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Effect of calcium salts of fatty acids on the nutritive value of diets, feeding behavior, and serum blood parameters of lactating Saanen goats grazing on stargrass

Ludmila Couto Gomes[1], Claudete Regina Alcalde[1], Ulysses Cecato[1], Gracielle Caroline Mari[1], Sérgio Mangano de Almeida Santos[1], Jessyka Guedes Mazziero[1]

[1] Universidade Estadual de Maringá, Departamento em Zootecnia, Maringá, PR, Brazil.

ABSTRACT - The objective of this study was to determine effects of the addition of calcium salts of fatty acids (CSFA) to the concentrate on the intake and digestibility of dry matter and nutrients and the grazing behavior of lactating Saanen goats. Five multiparous goats in their third lactation and four primiparous goats were used. The animals were distributed into two Latin square designs, which, for the multiparous goats was 5 × 5, with five treatments (0%, 1.5%, 3.0%, 4.5%, and 6.0% CSFA); and for the primiparous goats was 4 × 4, with four treatments (0%, 1.5%, 3.0%, and 4.5% CSFA). The addition of CSFA to the concentrate of lactating Saanen goats did not influence the time spent grazing, ruminating, or lying for multiparous goats. However, for primiparous goats, for the time spent grazing, there was a negative quadratic effect with the addition of CSFA to the concentrate. The treatments did not affect the intakes of dry matter, organic matter, crude protein, neutral detergent fiber, total carbohydrates, non-fiber carbohydrates, or total digestible nutrients for multiparous goats. No effects were observed on nutrient digestibility, except for crude protein and the ether extract, which increased the energy values of the diets with 3.5% CSFA. For primiparous goats, no effects were observed on intake or digestibility. Addition of CSFA can be used as an alternative to feed primiparous goats in grassland when the grazing time is a factor limiting intake. Addition of up to 3.5% of CSFA increases the energy value of diets for multiparous goats. These results suggest that calcium salts of fatty acids is an alternative energy supplement to feed lactating goats.

Key Words: dairy goats, grazing behavior, n-alkanes, rumen-inert fat, soybean oil, tropical climate

Introduction

Grassland livestock systems are an alternative to produce quality products at competitive prices (Branco et al., 2002). These systems can improve production indices while considering the economic, social, and environmental sustainability of the production process. Brazil has the eighth largest herd of small ruminants, sheep, and goats in the world (FAO, 2012). That reinforces the importance of new studies on feeding goats in Brazilian conditions for the future of nutrition systems and increasing information about tropical environments. Further, scientific journals have published few studies about specialized milk goats raised in grasslands and intensive management.

In general, adding lipids to the diet of lactating animals is an alternative to increase the diet energy density and improve nutrient digestibility and the performance of lactating animals (Palmquist and Mattos, 2011). In addition, lipids improve fat-soluble vitamin absorption, supply fatty acids to the membranes of tissues, act as precursors of metabolic pathways, and increase certain fatty acids in milk fat, especially polyunsaturated fatty acids (Palmquist and Mattos, 2011). However, depending on the amount supplied, the degree of unsaturation and the degree of rumen-protected lipids, reduced performance can occur owing to the decreased activity of cellulolytic microorganisms, with a consequent reduction in fiber digestibly (Palmquist and Mattos, 2011).

The addition of rumen-inert lipid in the form of calcium salts of fatty acids (CSFA) was proposed by Jenkins and Palmquist (1982). The CSFA is inert in the rumen and is dissociated in the acidic conditions of the abomasum. Among the benefits of CSFA is the possibility of increasing the energy content of the diet without influencing fiber digestibility, thereby allowing high levels of inclusion in ruminant diets (Baldin et al., 2013). In this sense, CSFA is interesting, because it does not change ruminal fermentation (Sirohi et al., 2010) and also improves milk quality (Souza et al., 2014). Thus, CSFA is an energy supplement that in combination with other foods can increase the dry matter intake providing good availability of nutrients for

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Corresponding author: ludmilagomes@zootecnista.com.br
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satisfactory responses in females for milk production. However, when CSFA is included in larger proportion in animal diets, its intake can be influenced. Sanz Sampelayo et al. (2002) reported that goats refused concentrate due to the reduced palatability of CSFA.

Thus, while the scientific literature has a high amount of works about the use of CSFA for lactating goats, studies with inclusions below 30 g day^{-1} and with goats raised in tropical grasslands are scarce. Therefore, the present study aimed to evaluate the effect of CSFA in the concentrate fed to multiparous and primiparous lactating Saanen goats on grazing behavior, the nutritive value of the diet, and serum blood metabolites.

Material and Methods

The experiment was conducted at an experimental farm in southern Brazil, northwestern region of Paraná State, city of Maringá (23°S latitude, 52°20' W longitude, 550 m asl); and the work was conducted in accordance with ethical standards (Project no. 014/2010 - MCT/CNPq Universal). The climate, according to the classification of Köppen-Geiger (Peel et al., 2007), is characterized as mesothermal Cfa - humid subtropical. The average monthly values of the meteorological data — maximum and minimum temperature (°C), air relative humidity (%) in the morning and afternoon, raining days, and total precipitation (mm) at the experimental farm — are available on the following website: http://www.fei.uem.br/.

Five multiparous Saanen goats (five years old) on their third lactation (57.0±2.7 kg body weight) and four primiparous Saanen goats (three years old; 54.0±1.8 kg body weight) were used. The goats had an average of 78±10 days in milk at the beginning of the experiment and an average milk yield of 2.8±0.1 kg day^{-1} and 2.7±0.1 kg day^{-1} for multiparous and primiparous goats, respectively. Goats were distributed into two Latin square designs with an experimental period of 21 days, including 14 days for adaptation and seven days for data collection. The Latin square design was 5 × 5, with five treatments (0%, 1.5%, 3.0%, 4.5%, and 6.0% CSFA) for the multiparous goats; and a 4 × 4 Latin square design with four treatments for primiparous goats (0%, 1.5%, 3.0%, and 4.5% CSFA). The experiment with primiparous and multiparous goats was conducted at the same time.

Pelleted concentrate was composed of ground corn, soybean meal, a mineral-vitamin supplement for goats, salt, and rumen-inert fat in the form of CSFA from a commercially available product derived from soybean oil (Lactoplus® from Dalquim Chemical Industry Ltd.; with 1.94 g g^{-1} total digestible nutrients, 820 g kg^{-1} ether extract, 100 g kg^{-1} calcium, 260 g kg^{-1} oleic acid, and 420 g kg^{-1} linoleic acid) at the set levels of inclusion (0%, 1.5%, 3.0%, 4.5%, and 6.0% of the concentrate) (Table 1). The amount of concentrate offered to the goats was established at 1.00 kg day^{-1} as feed, representing half of the estimated nutritional requirements of Saanen goats (NRC, 2007) with an average body weight of 60.0 kg and a milk yield of 3.00 kg day^{-1} with 3.5% fat.

