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Effect of the local forage resource, the "khortane" grass hay, on fatty acid of milk and meat of indigenous goats of southern Tunisia

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Abstract. The objective of this study was to determine the effect of the local feed resources on fatty acid profile of milk and meat of indigenous goat. 20 goats and 18 kids were divided in two groups each and received *ad libitum* oat hay diet (control diet: C) or mixed grass hay called "khortane" (diet K) in southern Tunisia. All groups received the same commercial concentrate. In the first experiment, milk from C diet goats was poorer in lauric (C12:0; 4.7% of total fatty acids methyl esters) and myristic (C14:0; 10.0%) acids than milk from K group ($P < 0.05$). The "khortane" considerably increased the total conjugated linoleic acid content in milk (0.75 vs. 0.64% FAME; $P < 0.05$). While the series n-3 fatty acids in milk were similar between the two diets. In addition, the n-6/n-3 ratio was more favorable in the C diet than in the K diets. In the second experiment, the content of saturated fatty acids (SFA) in meat was similar in the two diets. The mono-unsaturated fatty acids (MUFA) were significantly higher ($P <0.05$) in meat of K diet fed (47.4 *vs* 46.3% FAME). The polyunsaturated fatty acid level (PUFA) was not affected by the dietary treatment. Omega 3 was similar in two groups. The n6/n3 ratio is significantly affected by the diet; it was lowest in the meat of K group (3.3 *vs* 4.3). It is concluded that the milk and the meat produced by feeding animal "khortane"show a better nutritional quality, with a higher level of poly-unsaturated fatty acid.

Keywords. Arid land – Local forage – Indigenous goats – Milk – Meat – Chemical composition – Fatty acid profile.

Effet d'une ressource fourragère locale « khortane » sur la composition en acide gras du lait et de la viande des caprins de la population locale dans le sud tunisien

Résumé: *L'objectif de cette étude était de déterminer l'effet des ressources alimentaires locales sur le profil des acides gras du lait et de la viande des caprins de la population locale. 20 chèvres (lait) et 18 chevreaux (viande) ont été divisés en deux groupes et ont reçu chacun* ad libitum *le foin d'avoine (groupe contrôle C) et un mixte de foin d'herbe localement appelé : « khortane » (groupe K). Tous les groupes ont reçu le concentré commercial. Dans la première expérience, le lait de groupe contrôle a été pauvre en acide laurique (C12 :0 ; 4,7%) et en acide myristique (C14:0; 10,0% totale des acides gras) que le lait de groupe K. Le lait du groupe K présente une teneur légèrement plus élevée (P>0,05) en acide linoléique conjugué (0,75* vs *0,64%). Les acides gras de la série n-3 sont similaires dans le lait des deux groupes. En outre, le rapport n-6 / n-3 a été plus favorable dans le lait de groupes C que le lait de groupe K. Dans la deuxième expérience, la teneur en acides gras saturés a été comparable dans la viande de deux groupes. Les acides gras mono-insaturés a été significativement plus élevés (P<0,05) dans la viande de groupe K (47,3* vs *46,3%). L'Omega 3 a été similaire dans les deux groupes. Le régime alimentaire a affecté (P <0,05) le rapport n6 / n3 (3,1 et 4,3 respectivement pour les groupes Ko et C). Il est conclu que le lait et la viande produite a partir de « khortane » ont montré une amélioration de la qualité nutritionnelle, avec un niveau plus élevé de l'acide gras polyinsaturé.*

Mots-clés. *Région aride – Fourrage local – Caprin locale – Lait – Viande – Composition chimique – Profil d'acide gras.*

I – Introduction

In arid regions, milk and meat is mainly produced from goats and sheep. The more are harsh the conditions, the higher is the share of goat production. Goats are better adapted than cows and sheep to extensive conditions and to very harsh environments, because they have a better ability to consume cell wall-rich plant resources, such as shrubs and trees (Martinez, 2002). In these regions, goat farming is predominant and goats use rangelands as main components of their diet. When resources from rangelands cannot meet the maintenance and growth requirements of goats, the breeders developed several strategies to ensure the nutritional requirements of their livestock, such as the exploitation of some drought-tolerant shrubs and pastoral plants represents an effective strategy for livestock feeding. Several studies have demonstrated that cactus (*Opuntia ficus-indica f. inermis*), cladodes (Ben Salem *et al*., 1996; Misra *et al*., 2006) or fruits (Ben Salem *et al*., 2003) and saltbush (*Atriplex nummularia*; Ben Salem *et al*., 2002) and local resources (Ayeb *et al*., 2014) have a good nutritional value, when used as supplements in small ruminant diets. In addition, in southern Tunisia, the breeders profit from the favorable season to establish reserves by harvesting range species as *Stipa tenacissima* (Ayeb *et al*., 2013) and natural grass hay called "khortane" (Ayeb *et al*., 2011). "Khortane" is a mixture of annual and perennial species, which are always collected in the spring and stored for use in periods of drought, The most searched species to make the "khortane" are: *Launeae resedifolia, Chrysanthemum coronarium, Lolium multiflorum* and *Erodium glaucophyllum* (Ayeb *et al*., 2011).In summer and in drought period, "khortane" is a very important forage resource for small ruminants as well as equines and camels, however little information is available on the effects of this local resource, on meat and milk quality attributes. The aim of this work was to determine the effect of "khortane" resource on fatty acid profile of milk and meat from indigenous goats of southern Tunisia.

