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Time-dependent variations in milk fatty acid content of goats fed 3 different plant oils

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ABSTRACT

The effect of sampling time on milk fatty acid (FA) composition after separately adding 3 plant oils to an oil-free control diet (67% cereal-soybean-based concentrate and 33% alfalfa hay) was studied in 12 Malagueña goats. Individual animals were randomly allocated to 1 of the 4 treatments: control, 48 g/d of added high oleic (OSO) or regular (RSO) sunflower oil, or linseed oil (LO). Individual milk samples were taken at 0 (covariate), 1, 12, 24, 72, 120, 192, 312, and 504 h after the beginning of the experiment. Milk FA contents (g/100 g of total FA methyl esters) were analyzed in a completely randomized design with repeated measures using PROC MIXED of SAS (SAS Institute Inc., Cary, NC). Comparing results of 15 chosen FA (for example, medium-chain saturated FA *trans*-11 C18:1, *cis*-9,*trans*-11 C18:2, *trans*-10 C18:1, and C18:3n-3) indicated that throughout the duration of the experiment, feeding the control diet had little influence on the concentrations of most FA in milk. Most changes in milk FA composition due to oil supplementation had occurred within 192 h since the beginning of the experiment. However, the concentrations of 2 FA (*trans*-10 C18:1 in RSO and C18:3n-3 in LO treatments) continued to change until 504 h. By comparing FA values in milk fat from oil treatments with those of the control at the same sampling times, typical value differences for the 3 supplementary oils found at 504 h (21 d) were also observed at 312 h from the beginning of the experiment (13 d) and even earlier in some FA, such as medium-chain saturated FA at 120 h in RSO and LO and at 72 h in OSO, *cis*-9,*trans*-11 C18:2 and *trans*-10 C18:1 at 24 h in RSO, *trans*-11 C18:1 at 12 h in RSO and LO, and C18:3n-3 at 1 h in LO. In the conditions assayed in these experiments, reliable results of milk FA changes were obtained at sampling times shorter than 21 d. Monitoring early changes in milk FA after the addition of plant oils to diets could help in the study of rumen and mammary metabolism of dietary FA.
Key words: plant oil, fatty acid, goat milk, sampling time

INTRODUCTION

There is a scarcity of information dealing with the kinetics of milk FA composition responses to plant oil inclusions in the diet of dairy ruminants. Most information corresponds to work carried out with cows (Dhiman et al., 2000; Roy et al., 2006) and ewes (Gómez-Cortés et al., 2008a,b; Hervás et al., 2008). To our knowledge, only Chilliard et al. (2005) gave data on time-related changes to *cis*-9,*trans*-11 C18:2 content after introducing sunflower or linseed oils into dairy goat diets.

In most published papers, the first milk sample was taken 2 or 7 d after the introduction of the plant oil into the diets. However, in vitro work done by Mosley et al. (2002) and Jouany et al. (2007) showed changes in the accumulation of biohydrogenation (**BH**) intermediates and end products as soon as 0.5 h after oil inclusion in media inoculated with mixed rumen microbes. Fievez et al. (2007) indicated that rumen microorganisms are permanently adapted to biohydrogenate unsaturated FA from plants because they are always in contact with them in most ruminant diets. Different authors (Moate et al., 2004; Harvatine and Allen, 2006) have used information from in vivo experiments to build models describing rumen BH kinetics. These models predict a fast, strong lipolysis-BH reaction, which delivers unsaturated fats into the rumen and provide estimates for FA rumen passage rates. Whereas the model by Moate et al. (2004) practically precludes C18:3n-3 from escaping the rumen unaltered by BH, the model by Harvatine and Allen (2006) allows room for this to happen.

When studying the kinetics of FA responses to the inclusion of plant oils in dairy ruminant diets, one has

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to bear in mind that the observed effects on milk FA changes also imply the time from FA leaving the rumen to their secretion as milk triacylglycerols. Furthermore, although several authors have studied the response of milk FA composition to abomasal/duodenal infusions of long-chain FA (Drackley et al., 2007; Khas-Erdene et al., 2010), their studies show changes occurring in the milk fat FA profile at 5 d from the beginning of the infusions, at the earliest. The aim of this work was to obtain information about the timing of changes in FA contents in goat milk fat from 1 to 504 h (21 d) after introducing 3 different plant oils into the diet.

