*0,12*		*0,58*	*1,66*	*0,18*	*0,56*		*2,2*	*1,4*	*2,9*	*2,1*	*2,4*
n-3	*0,073*		*0,33*	*0,94*	0,073	0,22		*1,6*	*1,8*	1,2	*1,0*	*1,1*
LA/ALA			***1,92***	***1,90***	***2,47***	***2,55***		***1,58***	***0,81***	***1,8***	***2,56***	***2,4***
n-6/n-3			***1,76***	***1,77***	***2,47***	***2,55***		***1,38***	***0,78***	***2,4***	***2,18***	***2,10***
C 18 :1/ C 16 :0			***0,57***	***0,62***	***0,82***	***0,94***		***0,90***	***1,04***	***0,73***	***0,69***	***0,90***
AGS/n-3			***62,8***	***75,7***	***65,8***	***94,1***		***44,9***	***38,4***	***59,0***	***78,1***	***64,1***

Les analyses présentées dans le Tableau 2 ont été réalisées en méthodes de référence :

- Etude Office élevage : URH INRA Clermond Ferrand, Chromatographie phase gazeuse sur colonne capillaire CP Sil-88 de 100 m (Loor *et al.*, 2005, JDS, 88, 726-740)
- Ekiola et LPA : Laboratoire InvivoLabs à Saint Nolff, chromatographie en phase gazeuse des esters méthyliques d'acides gras (norme ISO 5508)
- Ayhe : laboratoire ABioC à Arzacq selon même méthode (norme ISO 5508 et 5509).

Les résultats sont exprimés soit en g/100g de produit (convention CIQUAL), soit en pourcentage des acides gras (%AG) pour les analyses par chromatographie en phase gazeuse. Nous avons complété avec quelques résultats complémentaires, issus en particulier des essais menés sur la ferme du lycée d'Oloron Soiex (LPA) portant sur l'incorporation (L2, ou pas L1) de matières grasse d'intérêt nutritionnel (Le Scouarnec J., 2012, effet de l'utilisation d'aliments gras sur la production de brebis laitières basco-béarnaises http://www.journees3r.fr/spip.php?article3506).

Ces résultats, et en particulier les ratios nutritionnels (LA/ALA, n-6/n-3, AGS/n-3), mettent en évidence des profils différents des valeurs de référence et des autres analyses présentées, avec un abaissement du pourcentage d'acide palmitique et au contraire des valeurs élevées pour les acides gras poly-insaturés (AGPI) et les oméga 3 (n-3). Les résultats observés peuvent être, pour certains critères, très éloignés des valeurs de référence du CIQUAL. De manière générale, il reste difficile de comparer des résultats issus de laboratoires différents et exprimés dans des unités différentes : de ce fait, éleveurs et techniciens sont rarement à même de tirer parti de ces analyses, et de les valoriser, tant techniquement que commercialement.

IV – Conclusions

L'association Bleu-blanc Cœur a su, au tournant du XXIème siècle, remettre la valeur santé des aliments pour les animaux et les hommes au centre de l'acte de production. Elle développe aujourd'hui une démarche holistique prenant en compte les dimensions environnementale et climatique, avec néanmoins des limites sur ces derniers indicateurs. La ferme Ekiola a pu y puiser les moyens de développer une gamme de produits diversifiés en phase avec les attentes sociétales, en cohérence avec le projet personnel des associés, et de bénéficier d'un encadrement technique adapté. Ces résultats, et en particulier les ratios nutritionnels (LA/ALA, n-6/n-3, AGS/n-3), mettent en évidence des profils très différents des valeurs de référence et des autres analyses collectées, avec un abaissement du pourcentage d'acide palmitique et au contraire une augmentation des acides gras d'intérêt, en leur conférant un réel intérêt nutritionnel. D'autres producteurs des Pyrénées Atlantiques (http://ouionatousledroitdebienmanger.fr/Tous-les-Produits-Bleu-Blanc-Coeur-autour-de-vous/64) semblent se tourner vers ce type de démarche. Cette préoccupation reste néanmoins très marginale dans la zone et peu abordée par les organisations (inter-)professionnelles, alors que d'autres filières, françaises (4ème bassin avec la gamme Petit Basque) ou européennes (Italie, Espagne) se sont emparées de ces problématiques.

Yogurt enrichment with *Spirulina* (*Arthrospiraplatensis*): effect on physicochemical, textural properties and consumers acceptance

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Abstract. Cyanobacterium*Spirulina* (*Arthrospiraplatensis*) is a filamentous multicellular, blue-green microalgae, known for its balanced biochemical composition (good quality proteins, balanced fatty acid profiles, vitamins, antioxidants and minerals). Moreover, since 1981, Food and Drug Administration has considered it as "generally recognized as safe" (GRAS) and recommends a consumption at a level up to 300 mg/kg body/day, when dried. Therefore this makes it interesting to incorporate into the formulation of novel functional products. The objective of the study was to develop a functional yogurt enriched with *Spirulina*. *Spirulina* powder (0.1-0.5 % of milk) was added to the standardized pasteurized milk, prior to lactic fermentation during manufacturing process. Physicochemical, textural and sensory properties were assessed. Preliminary formulations indicated that addition into yogurt of *Spirulina* powder in concentrations above to 0.3% of milk led to a weaker sensory acceptability. However, flavouring with vanilla/mint aromas has improved overall acceptability. Additional formulations showed that the incorporation of 0.12 and 0.24% resulted in a significant increase in proteins (up to +46%) and minerals contents (up to +23%) and in calorie value (up to +80%), but did not affect pH and syneresis. A higher curd strength was observed with 0.24%*Spirulina*-enriched product. Sensory quality was not affected by incorporating *Spirulina* up to 0.24% into yogurt. In conclusion the incorporation of *Spirulina* powder can enhance the nutritional quality of yogurt, without affecting its sensory properties.

Keywords. *Spirulina* – Functionalfoods – Nutritional value – Sensory quantitative descriptive analysis – Texture – Yogurt.

Enrichissement du yaourt avec la* Spiruline (Arthrospiraplatensis) : *effet sur les propriétés physicochimiques, texturales et l'acceptation des consommateurs

Résumé. *La cyanobactérieSpirulina (*Arthrospiraplatensis*) est une microalgue filamenteuse multicellulaire, bleu-vert, connue pour sa composition biochimique équilibrée (protéines de bonne qualité, profils d'acides gras équilibrés, vitamines, antioxydants et minéraux). En outre, depuis 1981, elle est classée comme «généralement reconnue comme sûre» (GRAS) et la Food and Drug Administration recommande une consommation journalière allant jusqu'à 300 mg/kg de masse corporelle, lorsqu'elle est séchée. Par conséquent, il est intéressant de l'intégrer à la formulation de nouveaux produits fonctionnels. L'objectif de l'étude était de développer un yogourt fonctionnel enrichi en spiruline. La poudre de spiruline (0.1-0.5 % de lait) a été ajoutée au lait pasteurisé standardisé avant fermentation lactique pendant le processus de fabrication. Les propriétés physicochimiques, texturales et sensorielles ont été évaluées. Les formulations préliminaires ont indiqué que l'addition dans le yaourt de poudre de Spiruline à des concentrations supérieures à 0.3 % de lait a conduit à une plus faible acceptation sensorielle. Cependant, l'aromatisation du yaourt enrichi par une combinaison vanille / menthe a amélioré l'acceptabilité globale. Des formulations supplémentaires ont montré que l'incorporation de 0.12 et 0.24 % a entraîné une augmentation significative des protéines (jusqu'à + 46%) et des contenus minéraux (jusqu'à + 23%) et en valeur calorique (jusqu'à + 80%), mais N'affecte pas le pH et la synérèse. Une résistance au caillé plus élevée a été observée dans le yaourt enrichi à 0.24 % de spiruline. La qualité sensorielle du yaourt n'a pas été affectée par l'incorporation de Spirulina jusqu'à 0.12%. En conclusion, l'incorporation de la poudre de Spiruline peut améliorer la qualité nutritionnelle du yaourt, sans affecter ses propriétés sensorielles.*

Mots-clés. *Spiruline – Aliments fonctionnels – Valeur nutritionnelle – Profil sensoriel – Texture – Yaourt.*

I – Introduction

The cyanobacterium*Spirulina(Arthrospiraplatensis*) planktonic blue–green algae, is gaining increasing attention because of its nutritional and medicinal properties. It is certified GRAS (Generally Recognized As Safe) and approved by the FDA since 1981. *Spirulina* is a source of proteins (up to 70%) and contains several minerals and vitamins such B12, B1 (thiamine), B2 (riboflavin), B3 (niacin) and tocopherol (vitamin E), as well as lipids (up to 7%) and essential fatty acids such as linoleic acid and γ-linolenic acid (Wells *et al*., 2017). The carbohydrate content is 15-20% of dry weight, composed of glucose and glycogen. Moreover, *Spirulina* is a valuable resource for natural antioxidants, such as phycocyanin pigments, carotenoids, and phenolic compounds (Wells *et al*., 2017). Interestingly, a noteworthy trend is the addition of *Spirulina* for the improvement of the nutritional properties of yogurt and fermented dairy products (Kavimandan, 2015). In fact, recent studies have shown that *Spirulina* can promote the growth of lactic acid bacteria not only in synthetic media but also in milk and yogurt (Kavimandan, 2015). The aim of this study was to investigate the effect of yogurt enrichment with *Spirulina* powder on physicochemical, textural and sensory quality of the yogurt.

II – Materials and methods

1. Materials

Spirulinaplatensis biomass was obtained from the Gatrana SA (SidiBouzid, Tunisia). The dried biomass contained 58% proteins, 1.5% lipids, 21% carbohydrates, and 9.41% ashes. Yogurt was manufactured by fermenting standardized pasteurized milk with the starter thermophilic culture (*Streptococcus salivarius subsp. thermophilus*and *Lactobacillus delbrueckiisubspbulgaricus*) according to standards ofSociétéLaitetDérivés (Tunisia).*Spirulina* powder (0.1-0.5 g per 100mL of milk, %) was added to the standardized milk, prior to fermentation step.

2. Analytical Analysis

Yogurtstitrable acidity, pH, total solids, ashes, fat (F) and proteins (P) contentsanalyses followed standard procedures and were performed in triplicate (AOAC, 2012).The carbohydrate (C) content was determined by subtracting the lipid, protein and ash contents from the solid content. The total caloric value was calculated by adding up the calories provided by the energy-containing nutrients, using the following calorie conversion factors: 4.27P+ 3.82C + 8.79F (Southgate, and Durnin, 1970). Syneresis (mL/125 g) was expressed as the exudate volume collected after 2h-refrigeration at 4°C. Apparent viscosity was measured by Rheomat FM180 (Rheometrics) equipped by coaxial cylinders (standard-size DIN) with a cylindrical rotor: height of the immersion roller (42mm),inner cylinder diameter (15mm).Thixotropic behaviour of the samples was evaluated by calculating the area of the hysteresis loop between the upward and downward shear stress/ shear rate curves. A sensory profile was performed by 10 trained panellists (ISO13299, 2016). Each attribute was quantified using the intensity scale (from 1 = not detected to 7 = extremely strong)

3. Statistical Analysis

Datas were analysed by One way ANOVA and Tukey test, using statistical software (GraphPad Prism V.4, 2003).A p value < 0.05 was considered significant for all analyses.

III – Results and discussion

1. Preliminary yogurt formulations

Prior to manufacturing of the final products for evaluation, preliminary formulation work was conducted in order to minimize the intense "*Spirulina*" algal flavour. Ten product prototypes with *Spirulina*doses ranging from 0 to 0.5% were formulated. Sensory preference evaluation indicated that incorporating a dose of *Spirulina* up to 0.3% and a combination of mint/vanilla aroma (0.07% in the milk prior fermentation) into the yogurt formulation minimized the inherent "*Spirulina*" flavour. As a result of the preliminary work, three lots of aromatised yogurts were manufactured containing 0 (control), 0.12% and 0.24% *Spirulina* powder. Addition of *Spirulina* did not affect hygienic quality of yogurt (data not shown).

2. Effect of Spirulina enrichment on flavoured yogurt quality

As shown in Table 1, addition of *Spirulina* at 0.24% led to a decrease of pH and an enhancement in titrable acidity ($p<0.05$). This increase in acidity was probably due to the fact that the S. platensis stimulated the growth of *L. bulgaricus* (Kavimandan, 2015).

Table 1. Physicochemical composition of flavoured yogurts enriched with increasing doses of *Spirulina* (n = 3)

Dose of *Spirulina*[1]	Titrable acidity (°D)	pH	Total solids (%)	Proteins (%)	Lipids (%)	Carbo-hydrates (%)	Ash (%)	Calorie value (Kcal/100g)
0%	79.0	4.61	21.0	3.63	2.56	14.19	0.65	54
0.12%	80.0	4.63	22.1	4.23	2.53	14.64	0.70	80
0.24%	95	4.57	22.9	5.30	2.63	14.17	0.80	99
$p_{\alpha=0.05}$[2]	0.042	0.31	<0.01	<0.001	0.18	ND[3]	<0.001	ND[3]

[1] %: g of *Spirulina* into 100 mL milk prior lactic fermentation.
[2] Tukey's Significant Difference.
[3] Not determined.

Total solid, protein and ash contents of yogurts with *Spirulina* were significantly higher than those of the control ones, because of the *Spirulina* biochemical characteristics (see Materials). There was no significant difference in carbohydrate and fat contents. Addition of *Spirulina* led to an increase in the yogurt calorie value. Similar results were observed by Shin *et al*. (2008) and Malik *et al*. (2013) on yogurts containing up to 0.5% of *Spirulina*.

As indicated in Table 2, addition of *Spirulina* has not significantly affected syneresis.

Table 2. Syneresis, viscosity and pressure drop properties of flavoured yogurts enriched with increasing doses of *Spirulina* (n = 3)

Dose of *Spirulina*	Syneresis (mL/125g)	Viscosity (Pa.s)	deltaP (Pa)
0	0.86 ± 0.11	3.15 ± 0.19	$5{,}105.10^5$
0.12	0.88 ± 0.10	3.37 ± 0.11	$4{,}707.10^5$
0.24	0.90 ± 0.10	3.59 ± 0.09	$3{,}723.10^5$
$p_{\alpha=0.05}$	0.401	<0.05	<0.01

Interestingly, the apparent viscosity of yogurts was increased with the addition of *Spirulina* in yogurt formulation.Similar results were found by Shin *et al*. (2008) and Malik *et al*. (2013) who found a higher viscosity in *Spirulina* enriched yogurts, when compared to the controls. Decrease in thixotropic value in the yogurt enriched with *Spirulina* indicated a better stability of the enriched product.This can be explained by the higher protein contents in *Spirulina* enriched yogurts, as shown in Table 1.Protein composition has been shown to influence the structure and texture characteristics of yogurts (Lee and Lucey, 2010).

Quantitative descriptive analysis of yogurts enriched with increasing doses of *Spirulina* revealed no significant effect of *Spirulina* addition onperceived milky odour, herbal odour, texture, sweet flavour, acid flavour, bitter flavour, algal taste, and herbal taste intensities (Fig. 1). However incorporating 0.24% of *Spirulina* powder into yogurt has induced a significant change in algal odour and after taste intensities. Interestingly, as confirmed by a preference test on 106 consumers(data not shown), this difference has not impaired the consumers' acceptance.

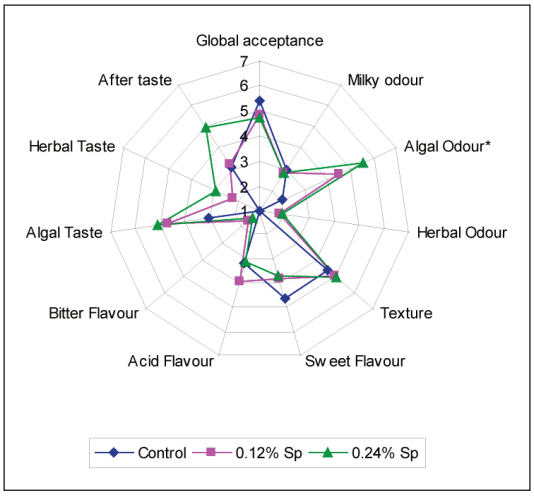

Fig. 1. Quantitative descriptive sensory evaluation of flavoured yoghurtsenriched with increasing doses of *Spirulina* (n = 10 trained panellists).

IV – Conclusion

Overall, our results showed that addition of *Spirulina* up to 0.12% into yogurt has improved the nutritional value of yogurt, without altering consumers' acceptance. This research identified the qualities that need further development and demonstrated the importance of early-stage consumer acceptance research for directing new product development.

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Performance of Eclipse Farm test coupled with e-Reader for screening antibiotics in sheep and goat's milk

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Abstract. The presence of antibiotic residues in milk is a concern due to technological and health reasons. Although various methods have been developed to analyse antibiotic residues in cow milk, such methods do not always work correctly with sheep and goat's milk. Herein, we present a study of the performance of a new system for the screening of antimicrobial residues in sheep and goat's milk. The method combines a microbial inhibitor test (Eclipse Farm) and a device (e-Reader) that integrates incubation at 65ºC and continuous monitoring of the change in colour. The performance of the new system was validated according to European Commission Decision 2002/657/EC. Sensitivity of the new system was evaluated on 12 molecules from several families of antimicrobials. The detection limits were close to European maximum residue limits (MRL). Detection capabilities (CCβ) were also determined for 7 molecules representing the main antimicrobial groups used in dairy husbandry (penicillins, cephalosporins, aminoglycosides, tetracyclins, sulphonamides and macrolides). Most of the molecules were detected at MRL level. The Eclipse Farm test coupled to e-Reader has shown to be a valuable tool for screening a broad-spectrum of antimicrobial residues in sheep and goat milk.

Keywords. Antimicrobial residues – Screening test – Sheep milk – Goat milk.

Evaluation de la performance du test Eclipse Farm 3G couplé avec le lecteur e-Reader pour le dépistage d'antimicrobiens dans le lait de brebis et de chèvre

Résumé. *La présence de résidus d'antimicrobiens dans le lait représente un problème technologique pour la filière laitière et un risque pour la santé publique. De nombreuses méthodes ont été développées pour analyser les résidus d'antibiotiques dans le lait de vache, cependant ces méthodes ne fonctionnent pas toujours correctement avec le lait de brebis et de chèvre. Dans ce travail, nous présentons une évaluation sur la performance d'un nouveau système de dépistage de résidus d'antibiotiques dans le lait de brebis et de chèvre. Le nouveau système combine un test d'inhibition microbienne (Eclipse Farm) et un dispositif (e-Reader) qui intègre une incubation à 65ºC et une surveillance continue du changement de la couleur du test. La performance du test a été validée conformément à la décision 2002/657/CE de la Commission Européenne. La sensibilité a été évaluée sur 12 molécules provenant de plusieurs familles d'antimicrobiens. Dans tous les cas, les limites de détection calculées étaient proches aux limites autorisées (Limite Maximale de Résidus). Les capacités de détection (CCβ) ont été également déterminées pour 7 molécules représentant les principaux groupes d'antimicrobiens utilisés dans l'élevage laitier (pénicillines, céphalosporines, aminoglycosides, tétracyclines, sulfamides et macrolides). La plupart des molécules ont été détectées au niveau de la LMR. L'Eclipse Farm combiné avec le e-Reader est donc un test à large spectre, qui permet de couvrir la détection d'un nombre important de molécules d'antimicrobiens dans le lait de brebis et de chèvre.*

Mots-clés. *Résidus des antimicrobiens – Test de dépistage – Lait de brebis – Lait de chèvre.*

I – Introduction

The use of antimicrobials in the context of preventive or curative treatments is a common practice in dairy animals. The administration of these drugs may lead to the presence of inadmissible levels of antimicrobial residues in milk. As a consequence, the presence of such residues in milk could cause interference with the manufacture of dairy products and some direct health implications. However, the selection of resistant bacteria is generally considered the main risk derived from the use of antimicrobials in farm animals. To protect consumers from the harmful effects of the antibiotic, the European Union established a legal framework setting of maximum residue limits (MRL).

Screening microbiological inhibition tests are most commonly used at the control first step since they are ready-to-use, cheap, easy to perform and have a broad spectrum of sensitivity. Commercial microbial tests in ampoule format are generally used in dairy farms. Moreover, a new portable device (e-Reader) has recently been validated for the automatic and objective detection of antibiotics in bovine raw milk in combination with the Eclipse Farm test (Mata *et al*., 2016).

In some Mediterranean countries, sheep and goat's milk production plays a prominent role and it is mainly destined for the elaboration of specific high quality cheeses. Thus, it is desirable to have analytical methods available to detect the most frequent drugs used in treatment in such species.

The aim of this work was to study the performance and applicability of the Eclipse Farm test in combination with the e-Reader for detection of antimicrobials in sheep and goat's raw milk.

II – Material and methods

1. Milk samples

To set the cut-off values of the system and to establish the preliminary limit of detection, ewe and goat's bulk milk samples were obtained from several milk control laboratories from different Spanish regions. All samples were previously tested with the Eclipse 100 (ZEULAB, Zaragoza, Spain) and TwinSensor (UNISENSOR, Wandre, Belgium) to confirm they were antibiotics-free. Samples were stored at 2–8°C and analysed for antimicrobials within 24 h after arrival. Milk composition, somatic cell counts (SCC) and bacterial count were analyzed by using MilkoScan 6000, Fossomatic 5000 and Bactoscan FC (Foss, Hillerød, Denmark). pH value was measured with a conventional pH-meter (Crison, Barcelona, Spain). Spiked samples with different antimicrobials were prepared as previously described by Mata *et al*. (2016).

2. Performance of Eclipse Farm Test and e-Reader

Eclipse Farm (ZEULAB, Zaragoza, Spain) is a microbial inhibitor tube test for the detection of antimicrobials in milk. The test procedure was carried out following manufacturer recommendations. Briefly, the test procedure includes addition of 100 µl of milk sample, a pre-incubation at room temperature for 1 h followed by a washing step and incubation in e-Reader.

According to Commission Decision 2002/657/EC, the false-positive rate that was calculated by analysing 250 ewe and 150 goat's individual milk samples. The determination of detection capabilities were performed as described in CRL guidelines for the validation of screening methods.

III – Results and discussion

1. Reading and interpretation of results

Cut-off level for Eclipse Farm coupled to e-Reader was initially set. For this purpose, 180 ewe and 123 goat tank raw milk samples were analysed (Fig. 1). Mean (42.6, 40.1) and standard deviation (7.8, 7.7) values were obtained for ewe and goat samples at the end point of the assays, respectively. Thus, a cut-off level of 63.4 and 63.2 was calculated (mean of the negative samples plus 3 times the standard deviation). For practical reasons, these figures were rounded to 65.

2. False-positive rate

Composition of ewe and goat milk presented a wide range of variation in quality. Fat ranged from 3.1 to 4.9% and from 3.1 to 8.3% in goat and ewe samples. Protein was 3.1 to 3.8 for goat and 4.8 to 7.1% for ewe samples. SCC (log) were between 1.2 and 3.8 for goat and 1.4 and 3.3 for ewe samples. Bacterial counts (log) reach to 2.7 and 2.4 for goat and ewe samples, respectively.

Very few or no false-positive results were found both for ewe (0.5%) and goat's (0%) milk samples. This result was coherent with those from other complementary tests (Eclipse 100 and TwinSensor).

3. Sensitivity and detection capabilities

Limits of detection in ewe and goat's milk for 12 antimicrobials are summarized in Table 1.

Table 1. Detection limits (µg L-1) of Eclipse Farm coupled to e-Reader in ewe and goat's raw milk

Antimicrobial	MRL	Detection limit[a]		e-Reader value[b]	
		Ewe	Goat	Ewe	Goat
Amoxicillin	4	4	4	77	111
Benzilpenicillin	4	3	3	132	144
Cephalexin	100	100	100	151	160
Cloxacillin	30	>30	30	68	101
Gentamycin	100	250	>250	78	68
Neomycin	1,500	600	600	91	82
Lincomycin	150	150	150	74	80
Tylosin	50	25	25	75	100
Sulfathiazole	100	80	80	130	121
Sulphametazine	100	100	100	106	101
Oxytetracycline	100	150	150	76	74
Tetracycline	100	200	150	91	93

[a] Positive results are defined as an e-Reader value higher than 65. [b] Mean value (n = 6).

Most of the antimicrobials showed detection limits at or below the MRL. In the case of the goat's milk, for benzylpenillin, neomycin, tylosin and sulfhiazole, the detection limits were lower than EU-MRL (Table 1), indicating a high sensitivity to detection of betalactams, amynoglicosides, macrolides and sulphonamides in this matrix. In this way, the detection of antibiotics in ewe's milk was also below their legal limits for the same substances, with the exception of cloxacillin. However, this test could neither detect gentamycin or tetracyclines at EU-MRL in both species.

Detection capabilities were determined for seven molecules that represent every family of antimicrobial included in this study. Results are showed for ewe (Table 2) and goat's milk (Table 3).

Table 2. Detection capability (µg/kg) of Eclipse Farm coupled to e-Reader in sheep milk

Antimicrobial	MRL	Detection capability[a]	No. positive[b]/no. samples	E-Reader value[b]
Amoxicillin	4	4	58/60	70.3 ± 9.2
Benzilpenicillin	4	4	59/60	90.1 ± 12.0
Cephalexin	100	100	60/60	140.1 ± 10.0
Gentamycin	100	250	20/20	83.8 ± 9.7
Oxytetracycline	100	300	20/20	100.4 ± 10.1
Sulfathiazole	100	80	40/40	103.9 ± 16.2
Tylosin	50	35	40/40	89.1 ± 14.1

[a] Positive results are defined as an e-Reader value higher than 65; [b] Mean ± SD.