Goats were milked manually twice daily (7.30 h and 15.30 h). The goats remained in the grassland for approximately seven hours (8.00 h to 15:30 h). After the afternoon milking, goats were fed the concentrate and were housed in individual pens for the evening and overnight. The goats had free access to water in the grassland and pens.

From day 10 to 19, a cellulose capsule of synthetic paired chain *n*-alkane ($C_{32}H_{66}$, Dotriacontane, 97% purity, ref. no. D223107, Sigma-Aldrich Corp., St Louis, MO, USA) was inserted into the rumen by an oral probe twice daily at 08.00 h and 16.00 h, supplying a total of 80 mg of $C_{32}H_{66}$/day.

Table 1 - Ingredients, chemical composition, and *in vitro* digestibility of the concentrate

Composition	Level of calcium salts of fatty acids[1]				
	0.0%	1.5%	3.0%	4.5%	6.0%
Ingredient (g kg^{-1} DM)					
Ground corn	695	676	658	639	621
Soybean meal	280	284	287	291	294
Calcium salts of fatty acids[2]		15.0	30.0	45.0	60.0
Mineral-vitamin supplement[3]	20.0	20.0	20.0	20.0	20.0
Salt	5.00	5.00	5.00	5.00	5.00
Chemical composition (g kg^{-1} DM)					
Dry matter (g kg^{-1})	915	916	921	922	926
Organic matter	951	948	945	943	940
Ash	48.8	51.7	55.0	56.6	59.8
Calcium	3.70	4.80	5.60	6.60	7.10
Phosphorus	4.70	4.80	4.80	4.80	4.90
Crude protein	188	189	195	189	183
Ether extract[4]	31.7	43.5	55.4	67.2	79.0
Neutral detergent fiber	107	103	100	112	115
Non-fiber carbohydrates	624	616	594	575	563
Total carbohydrates	731	719	694	687	678
In vitro digestibility (g g^{-1})					
Dry matter	0.854	0.854	0.848	0.842	0.848
Organic matter	0.879	0.879	0.863	0.864	0.867
Gross energy (Mcal kg^{-1})	3.87	3.95	3.99	4.07	4.09

[1] Level of calcium salts of fatty acids derived of soybean oil addition to the concentrate.
[2] Product commercial Lactoplus®, chemical composition: 3.39 Mcal kg^{-1} metabolisable energy; 820 g kg^{-1} fat; 100 g kg^{-1} Ca.
[3] Chemical composition (per kg of Caprinofós® with organic mineral): Ca - 240 g; P - 71 g; F - 710 mg (Max); Mg - 20 g; K - 28.2 g; S - 20 g S; Fe - 250 mg; Cu - 400 mg; Mn - 1,350 mg; Zn - 1,700 mg; Co - 30 mg; I - 40 mg; Se - 15 mg; Cr - 10 mg; vitamin A - 135,000 IU; vitamin D3 - 68,000 IU; vitamin E - 450 IU.
[4] From the result of the chemical composition of foods (ground corn and soybean meal) and the composition of the Lactoplus® label.

For grazing of primiparous and multiparous goats, an area of one hectare (1 ha) was used with stargrass (*Cynodon nlemfuensis*) maintained by continuous stocking (Table 2). The grassland was fertilized and corrected through physical and chemical analysis of the soil and grass demand. Fertilizer was applied at an N-P-K ratio of 8.00 kg ha^{-1} nitrogen, 67.0 kg ha^{-1} phosphorus, and 70.0 kg ha^{-1} potassium (200 kg of N-P-K fertilizer 4-20-20, 150 kg of single superphosphate, and 50.0 kg of potassium chloride) in September 2011, which was distributed by broadcasting 30 days before the input of goats. The grazing period was October 8 2011 to January 20 2012.

Samples of the forage for chemical analysis and manual separation of the morphological components (leaf blades, stems and sheaths, and dead material) were collected once in each experimental period; to ensure random sampling, one 1.00 m² wire square was thrown eight times in the paddock and the grass was cut 15.0 cm above the ground. Samples of forage to determine total forage mass were cut close to the soil. The sward height was measured with a wooden ruler graduated in centimeters at 20 random points. For the chemical analysis, samples of concentrate were taken during each experimental period and pooled.

Fecal grab samples were taken twice daily at 8.00 h and 16.00 h from day 15 to 20 and a portion (about 30 g) was dried for 48 h at 55 °C and composited per goat within period for later chemical analysis.

Samples of forage and feces from each period were oven-dried (55 °C for 72 h), then ground through a 1-mm screen sieve in a Wiley mill (MA340 Marconi®, Piracicaba, SP, Brazil). The concentrate was ground through a 1-mm sieve screen in a hammer mill (Solotest®, São Paulo, SP, Brazil). Dry matter was determined according to AOAC (1998) method no. 934.01. Ash was determined by combustion in a muffle furnace according to method no. 942.05 (AOAC, 1998). Calcium and phosphorus were analyzed using acid digestion with nitric and perchloric acid (1:2). After that, they were filtered to obtain a mineral solution. Calcium and phosphorus readings were obtained using atomic absorption (GBC 932 AA spectrophotometer in an air-acetylene flame) and colorimetry (Shimadzu UV-1601 UV-Visible spectrophotometer, Kyoto, Japan) (AOAC, 1990). Total nitrogen (TN) was evaluated using a Tecnal TE-036/1 apparatus (Tecnal®, Piracicaba, SP, Brazil) following AOAC (1998) method no. 988.05 and crude protein (CP) was estimated as TN × 6.25. The ether extract (EE) was assessed using a Tecnal TE-044/1 apparatus (Tecnal®, Piracicaba, SP, Brazil) according to method no. 920.39 (AOAC, 1998). The neutral detergent fiber (NDF) was evaluated as described by Van Soest et al. (1991) without the use of sodium sulfite and with the inclusion of heat-stable α-amylase (alpha-amylase Termamyl 2x, Tecnoglobo®, Curitiba, PR, Brazil). Total carbohydrates (TC) and total digestible nutrients (TDN) were estimated according to equations described by Sniffen et al. (1992). The method used to calculate feed energy values (Mcal kg^{-1}) using digestible energy (DE), metabolizable energy (ME), and net energy for lactation (NE_L) was applied using the following equations (NRC, 2007): DE = 0.04409 × TDN (%); ME = 1.01 × DE − 0.45; and NE_L = 0.0245 × TDN (%) − 0.12. Gross energy content was determined by combustion in an adiabatic bomb calorimeter (Parr Instrument Co.AC720®, Parr Instrument Company, Moline, IL, USA).