MATERIALS AND METHODS

The experiments were carried out on the premises of the Animal Production Department of Córdoba University (Córdoba, Spain). Animals were kept in accordance with Spanish regulations relative to the treatment of experimental animals. Twelve Malagueña goats were used (45 ± 5 DIM, 47 ± 4.2 kg live weight, and 2,287 ± 512 g of milk production/d at the beginning of the experiment). They were placed in individual cages of 1.0 × 1.4 m with slatted floors equipped with water and feeding troughs. All goats were fed a general-purpose diet without added fat (maize, oats, horsebeans, and alfalfa hay) from kidding until the beginning of the experiment.

Goats were randomly assigned to 1 of 4 treatments (3 goats per treatment): a basal control diet (67% concentrate and 33% alfalfa hay) with no added oil or a basal diet supplemented with 48 g/d of either high oleic sunflower oil (**OSO**), regular sunflower oil **(RSO**), or linseed oil (**LO**) as shown in Table 1. The experiments lasted 21 d. Milk samples were taken from milkings at 0 h (before oil supplementation) and 1, 12, 24, 72, 120, 192, 312, and 504 h after the addition of the corresponding oil. Milkings at 0 (covariate), 1, and 12 h were stripped out by hand after giving an i.v. dose of 2 to 3 IU of oxytocin to the goats. Daily DMI, BW changes, milk production and sampling, and diet analysis were carried out as in Martínez Marín et al. (2012).

Milk fats were extracted as described by Gómez-Cortés et al. (2008a). Fatty acid methyl esters (**FAME**)

Table 1. Ingredients, chemical composition, and nutritive value of the experimental diets

	Treatment[1]			
Item	Control[2]	OSO	RSO	LO
Diet (g/d)				
Alfalfa hay	600	600	600	600
Concentrate[3]	1,200	1,200	1,200	1,200
OSO[4]	—	48	—	—
RSO[4]	—	—	48	—
LO[4]	—	—	—	48
Chemical composition				
DM (%)	90.6	90.5	91.0	91.2
CP (% of DM)	17.0	16.4	16.4	16.5
NDF (% of DM)	28.2	27.5	27.0	26.9
AHEE[5] (% of DM)	2.4	5.6	5.5	5.8
Ash (% of DM)	7.6	7.5	7.5	7.5
Nutritive value[6]				
ME (Mcal/kg of DM)	2.67	2.77	2.77	2.77
MP (g/kg of DM)	123	119	119	119
FA from oil (g/d)				
C16:0	—	1.8	2.9	2.6
C18:0	—	1.4	2.0	1.8
cis-9 C18:1	—	41.0	14.2	10.0
C18:2n-6	—	2.7	27.9	8.0
C18:3n-3	—	—	—	23.9

[1]Control = basal diet with no added oil; OSO, RSO, and LO = diets enriched with 48 g/d of high-oleic sunflower oil, regular sunflower oil, and linseed oil, respectively.

[2]Control diet supplied 5.1, 0.8, 6.9, 18.9, and 6.5 g/d of C16:0, C18:0, *cis*-9 C18:1, *cis*-9,*cis*-12 C18:2, and C18:3n-3, respectively; calculated according to INRA (2002).

[3]Composition (g/kg, as fed): maize, 375; barley, 374.9; soybean meal, 200; vitamin and mineral premix (Maxi Nutral Ovejas; Nutral SA, Madrid, Spain), 30; binder (Exal; Tolsa S.A., Madrid, Spain), 20; antioxidant (Luctanox; Lucta S.A., Barcelona, Spain), 0.1.

[4]Included in the respective concentrates. High-oleic sunflower oil and RSO were purchased from Carrefour S.A. (Madrid, Spain). Linseed oil was supplied by Gustav Heess S. L. (Barcelona, Spain).

[5]Acid hydrolysis ether extract.

[6]Calculated from NRC (2007).