Table 3. Detection capability (µg/kg) of Eclipse Farm coupled to e-Reader in goat's milk

Antimicrobial	MRL	Detection capability[a]	No. positive[b]/no. samples	E-Reader value[b]
Amoxicillin	4	4	60/60	106.6 ± 19.8
Benzilpenicillin	4	3	40/40	119.9 ± 13.6
Cephalexin	100	100	60/60	137.7 ± 14.5
Gentamycin	100	300	20/20	102.2 ± 10.0
Oxytetracycline	100	250	20/20	84.8 ± 8.7
Sulfathiazole	100	80	40/40	106.2 ± 8.1
Tylosin	50	35	40/40	87.4 ± 9.8

[a] Positive results are defined as an e-Reader value higher than 65; [b] Mean ± SD.

In the case of sheep milk, all betalactams included in the study were detected to levels equal to their EU-MRL, and for macrolides and sulphonamides the results were even lower than MRL. However, the detection of gentamycin and oxytetracycline was greater than the values of MRL.

For goat's milk, results were quite similar than for sheep. However, results were different to those obtained by Beltrán *et al.* (2015) using different microbial tests to detect betalactams and non-betalactams antibiotics in sheep and goat's milk. For sheep milk, they obtained CCβ lower than the calculated in this study with exception of gentamycin, whose CCβ was similar. On the contrary, in the case of goat's milk, both amoxicillin and gentamycin were also similar, but benzilpenicillin and cephalexin were below the results obtained. The CCβ of tylosin was higher than the obtained in this study. As in the present work, no microbial test used by these authors was able to detect oxytetracycline at MRL level. Comparing these results with those reported in cow milk (Mata *et al.,* 2016) by using Eclipse Farm coupled to e-Reader, detection capabilities were lower than the results of our work for all molecules studied, except for amoxicillin, whose CCβ was the same to LMR.

IV – Conclusions

The Eclipse Farm test coupled to e-Reader device presents a low percentage of false-positive for the detection of antibiotics in ewe and goat's milk and most of the detection capabilities were at or below the EU-MRL level. The great performance of the Eclipse Farm coupled to e-Reader test makes it suitable to be included in ewe and goat's milk quality programs on farms and dairies.

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Fluorescence spectroscopy coupled with factorial discriminant analysis as a tool to identify sheep milk from different feeding systems

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Abstract. The present study aimed to determine the potential of Front face fluorescence spectroscopy (FFFS) to discriminate between milk samples from Sicilo-Sarde ewes fed three different diets – named control, faba bean meal and soybean meal - throughout the lactation stage (11 weeks). Milk samples were classified by factorial discriminant analysis (FDA). Similar results were obtained by separately applying (FDA) to different target nutrients (aromatic amino acids and nucleic acids (AAA + NA), tryptophan, vitamin A and riboflavin). In a second step, concatenation technique was applied to FFFS spectra. Results showed a good discrimination between milk samples from different lactation periods and diet compositions. Spectroscopic techniques may provide useful fingerprints, and allow the identification of milk samples from ewes fed different diets throughout the lactation periods.

Keywords. Ewe's milk – Lactation – Soybean meal – Faba bean – Front Face Fluorescence Spectroscopy – Factorial discriminant analysis – Concatenation.

La Spectroscopie de Fluorescence Frontale couplée à l'analyse factorielle discriminante pour identifier le lait des brebis alimentées de différents régimes alimentaires

Résumé. *L'objet de la présente étude est de tester le potentiel de la spectroscopie de fluorescence frontale (SFF) à discriminer le lait des brebis Sicilo-Sarde selon la nature de la source azotée (Tourteau de Soja ou féverole) utilisée en complementation et ce durant les onze premières semaines de lactation. Afin de déterminer le pouvoir discriminant des données de fluorescence, des AFD (analyse factoriel discriminante) ont été réalisées sur de spectres des quatre sondes intrinsèques utilisées (Trp, AAA et AN, Ribolavine et vitamine A). Une meilleure discrimination des laits, selon la nature du concentré et le stade de lactation a été obtenue en étudiant conjointement les différentes régions spectrales. Cette analyse combinée a été réalisée en utilisant la technique de concatenation. Les résultats obtenus ont montré que les techniques spectroscopiques peuvent fournir des empreintes digitales utiles et permettre l'identification d'échantillons de lait selon la nature du concentré utilisé en complementation des brebis durant la période de lactation.*

Mots-clés. *Brebis – Lactation – Tourteau de Soja – Féverole – Spectroscopie de Fluorescence Frontale – Analyse Factorielle Discriminante – Concatenation.*

I – Introduction

In Tunisia, Sicilo-Sarde dairy sheep feeding is based on grass grazing and forage, as a basal diet, and concentrate complementation all through the year (Rouissi *et al*. 2008). However, during the last years, the worldwide overall economic situation resulted in an increase in the price of raw materials used for livestock concentrate formulation (corn and soya). In this scenario, the search for other alternatives such as local food resources (barley, faba bean, etc) is still imperative. Milk con-

tains several intrinsic fluorophores, which represent the most important area of fluorescence spectroscopy. In the last years several authors (Karoui *et al*., 2005; Boubellouta and Dufour, 2008) used the spectroscopy of fluorescence tool to discriminate between milk and between the dairy products of various origins and / or from sheep having received various treatments. The objective of this study was to evaluate the potential of Front face fluorescence spectroscopy (FFFS) coupled with chemometric tools to discriminate between milk samples from Sicilo-Sarde dairy ewes fed different diets during the milking period.

II – Materials and methods

1. Animals

Forty-five Sicilo - Sarde ewes were divided into three homogenous groups according to their weight (51.3 ± 4.9 kg for the control (C) ; 51.9 ± 4.9 kg for the soybean meal (S) and 52 ± 5.4 kg for the faba bean meal (F), the litter size :1.47 ± 0.5 for (C) ; 1.4 ± 0.5 for (S) and 1.5 ± 0.5 for (F) and the rank of lactation : 2.4 ± 0.9, 2.6 ± 0.9and 2.6 ± 0.8 for the control, soybean and faba bean groups, respectively).

2. Diets

Ewes received oat hay at 1.5 kg dry matter (DM)/ewe/day, and each group of animals was supplemented with 500g / ewe / day of one of three iso – energetic and iso – proteic concentrates, named control, soybean meal and faba bean meal – diets, during the lactation period (11 weeks). Ingredients (%) and chemical composition (% DM) of concentrates and roughage are presented in Table 1.

Table 1. Ingredient proportions and chemical composition of aliments (% Dry Matter)

Concentrates	Control	Soy bean meal	Faba bean meal	Oat hay
Ingredients (%)				
Barley	35	82.5	71.5	–
Corn	30	–	–	–
Soybean meal	15	13.5	7	–
Faba bean meal	–	–	17.5	–
Wheat bran	15	–	–	–
VMC sheep*	5	4	4	–
Chemical composition				
Dry matter (%)	90	89	89	84
Organic matter	93.6	88.9	92.7	92.2
Crude protein	15.8	16.8	16.2	5.2
Crude fiber	5.1	9.4	7.6	39.7

* VCM: Vitamin-mineral complex.

3. Sampling and preservation of milk

Individual milk yield was recorded one day a week on one milking during the whole milking period (11 weeks). For each group, the milk samples collected from the different ewes (n = 15 per group) were mixed and an aliquot of 100 ml was taken and kept in a freezer at - 20 °C until analyses. Before each analysis, milk samples were thawed during one night at + 4 °C in a refrigerator. All the analyses were made in triplicate (n = 11 weeks x 3 repetitions = 33 analyses).

4. Fluorescence spectroscopy

Fluorescence spectra were recorded using a FluoroMax-2 spectrofluorimeter (Spex-Jobin Yvon, Longjumeau, France). The incidence angle of the excitation radiation was set at 56° to ensure that reflected light, scattered radiation and depolarisation phenomena were minimised. For each milk sample, three spectra were recorded.

5. Mathematical analysis of data

In a first step, Principal Components Analysis (PCA) was applied to the normalised spectra to investigate differences between the samples. In a second step, Factorial Discriminant Analysis (FDA) was performed on the first 10 Principal Components (PCs) resulting from the PCA applied to the fluorescence spectral data. Finally, the first 10 PCs of the PCA performed on each data set were pooled into one matrix and this new table was analysed by FDA. Chemometric analyses were performed in MATLAB (The Mathworks Inc., Natic, MA).

III – Results and discussion

The emission spectra (400 – 640 nm) of riboflavin are depicted in Fig. 1. Interestingly, Fig. 1 showed two spectral regions, being the broad peak at about 520 nm due to riboflavin (Miquel Becker *et al*., 2003). A difference in the fluorescence intensity at 520 nm was observed between control diet and treatments (milk from ewes fed soybean or faba bean meals). In addition, milk collected from ewes fed faba bean appeared to be less oxidised than that collected from ewes fed soybean meal. That might be due to the presence of antioxidants (e.g. tannins) present only in milk collected from ewes fed faba bean meal. The emission spectra of aromatic amino acids and nucleic acids (AAA + NA), and tryptophan recorded after excitation at 250 and 290 nm (data not shown) presented very similar shapes and can, therefore, hardly be distinguished visually.

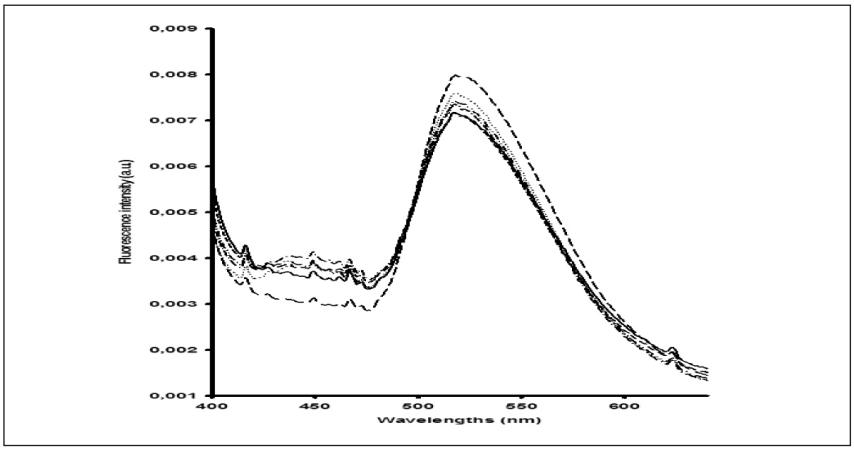

Fig. 1. Normalised fluorescence emission spectra of riboflavin recorded following excitation at 380 nm on Sicilo- Sarde ewe's milk fed faba bean after 1 (—) and 11 (...) weeks of lactation, soybean after 1 (- - -) and 11 (—..—..) weeks of lactation, and control diet after 1 (— —) and 11 (— ··· —) weeks of lactation.

In order to compare the results obtained from different intrinsic probes (target nutrients), concatenation technique was applied to AAA + NA, tryptophan, vitamin A and riboflavin spectra. The resultant similarity map is illustrated in Fig. 2. The similarity map allowed a good discrimination of milk samples according to the feeding system. Indeed, the three groups were well discriminated: milk from ewes fed the control diet gave negative scores according to the discriminant factor 1, and positive scores according to discriminant factor 2; milk samples from ewes fed faba bean meal had negative scores according to both discriminant factors 1 and 2; finally, milk samples from ewes fed soybean meal exhibited positive scores according to discriminant factor 1 and scores close to zero according to discriminant factor 2.

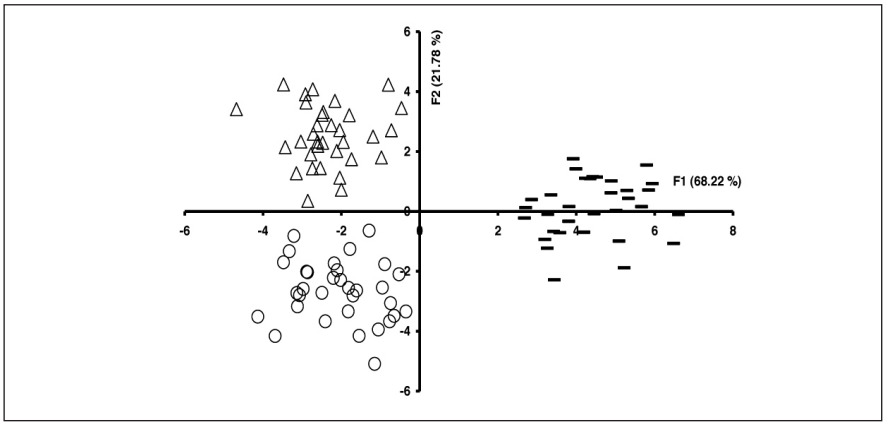

Fig. 2. Discriminant analysis similarity map determined by discriminant factors 1 (F1) and 2 (F2). Factorial Discriminant Analysis was performed on the 40 concatenated Principal Components corresponding to the Principal Components Analysis performed on the emission spectra of aromatic amino acids and nucleic acids, tryptophan, riboflavin and vitamin A of milk from Sicilo-Sarde ewes fed faba bean meal (o), soy bean meal (-) or a control diet (Δ).

IV – Conclusions

The results obtained in this study demonstrated that front-face fluorescence spectroscopy in combination with chemometrics can be considered as a fast, non-destructive and innovative technique to differentiate between milk samples from ewes fed different diets. The concatenation technique of the aromatic amino acids and nucleic acids (AAA + NA), tryptophan, vitamin A and riboflavin spectra allowed a good discrimination of milk from ewes fed different diets.

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Caractérisation de l'élevage caprin dans la région désertique de Bechar en Algérie

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Résumé. La wilaya de Bechar, située au sud-ouest algérien et caractérisée par un climat de type désertique, compte un effectif caprin de près de 64 000 têtes dont près de 52 000 chèvres. Dans l'objectif de caractériser l'élevage caprin dans cette région désertique, une enquête par questionnaire a été menée auprès de 100 éleveurs. Les résultats montrent que les caprins sont généralement élevés en association avec les ovins et y sont alimentés de la même manière, soit surtout basé sur du pâturage (85% des cas) avec complément à l'auge (surtout de l'orge, du son de blé et des déchets de dattes). Les pâturages sont constitués des ergs, regs, hamadas et lits d'oueds avec leurs végétations spécifiques. Ce type d'élevage constitue souvent (90% des cas) l'activité principale des éleveurs. Ces derniers sont généralement sans instructions et aucun n'a suivi de formation agricole. Les deux tiers des élevages sont orientés vers la production de viande (chevreaux à l'engrais). Deux tiers des élevages enregistrent deux chevrotages par an. Comme attendus, la majorité des éleveurs ne possèdent pas de terres agricoles. La taille du troupeau caprin varie souvent de 25 à 50 têtes, alors que les grand troupeaux (>100 têtes) sont rares (5%). Ces élevages sont constitués surtout (80%) de la race Arabia et logés généralement dans des écuries, gourbis ou Zriba. L'élevage caprin dans cette région désertique se distingue par son caractère extensif, orienté surtout vers la production de viande en utilisant surtout les parcours et en exploitant les sous-produits de la palmeraie.

Mots-clés. Chèvre – Élevage – Parcours – Viande – Bechar – Algérie.

Characterization of goat breeding in the desert region of Bechar in Algeria

Abstract. *The wilaya of Bechar, located in the south-west of Algeria and characterized by a climate of desert type, has a goat population of nearly 64000 head of which nearly 52000 goats. In order to characterize goat breeding in this desert region, a questionnaire survey was carried out among 100 breeders. The results show that goats are generally raised in association with sheep and are fed in the same way, mainly based on grazing (85% of the cases) with complement (especially barley, bran Wheat and date waste). Pastures consist of Ergs, Regs, Hamadas and wadis beds with their specific vegetation. This type of breeding often constitutes (90% of the cases) the main activity of the breeders. The latter are generally without instructions and none have undergone agricultural training. Two thirds of the farms are oriented towards the production of meat (goats to fattening). Two thirds of the farms record two periods of troughs per year. As expected, the majority of farmers do not own any agricultural land. The size of the goat herd often varies from 25 to 50 heads, whereas large flocks (> 100 heads) are rare (5%). These farms are mainly made up (80%) of the Arabia breed and generally housed in stables, gourbis or Zriba. Goat farming in this desert region is characterized by its extensive nature, mainly oriented towards the production of meat, using mainly the rangelands and exploiting the by-products of the palm grove.*

Keywords. *Goat – Breeding – Rangelands – Meat – Bechar – Algeria.*

I – Introduction

Largement distribuées à travers le monde, les caprins se trouvent surtout dans les milieux particulièrement hostiles de la planète. Certaines caractéristiques d'adaptation telles que les comportements alimentaires, l'efficacité de l'utilisation des aliments et, dans une certaine mesure, la to-

lérance à la maladie les prédisposent à profiter des ressources naturelles généralement dédaignés par les autres ruminants domestiques (Peters, 1987).

En Algérie, les caprins sont élevés dans toutes les zones géo-climatiques notamment les zones difficiles que sont les régions montagneuses au nord et les zones steppiques et subdésertiques (Moustaria, 2008). En 2015, le cheptel caprin algérien comptait un effectif dépassant cinq millions de têtes (MADR, 2016). Leurs rôles socio-économiques sont bien connus. D'un point de vue économique, la chèvre contribue au revenu et à la couverture des besoins en lait et viande d'une large couche de la population rurale.

Dans les régions montagneuses, notamment en Kabylie, ce type d'élevage est assez connu et généralement conduit en mode extensif (Kadi *et al*., 2014 et 2016 ; Mouhous *et al*., 2016). Cependant, les informations sur ce type d'élevage dans les zones subsahariennes algériennes sont, à notre connaissance, peu disponibles. D'où l'objectif de cette étude qui vise à caractériser l'élevage caprin dans une région saharienne qu'est la wilaya de Béchar.

II – Matériel et méthodes

1. Description de la région d'étude

Béchar est la plus grande wilaya –district– du sud-ouest algérien ; elle s'étend sur une superficie de près de 162 000 Km² (ANDI, 2013) et est distante de 1150 km de la capitale Alger. Le territoire de la wilaya de Béchar est caractérisé par cinq principaux reliefs que sont : les montagnes (dénudées et parfois élevées), les oueds (en nombre de six), les vallées (dont les principales sont Zouzfana, Guir Saoura), les Regs (vastes étendues rocailleuses) et les ergs (massifs dunaires pouvant atteindre 300m de hauteur).

La wilaya de Béchar est caractérisée par un climat de type désertique continental. On y distingue deux types de zones (ANDI, 2013). La zone de transition très chaude en été (+ 45°C) et froide en hiver (2°à 3°C) avec des précipitations de l'ordre de 60 mm/an et des vents de sable fréquents et souvent violents (100 km/h). La zone désertique caractérisée par des précipitations de l'ordre de 40 mm/an et des vents de sable très fréquents.

Selon DSA (2016), la wilaya de Bechar est caractérisée par une surface agricole totale de près de 1,5 millions d'ha dont seulement 2,5% (soit 35000 ha) est utile. Le reste constitue les pacages et parcours. Pour ce qui est du secteur de l'élevage, avec un effectif de près de 64 000 têtes dont près de 53 000 chèvres, les caprins occupent la deuxième place après les ovins (220 000 têtes) et avant les camelins (17 000 têtes) et les bovins (2600 têtes).

2. Méthodologie

La méthode utilisée est celle de l'enquête par questionnaire. Ce dernier est structuré en plusieurs rubriques comme l'identification des exploitations, la situation et le profil socio-économique de l'éleveur, la conduite de l'élevage (alimentation, reproduction, hygiène et prophylaxie) ainsi que la production des troupeaux et leurs commercialisations. Une enquête préliminaire a été d'abord réalisée à partir d'un questionnaire structuré servant de base aux discussions avec les éleveurs. L'enquête a concerné un total de 100 éleveurs et a duré deux mois (du 15 mars au 17 mai 2016). Les visites se sont faites par un seul passage. Un deuxième passage est effectué en cas de nécessité.

Au préalable, la collecte des informations sur la localisation des élevages a été réalisée sur la base de la liste des éleveurs obtenue auprès de la direction des services agricoles de la wilaya, des informations recueillies auprès des vétérinaires et des subdivisions agricoles.

Lors du dépouillement, les données collectées sur le terrain ont été passées en revue, codées et enregistrées dans une base de données conçue à l'aide du logiciel *Microsoft Excel 2013*. Ensuite, les données ont été rassemblées dans un fichier type tableur avec, en lignes, les différentes exploitations et, en colonnes, les variables explicatives et expliquées représentées par les différentes questions. Le fichier a été ensuite analysé avec le logiciel *StatBox 6.4.* La première partie de l'analyse statistique, partie qui sera présentée dans cette étude, a concerné les statistiques descriptives calculées pour chacun des paramètres (moyennes, écart-types et proportions).

III – Résultats et discussion

A. Situation socio-économique des éleveurs

L'âge des éleveurs enquêtés varie entre 24 et 82 ans (50 ans en moyenne). Il est à noter l'intérêt des jeunes à ce type d'élevage puisque 21% des éleveurs enquêtés ont moins de 35 ans et ce malgré les difficiles contraintes du milieu et l'absence de subventions de l'Etat. Dans la plupart des cas, les éleveurs exercent l'élevage caprin depuis l'enfance. L'élevage caprin est l'activité principale chez la quasi-totalité des enquêtés, 90% des éleveurs n'ont aucune autre activité.

Plus de la moitié (55%) des éleveurs enquêtés sont sans niveau d'instruction, un tiers (31%) ont un niveau primaire, 7% ont un niveau moyen, et ceux qui ont le niveau secondaire constituent 5% du total. Le niveau supérieur ne représente que 1%.

B. La composition des cheptels

Parmi des élevages enquêtés, 70% sont orientés vers la production des chevreaux d'engrais, 17% sont de type mixte (lait - chevreaux) alors que les élevages orientés vers la production laitière seule ne représente que 4% du total, le reste (9%) est orienté vers l'autoconsommation. Cette orientation vers la production de viande est signalée dans plusieurs pays méditerranéens comme le Maroc (Chentouf *et al.,* 2005) et le Portugal (Pacheco, 2002). Chez la majorité des élevages enquêtés (60%), l'élevage constitue un héritage familial de père en fils.

Chez presque la moitié des éleveurs enquêtés, la taille de troupeau varie de 25 à 50 têtes, 10% des éleveurs ont moins de 25 têtes et seulement 5% des troupeaux dépasse 100 têtes. Aussi, chez la majorité des éleveurs, les caprins sont mélangés avec des ovins.

Comme attendu, la race locale *arbia* est de loin (81%) la plus représentée dans les élevages enquêtés eu égard à sa rusticité et à son adaptation aux difficiles conditions d'élevage et de milieu.

C. La conduite d'élevage

Dans la majorité (73%) des élevages visités, les bâtiments sont constitués de bergeries ou *Zriba* souvent dans un état délabré. Ceci est rapporté aussi au Maroc par Alami *et al.* (2005) qui signalent des logements des troupeaux caprins construits en argile avec des toitures en tôle.

Dans 85% des cas, l'alimentation du cheptel est basée sur le pâturage + complément. Le complément est généralement de l'orge, du son de blé et surtout des déchets de dattes.15% des éleveurs alimentent exclusivement leurs animaux à l'auge, ce sont ceux ayant des terres agricoles. Dans le calendrier alimentaire, la valorisation des sous-produits de la palmeraie prend une place importante. Ainsi, dattes sèches et déclassées et noyaux sont utilisés toute l'année.

Pour ce qui est des parcours, la répartition de la végétation saharienne dépend de la géomorphologie du milieu ; elle se localise dans les fonds des Oueds et aux creux des dépressions. Les Ergs, les Regs et les lits d'Oueds ont chacun une végétation spécifique avec divers groupements

végétaux. Les espèces les plus abondantes dans les Regs et les Ergs sont le Drinn (*Stipagrostis pungens),* Rguig *(Helathmum lipii),* Oum Rekba *(Panicum turgidum),* Gartoufa *(Cotula cinerae)*. Les lits d'oueds sont les plus riches et les plus diversifiés et les espèces végétales dominantes sont Tamaris *(Tamarix gallica)* et Souid *(Suaeda fructicosa).*

Chez 70% des éleveurs, le chevrotage est de l'ordre de 2 fois par an, le reste n'a qu'un chevrotage par an. Aussi, les chevrotages s'étalent sur toutes les saisons de l'année.

IV – Conclusions

L'élevage caprin dans cette région désertique se distingue par son caractère extensif, orienté surtout vers la production de viande en utilisant surtout les parcours et en exploitant les sous-produits de la palmeraie. La rusticité et l'adaptation de la race locale *Arabia* aux conditions de cette région désertique font de cette race un important atout qui mérite des études approfondies.

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Strategies of transition towards a more sustainable food model
Contribution of the Malagueña goat

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Abstract. In the last decade the goat industry of Malaga (Spain) had a remarkable development which was accompanied by a progressive intensification of the production system. A significant percentage of the milk and goat products obtained in the province of Malaga are destined for processing and marketing outside the territory. This constitutes one of the main weaknesses of goat production in this area. As consequence, farmers do not participate of the added value obtained from processed products. Likewise, the Andalusian consumers have little knowledge of goat activity and they consume few local goat products. These circumstances lead a progressive abandonment of traditional livestock in spite of its importance from an economic, social and environmental point of view. Aware of this situation, the Malagueña Goat Breeders Association is carrying out a three-year project funded by the Daniel & Nina Carasso Foundation. The programmed actions are grouped around four types of activities: i) to develop an own offer of local and quality products by the goat farmers; ii) creation of a stable tourist services structure; iii) to promote the transition to more sustainable production models such as ecological certification and iv) carried out transversal actions to divulge the diverse activities of the project. The most outstanding actions carried out so far include the opening of the Multifunctional Center of the Malagueña Goat, the approximation level evaluation of the Malagueña goat farms to the organic model, and diverse informative activities such as publications, TV programs and congress presentations.

Keywords. Breeder association – Sustainability – Local products – Tourist services.

I – Introduction

In the last decade the goat industry of Malaga (Spain) had a remarkable development. It had a transition from a traditional and local activities to more professional activities. Likewise, products of this industry now have more presence in the markets, even international ones. This has been accompanied by a progressive intensification of the production system, by increasing the feed purchase and reducting the grazing and the forages cultivation (Bernués *et al*., 2011).