Table 2 - Chemical composition, *in vitro* digestibility, and forage mass of stargrass (*Cynodon nlemfuensis*)

	Stargrass	SDM
Chemical composition (g kg^{-1} DM)		
Dry matter (g kg^{-1})	339	16.1
Organic matter	943	3.51
Ash	57.3	3.51
Calcium	2.04	0.05
Phosphorus	2.26	0.31
Crude protein	109	9.34
Ether extract	15.1	0.98
Neutral detergent fiber	656	39.3
Total carbohydrates	819	13.9
Non-fiber carbohydrates	163	35.0
In vitro digestibility (g g^{-1})		
Dry matter	0.59	0.01
Organic matter	0.64	0.02
Sward height (m)	0.26	0.06
Forage mass (kg DM ha^{-1})		
Forage mass	3.54	0.61
Forage mass (above 0.15 m)	392	312
Leaf blade	338	129
Stem and sheath	516	182
Leaf:stem ratio	0.67	0.17

SDM - standard deviation of the mean; DM - dry matter.

The *in vitro* dry matter and organic matter digestibility (IVDMD and IVOMD, respectively) of the five concentrates (0%, 1.5%, 3.0%, 4.5%, and 6.0% CSFA) and stargrass were determined according to the procedure described by Tilley and Terry (1963) using an artificial rumen (ANKOM Technology®, Macedon, New York, USA) according to Santos et al. (2000). The concentrates offered to the animals and the stargrass were incubated separately. The rumen fluid used as an inoculum was drawn from the rumen of three cannulated crossbred ½ Boer ×½ Saanen goats fed stargrass and transferred into pre-warmed thermos bottles. The *in vitro* digestibility (IVD) was calculated as the difference between the incubated and residual amount of feed, using the following equation: IVD =100 – [(W3 – (W1 × W4)) × 100/W2], in which W1 is the empty filter weight;

W2 is the sample weight; W3 is the filter final weight; and W4 is the filter blank correction.

The grazing behavior of lactating Saanen goats was measured by observing each goat with identification from the 16th to 18th day of each experimental period. The goats were assessed by direct observation three days per period, during the grazing period (six hours per day), with observations made every 10 min (Carvalho et al., 2007), totaling 108 observations per goat per period, consequently totaling 2700 observations for multiparous goats and 1728 observations for primiparous goats. The activities performed by the goats were assessed by the recording, according to the times spent grazing, ruminating standing and lying, and resting standing and lying. The behavioral activities were considered mutually exclusionary; in other words, for every record, each animal was classified in only one activity.

On the days used for measuring the grazing behavior of lactating Saanen goats, environmental variables were recorded (Table 3), including wind speed, air temperature, air relative humidity, and dew point temperature, which were collected using a hygro-thermo-anemometer (Kestrel 3000®, Nielsen-Kellerman, Boothwyn, PA, USA). The black-globe temperature was obtained by a black plastic ball with 15 cm diameter and an alcohol column thermometer (black-globe thermometer). During data collection, the equipment was positioned 0.80 m above the soil, simulating the height at the goat dorsum. The climate data collection was performed simultaneously with measuring feeding behavior, every hour, during the six hours of grazing.

For the evaluation of the environment, the black-globe humidity index (BGHI) was used, as proposed by Buffington et al. (1981), and used to determine the radiant thermal load (CTR), as proposed by Esmay (1969), using the following equations:

$$BGHI = BG_T + 0.36\ DP_T + 41.5;\ CTR\ (W.m^{-2}) = \sigma\ MR_T^4$$

and

$$MR_T = 100\ (2.51\ W_S\ 0.5\ (BG_T - A_T) + ((BG_T + 273.15)/100)^4)^{0.25},$$

in which BG_T = black-globe temperature (°C); DP_T = dew point temperature (°C); σ = Stefan-Boltzmann constant (5.67×10^{-8} W m^{-2} K^{-4}); MR_T = mean radiant temperature (ºK); A_T = air temperature (ºC); and W_S = wind speed (m s^{-1}).

To determine the serum blood biochemical composition, i.e., glucose cholesterol, triglycerides, urea, calcium, and phosphorus, blood was sampled after the morning milking, every 17th day of each experimental period. Blood samples were collected by puncture of the jugular vein, using disposable hypodermic needles, and the blood was placed in test tubes containing 10 mL. After 15 min at 3,400 rpm at room temperature in a centrifuge (Tecnal 2006-BABY I®, Piracicaba, SP, Brazil), serum

Table 3 - Mean values of environmental variables in each experimental period

Environmental variable	Period 1	Period 2	Period 3	Period 4	Period 5
Air temperature (°C)					
Maximum	29.7	28.4	32.4	29.7	32.8
Minimum	23.9	23.9	24.0	25.7	21.4
Average days	26.7	26.8	29.0	28.6	27.2
Black-globe temperature (°C)					
Maximum	40.3	41.7	48.0	44.0	44.0
Minimum	34.0	31.7	34.7	36.3	30.3
Average days	37.0	38.1	40.7	41.5	40.0
Air relative humidity (%)					
Maximum	61.0	68.0	66.0	51.0	81.0
Minimum	46.0	49.0	38.0	34.0	53.0
Average days	53.0	58.7	51.4	40.9	68.7
Wind speed (m s^{-1})					
Maximum	1.7	1.8	1.9	1.8	2.0
Minimum	0.3	0.7	0.3	0.3	0.7
Average days	1.0	1.0	1.1	0.8	1.2
Temperature of black-globe and humidity index					
Maximum	87.8	90.1	92.0	89.6	93.3
Minimum	81.6	79.2	82.4	83.3	78.1
Average days	84.3	86.1	88.6	87.9	88.9
Radiant thermal load (W m^{-2})					
Maximum	666	681	615	733	741
Minimum	526	528	571	550	570
Average days	600	613	642	633	655

Period 1 - October 8 to October 28, 2011; Period 2 - October 29 to November 18, 2011; Period 3 - November 19 to December 9, 2011; Period 4 - December 10 to December 30, 2011; Period 5 - December 31, 2011 to January 20, 2012.

was obtained from the blood, placed in Eppendorf tubes, and frozen for subsequent analyses.

