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Dietary effects on meat chemical traits and fatty acids composition in intramuscular lipids of Sarda x Ile de France heavy lambs

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Abstract. The effect of diet on meat chemical traits and fatty acids content were evaluated in Sarda x Ile de France lambs. Eighteen lambs that are off-springs from Ile de France rams and Sarda ewes, after a suckling period of 50 days, were divided into three groups homogeneous for sex and twin birth: (i) group HL with lambs raised in stall and fed alfa-alfa hay and commercial concentrate; (ii) group PL in which lambs were raised at pasture (*Lolium italicum* L) for 24 hours a day; and (iii) group ML with lambs suckled by their mothers. The mothers grazed for 7 hours per day and received as supplements alfalfa hay and commercial concentrate. Lambs were slaughtered at 20-26kg live weight. Chemical composition of meat samples (*Longissimus dorsi* muscle) was similar for all dietary treatments. Fatty acid composition was strongly affected by feeding system. Meat from grazing lambs and lambs suckled by their mothers showed higher proportions of ω3 PUFA, conjugated linoleic acid (CLA 9c 11t, P<0.05) and lower ω6/ω3 ratio than that of meat from stall-fed lambs (P<0.001). In conclusions, meat fatty acid composition was improved in the PL and in the ML groups than in the HL groups.

Keywords. Feeding mode – Heavy lambs – Meat quality – Fatty acids.

Effet de l'alimentation sur les caractéristiques chimiques et sur la composition en acides gras des lipides intramusculaires de la viande d'agneaux lourds Sarda x Ile de France

Résumé. *L'effet de l'alimentation sur les caractéristiques chimiques et sur la composition en acides gras a été évalué sur la viande des agneaux Sarda x Ile de France. Dix-huit agneaux, descendance de béliers Ile de France et de brebis Sarda, après une période d'allaitement de 50 jours, ont été répartis dans les groupes suivants, homogènes pour le sexe et la naissance de jumeaux : (i) groupe sevré en stabulation et soumis à un régime composé de foin de luzerne et de concentré commercial ; (ii) groupe sevré en pâturage* (Lolium italicum*) pendant 24 heures par jour ; et (iii) un groupe d'agneaux allaités par leurs mères. Les mères pâturaient pendant 7 heures par jour et ont reçu, en tant que compléments, du foin de luzerne et du concentré commercial. Les agneaux ont été abattus à 20-26 kg de poids vif. La composition chimique des échantillons de viande* (Longissimus dorsi*) était similaire pour tous les traitements alimentaires. La viande des agneaux au pâturage (groupe Herbe) et des agneaux allaités par leurs mères (groupe Lait) a montré une plus grande proportion de ω3-PUFA, d'acide linoléique conjugué (CLA 9c 11t, P<0,05) et une valeur moins élevée pour ce qui concerne le ratio ω6/ω3 (P <0,001) que celle de la viande des agneaux nourris à l'étable (groupe en stabulation). En conclusion, la composition en acides gras de la viande des agneaux des groupes en pâturage et allaités par leurs mères est meilleure que celle de la viande du groupe en stabulation.*

Mots-clés. *Mode d'alimentation – Agneaux lourds – Qualité de la viande – Acides gras.*

I – Introduction

In Sardinia the light suckling lamb is a traditional and typical product, which in 2001 received the PGI identification, named "Agnello di Sardegna" (Reg. 138/01). Similarly to what occurs in other countries of the Mediterranean basin, Sarda suckling lambs are raised following their mothers at pasture and are slaughtered at a cold carcass weight < 7 kg. The PGI product specification

provides also the “heavy lamb” typology (cold carcass weight 10-13 kg), but in this case lambs come either from Sarda sheep in purity or from cross-breeding with other highly specialized meat breeds like Ile de France and Berrichon du Cher. The product specification requires that heavy lambs are raised at pasture and fed with fresh forages.

It is known that the ruminant diet can play a significant role in improving meat quality in terms of nutraceutical compounds that are beneficial to consumer health (Wood *et al.*, 2004). Changes in intramuscular fatty acid composition are linked to the respective fatty acid content in the feed offered, though rumen biohydrogenation has a considerable impact in reducing the concentration of polyunsaturated fatty acids (PUFA) in ruminants. When compared to grain feeding, pasture increases the ω3-PUFA content and decreased the C18:2-ω6/C18:3-ω3 ratio in lamb meat (Popova, 2007; Santos-Silva *et al.*, 2002). Likewise, French *et al.* (2000) demonstrated that, when grown at the same rate, muscle from cattle fed a high grass intake had a higher PUFA/SFA ratio and a lower ω6/ω3 PUFA ratio than that of muscle from cattle fed concentrates rich in barley and maize grain.

The aim of the present study was to compare the effects of three different dietary treatments on meat quality in terms of macronutrients and fatty acid content in Sarda x Ile de France heavy lambs.