Andalusia is the Spanish region (Autonomous Community) most producing goat milk and the second of the European Union. Also, the province of Malaga is the highest producer of Andalusia (28%). Most of the milk is sold to dairy industries located in other Spanish Autonomous Communities such as Castilla La Mancha and Castilla y León or in European Union countries like France. In this way, the milk quantity processed in the province of Malaga is scarce compared to the total collection.

All this has a number of negative consequences for the goat industry. One of them is the lack of autonomy that breeders have in terms of feeding goats. Another consequence is related to adverse environmental effects due to the non-use of grazing resources (Castel *et al*., 2011) and the high global energy consumption. This consumption includes the transport of both purchased foods and sold products. Also a negative consequence is the inability of farmers to defend the price of their

products. This is because market prices, in the case of milk that is the main product obtained, have a high volatility (Ripoll-Bosch *et al*., 2014). This is accompanied by the fact that farmers have little negotiating capacity and that they do not participate in the processes of transformation and commercialization, which means a loss of the added value of milk.

In addition to the negative aspects related to the production and marketing of goat products, there are also sociological aspects. The Andalusian society has little knowledge of caprine activity in general and the Malagueña breed and its products. The increase in the consumption of products derived from goat production could contribute to the economic, social and cultural development of the Andalusian rural society. Likewise, the development of goat activity as a result of increased consumption of the products would contribute to the maintenance of the natural environment. On the other hand, the goat industry has difficulties in continuously offering products of the Malagueña goat in a market that is dominated by certain agents (links) of the food chain (in particular, processing and distribution of the production). These agents have the ability to influence over the consumer preferences by offering products obtained from other models of intensive production or more industrial transformation which provide them a greater profitability.

These circumstances together with the turbulences of the current agrarian markets, causes cyclical crises in the goat sector, with significant declines in milk sales prices, increases in the prices of animal feed, or both. In Andalusia during the last decade these crises have made that hundreds of familiar goat farms dispraised. All this entails a lack of generational change (with the aging of the farmers) (Bernués *et al*., 2011), a lack of entrepreneurship and a decrease in investments in research and development, which entails that the consumption of local goat products continues being scarce while the consumers adapt to the agro-food model described.

Therefore, it is urgent to change the predominant agro-food model in order to not repeat that occured with the cow milk industry of Malaga which has practically disappeared. The concern is greater in this case because it is to maintain an emblematic cattle sector for the province of Malaga, with a breed of goat perfectly adapted to the territory.

Therefore, the Malagueña Goat Breeders Association (CABRAMA) is carrying out a project funded by the Daniel & Nina Carasso Foundation. This project aims to help solve the problems described and thus boost the goat sector and promote their products. It aims to establish an alliance between goat farmers in the province of Malaga and citizens to ensure the survival of farms and facilitates the access of the people to quality food based on local markets.

II – Materials and methods

The programmed actions of the project are grouped around four types of activities: (i) development of an own offer of local and quality products by goat producers; (ii) creation of a stable tourist services structure; iii) to promote the transition to more sustainable production models such as ecological certification and iv) transversal actions to divulge the content of the project.

In the first type of activities were proposed the following actions: presentation of the project to CABRAMA members; offering the use by the farmers of the facilities and personnel of the dairy processing plant of the Sociedad Agraria de Transformación (SAT) named «Productos de la cabra Malagueña»; training for the production of dairy products; advice on placing innovative products on the market; advice in the administrative and business field to implement cheese-making projects and for the diversification of activities; establishment of a marketing infrastructure; creation of own brand; and conducting market research. The second type of activities included advice and training to develop tourism related to the consumption of goat products, analysis of administrative requirements to carry out such activities, design and supply of tourist activities, and the design of a strategy to divulge such activities.

Among the actions of the third type of activities, studies were proposed to evaluate the level of approximation of farms associed to CABRAMA to the ecological production model, and the key elements of the sustainability of ecological goat production systems. It was also proposed to carry out a market study on the consumer demand for organic goat products, the analysis of their preferences and the current offer of these products. The fourth type of activities refers to the divulgation of the project, therefore it was proposed the design of advertising in various media, participation in scientific and professional forums, publication of articles of diffusion and the permanent divulgation of activities through the CABRAMA Web and social networks.

The main material resources to support the project include several CABRAMA facilities in Casabermeja (Malaga), such as its own headquarters, the Multifunctional Center of the Malagueña Goat and the SAT Dairy factory. This SAT is an associative entity that transforms and markets products from the Malagueña goat. The CABRAMA staff is responsible for the execution of the project and logistics for events, training activities and publications. Other participants in the project are the Department of *Ciencias Agroforestales* of the *Escuela Técnica Superior de Ingeniería Agronómica* of the *Universidad de Sevilla*, el *Excelentísimo Ayuntamiento de Casabermeja* (Málaga) and FRESYCA (Fédération Régionale des Syndicats Caprins de Charentes-Poitou-Vendée), which is a French group of producers of goat's milk with a large trajectory in the promotion and valorization of the goats products through the own transformation of their products and the use of short marketing channels.

III – Results and discussion

In this section we show the progress of the different programmed activities.

1. Activity 1: own offer of local and quality products

The project was presented at an Assembly of CABRAMA members in February 2017; The documentation for the use of the dairy plant was prepared and the advice and design of an own brand of the products of the Malaga goat has begun, as in the case of the fresh and ripened cheeses of the "El Garrote" brand. Also two livestock farmers started the elaboration of products in the processing plant.

2. Activity 2: stable structure of tourist services

The Multifunctional Center of the Malagueña Goat was built, conditioned and begun their activities in Casabermeja (Malaga). FRESYCA has also been advised in the training for the elaboration of cheeses and in several aspects on short marketing channels (proximity marketing).

3. Activity 3: more sustainable production models

17 goat producer members of CABRAMA were interviewed through a questionnaire of 56 questions included in 9 sections, with the objective of knowing the level of approximation of their farms to the ecological production model. The sections of the questionnaire were: nutritional management, sustainable pasture management, fertilization and soil contamination, pest and weed control, veterinary prophylaxis and care, breeds and breeding, animal welfare, food safety and management and marketing (Mena *et al*., 2012).

Preliminary results indicate that goat farms had an average rating of 56% of approximation to the ecological model. The nearest aspects to this production model were food safety (91%), animal welfare (63%), pest and weed control (62%), and sustainable pasture management (61%). On the other hand, fertilization and soil contamination (34%), along with management and marketing issues (31%), had the lowest qualification for the conversion to the ecological model.

4. Activity 4: transversal actions for the dissemination of the project

Displays with information about the project were elaborated. They deal with the benefits of sustainable food with products from the Malagueña goat and on the offer of tourist activities of CABRAMA. Informative brochures on the tourist activities offered by the Association were also elaborated. Three articles have been published in magazines related to the agricultural sector: one in the "Labrando Futuro" Magazine (nº 47) and two in the "Málaga Ganadera" magazine (issues 48 and 49). In the last months also we had presentations in TV programmes, two in the program *Tierra y Mar* and one in the program *Cómetelo*, all transmitted by the Canal Sur of the Andalusian Television in Malaga.

Finally, the communication "Consumer preference for dairy products of the Malagueña goat" was presented at the 8th Goat National Forum held in Carmona (Seville) in May 2017, continuing the works about this subject (Ruiz *et al*., 2014). We also participated in the organization of the Conferences on Animal Health and Food Security organized by ECOVALIA which took place in Casabermeja (Malaga) in March 2017.

IV – Conclusions

The progress obtained so far show the possibilities to make a more sustainable agro-food model based on the Malagueña goat and its products. For CABRAMA is very important to share the results obtained from this project. These results could be used by other professionals and citizens in general, and even in other territories, to develop similar interesting experiences for everyone. The implementation of these types of projects in the predominant agro-food model could favor the dissemination of results which are priority for the whole goat industry.

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Durabilité de l'élevage ovin systèmes en Tunisie centrale: cas de la région de Sidi Bouzid

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Résumé. Les systèmes d'élevage ovin dans la région de Sidi Bouzid représentent le premier pôle producteur de viande ovine tunisienne par excellence. C'est dans ce cadre que s'intègre l'objectif de notre travail et qui consiste à étudier la durabilité de ces exploitations et à dégager les contraintes qui la limitent tout en proposant des remèdes pour l'améliorer et des perspectives pour conserver les ressources animales dans la zone d'étude. Les résultats obtenus par AFCM et CAH nous ont permis de distinguer trois groupes d'éleveurs et trois niveaux de durabilité déterminés par la méthode IDEA. Le premier groupe représente les grandes exploitations qui disposent de superficies agricoles utiles les plus élargies (100 ±10 ha) avec un cheptel (200±10 UF) et une superficie fourragère importante en irrigué (20±3 ha) mais qui présente une durabilité limitée par l'échelle socio-territoriale (52,3). Le second groupe regroupe les petits éleveurs qui possèdent des petites superficies (5±1 ha) avec une taille de cheptel variable et une durabilité limitée par l'économie de l'exploitation (58,2). Le troisième groupe renferme les éleveurs ayant une superficie utile de taille moyenne (50±5 ha) et des troupeaux de moyennes tailles (50±10 UF), ce groupe représente une durabilité limitée par des paramètres liés aux pratiques agricoles et environnementales. Agir sur la sensibilisation des éleveurs de s'intégrer dans des associations et des structures associatives dans le cas du premier groupe, d'augmenter les subventions de l'état dans le cas du second groupe et sur la vulgarisation dans le cas du troisième groupe permettraient d'améliorer la rentabilité et la durabilité des systèmes d'élevage ovin dans la région de Sidi Bouzid.

Mots-clés. Systèmes d'élevage ovin – Sidi Bouzid – Durabilité-IDEA.

Sustainability of the sheep farming systems in central Tunisia: case of the region of Sidi Bouzid

Abstract. *The sheep farming systems is a main activity in the region of Sidi Bouzid, which represents the first Tunisian breeding pole of meat sheep. This work has been undertaken to carry out twofold objectives. Firstly, it seeks to give more information on the functioning of these farming systems and secondly, it studies their sustainability and identifies the difficulties and constraints that limit this sector by providing opportunities to conserve animal resources and proposing solutions to improve them to make them more efficient and sustainable. Using the AFCM and the CAH methods, results have allowed us to distinguish between three groups of breeders and three levels of sustainability using the IDEA method. The first group represents large-scale farms (100±10ha) with large livestock number (200±10) and an important irrigated forage area (20±3) but their sustainability is limited by the socio-territorial level. The second group is represented by the small farms (5±3ha) and a limited animals' number (10±5) is constrained by the farm's economic conditions. The third group is represented by the medium size scale farms (50± 5ha) and is limited by the agro- ecologic scale. Acting on associative actions in the case of the first group and on the subvention of agriculture goods in the case of the second group and using new technologies in animal breeding may improve the profitability and the sustainability of the sheep farming systems in the zone of Sidi Bouzid.*

Keywords. *Sidi Bouzid – Sheep farming systems – Sustainability – IDEA.*

I – Introduction

En Tunisie l'élevage ovin assure d'une part 48% de la consommation de viandes rouges et d'autre part, constitue une source de rentabilité. Afin de combler le déficit du secteur, l'Etat autorise les privés à importer une partie des besoins intérieurs sous forme de viande de vache congelée. Cette situation est la résultante de nombreuses entraves écologiques, techniques et socioéconomiques qui limitent le développement de l'élevage ovin. En effet, en Tunisie, « L'agneau de Sidi Bouzid » jouit d'une renommée nationale, fondée sur la rusticité de la race ovine Barbarine, prédominante dans cette région, et sur l'image que le consommateur Tunisien se fait des animaux élevés sur les grands parcours du centre du pays. La région de Sidi Bouzid est historiquement connue comme le « pays moutonnier ». Or cette image est cours de déperdition pour plusieurs raisons dont la diminution des surfaces pastorales et la dégradation des parcours, les difficultés de commercialisation des produits de l'élevage ovins (viande, laine, peaux…), la baisse de rentabilité de l'activité élevage ovin, le changement des habitudes alimentaires du consommateur tunisien qui se détourne vers les viandes blanches ainsi que la faible productivité des troupeaux. Par ailleurs, plusieurs races ovines sont actuellement élevées dans le centre Tunisien selon des modes très disparates. Leurs produits sont commercialisés à travers des circuits, et dans des conditions mal identifiées et peu étudiées. L'étude des pratiques et des performances de reproduction et de production permettrait de comprendre l'influence des facteurs de conduite et de l'environnement sur la productivité des troupeaux, de mieux cerner les objectifs et les stratégies des producteurs afin de proposer des actions de développement compatibles avec les moyens des producteurs et les dynamiques des systèmes de production. Le manque d'études analysant d'une manière globale la durabilité de ces élevages en tenant compte des trois composantes environnementale, sociale et économique nous a conduits à caractériser les différents systèmes d'élevage ovin existants dans la région de Sidi Bouzid et à évaluer leur durabilité sur le moyen et le long termes et enfin à cerner les atouts et contraintes à leur développement pour proposer des solutions pour les améliorer.

II – Materiels et methodes

Le gouvernorat de Sidi Bouzid se situe au Centre Ouest du pays. Il est délimité par les gouvernorats de Kairouan et Siliana au Nord, Kasserine et Gafsa à l'Ouest, Sfax à l'Est et Gabès au Sud. Etant donné ses caractéristiques climatiques et géographiques, cette région possède plusieurs avantages dans le secteur agricole qui la démarque des autres régions tunisiennes. Les enquêtes utilisées reposent essentiellement sur un questionnaire établi permettant le recueil d'un maximum d'informations sur l'élevage des petits ruminants, notamment les ovins dans la région d'étude.

La méthode de «Boule de neige» a été adoptée pour la collecte des données par questionnaire. Il s'agit d'accumulation progressive de connaissances directes ou indirectes. Cette méthode consiste à recourir aux personnes en mesure de suggérer le nom d'autres gens susceptibles de participer à une étude. Ces personnes pourront à leur tour faire la même chose jusqu'à ce que l'on obtienne un nombre suffisant de personnes interrogées. L'échantillon augmente en taille, comme une boule de neige que l'on roule, à mesure que le cycle se répète (Grinnell, 1997 ; Brahmi., 2008).

L'analyse des données s'est faite d'abord par la création d'une base de données sur Microsoft Excel version 2007 avec un codage des réponses afin d'en faciliter le traitement. Puis la saisie des réponses du questionnaire d'enquête a été faite sur cette base de données. En utilisant les tableaux croisés dynamiques de Microsoft Excel, nous avons réalisé toutes les statistiques descriptives nécessaires pour la description des résultats globaux. Cette même base de données a servi pour réaliser d'autres analyses statistiques telles que l'ACP, l'AFCM et la CAH.

III – Resultats et discussion

1. Aperçu général sur les exploitations enquêtées

Les éleveurs ont été choisis sur la base d'une diversité des situations fournis par l'O.E.P. Un échantillon représentatif, a été retenu à partir des critères taille du troupeau, la nature du parcours, les conditions climatiques et présence ou non des ressources fourragères. 100 enquêtes ont été réalisées dans les différentes délégations du gouvernorat de Sidi Bouzid dans le secteur organisé et le secteur privé. Les 10 exploitatuions que compte le secteur organisé ont été visitées (10 % de l'échantillon, 2343 femelles, 29,22% de l'effectif total des exploitations enquêtées). Les fermes relevant du secteur public, sont détenues par l'Office des Terres Domaniales (OTD), par l'Office de l'Elevage et des Pâturages (OEP), ou par des Unités Coopératives de Production Agricole (UCPA) telles que celle située à Omrane Menzel Bouzayen.

Les exploitations enquêtées détiennent un effectif total de 8359 brebis majoritairement de race Barbarine et de race Queue Fine de l'Ouest, soit une moyenne de 83,59 brebis par éleveur. La répartition des enquêtes était faite aléatoirement et dépendait en partie de la disponibilité des techniciens et des moyens de transport au niveau de la direction régionale de l'Office de l'Elevage et des Pâturages de Sidi Bouzid. La variabilité des effectifs est importante ce qui s'explique par un écart type 10,96 brebis (maximum 1596 - minimum de 10 brebis). La moyenne des superficies agricoles utiles est de 149,14 hectares, dont 4,86 ha en moyenne sont consacrées à l'alimentation animale ce qui explique le recours à l'achat des aliments concentrés. La superficie moyenne des parcours et des fourrages destinés aux ovins ne dépasse pas les 3 hectares. Le nombre moyen de béliers par exploitation est de 2 soit une sex-ratio de l'ordre de 2 béliers/20brebis ce qui est dans les normes. Les taux moyens de fertilité et de prolificité sont respectivement de 92% et 103% ce qui pourrait être considéré dans les normes des deux races élevées dans la zone d'étude. Un taux d'avortement de l'ordre de 1,2 % a été enregistré et pourrait être expliqué par un manque de soins vétérinaires dans plusieurs et/ou des manques de respect des conditions d'hygiène. Les durées d'engraissement (7 mois ±2) et d'allaitement (2±1) sont très variables et dépendent de l'objectif de l'éleveur. L'élevage dans cette zone pourrait être généralement considéré comme extensif et son aptitude à la conversion en biologique est possible si on arrive à maîtriser le côté alimentation et conversion des animaux et des terres.

La typologie des exploitations enquêtées a été réalisée par AMC. Pour pouvoir déterminer les différents groupe ou classes des éleveurs dont les systèmes d'élevage ovin se distinguent les uns les autres par un nombre de paramètres liés soit à la conduite de l'élevage lui-même, soit à l'exploitation à la disponibilité en superficie ou de fourrages et parcours ou encore aux paramètres de reproduction.

Les résultats montrent les 2 axes les plus importants. Un axe regroupe les paramètres de tailles soit superficie ou troupeau et d'envergure, un deuxième axe montre les paramètres de la conduite d'engraissement et de la reproduction soit les taux de fertilité et de prolificité en tenant compte de l'échelle limitant la durabilité de l'exploitation agricole. L'interprétation de ces résultats nous a permis de dégager 3 principaux groupes d'éleveurs ovins au sein du gouvernorat de Sidid Bouzid :

- **Le premier groupe** : représente les exploitations sur des vastes superficies agricoles avec une grande taille de cheptel et une superficie fourragère importante en irrigué mais qui présente une durabilité limitée par l'échelle socio-territoriale.
- **Le deuxième groupe** : renferme les petits éleveurs qui possèdent des petites superficies avec une taille de cheptel variable et une durabilité limitée par l'économie de l'exploitation.
- **Le troisième groupe** : renferme les éleveurs ayant une superficie utile de taille moyenne et des troupeaux de moyennes tailles, ce groupe représente une durabilité limitée par des paramètres liés aux pratiques agricoles et environnementaux.

2. Etude générale de la durabilité des exploitations agricoles enquêtées

Pour la moyenne des exploitations, nous avons obtenu des résultats pour chaque échelle. Comme nous remarquons dans la Fig. 1, la note de durabilité de l'échantillon étant la valeur la plus faible des trois échelles puisque ce sera sur cette échelle que l'éleveur devra porter ses efforts. En effet, dans notre cas, l'échantillon est limité par l'échelle socio-territoriale pour avoir une note de durabilité de 52,31.

Les objectifs désignés par la dimension socio-territoriale sont: le développement humain, la citoyenneté, l'éthique, la cohérence et le développement local du généralement à l'implication de l'éleveur ou des membres de sa famille dans des structures associatives. De même, avoir une responsabilité dans une structure et l'habitation sur ou à proximité de l'exploitation, ce qui n'est pas le cas pour 79% des éleveurs qui choisissent vivre en ville et par conséquent, ils accentuent la désertification rurale. En outre l'éleveur a un faible niveau de formation et technique, on fait 10% des éleveurs ayant un niveau d'instruction supérieur, 10% ont un niveau secondaire, 50% ont un niveau primaire et 30% sont analphabètes. L'éleveur traditionnel est un pasteur: son prestige se mesure au nombre de têtes de bétail qu'il possède plutôt qu'à l'état et à la productivité de son troupeau. D'autre part, certains n'encouragent pas à promouvoir l'élevage et ce dernier pour eux se limite à un élevage de subsistance. La Fig. 2 montre les notes des composantes de durabilité pour l'ensemble des exploitations sans tenir compte des systèmes de production. Il ressort d'après ce graphique que les indicateurs; emploi et services, organisation de l'espace et la transmissibilité de l'exploitation agricole ont les valeurs respectivement les plus faibles (11,89, 12,87 et 11,95).

L'examen de l'échelle agro écologique montre bien pour la composante diversité, que l'indicateur; diversité des cultures pérennes ayant la valeur la plus faible 1,93. Ce qui peut être expliqué par le fait que les prairies permanentes ou temporaires de plus de 5 ans sont souvent très réduites ou absentes à cause des conditions climatiques parfois rudes, manque du matériel technique et financier pour l'irrigation, ces résultats s'accordent avec ceux de Mhamdi (2008) qui a évalué des fermes pilotes en comparant leurs indices aux indices de groupes. L'arboriculture est la plus valorisée. L'agroforesterie, cultures ou prairies associées sous vergers sont limitées par la surface forestière réduite ainsi que la sous-exploitation des sous vergers.

L'amplitude au sein de l'échelle agro-écologique est de 31 points, les notes allant de 44 à 76,5. La médiane est de 61 points. Un nombre faible des exploitants (27) se situent à moins de 5 points de celle-ci.Cette valeur peut être considérée comme élevée. L'amplitude au sein de l'échelle socio-territoriale est beaucoup plus faible. Seulement 18 points séparent le plus fort du plus faible et la médiane se situe à 53 points. Or, Viaux (2004) a indiqué que les composantes de la durabilité socio-territoriale et leurs objectifs n'ont pas été définis par la «science» parce qu'il n'existe aucune définition scientifique précise ni aucune norme officielle du socialement équitable. C'est une notion qui dépend de l'opinion de la société. La dispersion au sein de l'échelle économique est aussi importante. Cela est essentiellement dû à quelques valeurs extrêmes qu'il faudra analyser (valeurs peu représentatives de l'échantillon). Ceci est conforté par le niveau de la médiane (59 points) et la hauteur du premier quartile (31 points).Partant du principe qu'il n'y a pas de compensation possible entre les échelles, la note de durabilité d'une exploitation est la plus faible des trois notes obtenues Vilain (2003). Dans la plupart des exploitations étudiées, la valeur limitante est donnée par l'échelle socio-territoriale. Les exploitations étudiées ont des notes de durabilité assez proches: la médiane est de 59 et plus de la moitié des individus se trouvent à moins de 2 à 3 points de celle-ci.

Pour l'échelle socio-territoriale, les indicateurs : services, pluriactivité et formation ont des notes égales à zéro. De ce fait, l'encadrement de proximité des producteurs pour faciliter la prise de décisions concernant les bonnes pratiques est exigé pour contribuer à l'amélioration des revenus qui leurs permettent d'améliorer leurs conditions de vie en favorisant l'épanouissement social.

L'étude de l'échelle économique montre que l'indicateur taux de spécialisation a eu la valeur la plus faible comparé à l'autre indicateur de la composante viabilité avec un score de 5,62 ce qui reflète bien le non spécialisation des exploitations agricoles. Pourtant, les enquêtes révèlent que l'élevage est le parent pauvre des pratiques identifiées car comme nous savons bien que dans la zone de l'étude l'élevage est associé aux cultures saisonnières et à l'arboriculture afin de profiter du fumier pour l'amélioration de la fertilité du sol. L'amplitude au sein de l'échelle agro-écologique est de 31 points, les notes allant de 44 à 76,5. La médiane est de 61 points. Un nombre faible des exploitants (27) se situent à moins de 5 points de celle-ci. Cette valeur peut être considérée comme élevée. L'amplitude au sein de l'échelle socio-territoriale est beaucoup plus faible. Seulement 18 points séparent le plus fort du plus faible et la médiane se situe à 53 points. Or, Viaux (2004) a indiqué que les composantes de la durabilité socio-territoriale et leurs objectifs n'ont pas été définis par la «science» parce qu'il n'existe aucune définition scientifique précise ni aucune norme officielle du socialement équitable. C'est une notion qui dépend de l'opinion de la société. La dispersion au sein de l'échelle économique est aussi importante. Cela est essentiellement dû à quelques valeurs extrêmes qu'il faudra analyser (valeurs peu représentatives de l'échantillon). Ceci est conforté par le niveau de la médiane (59 points) et la hauteur du premier quartile (31 points). Partant du principe qu'il n'y a pas de compensation possible entre les échelles, la note de durabilité d'une exploitation est la plus faible des trois notes obtenues Vilain (2003). Dans la plupart des exploitations étudiées, la valeur limitante est donnée par l'échelle socio-territoriale. Les exploitations étudiées ont des notes de durabilité assez proches: la médiane est de 59 et plus de la moitié des individus se trouvent à moins de 2 à 3 points de celle-ci.

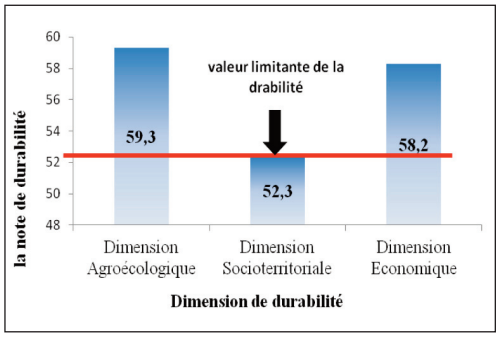

Fig. 1. Représentation numérique de la durabilité des exploitations ovines (présent travail).

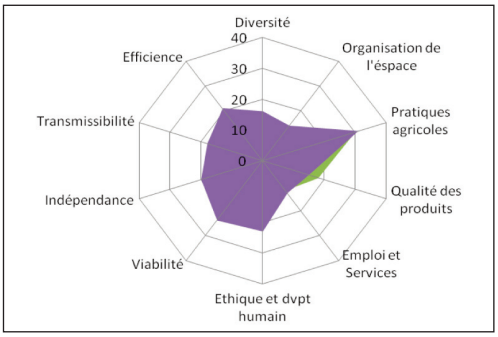

Fig. 2. Représentation graphique des composantes de la durabilité des exploitations ovines de la région de Sidi Bouzid.

