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Effect of carob pulp on growing performances, nutritional, and technological quality of meat and perirenal fat from goat

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Abstract. The objective of this study is to evaluate the effect of condensed tannins (CTs) distribution using carob pulp in diet on meat and carcass quality and growth performance of kids. Three diets with 0%, 25%, and 45% of carob pulp (C0, C5 and C10, respectively) were distributed to 3 groups of kids from weaning to slaughter at 6 months of age. C5 kids showed highest ADG_{90-180} and final weight at 180 days (73.33 g/day; 18.50 kg respectively). Meat moisture, fat, pH and water retention showed no variation. However, C5 contains more protein ($P<0.05$).The linoleic acid composition in meat increase with C10 ($P<0.05$). The low intakes of CTs seem to be insufficient to fully protect certain unsaturated fatty acids against bio-hydrogenation of fatty acids (DFA 67.03% *vs* 64.91% and 66.54% respectively for C0, C5 and C10, $P>0.05$). The same result was observed for perirenal fat. Omega 6 and C18:1n9 experienced an increase in meat from goats fed with the C10 diet ($P>0.05$). Carob use in kids diet is accompanied by an improvement of protein and desirable fatty acids, especially linoleic acid, in meat.

Keywords. Carob – Meat quality – Growth – Kids.

Effet de la pulpe de caroube sur la qualité nutritionnelle et technologique de la viande et du gras périrénal des chevreaux

Résumé. *L'objectif de ce travail est d'évaluer l'effet de la distribution des tanins condensés (TCs) en utilisant la pulpe de caroube dans l'alimentation, sur la qualité (carcasse; viande) et sur la croissance des chevreaux. Trois rations avec* 0%, 25%, 45% *de pulpe de caroube (C0, C5 et C10 respectivement) ont été distribué à 3 groupes de chevreaux du sevrage jusqu'à l'abattage à 6 mois. Les chevreaux C5 ont enregistré un* GMQ_{90-180} *et un poids final à 180 jours les plus élevés (73,33 g/jour; 18,50 kg). L'humidité de la viande, la matière grasse, le pH 0 et 24h post mortem et la rétention d'eau n'ont révélé aucune variation. Toutefois, la viande C5 contient plus de protéines (P<0,05). La composition de la viande en acide linoléique a augmenté avec C10 (P<0,05). Les faibles apports de tanins semblent insuffisants pour protéger complètement certains acides gras insaturés contre la biohydrogénation des acides gras (DFA 67,03%* vs *64,91% et 66,54% respectivement pour C0, C5 et C10, P>0,05). Le même résultat a été observé pour la graisse périrénale. Oméga 6 et C18:1n9 ont connu une augmentation dans la viande de chevreaux recevant la ration C10 (P>0,05). L'utilisation de la pulpe de caroube est accompagnée d'une amélioration des protéines et des acides gras désirables, en particulier linoléique, de la viande.*

Mots-clés. *Caroube – Qualité de la viande – Croissance – Chevreaux.*

I – Introduction

In northern Morocco, goat meat is produced on pastures that are known by their forage resources rich in phenolic compounds mainly the condensed tannins (CTs) (Chebli *et al.*, 2012). The latter are anti-nutrients that weaken productivity in meat from these farms (Makkar, 2003). However, CTs can protect certain beneficial nutrients, such as desirable fatty acids, against ruminal biodegradation and thereafter these nutrients can be found in animal products, and consequently improve their quality (Min *et al.*, 2003; Ramírez-Restrepo and Barry, 2005). However, studies showing the impact of CTs on productivity and quality of goat meat are not locally available in Morocco. Thus, optimal use of feed resources rich in CTs is to be undertaken, in order to preserve the effectiveness of food digestibility and at the same time the quality of animal products. This work aims to identify the effect of CTs distribution using carob pulp in supplement diet, focusing on growth performance and fattening and also in the carcass and the meat quality of kids of the local goat population in northern Morocco.

II – Materials and methods

Three concentrate supplementations (C0, C5 and C10) with respective intake levels of CTs (0, 2.7, 5.6 g/day/kid) were distributed respectively to 3 groups of kids (7 per group) from weaning (at 90 days) until the age of 180 days. The control group (C0) received a concentrate supplement containing grain of barley, maize, faba bean and sunflower cake. In the group tests, the carob pulp (*Ceratonia siliqua*) was used as a source of CTs by incorporating 25% and 45%DM of the carob pulp, respectively, in the C5 in C10 concentrate diet. The local carob pulp of northern Morocco contains an average of 20% of TCs.