II – Material and methods

Experiment 1: 20 indigenous goats (body weight = 25.20 ± 3.36 kg; age = 4.10 ± 0.70 years; late lactation) were divided into two homogeneous groups. All animals were fed *ad libitum*: oat hay (control diet: C) or a mixed grass hay called "khortane" (diet K). All groups received the same quantity (500 g/d per goat) of the same commercial concentrate as supplementation. The total duration of the experiment was 60 days (including 15 days of adaptation), starting at 15 May up to 15 July. The milk production was recorded every day. Individual milk samples were taken from each goat for six weeks. Sixty milk samples for each group was collected in the period of trial were analyzed for their fatty acid composition.

Experiment 2: 18 kids (body weight = 15.85 kg; age = 4.5 months) were divided into two homogeneous groups. Animals received oat hay (control C) or the "khortane" (diet K). All kids received the same quantity (350 g/d per goat) of the same commercial concentrate as supplementation. The feeding trial lasted 210 days. After slaughter, the left half-carcass was cut into six joints following the procedures of Colomer *et al*.(1967).The muscle *Longissimus dorsi* was taken to determine the fatty acid composition.

The "khortane" was composed from 16 annual and perennial species; the specific contribution (SC) was dominated by *Launaea resedifolia*, *Lolium multiflorum* and *Chrysanthemum coronarium.*

Milk fat was extracted according to Murphy *et al*. (1990)and was trans-methylated according to IDF 182:2002/ISO 15884:2002. Meat fat was obtained according to Hara and Radin method, and fatty acid methyl esters were obtained according to Chin *et al*. (1992). Separation and quantification of the methyl esters were carried out using a gas-chromatograph Varian 3600; (100 m x 0.25 mm, 0.25 um phase; Supelco Inc., Bellefonte, CA), equipped with a split/splitless injector and a flame ionization detector. The fatty acid profile of feeds are reported in Table 1.

Table 1. Chemical composition (% dry matter) and fatty acid profile [% total fatty acids methyl esters (FAME)] of supplied feeds

Samples	Oat hay	"Khortane"	Concentrate
Fatty acids (% FAME)			
C16:0	30.35	26.68	15.73
C18:0	5.47	4.09	1.63
C18:1	15.68	5.38	20.67
C18:2	21.00	20.5	55.07
C18:3	12.51	24.33	4.06
SFA	45.99	44.65	18.4
MUFA	17.5	7.64	21.9
PUFA	36.52	47.71	59.7

SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids.

The results of milk and meat fatty acids were submitted to ANOVA ($\alpha = 0.05$). The model included the effects of forage resource (F, 2 levels).Significance of difference (*P<0.05*) between means was determined with Duncan test.

III – Results and discussion

Table 2 shows the results of milk fatty acids composition of control (C) and "khortane" (K) groups. The effect of diet is significant for the majority of identified milk fatty acids (P <0.05). The percentage of saturated fatty acids (SFA) in milk was significantly higher in K than in the C diet (P < 0.01).In milk from Control diet, the highest content of MUFA could be related to the highest content of oleic acid (C18:1 cis9, P< 0.001) which in turn could result either from ruminal biohydrogenation of dietary C18:2, as well as by the direct contribution of C18:1present at high concentration in the ingested oat hay. The high ruminal biohydrogenation of dietary C18:2, in the control group, is also underlined by the highest amount of stearic acid (C18:0) produced in milk respect to the K diet (P< 0.001). PUFA wasslightly higher in milk from K diet than C diet. The higher level of PUFA in the milk from grass hay as a proof of the correlation between floristic composition of "khortane" and a better milk quality. Milk from K fed goat showed the highest (P<0.05) concentration of CLA, as expected due to the high concentration of PUFA, particularly C18:3 acids in the offered "khortane" forage (Table 1).

