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Effects of ewe feeding system (grass *vs* concentrate) on milk fatty acid composition

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SUMMARY – The aim of this work was to investigate whether and how the feeding system could affect ewe milk fatty acids. Twenty pregnant Comisana ewes were divided into two groups of ten one month before lambing and allowed two different feeding systems: Pasture group (P) grazed on a vetch pasture; Stall group (S) was given hay, a commercial concentrate and a mixture of barley and faba bean. After lambing, individual milk samples were taken weekly and analysed for fatty acid composition. The trial went on for 38 days. Milk from P ewes was poorer in lauric (C12:0), myristic (C14:0) and palmitic (C16:0) acids than milk from S ewes ($P < 0.05$, $P < 0.001$ and $P = 0.001$ respectively). Trans-vaccenic acid (C18 :1 *trans*11) was significantly higher ($P < 0.001$) in milk from P animals compared to S ewes. Linoleic acid (C18:2 n-6) tended to be higher ($P = 0.06$) in milk from S ewes while linolenic acid (C18:3 n-3) was significantly higher ($P < 0.001$) in milk from P animals (1.72 *vs* 0.79% total fatty acids). Conjugated linoleic acid (C18:2 *cis*9, *trans*11) was almost double in milk from P ewes compared to S animals (2.53 *vs* 1.33% total fatty acids, $P < 0.001$). The ratio between linoleic and linolenic acids was higher ($P = 0.001$) in milk from stall-fed ewes.These results indicate that the ewe feeding system strongly affects milk fatty acid profile and, particularly, that grass feeding enhances milk dietetic quality.

Keywords: Concentrate, ewe, milk, pasture, fatty acids.

***RESUME –** "Effet du régime alimentaire (pâturage* vs *concentré) sur la composition en acides gras du lait de brebis". L'expérience a visé à rechercher si et comment le régime alimentaire peut influencer la composition en acides gras du lait de brebis. Vingt brebis gestantes de race Comisana ont été séparées en deux groupes un mois avant la naissance des agneaux pour recevoir deux régimes alimentaires différents : le groupe Pâturage (P) a pâturé une prairie de vesce; le groupe Concentré (S) a été alimenté avec du foin, du concentré commercial et un mélange d'orge et de fèves. A partir de la mise bas, un échantillon de lait de chaque brebis a été prélevé chaque semaine et analysé. Le lait du groupe P était moins riche en acides gras laurique (C12:0), myristique (C14:0) et palmitique (C16:0) que le lait du groupe S (P < 0,05, P < 0,001 et P = 0,001 respectivement). La teneur en acide vaccénique (C18 :1 trans11) a été significativement plus élevée dans le lait du groupe P que dans le lait du groupe S (P < 0,001). La teneur en acide linoléique (C18:2 n-6) a eu tendance à être plus élevée (P = 0.06) dans le lait du groupe S que dans le lait du groupe P. Par contre, la teneur en acide linolénique (C18:3 n-3) a été significativement plus élevée dans le lait du groupe P que dans le lait du groupe S (1,72* vs *0,79% des acides gras totaux, P < 0,001). L'acide linoléique conjugué (C18:2 cis9, trans11) a été presque doublé (2,53* vs *1,33% des acides gras totaux) dans le lait du groupe P par rapport au lait du groupe S. Ces résultats indiquent que le régime alimentaire des brebis a un effet important sur la composition en acides gras du lait et que l'alimentation au pâturage en particulier améliore la qualité nutritionnelle du lait.*

***Mots-clés :** Concentré, brebis, lait, pâturage, acides gras.*

Introduction

Dietetic quality of animal products, meat and milk, has become subject of several researches. It has been demonstrated the possibility to enhance meat and milk quality by adopting an extensive management, based on the grass feeding system, rather than an intensive one. Pasture seems to be a good means to naturally manipulate the fatty acid composition of both milk (Shingfield *et al*., 2005) and meat (Purchas *et al*., 2005).

However, most of studies on milk regard the effect of pasture on cow milk (Chilliard *et al*., 2000;

Shingfield *et al*., 2005). To our knowledge, there are very few reports on the effects that ewe feeding system (grass *vs* concentrate) has on milk fatty acids. Dietetic quality of ewe milk could be influenced by seasonal and ambient conditions (Banni *et al*., 1996), by dry matter intake at pasture (Cabiddu *et al*., 2001; Avondo *et al*., 2002) and by forage species (Addis *et al*., 2005). Furthermore, it is thought that probably exists also an "animal species effect" on milk quality. Indeed, ewe milk, compared with milk produced by cows and goats fed in a similar way, can be richer in conjugated linoleic acid (CLA) and trans-vaccenic acid (Jahreis *et al*., 1999). Therefore the interaction between the species, ovine, and the feeding system, pasture, could be the better way to improve dietetic quality of ewe productions.

Among all mentioned variables affecting milk fatty acids, we focused our study on the relationship between the feeding system and the fatty acid profile in ewe milk. Furthermore we considered the effect of a specific forage species on ewe milk quality. To study these aspects we compared grass-fed to concentrate-fed animals.

