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The use of linseed and cottonseed to change the milk fatty acid profile in early lactation dairy goats

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SUMMARY – Renewed attention is being paid to the fatty acid (FA) composition of dairy products, because of the benefits of consumption of some long chain fatty acids on human health. The aim of this work was to evaluate the effects of dietary fat supplements on the FA composition of milk from goats in early lactation. Sixteen Sarda breed goats, fed 1.5 kg/day of concentrate and hay *ad libitum,* were divided into two groups: eight goats were supplemented with 32 g/d of fat from linseed (LIN) with a high C18:3 content, while the second group of animals received 32 g/d of fat from cottonseed (COT) with a high C18:2 content. The trial lasted 5 weeks: a 2-week preliminary period (PRE), a 2-week experimental period (EXP) and 1 week of recovery where the fat supplement was removed (REC). The FA profile of the goats' milk was determined by gas chromatography. The milk FA profile did not differ between PRE and REC periods. In the EXP period the milk FA profile was significantly influenced by the fat source. LIN significantly decreased the content of C14:0, C16:0 and the n-6/n-3 ratio more than COT did, whereas it increased the content of t11-C18:1, C18:3 n-3 and c9,t11 conjugated linoleic acid (CLA). As expected the t10,c12 CLA, the C20:5 n-3 (eicosapentaenoic acid, EPA) and C22:6 n-3 (docosahexaenoic acid (DHA) contents were low with both LIN and COT supplements, and did not differ with the two fat sources used. The results suggest that it may be possible to enhance the nutritional value of goat milk fat in early lactation by adding linseed to the diet.

Keywords: Cottonseed, fatty acid, goat milk, linseed.

RESUME – *"Utilisation de graines de lin et de coton pour modifier le profil du lait en acides gras chez des chèvres laitières au premier stade de lactation". Une attention accrue est actuellement portée à la composition en acides gras (AG) des produits laitiers, en raison des bénéfices de la consommation d'acides gras à chaîne longue sur la santé humaine. Le but de ce travail était d'évaluer les effets de suppléments alimentaires de matières grasses sur la composition en AG du lait de chèvres au premier stade de lactation. Seize chèvres de race sarde, recevant 1,5 kg/jour de concentré et du foin* ad libitum*, ont été divisées en deux groupes : huit chèvres étaient supplémentées avec 32 g/j de matières grasses de graines de lin (LIN) ayant une forte teneur en C18:3, tandis que le deuxième groupe d'animaux recevait 32 g/j de matières grasses de graines de coton (COT) ayant une forte teneur en C18:2. L'essai a duré 5 semaines : une période préliminaire de 2 semaines (PRE), une période expérimentale de 2 semaines (EXP) et 1 semaine de récupération où le supplément de matières grasses était supprimé (REC). Le profil en AG du lait des chèvres était déterminé par chromatographie de gaz. Le profil en AG du lait ne différait pas entre les périodes PRE et REC. Sur la période EXP le profil en AG du lait était significativement influencé par la source de matières grasses. LIN réduisait significativement la teneur en C14:0, C16:0 et le ratio n-6/n-3, plus que ne le faisait COT, tandis qu'il augmentait la teneur en t11-C18:1, C18:3 n-3 et c9,t11 acide linoleique conjugué (CLA). Comme espéré, les teneurs en t10,c12 CLA, C20:5 n-3 (acide eicosapentaénoïque, EPA) et C22:6 n-3 (acide docosahexaénoïque, DHA) étaient faibles avec les suppléments LIN et COT, et ne différaient pas selon les deux sources de matières grasses utilisées. Les résultats suggèrent qu'il serait possible d'améliorer la valeur nutritionnelle des matières grasses du lait de chèvre lors du premier stade de lactation en ajoutant des graines de lin à l'alimentation.*

Mots-clés : *Graines de coton, acides gras, lait de chèvre, graines de lin.*

Introduction

Fat supplements are used in the diets of dairy animals in early lactation to increase the energy density. Recently dietary fat supplements have been regarded as important tools for modifying the fatty acid (FA) composition of dairy products. In dairy goats supplementing the diet with free oils from plant and seeds tends to increase unsaturated FA, included conjugated linoleic acid (CLA). This has potential anticarcinogenic, immunomodulating and antiatherosclerotic effects (McGuire and McGuire, 2000). Mir *et al.* (1999) reported a marked increase of milk CLA in goats fed diets supplemented with canola oil. Chilliard *et al.* (2003) observed a substantial increase in the C18:3, CLA and vaccenic acid

(VA) content in the milk fat of goats given dietary supplements of free oil from linseed but no variations were found when whole linseed was used. Cenkvári *et al.* (2004) found a modest increase of linoleic and linolenic acids (by 7.9 and 5.9% respectively) when Ca-soap of linseed was added to the diet of goats. Feeding extruded soybean increased the n-6/n-3 FA ratio and the proportions of oleic, linoleic and linolenic acids in milk fat at the expense of most of the saturated FA (Schmidely and Sauvant; 2001; Schmidely *et al.*, 2005).