II – Materials and methods

Eighteen Sarda x Ile de France lambs were raised at pasture together with their mother until a live weight of 10-14 kg. After weaning, they were randomly assigned to one of three dietary treatments: PL (pasture lambs, 6 animals), fed at pasture on a ryegrass sward for 24h/day; HL (housed lambs, 6 animals) fed with alfalfa hay (765 g DM/head day) and commercial concentrate (516 g DM/head day); ML (suckled lambs, 6 animals) suckled by their mothers . The animals were weighed weekly and they were slaughtered at 20-26 Kg live weight (Sitzia et al., 2011). The carcass weight was recorded after 24 hours at 4°C and M. *longissimus dorsi* was taken for chemical analysis and intramuscular fatty acid (FA) composition. Meat samples were analysed for dry matter, fat, ash, protein in accordance with ASPA indications (1996). Muscle lipids were extracted by means of a hexane/2-propanol solution (3:2 v/v), according to Hara – Radin method (Hara *et al.*, 1978). Fatty acids were converted to methyl esters (Chin *et al.*, 1992), separated and quantified using a Varian 3900 gas chromatograph, with a SP2560 capillary column (100m x 0.25mm x 0.2μm). Statistical treatment of the data was performed using the STATGRAPHIC software (STATGRAPHICS Centurion XV, version 15.1.02. StatPoint, INC.). The effect of feeding treatments on chemical parameters and fatty acids content was assessed using the general linear model (α=0.05) procedure. A multiple comparison test (Tukey) was used to separate means.

III – Results and discussion

The proximate composition of *Longissimus dorsi* muscle is shown in Table 1. Dietary treatment had no significant effect (P>0.05) on moisture, fat, protein and ash content. Feeding system significantly affected the fatty acid composition of lambs’ intramuscular fat (Table 2). Meat from lambs suckled by their mothers (ML group), was characterized by a higher content of medium chain fatty acids, particularly C12:0 (P<0.05), C14:0 (P<0.01) and C16:0 (P<0.05), when compared to meat of grazing lambs (PL group). Suckled lamb, from a metabolic point of view, can be considered as a non ruminant, and consequently qualitative and quantitative fatty acid profile of suckling lamb meat may reflect the composition of the ingested milk (Velasco *et al.*, 2004,) that is commonly characterized by a high content of medium chain fatty acids. Meat from lambs fed at stall showed an intermediate concentration of medium and long chain fatty acids, but a significantly lower content of monounsaturated fatty acids (C18:1 9 cis, P<0.05 and C18:1 11 trans, P<0.01) when compared to meat from lambs reared at pasture.

Table 1 Chemical parameters (mean ± sd) in M. *Longissimus dorsi* of Sarda x Ile de France lambs

	Treatment†			Effect of feeding
	ML	HL	PL	
Moisture (%)	75.08 ± 1.12	75.78 ± 0.91	75.72 ± 0.67	ns
Fat (%)	2.33 ± 0.75	1.98 ± 0.48	2.09 ± 0.27	ns
Protein (%)	20.91 ± 0.40	20.79 ± .0.26	21.06 ± 0.39	ns
Ash (%)	1.22 ± 0.07	1.18 ± 0.02	1.21 ± 0.02	ns

†ML, suckled lambs; HL, housed lambs; PL, pasture lambs.
ns: not significant.

Table 2. Fatty acid composition (mean ± sd)in intramuscular fat of M *Longissimus dorsi* of Sarda x Ile de France lambs

