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Feeding of palm oil fatty acids or rapeseed oil throughout lactation: Effects on energy status, body composition, and milk production in Norwegian dairy goats

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ABSTRACT

The objective of this experiment was to examine how supplements of rapeseed oil or palm oil fatty acids would affect milk production and composition, body lipid stores, and energy balance in 30 multiparous goats of Norwegian dairy goat breed. The experiment lasted 230 d, with 1 to 120 d in milk (DIM) for indoor feeding (P1), 120 to 200 DIM for mountain grazing (P2), and 200 to 230 DIM for indoor feeding (P3). Grass silage was fed according to appetite during indoor feeding periods. After an adjustment period (1–60 DIM) when the control diet was given to the goats, the animals were subdivided into 3 groups of 10 goats. Treatments (60–230 DIM) were (1) basal concentrate (control; no added fat); (2) control concentrate with 8% (added on air-dry basis) hydrogenated palm oil enriched with palmitic acid (POFA); and (3) control concentrate with 8% (added on air-dry basis) rapeseed oil (RSO). Individual energy balances based on energy intake and milk production were estimated on 10, 30, 60, 90, 120, 200, and 230 DIM. At the same times, body weight (BW), body condition score (BCS), body mass index, and body tissue stores using computed tomography were monitored. Silage intake was depressed by POFA throughout the experimental period. Reduced BW and body mass index were observed in the POFA and RSO groups, whereas no effect on BCS or body composition was observed throughout lactation. Generally, a minor decrease in BW was observed from 10 to 120 DIM (only 0.6 kg on average) and the total amount of body lipid was reduced by 4.4 kg. During the mountain grazing period, a further reduction in body lipid stores (2.7 kg) was observed, and BW was reduced by 3.9 kg in the same period. The goats mobilized, on average, 72% of their fat reserves during the first 200 DIM. In this period, dietary fat supplementation did not reduce the mobilization of adipose tissue but resulted in greater milk fat yield (2 kg more, on average, compared with the control group). Milk yield was not affected by POFA or RSO supplementation. Milk fat content was higher in the POFA group than in the control and RSO groups. Milk protein and lactose contents were not affected by lipid supplements. In late lactation, a rapid accumulation of fat deposits followed the intense mobilization during the grazing period. Dietary lipid supplements had no effect on milk fat yield at this stage. Milk production depends heavily on the ability to mobilize body lipid stores, and neither POFA nor RSO supplements at rates used in our study affected this mobilization.
Key words: goat milk production, palm oil, rapeseed oil, energy status, adipose tissue mobilization

INTRODUCTION

Over the last 15 yr, a rapid structural development has taken place in Norwegian dairy goat farming, which has resulted in larger farm units, in which average yields per animal increased from 560 to 725 kg/yr. The total volume of goat milk delivered to the market has not changed, however.

Dry matter intake and ingested energy and nutrients are the main factors influencing milk yield and composition (Morand-Fehr et al., 2007). In high-yielding cows, dietary lipid supplementation can be a practical tool to increase energy intake in early lactation (Chilliard, 1993). Fatty acids derived from calcium salts of palm oil are commonly used for dairy energy supplementation (Onetti and Grummer, 2004; Rabiee et al., 2012). Feeding trials with calcium salts of palm oil fatty acids in dairy goats are scarce. When calcium salts of palm oil fatty acids were added to the diet of Alpine goats at rates of 0, 3, 6, and 9%, Teh et al. (1994) observed that milk yield and BW gain decreased linearly with the rate of inclusion, whereas milk fat content increased. Otaru et al. (2011) reported that an addition of 4%

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palm oil in concentrate increased daily milk production by 29% and did not affect BW of low-yielding Red Sokoto goats.

Palm oil is rich in palmitic acid (C16:0), and leads to elevated milk palmitic acid concentrations, which is considered unfavorable in human nutrition (Shingfield et al., 2008). Conversely, plant oils rich in PUFA can be used to obtain beneficial changes in milk fat composition by a reduction in fatty acids synthesized de novo (C10:0 to C16:0) and an increase in C18:0, C18:1 *cis*-9, CLA *cis*-9,*trans*-11, and n-3 PUFA in cows and goats (Chilliard et al., 2003; Bernard et al., 2009a).