III – Discussion et perspectives

1. Analyse de la durabilité agro-écologique

Les résultats obtenus pour l'échelle agro-écologique sont les plus élevés et bien regroupés par rapport aux autres dimensions de la durabilité, mais notre enquête a montré que pour la composante «Diversité», en ce qui concerne l'indicateur «diversité des cultures annuelles et temporaires», La présence des légumineuses est peu significative à cause de la méconnaissance des agriculteurs de leurs intérêts (amélioration de la fertilité des sols, alimentation du cheptel), la cherté de la semence, les conditions pédoclimatiques difficiles, ce qui demande des itinéraires techniques spécifiques et souvent très coûteux. Et pour l'indicateur «Diversité des cultures pérennes», les prairies permanentes ou temporaires de plus de 5 ans sont souvent très réduites ou absentes à cause

des conditions climatiques rudes (sécheresses répétées) et le manque des ressources en eau et du matériel technique et financier pour l'irrigation. Alors que pour l'assolement, il est caractérisé par une répartition quaternaire des surfaces (blé – orge – avoine – cultures maraîchères) et le maraîchage occupe toujours la part de lion de la surface assolable.

Pour l'indicateur «Dimension des parcelles»: on a remarqué une très grande variabilité de la dimension des parcelles des exploitations (trop petites et trop grandes). Les surfaces des zones de régulation écologique au sein des exploitations sont souvent inférieures à 5% de la surface agricole utile. Les points d'eau sont soit des puits, soit des forages qui sont destinées généralement pour les cultures fourragères. La majorité des éleveurs ne font pas d'aménagements antiérosifs et si cette composante existe chez une minorité, elle est faite soit sous forme des plantations d'arbres ou d'arbustes soit la mise en défens.

Pour la gestion des ressources fourragères, l'enquête a révélé l'absence d'application de la technique d'ensilage (excepté 5 exploitations), la dominance du système fauche + pâture, l'utilisation des chaumes par les animaux durant la période estivale, la paille étant considérée comme fourrage, la rareté de la culture du maïs, des prairies permanentes et de forêts ou vergers pâturés.

Les producteurs utilisent peu de fertilisants minéraux car l'eau est un facteur limitant. En outre on a noté la rareté des cultures pièges à l'azote. Les exploitants utilisent du fumier pour les différentes cultures pour le traitement des effluents, mais on a constaté l'absence du lisier sauf dans une seule exploitation, le non utilisation du compost et l'utilisation restreinte des pesticides (arboriculture, maraîchage) ainsi que l'absence de désherbage des prairies naturelles.

Pour le bien-être animal, les pâturages ne sont pas protégés, la production est en semi-plein air et le zéro pâturage est utilisé dans des conditions climatiques défavorables (chaleur, pluie, froid,…), en plus les pratiques hors normes: la conduite de l'alimentation, de la reproduction, nettoyage et l'état des bâtiments est jugée moyenne a mauvaise dans plus de la moitié des exploitations enquêtées. La pratique de l'irrigation est dépendante de la taille des surfaces, présence des ressources en eau, la nature des cultures et des moyens techniques et financiers. De ce fait, on a constaté qu'il y a des exploitations qui ne pratiquent pas l'irrigation, des exploitations qui irriguent dans des périodes où les précipitations sont faibles, des exploitations qui irriguent toutes les cultures, d'autres qui irriguent seulement les cultures maraîchères… L'irrigation est effectuée dans la majorité des exploitations à partir des puits et des eaux usées. Pour l'indicateur irrigation, Damjan et Glavic (2005) ont signalé qu'il est indispensable d'intégrer le facteur disponibilité de l'eau. De ce fait, on classe les exploitations en trois groupes: (i) les exploitations qui disposent des ressources en eau externes auront une note maximale ; (ii) les exploitations qui disposent des puits ou des forages peu profonds auront une note moyenne ; (iii) les exploitations qui disposent des forages ou des sondes profonds auront une note minimale.

Pour l'indicateur «Dépendance énergétique», la majorité des exploitations utilise le gasoil et l'électricité.

2. Analyse de la durabilité socio-territoriale

La littérature n'est pas très riche concernant les méthodes d'évaluation sociale des exploitations agricoles. La difficulté majeure de cette évaluation tient dans le fait que bon nombre de critères sont qualitatifs et subjectifs et que la liste des critères pertinents fait débat.

Les variables évaluées sont les suivantes:

(i) L'emploi, au sens strict, traite du nombre d'emplois, de leur durée annuelle, du statut des actifs, de l'importance de l'activité des personnes hors statut (main d'œuvre « masquée ») et du volume de production par actif.

(Ii) Le travail. Cela concerne sa rémunération et ses conditions de son exercice : durée, pénibilité, ainsi que les facteurs de stress.

Le métier renvoie aux connaissances mobilisées, à la satisfaction apportée par le travail, les conditions de vie et l'évolution de l'exploitation Les résultats obtenus pour l'échelle socio-territoriale sont faibles, en raison du manque de formation et de la faible note de la composante « Emploi et services ». Ce résultat se trouve chez les 100 exploitations enquêtées, donnant de fait, une faible note de durabilité, qui va dans le même sens avec les résultats de Mhamdi (2009). Ce dernier a indiqué que le besoin de formation des producteurs et de leurs organisations, notamment en termes d'alphabétisation, ne peut trouver une solution durable qu'à travers une volonté affichée de l'Etat à appuyer les producteurs et à réduire le taux d'analphabétisme. Le manque ou l'insuffisance de connaissances techniques est parfois à l'origine du non-respect des recommandations techniques. La méconnaissance des raisons qui sous tendent les recommandations ne permet pas de valoriser le travail fourni. Un autre exemple est celui des variétés améliorées qui exigent des conditions rigoureuses pour exprimer leur potentiel de production. Le non-respect des recommandations peut entraîner une dépréciation des variétés proposées alors que des efforts considérables avaient été engagés pour la mettre au point.

Beaucoup de choses ont été dites à propos de ces discordances: logique irrationnelle, esprits conservateurs, incapacité d'adaptation et d'adoption à cause des traditions, etc. Pourtant, les producteurs sont capables d'innover et de s'adapter aux situations nouvelles. Ils sont capables d'expérimenter dans de nombreux domaines. En effet, les décisions que prend le producteur sont fonction de ses préférences, des ses connaissances et des ressources disponibles. Ainsi, le paysan «fortement intégré au monde agricole, à ses services et à ses institutions», adoptera différemment une technique de celui qui, «désireux pourtant d'innover, est moins proche du développement…». Pendant longtemps, l'approche de la vulgarisation se résumait à un transfert de technologies.

Les services de l'agriculture ont longtemps basé leur démarche sur le fait que, pour améliorer la production agricole, il existait des techniques modernes dont l'efficacité a été démontrée par la recherche agronomique. Ces dernières décennies, la tendance est à la responsabilisation des producteurs, qui suggère une grande participation des producteurs. L'intérêt de la recherche à étudier les systèmes de production et l'implication des producteurs aux méthodes de diagnostic participatif permettent l'émergence des besoins effectifs d'appui et de conseil.

La qualité de vie des éleveurs, est en moyenne sensiblement améliorée par la possibilité de se libérer plus souvent est de l'astreinte quotidienne (week-end et vacances).

3. Analyse de la durabilité économique

La dispersion pour les résultats économiques diffère de celle des autres échelles. Cela peut s'expliquer par le nombre d'appellations différentes que l'on retrouve dans notre échantillon et les stratégies de commercialisation, qui ne permettent pas toutes de valoriser les produits ovins à la même valeur, mais aussi par des situations d'endettement différentes.

Au niveau économique, les producteurs sont soumis à des risques élevés à cause des maladies sur les végétaux et les animaux, avec une pression à l'aval sur les coûts de production et les prix de vente, dans un contexte de forte concurrence et de faible pouvoir d'achat des consommateurs. Le caractère périssable et saisonnier des productions renforce les risques commerciaux. Les innovations techniques pour rendre les rendements plus stables doivent être adaptées aux faibles capacités financières des producteurs. Sur ce groupe, la viabilité économique est la plus variable. La note sur le taux de spécialisation est globalement faible ce qui met en évidence la fragilité de l'exploitation.

4. Perspectives

- **Gestion du fumier.** En matière de gestion du fumier il est recommandé d'élaborer des pratiques de gestion permettant d'utiliser de façon rentable le fumier et les sous-produits organiques pour réduire au minimum l'impact environnemental.
- **Gestion des pâturages.** Afin d'assurer une bonne gestion des pâturages, l'acquisition des connaissances est exigée en vue, de stimuler une industrie de l'élevage en grand pâturage qui soit écologiquement durable grâce à la maîtrise des interactions entre le bétail, les insectes, les plantes, le sol et l'eau et élaborer des stratégies de gestion intégrant l'élevage avec les autres ressources.
- **Qualité des sols.** Elaboration de pratiques de gestion applicables aux prairies semi-arides pour préserver la qualité des sols, maintenir leur productivité à long terme et réduire au minimum les risques pour les milieux environnants.
- **Utilisation durable des terres.** Intégration des données sur les terres et extrapolation pour produire des stratégies de gestion des terres compatibles avec l'exploitation durable des écosystèmes.
- **Qualité de l'eau.** Vu le rôle important que joue l'eau dans la durabilité de l'agriculture, on recommande d'élaborer des systèmes et des stratégies de gestion pour augmenter ou conserver les ressources hydriques et atmosphériques par l'acquisition de nouvelles connaissances et de nouvelles technologies.
- **Nutrition des animaux.** Élaboration de stratégies nutritionnelles pour améliorer l'efficacité de la production ovine et la qualité du produit tout en maintenant les animaux en bonne santé et en limitant au minimum l'impact environnemental. La production des cultures fourragères permet la constitution de stocks d'alimentation pour la complémentation des aliments de trait en utilisant des espèces à croissance rapide qui ont suscité un intérêt chez les producteurs.
- **Santé animale.** Chercher à lever les contraintes sanitaires au développement des productions animales en luttant contre les agents de transmission des pathologies animales. Cela se traduit par la mise au point d'outils de diagnostic et de méthodes efficientes de contrôle des maladies parasitaires.
- **Formation et vulgarisation.** Renforcer le dispositif d'encadrement et tendre vers un encadrement de proximité des producteurs pour faciliter la prise de décisions concernant les bonnes pratiques. Ainsi, les formations en salles, les ateliers et les conseils de gestion des exploitations visent à former et à conseiller les producteurs pour une mise en œuvre durable de l'approche.
- **Pratiques culturales.** Encourager les bonnes pratiques agricoles à la fois durables et sans danger pour les producteurs et qui contribuent à améliorer leurs conditions de vie. L'objectif est de répondre à une demande croissante du marché, de s'intégrer dans une filière verticale et un réseau sous-régional, et de permettre aux producteurs de diversifier leurs spéculations

IV – Conclusion et recommandations

L'essai d'analyse des systèmes d'élevage ovin dans la région de Sidi Bouzid, nous a permis d'aborder une approche générale sur ce secteur. Tout d'abord, on constate que l'élevage ovin est l'une des activités agricoles principales dans les exploitations de la région d'étude. En effet, on a pu ressortir une diversité des exploitations pratiquant l'élevage ovin. Cette diversité est due essentiellement à la structure et les potentialités des exploitations, la taille et la diversité des troupeaux, les ressources alimentaires et la conduite des ovins. Trois classes d'éleveurs ont été dégagées dont

chacune avait ses caractéristiques. La première classe est principalement caractérisée par les grandes surfaces, les grands effectifs, le recours à l'engraissement de courte durée avec une durabilité qui peut être améliorée en jouant sur quelques indicateurs sociologiques telle que l'acquisition d'une formation ou l'intégration dans une structure associative. La deuxième classe regroupe les éleveurs qui ont des petites exploitations d'où résultent les problèmes économiques. La troisième classe est celle des éleveurs ayant de moyens effectifs et de faibles surfaces agricoles et qui sont caractérisés par leurs fausses pratiques agricoles.

Il faudrait donc sensibiliser les éleveurs et mettre en place des méthodes de vulgarisation adéquates pour permettre aux éleveurs de premier et de dernier groupe de comprendre leurs points faibles. Par contre dans le cas du deuxième groupe, le plus défavorisé malgré l'importance de l'élevage ovin dans l'assurance de la survie des éleveurs, les subventions de l'Etat concernant l'alimentation doivent être augmentées.

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Validation of a microbiological inhibition system based on Eclipse Farm 3G coupled with e-Reader to screening β-lactam and tetracycline antibiotics in goat's cheese whey

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Abstract. The presence of antimicrobial residues in milk and dairy products could cause negative technological effects and represents a risk for consumer health. During the cheese-making process, antibiotics could be retained in curd or eliminated in whey to a greater or lesser extent. Whey is a by-product used in the manufacture of foodstuffs for human consumption and animal feeding and therefore, the presence of antibiotic residues in this product should be controlled. Thus, it is crucial to develop an analytical strategy to screen antibiotics in whey. A new system for screening antibiotics in raw milk was recently developed, in which a microbial inhibitor tube test (Eclipse Farm) and a device (e-Reader) are coupled. The new system allows the incubation of the test and a continuous monitoring of the test colour change. The aim of this work was to study the performance of the new system for the detection of β-lactam and tetracycline residues in goat's cheese whey. A preliminary study demonstrated the necessity to include a one-hour diffusion period at room temperature. The performance was validated in agreement with European Commission Decision 2002/657/EC. Specificity of microbial test was evaluated by analysing one hundred and thirty whey samples. Results showed a low percentage of false-positive results. The detection limits for amoxicillin, benzilpenicillin, cephalexin and oxytetracycline in goat's cheese whey were calculated and the detection capabilities (CCβ) were below or at the MRL levels, with the exception of amoxicillin, which was slightly above them. In conclusion, Eclipse Farm coupled to e-Reader represents an appropriate method to screen β-lactams and tetracycline residues in whey.

Keywords. Whey – Antibiotic – β-lactams – Tetracyclines – Screening test.

Validation d'un système d'inhibition microbiologique basé sur Eclipse Farm 3G couplé avec un lecteur e-Reader pour le dépistage des antibiotiques β-lactam et tetracycline dans le lactosérum de fromage de chèvre

Résumé. *La présence de résidus d'antibiotiques dans le lait et les produits laitiers peut entraîner des problèmes technologiques et un risque pour la santé des consommateurs. Pendant le processus de fabrication du fromage, les antibiotiques peuvent rester attachés au caillé ou peuvent être éliminés dans le sérum. Le lactosérum est un sous-produit utilisé dans la fabrication de denrées alimentaires destinées à la consommation humaine et à l'alimentation animale et, par conséquent, la présence de résidus d'antibiotiques dans ce produit doit être bien contrôlée. Il est donc essentiel de mettre en place une stratégie analytique pour l'analyse des antibiotiques dans le lactosérum. Un nouveau test d'inhibition microbienne (Eclipse Farm) couplé avec un dispositif d'incubation et de lecture (e-Reader) a été récemment développé pour le dépistage d'antibiotiques dans le lait cru. Le nouveau système permet l'incubation et la surveillance continue du changement de la couleur du test. L'objectif de ce travail consistait à étudier la performance du nouveau système pour la détection des résidus de β-lactames et de tétracyclines dans le lactosérum du fromage de chèvre. Une étude préliminaire a démontré la nécessité d'inclure une étape de diffusion d'une heure à température ambiante. Le système a été validé conformément aux procédures décrites dans la décision 2002/657/CE de la Commission Européenne. La spécificité du test a été évaluée en analysant 130 échantillons de lactosérum. Les résultats ont montré un faible pourcentage de résultats faussement positifs. Les limites de détection pour l'amoxicilline, la benzilpenicilline, la cé-*

phalexine et l'oxytétracycline dans le lactosérum du fromage de chèvre ont été calculées, ainsi que les capacités de détection (CCβ), toutes en dessous ou au même niveau que les Limites de Résidus Maximum (LRM), sauf pour l'amoxicilline, avec une limite légèrement supérieure. En conclusion, Eclipse Farm couplé à e-Reader représente une méthode appropriée pour la détection des résidus des β-lactames et tétracyclines dans le lactosérum de chèvre.

Mots-clés. *Lactosérum – Antibiotique – β-lactames – Tétracyclines – Test de dépitage.*

I – Introduction

The wide use of antimicrobials in food-producing animals, to prevent and to treat diseases, can constitute a problem in milk and dairy products due to the presence of antibiotic residues. In fact, their presence in milk could cause negative technological effects (Berruga *et al*., 2008). Moreover the presence of antibiotics in milk products could have direct health implications for the consumers with allergic reactions and lead to an increase of resistant bacteria with serious consequences in human and animal health (WHO, 2014). To guarantee the consumer health, the European Union established the Maximum Residue Limits (MRL) in milk but up to now, no limits has been established for dairy products, as cheese and whey (EC, 2010).

Whey is a by-product of cheese-making process with many applications in food industry and livestock and therefore, possible presence of drug residues could have direct negative effects for human and animal health and in dairy sector by affecting fermentation processes. During cheese-making process, antibiotics present in milk, could be retained in cheese or carried in whey depending of the chemical nature of each substance (Cabizza *et al*., 2016). For all these reasons, the availability of an analytical strategy to screen antibiotics in whey seems necessary.

In last years the strategy to control of antibiotics in milk has been introduced at different levels of the chain. Nowadays, not only central laboratories but dairies and farmers are aware with the control of antibiotics. Thus, the availability of automatic screening methods has become a real need. A new system for the screening of antibiotics in raw milk was recently developed (Mata *et al*., 2016). This new system combine a microbial inhibitor tube test (Eclipse Farm 3G) and a device (e-Reader) that allows the incubation of the test and the continuous monitoring of the color change. The aim of this work was to study the performance of this new system for detection of β-lactams and tetracyclines in goat's cheese whey.

II – Material and methods

1. Whey Samples

Whey samples were produced by the application of a laboratory scale cheese-making, as described by Giraldo *et al.* (2017). Raw milk was obtained from the experimental flock of healthy and untreated Murciano-Granadina goats at Universitat Politècnica de Valencia (Valencia, Spain). Whey samples were analyzed for chemical composition using MilkoScan 6000 (Foss, Hillerød, Denmark) and the pH value was valued by a pH-meter (Crison, Barcelona, Spain).

2. Antibiotics

Four antibiotics representative of the most used molecules in veterinary were chosen. The molecules tested were amoxicillin, benzilpenicillin, cephalexin, and oxytetracycline. All antibiotics were purchased from Sigma-Aldrich Química, S.A. (Madrid, Spain). Stock solutions (1 mg/mL) were prepared in according to International Dairy Federation (ISO/IDF, 2003). Working dilutions were prepared daily.

3. Performance of Eclipse Farm 3G Test and e-Reader

To assay the detections of antibiotics in whey, Eclipse Farm 3G test (ZEULAB, Zaragoza, Spain) coupled to the e-Reader detector were used. The test procedure was carried out following manufacturer recommendations, doing a preliminary study to improve the system for the analysis of milk whey samples. This modification of original instructions was necessary to eliminate gradients of color (purple and yellow). For this, 10 goat's milk whey samples were tested with different treatments: centrifugation (3000 rpm, 10 minutes), heating (80ºC, 10 minutes), centrifugation and heating (under the same conditions) and with pre-diffusion for one hour at room temperature.

Previously, cut-off level for Eclipse Farm coupled to e-Reader was calculated following indications by Mata *et al.* (2016). Seventy-five goat's milk whey samples were used, obtaining their mean and standard deviation. The cut-off for microbiological test was the result of mean value plus three times the standard deviation.

A study of false positive rate was also carried out and, in this case, 130 negative goat's milk whey samples were tested.

To determinate the detection capabilities (CCβ) with whey samples the method previously described by Mata *et al.* (2016) was applied according to the CRL guidelines (CRLs, 2010).

III – Results and discussion

After evaluating several procedures to prepare samples for the analysis, adding a step of pre-diffusion for 1 hour at room temperature was selected as the best choice.

The cut-off was calculated by using the mean value from 75 negative samples (41.2) and the corresponding standard deviation (7.0). The result was of 62.1 (mean of the negative samples plus 3 times the standard deviation), as it is observed in Fig. 1. Thus, e-reader values equal or above 62 were considered as positive samples.

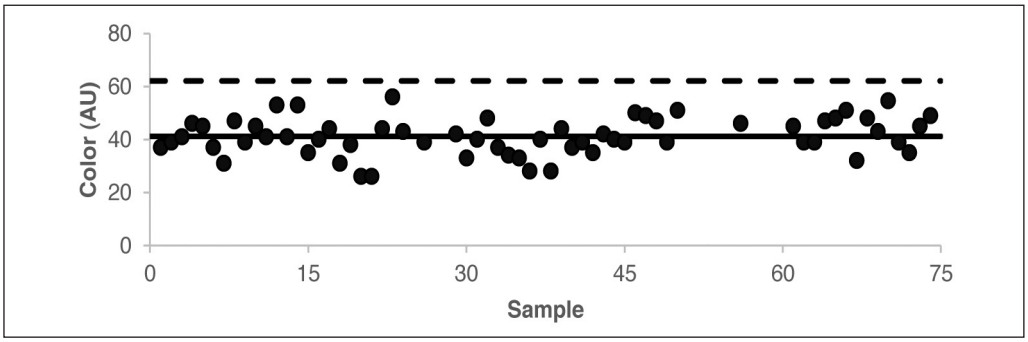

Fig. 1. Results obtained by e-Reader for 75 goat's whey samples analysed with Eclipse Farm test. Solid line indicates the average value. Dashed line indicates the proposed cut-off level with a confidence interval higher than 99%.

The composition of goat's whey samples is presented on the Table 1. A minimum false-positive rate was found for these goat's milk whey samples, which was equal to 2.3%. This percentage is in agreement with the false positive rate calculated by Beltrán *et al.* (2015) for goat's milk using different microbial inhibitor tests (BRT MRL, 1.4%; Delvotest SP-NT, 4.3%; Delvotest DA, 3.1%; Eclipse 100, 0.6%). Therefore, Eclipse Farm coupled to e-Reader continues being appropriated, on terms of false-positive results, when whey matrix is analyzed.

Table 1. Quality parameters of goat's milk whey samples free of antimicrobials

Parameters	Mean	SD[a]	Minimum	Maximum
pH	6.45	0.22	5.46	6.69
Fat	0.68	0.16	0.33	1.21
Protein	1.09	0.15	0.83	1.48
Lactose	4.91	0.10	4.63	5.10
Total solids	6.69	0.16	6.36	7.12

[a] SD: standard deviation.

The detection limits and detection capabilities goat's milk whey for 4 antimicrobials are summarized in Table 2.

Table 2. Detection limits (µg/kg) and detection capabilities of Eclipse Farm coupled to e-Reader for four representative β-lactams and tetracycline residues in goat's milk whey

Antimicrobial	MRL[a] (µg/kg)	Detection limit[b] (µg/kg)	e-Reader value[c]	Detection capability[b] (µg/kg)	No. positive[d]/ no. samples	e-Reader value[d]
Amoxicillin	4	4	71.4 ± 5.3	5	20/20	106.8 ± 11.8
Benzilpenicillin	4	3	107.0 ± 15.2	3	40/40	117.2 ± 24.4
Cephalexin	100	>50	63.2 ± 18.4	60	39/40	108.4 ± 19.2
Oxytetracycline	100	>60	67.8 ± 12.3	100	60/60	94.9 ± 12.2

[a] MRL: EU Maximum Residue Limit (µg/kg).

[b] Positive results are defined as an e-Reader value higher than 62.

[c] Mean ± SD (n = 5).

[d] Mean ± SD.

According to the Table 2, all the obtained detection limits are below or equal to their corresponding MRLs. However, in the case of detection capabilities, in which a higher number of samples is tested, amoxicillin has shown a higher value (CCβ = 5 µg/kg) than their legal limit. It is observed that when a low e-Reader value is determined for the detection limit (amoxicillin and oxytetracycline) the corresponding CCβs are higher but with high e-Reader values (Table 2). These results suggest that CCβs for both molecules are close to detection limits but statistically do not reach the same level. Moreover, standard deviations were relatively high, suggesting that there is an important variability in the results between repetitions of fortified whey samples.

Comparing our results with those reported by other authors in milk, some differences are found. Beltrán *et al.* (2015) obtained CCβ higher than the calculated in this study using different microbiological tests (BRT MRL, Delvotest SP-NT, Delvotest DA and Eclipse 100) in sheep and goat's milk. In the case of goat's milk, in general, all detection capabilities were lower than the obtained for cheese whey samples, with the exception of the cephalexin, whose CCβ for BRT MLR and Delvotest SP-NT was around or above their MRL (>100 µg/kg and 75 µg/kg respectively) and oxytetracycline could not be detected at MRL by any test used in this study.

Using Eclipse Farm coupled to e-Reader to analyze cow's milk samples, Mata *et al.* (2016) studied detection limits and detection capabilities for these same antimicrobials and they obtained results too similar to this study. Regarding detection capabilities, the e-Reader values in cow's milk were lower than in goat's cheese whey for amoxicillin (CCβ = 4 µg/kg) and cephalexin (CCβ = 50 µg/kg), but for oxytetracycline, detection capability was the same for both matrices.

Finally, these results could be compared with the obtained by Giraldo *et al.*, (2016), who tested also these same antibiotics in goat's milk whey, using Eclipse 100 (ZEULAB, Spain), a microbiological

test with similar characteristics than the used in this study. Detection capabilities were slightly lower than the calculated in this study for amoxicillin (CCβ = 3.9 µg/kg), benzylpenicillin (CCβ = 2.6 µg/kg) and cephalexin (CCβ = 48.4 µg/kg). On the contrary, for oxytetracycline, the CCβ was above the MRL of this molecule (116.8 µg/kg).

IV – Conclusions

Eclipse Farm coupled to e-Reader allow to detect benzipenacillin, cephalexin and oxytetracycline to concentrations below or equal to their MRLs, with a minimum rate of false-positive results. Thus, this method could be a good alternative to screening of β-lactamsand tetracyclines residues in cheese whey.