The aim of the experiment was to check the effects of dietary supplements from two fat sources, extruded linseed (Linoies, Cortal©) or whole cottonseed, on the milk FA composition in dairy goats in early lactation.

Materials and methods

The trial was carried out on sixteen Sarda breed goats in early lactation. Animals were fed 1.5 kg/day of a complete commercial pellet containing 33% of NDF, 15.5% of CP and based on dried forages, grains, products and by-products of oilseed and sugar industry, mineral and vitamin integrator (50 g/day) and hay *ad libitum* plus a supplement of 160 g/d of extruded linseed (LIN) or 90 g/d of cottonseed (COT). Extruded linseed has high C18:3 n-3 content (52% of total FA) whereas cottonseed has high C18:2 n-6 content (53% of total FA). The quantities of linseed (34% EE) and cottonseed (19.5% EE) chosen supplied the same amount of fat to the animals of two groups (32 g/day). The trial lasted 5 weeks, from day 7 after parturition: a 2 week preliminary period (PRE), without fat supplementation, a 2 week experimental period (EXP), and 1 week where the fat supplements were removed (REC). Because the goats were suckling their kids, the individual milk samples (about 100 ml) were collected weekly in the morning before the kids started to suckle after had been separated the previous night.

Fat from milk was extracted as reported by Nudda *et al.* (2005). Fatty acid methyl ester (FAME) from milk fat were obtained using the methylation procedure of FIL-IDF standard (1999). The chromatographic conditions were as described by Nudda *et al.* (2005). The content of each FA was expressed as a percentage of total FA.

Data were analyzed by ANOVA with a 2×3 model including treatments (LIN, COT) and periods (PRE, EXP, REC) effects and their interaction.

Results and discussion

Overall changes in the composition of individual FA when cottonseed was added to diet were modest (Table 1). Only the C14:0 content was significantly decreased by dietary cottonseed supplements, when compared to PRE period. DePeters *et al.* (1985) found that adding cottonseed to cows diet reduced the synthesis of fatty acids in the mammary gland (C4-C14), and increased C18:0 and C18:1. This tendency was observed in this trial with goats but the difference was not significant.

Compared to PRE period, the linseed supplement markedly influenced the FA profile of the milk fat. The LIN reduced the C14:0, C16:0 and C16:1 concentrations. A similar trend has already been observed with other oil sources (Chilliard *et al.*, 2003). In terms of human health, the decrease of C14:0 and C16:0 marks an improvement in the FA profile of milk because they raise the cholesterol levels (Kris-Etherton and Yu, 1997).

The linseed supplemention significantly increased the C18:3 n-3, overall n-3 FA, and total CLA content. The isomer c9, t11 CLA (Fig. 1) in milk from the LIN group during the EXP period increased twofold compared to the PRE period. The increase in c9,t11 CLA from using linseed supplements was higher than that observed in goats by Chilliard *et al.* (2003) when they used whole or free oil linseed supplements.

The VA was significantly affected by the linseed supplementation. A close relationship between c9,t11 CLA and VA was found in milk ($R^2 = 0.97$). This is consistent with the predominant origin of this CLA isomer, which is the synthesis in the mammary gland from VA via Δ^9-desaturase enzyme (Fig. 2), as has already been reported for sheep (Nudda *et al.*, 2005) and cows (Griinari *et al.*, 2000; Piperova *et al.*, 2002).

Table 1. Fatty acids profile (% of total FA) of milk from goats fed diets containing extruded linseed cake (LIN) or cottonseed (COT)

	Periods†					
	PRE		EXP		REC	
	COT	LIN	COT	LIN	COT	LIN
C6-C12	16.3	16.6	15.3	14.2	15.9	16.0
C14:0	7.24[a]	7.44[a]	6.17[b]	5.32[c]	6.91[a]	6.68[a]
C14:1	0.07	0.08	0.06	0.04	0.07	0.08
C16:0	22.57[a]	23.41[a]	22.88[a]	19.21[b]	22.36[a]	22.97[a]
C16:1	0.67[a]	0.57[a]	0.50[a]	0.36[b]	0.54[a]	0.49[a]
C18:0	13.76	15.30	17.42	17.63	16.24	17.12
C18:1 t11 (VA)	1.41[a]	1.29[a]	2.66[a]	6.59[b]	2.24[a]	1.74[a]
C18:1 c9	26.71	24.81	22.74	20.92	23.39	23.01
C18:1 total	30.71	28.38	28.28	31.20	28.47	27.36
C18:2 total	3.81	3.44	3.82	4.31	3.61	3.45
C18:3 n-6	0.048[e]	0.049[e]	0.078[f]	0.053[e]	0.066[ef]	0.061[ef]
C18:3 n-3	0.84[a]	0.73[a]	0.69[a]	1.60[b]	0.88[a]	0.81[a]
CLA c9,t11	0.65[a]	0. 60[a]	0.91[a]	1.93[b]	0.89[a]	0.72[a]
CLA t10,c12	0.020	0.013	0.018	0.013	0.012	0.009
CLA total††	1.14[a]	1.05[a]	1.38[a]	2.63[b]	1.37[a]	1.19[a]
EPA†††	0.077	0.069	0.062	0.069	0.070	0.077
DHA†††	0.090	0.096	0.070	0.064	0.071	0.088
n-6 total†††	3.99	3.61	3.74	4.36	3.74	3.57
n-3 total††††	1.01[a]	0.90[a]	0.82[a]	1.73[b]	1.02[a]	0.97[a]