Oat hay was distributed in all groups equitably during the period of the experiment. In the three groups, concentrate diet distributed had an equal level of energy and protein (0.8 UFV, 70 g PDI). The growth control is performed every 15 days in the morning on fasting animals.

24 hours after slaughter, meat samples were taken from the *Longissimus dorsi* muscle (LD), the *Semimembranosus* muscle (SM) of thigh and from perirenal fat in order to perform analysis on dietary, technological and organoleptic meat quality. Measurements were taken on carcass weight just after slaughter and cold carcass weight (24 hours after slaughter at a room temperature of an average of 20℃), the weighing of perirenal fat, the carcass length, thickness and length of the thigh. Also measurements were taken on: Consumption index [feed Intake (kg)/Average daily gain ADG (kg)]; Carcass yield (%) [(HW/LW)*100; where HW: carcass weight after removal of the head, skin, offal and fours; LW: live weight before slaughter]; Compactness index [carcass weight/carcasse length]; Muscle index [thickness of the thigh/leg length]; and Conformation index [which is the sum of the two indexes].

The colour of the cover fatty tissue was measured on a thickness of 1 to 1.5 cm of the LD 12 h post-mortem using the Minolta Chromameter CR410. The values of Lightness (L*), Redness (a*) and Yellowness (b*) were given by Chromameter once it is placed on a specific location of the carcass. Color score of fat cover was calculated as cited in Normand and Brouard-Jabet (2002). Meat texture was assessed 24 hours post-mortem using a Texturometer (Texture Analyzer -PRO-TMS) on a piece of LD 1 cm thick and 3 cm long. The pH was determined at 0 and 24 hours post-mortem with a portable pH meter HANNAHI 99163. Retention capacity of water is measured according to Grau and Hamm (1953; cited in Ait Bella, 2006) by exerting a force of 2.250 kg weight for 5 minutes.

To perform the analysis of meat fatty acids, the samples were taken from the LD (between 12th and 13th ribs). Content of meat protein, fat, ash and moisture is carried out on *Semimenbranosus* muscle of the thigh according to the AOAC (1997). Fatty acids were extracted by the method of Folch *et al.* (1957) and esterified according to Christie (1993) and Shehata *et al.* (1970 respectively) for meat and fat samples. The esters of fatty acids were determined using gas chromatography (Varian CP-3800) equipped with a flame ionization detector and a capillary column of 100 m.

For the different parameters studied, the analysis of variance, multiple comparison of means and the calculation of standard error of means were performed using the statistical package SAS (2002).

III – Results and discussion

Moderate rate (C5) of carob pulp incorporated in the concentrate diet improved significantly the growth performance of kids (Table 1). Indeed, C5 group have registered a highest weight gain between 90-180 days compared to C0 and C10 (73.33 *vs* 42.90 and 38 g/day, P<0.05) and a highest weight at 180 days (18.50 *vs* 15.46 and 15.22 kg, P<0.05) respectively. With C5 group, consumption index is lower compared to C0 and C10 group (7.72 *vs* 12.18 and 19.56 respectively, P<0.05). CTs in carob used in high quantities (C10) inhibit the activity of digestive enzymes, which reduce the growth of animals. The decrease in growth in C10 kids is due to the inhibition of digestive enzymes caused by CTs contained in carob used at large quantities (Vasta *et al.*, 1999, El Otmani *et al.,* 2011).

Table 1. Effect of carob pulp on growth performance of kids in control (C0) and test (C5 and C10) group (n = 7/group)

	C0	C5	C10	SEM	Probability
Initial live weight (kg)	11.6	11.90	11.80	0.7979	0.9641
Final live weight (kg)	15.46^{ab}	18.50^{a}	15.22^{b}	0.9880	0.0466
$ADG_{90\text{-}180}$ (g/day)	42.90^{b}	73.33^{a}	38.00^{b}	7.3981	0.0111
Feed intake (g DM/kid/day)	500^{c}	535^{b}	620^{a}	0.000	0.0001
Consumption index	12.18^{ab}	7.72^{b}	19.56^{a}	2.6713	0.0262
Cold carcass weight (kg)	5.87	6.44	5.87	0.5570	0.7123
Carcass yield (%)	40.48	36.80	39.88	1.6856	0.2905

Within the same row, means with different superscript are significantly different (P<0.05).
SEM: Standard error of the mean.