Acknowledgments

This work is part of the AGL-2013-45147-R funded by the Ministry of Science and Innovation (Madrid. Spain).

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Mountain pasture management by goat farmers: case of the Kabylia region (Algeria)

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Abstract. The aim of this study is to characterize goat breeders' pasture management strategies. 16 goat farms, located in a steep mountainous area in Tizi-Ouzou, were monitored for one year. Results show that goat breeding, with flocks ranging from 5 to 136 head, is regarded as the principal activity and under extensive conditions. Feeding is primarily based on the exploitation of pastures. On average, animals spend 6 hour/day on pasture. Pastures are made up of natural meadows, maquis and forests. The surface area of these pastures varies during the year according to the seasons, from 5 to 9 ha / breeder. It is in autumn and winter when the grazing period is reduced, and therefore the animals' requierements are not sufficiently covered. For this purpose, hay, stubble and limbing are used during this part of the year. Limbing concerns plant species such as Algerian oak, cork oak, ash, broom and olive leaves. In addition, the distribution of supplements is based on the goat's milk production strategy (low, medium and high production). Animals receive, throughout the year, a small amount of supplements, on average 135 g/head/day. These supplements may be green fodder, straw or concentrates. The latter is initially intended for cows, and contains wheat bran, corn or barley.

Keywords. Goat breeding – Pastures – Feed – Mountainous area – Algeria.

Gestion des parcours de montagne par les éleveurs caprins : cas de la région de Kabylie en Algérie

Résumé. *L'objectif de ce travail est de caractériser les stratégies de gestion des parcours de montagne par les éleveurs caprins. 16 exploitations caprines, situées en zone montagneuse à forte pente de Tizi-Ouzou, ont été suivies pendant une année. Les résultats montrent que l'élevage caprin, dont la taille des cheptels varie de 5 à 136 têtes, est considéré comme activité principale menée de façon extensive. L'alimentation se base essentiellement sur l'exploitation des pâturages. Le temps passé par les animaux sur les pâturages est en moyenne de 6 heures/jour. Les pâturages sont constitués de prairies naturelles, maquis et forêts. Durant l'année, la surface de ces pâturages varie en fonction des saisons de 5 à 9 ha/éleveur. C'est en automne et en hiver que la période de pâturage diminue, de ce fait les besoins des animaux ne sont pas suffisamment couverts. À cet effet, le foin, les chaumes et l'ébranchage sont exploités durant cette partie de l'année. L'ébranchage concerne les espèces végétales comme le chêne zéen, le chêne-liège, le frêne, le genêt et les feuilles d'olivier. En outre, la distribution de complément se fait en fonction de la stratégie de production de lait de chèvre (faible, moyenne et forte production). Les animaux reçoivent, durant toute l'année, une faible quantité de complément qui est en moyenne de 135 g/tête/jour. Ce complément peut être du fourrage vert, de la paille ou du concentré. Ce dernier est constitué de concentré destiné initialement aux vaches, de son de blé, de maïs ou d'orge.*

Mots-clés. *Exploitation caprine – Pâturages – Alimentation – Zone montagneuse – Algérie.*

I – Introduction

In mountainous areas in Algeria, as in other countries of North Africa and the Sahel, small ruminants contribute substantially to the food and economic security of mountain households (Bengoumi *et al.*, 2013). Changes in the farming environment affected small ruminant production systems. These changes induced adaptations related to conducting of breeding and production orientation (Dubeuf and Boyazoglu, 2009).

In Tizi-Ouzou in the Kabylia region (Algeria), dairy goat farming operates in an appropriate environment because of its relief and vegetation (presence of vegetation, forests, ...). Breeding is conducted under extensive conditions. These food sources seem to be insufficient for the animals, from where the appearance of complementation with concentrates.

Flocks are of small size and are characterized by low productivity, about 1 kg milk / goat / day according to Kadi *et al*. (2013) and Mouhous *et al.* (2015). According to Kadi *et al*. (2015), in this type of farming system, production is not always sufficient, but it is at a lower cost.

This work aims to characterize the feeding behaviour related to grazing management in the mountainous zone of Tizi-Ouzou (Algeria).

II – Materials and methods

The study was conducted in the mountainous region of Tizi-Ouzou (Kabylia), 100 km east of Algiers). Five different physical arrays by topography and vegetation cover characterize the study area (Figure 1). The average rainfall reached 762 mm / year. The study area has 25,370 ha of pastures and rangelands and 115,000 ha of forests, accounting for 10% and 47% of the total land area, respectively.

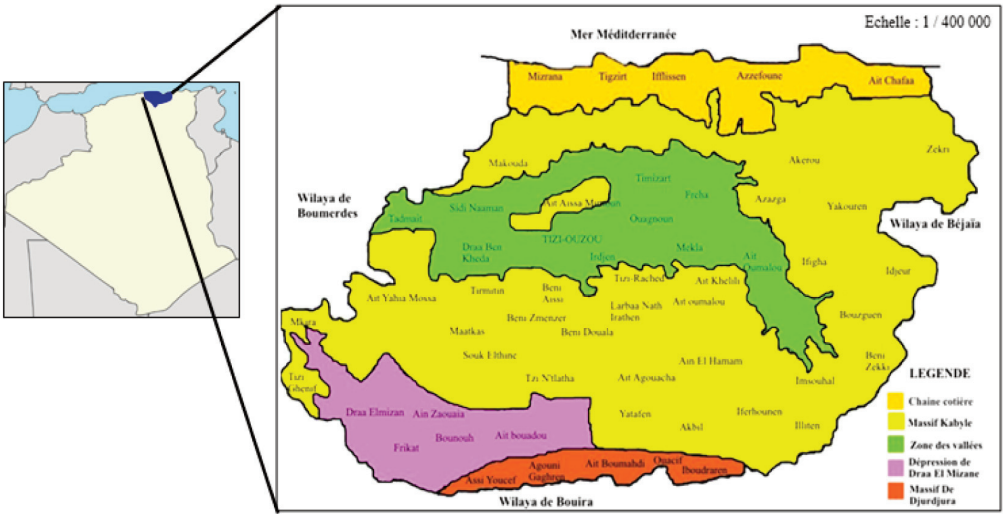

Fig. 1. Physical settings of the study area (DPAT, 2010).

Sixteen goat farms were chosen to be monitored from March 2012 to February 2013. In the selection process of farms, farmers's consent was provided so as to be monitored for a year and receive researchers once or twice a month. The farms are distributed as shown on the physical settings of the study area.

The sections of the questionnaire were related to the feeding behaviour of goats related to mountain pasture management and supplementation with concentrates.

In mountain areas where the forage supply is low, goat farms have low utilised agricultural area (0-4 ha, on average) and the number of dairy goats does not exceed 86 per farm (Table 1). In these 16 farms, goat farming is the main activity.

Table 1. Characteristics of 16 monitored farms

Characteristics	Minimum/maximum	Average	Standard deviation
Number of workers	1 to 3	2.24	0.66
Cultivated UAA (ha)	0 to 4	0.9	1.0
Livestock (head)	5 to 136	34	32.2
Number of dairy goats (head)	3 to 86	16	19.6
Amount of milk sold (kg/year/farm)	72 to 39 350	3 854	9 607

III – Results and discussion

1. Feeding behaviour

Concentrates are distributed in small amounts. The follow-up of goat farms has established a forage calendar. This shows the importance of grazing in goats' diet. The extensive system managed by goat farmers is primarily based on pasture management to meet the dietary requirements of animals as already reported by Kadi *et al.* (2015).

2. Grazing management in goat farms

Goat farms are generally located in mountainous areas with steep slopes. According to the feeding calendar, animals graze all year round in the forest (Figure 2). Supplementation with concentrates is also all year round but in very small amounts (on average, 135 g/head/day). This practice is not reported in neighbouring countries such as Morocco (Chentouf *et al*., 2006).

Complementation by limbing is practiced in autumn and winter. The main plant species used for feeding goats are Algerian oak (*Quercus canariensis*), cork oak (*Quercus suber*), narrow leaf ash (*Fraxinus angustifolia*), spinybroom (*Calycotum spinosa*) and olive leaves (*Olea europea*). Animals receive hay during autumn and winter, when pastures do not cover the the animals' nutritional needs sufficiently and the grazing period is reduced. Stubble, which surface area is small, is only used for two months after mowing hay.

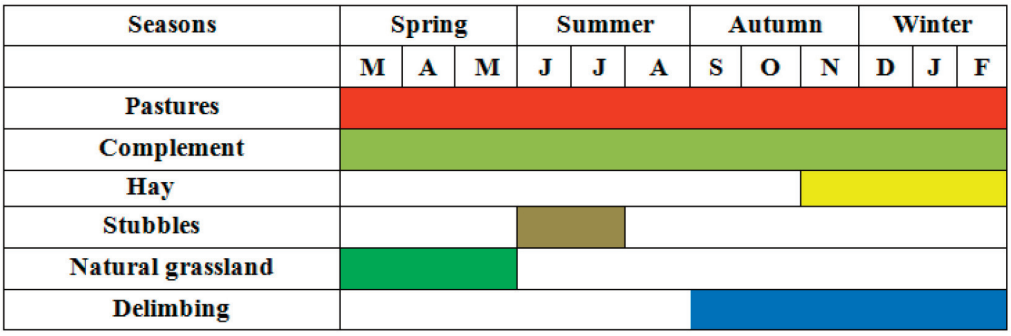

Fig. 2. Feeding calendar in goat breeding (March 2012-February 2013).

Furthermore, grazing time varies from season to season (Figure 3). In spring (March to May), grazing time is 7 hours. Animals go out from 12.00 to 19.00. In summer (June-August), the time spent grazing increases to 9 hours / day. Moreover, animals graze in the morning and in the afternoon. They rest at noon on the farm when the temperature is very high. In autumn and winter, grazing time is reduced. Animals graze in the afternoon (12:00 to 15:00) given the rough climatic conditions and very low temperatures in the mountains.

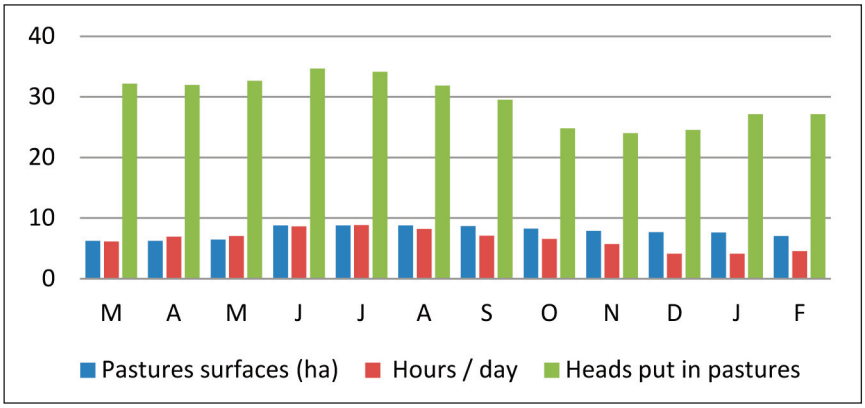

Fig. 3. Pasture Management in goat farms (2012-2013).

Grazed surface areas change from season to season. In spring the average pasture area is 5 ha / farmer. Forests, scrub and native grasslands make up this area. However, in summer the area of pastureland is 9 ha / farmer, on average. This increase in size is stubble is grazed during this period. The use of pastures is a special characteristic of an extensive breeding mode and is common in several countries throughout the world (Escareño *et al*., 2013) and in the Mediterranean area in particular (Oregui and Falagán, 2006).

3. Supplementation in goat farms

Breeders also distribute some green forages, straw and concentrates. Livestock unit numbers (LU) have been used for variables easy to discuss. Indeed, the quantities of green fodder distributed are negligible. Breeders have also been classified according to the amount of milk produced, and three groups have been formed: low, medium and high milk production. Low and medium production groups amount to 3 kg/LU, while the high production group (big farmers) produce twice the amount of milk as the previous groups (6 kg/LU). As in the case of green fodder, straw is distributed in small amounts that do not even reach ½ kg for groups 1 and 3. Green forages and straw are distributed only to females. Concentrates are distributed to all animals. They are wheat bran, barley or industrial concentrates. This is the average production group that reports the largest amount distributed (335 g/goat/day and 260 g/goat/day). Other groups do not exceed 200 g/animal/day.

The low production group distributes less than 100 g/head/day, and the high production group 150 g/head/day. Consequently, taking into account pasture use and feeding practices, milk production is 3 854 kg/year/farm, on average.

IV – Conclusion

In mountainous areas, goat farms are managed under extensive conditions. Pastures are mainly forests and natural grasslands. These are the main sources of feed for goats. With the aim of reducing feed costs, goat flocks of small size use these pastures on a daily basis and throughout the year. The average surface area of pastures exploited is 8 ha/breeder with an average time spent on pasture of 6 hours/day.

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Sensory and microbiological evaluation of Drâa goat cheese and study of its stability during storage

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Abstract. Goat cheese in the oasis regions of Morocco remains a poorly characterized and studied product, in spite of the genetic potential of the oases and the efforts deployed by the Moroccan State to promote this dairy product.

The present work aims to contribute to the characterization of Drâa goat cheese through (i) sensory and microbiological evaluation and (ii) studying stability of this cheese during storage.

Thus, 8 cheese bars (from a milk mixture of at least 2 goats / cheese tablet) have been produced at the laboratory scale. The microbiological and sensorial characteristics of cheese were determinated. The stability study was focused on the monitoring of 3 parameters: fungal flora, drying rate and lactic acid content at intervals of 0, 8 and 16 days of storage.

The results show that Drâa goat cheese contains (CFU/ml) respectively: $8{,}33.10^{+08}$, $9{,}35.10^{+06}$, $2{,}17.10^{+04}$ and $6{,}83.10^{+03}$ of lactic acid bacteria, psychrotrophic bacteria, yeast and Molds.

Sensory analysis revealed a highly significant difference between the Drâa cheese and that produced with Alpine goat milk. The scores obtained by the hedonic test are 5.3/10 for the odor, 4.9/10 for the taste and 5.9/10 for the consistency.

For the storage of Drâa cheese, it was concluded that the acidity (P = 0.03) and the fungal flora, yeast (P = 0.004) and molds (P = 0.003), increased with a significant manner during the 16 days of cold storage; however, no significant difference was recorded for water content.

Keywords. Goat – Cheese – Drâa – Microbiology – Sensory – Storage.

Évaluation sensorielle et microbiologique du fromage de chèvres Drâa et étude de sa stabilité pendant l'entreposage

Résumé. *Le fromage de chèvre des zones oasiennes du Maroc reste une denrée alimentaire mal caractérisée et étudiée, malgré le potentiel génétique de la race Drâa et les efforts déployés par l'état Marocain pour la promotion de ce produit laitier en lien avec l'image des oasis.*

Le présent travail se propose de contribuer à la caractérisation du fromage de chèvre Drâa à travers (i) une évaluation sensorielle et microbiologique et (ii) une étude de stabilité de ce fromage au cours du stockage.

Ainsi, 8 tablettes de fromage (issues d'un mélange du lait de 2 chèvres au moins/tablette) ont été fabriquées et caractérisées de point de vue microbiologique et sensoriel en laboratoire. L'étude de stabilité a porté sur le suivi de 3 paramètres : flore fongique, taux de dessèchement et la teneur en acide lactique à des intervalles de 0, 8 et 16 jours du stockage.

Les résultats montrent que le fromage de la chèvre Drâa renferme (en CFU/ml) respectivement $8{,}33.10^{+08}$, $9{,}35.10^{+06}$, $2{,}17.10^{+04}$ et $6{,}83.10^{+03}$ de bactéries lactique, bactéries psychrotrophes, levures et moisissures.

L'analyse sensorielle a permis de déceler une différence hautement significative entre le fromage de la chèvre Drâa et celui produit avec du lait de la chèvre Alpine. Les scores obtenus par l'épreuve hédonique sont 5.3/10 pour l'odeur, 4.9/10 pour le goût et 5.9/10 pour la consistance.

Pour le stockage du fromage Drâa, il a été conclu que l'acidité et la flore fongique connaissent une augmentation significative durant les 16 jours du stockage frigorifique. Cependant, aucune différence significative n'a été enregistrée pour la teneur en eau.

Mots-clés. *Fromage – Chèvre – Drâa – Microbiologie – Sensorielle – Stockage.*

I – Introduction

Au Maroc, le lait de chèvre est rarement valorisé (FAO, 1996). Face à cette situation, les responsables nationaux ont pris conscience de la nécessite de développer la production laitière caprine et lui assurer un meilleur 'processing' à travers la transformation fromagère qui constitue la meilleure voie de valoriser le lait de chèvre.

Dans ce contexte, la présente étude propose de continuer les travaux de recherche entrepris par l'INRA (Maroc) pour caractériser et valoriser le lait de chèvre dans le Maroc (Zantar, 2008 ; Noutfia, 2014). Dans ce sens, une caractérisation sensorielle et microbiologique du fromage de la chèvre Drâa (race caprine typique aux oasis du Sud Est Marocain), ainsi que sa stabilité au cours du stockage sera établie à travers cette étude.

II – Matériel et méthodes

Le fromage de chèvre Drâa a été fabriqué en laboratoire à partir du lait issu d'un cheptel conduit en élevage intensif à la station expérimentale d'Errachidia. Huit tablettes de fromage ont étés produites à l'aide d'une coagulation mixte suivie d'un égouttage de 15h à 25°C. Le fromage a été conservé au réfrigérateur à 4°C pendant 3 semaines.

Les tests microbiologiques ont porté sur la recherche des (i) coliformes totaux (CT) et fécaux (CF), (ii) bactéries lactiques, (iii) psychrotrophes et (iv) levures et moisissures.

L'analyse sensorielle a porté sur un test triangulaire et une épreuve hédonique. Pour cette épreuve, 3 attributs sensoriels ont étés analysés et notés sur une échelle de 0 à 10. Le fromage de chèvre Drâa a été comparé avec celui de la race Alpine et du fromage mi chèvre produits dans la région oasienne du Sud Marocain.

Les paramètres contrôlés au cours du stockage (à des intervalles de 0, 8 et 16 jours) sont l'acidité, la perte en poids (matière sèche) et les levures et moisissures.

III – Résultats et discussion

1. Analyse microbiologique

Le tableau 1 reporte la charge en microorganismes recherchés dans le fromage ''Drâa''.

Tableau 1. Charge microbienne du fromage fabriqué

Microorganismes	Teneur en Log10 (UFC/ml)	Limite tolérée
Coliformes totaux (CT)	2,40	<4
Coliformes fécaux (CF)	2,34	Non disponible
Bactéries lactiques	8,92	Non disponible
Bactéries psychrotrophes	6,97	<6
Levures	4,34	5
Moisissures	3,83	5

Le tableau 1 montre que la flore indicatrice d'une contamination fécale (CT et CF) est largement inférieure au seuil fixé par la norme. Ceci peut être expliqué par la bonne conduite de la traite et les meilleures conditions de transformation. La charge en bactéries lactiques et psychrotrophes est dans les limites qui (i) garantissent des meilleures qualités organoleptiques (goûts et odeurs) et qui (ii) limitent le déclenchement des réactions enzymatiques (de protéolyse et de lipolyse) non recherchées dans ce type de fromage frais.

Pour la flore fongique, le seuil d'apparition des défauts et de contamination est souvent supérieur à 10^{+05} (Rosset *et al.,* 2002). Selon les résultats obtenus, il ressort que le fromage fabriqué est loin d'être sujet de ce genre de défauts liés à cette flore fongique.

2. Analyse sensorielle

Les résultats de l'épreuve hédonique sont reportés dans le tableau 2.

Tableau 2. Analyse sensorielle du fromage de chèvre dans la région oasienne du Sud Maroc

	Fromage Drâa	Fromage mi chèvre	Fromage Alpine
Odeur	5,3	6,25	5,25
Goût	4,9	6,75	6,7
Consistance	5,85	6,2	6,4

En analysant ce tableau, on remarque que les attributs sensoriels des fromages mi-chèvres et Alpine sont proches. En plus, le meilleur profil sensoriel est celui du fromage mi chèvre, suivi de fromage Alpine.

Par ailleurs, une différence hautement significative entre le fromage ''Drâa'' et ''Alpine'' a été révélée par le test triangulaire (à des seuils de confiance de 0.95%, 0.99% et 0,999%).

3. Evolution au cours du stockage

A. Matière sèche

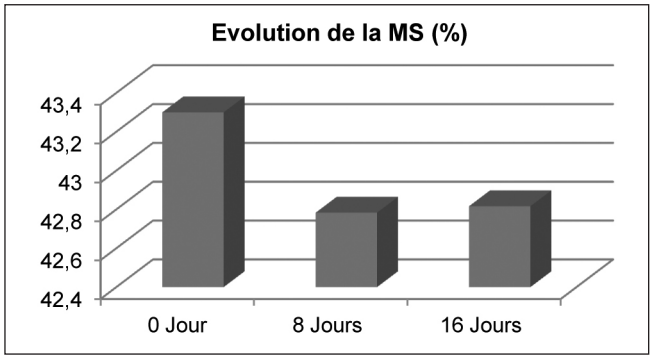

Fig. 1. Effet de stockage sur la matière sèche du fromage.

L'évolution de la teneur en MS au cours du stockage connaît une légère chute de 43,3% à 42,9%. Cependant, aucune différence significative entre la quantité de la MS à la fabrication et à 16 jours n'a été notée.

Ceci démontre que malgré le climat sec de la région, une conservation adéquate (film en plastique alimentaire) garde intacte la teneur en extrait sec du fromage.

B. Taux d'acidification

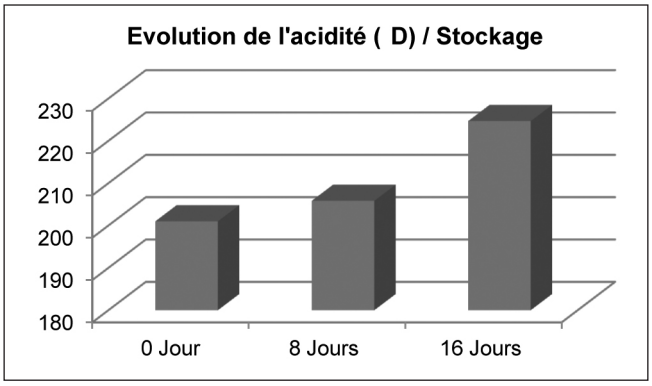

Fig. 2. Effet de stockage sur l'acidité du fromage.

La teneur en acide lactique augmente d'une façon significative ($p<0,05$) au cours du stockage, car avec une moyenne de 204°D au début, l'acidité atteint 222°D après 16 jours, soit un gain de 18°D.

Ceci témoigne d'une fermentation lactique au niveau du fromage stocké… Ce constat concorde avec les conclusions avancées par (Yedri, 2010 ; Yessraoui, 2002).

C. Levures et moisissures

L'effet de stockage sur la flore fongique du fromage est reporté dans le tableau 3.

Tableau 3. Valeurs logarithmiques moyennes des levures et moisissures au cours du stockage

Log (UFC/ml)	0 Jour	8 Jours	16 Jours
Levures	4,34	6,03	11,01
Moisissures	3,83	6,32	10,90

Les levures et les moisissures ont été signalées comme étant le principal facteur déterminant de la durée de vie du fromage frais (Lewis et Dale, 2000). Un point de coupure de $\geq 10^5$ UFC/g a été choisi pour marquer la fin du shelf-life (Al-Kadamany *et al.,* 2003).

Dans cette étude, la charge en levures et moisissures augmente au cours du stockage et d'une façon significative ($p<0,05$). En plus et selon les recommandations de (Al-Kadamany *et al.,* 2003), le shelf-life le fromage frais fabriqué est atteint à partir de la première semaine de fabrication.

IV – Conclusion

Le présent travail a démontré que le fromage frais de la chèvre Drâa présente une bonne qualité hygiénique et technologique. Cependant, son appréciation sensorielle est faible comparativement à d'autres types de fromage de chèvre. Aussi, sa stabilité au cours du stockage frigorifique ne dépasse pas 8 jours.

On recommande de valoriser davantage le lait de chèvre Drâa en fromage affiné et semi-affiné et d'étudier les améliorations probables sur sa stabilité et sa qualité sensorielle.

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Effect of livestock stocking rate on fatty acid and tocol composition of milk from sheep managed under part-time grazing

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Abstract. Dairy sheep management system in the Basque Country (northern Spain) is based predominantly on part-time grazing from late winter to early summer. The milk produced is primarily used for cheese-making and having high nutritional quality milk at the lowest cost possible is important for cheese makers. Intensification of the system can have strong influence on farm profitability, environment, and milk and cheese quality. The aim of the present work was to investigate the effect of sheep stocking rate managed under part-time grazing on milk quality measured as fatty acid (FA) and tocol (TC) composition. Two homogeneous groups of 60 ewes each grazed on the same paddocks divided at high (H) and low (L) stocking rate, respectively. Bulk milk samples were taken once a month from mid-April to June. TC profile of milk samples was similar in both groups of animals over the sampling period although the highest contents of the major TC (α-tocopherol; mg/100 DM) were found in samples collected in June. Changes in the FA content (g FA/100 g milk fat) affected by stocking density were mainly observed in the unsaturated FA fraction. Samples from L group showed higher content than H group of α-linolenic (18:3n-3) and associated rumen biohydrogenation intermediates as rumenic (9*c*,11*t*-18:2) and vaccenic (11*t*-18:1) which are considered beneficial for human health. Changes in diet due to stocking rate seemed to be linked to differences in the milk FA composition.

Keywords. Fatty acids – Tocopherols – Sheep raw milk – Grazing management.