The ratio n6/n3 in milk from C and K diet was higher than level recommended by the nutritionist (ω6/ω3ratio not exceeding 4).

Results of fatty acids composition of *Longissimus dorsi* muscle are shown in Table 2. Meat from two groups had similar content of saturated fatty acids (SFA). No treatment effect was found for myristic (C14:0), palmitic acid (C16:0) and stearic (C18:0) acid. Meat from K diet showed the highest content of MUFA (47.3 *vs* 46.3%), *P*<0.05). The major mono-unsaturated fatty acids such as: oleic (C18:1 cis-9), vaccenic (C18:1 trans-11) and CLA cis-9, trans-11 acids, were not affected by diet. Although the content of n-3 and n-6 fatty acids were not affected by feed treatment. In particular "khortane", characterized by several pastoral species, is richer in polyunsaturated fatty acids and linolenic acid (Table 1) respect to oat hay, but nevertheless the level of PUFA in *Longissimus dorsi* muscle from goat's kid fed with "khortane" tended to be lower respect to oat hay. Nutritional recommendations are to increase the level of ω3 fatty acids in the diet by focusing on foods with a ω6/ω3 ratio not exceeding 4 (Department of Health, 1994). *Longissimus dorsi* muscle from goat's kid fed with "khortane" had a ω6/ω3 ratio (3.17) below the recommended value. Feeding based on oat hay leads to a ω6/ω3 ratio value slightly greater than the recommended limit.

Table 2. Fatty acid composition in goat milk and in kid meat from C (control) and K ("khortane") groups

	Milk				Meat			
% FAME	**C**	**K**	***SEM***	***P***	**C**	**K**	***SEM***	***P***
C10:0	12.15	13.63	0.307	ns	0.14	0.17	0.16	ns
C12:0	4.66 [b]	5.63 [a]	0.141	**	0.14	0.18	0.17	ns
C14:0	10.02 [b]	11.48 [a]	0.216	**	2.14	2.51	2.45	ns
C16:0	25.93	27.73	0.518	ns	19.65	20.44	20.60	ns
C18:0	6.56 [a]	4.46 [b]	0.245	***	15.31	14.59	15.18	ns
C18:1 11t	0.71	0.81	0.047	ns	2.26	2.35	2.13	ns
C18:1 9c	20.16 [a]	16.14 [b]	0.419	***	1.52	1.44	1.45	ns
C18:1 16c	0.06	0.07	0.004	ns				
C18:2 9c,13t	0.22	0.21	0.008	ns	0.25	0.27	0.25	ns
C18:2 9c12t	0.01[b]	0.08 [a]	0.004	***	0.12	0.13	0.12	ns
C18:2 9t12c	0.08	0.01	0.020	ns	0.02	0.02	0.02	ns
C18:2 11t15c	0.01	0.01	0.015	ns	0.06	0.08	0.07	ns
C18:2 9c12c	1.74 [b]	2.11 [a]	0.060	*	5.73	4.68	5.26	ns
C18:2 9c15c	0.01	0.01	0.022	ns	0.04	0.04	0.04	ns
C18:3 6c,9c,12c					0.04	0.04	0.04	ns
C18:3 9c12c15c	0.27	0.26	0.01	ns	0.46	0.59	0.53	ns
CLA	0.64	0.75	0.033	ns	0.53	0.51	0.51	ns
SFA	72.25 [b]	75.55 [a]	0.505	**	42.14	42.53	43.22	ns
MUFA	24.43[a]	20.76 [b]	0.458	***	46.32 [b]	47.38 [a]	45.68	*
PUFA	3.32	3.69	0.093	ns	11.54	10.09	11.10	ns
n3	0.37	0.34	0.017	ns	2.09	2.26	2.29	ns
n6	2.10 [b]	2.40 [a]	0.063	*	8.68	7.05	8.06	ns
n6/n3	6.33 [b]	7.31 [a]	0.229	**	4.39 [a]	3.17 [b]	3.66	**

[a,b] Means within a row with different superscripts differ significantly; SEM: standard error of mean. C, group control (oat hay); K, grass hay called "khortane"; SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; CLA, conjugated linolieic acids.

IV – Conclusion

In this experiment, we have demonstrated that pastoral feeding "khortane" strongly enhanced the dietetic quality of goat meat compared to conventional feeding (oat hay), particularly by increasing the proportion of CLA and the ratio between n6 and n3 in meat.

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