Carob incorporation shows no significant effect of compactness index but there is a difference between treatment C5 and C10 concerning muscle and conformation index (P<0.05). Slightly lower indices are obtained with C5 (0.46 and 0.57 respectively, P <0.05). This difference is due to the carcasses and thigh length of C5 kids which are longer than TC10 (Table 2).

Table 2. Effect of carob pulp on carcass characterization of kids in control (C0) and tests (C5 and C10) group (n = 7/group)

	C0	C5	C10	SEM	Probability
Carcass length (cm)	56.20	57.50	54.70	0.7810	0.0760
Thigh length (cm)	26.20	27.50	24.70	0.7810	0.0760
Thigh thickness (cm)	12.42	12.54	12.48	0.1706	0.8849
Compactness index	0.10	0.11	0.11	0.0090	0.8427
Muscle index	0.47^{ab}	0.46^{b}	0.51^{a}	0.0108	0.0213
Conformation index	0.58^{ab}	0.57^{b}	0.61^{a}	0.0120	0.0435
Color score of fat cover	5.52^{a}	4.49^{ab}	4.15^{b}	0.4104	0.0472
Lightness (L*)	40.07^{b}	43.23^{a}	42.70^{a}	0.7964	0.0346
Redness (a*)	21.52	21.29	21.57	0.5115	0.9161
Yellowness (b*)	6.81^{a}	4.99^{b}	5.78^{ab}	0.3833	0.0179

Within the same row, means with different superscript are significantly different (P<0.05). SEM: Standard error of the mean.

C5 fat cover shows a higher color score than C10 (4.49 *vs.* 4.15 respectively, P<0.01). About the C5 meat of LD, lightness (L*) is higher and yellowness is low (43.23 and 4.99 respectively, P<0.05). These indices indicate a satisfactory color of the C5 carcass and meat.

About the dietary quality, meat protein content obtained with C5 diet is higher than in C10 (17.24 vs. 15.35 respectively, P<0.05; Table 3). This result shows that the protein content of goat meat is improved with moderate level of carob pulp not exceeding 25% DM (equal to 2.7 g/day/kid of CTs). This result can be explained by the minimization of ammonia losses of nitrogen in the urine which result from the reduction of amino acids degradation with the presence of moderate amounts of CTs contained in carob. Protein contents slightly higher ranging between 19.5% and 22.2% are reported by Ding *et al.* (2010), Werdi Pratiwi *et al.* (2007), Sen *et al.* (2004) and El Otmani *et al.* (2011).

No significant effect of carob has been recorded on meat moisture, content fat and pH (0 and 24 hours) post mortem. Also, there was no significant variation in the water holding capacity of *Semimenbranosus* or *Longissimus dorsi* meat between the different tested diets (Table 3). These results are consistent with those of Ding *et al.* (2010), Sen *et al.* (2004) and Werdi Pratiwi *et al.* (2007). However, we notice a tendency to a decrease in meat fat and an increase in acidity (0 and 24 hours) post mortem with C10 diet (P>0.05).

Table 3. Effect of carob pulp on dietetical and technological parameters of kids meat in the control (C0) and tests (C5 and C10) group (n= 7/group)

	C0	C5	C10	SEM	Probability
Protein (%)	16.32[ab]	17.24[a]	15.35[b]	0.4823	0.0292
Ash (%)	2.88	2.84	2.7	0.0589	0.0834
Thigh moisture (%)	74.05	75.2	76.29	0.6505	0.091
Longissimus moisture(%)	72.96	75.69	76.02	1.019	0.1065
Fat (%)	4.61	3.24	3.86	0.732	0.418
pH (0 hours)	6.52	6.62	6.42	0.1767	0.1391
pH (24 hours)	5.68	5.75	5.60	0.0125	0.3221
Water-holding capacity (thigh)	45.28	47.12	44.12	1.7715	0.5015
Water-holding capacity (*Longissimus dorsi*)	25.36	25.94	25.95	2.7187	0.9849

SEM: Standard error of the mean.
Within the same row, means with different superscript are significantly different (P<0.05).

