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Effect of adding palm oil to the diet of dairy sheep on milk production and composition, function of liver and kidney, and the concentration of cholesterol, triglycerides and progesterone in blood serum

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ABSTRACT

The aim of this study was to evaluate the effect of adding palm oil to the diet of dairy sheep on milk production and composition, function of liver and kidney, and the concentration of cholesterol, triglycerides and progesterone in blood serum. Thirty ewes in early lactation were divided into three groups ($n = 10$) receiving an isoproteic and isoenergetic diet. Palm oil (PALM) was added to the diet at different concentrations: 0% (PALM0), 4.0% (PALM4) and 6.0% (PALM6). Milk production was evaluated on days 0, 60, 120, and blood samples were collected in the same periods. Sera samples were analyzed for aspartate aminotransferase (AST), gamma-glutamyltransferase (GGT), urea, creatinine, cholesterol, triglycerides, and progesterone. Changes in the volume of milk produced and milk composition (fat, protein, and lactose) in sheep fed with palm oil were not observed between groups. No significant difference was observed between groups for AST, GGT, and creatinine at day 60. However, an increase was observed in AST and GGT activities in the sera of animals from the group PALM4 compared to the control group (PALM0) at day 120. Urea, cholesterol, triglycerides, and progesterone levels had a significant increase in animals from groups PALM4 and PALM6 when compared to the group PALM0 at days 60 and 120. In summary, the addition of palm oil in the diet of dairy sheep influences the metabolism of lipid and protein and caused an increase on liver enzyme activity in proportion to palm oil concentration. The protected fat increased the levels of progesterone, which may improve reproductive performance.

1. Introduction

The addition of lipids in the diet of dairy animals has received attention in recent years, mainly due to genetic improvement of livestocks and consequently increased

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milk production per animal (Oliveira et al., 2012). The increase of diet density for animals in early lactation represents an effort to compensate for low energy intake during the postpartum period and to avoid a negative energy balance that could compromise milk production throughout lactation (Butler and Canfield, 1989).

Protected fat is a source of fatty acids involved in a protein layer that remains relatively inert in the ruminal content under normal pH (Jenkins and Palmiquist, 1984). The complete dissociation of protected fat occurs only under acidic conditions found in the abomasum, which increases the energy density of the diet without changing the digestion of fibrous portion (Jenkins and Palmiquist, 1984). In addition, the diet with protected fat may increase cholesterol levels, a precursor of progesterone, which could increase cattle reproductive performance (Mihm and Austin, 2002; Ghoreishi et al., 2007).

The addition of protected fat to feed cattle may limit negative energy balance and/or shorten the duration of this period. Hammon et al. (2008) observed that the introduction of protected extruded soybean and protected fat in feeding doses for cows induced an increase in yield and lactose content in milk and lowered glucose concentration in blood. In a recent study, researchers found that when they added a form of protective palm oil to the diet of Holstein-Friesian cows, there was no change in milk production, milk fat, and milk protein (Kupczyński et al., 2012). Jersey cows fed with palm oil had higher milk production (Duarte et al., 2005). Healthy individuals who eat palm oil in the diet show increased serum cholesterol (Tholstrup et al., 2011). However, very little is known about the effect of palm oil in the production of milk. Moreover, the effect of palm oil in dairy sheep is unknown; if this diet influences serum lipid metabolism, it would cause losses in animal production and health. Therefore, this study evaluates the effect of adding palm oil to the diet of dairy sheep on milk production and composition, function of liver and kidney, and the concentration of cholesterol, triglycerides, and progesterone in blood serum.

2. Materials and methods

2.1. Palm oil

Palm oil (PALM; Agelac 84®) was purchased from *Raupp Comércio & Importação Ltda*. This product is palm protected fat produced by reacting palm fatty acid with calcium hydroxide as previously described by Bianchi et al. (2013).

2.2. Experimental animals and groups

Thirty adult female Lacaune sheep in the beginning of the lactating period (±10 days), randomly selected with approximately the same body weight (56.2 ± 3.9 kg), age (24.2 ± 1.1 months), the same number of offspring (second lactation), volume of milk production (1.9 ± 0.46 L), and milk composition (fat, protein, lactose, nonfat dry and total solids) were used in three experimental groups (0% (PALM0), 4.0% (PALM4), and 6.0% (PALM6)), totaling 10 animals per group. Isoenergetic and isonitrogenous diets were prepared (Table 1).

Table 1
Composition of the experimental concentrates and nutrients of silage offered in the diet of dairy sheep (% dry matter).

Ingredients of concentrate	PALM0[a] (%)	PALM4[a] (%)	PALM6[a] (%)
Palm oil	0.0	4.0	6.0
Corn grain	51.0	30.0	19.0
Soybean meal	43.0	41.0	40.0
Wheat bran	2.0	21.0	31.0
Baking soda	0.5	0.5	0.5
Calcitic limestone	1.0	1.0	1.0
Vitamin and mineral	2.5	2.5	2.5
Nutrients of concentrate (%)			
Dry matter	88.7	89.2	89.5
Crude protein	21.5	21.8	21.9
Total digestible nutrients (TDN)	73.4	73.7	73.8
Nutrients of silage (%)			
Dry matter	31.3	31.3	31.3
Crude protein	7.4	7.4	7.4
Total digestible nutrients (TDN)	67.0	67.0	67.0

[a] The groups PALM0, PALM4, and PALM6 correspond to 0.0, 4.0, and 6.0% of palm oil added to the diet, respectively.

The experiment began approximately 12 days postpartum (day 0). Offspring were kept with their mothers for only five days post-partum and then removed to a separate environment and fed with lamb milk replacer 4 times a day for 45 days. Subsequently, the sheep (mothers) were transferred into the experimental pens, where they remained for seven days as an adaption period (before day 0 of the study).

All animals of each treatment were confined in collective pens (24 m^2 each) with floors of wood shavings and fed silage, concentrate (50:50), and water *ad libitum*. To ensure diet ingestion, animals were individually fed twice a day (07:00 AM and 07:00 PM) with concentrate followed by silage (approximately 3.5 kg/day/animal). The silage composition was shown in Table 1. After the feeding period of 1 h, leftover silage was removed and animals were placed back into their pens. The animals consumed quantities of concentrate and silage proportional to their body weight in each group, avoiding interference with the variables analyzed.

2.3. Milk production and composition

Automatic milking was performed twice a day at 05:00 AM and 04:00 PM. Milk production was measured on days 0, 60, and 120 for each animal, with the use of meter type milk meters (True-test®, Auckland, New Zealand). Milk chemical composition (fat, protein, and lactose) was performed using Infrared Milk Analyzer Bentley® 2000.

2.4. Blood sampling

Diet effect on liver and kidney function, cholesterol, and triglycerides was evaluated at 0, 60, and 120 days after the beginning of the experiment. The animals were restrained manually for blood collection by jugular vein puncture using vacutainers. Blood was stored in tubes