Serum glucose, cholesterol, triglycerides, urea, calcium, and phosphorus concentrations were analyzed using commercial kits (glucose-PP CAT. 434, cholesterol-PP CAT. 460, triglycerides-PP CAT. 459, urea-PP CAT. 427, calcium-PP CAT 448, phosphorus-PP CAT 342; Gold Analisa Diagnostica®, Belo Horizonte, MG, Brazil) in a spectrophotometer (Shimadzu UV-1601 UV-Visible Spectrophotometer®, Kyoto, Japan).

Milk samples were collected on the 15th day of each period from each goat from two consecutive milkings and pooled on a yield basis. For the chemical composition determination, milk samples were stored at 4 ºC with a preservative (2-bromo-2-nitropropane-1,3-diol) until analyzed for fat, protein, lactose and total solids by infrared spectroscopy (Bentley model 2000®; Bentley Instrument Inc., Chaska, MN, USA). The milk yield was corrected to 4.0% fat according to the NRC (2007) using the NRC (2001) equation.

The extraction and determination of the *n*-alkane content in forage and feces were performed according to Mayes et al. (1986), modified by Vulich et al. (1995); the analysis was based on direct saponification of samples.

A gas chromatograph (GC Agilent 7890A®, Palo Alto, CA, USA) equipped with a mass selective detector (MS Agilent 5975C®, Palo Alto, CA, USA) was used to identify and quantify the *n*-alkanes. The column used was a Zebron™ ZB-5MS (30 m × 0.32 mm × 0.25 µm, absorbent composed of 5% phenyl-arylene-95% polydimethylsiloxane (Phenomenex Inc., Torrance, CA, USA). The carrier gas was H_2 at a constant flow of 1 mL/min. Temperature gradients were controlled for the injector (300 ºC) and the column (130 ºC for 1 min; 10 ºC/min until 210 ºC, and 5 ºC/min to 310 ºC hold for 1 min; 32 min). The MS source temperature was set at 250 ºC and the temperature of the MS quadrupole was 120 °C. With a microliter syringe, 1 µL of the sample was injected with a split ratio of 1:10.

The gas chromatograph process was calibrated with an external standard solution of a synthetic *n*-alkanes mix C_{24}, C_{26}, C_{28}, C_{32}, C_{34}, and C_{36} (Tetracosane 99% purity ref. no. T8752, Hexacosane 99% purity ref no. 241687, Dotriacontane 97% purity ref. no. D223107, Tetratriacontane 98% purity ref. no. 287261, Hexatriacontane 98% purity ref. no. 52919; Sigma-Aldrich Corp., St Louis, MO, USA). The chromatography peak areas corresponding to each *n*-alkane were determined by MSD ChemStation Data Analysis® (Agilent Technologies, Palo Alto, CA, USA). The identified peaks were converted to *n*-alkane quantity with regard to each peak area and the internal standard C_{34}, and then calculated as mg g^{-1} of DM.

The dry matter intake (DMI) was estimated in forage and feces based on the concentration of *n*-alkanes naturally present in the diet (C_{31} and C_{33}) and the homologue C_{32}, which was orally administered. The estimated values of DMI with the C_{31}:C_{32} and C_{33}:C_{32} pairs were obtained by the equation of Mayes et al. (1986). The DM digestibility was estimated by the following equation: DMD = 1 − (ID/IF) × 100; in which DMD = dry matter digestibility coefficient by *n*-alkane; ID = internal content of *n*-alkane in the forage; and IF = internal content of *n*-alkane in the feces.

The experiment was analyzed according to a 5 × 5 Latin square design for multiparous goats and a 4 × 4 Latin square design for primiparous goats, using the procedure of Sisvar (version 5.3, build 86, Federal University of Lavras, MG, Brazil) according to the general model below:

$$Y_{ijk} = \mu + \alpha_i + \beta_j + \tau_k + e_{ijk},$$

in which Y_{ijkl} = dependent variable; μ = overall constant; α_i = effect of concentrate *i*; β_j = effect of period *j*; τ_l = effect of animal *l*; and e_{ijk} = random error.

The data of nutritive value of diets, feeding behavior, and serum blood parameters were assessed by variance analysis (ANOVA) followed by linear and/or quadratic effects of addition of CSFA to the concentrate of lactating Saanen goats. The significance ($\alpha = 0.05$) of type-I error was adopted as the critical value of the probability of type-I error.

Results

There was no significant effect on the intakes of dry matter, organic matter, crude protein, neutral detergent fiber, total carbohydrates, non-fiber carbohydrates, or total digestible nutrients for multiparous grassland Saanen goats fed the concentrates containing CSFA (Table 4). However, the ether extract intake increased linearly with the addition of CSFA to the concentrate. The digestibility coefficients of dry matter, organic matter, neutral detergent fiber, total carbohydrates, and non-fiber carbohydrates were not changed by CSFA in the concentrates. However, a significant effect of crude protein and ether extract digestibility coefficients led to an increase in the energy value of the diet, total digestible nutrients, digestible energy, metabolizable energy, and net energy for lactation.

When primiparous lactating Saanen goats were fed CSFA, there was no significant effect on the intake and digestibility coefficients of dry matter and nutrients;

consequently, the energy value of diets was not changed. However, the inclusion of CSFA changed the ether extract intake and digestibility coefficients (Table 5).

The addition of rumen-inert fat as CSFA to the concentrate of multiparous grassland Saanen goats had no effect on their milk yield (2.80±0.10 kg). Similar to multiparous goats, the treatment of primiparous Saanen goats had no effect on milk yield (2.67±0.09 kg day^{-1}).

The addition of CSFA to the concentrate fed to lactating Saanen goats did not influence the spent time grazing, ruminating, or lying for multiparous goats (Table 6). However, for primiparous goats, there was a negative quadratic effect for time spent grazing due to addition of CSFA to the concentrate.

The treatments did not affect the serum blood concentration of glucose, triglycerides, urea, calcium, or phosphorus in Saanen goats, either multiparous or primiparous. However, there was a liner increase in the cholesterol concentration when multiparous goats were fed CSFA (Table 7).

Discussion

The air temperature during the grazing period was within the comfort zone for goats, i.e., 20 to 30 ºC (Baêta and Souza, 2010), except for two experimental periods (periods 3 and 5), when the maximum environmental temperature exceeded 30 ºC. However, in this study, the air temperature did not exceed the upper critical temperature for goats (35 ºC).

