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Changes in milk fatty acid profile and animal performance in response to fish oil supplementation, alone or in combination with sunflower oil, in dairy ewes

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ABSTRACT

Ruminant diet supplementation with sunflower oil (SO) and fish oil (FO) has been reported as a good strategy for enhancing some milk fat compounds such as conjugated linoleic acid (CLA) and n-3 polyunsaturated fatty acids in dairy cows, but no information is available regarding dairy sheep. In this work, ewe diet was supplemented with FO, alone or in combination with SO, with the aim of improving milk nutritional value and evaluating its effect on animal performance. Sixty-four Assaf ewes in mid lactation, fed a high-concentrate diet, were distributed in 8 lots of 8 animals each and assigned to 4 treatments (2 lots/treatment): no lipid supplementation (control) or supplementation with 20 g of SO/kg (SO), 10 g of FO/kg (FO), or 20 g of SO plus 10 g of FO/kg (SOFO). Milk production and composition, including a complete fatty acid profile, were analyzed on d 0, 3, 7, 14, 21, and 28 of treatments. Supplementation with FO tended to reduce dry matter intake compared with the control treatment (−15%), and its use in combination with SO (SOFO) resulted in a significant decrease in milk yield as well (−13%). All lipid supplements reduced milk protein content, and FO also reduced milk fat content by up to 21% alone (FO) and 27% in combination with SO (SOFO). Although the mechanisms involved in FO-induced milk fat depression are not yet well established, the observed increase in some milk *trans*-FA that are putative inhibitors of milk fat synthesis, such as *trans*-9,*cis*-11 CLA, and the 63% decrease in C18:0 (consistent with the theory of reduced milk fat fluidity) may be involved. When compared with the control, lipid supplementation remarkably improved the milk content of rumenic acid (*cis*-9,*trans*-11 CLA; up to 4-fold increases with SO and SOFO diets), whereas FO-containing diets also increased milk n-3 polyunsaturated fatty acids, mainly docosahexaenoic acid (with mean contents of 0.29 and 0.38% of total fatty acids for SOFO and FO, respectively), and reduced the n-6:n-3 FA ratio to approximately half the control value. All lipid supplements resulted in high levels of some *trans*-FA, mainly *trans*-11 C18:1 (vaccenic acid) but also *trans*-10 C18:1.
Key words: conjugated linoleic acid, milk fat depression, n-3, sheep

INTRODUCTION

Marine lipids are rich in long-chain n-3 polyunsaturated fatty acids (**PUFA**) that, as potent inhibitors of *trans*-C18:1 ruminal reduction, promote the outflow of *trans*-11 C18:1 (vaccenic acid, **VA**), that is subsequently desaturated to *cis*-9,*trans*-11 C18:2 (rumenic acid, **RA**) in the mammary gland (Lock and Bauman, 2004). A combination of a high linoleic vegetable oil such as sunflower oil (**SO**), substrate for VA formation in the rumen, and marine lipids, such as fish oil (**FO**), is then considered a good nutritional strategy for enhancing *cis*-9,*trans*-11 conjugated linoleic acid and n-3 PUFA in milk fat (Palmquist and Griinari, 2006; Shingfield et al., 2006). Although FO inclusion in dairy cow diets has been associated with milk fat depression (**MFD**), initial objections to fat reduction have been put aside by consumers' increasing interest in healthier food products (Lock and Bauman, 2004; Shingfield et al., 2008) and the decreasing market value of milk fat, as well as the additional benefits to animal health (Griinari and Bauman, 2006). However, in contrast to dairy cow milk, ovine milk is almost entirely destined to cheese production and decreases in the solid fractions or alterations to the fat:protein ratio caused by lipid supplementation may have a negative effect on cheese yield and quality (Bocquier and Caja, 2001). Notwithstanding, some authors have reported that sheep seem less prone to MFD than cows when fed high-concentrate diets plus free vegetable oils (Pulina et al., 2006; Hervás et al., 2008).