Regarding the fatty acids composition (Table 4), goat meat contains predominantly oleic, palmitic, stearic, arachidic acid and desirable fatty acids. This result is consistent with Mahgoub *et al*. (2002), Santos *et al.* (2007), Beserra *et al.* (2004), Werdi Pratiwi *et al.* (2007), Ding *et al.* (2010), and Zerrouk *et al.* (2010). However, there is an increase in conjugated linolenic acid (CLA, 18:2n6c) when CTs are distributed at a high amount (0.14% vs. 0.09%, P<0.05, respectively for C10 and C5). Moderate intake of CTs (C5) seems to be insufficient to fully protect certain unsaturated fatty acids against the bio-hydrogenation of carbon chains of fatty acids. The proportion of CLA obtained with C5 diet is, indeed, below that of the control group (0.09% vs. 0.12%, P<0.05). While, the voluntary intake of concentrate containing 45% of carob pulp explains the obtaining of high CLA content in meat (0.48%, Vasta *et al.* 1999). El Otmani *et al.* (2011) also reported a significant increase in CLA content by incorporating *Lupinus angustifolius* containing 0.075% of alkaloids which are also phenolic compounds such as CTs. Linolenic acid which is an essential fatty acid of Omega 3 group and eicosatrienoic acid of omega 6 group, both showed an increase in the LD with high intake of CTs in diet (0.69% *vs*. 0.32%, and 1.03% *vs*. 0.32% respectively for C10 and C0, P>0.05).

Globally, the use of CT in the diet of growing and fattening kids is accompanied by a significant improvement in meat content of protein and fatty acid particularly the desirable linoleic acid, especially with use of high CT use in diet (5.6 g/day/kid of CTs).

Table 4. Effect of carob pulp on fatty acids composition (% of total fatty acids) of *Longissimus dorsi* of the control (C0) and tests (C5 and C10) group of kids (n= 7/group)

Fatty acids	C0	C5	C10	SEM	Probability
Myristic acid (C14)	3.11	2.91	2.87	0.21	0.6985
Palmitic acid (C16)	22.02	20.63	21.54	0.97	0.6089
Stearic acid (C18)	13.08[b]	15.11[ab]	16.99[a]	0.98	0.0494
Oleic acid (C18:1n9)	53.24	48.72	48.15	2.28	0.2654
Linoleic acid (C18:2n6c)	0.12[ab]	0.09[b]	0.14[a]	0.01	0.0132
Linolenic acid (C18:3n3)	0.32	0.59	0.69	0.22	0.4905
Arachidic acid (C20)	7.53	10.95	8.35	1.94	0.4538
Eicosatrienoic acid(C20:3n6)	0.32	0.46	1.03	0.38	0.4122
Behenic (C22)	0.26	0.53	0.23	0.16	0.4202
Desirable fatty acids	67.03	64.91	66.54	2.03	0.7465
Mono-unsaturated fatty acids	53.24	48.72	48.15	2.28	0.2654
Poly-unsaturated fatty acids	0.71	1.08	1.40	0.47	0.5905
Unsaturated fatty acids	53.95	49.80	49.55	2.75	0.4042
Saturated fatty acids	46.06	50.20	50.44	2.49	0.4046

Means within the same row with different superscript are significantly different ($P<0.05$).
SEM: Standard error of the mean.

IV – Conclusions

Moderate intake of CTs provides leaner and drier meat with more protein content. But, with no changes in technological quality. However, the quantity of desirable fatty acids improves when a high rate of CTs is distributed in the concentrate diet. CTs exist in most plants and in agricultural by-products, particularly in fodder shrubs most eaten by goats (Ayadi *et al.*, 2010). Therefore, high intake of CTs on these pastures could occur. This confirms the good quality of fatty acids in kids meat produced on pasture. However, this quality is obtained despite the dry matter digestibility, resulting in a decrease in weight productivity of kids (Chentouf *et al.*, 2006). Developing of a technique for improving the digestibility of ingested matter in goats and preserving the quality of fatty acids composition of meat can increase the goat farming income in mountain areas where animal diets are based on grazing.

References

Ait bella M., 2006. Contribution à l'élaboration des bases de qualification de la viande bovine locale : cas de la race Oulmès-Zaër. Mémoire de 3ème cycle en agronomie. I.A.V Hassan II.
AOAC, 1997. *Official Methods of Analysis of AOAC International*, 16th edition. Association of Official Analytical Chemists, Washington, DC, USA. pp. 2000
Ayadi M., Arakrak A., Chriyaa A. and Chentouf M., 2010. Evaluation des teneurs en substances anti-nutritionnelles des principaux sous produits de la region. In: Rapport annuel de l'INRA-Tanger, p. 32-39.
Beserra F.J., Madruga M.S., Leite A.M., Da Silva E.M.C.and Maia E.L., 2004. Effect of age slaughter on chemical composition of meat from Moxoto goats and their crosses. In: *Small Rum. Res.,* 55, p. 177-181.
Chebli Y., Chentouf M., Mrabet R. and Ayadi M., 2012. Characterization of botanical composition and biomass production of silvopastoral grazing in Moroccan Rif. In: XIth International conference on goats. 24-27 September, Gran Canaria, Spain.