Effet du taux de stockage du bétail sur la composition des acides gras et des tocophérols du lait provenant de moutons gérés sous le pâturage à temps partiel

Résumé. *Le système de gestion des ovins laitiers au Pays Basque (nord de l'Espagne) repose principalement sur le pâturage à temps partiel de la fin de l'hiver jusqu'au début de l'été. Le lait produit est principalement utilisé pour la fabrication de fromage. La production du lait de bonne qualité nutritionnelle à coût aussi bas que possible est important pour les fromagers. L'intensification du système peut avoir une forte influence sur la rentabilité du troupeau, l'environnement et la qualité du lait et du fromage. L'objectif du ce travail a été d'étudier l'effet du taux de stockage des brebis géré par le pâturage à temps partiel sur la qualité du lait mesurée en tant que la composition d'acide gras (FA) et tocophérols (TC). Deux groupes homogènes de 60 brebis pâturent chacun sur les mêmes enclos divisés à un taux de stockage élevé (H) et faible (L), respectivement. Des échantillons de lait en vrac ont été prélevés une fois par mois de la mi-avril à juin. Le profil de TC des échantillons de lait était similaire dans les deux groupes d'animaux au cours de la période d'échantillonnage, bien que le plus grand contenu du TC principal (α-tocophérol ; mg/100 DM) a été trouvé dans les échantillons prélevés en juin. Les modifications de la quantité FA (g FA/100g de matière grasse du lait) affectées par la densité du stock ont été principalement observées dans la fraction non saturée de FA. Les échantillons du groupe L ont montré une quantité plus élevée que le groupe H d'acide α-linolénique (18:3n-3) et les intermédiaires de biohydrogénation du rumen associés en tant que rumenique (9c,11t-18:2) et vaccenique (11t-18:1), qui sont considérés comme bénéfiques pour la santé humaine. Les changements de régime liés au taux de stockage semblent être liés aux différences dans la composition du FA du lait.*

Mots-clés. *Acides gras – Tocophérols – Lait cru mouton – Gestion du pâturage.*

I – Introduction

Nowadays, the sustainability of sheep livestock in the Mediterranean area is seriously compromised by factors such as economic profitability, technical viability and environmental impact of the production system. In this context, innovation in management practices can be crucial to improve farm sustainability, particularly taking into account that grazing management is usual among shepherds, and that dairy sheep systems contribute to the actual landscape configuration and cultural heritage within the Mediterranean basin (Ruiz *et al.*, 2009). Livestock stocking rate is important to optimize grazing resources but little attention has been paid to grazing practices during the last decades. A non-optimal use of natural resources can sometimes generate under-grazing resulting in pasture degradation with the subsequent turning to scrub, or in other cases, overgrazing and soil erosion (Mandaluniz *et al.*, 2009; Teague *et al.*, 2011). Therefore, shepherds and farmers need to improve the utilization of grassland and forage resources, and in consequence, the sustainability of sheep production. Regarding the impact of the dairy sheep grazing regime, a previous work showed no significant differences related to stocking rate in the herbage mass or dairy production parameters. However, a higher stocking rate obtained by rotational grazing regime resulted in a higher amount of forage harvested by conservation which improves the farm forage autonomy and reduces the carbon footprint (Mandaluniz *et al.*, 2016). However, to the best of our knowledge there is very little information in the scientific literature on the composition of milk from grazing sheep managed under different livestock stocking rates. To a great extent, the traditional management of the Latxa sheep in the Basque Country (northern Spain) is based on part-time grazing from late winter to early summer. The raw milk is primarily used for cheese-making (Idiazabal – protected denomination of origin, PDO).

The aim of the present work was to investigate the effect of sheep stocking rate managed under part-time grazing on milk nutritional quality measured as fatty acid (FA) and tocol (TC) composition.

II – Material and methods

1. Experimental design

The experiment was conducted with 120 Latxa dairy sheep of the NEIKER-Tecnalia experimental flock in Vitoria-Gasteiz (Basque Country, Spain) during spring milking period following a part-time grazing. Ewes were randomly assigned into two homogeneous groups of animals (60 ewes/group) according to the month of lactation, daily milk production, live weight and body condition score. Both groups of sheep received 0.8 kg of concentrate (DM basis)/ewe/day which was offered at morning and evening milkings. After morning milking ewes grazed on pasture managed at low (L) or high (H) stocking rate, respectively. After evening milking, both groups received *ad libitum* fescue hay. The L group had 10 livestock units (LU)/ha whereas the H stocking rate was 7 times greater. The ewes of H group grazed 2-3 days/plot with 24 ± 2 days of rest periods between grazings. The ewes of L group grazed 6-10 days/plot with 15 ± 3 days of rest periods. All paddocks used by L and H sheep groups were similar in vegetation composition and production (Mandaluniz *et al.*, 2015). Replicated bulk milk samples (1.5 L) from L and H sheep groups were taken once a month from mid-April to June, and sample collection started after 2 weeks of adaptation period (early April).

2. Chemical analysis

Fat and DM content of milk samples was determined using a near infrared spectroscopy equipment. Milk FA were extracted and derivatized to FA methyl esters (FAME) following a miniaturized method previously described by Aldai *et al*. (2012). The analysis of FAME was carried out by gas-chromatography with flame ionization detector as previously described (Kramer *et al*., 2008; Delmonte *et al*., 2011). Results were expressed as g of FA/100 g milk fat. Milk TC were extracted us-

ing a one-step solid-liquid phase and analysed by high-performance liquid chromatography using fluorescence detection as previously described (Valdivielso *et al*., 2015). Results were expressed as mg of TC/100 g of milk DM.

3. Statistical analysis

The general linear model of analysis of variance (ANOVA) was used to investigate the effect of stocking rate (low and high) and sampling period (April, May and June) on the FA and TC composition of sheep milk. Stocking rate was nested within sampling period and the following model was used:

$$Y_{ijk} = \mu + SR_i(SP_j) + SP_j + \varepsilon_{ijk}$$

where Y_{ijk} = dependent variables; μ = intercept; SR_i = stocking rate fixed effect; SP_j = sampling period fixed effect; and ε_{ijk} = random residual effects. Tukey's test was used for multiple comparisons between milk samples from different sampling months. Statistical significance was declared at $P \leq 0.05$. Three significant figures were used to express mean and standard error of the mean values.

III – Results and discussion

Table 1 shows the fat content and FA composition of milk samples from L and H stocking rates throughout the sampling period. Milk fat content did not change with stoking rate whereas a significant increase milk fat was observed from April to June. Ewes of both stocking rates were at the same lactation stage and milk nutritional composition changes over the lactation curve increasing the fat content (Leiber *et al*., 2004). Overall, the FA profile of all milk samples was the typically found in ruminants produced under grazing systems (Table 1), showing considerable content of α-linolenic acid (18:3n-3) and related rumen biohydrogenation intermediates such as vaccenic acid (11*t*-18:1), 13/14*t*-18:1, and 11*t*,15*c*-18:2. Rumenic acid (9*c*,11*t*-18:2) was the main conjugated linoleic acid (CLA) in all milk samples representing 75% of the total CLA content. The presence of n-3 polyunsaturated FA (PUFA), *iso* branched-chain FA (*iso*-BCFA), and vaccenic and rumenic acids in milk samples conferred to them potential benefits for human health (Wang *et al*., 2012; Aldai *et al*., 2013).

Milk from ewes grazed at high stocking rate (H group) showed higher content ($P \leq 0.05$) of total saturated FA (SFA) and BCFA in comparison to milk from ewes grazed at low stoking rate (L group). In fact, the content of most individual SFA (except of stearic acid, 18:0) and BCFA like *anteiso*-15:0 were higher in milk from H than L stocking rates (Table 1). Normally, short- and medium-chain SFA, including most of myristic acid (14:0) and about half of palmitic acid (16:0) are synthesized *de novo* in the mammary gland while *iso*- and *anteiso*-15:0 are mainly synthesized by rumen bacteria from leucine and isoleucine dietary amino acids (Shingfield and Griinari, 2007). Therefore, these results could be indicative that sheep from high stocking rate could have ingested a higher content of protein-rich botanical species that could favor *de novo* BCFA synthesis in the rumen.

Milk samples from ewes grazed at low stocking rate (L group) showed higher content ($P \leq 0.05$) of monounsaturated FA (MUFA), CLA, non-conjugated dienes and trienes and polyunsaturated FA (PUFA) compared to milk samples from H group (Table 1). It seemed that grazing at low stoking rate allowed sheep to specifically select botanical species that caused a higher intake of PUFA, especially α-linolenic acid, compared to sheep grazed at high stocking rate conditions. Higher dietary intake of PUFA could increase the formation of rumen biohydrogenation intermediates such as several CLA, nc-dienes and trienes and *trans*-MUFA, and could also promote the escape of PUFA (α-linolenic and linoleic (18:2n-6) acids) from rumen metabolism becoming available for the mammary gland and, simultaneously, decreasing short- and medium-chain FA *de novo* synthesis.

Table 1. Fat content (g/100 g milk) and fatty acid (FA) composition (g/100 g fat) of bulk milk samples from sheep grazed under part-time grazing at two stocking rates (low and high) and collected over three sampling peridos (April, May and June)

	Stocking rate		Sampling month			SEM	Significance
	Low	High	April	May	June		Stocking rate
Fat content	6.45	6.53	5.96^{b}	6.43^{b}	7.18^{a}	0.102	ns
16:0	19.0	19.3	19.5^{a}	19.4^{a}	18.6^{b}	0.0316	*
18:0	13.6	13.7	13.2^{c}	13.6^{b}	14.1^{a}	0.0629	ns
SFA	58.1	59.3	62.6^{a}	59.2^{b}	54.4^{c}	0.0974	*
i-16:1	0.294	0.298	0.318^{a}	0.270^{b}	0.302^{a}	0.00245	ns
i-17:0	0.337	0.337	0.315^{b}	0.304^{b}	0.391^{a}	0.00392	ns
iso-BCFA	1.14	1.14	1.09^{b}	1.03^{c}	1.29^{a}	0.00524	ns
ai-15:0	0.511	0.527	0.539^{a}	0.469^{b}	0.550^{a}	0.00237	*
ai-17:0	0.404	0.407	0.401^{b}	0.371^{c}	0.444^{a}	0.00212	ns
anteiso-BCFA	0.956	0.980	0.987^{b}	0.878^{c}	1.04^{a}	0.00405	*
BCFA	2.44	2.49	2.48^{b}	2.26^{c}	2.65^{a}	0.0124	*
9*c*-16:1	0.619	0.601	0.514^{c}	0.578^{b}	0.739^{a}	0.00376	*
9*c*-18:1	23.9	23.4	19.6^{c}	23.0^{b}	28.3^{a}	0.0697	*
cis-MUFA	26.4	25.9	22.0^{c}	25.5^{b}	30.9^{a}	0.0617	*
11*t*-18:1	1.76	1.69	1.86^{a}	1.80^{a}	1.52^{b}	0.00944	*
13/14*t*-18:1	0.806	0.755	0.882^{a}	0.834^{b}	0.626^{c}	0.00496	*
trans-MUFA	5.51	5.15	5.70^{a}	5.59^{a}	4.70^{b}	0.0429	*
MUFA	31.9	31.0	27.7^{c}	31.1^{b}	35.6^{a}	0.0698	*
7*t*,9*c*-18:2	0.0709	0.0660	0.0676	0.0686	0.0691	0.000120	ns
9*c*,11*t*-18:2	0.840	0.808	0.793^{b}	0.841^{a}	0.839^{a}	0.00591	*
CLA	1.13	1.08	1.08^{b}	1.14^{a}	1.08^{b}	0.00588	*
9*c*,13*t*-18/ 8*t*,12*c*-18:2	0.374	0.361	0.354^{b}	0.384^{a}	0.365^{ab}	0.00361	*
11*t*,15*c*-18:2	0.258	0.239	0.246^{b}	0.315^{a}	0.185^{c}	0.00399	*
nc-dienes & trienes	1.46	1.41	1.45^{ab}	1.51^{a}	1.35^{b}	0.0253	ns
18:3n-3	0.847	0.746	0.746^{c}	0.873^{a}	0.769^{b}	0.00177	*
22:5n-3	0.126	0.118	0.111^{b}	0.113^{b}	0.143^{a}	0.00264	ns
n-3	1.19	1.10	1.07^{b}	1.22^{a}	1.14^{ab}	0.0105	*
18:2n-6	1.88	1.69	1.71^{c}	1.82^{b}	1.84^{a}	0.00200	*
20:4n-6	0.155	0.142	0.146	0.140	0.160	0.00434	ns
n-6	2.28	2.13	2.15^{b}	2.20^{ab}	2.27^{a}	0.00947	*
PUFA	3.47	3.23	3.22^{b}	3.42^{a}	3.41^{a}	0.0172	*

SEM, standard error of the mean; SFA, saturated FA; BCFA, branched chain FA; MUFA, monounsaturated FA; CLA, conjugated linoleic acid; nc, non-conjugated; PUFA, polyunsaturated FA; ns, not significant ($P > 0.05$); *, $P \leq 0.05$.

[a,b,c] Means within a row with different superscripts differ ($P \leq 0.05$) between sampling months.

As mentioned above, with few exceptions, significant changes ($P \leq 0.05$) in milk individual FA contents were observed over lactation period. Overall, the content of SFA and *trans*-MUFA decreased ($P \leq 0.05$) from April to June (late lactation), while the content of BCFA, *cis*-MUFA, n-3 and n-6 PUFA increased ($P \leq 0.05$) over the sampling period.

Tocol profile of milk samples was similar for both stocking rates (L and H) over the sampling period being α-tocopherol the main TC (around 95-99%) in all milk samples (Table 2). Very small amount of γ-tocopherol, α- and γ- tocotrienols were found in milk samples from both stocking rates. This milk TC profile was quite similar to that obtained in previous works for sheep raw milk (Valdivielso *et al.*, 2015). Not significant differences ($P > 0.05$) were found in the TC content of milk samples from H and L groups over the sampling period although the content of α-tocopherol and that of other minor TC increased from April to June (Table 2).

Table 2. Dry matter (DM) content (g /100 g milk) and tocol composition (mg/100 g of DM) of bulk milk samples from sheep grazed under part-time grazing at two stocking rates (low and high) and collected over three sampling peridos (April, May and June)

	Stocking rate		Sampling month			SEM	Significance
	Low	High	April	May	June		Stocking rate
DM content	10.5	10.4	10.3[b]	10.3[b]	10.5[a]	0.0439	*
α-tocopherol	1.67	2.06	1.46[a]	1.37[a]	2.77[b]	0.890	ns
α-tocotrienol	0.00757	0.00741	ND	ND	0.0224	0.0118	ns
α-tocopherol	0.0538	0.0753	0.0419	0.0474	0.104	0.0406	ns
α-tocotrienol	0.00327	0.00726	0.00537	ND	0.0104	0.00777	ns
Tocols	1.73	2.15	1.50[a]	1.42[a]	2.90[b]	0.955	ns

SEM, standard error of the mean; ND, not detected; ns; not significant ($P > 0.05$).
[a,b,c] Means within a row with different superscripts differ ($P \leq 0.05$) between sampling months.

IV – Conclusions

Fatty acid composition of sheep milk managed under part-time grazing was slightly affected by the stocking rate conditions and the tocol content of milk samples from ewes grazed at low or high stocking rates did not change. From a nutritional milk fat quality point of view, the milk samples from ewes grazed at low stocking rate showed higher contents of fatty acids which are considered beneficial for human health. Changes in the animal selection of botanical species seemed to be associated to differences in the fatty acid composition of milk samples from ewes grazed at low or high stocking rates.

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Sustainability of dairy sheep farming: Examples from Greece and Spain

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Abstract. In the European Union (EU), the European Commission has included in its Europe 2020 strategy the 'Sustainable growth: promoting a more resource efficient, greener and more competitive economy.' The EU has also recognized the positive role of agriculture and livestock in rural areas in delivering 'multiple economic, social, environmental and territorial benefits.' In the framework of the research project FLINT ('Farm Level Indicators for New Topics in Policy Evaluation'), one of the main aims was to provide a review of indicators and to collect the related data from farms to determine the level of sustainability. The concept of *sustainability* refers not only to the triple-bottom-line approach – Profit (economic), Planet (environmental) and People (social) - but also to other issues like innovation, risk management, market outlets and quality labeling, advisory services, and climate change. The small ruminant sector was one of those that included this, as its contribution to the strategy of sustainable growth has recognized. In this paper, we present two cases referring to the dairy sheep sector in Greece (Ipeirus) and Spain (Navarra). A collection of core indicators will be presented to describe the sustainability level for dairy sheep farming between the two countries. Due to the small sample size, dairy sheep farming in both countries shows a high degree of heterogeneity and diversity. Only qualitative factors, like the use of processing at the farm level, the use of short supply chains and qualitative labels could be derived to support the sustainable view of traditional producing systems. The assessment of the sector's sustainability level helps to develop the appropriate decisions/policies either at the local farm or larger territorial level.

Keywords. Sustainability – Dairy sheep – Greece – Spain.

I – Introduction

In the Mediterranean region, sheep and goat farming is an important and well-established activity. It is characterized as a significant provider of income, employment, environmental protection, and social cohesion for rural areas. At the European level, sheep and goat farming is a minor agricultural activity, but agricultural policy measures always give priority to small ruminant livestock farming which employs a significant percentage of the work force. In the EU, the sheep population is on a declining trend. The evaluation of sustainability will play a significant role in the future of the latter, in order to halt its decline via appropriate management, support decisions, and appropriate policies.

Greece and Spain are among the six leading sheep-producing countries. In both countries, the sheep sector accounts for a significant contribution to the gross animal production value. Sheep holdings differ greatly concerning size, structure and applied production systems. Both countries face similarities and differences, characteristics like herd liquidation in small farms, and a significant increase of larger holdings in professional and commercial livestock farms. Moreover, the sector faces the significant effects of the lack of intergenerational succession.

Case studies from Greece and Spain were presented in the framework of the Farm Level Indicators for New Topics in policy evaluation or "FLINT" project (EU FP7) in order to assess the sector's sustainability attributes. The overarching objective of the FLINT project was to explore not only the economic indicators but also the environmental, social, and other factors that support the dynamism of farms. This study tries to present the status and the diverse points between the two countries in the small ruminant sector according to their sustainability attributes.

II – Methodology – Theoretical Issues

This analysis was conducted through the FLINT project, which aims to extend the traditional Farm Accountancy Data Network (FADN) database to include information on environmental, social and other issues like innovation, risk, and quality aspects (Poppe *et al*., 2016). In line with the regular FADN data collection, following the same stratification based on the farming type and farm economic size classes, at least 25 observations were collected per principal type of farming. Data for the sheep sector were collected in Greece and Spain via face-to-face interviews and relate to the accountancy year 2015. The analysis is based on data from 30 farms in Ipeiros-Greece and 24 farms in Navarra-Basque country (one farm was excluded from the analysis due to its large number of animals, as an outlier).

At first, FLINT analyzed the needs of Common Agricultural Policy (CAP) and related environmental policies for information gaps. The development of new indicators was introduced to provide information on farm-level sustainability. The development of a farm-level dataset will support the assessment of policy incentives in agricultural sectors and decision-making processes from the farmers' point of view. Moreover, farm-level sustainability information will determine the factors that affect their performance and long-term dynamics. An extensive literature review made a selection of core variables and concluded on 33 sustainability themes (Latruffe *et al*., 2016). The themes cover the three pillars of Triple P: People, Profit, and the Planet. Through a stakeholder analysis, the number of indicators was reduced according to their usefulness and effectiveness (Hererra *et al*., 2016).

In Greece, the survey took place in the northern region of Ipeiros, which is among the most significant livestock Greek areas. It is considered to be a less favoured area, and sheep-goat farming plays a major role in the livelihoods of farmers. In Ipeiros, sheep farms account for 11% of Greek sheep farms with a falling trend. Farm structures have changed; while the number of small sheep farms has decreased, the number of large flocks has increased. Sheep and goat farming is the main source of income for the rural population, and this is a traditional farming practice passed on from father to son. Most of the milk produced by sheep and goat animals are turned to cheese in dairy industries in Ipeiros, a self-sufficient region of 97.5% of the goat-sheep milk production. Dairy industries produce a variety of traditional products, which are both PDO (officially designated) and conventionally manufactured. Cheese production in the farm is illegal according to the Greek manufacturing legislation. However, all farmers produce cheese, yogurt, and other traditional products for domestic consumption.

In Spain, data were collected from northern Spain, in Navarra. In this area, sheep farming is one of the most common sectors of animal production in the territory. Around 22% of livestock farms are sheep farms with the main specialization being that of milk production. Sheep milk production is the most traditional livestock system in the territory with a strong emphasis on using the natural pasture uplands (Batalla, *et al*. 2014). Permanent grasslands are a major nutritional source for sheep farms during the summer season. There are 275 farms producing sheep milk, of which 84% use indigenous breeds, 9% use foreign breeds, and the remaining employ mixed breeds. Farmers who use native breeds and natural food produce higher quality products and place greater importance on the quality of milk than farmers who produce PDO cheese products (PDO Idiazabal cheese and PDO Roncal). 54% of cheese production is made directly by farmers in farms (Batalla *et al*., 2014).

III – Results

1. Economic Pillar

The evaluation of economic sustainability is focused on viability, productivity, and dependence. An overall assessment showed that from the economic point of view, dairy sheep farms in Spain showed better economic results. Spanish farmers maximized their value, using the production indi-

cators in an efficient and productive way. Specifically, the number of livestock unit (LU) per utilized agricultural area (ha) and the number of livestock unit per annual working unit (AWU) is higher in Spain in comparison with the corresponding numbers in the Greek sheep farms (Table 1). Spanish farms have better productivity either for labor or animal factor of production. However, the level of specific livestock costs is the same for both countries (Table 2). Spanish dairy sheep farms show a strong relationship between the score obtained for the productivity and the intensification level (land and labor). The evidence for this improved economic performance can be explained with reference to the added value of Spanish output. It is the defining difference between the two countries. In Spain, farmers produce traditional cheese at the farm level. Moreover, the innovation of using alternative market channels, direct sales, offers them higher margins. On the contrary, in the Ipeiros area prices for both sheep and goat milk are higher than the mean average of Greece, the economic performance of Greek sheep farmers is quite poor. Traditional cheeses are produced outside the farm. Therefore, the two countries showed differences in the management strategy. Finally, economic results for both countries rely on subsidies received from the EU under CAP provisions as these constitute an important part of their total earnings which means a lower level of economic sustainability for them.

Table 1. Structural Characteristics of sheep farmers (FADN principal type of farming: specialist sheep, goats, and other grazing), Ipeiros-Greece and Navarra-Spain

	Ipeiros, Greece	Navarra, Spain	t-test
Total Livestock units (LU)	29.92	57.07	*
Land, number of UAA (ha)	25.34	37.91	*
Number of heads LU Sheep and Goats	29.84	53.82	*
Labour, number of annual working units (AWU) on the farm	1.80	2.05	
Successor (%)	40%	56%	
Sheep and Goat Production (€)	9,256	15,103	*
Ewe's and goat milk (€)	35,342	132,327	*

Source: the authors, based on FADN and FLINT data.

2. Environmental Pillar

Ruminant agriculture is more emissions-intensive than other forms of agriculture (Ryan *et al*. 2015). Environmental farm level indicators are derived at the farm gate level. The farm gate approach uses nutrients in imports and exports over which the farmer has direct control, and this helps to assess the environmental pressure (Buckley *et al*., 2015). Two indicators were estimated at the farm gate level. The first refers to the N balance and presents the pressure on environmental quality. It is derived by subtracting the total quantities of N exported from the total quantities imported. The second refers to the GHG emissions per farm (tons of carbon dioxide equivalent, tCO2 eq). It is estimated using the Tier 1 and Tier 2 procedure (Intergovernmental Panel on Climate Change IPCC). Results showed that both countries have similar levels of GHG emissions per LU, and output (Table 2). However, results for N revealed that in Greece the level of N is lower than in Spain.

3. Social Pillar

In both countries, farmers have the same level of overall quality of life (Table 2). Satisfaction with work balance is higher in Spain (6,3) than in Greece (4,6). The level of satisfaction regarding the quality of life is almost at the same level (6,1 for Greece and 6,3 for Spain). The indicator satisfaction with respect to freedom of making decisions is held at a high value among Greek farmers (9,1). On the other hand, stress perception is significant among Greek farmers. More than half of Greek farmers do not recommend sheep farming activity for their children in contrast to Spanish farmers. All the social indicators above indicate better social sustainability in the Spanish sheep sector in comparison with the corresponding Greek farms.

Table 2. Sustainability Indicators of sheep farmers (FADN principal type of farming: specialist sheep, goats, and other grazing), Ipeiros-Greece and Navarra-Spain

	Ipeiros, Greece	Navarra, Spain	t-test
TTotal farm output in value related to utilized agricultural area (€/ha)	2,853	11,415	*
Total farm output in value related to the number of livestock units (€/ LU)	1,930	2,681	*
Total farm output in value related to total farm labor (€/AWU)	32,270	70,104	*
Operational costs on the farm related to total farm output (%)	0,47	0,49	
Farm net value added related to total farm labor (€/AWU)	15,176	26,063	
Farm income related to family labor (€/FWU)	14,188	26,092	*
% Subsidies per LU related to gross Farm Income	0.05	0.12	*
Total livestock output (€)	45,225	149,643	*
Total livestock output /LU	1,569	2,649	*
Subsidies sheep and goat (€)	1,048	7,052	*
Environmental Indicators			
The quantity of greenhouse gases (GHG) emitted by farms measured at the farm level (t eq CO_2)	87	162	
The quantity of GHG emitted by farms at farm level per livestock unit (LU) (t eq CO_2 per LU)	2.85	2.91	*
The quantity of GHG emitted by farms measured at farm level per Euro of output t eq CO_2 /€	0.0001	0.0013	
N balance at the farm level (kg/ha)	97	173	
Social Indicators			
Satisfaction with job (0 - 10)	7.7	7.4	
Satisfaction with work-life balance (0 - 10)	4.6	6.1	*
Satisfaction with being a farmer (0 – 10)	6.8	7.8	*
Satisfaction with quality of life (0 - 10)	6.1	6.2	
Satisfaction with freedom of making a decision (0 - 10)	9.1	7.4	*
Stress perception (0 - 10)	8.1	5.3	*

Source: the authors, based on FADN and FLINT data.