†Periods: PRE = no fat supplement; EXP = LIN (linseed) or COT (cottonseed) supplement; REC = recovery (withdrawn of fat supplement).
††The isomers have been summed because the chromatographic condition was not adequate to allow accurate individual quantification.
†††EPA: eicosapentaenoic acid; DHA: docosahexaenoic acid.
††††n-6 total includes C18:2 n-6, C20:3 n-6, C20:4n-6 and C22:4n-6.
†††††n-3 total includes C18:3 n-3, C20:5 n3 (EPA), C22:6 n-3 (DHA).
[a,b,c]P < 0.05; [e,f]P < 0.10.

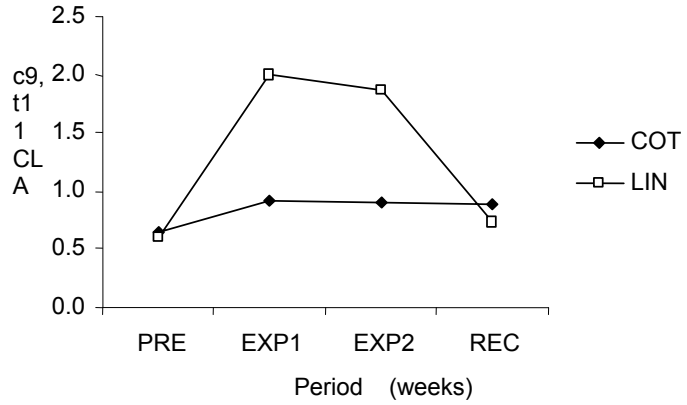

Fig. 1. The concentration of c9,t11 CLA in milk fat of goats fed diets supplemented with linseed (LIN) or cottonseed (COT).

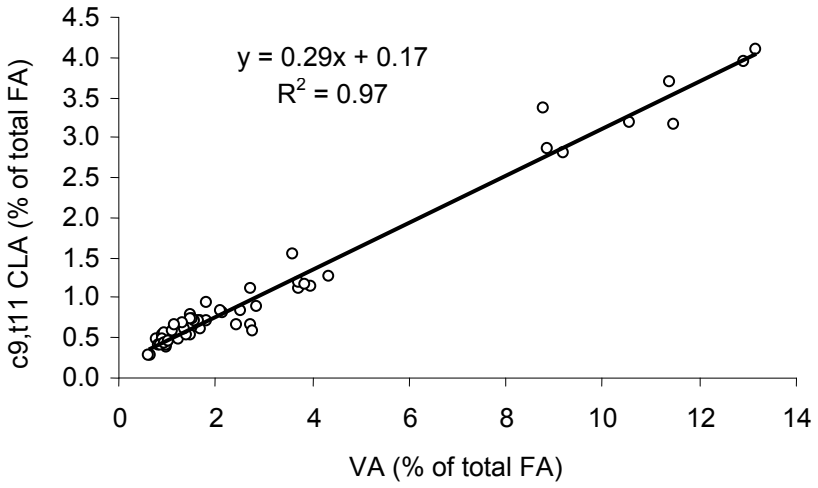

Fig. 2. Relationship between cis9,trans11 CLA and vaccenic acid (VA) in milk from goats.

The EPA and DHA contents, which were extremely low as they are in the milk of all ruminants, were not influenced by the oilseed supplements.

No differences were detected in the FA profile for the PRE and REC periods for either the LIN or COT groups. This indicated that when the fat supplements were withdrawn the FA profile returned to that observed before the addition of fat.

Conclusions

The addition of cottonseed as a fat supplement to the diet of goats in early lactation did not modify the FA profile of the milk. The use of linseed supplement markedly influenced the fatty acid profile of the milk fat. Linseed supplement increased the unsaturated FA such as VA, c9,t11 CLA and C18:3 n-3 contents and reduced the C14:0 and C16:0 concentration. Extruded linseed was shown to be a valuable supplement which improves the nutritional value of goat milk fat.

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