Chentouf M., Ben Bati M., Zantar S., Boulanouar B. and Bister J.L., 2006. Evaluation des performances des élevages caprins extensifs dans le nord du Maroc. In: *Options Méditerranéennes,* 70, p. 87-94.
Christie W.W., 1993. *Advances in Lipid Methodology*. Second Ed. The Oily Press Ltd, Dundee, Scotland. p. 69-111.
Ding W., Kou L., Cao B. and Wei Y., 2010. Meat quality parameters of descendants by grading hybridization of Boer goat and Guanzhong Dairy goat. In: *Meat Sc.,* 84, p. 323-328.
El Otmani S., Ayadi M. and Chentouf M., 2011. Effet du lupin sur la production et la qualité de la viande chez les chevreaux en croissance et engraissement. In: *18ème journées Rencontres Recherches Ruminants*. 7 et 8 Décembre, Paris, France.
Folch J., Lees M. and Stanley G.H.S., 1957. A simple method for the isolation and purification of total lipids from animal tissues. In: *J. Biol. Chem*., 226, p. 497-509.
Mahgoub O., Khan A.J., Al-Maqbaly R.S., Al-Sabahi J.N., Annamalai K. and Al-Sakry N.M., 2002. Fatty acid composition of muscle and fat tissues of Omani Jebel Akhdar goats of different sexes and weights. In: *Meat Science*, 61, p. 381-387.
Makkar H.P.S., 2003. Effects and fate of tannins in ruminant animals, adaptation to tannins, and strategies to overcome detrimental effects of feeding tannin-rich feeds. In: *Small Rumin. Res.*, 49, p. 241-256.
Min B.R., Barry T.N., Attwood G.T. and McNabb W.C., 2003. The effect of condensed tannins on the nutrition and health of ruminants fed fresh temperate forages: A review. In: *Anim. Feed Sci. Technol*., 106, p. 3-19.
Normand J. and Brouard-Jabet S., 2002. Guide pratique. Apprécier la qualité du gras de couverture des carcasses d'agneaux : Couleur et fermeté. Institut de l'Elevage, Interbev et OFIVAL. 45 p.
Ramírez-Restrepo C.A. and Barry T.N., 2005. Alternative temperate forages containing secondary compounds for improving sustainable productivity in grazing ruminants. In: *Animal Feed Science and Technology*, Volume 120, Issue 3, p. 179-201.
Santos V.A.C., Silva A.O., Cardoso J.V.F, Silvestre A.J.D., Silva S.R., Martins C. and Azevedo J.M.T., 2007. Genotype and sex effects on carcass and meat quality of suckling kids protected by the PGI "Cabrito de Barroso". In: *Meat Science,* 75, p. 725-73.
SAS, 2002. *SAS User's Guide (Editor): Statistics*, Version 9.00 SAS Institute Inc., Cary, NC, USA.
Sen A.R., Santra A. and Karim S.A., 2004. Carcass yield, composition and meat quality attributes of sheep and goat under semiarid conditions. In: *Meat Science*, Vol. 66, p. 757-763.
Shehata, A.J., De Man. J.M. and Alexander, J.C., 1970. A simple and rapid method for the preparation of methyl esters of fats in milligram amounts for gas chromatography. In: *Canadian Inst. Food Sci. Technol. J.,* 3, p. 85-89.
Vasta V., Lanza M., Pennisi P., Bella M. and Priolo A., 1999. Effect, of dietary condensed tannins on lamb intramuscular fatty acids. In: *Options Méditerranéennes*, Series A, No. 74, p. 35-39.
Werdi Pratiwi N.M., Murray P.J. and Taylor D.G., 2007. Feral goats in Australia: A study on the quality and nutritive value of their meat. In: *Meat Science*, Vol. 75, p. 168-177.
Zerouk H.M., Zantar S., Chentouf M. and Laglaoui A., 2010. Mise au point de quelques méthodes de contrôle de la qualité caprine. Rapport d'activité 2009/10 du Centre Régional de la Recherche Agronomique de Tanger, p. 122-125.