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Whole extruded linseed in the diet of dairy ewes during early lactation: effect on the fatty acid composition of milk and cheese

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ABSTRACT: In a long term supplementation trial (10 weeks), the effects of the inclusion of whole extruded linseed in the diet of dairy ewes on milk and cheese fatty acid composition were evaluated. Two groups of 24 Sarda ewes in early lactation were randomly assigned to control concentrate (800 g/d concentrate, C) or whole extruded linseed concentrate (L, 700 g/d, with 30% of extruded linseed, Omega-Lin®). Results showed that, after 2 weeks on the L diet, the milk content of unsaturated fatty acid (UFA), including rumenic acid (RA), vaccenic acid (VA) and alfa-linolenic acid (ALA) increased sharply compared to C group, reaching the highest levels after 7-8 weeks (3.06, 7.31 and 2.31 g/100 g milk fat for RA, VA and ALA, respectively). During the last 2 weeks of the experimental period, when pasture was included in the diet of both groups, the content of the above fatty acids slightly decreased in milk from L group, whereas in milk from C group increased. Nevertheless, the average content of these fatty acids in milk from L group remained significantly higher than that of milk from C group. Compared with the control, the L diet resulted in a significant reduction (-17%) in the concentration of saturated fatty acid in milk. The fatty acid content of the cheese obtained from milk of the two groups reflected the milk fatty acid composition. The inclusion of extruded linseed in the diet of dairy ewes improved the nutraceutical properties of milk and cheese, but further researches are needed in order to better understand the relationship between basal diet and lipid supplementation in dairy ewes.

Key words: Extruded linseed, CLA, Milk, Ewe.

INTRODUCTION – Conjugated linoleic acid is a generic term used to describe single or mixtures of positional and geometric isomers of C18:2 fatty acids containing a conjugated double bond. *Cis*-9, *trans*-11 CLA (namely rumenic acid, RA) has been associated with anticarcinogenic activity in *in vitro* and in animal models studies. In light of the potential benefits to human health, there is considerable interest in developing nutritional strategies to enhance milk fat RA content. The RA concentration in milk fat can be increased several fold by feeding of fresh pasture or by the addition of plant and marine oil supplements to typical dairy rations. Use of such strategies has allowed for the production of RA-enriched products. However, several studies have reported that the response of milk RA content in dairy cow to dietary lipid supplementation appeared transitory and decreased over time (Shingfield *et al.*, 2006). On the other hand, studies on the use of lipid supplementation in the diet of dairy sheep are very limited compared with dairy cows, and results are referred to short time period supplementation (Mele *et al.*, 2006; Zhang *et al.*, 2006a). Aim of this work was to study the response of milk fatty acid composition, including RA, to dietary supplementation of whole extruded linseed over a 70 days period, during early lactation in Sarda ewes.

MATERIAL AND METHODS – Two groups of 24 Sarda ewes in early lactation (after lamb weaning) maintained in a commercial dairy herd were randomly assigned to control concentrate (800 g/d, C) high in non struc-

tural carbohydrates (32.7% on dry matter basis) or extruded linseed concentrate (L, 700 g/d, with 30% of extruded linseed, Omega-Lin®). The forage basis of the two diets was identical (grass hay *ad libitum* supplemented). Concentrate intake was daily individually controlled, while forage intake was controlled as group intake. The energy and protein concentration of the two diets was similar (233 g/d of metabolizable protein and 0.88 UFL/kg on dry matter basis for both diets). The whole experimental period lasted 10 weeks from the end of January to the end of March 2006. During the first 6 weeks pasture was not available, as a consequence of the low environmental temperature and the diets were composed only by concentrate and grass hay. In the last part of the experimental period, both groups grazed a pasture composed by a mixture of *Avena sativa*, *Lolium italicum* and *Trifolium repens* for 4 hour/day. Individual milk samples were weekly collected, while cheese was twice produced: at the middle and at the end of the experimental period. Fat from milk and cheese was extracted and analysed for fatty acid composition, according to Secchiari *et al.* (2003). Data were analysed according to a mixed linear model with diet, time of sampling and diet x time of sampling as fixed factors and lactation as random factor (48 individual lactation), that accounted for variation associated with each particular lactation (SAS, 1999).

RESULTS AND CONCLUSIONS – Dietary supplementation with extruded linseed resulted in marked alterations in milk fatty acid composition relative to control diet, changes that were characterized as a reduction in saturated fatty acids (SFA) and an increase in *trans* fatty acids (TFA), monounsaturated fatty acids (MUFA), and polyunsaturated fatty acids n-3 (mainly alfa-linolenic acid, ALA) (table 1). Concentrations of RA, vaccenic acid (VA), increased sharply after 2 weeks on the L diet, reaching the highest levels of enrichment after 7-8 weeks (3.06, 7.31 g/100 g milk fat for RA and VA, respectively). During the last 2 weeks, when pasture was included in the diet of the both groups, the content of RA, VA and ALA slightly decreased in milk from L group while increased in milk from C group (table 1 and figure 1). Nevertheless, the average content of these fatty acids in milk from L group remained significantly higher than that of milk from C group. The average level of enrichment in RA, VA, and ALA was consistent with those derived in a previous study examining the effect of increasing concentrations of whole untreated linseed in the diet of dairy sheep (Zhang *et al.*, 2006b). In dairy cows, milk fat RA and VA responses to lipid supplementation were reported to be transitory and decreased over time (Shingfield *et al.*, 2006), probably as a consequence of changes in ruminal biohydrogenation processes.

Table 1. Temporal changes of selected fatty acid composition in milk from ewes fed control (C) or extruded linseed (L) diet.