IV – Conclusions

The comparative cross-country analysis (Greece and Spain) undertaken is a pilot study to present some core sustainability indicators in the dairy sheep sector. Due to the small sample size, dairy sheep farmers in both countries show a high degree of heterogeneity. There is diversity across and within dairy sheep farmers in both countries. The indicators we proposed for sheep farmers, show a better economic profile for Spain than for Greece. While environmental sustainability was better for Greek farms, it was observed and documented that social indicators provide a higher level of satisfaction to Spanish farmers. However, due to the limited size of the sample, it is not possible to extrapolate the results obtained from the case studies. Therefore, the comparison of sustainability efforts between the two countries does not apply for the entire sector. The qualitative inference of the two case studies could refer to factors like the use of processing at the farm level, the use of short supply chains and qualitative labels with a high social diversification index. These might give a more sustainable view of traditional producing systems that support areas with limited opportunities and valuable natural resources.

Acknowledgments

We are grateful to the FLINT project. This work was partly funded by the EU Seventh Framework Programme grant number 613800. The opinions expressed in this paper are not necessarily those of the EU.

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La consommation de lait de brebis dans la région de Rabat Salé Zemmour Zaer au Maroc

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Résumé. Le lait est réputé être un aliment sain, grâce à sa composition bien équilibrée en nutriments essentiels et non essentiels (lipides, protéines, acides aminés, vitamines, minéraux, agents immunologiques, oligosaccharides et hormones). Ces caractéristiques confèrent au lait de brebis des propriétés antioxydantes, antimicrobienne et immuno-modulatrice, etc. Or malgré ses qualités nutritionnelles, le lait de brebis et ses dérivés sont presque inconnus par le consommateur marocain. Plusieurs raisons expliques cette situation, particulièrement les habitudes de consommation et de la disponibilité des produits sur le marché marocain. Pour mieux approcher cette réalité, une enquête de consommation dans les villes de Rabat et Salé, a été effectuée. L'enquête a permis la mise en évidence des préférences du consommateur ainsi que les idées ancrées vis-à-vis de la consommation des produits laitiers de façon générale et le lait de brebis et son fromage plus particulièrement.

Mots-clés. Enquête – Consommation de produits laitiers – Lait de brebis marocain.

Investigation on the Ewe's milk consumption in the Rabat Salé Zemmour Zaer area –Morocco–

Abstract. *Milk is considered to be a healthy food, due to its composition well balanced In essential and non-essential nutrients (lipids, proteins, amino acids, vitamins, minerals, immunological agents, oligosaccharides and hormones). These characteristics give ewe milkantioxidant, antimicrobial and immune-modulatory properties.Nevertheless, ee milk and its derivatives are almost unknown by the Moroccan consumer. Indeed, this is due to several reasons, which include consumer habits and the availability of products on the Moroccan market. To approach this reality, a survey on e ewe's milk consumption has been carried out in the Rabat Salé Zemmour Zaer area. This work highlights the consumer preferences and ideas anchored regarding the consumption of dairy products in general and sheep's milk and cheese in particular.*

Keywords. *Investigation – Dairy product consumption – Moroccan ewe's milk.*

I – Introduction

De nos jours, la place de la production laitière dans l'alimentation humainr est un sujet qui concerne l'ensemble du monde que ce soit au niveau de la consommation de lait liquide ou des autres produits laitiers.Si le production de lait de vache est prioritaire sur ces questions, la place des laits d'autres espèce est aussi un sujet d'impportance et depuis longtemps, en particulier pour le lait de brebis. (Vieira, 1950).

Les produits dérivés du lait des brebis et des chèvres, peuvent présenter une alternative intéressante au produits issus des laits de vache par leur goût spécifique, leur texture, leur typicité et leur image d'aliment naturel et sain. Néanmoins, les consommateurs demandent de plus en plus d'informations concernant la qualité hygiénique et la composition nutritive de ces produits. Toutes ces caractéristiques peuvent être influencées par plusieurs facteurs, tel que la race, la génétique, la physiologie, l'alimentation, l'environnement et la technologie utilisée (Raynal et coll., 2008). Ces

produits sont d'un intérêt économique particulier pour certaines régions du monde. Dans les pays en voie de développement, la production de ces types de lait est devenue une stratégie utile de lutte contre les problèmes de santé et de malnutrition, spécifiquement au niveau des populations infantiles (Haenlein, 1996, 2001, 2004).

Malgré ses qualités nutritionnelles, le lait de brebis et ses dérivés sont quasiment méconnus par le consommateur marocain.

II – Matériel et méthodes

1. Lieu de l'enquête

Pour connaitre la consommation des produit laitiers ovins, une enquête a été menée à deux niveaux: Tout d'abord, auprès des habitants des villes de Rabat et de Salé et en particulier auprès des clients du centre commercial de la grande surface ACIMA, Ensuite, le deuxième niveau de l'enquête, a été effectué au sein des administrations actrices dans le domaine, notamment l'association nationale des ovins et caprins (ANOC), le laboratoire d'analyses et recherches vétérinaires (LARV) et enfin auprès de la cellule de la coordination nationale et du développement humain au Ministère de l'intérieur.

2. Déroulement de l'enquête

Les consommateurs interrogés étaient issus de différentes classes sociales et intellectuelles ; ce choix a été fait pour diversifier notre échantillon de référence, parmi les rayons des produits frais du supermarché.

Les questions allaient du plus général au plus spécifique, de la consommation des produits laitiers de façon globale jusqu'à la connaissance de leurs caractéristiques nutritionnellesdes laits et fromages de brebis et leur avis les concernant.. En ce qui concerne la deuxième partie de l'enquête, elle s'est déroulée sous forme d'entretiens avec des responsables des administrations concernées.

3. Traitement des résultats

Les résultats de l'enquête, ont été saisis et traités par le logiciel SPSS version 16.0 (SPSS, 2007).

III – Resultats et discussion

1. Enquête sur la consommation des produits laitiers dans la zone de Rabat Salé Zemmour Zaer

Pour réaliser l'enquête avec les consommateurs de la région, le groupe choisi était composé d'une centaine de personnes, dont 67% sont des femmes et 33% des hommes. Les 58% des interrogés appartiennent à une tranche d'âge comprise entre 21 et 30 ans. Du point de vue socio-économique, 66% des enquêtés étaient célibataires, 26% des universitaires, 12% des employés et 6% des cadres. A noter que 21% avaient des salaires compris entre 500 et 1000 € (voir Annexe I).

Les données recueillies, concernant la consommation des produits laitiers dans la région de Rabat Salé Zemmour Zaer, montrent que 75,5% des consommateurs se intègrent des produits laitiers dans leur apport énergétique journalier. La figure 1 précise les niveaux de consommation selon les différentes catégories socio-économiques (figure 1):

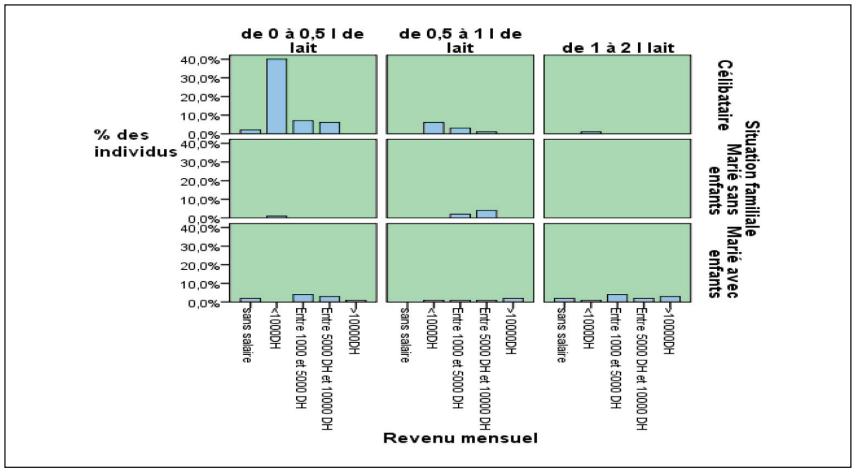

Fig. 1. Consommation journalière en produits laitiers (en équivalent litre) en fonction de la situation familiale et le revenue mensuel des enquêtés.

Cette figure met en évidence que toutes classes de salaire confondues, la tranche des célibataires représente la grande majorité des consommateurs dans la catégorie 0 à 0,5 litres de lait /jour, tandis que les couples mariés et avec des enfants qui boivent du lait consomment en général dee 1 à 2 litres de lait/jour, mais seuls 10% de cette catégorie.

De façon générale, Le niveau deconsommation en produits laitiers est très faible dans le but de d'identifier les causes principales de cette faible consommation, différentes causes ont été analysées.

A. Effet du prix des produits laitiers

Soixante quinze pour cent des enquêtés trouvent le prix des produits laitiers abordable quelque soit leur classe sociale. Le prix n'est donc pas la cause principale de cette faible consommation des produits laitiers.

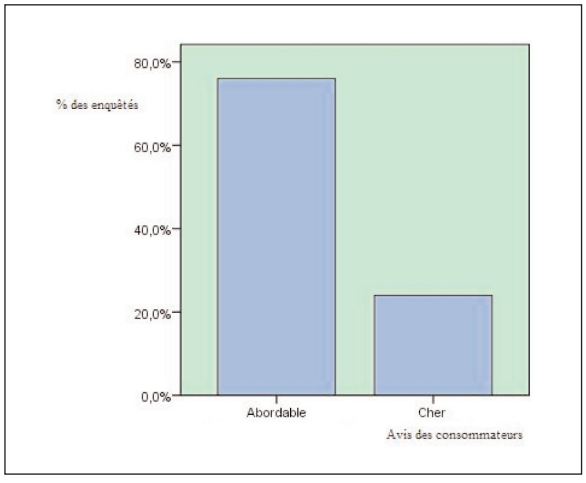

Fig. 2. Avis des enquêtés sur le prix des produits laitiers.

B. *Effet de la valeur nutritionnelle et habitudes de consommation sur la consommation en produits laitiers*

80% des enquêtés trouvent que les produits laitiers ont une bonne valeur nutritionnelle tive. Ils sont consommés principalement : Dans 70% des cas pour l'équilibre alimentaire et pour leur apport en calcium tandis que le reste les consomme soit par habitude ou pour leur goût soit pour le plaisir.

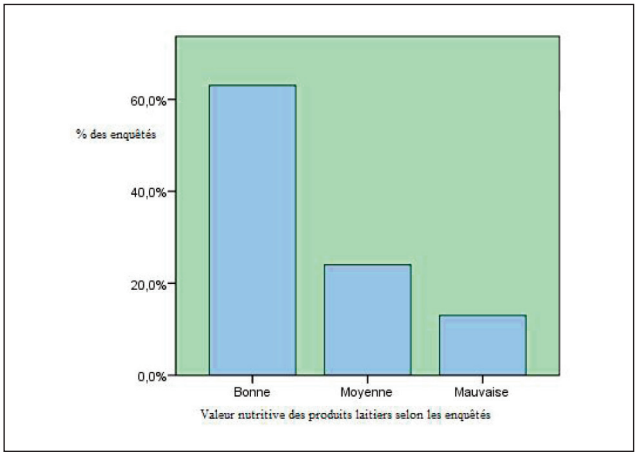

Fig. 3. Avis des enquêtés sur la valeur nutritive des produits laitiers.

C. *Consommation du lait de brebis*

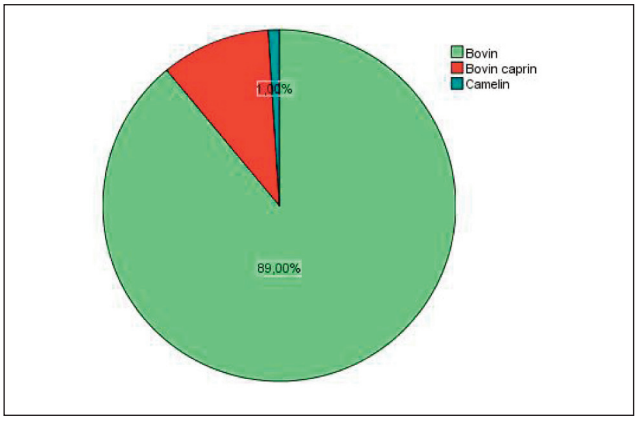

Fig. 4. Répartition de la consommation du lait par son origine.

D'après ce graphe, plus de 90% des enquêtés consomment du lait d'origine bovine, tandis que 1% consomment du lait d'origine cameline ce dernier point est expliqué du fait que ce sont des habitants du Sahara. Une quasi absence de la consommation du lait de brebis, est observée. Ladite situation est expliquée par la figure 4.

On otte que pour plus de 40% des enquêtés, leur absence d'achat s'explique par la non disponibilité des produits laitiers ovins sur les rayons de vente, alors que pour 30%, ils n'ont pas d'idée quant à leurs caractéristiques nutritionelles ou gustatives.

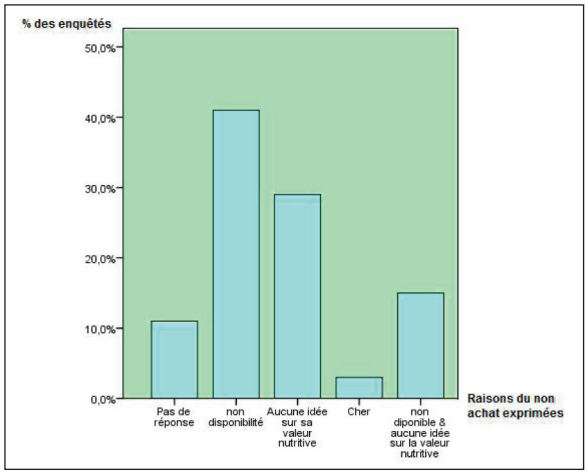

Fig. 5. Raisons de la non consommation du lait de brebis.

70% des enquêtés pensent que le lait bovin est celui qui contient plus de nutriments, tandis que moins de 20% sont pour le lait ovin. Si la question est re formulée ainsi *,"Si le lait de brebis était deux fois plus riche que le lait de vache le consommeriez vous ?".* Les réponses étaient satisfaisantes, 85% oui et 15% non, ce qui donne des pzerspectives intéressantes, le consommateur marocain étant toujours attentif à ce qu'il y a de meilleurs.

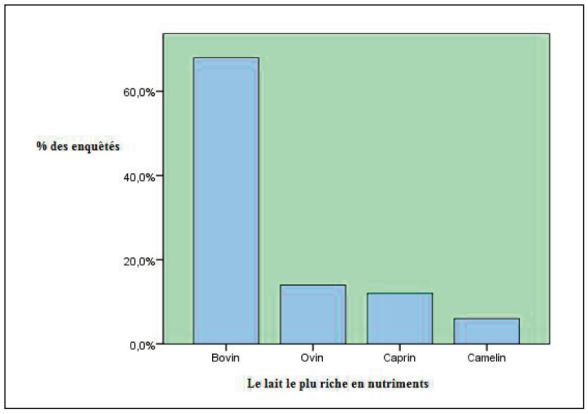

Fig. 6. Richesse en micro et macronutriments du lait selon les enquêtés.

D. Consommation du fromage de brebis

Un pourcentage de 20% des enquêtés a confirmé avoir consommé du fromage de brebis, et cela soit à l'étranger, soit à l'échelle du Maroc (fromage traditionnel). Ces consommateurs ont qualifié le fromage de brebis au niveau organoleptique comme suit :

- Le goût : de bon à très bon ;
- La texture : de bonne à Très bonne ;
- L'odeur : de bonne à très bonne.

Nous concluons que le fromage de brebis est bien apprécié au vu de ses qualités organoleptiques. Cependant, plus de la moitié des consommateurs trouvent que les prix sont chers du fait qu'il est importé de France (Roquefort : 22 €/Kg, (Etorki : 33 €/kg).

IV – Conclusions

Les objectifs spécifiques de cette étude ont été fixé comme suit : mener une enquête auprès d'un échantillon de la population de la région de Rabat Salé Zemmour Zaer, afin de déterminer la perception de la consommation des produits laitiers en matière de : la quantité, la qualité et l'origine, ainsi que d'étudier de près la place du lait de brebis et ses dérivés, notamment le fromage, dans la consommation de la population.

L'enquête a révélé une faible consommation en produits laitiers, qui peut être expliquée par les habitudes de consommation des marocains qui privilégient le thé et les céréales au petit-déjeuner. En ce qui concerne le lait de brebis et ses dérivés, une quasi absence de la consommation a été relevée, en le comparant avec les laitages bovin et caprin. Ceci est dû à une non disponibilité du produit sur les rayons de vente et une méconnaissance de sa valeur nutritive.

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The commitment of sheep and goat production systems in the agro – ecological transition: a collective participative approach in Corsica

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Abstract. The importance of environmental challenges in agriculture and livestock production requires an ecological transition of the production systems including the sheep and goat ones. In this context, establishing the conditions for agro – ecological changes and building innovative pathways of changes could favor this transition. After a presentation of some theoretical concepts behind the idea of ecological transition and agro – ecology, the objective of this communication is to report the implementation of a participative approach involving scientists, technicians, teachers and breeders in Corsica Island focusing on pastoral systems. This approach aims to design the performances of the systems from their triple social economic and environmental dimensions, how they are in line with the agro – ecological orientations and how to improve them. Inspired from previous methodologies but innovating through a participative approach, an easy-to-implement method has been adjusted to the characteristics of the local systems and agro-ecological criteria for sheep and goat herds and systems, we designed 10 groups of indicators including societal dimensions integrated in an Agroecological Livestock Proximity Index (ALPI). The exchanges during the sessions have shown that agro-ecology is not only an institutional injunction. It is also a collective methodological approach and pathway to design which innovations could support the sustainable development and changes in sheep and goat farming and specially, in pastoral systems. The utilization of this method and its further developments are evoked.

Keywords. Ecological transition – Innovative conception – Sustainable development – Sheep and goat production – Pastoral systems.

L'engagement des systèmes de production ovine et caprine dans la transition agro écologique : Une approche participative collective en Corse

Résumé. *L'importance des défis environnementaux dans l'agriculture et en production animale nécessite une transition écologique des systèmes de production, y compris pour les systèmes ovins et caprins. Dans ce contexte, établir les conditions pour des changements agro-écologiques et la création de voies de changements innovantes pourraient favoriser cette transition. Après une présentation des principaux concepts théoriques derrière l'idée de la transition écologique et de l'agro écologie, l'objectif de cette communication est de mettre en place une approche participative impliquant des scientifiques, des techniciens, des enseignants en Corse en se concentrant sur les systèmes pastoraux. Cette approche vise à concevoir les performances des systèmes à partir de leurs trois dimensions sociales, économiques et environnementales, quelle est leur proximité aux orientations agro-écologiques et comment l'améliorer. Inspirée des méthodologies antérieures, mais en développant une approche participative, une méthode facile à mettre en œuvre a été adaptée aux caractéristiques des systèmes locaux de Corse et des critères agro écologiques pour les troupeaux et systèmes locaux ovins caprins systèmes ont été définis pour 10 groupes d'indicateurs intégrant la dimension sociétale et intégrés dans un Index de Proximité de l'Elevage (ALPI). Les échanges au cours des sessions ont montré que l'agro écologie n'est pas seulement une injonction institutionnelle. C'est aussi une démarche méthodologique collective et un moyen de concevoir quelles innovations pourraient soutenir le développement durable et les changements dans l'élevage ovin caprin et en particulier dans les systèmes pastoraux. Les modes d"utilisation de cette méthode et ses développements ultérieurs sont évoqués.*

Mots-clés. *Transition écologique – Conception innovante – Développement durable – Production ovine et caprine – Systèmes pastoraux.*

I – Introduction

Since World War II, the development of Agriculture and Animal production has been dominated by one main model based on the improvement of technical performances of the production factors. Most of innovations have led to a more intensive use of external inputs (Stassart *et al*., 2012) with a significant and permanent growth of production units. They have not considered their negative effects not only on biodiversity, ecosystems and climate change but also on working conditions, human welfare, resilience of the farms, structural weaknesses and disparities (Mazoyer and Roudard, 1997).

This realty had important consequences on the Sheep and Goat sectors in the Mediterranean. Once based mainly on the use of natural resources provided by rangelands, the production systems have been more and more artificialized with an increasing use of feed stuffs, more and more intensive grasslands, and the use of specialized breeds for milk or meat (Dubeuf *et al*., 2016).

The awareness of these negative effects have emerged in the 80's and several concepts and frameworks have addressed the sustainability of Agriculture (agro-ecology, organic agriculture, integrated production, sustainable intensification, conservation agriculture, etc.). The application of these concepts, and specially agro-ecology for animal production, has been more recent and proposed new ways of producing in favor of the integration of animals in an agro-ecosystem (Gliessmann, 2006; Tichit and Dumont, 2016). But this integration of agro-ecology has been nearly absent for pastoral systems (Bellon *et al*., 2016).

After a presentation of the several dimensions of agro- ecology for sheep and goat systems, this article explores a methodology implemented in Corsica to include the several actors (farmers, technicians, public services, industrials, etc…) in the process of greening of sheep and goat farming and address their agro-ecological transition. The relationship between agro-ecological transition and sustainable development is also explored.

II – Agro – ecological transition and ecologically intensive bio –diversity based sheep and goat farming

The word agro-ecology used for the first time in 1930 by a Russian agronomist (Bensin, 1928) has been conceptualised by Altieri (1983) as the science to define principles, to study, design and manage productive, efficient to use natural resources, socially just and economically viable sustainable agro-ecosystems. In Agro-ecology, the emphasis is on biodiversity in order to understand better the mechanisms which underlie and strengthen the biologic regulation in diversified systems (Kremen *et al*., 2012).

The first and prevailing vision of agro-ecology is based on the comprehension, the utilization and imitation of ecological processes implemented within agro-systems rather than on their artificialization and utilization of chemical inputs (Griffon, 2006). Although it introduces a first paradigm shift in the organization of production systems, it advocates an "ecological intensification" (EI) and an increasing resource use efficiency, organizing the substitution of chemical inputs by organic ones, developing precision agriculture technologies or even using genetically modified organisms (Godfray *et al*., 2011). Focused on minimizing the negative impact of agriculture on the environment, the main objectives of EI are to keep on raising incrementally the limits of yields and encouraging the still dominant pathways of specialization and modernization (Duru *et al*., 2014). But regarding animal production and especially small ruminant farming, an issue has been mainly ignored: understanding the integration of the animal in its agro-ecosystem to get levers and conciliate sustainably not only environmental but also economic, social and societal concerns (Gliesmann, 2006). The dominant model has largely favored a divorce between agriculture and food systems. There has been a gap between the world of production and the world of consumers, a break between productive practices with mass intensified production on one side and mass distribution of global

products on the other side. Biodiversity based animal production could be a framework for proposing new ways of producing to meet the growing demand for food by linking food to productive practices and the production environment. This new type of agriculture and animal production must also have the status of activity of general interest. This approach would be very relevant for Mediterranean rural areas like Corsica where until more recently than in regions where intensification has been widely developed, village communities have remained very perennial with locally anchored niche products and the dialogue between society and agriculture and /or Animal Production has to be reopened (Sorba *et al*., 2017). It would be more relevant to consider also the ecosystemic services of activities as sheep and goat farming at field, farm, landscape and rural territories level in redesigned systems based on an ecologically intensive biodiversity (Griffon, 2006). To be operational, ecologically intensive biodiversity based agriculture requires a changing regime to organize this transition, change the way to face problems and find solutions.

III – The collective analysis of the current functioning of small – ruminant systems in Corsica: a method, an initiative and a first step to address agro-ecological transition and sustainable development for sheep and goat farming

In Corsica, the regional services of the French Ministry of Agriculture have decided to organize with INRA a training program to sensitize local extension agents and teachers on agro-ecology. This program is a component of an ambitious national project of this Ministry, defined in 2011 to support agro-ecology called “Enseigner à produire autrement” (Teach to produce differently). This project has followed the 5 principles of Agro-ecology (Dumont *et al*., 2013) (P1 Integrated management of animal health, P2 Lower inputs, P3 Lower pollutions, P4 Strengthen diversity to increase resilience, P5 Preserve biodiversity by adapting practices) and promotes the social, economic and environmental triple performance. Within the National project, the Ministry had designed the IDEA method (http://www.idea.chlorofil.fr) based on the monitoring of farm sustainability indicators methodology. This method provides a holistic approach of the sustainability of farm systems through self-assessment for all types of French farming systems. But as it appears not to be specific to animal production and poorly adapted to Mediterranean pastoralism, the regional program decided to use a near but different method.

The organizers invited not only teachers and trainers of the regional public agricultural schools but also technicians from the Chambers of Agriculture, the regional agricultural office, pastoralists and public officers dedicated to agriculture and twenty five participants on average have attended each session. The first 4 sessions have been devoted to inform the participants about agro-ecology in an interactive way. The 5th session had the objective to characterize the agro-ecological orientations of sheep and goat farming system. The method used has been inspired by that specifically designed for small ruminant Mediterranean farming systems by an international team for pastoral and grazing herds (Mena *et al*., 2012). In this method, the indicators and criteria are chosen by a multivariable analysis (Principal Component Analysis) and the tool tested in a large number of situations including Sardinia (Ruiz *et al*., in press) and Andalusia (Ruiz *et al*., 2016) to identify the diversity of agro-ecological profiles. Regarding the choice of indicators and the discussion of criteria, we adopted a more participative framework following here the participatory approach proposed by Duru *et al*. (2015) in 5 steps:

(i) analyze the current functioning of local agriculture,

(ii) identify future exogenous changes that may determine its future (drivers),

(iii) design local organization of the expected territorial biodiversity-based agriculture (forecasting),

(iv) design the major steps of the transition from the current situation to this new form of local agriculture (back casting),

(v) design governance structures and management strategies adapted to guide the transition.

During the last session, the method has been tested in two farms. The first test has been implemented in the farm of the local agricultural college to survey the agro-ecological characteristics of their organic dairy flock with farm cheese making. The second one has been on a pastoral goat cheese making goat farm.