The air relative humidity ranged from 34 to 81%. According to Baêta and Souza (2010), the ideal relative

Table 4 - Dry matter and nutrient intake and total apparent digestibility of multiparous Saanen goats in grassland fed experimental diets

	Level of calcium salts of fatty acids[1]					SEM	P-value		
	0.0%	1.5%	3.0%	4.5%	6.0%		A	L	Q
Body weight	57.3	56.3	57.1	57.1	57.4	0.54	0.67	0.59	0.41
DMI (kg day^{-1})									
DMI	1.94	1.96	2.20	1.90	2.19	0.08	0.06	0.12	0.97
Forage DMI	1.02	1.04	1.28	0.98	1.26	0.08	0.07	0.14	0.97
Concentrate DMI	0.92	0.92	0.92	0.92	0.93				
DMI (BW$^{0.75}$)	93.6	95.4	106	91.6	105	4.32	0.09	0.18	0.86
Nutrient intake (kg day^{-1})									
OM	1.83	1.85	2.08	1.79	2.06	0.08	0.06	0.14	0.97
CP	0.28	0.28	0.32	0.28	0.31	0.01	0.05	0.23	0.47
EE[2]	0.04	0.06	0.07	0.08	0.09	0.001	<0.01	<0.01	0.92
NDF	0.76	0.78	0.93	0.74	0.93	0.06	0.07	0.11	0.96
TC	1.50	1.51	1.69	1.44	1.66	0.07	0.09	0.28	0.95
NFC	0.74	0.73	0.76	0.69	0.73	0.01	0.06	0.20	0.88
TDN	1.22	1.33	1.45	1.35	1.44	0.06	0.10	0.03	0.25
Digestibility coefficient (g g^{-1})									
DM[3]	0.62	0.68	0.65	0.69	0.63	0.02	0.05	0.59	0.03
OM[4]	0.64	0.69	0.67	0.71	0.65	0.02	0.05	0.55	0.04
CP[5]	0.58	0.67	0.64	0.68	0.62	0.02	0.03	0.21	0.01
EE[6]	0.60	0.73	0.75	0.84	0.81	0.02	<0.01	<0.01	<0.01
NDF	0.50	0.56	0.55	0.59	0.53	0.02	0.06	0.57	0.52
NFC	0.82	0.84	0.80	0.84	0.80	0.02	0.26	0.31	0.53
TC	0.66	0.70	0.67	0.71	0.65	0.02	0.09	0.93	0.07
Energy value of diets (Mcal kg^{-1})									
TDN (g g^{-1})[7]	0.63	0.68	0.66	0.71	0.66	0.02	0.02	0.09	0.03
DE[8]	2.77	3.01	2.90	3.14	2.89	0.08	0.02	0.09	0.03
ME[9]	2.35	2.59	2.48	2.73	2.48	0.07	0.02	0.09	0.03
NEL[10]	1.54	1.67	1.61	1.75	1.61	0.04	0.02	0.09	0.03

SEM - standard error of the mean; A - ANOVA; L - linear; Q - quadratic
DMI - dry matter intake; BW - body weight; DM - dry matter; OM - organic matter; CP - crude protein; EE - ether extract; NDF - neutral detergent fiber; NFC - non-fiber carbohydrates; TC - total carbohydrates; TDN - total digestible nutrients; DE - digestible energy; ME - metabolisable energy; NEL - net energy for lactation.
Digestible, metabolisable, and net energy were estimated by NRC (2007) equations.
[1] Level of calcium salts of fatty acids derived from soybean oil addition to the concentrate.
[2] $Y = 0.04 + 0.01x$; $r^2 = 0.99$.
[3] $Y = 0.59 + 0.05x - 0.01x^2$; $r^2 = 0.76$.
[4] $Y = 0.64 + 0.03x$; $r^2 = 0.80$.
[5] $Y = 0.65 + 0.03x - 0.004x^2$; $r^2 = 0.48$.
[6] $Y = 0.63 + 0.03x - 0.005x^2$; $r^2 = 0.47$.
[7] $Y = 0.63 + 0.03x - 0.004x^2$; $r^2 = 0.54$.
[8] $Y = 2.78 + 0.14x - 0.02x^2$; $r^2 = 0.54$.
[9] $Y = 2.36 + 0.15x - 0.02x^2$; $r^2 = 0.54$.
[10] $Y = 1.54 + 0.08x - 0.01x^2$; $r^2 = 0.54$.

humidity for animal rearing is between 50 and 70%; thus, the animals spent most part of the grazing period in ideal humidity conditions.

To assess the suitability of thermal comfort of a facility, several indices are used. The black globe humidity index (BGHI), proposed by Buffington et al. (1981), is a more exact indicator of animal comfort, especially when animals are exposed to direct and indirect solar radiation. The average BGHI values were above those of normal conditions (average = 87.20; minimum = 78.10; and maximum = 93.30) according to Baêta and Souza (1997) (BGHI values up to 74.00 define a comfortable situation; 74.00 to 78.00, an alert situation; 79.00 to 84.00, a dangerous situation; and over 84, an emergency).

The dry matter and nutrient intakes were not modified by the addition of CSFA to the concentrates of multiparous or primiparous Saanen goats on a stargrass grassland, which were 2.04 and 2.11 kg day^{-1}, respectively. Molina (2013) also showed 2.0 kg day^{-1} DMI for Saanen goats fed 0, 6.25, 12.50, 18.75, and 25.0 g kg^{-1} CSFA from soybean oil in the diet. Therefore, for goats fed diets with low percentages of CSFA (0%, 1.5%, 3.0%, 4.5%, and 6.0% CSFA in the concentrate), the risks of palatability problems are reduced. Although calcium salts of fatty acids have the characteristic odor of soap, their inclusion in the diets did not restrict the intake of dry matter. Furthermore, pelleting and good mixture of the ingredients are essential to reduce the selection ability and avoid intake reduction. The dry mater intake determines the intake of all other nutrients and, therefore, is considered a limiting factor for ruminant production (Fonseca et al., 2006).

The CSFA in small quantities did not change the rumen environment, since the NDF digestibility was not affected. The CSFA probably did not reduce the rate of cell division and the growth of cellulolytic bacteria, which impairs fiber digestion. Thus, the diets probably provided the same rate of rumen passage and consequently the same dry matter intake.

When compared with other studies in which the goats were kept on a grassland, these results are in agreement.