Materials and methods

Animal management

Twenty pregnant Comisana ewes were selected one month before lambing and divided into two groups of 10 animals. The first group of ewes was allowed to graze a monocultural pasture of vetch (*Vicia sativa*) (Pasture group, P). The second group of animals was penned in a collective box and was given hay (1.3 kg/head/d; as fed), a commercial concentrate (0.5 kg/head/d; as fed) and a mixture of barley and faba bean (0.5 kg/head/d; as fed) (Stall group, S). The feeding system remained the same for all the duration of the trial. After parturition lambs were divided in the respective groups (pasture or stall) and were allocated in two different multiple boxes. Lambs were fed only with maternal milk. They were allowed to stay with dams in their boxes between 18:00 and 07:00 of the following day. The experiment went on for 38 days, till lambs slaughtering.

Feed sampling and analyses

Once a week, a sample of grass was taken by cutting it at 3 cm above the ground. The sampling was made taking a surface of 200 cm^2 of grass 100 times per ha at equal distance (i.e. 10 m). For each food given in stall, two samples were taken, one at the beginning and one at the end of the trial, then collected in one sample for analysis. All the samples were analysed for fatty acids as reported by Sukhija and Palmquist (1988). Neutral detergent fibre (NDF; Van Soest *et al*., 1991) and crude protein (CP; Association of Official Analytical Chemists, 1995) of the feeds were also determined.

Milk fatty acid composition

Individual milk samples were taken from each ewe one week after parturition and once per week for the following three weeks. They were taken in the afternoon milking after 8 hours on pasture without lambs and stored at -20°C until the end of the trial. At the time of analysis, the milk was thawed for 24 h at 4°C, homogenized by a manual mixing and, for each ewe, a bulked sample was obtained by mixing 40 ml of milk from each of the four samplings. The fatty acid profile of milk fat was determined by Gas-Chromatograph as fatty acids methyl esters (FAMEs). We applied the modified procedure of Sukhija and Palmquist (1988) as described by Tice *et al*. (1994). Fatty acids were expressed as g/100 g of methyl esters.

Results and discussion

The chemical composition of feeds and the fatty acid profile of both feeds and milk are reported in Tables 1 and 2 respectively.

Table 1. Chemical composition (g/kg dry matter) and fatty acid profile (g/100g total fatty acids) of feeds consumed by ewes

	Vetch pasture	Hay	Commercial concentrate	Barley	Faba
Chemical composition					
Dry matter (g/kg)	156	612	891	836	839
Crude protein	211	108	191	102	263
Ether extract	21	17	78	19	13
Neutral-detergent fibre	366	624	270	380	360
Fatty acid					
C12:0	1.80	1.40	0.03	0.20	0.13
C14:0	0.71	1.12	0.12	1.22	0.43
C16:0	13.45	18.33	11.60	22.55	13.62
C16:1	0.17	0.45	0.15	0.45	0.13
C18:0	2.35	4.31	3.64	5.70	2.77
C18:1 *cis*9	3.47	8.29	19.10	12.50	22.23
C18:2 n-6	14.03	16.98	51.65	48.21	48.44
C18:3 n-6	0.76	0.35	0.10	0.20	2.75
C18:3 n-3	63.26	48.77	13.62	8.98	9.52
SFA†	18.31	25.16	15.39	29.67	16.95
MUFA†	3.64	8.74	19.25	12.95	22.36
PUFA†	78.05	66.10	65.37	57.39	60.71

†SFA = sum of ($C_{12:0}$ + $C_{14:0}$ + $C_{16:0}$ + $C_{18:0}$); MUFA = sum of ($C_{16:1}$ + $C_{18:1\ cis9}$); PUFA = sum of ($C_{18:2\ n\text{-}6}$ + $C_{18:3\ n\text{-}6}$ + $C_{18:3\ n\text{-}3}$).

Table 2. Effect of ewes feeding system on main milk fatty acids (g/100g total fatty acids)

Feeding system	Pasture	Stall	S.E.M.	P-value
No. of ewes	10	10		
C4:0	5.82	5.70	0.149	0.706
C6:0	5.73	5.91	0.172	0.609
C8:0	5.06	5.05	0.113	0.976
C10:0	10.15	11.33	0.388	0.134
C12:0	5.47	5.97	0.123	0.037
C14:0	9.11	10.29	0.184	0.000
C16:0	17.10	19.16	0.352	0.001
C18:0	9.14	8.86	0.294	0.645
C18:1 *trans*11	1.72	0.79	0.140	0.000
C18:1 *cis*9	15.58	14.52	0.411	0.204
C18:2 n-6	3.00	4.02	0.278	0.063
C18:3 n-3	4.87	3.56	0.188	0.000
C18:2 *cis*9, *trans*11	2.53	1.33	0.151	0.000
C18:2 n-6/C18:3 n-3	0.61	1.14	0.086	0.001
SFA†	67.58	72.27	0.757	0.000
MUFA†	17.30	15.31	0.456	0.000
PUFA†	10.40	8.91	0.359	0.006

†SFA = sum of ($C_{4:0}$ + $C_{6:0}$ + $C_{8:0}$ + $C_{10:0}$ + $C_{12:0}$ + $C_{14:0}$ + $C_{16:0}$ + $C_{18:0}$); MUFA = sum of $C_{18:1\ trans11}$ + $C_{18:1\ cis9}$); PUFA = sum of ($C_{18:2\ n\text{-}6}$ + $C_{18:3\ n\text{-}3}$ + $C_{18:2\ cis9,\ trans11}$).