FAME (%)†	Treatments††			Effect of feeding
	ML	HL	PL	
C10:0	0.38 ± 0.12	0.28 ± 0.05	0.40 ± 0.20	ns
C12:0	0.75^{a} ± 0.17	0.59^{ab} ± 0.17	0.41^{b} ± 0.05	*
C14:0	6.76^{a} ± 0.83	4.94^{b} ± 0.73	4.52^{b} ± 0.58	**
C16:0	26.15^{a} ± 2.17	25.07^{ab} ± 0.92	23.47^{b} ± 1.40	*
C18:0	13.79^{b} ± 1.05	16.76^{a} ± 0.86	17.83^{a} ± 1.53	***
C18:1 11t	2.23^{b} ± 0.31	2.08^{b} ± 0.29	2.97^{a} ± 0.49	**
C18:1 9c	31.92^{ab} ± 3.86	30.26^{b} ± 2.11	34.96^{a} ± 1.73	*
C18:2 9c,12c	8.73^{b} ± 1.38	11.67^{a} ± 1.24	7.12^{b} ± 0.26	***
C18:3 9c,12c,15c	2.89^{a} ± 0.62	2.12^{b} ± 0.31	2.98^{a} ± 0.32	*
CLA 9c,11t	1.10^{a} ± 0.11	0.76^{b} ± 0.16	0.98^{ab} ± 0.19	*
CLA 11t,13c	0.04 ± 0.01	0.04 ± 0.01	0.06 ± 0.05	ns
C20:4 5c,8c,11c,14c	2.64^{ab} ± 0.34	3.10^{a} ± 0.73	2.21^{b} ± 0.39	*
C20:5 5c,8c,11c,14c,17c	0.55 ± 0.18	0.42 ± 0.09	0.46 ± 0.15	ns
C22:5 7c,10c,13c,16c,19c	1.41 ± 0.35	1.41 ± 0.26	1.19 ± 0.37	ns
C22:6 4c,7c,10c,13c,16c,19c	0.66^{a} ± 0.12	0.48^{b} ± 0.14	0.44^{b} ± 0.07	*
SFA	47.83 ± 2.94	47.65 ± 1.25	46.63 ± 0.37	ns
MUFA	34.15^{ab} ± 3.72	32.34^{b} ± 2.05	37.92^{a} ± 1.28	*
PUFA	18.02^{ab} ± 2.89	20.01^{a} ± 2.16	15.44^{b} ± 1.26	*
UFA	52.17 ± 2.94	52.35 ± 1.25	53.37 ± 0.37	ns
ω3	5.51 ± 1.20	4.43 ± 0.58	5.07 ± 0.74	ns
ω6	11.37^{b} ± 1.70	14.78^{a} ± 1.91	9.33^{b} ± 0.56	***
ω6/ω3	2.09^{b} ± 0.19	3.36^{a} ± 0.43	1.86^{b} ± 0.22	***
AI	1.04^{a} ± 0.16	0.87^{ab} ± 0.09	0.79^{b} ± 0.06	**
TI	1.20 ± 0.16	1.27 ± 0.07	1.18 ± 0.06	ns
P/S	0.38^{ab} ± 0.07	0.42^{a} ± 0.05	0.33^{b} ± 0.03	*

†SFA: Saturated fatty acids; MUFA: Monounsaturated Fatty Acids; PUFA: Polyunsaturated Fatty Acids; UFA: Unsaturated Fatty Acids. ω3: omega 3 fatty acids; ω6: omega 6 fatty acids;. AI = (C12:0 + (C14:0*4) + C16:0)/UFA;TI = (C14:0+C16:0+C18:0)/((0.5*ω6)+(0.5*MUFA)+(3* ω3)+(ω3/∑ω6); P/S = PUFA/SFA. ††ML, suckled lambs; HL, housed lambs; PL, pasture lambs; ns: not significant. *p <0.05; **p<0.01; ***p<0.001; a-b Means within row with different superscript letters differed significantly.

The content of polyunsaturated fatty acids (PUFA), determined in intramuscular fat of

Longissimus dorsi muscle, closely reflects the fatty acid composition of ingested fed. Pasture and suckled lambs (PL and ML) showed a very similar qualitative and quantitative profile of polyunsaturated fatty acids. The intramuscular fat of both PL and ML groups showed significant higher values of linolenic (C18: 3 9cis, 12cis, 15cis, P<0.05) and rumenic acids (CLA 9cis, 11trans, P<0.05) compared to that of HL lambs. ML lambs, following their mothers out to pasture, may have ingested small amounts of grass in addition to milk, that is characterized, by a high proportion of linolenic acid (C18:3 9cis, 12cis, 15cis, 78.57%) . It is reknown that grass-based diets increase linolenic acid contents in lamb tissues (Bas et al., 2000) and that the level of CLA 9cis, 11trans increases with the incidence of pasture in the diet since it is related with the level of the CLA precursor, linolenic acid, in the ingested grass (Schimd et al., 2005). Conversely, meat from lambs reared at stall is characterized by a significantly higher content of linoleic acid (C18: 2 9cis, 12cis) and of omega-6 fatty acids (ω6) (P <0.001) than that of other groups; indeed, these animals were fed a diet based on commercial concentrate that is rich in linoleic acid (C18:2 9cis 12cis 46.51%).

In order to assess the effects of feeding treatments on nutritional value of fat some indices have been determined (ω6/ω3 ratio, P/S ratio, AI and TI indices). Due to the concentration of ω6 and ω3 fatty acids, meat from PL and ML lambs showed a significantly lower ω6/ω3 ratio (P<0.001) than that of HL group (1.86, 2.09 and 3.36 respectively). It is highly recommended that in the human diet this ratio is less than 4 (Department of Health, 1994); in this experiment the ω6/ω3 ratio was below the recommended value in the meat from lambs in all the groups. The P/S ratio in all groups was found to be less than the recommended limit of 0.45, although the lowest value was observed in meat of lambs kept on pasture. The atherogenic index (AI) significantly varied (P<0.01) from 0.79 for grazing lambs to 1.04 for suckled lambs. These values were lower than those reported by Vacca *et al.* (2008) for Sarda lambs fed with maternal milk.

IV – Conclusions

In conclusion, according to the assessment of the nutritional quality indexes ω6/ω3, P/S and AI, meat from grazing lambs was found to be qualitatively higher than that of other groups and particularly with respect to that of lambs held in stall and supplied with hay and concentrate.

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