Table 5 - Dry matter and nutrient intake and total apparent digestibility of primiparous Saanen goats in grassland fed experimental diets

	Level of calcium salts of fatty acids[1]				SEM	P-value		
	0.0%	1.5%	3.0%	4.5%		A	L	Q
Body weight	54.0	53.9	53.9	54.0	0.63	0.99	0.97	0.81
Dry matter intake (g day^{-1})								
DMI	2.04	2.20	2.08	2.10	0.12	0.80	0.90	0.58
Forage DMI	1.12	1.29	1.16	1.18	0.12	0.80	0.94	0.58
Concentrate DMI	0.92	0.91	0.92	0.92				
DMI (BW$^{0.75}$)	102	111	104	106	5.45	0.74	0.89	0.54
Nutrient intake (g day^{-1})								
OM	1.93	2.08	1.96	1.99	0.12	0.80	0.93	0.58
CP	0.29	0.30	0.30	0.30	0.01	0.87	0.73	0.51
EE[2]	0.05	0.06	0.07	0.08	0.002	<0.01	<0.01	0.58
NDF	0.83	0.94	0.85	0.87	0.08	0.79	0.90	0.60
TC	1.59	1.72	1.59	1.61	0.10	0.78	0.86	0.59
NFC	0.76	0.78	0.74	0.73	0.02	0.48	0.26	0.59
TDN	1.29	1.48	1.30	1.42	0.07	0.24	0.51	0.60
Digestibility coefficient (g g^{-1})								
DM	0.63	0.67	0.61	0.66	0.02	0.22	0.66	0.86
OM	0.65	0.68	0.63	0.68	0.02	0.22	0.63	0.90
CP	0.60	0.62	0.59	0.63	0.02	0.71	0.58	0.71
EE[3]	0.63	0.71	0.75	0.80	0.03	0.04	<0.01	0.70
NDF	0.51	0.60	0.50	0.56	0.02	0.06	0.67	0.53
TC	0.66	0.69	0.64	0.68	0.02	0.17	0.89	0.96
NFC	0.81	0.79	0.78	0.81	0.02	0.69	0.91	0.28
Energy values of diets (Mcal kg^{-1})								
TDN (g g^{-1})	0.61	0.72	0.66	0.69	0.05	0.56	0.54	0.50
DE	2.71	3.19	2.89	3.03	0.24	0.56	0.54	0.50
ME	2.29	2.77	2.47	2.61	0.24	0.56	0.54	0.50
NEL	1.50	1.77	1.61	1.69	0.13	0.56	0.54	0.50

SEM - standard error of the mean; A - ANOVA; L - linear; Q - quadratic
DMI - dry matter intake; BW - body weight; DM - dry matter; OM - organic matter; CP - crude protein; EE - ether extract; NDF - neutral detergent fiber; NFC - non-fiber carbohydrates ; TC - total carbohydrates; TDN - total digestible nutrients; DE - digestible energy; ME - metabolisable energy; NEL - net energy for lactation.
Digestible, metabolisable, and net energy were estimated by NRC (2007) equations.
[1] Level of calcium salts of fatty acids derived from soybean oil addition to the concentrate.
[2] Regression equation: $Y = 0.05 + 0.007x$; $r^2 = 0.99$.
[3] Regression equation: $Y = 0.64 + 0.37x$; $r^2 = 0.97$.

Rufino et al. (2012) supplemented Anglo-Nubian goats with 1.5% body weight on Tanzania-grass and showed 1.89 kg day^{-1} DMI. Mancilla-Leytón et al. (2013) observed 1.87 kg day^{-1} DMI when goats were supplemented with 0.5 kg day^{-1} concentrate in scrublands (158.8 g kg^{-1} CP and 579.4 g kg^{-1} NDF). In this study, the largest amount of concentrate (1.00 kg day^{-1} or 1.75% of body weight) resulted in the greatest dry matter intake (about 150 g).

Table 6 - Time spent on different feeding behaviors by multiparous and primiparous lactating Saanen goats

Behavior	Level of calcium salts of fatty acids[1]					SEM	P-value		
	0.0%	1.5%	3.0%	4.5%	6.0%		Model	L	Q
				Multiparous goats					
Percentage									
Grazing and drinking water	71.1	74.0	77.9	69.8	67.6	3.2	0.24	0.28	0.09
Ruminating standing	4.11	4.15	4.10	2.12	3.20	1.61	0.87	0.46	0.98
Ruminating lying	13.1	10.8	10.7	16.1	16.3	2.79	0.42	0.19	0.35
Resting standing	6.85	7.27	5.78	8.35	8.93	1.68	0.70	0.34	0.50
Resting lying	4.81	3.73	1.61	3.03	3.96	2.02	0.84	0.71	0.34
Time (h)									
Grazing and drinking water	4.26	4.44	4.67	4.18	4.05	0.19	0.24	0.28	0.09
Ruminating standing	0.25	0.25	0.25	0.13	0.19	0.10	0.87	0.46	0.98
Ruminating lying	0.79	0.65	0.64	0.99	0.98	0.18	0.42	0.19	0.35
Resting standing	0.41	0.44	0.35	0.50	0.54	0.10	0.70	0.34	0.50
Resting lying	0.29	0.22	0.10	0.18	0.24	0.12	0.84	0.71	0.34
				Primiparous goats					
Percentage									
Grazing and drinking water[2]	82.0	74.5	77.2	79.1		1.03	0.01	0.26	<0.01
Ruminating standing	3.98	4.00	6.01	4.68		1.03	0.52	0.41	0.54
Ruminating lying	8.71	12.8	13.4	12.1		1.95	0.40	0.26	0.22
Resting standing	4.68	7.36	3.34	4.04		1.72	0.44	0.47	0.59
Resting lying	0.68	1.35	0.00	0.00		0.64	0.45	0.29	0.62
Time (h)									
Grazing and drinking water[3]	4.91	4.47	4.63	4.75		0.06	0.01	0.26	<0.01
Ruminating standing	0.24	0.24	0.36	0.28		0.06	0.52	0.41	0.54
Ruminating lying	0.52	0.77	0.81	0.73		0.12	0.40	0.26	0.22
Resting standing	0.28	0.44	0.20	0.24		0.10	0.44	0.47	0.59
Resting lying	0.04	0.08	0.00	0.00		0.04	0.45	0.29	0.62

SEM - standard error of the mean; L - linear; Q - quadratic.
[1] Level of calcium salts of fatty acids derived from soybean oil addition to the concentrate.
[2] Regression equation: $Y = 81.41 - 5.08x + 1.04x^2$; $r^2 = 0.79$.
[3] Regression equation: $Y = 4.88 - 0.30x + 0.06x^2$; $r^2 = 0.79$.