Pasture group grazed on a young pasture as results from its content of crude protein and NDF (Table 1). Vetch pasture presented the higher proportion of polyunsaturated fatty acids (PUFA), particularly of linolenic acid. On the contrary, feeds consumed by S group were richer in saturated fatty acids (SFA), particularly barley and hay. The commercial concentrate presented lower SFA than the vetch pasture. The highest level of palmitic acid (C16:0) was found in barley. Among PUFA, the highest level in linoleic acid was found in concentrates given to S ewes.

Regarding milk fatty acid composition, ewes fed pasture produced a milk with a lower ($P<0.001$) percentage of SFA and a higher percentage of PUFA ($P<0.01$) than ewes given concentrates.

Milk saturated fatty acids

Within SFA, lauric (C12:0), myristic (C14:0) and palmitic (C16:0) acids were higher in milk from S ewes than in milk from P ewes ($P<0.05$, $P<0.001$ and $P = 0.001$ respectively). This result is probably linked to the fatty acid profile of ewes'diet (Table 1). In fact, barley and hay had higher proportions of palmitic and myristic acids than vetch pasture. There were not significant differences among the two treatments for stearic acid (C18:0).

The lower proportion of SFA in milk from grazing ewes attests the higher healthiness of this product compared to milk produced by ewes given concentrates. SFA are included among the main factors responsible for cardio-vascular diseases. Literature has demonstrated that there is a strong link between the risk of cardio-vascular diseases and the consumption of dairy products (Warensjo *et al*., 2004). Therefore the production of milk poorer in SFA should become one of the main target in the field of animal production.

Milk polyunsaturated fatty acids

The higher level of PUFA in the milk from grazing ewes stands as a proof of the correlation between pasture diet and a better milk quality. According to Chilliard *et al*. (2000), PUFA are not synthesized by ruminant tissues, therefore their concentration in milk depends firstly on the PUFA content of the diet and secondly on the amount of PUFA which escapes ruminal biohydrogenation. In our experiment, the use of vetch pasture led to a higher intake of α-linolenic acid, a precursor of n-3 PUFA, and therefore to the production of a milk richer in this fatty acid. On the contrary milk from S ewes tended to be richer in linoleic acid (C18:2 n-6) than milk from S ewes ($P = 0.06$).

Conjugated linoleic and trans-vaccenic acids

Conjugated linoleic acid (C18:2 *cis*9, *trans*11; CLA) was almost double in milk from grass-fed ewes than in milk from animals given concentrates ($P<0.001$). Several studies on cow milk have demonstrated that grass feeding system enhances milk CLA proportion (Jahreis *et al*., 1997; Shingfield *et al*., 2005), particularly when forages are at an early growth stage (Chouinard *et al*., 1998). CLA was present in the milk from both groups because it is a product of endogenous formation. It originates from the ruminal biohydrogenation of linoleic and linolenic acids (Chilliard *et al*., 2000) and from the desaturation of trans-vaccenic acid (C18:1 *trans*11) in mammary gland (Corl *et al*., 2001). The grass feeding system increases the proportion of milk CLA by acting on both ways of formation. Firstly, grazing animals ingest high quantities of α-linolenic acid that is positively correlated with the proportion of CLA in milk (Cabiddu *et al.,* 2001). Secondly, there is a higher production of trans-vaccenic acid in the rumen of grazing animals and therefore a stronger flow to mammary gland. Indeed, in our experiment, the concentration of trans-vaccenic acid was more than doubled in the milk from grazing ewes than in the milk from stall-fed animals ($P<0.001$). Shingfield *et al*. (2005) thought that the low quantity of CLA in the milk from stall-fed ruminants could be due to a shift in ruminal biohydrogenation resulting in a lower production of C18:1 *trans*11 and in a higher production of C18:1 *trans*10.

Conclusions

In this experiment, we have demonstrated that a vetch-based pasture feeding strongly enhanced the dietetic quality of ewe milk compared to concentrate-feeding, particularly by increasing the proportion of CLA and by lowering both SFA content and the ratio between linoleic and linolenic acids. Taking into account that ewe milk is generally used as cheese and ricotta and that milk transformation does not influence the CLA content of dairy products (Luna *et al*., 2005), grass feeding could probably become a means to improve the dietetic characteristics of sheep dairy products.

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