Each survey lasted during approximately two hours, the farmer having previously collected his own personal documentation.

1. The choice of synthetic indicators and criteria

During the participatory sessions, the choice of indicators proposed by Mena *et al*. (2012) has been analysed. The formulation and the relevance of each criterion were discussed collectively regarding the characteristics of sheep and goat systems in Corsica.A global Agro-ecological Livestock Proximity Index (ALPI) has been estimated and the weight of each indicator has been chosen collectively. The participants have considered also that agro-ecology has a societal dimension and insisted on the interaction with society at a territorial level. Consequently a societal indicator has been added to the three economical, social and environmental performances. Within each indicator, the several criteria have been discussed and chosen to consider the specificity of sheep and goat systems in Corsica. The list of indicators and criteria is given on Tables 1a and b. Each indicator (sum of scores of the respective criteria, see Table 2 as an example) has been positioned on a Radar to characterize the Agro-ecological profile of each farm.

Besides, during the sessions, by considering the historical pastoral background of animal production in Corsica, the hypothesis proposed by the participants is that pastoralism could be a lever for agro-ecological transition in Corsica and the pastoral components of sheep and goat farming must be discussed for implementing the agro-ecological future of Corsica.

2. Results of the surveys in the two farms tested and comments

The results of the survey in the two farms and their profiles are given on Table 3. The two cases have rather good agro-ecological characteristics, the organic dairy sheep farm having an ALPI of 75.32% and the pastoral one 58.94%. Animal welfare and the use of local resources are rather good for the two examples but the characteristics are more contrasted for the other indicators with a lower scoring for feeding and grazing characteristics or for marketing. Besides, these agro-ecological profiles do not say much about the operational management of each case.

The profile of the organic farm in the agricultural college shows that feeding and grazing management are the main weak points in this type of farm. A deeper discussion with its manager has specified that it was mainly due to a lack of control of reproduction. Organic specification forbids chemical or hormonal treatment, and the method to manage natural reproduction by playing on mating effects of the rams has not been stabilized. The consequences are a large period of lambing, a low level of fertility and a difficulty to manage feeding and grazing periods at the flock level. The lack of integration of this didactic farm in the professional environment has been identified as the other weak point regarding its agro-ecological characteristics.

The second farm is a pastoral goat farm. Although he has rather environmental friendly practices, characterized by an exclusive use of good quality rangelands, its environmental and economical characteristics are impacted by a rather important use of hay and grain, usually bought outside the island. Some animal health problems (10% loss of grazing animals, pathologies, loss of productivity,%

of infertility...) are seen as a fatality by the farmers but it shows rather a lack of control of his management practices. Another interesting point is the criterion on stocking rate (4 to 8 heads per ha). The pastoral farm having a very low stocking rate (0.3 goats/ha), the practices of the farmer could not be adapted to control the vegetation of his rangelands with such a little herd. Limiting the area for grazing or increasing the number of heads thanks to some area of forage crop would probably increase the efficiency of his system without negative effect on his agro-ecological characteristics.

For these two cases a compromise has to be found between organic or pastoral practices and the sustainable development of the farms. Some orientations toward more agro-ecological systems have been suggested, showing that the way to choose has to be designed for every situation.

3. The contribution of the method to the agro-ecological transition; discussion among the participants

Although each indicator is synthetic and gives the same weight to each criterion which has yet to be improved, the method gives a first and systemic approximation of agro-ecology in the studied farms and systems. It is the reason why it could be relevant to extend this analysis to a large number of farms and test its relevance.

Simultaneously, the value and weight of each indicator in the calculation of the ALPI could be questioned as the weights are subjective choices. If ALPI is probably less useful than the profile to understand the transition processes, it shows nevertheless that several agro-ecological profiles could led to the same “intensity” of agro-ecology and that no given production system would have by nature agro-ecological characteristics (like the pastoral systems systematically considered as already agro-ecological) according to the control and knowhow of the farmer.

The participants have also raised several more methodological other questions: how to evaluate the quality of the collected information? How to characterize and evaluate the local practices? How to consider pluriactivity? Is the place given to the food production enough? Radars have been designed to give a synthetic view of the agro-ecological diagnosis on each farm. They are a didactic way to open the discussion between the farmers and agents working with them on their possible pathways to agro-ecological transition. The two examples show clearly that for every farm it could be designed a proper pathway, the proximity to the agro-ecological ideal remaining multi direction. Another point of discussion could be the speed of the transitions to be implemented, given to the concrete situation and the capacity of the farmer. But the systemic relations between the various indicators have still to be specified as aggregation of factors and key points of agro-ecological transition. And the relationship among farmers and local actors at the territorial level needs to be better taken into account.

IV – Conclusions

The method developed in the Corsican training programme proposed a tool to open a broad dialogue between the farmers and the several actors working with them. It gives interesting systemic directions on how to improve not only ecologically but also to make more sustainable their activity. We see by this way that agro-ecology could be a strong driver to formulate objectives of sustainable development and particularly in rural, isolated or mountainous hinterlands with strong social issues. It shows also that the coexistence of several production models in near territories and according to their resources, markets and infrastructures might make possible to think agro-ecological transitions. With a compilation of a large number of this type of surveys at a territorial level, such an approach could help also policy makers and professionals to define their sustainable development strategies.

However, according to the participants, the characterization of the farms has also to be more inserted in their territory. The configuration of the food systems combining agricultural dimensions and consumers practices has been presently largely ignored (only 3 criteria on marketing) as the food autonomy at the territorial level. By choosing a participatory approach to open this dialogue and characterize the systemic functioning of the sheep and goat system, we have only began to cross the first step proposed by Duru *et al*.(2015). Keeping with this participative way of working, it remains to combine drivers, forecasting and back stepping, that is to say identify the exogenous drivers that may determine their futures, design collective organizations and innovations of the expected territorial biodiversity-based livestock and the major steps of the transition from the current situation to this new form of local agriculture (back casting).

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Table 1a. Criteria discussed during a focus group regarding pastoral systems in Corsica [indicators 1 to 4]

If the criterion is considered as applied, the score is one; if not, it is zero. For each indicator, the score is the addition of the score of all criteria – adapted from Mena et al., 2012.

1. Animal nutrition

1.1. Animals graze daily for at least 6 h.
1.2. At least 50% of daily ration (for milked females) and 60% (for other animals) is common forage and/or grass (fibres).
1.3. The farm has lands to produce forage.
1.4. The farm produces grain for goats.
1.5. 80% of the feed for animals have been produced on the farm or near the farm (in the island).
1.6. The farm uses only forage produced regionally (in the island for the Corsican case).
1 7. The goats receive less than 500 g/head/day concentrate.

2. Sustainable pasture management

2.1. Rangelands provide more than 60% of the dry matter of the diet (Rangelands being defined as spontaneous grass or forest lands grazed freely by the herds including transhumance.
2.2. Rotational grazing is practiced on cultivated pastures (with at least 5 cm of grass before reintroducing the herds).
2.3. Stocking rate is between 4 and 5 goats per ha. (Average optimal stocking rate to valorize the potential of rangelands in the local conditions).
2.4. Stocking rate is adequate (No need for more land according to the farmer's declaration).
2.5. The farmer cultivates leguminous crops in isolation or associated with grains.
2.6. There is a mechanical intervention of the farmer on rangelands to improve them.
2.7. The potentialities of rangelands are adapted for goats (more than 400 kg DM/ha with an opened environment and an high of scrubs between 60 cm and 2 meters).
2.8 The breeder practices transhumance during at least two months.

3. Crops and forage practices

3.1. The farmer uses mineral or organic fertilizers <100 U nitrogen / ha) on the cultivated areas.
3.2. The farmer makes and applies compost, or manure and the lands are always covered in summer (no bare grounds).
3.3. The farmer has already carried out soil profiles and analysis.
3.4. There is no proved risk of contamination soil or water reserves by white waters and manure.
3.5. The farmer uses tines and disc tools for tillage or direct seeding by over seeding or he ploughs less than 20 cm deep.
3.6.The farmer practices rotations of different crops (including green manure).
3.7. No herbicides on forage areas (Direct seeding without herbicides).
3.8. The farmer uses woody resources as forage.

4. Disease prevention

4.1. The body condition of the herd is satisfactory.
4.2. The introduced animals are quarantined (a sufficiently long time).
4.3. The farmer carries out natural treatments mainly with natural products (herbalism or homeopathy).
4.4. The farmer treats parasites only when necessary and never more than twice per year (no systematic treatment, after a faeces analysis, or with natural treatments).
4.5. The farmer controls regularly water quality.
4.6. Livestock facilities are generally clean.
4.7. Hygienic-sanitary control of all aspects of milking is adequate.
4.8. The watering facilities are correct (no direct access to streams, no watering in ponds, etc ...).
4.9. Sick animals are isolated and crawl spaces are provided in accordance with the regulations.
4.10. The rangelands are closed (to avoid contacts with wildlife, wandering of animals and ease the rangelands management).

Table 1b. Criteria discussed during a focus group regarding pastoral systems in Corsica [indicators 5 to 10]

If the criterion is considered as applied, the score is one; if not, it is zero. For each indicator, the score is the addition of the score of all criteria – adapted from Mena et al., 2012.

5. Breeds and reproduction

5.1. 75% or more of the animals are autochthonous and/or adapted to the region.
5.2. Animal reproduction is natural: no hormones are administered to synchronize heat, induce birth, etc.
5.3. Births are distributed in order to minimize dependence on purchased feed.

6. Animal welfare

6.1. The farmer uses natural lactation until 30-35 days.
6.2. Lactation period is at least 40 days (the lambs are not killed at birth).
6.3. Covered area is at least 1.5 m^2 per adult sheep or goat and 0,35 m^2 per kid or lamb.
6.4. Outside space is at least 2.5 m^2 per adult animal (0,5 m^2 per kid or lamb).
6.5. Livestock have permanent access to open spaces, preferably to grasslands.
6.6. The farmer does not systematically tie up or isolate animals and limit their stress by his practices (no electric sting, water spray in summer, soft dehorning...).
6.7. The area for housing offspring is sufficient, protected from inclement weather and clean and well ventilated.
6.8. Adult animals have sufficient access to water, food, ventilation, light and adequate temperature and humidity.
6.9. The conditions of transport before slaughtering are satisfactory.

7. Food safety and hygiene

7.1. The farm can prove the absence of pathogens and is free of governmentally controlled diseases (principally brucellosis and tuberculosis).
7.2. The farm complies with the regulatory criteria of sanitary quality and good practices.
7.3. The farmer makes tests for chronic mastitis.
7.4. Analyses of milk during the past year indicate an absence of bacterial growth inhibitors.
7.5. The farmer follows waiting periods for treatments and had no inhibitors.
7.6. The effluents are stored in such a way that they not contaminate the environment.
7.7. The farmer disinfects the litters.

8. Marketing and management

8.1. The farmer adequately records information (of vet .treatments feed management, purchases and sales).
8.2. All the products are sold locally to industry, cooperatives or regional shops.
8.3. The farm closes the productive cycle (farm processing).
8.4. The farmer sells his products to local consumers directly at the farm or through local shops or markets.
8.5. The milk is processed in units where local material is used and accepted.

9. Conditions of social and economic sustainability

9.1. The farmer thinks he has good standards of living and good working conditions.
9.2. The farmer is less than 55 years or his succession is planned.
9.3. The farmer thinks he has a correct income.
9.4. Without public subsidies (Pillar II of the European CAP), the farm could continue his activity?
9.5. The farmer has other agricultural, livestock not agricultural activities.
9.6. The farmer is an active member of professional Associations or Unions.
9.7. Collective works with other farms are usual (formally or not).
9.8. The farmer thinks he is well integrated socially
9.9. There are other sources of income within family?

10. Environmental sustainability and societal contribution

10.1.The farm is well integrated in one's environment, looks clean and without visual pollution.
10.2. The farmer is involved in the restoration of his heritage (old buildings, terraces, threshing areas...).
10.3. The farmer is aware of his animal (local breeds, wild species...) or vegetal (protected natural plan reserves) heritage and assumes it (for instance by participating to collective actions in favour of bio -diversity.
10.4. The farmer practices transhumance regularly and follows his herd at least one a week.
10.5. The location of the farm is a real contribution for maintaining local traditional landscapes.
10.6. The farm is not located in natural hazard zone or the farmer tries to limit it (cleaning of rive banks against floods, firewalls area...).

Table 2. Example of application of the method on management of feeding (indicator 1) for the pastoral goat farm[1] tested in Corsica

1. Grazing on pasture during more than 6 hours a day	1
2. More than 50% of the diet is composed by fibers	1
3. The farm has lands to produce forage	0
4. The farm produces grain for goats	0
5. 80% of the feed for animals have been produced on the farm or near the farm (in the island)	1
6. The farm has used only forage produced in the Island	0
7 .The goats receive less than 500 g/head/day concentrate	1
8. The farm distributes shrub woody resources (“a frasca”)	0
Total	4/8 (50%)

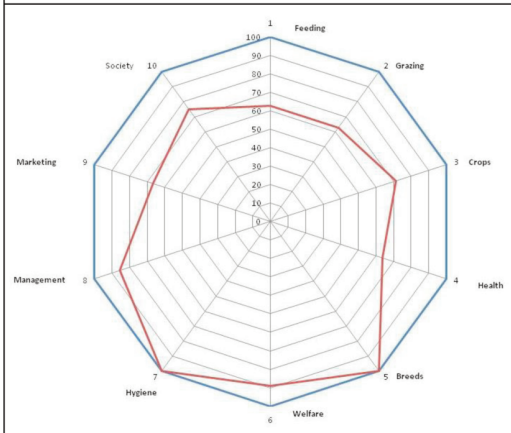
[1] Farmer description: “The goats graze all day long during the day but the farm has no lands to produce its own conserved forage and its grain. Consequently, concentrates and hay are bought and a part of it (grain and hay) is bought on the French continent. Consequently, to control the body conditions of his herd, the breeder gives an average of 520 g/day of concentrate”.

Table 3. Examples of agro – ecological profiles and ALPI (Agro – ecological Livestock Index)

Case 1 – organic dairy sheep farm

Score (%)	Indicator	Weighing factor
62,50	Feeding	0.16
62,50	Grazing	0.14
71,43	Crops	0.08
63,64	Health	0.08
100,00	Breeds	0.08
88,89	Welfare	0.06
100,00	Hygiene	0.09
85,71	Management	0.11
66,67	Marketing	0.12
75,00	Society	0.08

ALPI =75.32



Case 2 – Pastoral farm

Score (%)	Indicator	Weighing factor
50	Feeding	0.16
50	Grazing	0.14
42,86	Crops	0.08
72,73	Health	0.08
75	Breeds	0.08
100	Welfare	0.06
50	Hygiene	0.09
71,43	Management	0.11
44,44	Marketing	0.12
62,5	Society	0.08

ALPI = 58.94

Programme

Joint Seminar of the FAO-CIHEAM Sub Network on Production Systems & Sub Network on Nutrition

"Innovation for Sustainability in Sheep and Goats"

(Vitoria-Gasteiz, Spain, 3-5 October 2017)

PROGRAMME

3rd October

08:30 - 9:00 Registration

09:00 - 09:15 Presentation of the agenda and objectives of the Seminar

Session 1. Innovation's conceptual and practical framework. Application to the agro-food sector

Chair person: ***Cledwyn THOMAS*** *(EEAP)*

09:15 – 10:00 Keynote presentation: **Leire BARAÑANO,** Neiker-Tecnalia, Spain

10:00 – 10:45 S1 Oral presentations

The interest of devices of learning organizational to be resilient in a context of rapid change in agri-food systems. Between upstream and downstream, the example of a cheese cooperative. **Martine NAPOLEONE**, INRA-UMR SELMET SAD, France

Towards a pan-European typology of sheep and goat farms: A meta-analysis. **Alexandros THEODORIDIS**, Aristotle University of Thessaloniki, Greece

Environmental Implications of Different Production Systems in a Sardinian Dairy Sheep Farm. **Antonello FRANCA**, CNR-ISPAAM, Italy

Reference indices of the goat milk price. **Yolanda MENA GUERRERO**, Universidad de Sevilla, Spain

10:45 – 11:15 **Opening ceremony**

11:15 – 11:45 Coffee-break

11:45 – 12:15 Discussion

Session 2. Innovations to adapt sheep and goat feeding and production systems and industry to new societal demands

Chair persons: ***Hichem BEN SALEM*** *(IRESA)* ***and Roberto RUIZ*** *(NEIKER)*

12:15 – 13:00 Keynote presentation (Plenary): **Anna NUDDA,** Univ Sassari, Italy

13:00 – 14:00 Lunch

14:00 – 14:45 Keynote presentation (Plenary): **Paula GASPAR,** Univ. Extremadura, Spain

14:45 – 15:30 S2 Oral presentations (parallel sessions on Nutrition and Production Systems)

Nutrition

Early weaning of kid goats does not compromise rumen microbial colonization and post-weaning digestive capacity. **Ignacio MARTÍN GARCÍA**, CSIC-EEZ, Spain

Effect of the proportion of dry beet pulp in the diet on lamb fattening performance, carcass characteristics and meat quality. **Mohammed BENBATI**, INRA Maroc, Morocco

Effect of tannins on indoles content and pastoral flavour of lamb meat. **Edi PIASENTIER**, University of Udine, Italy

Anti-inflammatory and analgesics in types of willow browsed by goats. **Hussein MUKLADA**, ARO Natural Resources, Israel

Production Systems

PESagri: A novel payments for ecosystem services framework for targeted agrienvironmental policy. **Alberto BERNUÉS**, CITA, Spain

Assessment of energy footprint of sheep meat in two different farming systems in Tunisia. **Ridha IBIDHI**, INRAT, Tunisia

The implementation of some regenerative practices to improve the sustainability of latxa dairy sheep system. **Nerea MANDALUNIZ**, Neiker, Spain

Adaptation of goats feeding system to the adverse economic conditions by changing the grazing management practices. **Theodoros MANOUSIDIS**, Democritus University of Thrace, Greece

15:30 – 16:15 Viewing of posters (S1-S2)

16:15 – 17:00 S2 Oral presentations (parallel sessions on Nutrition and Production Systems)

Nutrition

Feeding behaviour, intake, apparent digestibility and plasma metabolites of Latxa dairy ewes as affected by cold-pressed oilseed cakes and sainfoin. **Aser GARCÍA RODRÍGUEZ**, Neiker, Spain

Effect of grazing activity and supplementary feeding on energy utilization by goats. **Ahmed ASKAR**, Desert Research Center, Egypt

Drinking high salt water from weaning to adulthood: Effect on body weight gain, body condition scores, metabolites profile, food and water intakes, ruminal fermentation, food digestibility, nitrogen balance and microbial synthesis in Barbarine male lambs. **Wiem MEHDI EL-GHARBI**, Faculty of Sciences of Bizerte, Tunisia

The level of nutrition of suckling lambs modifies the colonic epimural bacterial community and feed efficiency traits during the fattening period. **Javier DE FRUTOS VIDAL**, Instituto de Ganadería de Montaña (CSIC-Univ. León), Spain

Production Systems

The respectful animal farming: condition of its sustainability. **Elisabeth LECRIVAIN**, INRA, SAD - UR Ecodéveloppement, France

Sheep dairy and meat products: from consumers' perspective to industry innovations. **Daniel MARTÍN-COLLADO**, INIA, Spain

Innovation aspects of Serdaleh, a traditional Lebanese cheese produced from raw extensive goat's milk. **Christelle SALAMEH**, Holy Spirit University of Kaslik, Lebanon

Goat value chain in Algeria, sustainable development proposals to cope with changes. **Hossem SAHRAOUI**, University of Setif, Algeria

17:00 – 17:30 Discussion

18.00 – Guided visit to Vitoria city

4th October

Session 3. Precision farming and other technical innovations for increasing efficiency in sheep and goats

Chair person: ***Dunixi GABIÑA***

09:00 – 9:45 Keynote presentation: **George STILWELL**, Univ Lisbon, Portugal

09:45 – 10:30 Keynote presentation: **François BOCQUIER**, Supagro Montpellier, France

10:30 – 11:00 S3 Oral presentations

Innovations in the selection program of the UPRA-Grupo Pastores in Rasa aragonesa sheep breed. **Leticia RIAGUAS RUPÉREZ**, Oviaragón, Spain.

Phenotyping intake rate in dairy goats, a useful repeatable trait which can be measured automatically. **Sylvie GIGER-REVERDIN**, UMR INRA-AgroParisTech MoSAR, France

Eye and muzzle temperature measured using infrared thermography to assess sheep stress during shearing and foot-trimming. **Mariana ALMEIDA**, CECAV, Univ. Trás-os-Montes e Alto Douro, Portugal

11:00 – 11:30 Coffee-break

11:30 – 12:30 S3 Oral presentations

Remote sensing for real time estimate of aboveground biomass productivity in mountain pasture. **Bruno RONCHI**, University of Tuscia, Italy

Eskardillo: a platform based on individual animal data collection to improve decision making in dairy goat farms. **Alejandro BELANCHE GRACIA**, CSIC-EEZ, Spain

Feeding strategy of Lacaune dairy sheep: dairy ewes fed in group according to their milk yield. **Philippe HASSOUN**, INRA UMR SELMET, France

Clustering of lactation curves on French dairy goats. **Mathieu ARNAL**, INRA-GenPhySE, Idele, France

The gaps and environmental challenges for small ruminant production in Turkey. **Yildirir MESUT**, General Directorate Agricultural Research and Policies, Ministry of Agriculture, Turkey

12:30 – 13:00 Discussion

13:00 – 14:00 Lunch

Session 4. Success stories of innovations in the sheep and goat industry, with special focus on increasing consumption and adding value to products

*Chair person : **Eva UGARTE** (NEIKER)*

14:00 – 14:45 Keynote presentation: **Raffaele ZANOLI**, Univ. Politecnica delle Marche, Italy

14:45 – 15:30 Keynote presentation: **Hichem BEN SALEM** , IRESA, Tunisia, and **Mohammed BENGOUMI**, FAO-SNE, Tunisia

15:30 – 16:15 Poster viewing (S3-S4)

16:15 – 17:30 S4 Oral presentations

Fluorescence spectroscopy coupled with factorial discriminant analysis technique to identify sheep milk from different feeding systems. **Moncef HAMMAMI**, ESA Mateur, Tunisia

	Ekiola: manage feeding of a milk sheep flock based on the use of milk fatty acid composition to better care for animals and increase the health value of dairy farm-products. **Jean-Marc ARRANZ**, GIS-id64 / Chambre Départementale d'Agriculture, France
	The commitment of sheep and goat production systems in the agro–ecological transition: a participative approach for pastoral systems. **Jean Paul DUBEUF**, INRA-LRDE, France
	Sustainability of the dairy sheep farming: Examples from Greece and Spain. **Irene TZOURAMANI**, Agricultural Economics Research Institute – DEMETER, Greece
	Validation of a microbial inhibition test based on Eclipse Farm coupled with e-Reader for antibiotics screening in sheep and goat milk and goat's cheese whey. **Jennifer GIRALDO**, Univ. Politecnica de Valencia, Spain
	Sensory & microbiological evaluation of Drâa goat cheese and study of its stability during storage. **Younes NOUTFIA**, INRA Maroc, Morocco
17:30 – 18:00	Discussion and closing session
20:30 –	***Social dinner***

5th October

Field trip	
9:00 – 11:30	Experimental dairy Latxa flock at Neiker (including experiences from the LIFE projects that concluded in 2016 on rotation grazing and supplementing with rapeseed cake)
11:30 – 12:30	Ardiekin: Latxa and Carranzana dairy ram breeding centre
12:30 – 13:30	***Lunch***
13:30 – 17:00	Visit to mountain communal pastures

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Centre International de Hautes Etudes Agronomiques Méditerranéennes

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SERIES A: Mediterranean Seminars
2019 – Number 123

Innovation for Sustainability in Sheep and Goats

Edited by:
R. Ruiz, A. López-Francos, L. López Marco

Sheep and goat farming systems face a harsh present and an uncertain future, apparently compromised by a general lack of competitiveness stemming from poor technical and economic results, but also due to severe social and environmental challenges. Innovative solutions are needed to make the sheep and goat value chain more efficient, profitable and sustainable, but also more appealing for society, particularly to guarantee generational turnover for farms. Such innovations should be aimed at improving production techniques, labour organisation, equipment and infrastructures and developing collective programmes for selection or health campaigns. Innovation should also contribute to strengthening social forms of organisation such as product quality schemes or communal areas management. Also, innovative feeding strategies coupled with precision flock management practices that reduce gaps in production and adjust to the environmental challenges, hold promise to tackle the above mentioned objectives.

This publication compiles 81 contributions presented at the **joint Seminar of the FAO-CIHEAM Sub-Networks on Production Systems and Nutrition on Sheep and Goats, held in Vitoria-Gasteiz, Spain, in October 2017.** The Seminar was co-organised between the Department of Animal Production of Neiker-Tecnalia (the Basque Institute for Agricultural Research and Development) and the Mediterranean Agronomic Institute of Zaragoza (IAMZ-CIHEAM), with collaboration of the H2020 Project iSAGE (Innovation for Sustainable Sheep and Goat Production in Europe), the FAO, and support of the Department for Economic Development and Infrastructures of the Basque Government, the Municipality of Vitoria-Gasteiz, the Diputación Foral de Alava and the Idiazabal Denomination of Origin.

The articles are grouped into the four thematic sessions of the Seminar: (i) Innovation's conceptual and practical framework: application to the agro-food sector; (ii) Innovations to adapt sheep and goat feeding and production systems and industry to new societal demands; (iii) Precision farming and other technical innovations for increasing efficiency in sheep and goats; (iv) Success stories of innovations in the sheep and goat industry, with special focus on increasing consumption and adding value to products.

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iSAGE

Food and Agriculture Organization of the United Nations

ISBN: 978-2-85352-590-9
ISSN: 1016-121-X

Prix: 76,22 Euro

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