Despite the promising results obtained for lipid inclusion in dairy ewe diets (Pulina et al., 2006) and the ample background about FO supplementation in dairy cows (Doreau and Chilliard, 1997; Palmquist and Griinari, 2006; Shingfield et al., 2006), few stud-

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Table 1. Ingredients and chemical composition of the experimental diets[1]

Item	Control	SO	FO	SOFO
Ingredient (g/kg of fresh matter)				
Dehydrated alfalfa hay (particle size >4 cm)	200	196	198	194
Whole corn grain	250	245	247	242
Soybean meal	200	196	198	194
Whole barley grain	150	147	149	146
Beet pulp	90	88	89	87
Molasses	65	64	64	63
Salts[2]	40	39	40	39
Minerals and vitamins[3]	5	5	5	5
Sunflower oil[4]	0	20	0	20
Fish oil[5]	0	0	10	10
Chemical composition (g/kg of DM)				
OM	893	891	891	892
CP	205	208	203	203
NDF	226	222	220	219
ADF	125	121	122	120
Ether extract	31	54	41	67

[1]Diets: control = with no oil supplementation; SO = supplemented with 20 g of sunflower oil/kg of fresh matter); FO = supplemented with 10 g of fish oil/kg of fresh matter; SOFO = supplemented with 20 g of sunflower oil plus 10 g of fish oil/kg of fresh matter.

[2]Contained: $NaHCO_3$ (375 g/kg), $CaCO_3$ (350 g/kg), Ca_2HPO_4 (150 g/kg), and mine salt (125 g/kg).

[3]INA OV1 (Evialis, Madrid, Spain).

[4]Contained (% total fatty acid methyl esters): C16:0 (7.5), C18:0 (4.3), C18:1 (26.3), and C18:2 (60.5).

[5]Semirefined tuna and sardine oil (Afampes 121 DHA, Afamsa, Vigo, Spain); contained (% total fatty acid methyl esters): C16:0 (21.4), C18:0 (5.9), C18:1 (14.9), C18:2 (1.7), C20:5 n-3 (6.3), and C22:6 n-3 (17.8).

ies have examined the effects of FO inclusion in the diet of lactating ewes (Kitessa et al., 2003; Capper et al., 2007) and, to date, the study by Reynolds et al. (2006) provides the only available information about diet supplementation with marine lipids (marine algae biomass oil) plus a high linoleic vegetable oil (soybean oil) in this species. On this basis and taking into account our previous works (Gómez-Cortés et al., 2008a; Hervás et al., 2008), we hypothesized that the combined use of SO and FO would result in a healthier milk fatty acid (**FA**) profile in dairy ewes, with the potential to increase CLA and n-3 PUFA concentrations. Therefore, this work was conducted with the aim of studying the effects of diet supplementation with FO, SO, and their combination (**SOFO**) on animal performance and milk FA composition in dairy ewes.

MATERIALS AND METHODS

Animals and Experimental Diets

Sixty-four multiparous Assaf ewes (BW = 86.4 ± 1.21 kg) in mid lactation (at wk 12 at the beginning of the experiment) were used. The ewes were distributed in 8 lots of 8 animals each, balanced for milk yield, BW, days postpartum, and number of lactation, and allocated at random to 4 experimental treatments (2 lots per treatment): control, supplemented with SO, supplemented with FO, and supplemented with SOFO.

The diets, prepared in a feed mixer every week, consisted of a TMR based on alfalfa hay and a concentrate with no supplementation (control) or supplemented with 20 g of SO/kg of fresh matter (SO diet), 10 g of FO/kg of fresh matter (FO diet), and 20 g of SO plus 10 g of FO/kg of fresh matter (SOFO diet). The ingredients and chemical composition of the 4 experimental diets, which included molasses to avoid selection of dietary components, are given in Table 1. During a 3-wk adaptation period (before the beginning of the trial), all the animals received the control diet. Clean water and a vitamin and mineral supplement were always available and fresh diets were offered daily ad libitum at 0900 and 1900 h.

The ewes were milked at approximately 0830 and 1830 h in a 1 × 10 stall milking parlor (DeLaval, Madrid, Spain). The experiment lasted for 4 wk and was carried out in accordance with Spanish Royal Decree 1201/2005 for the protection of animals used for experimental purposes.

Measurements, Sample Collection, and Chemical Analyses

Samples of offered and refused diets were collected once a week, stored at −30°C, and then freeze-dried. The DMI was therefore recorded weekly for each experimental lot. Samples were analyzed for DM (ISO, 1999a), ash (ISO, 2002a), and CP (ISO, 2005). Neutral