Table 7 - Blood biochemical concentration of multiparous and primiparous lactating Saanen goats in grassland fed experimental concentrate

mg dL^{-1}	Level of calcium salts of fatty acids[1]					SEM	P-value		
	0.0%	1.5%	3.0%	4.5%	6.0%		A	L	Q
				Multiparous					
Glucose	54.3	55.0	58.9	58.2	60.2	3.48	0.71	0.19	0.89
Cholesterol[2]	75.0	93.6	103.3	99.30	110	6.38	0.02	0.003	0.24
Triglycerides	25.5	20.1	24.5	24.3	25.6	3.06	0.71	0.66	0.45
Urea	53.8	53.0	52.1	51.4	54.9	2.93	0.92	0.94	0.44
Calcium	7.83	7.88	8.45	8.16	7.79	0.39	0.73	0.86	0.27
Phosphorus	3.09	2.84	3.20	3.16	3.44	0.25	0.61	0.23	0.52
				Primiparous					
Glucose	61.9	57.8	61.8	60.7		3.03	0.77	0.99	0.64
Cholesterol[3]	93.1	101	111	108		4.58	0.10	0.03	0.28
Triglycerides	23.2	26.0	26.0	28.2		2.57	0.62	0.22	0.95
Urea	53.7	51.0	53.2	52.1		2.31	0.85	0.82	0.75
Calcium	9.42	7.93	9.19	8.43		0.51	0.25	0.49	0.50
Phosphorus	3.23	3.51	3.93	3.65		0.21	0.22	0.12	0.23

SEM - standard error of the mean; A - ANOVA; L - linear; Q - quadratic.
[1] Level of calcium salts of fatty acids derived from soybean oil addition to the concentrate.
[2] Regression equation: $Y = 81.1 + 5.05x$; $r^2 = 0.81$.
[3] Regression equation: $Y = 95.0 + 3.80x$; $r^2 = 0.79$.

According to the NRC (2007), for grazing multiparous goats with 57.00 kg body weight and 3.00 kg day^{-1} milk yield, the metabolizable energy (ME) requirement for maintenance, production, and activity is 4.65 Mcal day^{-1}. Grazing primiparous goats with 54.00 kg body weight and 2.70 kg day^{-1} milk yield require 4.25 Mcal day^{-1} ME. The multiparous and primiparous goats in this study ingested 2.04 and 2.11 kg day^{-1} DM, and the average values of ME in the diets were 2.53 and 2.54 Mcal kg^{-1}, respectively. Thus, all energy requirements for maintenance, production, and activity were met (5.16 and 5.36 Mcal day^{-1} ME intake for multiparous and primiparous goats, respectively) and the goats were able to achieve the expected production. Also, the ME surplus of 0.51 and 1.11 Mcal day^{-1} for multiparous and primiparous goats, respectively, can be used for body weight gain.

The crude protein requirement was 281 g day^{-1} for multiparous and 266 g day^{-1} for primiparous goats; the crude protein intake was 295 g day^{-1} and 298 g day^{-1}, respectively. Thus, according to the NRC (2007), the goats consumed more than the required amount of protein.

The digestibility coefficient of dry matter for multiparous and primiparous Saanen goats fed different levels of CSFA was 0.65 g g^{-1} and 0.64 g g^{-1}, respectively. These values were close to the 0.63 g g^{-1} and 0.65 g g^{-1} observed by Silva et al. (2007) and Molina (2013), respectively; Silva et al. (2007), who fed goats Tifton hay (210 g kg^{-1} CP, 819 g kg^{-1} NDF) and 500 g kg^{-1} CSFA from palm oil added to the diet; and Molina (2013), who fed goats with oat hay (78 g kg^{-1} CP, 697 g kg^{-1} NDF) and 0, 6.25, 12.5, 18.75, or 25.0 g kg^{-1} DM of CSFA from soybean oil.

However, other authors have reported higher values for dry matter and nutrient digestibility, such as Sanz Sampelayo et al. (2002) and Souza et al. (2014), who showed 0.69 g g^{-1} DMD; Sanz Sampelayo et al. (2002), who fed goats alfalfa hay (210 g kg^{-1} CP; 450 g kg^{-1} NDF) and 0, 900, or 1200 g kg^{-1} DM of a rumen-inert fat in the concentrate; and Souza et al. (2014), who fed goats corn silage and 0, 28.7, 54.6, or 80.5 g kg^{-1} DM of CSFA. The higher digestibility of dry matter reported by Sanz Sampelayo et al. (2002) and Souza et al. (2014) may be related to the forages used. It is usually known that maize silage and alfalfa hay are more digestible than grass pastures or hay (oat and Tifton). Another reason could be the lower amount of CSFA in this study, which conferred a diet with lower energy values than those provided by Sanz Sampelayo et al. (2002) and Souza et al. (2014).

The positive linear effect on ether extract intake (EEI) for multiparous and primiparous lactating goats fed concentrate containing CSFA is explained by the ether extract (EE) content in the concentrate (Table 1). The addition of 15 g of CSFA to the concentrate increases the EE content to 11.8 g kg^{-1}. This same positive linear effect was observed for the ether extract digestibility coefficient (EED). This effect may be associated with a higher concentration of unsaturated fatty acids in CSFA available in the intestine, which have higher solubility in micelles and are thus more digestible as compared with fatty acids with a higher degree of saturation (Palmquist and Mattos, 2011). The effect observed for EED contributed to the energy values of multiparous diets, which presented a quadratic effect with the addition of CSFA to the concentrate. The fact that ether extract provides 2.25 times more energy than carbohydrates and protein explains the improvement in the total digestibility of nutrients and increased energy availability for multiparous goats.

The addition of CSFA to the concentrate for multiparous and primiparous goats changed the neutral detergent fiber digestibility coefficient (NDFD); this result shows that forms of rumen-inert lipids cannot decrease cell wall digestibility, as previously shown by Sanz Sampelayo et al. (2002), Souza et al. (2014), and Molina (2013).

The proximity between the average organic matter digestibility (0.67 g g^{-1} for multiparous and 0.66 g g^{-1} for primiparous) and total digestible nutrients (0.67 g g^{-1} for multiparous and 0.67 g.g^{-1} for primiparous) showed that *n*-alkanes are a good marker to estimate dry matter intake and digestibility for grassland goats (Narvaez et al., 2012; Osoro et al., 2013).

Although the environmental conditions were not favorable for livestock grazing, the goats yielded close to the expected 3.00 kg day^{-1}, i.e., the milk yields for multiparous and primiparous goats were 2.80 and 2.70 kg day^{-1}, respectively. This yield was achieved by the goats because, in addition to forage, the goats were fed 1.00 kg day^{-1} of concentrate, and thus it was possible that the nutritional requirements were achieved and maintain the yield.