Among Norwegian plant fat resources, rapeseed is a promising feed supplement, which could improve both the milk sensory properties and nutritional quality through its fatty acid composition, in addition to sustaining a production relying on national resources. Indeed, previous studies in goats have shown that feeding rapeseed reduces milk lipoprotein lipase (**LPL**) activity and the level of free fatty acids, decreases milk short- and medium-chain SFA, and increases C18:0 and C18:1 *cis*-9 (Ollier et al., 2009). Supplements of rapeseed oil to Norwegian goats resulted in lower free fatty acid content and better milk taste compared with the control group or a group fed palm oil–derived fatty acid supplementation (Inglingstad et al., 2017).

The objective of the present study was to examine how supplementation of rapeseed oil (rich in long-chain UFA) or palm oil–derived fatty acids (rich in SFA) would affect milk production and composition, body lipid stores and energy status in dairy goats. We hypothesize, therefore, that rapeseed oil in the diet will improve energy status and milk production in dairy goats.

MATERIALS AND METHODS

Experimental Design

The experiment was carried out at the Norwegian University of Life Sciences, Department of Animal and Aquaculture Sciences, Ås, in agreement with the laws and regulations controlling experiments on live animals in Norway and under the supervision of the Norwegian Animal Research Authority.

The experiment included 30 goats of the Norwegian dairy goat breed in second to fourth lactation, kidding from February 3 to March 7. Average BW 2 d after kidding was 54.4 ± 6.7 kg.

The experiment had a continuous design, lasted for 230 d and consisted of 3 periods with 1–120 DIM for indoor feeding (**P1**), 120–200 DIM for mountain grazing (**P2**), and 200–230 DIM for indoor feeding (**P3**). In the first half of P1, called the preparatory period (1–60 DIM), all goats were fed a basal concentrate without added fat (control). Thereafter, the goats were allocated to 3 groups, each of 10 goats, based on age, date of kidding, BW, milk yield, and genotype [homozygous (**E12–00**; homozygous for a deletion in exon 12 of the gene encoding α_{S1}-CN, *CSN1S1*, which causes low or no synthesis of α_{S1}-CN in their milk) or heterozygous (**E12–01**; goats with only one deletion in exon 12 of *CSN1S1*)]. In addition to low or no expression of α_{S1}-CN in the milk, this deletion correlates with reduced contents of protein, fat, and lactose and increased milk yield (Dagnachew et al., 2011). Each group consisted of 7 goats heterozygous (E12–01) for the deletion in exon 12 at the α_{S1}-CN locus, and 3 were homozygous (E12–00) for this deletion.

Experimental Concentrates

The 3 experimental concentrates (and corresponding experimental groups) were (1) control concentrate (**CON**); (2) control concentrate with 8% (added on an air-dry basis) hydrogenated palm oil fatty acids enriched with palmitic acid (Akofeed Gigant 60, AarshusKarlshamn Sweden AB, Karlshamn, Sweden; **POFA**); and (3) control concentrate with 8% (added on an air-dry basis) rapeseed oil (AarshusKarlshamn Sweden AB; **RSO**). The experimental concentrates (Table 1), were produced by Centre for Feed Technology at the Norwegian University of Life Sciences.

Table 1. Composition (g/kg) of the 3 experimental concentrates

	Treatment[1]		
Ingredient	CON	POFA	RSO
Barley	540	460	460
Rapeseed meal, Expro 00SF[2]	90	90	90
Soybean, extracted	160	180	180
Beet pulp, unmolassed	120	100	100
Molasses	50	50	50
Akofeed Gigant 60 vegetable fat[3]	—	80	—
Rapeseed oil[4]	—	—	80
Mineral and vitamin premix	40	40	40

[1]CON = basal diet containing no additional fat; POFA = basal diet supplemented with hydrogenated palm oil enriched with palmitic acid; RSO = basal diet supplemented with rapeseed oil.

[2]Rapeseed meal, Expro 00SF (AarhusKarlshamn Sweden AB, Karlshamn, Sweden).

[3]Akofeed Gigant 60 (AarhusKarlshamn Sweden AB) contained (g/kg of total FA): C14:0 (20), C16:0 (minimum 600), C18:0 (maximum 270), C18:1 (100), C18:2 (10).

[4]Rapeseed oil (AarhusKarlshamn Sweden AB) contained (g/kg of total FA): C16:0 (45), C18:0 (15), C18:1 (620), C18:2 (205), C18:3 (85), C22:1 (10), others (30).