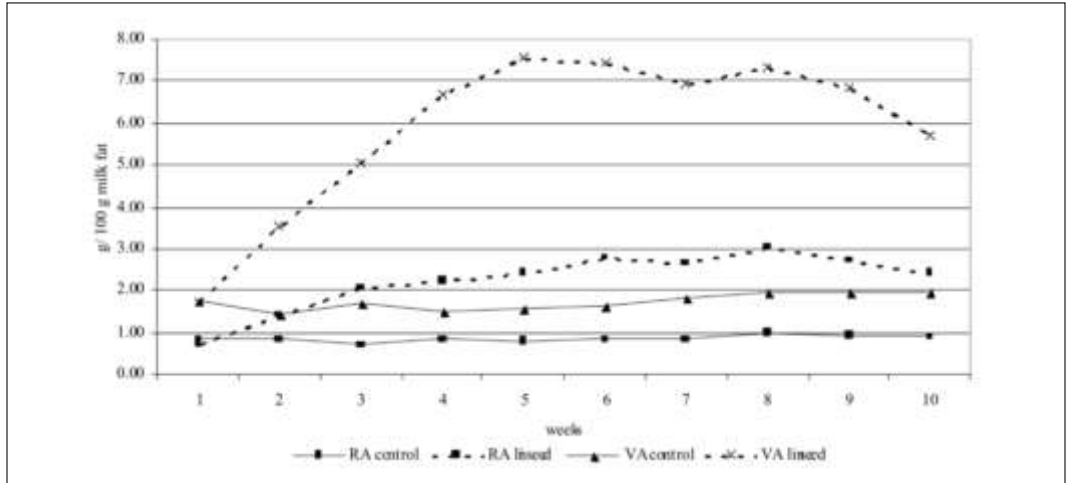
	Diet	weeks										SE
		1	2	3	4	5	6	7	8	9	10	
SFA	C	52.39	51.26 ^A	58.20 ^A	54.02 ^A	53.47 ^A	54.93 ^A	55.41 ^A	52.44 ^A	54.58 ^A	55.64 ^A	0.62
	L	53.36	46.74 ^B	45.27 ^B	46.68 ^B	43.40 ^B	41.15 ^B	43.58 ^B	41.59 ^B	44.37 ^B	45.56 ^B	
MUFA	C	26.00	26.27 ^A	20.73 ^A	24.13 ^A	22.62 ^A	23.97 ^A	22.17 ^A	22.47 ^A	24.61 ^A	20.88 ^A	0.45
	L	24.62	30.36 ^B	30.78 ^B	29.29 ^B	30.31 ^B	31.34 ^B	28.99 ^B	29.79 ^B	31.27 ^B	28.46 ^B	
TFA	C	3.30	2.90 ^A	3.60 ^A	3.29 ^A	3.57 ^A	3.60 ^A	4.08 ^A	4.29 ^A	4.20 ^A	4.35 ^A	0.21
	L	3.31	6.47 ^B	8.52 ^B	10.55 ^B	11.59 ^B	11.41 ^B	10.69 ^B	11.00 ^B	10.73 ^B	9.43 ^B	
PUFA n-6	C	2.19	2.60	2.14	2.53	2.57	2.53	2.52	2.40	2.24	2.12	0.05
	L	2.10	2.65	2.22	2.32	2.46	2.36	2.38	2.40	2.21	2.19	
ALA	C	0.80	0.68 ^A	0.76 ^A	0.65 ^A	0.64 ^A	0.72 ^A	1.14 ^A	1.16 ^A	1.24 ^A	1.00 ^A	0.04
	L	0.76	2.07 ^B	1.90 ^B	1.94 ^B	2.00 ^B	2.01 ^B	2.31 ^B	2.25 ^B	1.95 ^B	1.82 ^B	
PUFA n-3	C	0.95	0.88 ^A	0.91 ^A	0.83 ^A	0.83 ^A	0.90 ^A	1.31 ^A	1.34 ^A	1.44 ^A	1.15 ^A	0.05
	L	0.90	2.25 ^B	2.07 ^B	2.13 ^B	2.18 ^B	2.18 ^B	2.49 ^B	2.43 ^B	2.13 ^B	1.97 ^B	
n-6/n-3	C	2.32	2.99 ^A	2.39 ^A	3.13 ^A	3.15 ^A	2.85 ^A	1.97 ^A	1.84 ^A	1.62 ^A	1.85 ^A	0.04
	L	2.31	1.24 ^B	1.08 ^B	1.11 ^B	1.15 ^B	1.09 ^B	0.97 ^B	0.99 ^B	1.05 ^B	1.12 ^B	

SFA: saturated fatty acids; MUFA: monounsaturated fatty acids; TFA: trans fatty acids; PUFA: polyunsaturated fatty acids; ALA: alfa-linolenic acid.

Values with different letters within same columns are significantly different (A,B=P < 0.01).

In the current study, the L diet caused a rapid increase in milk fat RA and VA content, and the level of the enrichment was maintained over 8 weeks (figure 1).

Figure 1. Temporal changes of rumenic acid (RA), vaccenic acid (VA) in milk from ewes fed control or extruded linseed diet.



The slight decrease observed in the last part of the experiment was probably due to the change of basal diet as a consequence of the inclusion of pasture. Interestingly, although pasture represent a dietary source of ALA that has been shown to increase milk fat RA, VA and ALA in dairy ewes (Addis *et al.*, 2005), in the present experiment there was a lack of response that requires further investigation. On the other hand, Kay *et al.* (2004) previously reported the failure of plant oil supplements to increase the concentration of RA in milk fat from pasture-fed cows.

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