Goats with high milk yield need more nutrients, mainly energy, to support their high levels of productivity. When reared in grasslands, goats can reduce the time spent grazing and, consequently, reduce dry matter and energy intakes to maintain productivity. According to Ferrazza et al. (2012), Ribeiro et al. (2012), and Veloso Filho et al. (2013), the time spent grazing, ruminating, and resting normally changes according to the quality and quantity of forage. Furthermore, according to Silva et al. (2009), supplementation with concentrate can also change grazing behavior. Van Soest (1994) reported that the time spent ruminating is directly linked to neutral detergent fiber and the physical form of the diet. Thus, monitoring and

understanding ruminant grazing behavior are essential to the efficient management of livestock systems.

The addition of CSFA to the concentrate for primiparous goats changed the time spent grazing; the estimated critical level, in other words, the shortest time spent grazing, was reached when the addition of CSFA was 2.5%. Although the treatment decreased the time spent grazing, there was no effect on dry matter intake or milk yield in primiparous goats. This result is interesting when the time for grazing is a limiting factor for dry matter intake. With the estimated level of 2.5% CSFA for goats, even at a lower grazing time, the goats were able to eat the required amount of dry mater intake to maintain their production. Thus, further studies are needed to understand the real effect of CSFA in the feeding behavior of animals.

The structural and chemical properties of grass also can influence feeding behavior. Bratti et al. (2009) concluded that the structural characteristics, such as the mass of leaf blades and stems with sheaths, are a fundamental factor in animal grazing preference. Carvalho et al. (2006) evaluated different fiber levels in terms of the neutral detergent fiber in the forage and diet on the intake behavior of goats in lactation and concluded that feeding, ruminating, and total chewing times linearly increased with an increase in the neutral detergent fiber level in the diet. However, in this study, the grass structural characteristics did not change among the treatments, and the small amount of CSFA added to the concentrate did not influence grass intake behavior. Although all these factors interfere with feeding behavior, in this study, all the animals were raised under the same conditions, and so changes due to these factors were not observed.

The time spent on feed consumption was intercalated with one or more ruminating and resting periods. Therefore, multiparous goats dedicated 72% of their time to grazing, 17% to rumination, and 11% to resting. On the other hand, primiparous goats dedicated 78% of their time to grazing, 16.5% to rumination, and 5.5% to resting. The main reason why primiparous spend more time grazing is because they are smaller than multiparous goats (54.0 kg vs. 57.0 kg) and therefore should have a smaller rumen and to eat the same amount of dry mater the animals spent more time grazing. However, primiparous goats ate 106 g kg^{-1} DM of $BW^{0.75}$ (3.91% of body weight), while multiparous goats ate 98.3 g kg^{-1} DM of $BW^{0.75}$ (3.58% of body weight).

Furthermore, the greater amount of time dedicated to grazing and the lesser amount of time dedicated to resting by primiparous goats may be related to the need to recover body weight and the higher nutritional requirements of these animals, which, besides maintenance and production requirements, need nutrients for growth. Although primiparous goats had already reached the adult age (more than 24 months), they did not reach the average adult body weight of herd they came from (about 57 kg of adult body weight). Therefore, these animals supposedly increased their grazing and ruminating times to optimize their dry matter intake. However, the milk yields for multiparous and primiparous goats were similar, i.e., 2.8 and 2.7 kg day^{-1}, respectively.

The values shown in this study for concentrations of glucose, cholesterol, and triglycerides in the blood serum for multiparous and primiparous goats were in the ranges described by Mundim et al. (2007). According to these authors, the reference values for glucose, cholesterol, and triglycerides should range between 50 and 75 mg dL^{-1}, 80 and 130 mg dL^{-1}, and 6 and 32 mg dL^{-1}, respectively.

Therefore, the values obtained for serum glucose (54.35 to 61.94 mg dL^{-1}) show that there was adequate glucose control, because the values are in agreement with the literature data (Canaes et al., 2009; Tanwar et al., 2000). Other studies have reported similar results when feeding goats diets containing CSFA. Molina (2013) evaluated the effect of adding CSFA to the diet of Saanen goats, with no observed interference with blood glucose, with an average of 50.98 mg dL^{-1}. Similarly, Souza et al. (2014) did not observe changes in serum blood glucose when CSFA rich in polyunsaturated fatty acids was added to increase the dietary energy in the diet of Saanen goats.

The linear increase in blood cholesterol in multiparous Saanen goats fed CSFA may be related to the increased available fat in the diet, resulting in an increase in the cholesterol content for the biosynthesis of lipid proteins and transporters of lipids, thus stimulating the synthesis of cholesterol by enterocytes (Chilliard et al., 1986). This increase in the cholesterol content in response to feeding CSFA has been shown in the literature (Rapetti et al., 2009; Titti, 2011; Souza et al., 2014).

Addition of CSFA to the concentrate did not influence the blood triglyceride content in multiparous or primiparous goats, which averaged 23.98 and 25.83 mg dL^{-1}, respectively. The absence of significant variation in plasma triglyceride levels is in agreement with previous results on lactating goats fed different levels and sources of lipids (Rapetti et al., 2009; Titti, 2011; Molina, 2013; Souza et al., 2014).

The average blood urea content was 53.02 mg dL^{-1} for multiparous goats and 52.48 mg dL^{-1} for primiparous goats. Although urea was at a higher concentration than that reported by Mejía et al. (2012), who suggested that the blood urea nitrogen (BUN) reference values should range between 10 and 21 mg dL^{-1} (equal to 21 to 45 mg dL^{-1} urea

blood content), urea still remained within the range of 28 to 104 mg dL^{-1} observed by Mundim et al. (2007). Similar values have been reported by other authors when CSFA derived from soybean oil was added to the diet of lactating goats: Souza et al. (2014) observed values between 25 and 65 mg dL^{-1} and Molina (2013) observed values between 60 and 65 mg dL^{-1}. The blood urea content recommended above is likely due to the lower availability of energy for the rumen bacteria and the excess dietary protein (discussed previously), which increases the ammonia nitrogen in the rumen fluid. This excess nitrogen in the rumen passes to the blood and is excreted in the milk and/or urine.

Conclusions

Addition of 3.5% of calcium salts of fatty acids (35 g day^{-1}) increases the energy value of diets for multiparous grassland goats. Addition of calcium salts of fatty acids to the concentrate results in little effect on grazing time and does not change the nutritive value of diets for primiparous Saanen grassland goats. These results suggest that calcium salts of fatty acids are an alternative energy supplement for feeding lactating goats.

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