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Soybean meal or cotton by-products associated with urea as source of nitrogen in the diet of lactating goats

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ABSTRACT - The objective of this study was to evaluate the influence of sources of nitrogen on the intake and digestibility of nutrients and production and chemical composition of goat milk. Soybean meal (SBM), soybean meal + urea (SBM+U), cottonseed meal + urea (CM+U), cottonseed cake + urea (CC+U) and whole cottonseed + urea (WC+U) were used, representing the different sources of nitrogen in the diet. Ten crossbred goats were used (Alpine + Saanen), weighing on average 47.90±1.94 kg of body weight at 30 days of lactation, distributed in a double Latin square (5 × 5) with five treatments and five periods. There was influence of the different sources of nitrogen on the intakes of dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE), neutral detergent fiber (NDF) and non-fiber carbohydrates (NFC) of animals, with the lowest values found in most of the variables studied for animals that received CC+U and WC+U. There was an effect of diets on the DM, OM, CP and NFC digestibility coefficients. The diet with sole addition of SBM presented the best result regarding the amount of milk produced, followed by animals fed SBM+U and CM+U and values of 2.05 kg/day; 1.92 kg/day; 1.73 kg/day; 1.47 kg/day; and 1.24 kg/day of milk for diets with SBM, SBM+U, CM+U, CC+U and WC+U, respectively. Milk composition was also changed, and the diet with WC+U showed higher percentages: 0.1208 and 0.0041 percent, for total solids and fat, respectively. There was no difference in nitrogen balance between treatments. The use of SBM+U and CM+U did not compromise the milk performance and characteristics, but the use of CC+U and WC+U is indicated in periods of low milk production.

Key Words: cottonseed cake, cottonseed meal, milk constituents, NDFi, nitrogen balance, whole cottonseed

Introduction

The quality and quantity of protein is a determinant factor in the diet of ruminants due to the high demand for this nutrient during lactation and to the response variability to different sources of nitrogen available (NRC, 2001). Soybean meal is the main source of protein for these animals for containing protein of high biological value, but according to Van Soest (1994), protein sources of high biological value may lose essential amino acids due to the high content of rumen degradable protein (RDP). Thus, alternative sources of protein with higher contents of rumen-undegradable protein (RUP) have been the focus of several studies (Pina et al., 2006).

Studies with cotton by-products such as whole cottonseed, cottonseed meal and cottonseed cake, which have considerable amounts of RUP (NRC, 2001), for lactating goats, are still scarce. The quality of these products largely depends on processing, and they have a high protein content (32.72 g/100 g DM) and an average fiber content (33 g/100 g DM), although they may vary depending on the amount of hulls and residual oil (Bomfim et al., 2009). An appropriate RDP:RUP ratio is also an important factor; thus, associations of these sources of urea can optimize the use of these ingredients by ruminants, since the ingested urea is hydrolyzed by the action of urease synthesized by rumen bacteria, producing ammonia and carbon dioxide, and the ammonia produced is converted into microbial protein (Harmeyer & Martens, 1980).

The production and composition of goat milk can also be influenced by the inclusion of foods rich in protein due to the nitrogen concentration (N) and to the profile of rumen degradation of sources of N (Wu & Satter, 2000). However, the use of sources of protein with low rumen degradation in substitution to sources of greater degradation in many studies has led to inconclusive results, or even to negative responses in animal performance. The possible reasons for this fact are the reduction of microbial protein

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synthesis and the inclusion of sources of RUP with poor essential amino acid profile or low intestinal digestibility (Clark et al., 1992).

The objective of this study was to evaluate, in lactating goats, the effect of the use of soybean meal, cottonseed meal, cottonseed cake and whole cottonseed associated with urea on the intake and apparent digestibility of nutrients and production and chemical composition of milk.

Material and Methods

Ten Alpine × Saanen crossbred goats with average weight of 47.90±1.94 kg of body weight (BW) and 30 days of lactation were evaluated at the Unit for Small Ruminant Research, Universidade Federal da Paraíba, Areia, Paraíba, Brazil. The animals were treated for internal and external parasites, remaining in individual stalls with cement floors, provided with water and feeder.

Treatments consisted of diets in the form of complete mixture, composed of coast-cross hay (*Cynodon dactylon*) and concentrate (Table 1), with different sources of nitrogen: soybean meal (SBM; control); soybean meal + urea (SBM+U); cottonseed meal + urea (CM+U); cottonseed cake + urea (CC+U); and whole cottonseed + urea (WC+U) (Table 2), formulated according to NRC (2007) to meet the requirements of lactating goats with production of 2 kg/goat/day corrected for body fat percentage of 0.04. Feed was provided immediately after milking at 07h30 and 16h30, allowing for a percentage of 0.2 of leftovers.

The experimental design was a Latin square (5 × 5), with five periods and five treatments represented by different sources of nitrogen in the diet, using two simultaneous squares with five animals each. The experiment lasted 100 days, divided into 5 periods of 20 days, of which the first 15 days of each period were used for adaptation of animals to the experimental diets and 5 days for data collection.

Consumption data were obtained from the records of feed supplied and leftovers during the five days of data collection of each experimental period. Leftovers were weighed individually in the morning, sampling the percentage of 0.1, and then frozen at -15 ^{o}C. Later, ingredients and leftovers were dried in an oven with forced ventilation (55-60 ^{o}C) for 72 hours and milled in a knife mill with sieves of 1 mm screen. To evaluate the DM, OM, CP, EE, NDF and NFC digestibility coefficient, feces were directly collected from the final portion of the rectum every 27 hours and each harvest period was performed on the 1st, 2nd, 3rd, 4th and 5th days at 6h00, 9h00, 12h00, 15h00 and 18h00, respectively. Samples of feces were stored at -15 ^{o}C and subsequently, similarly for feed and leftovers, they were processed at the end of each experimental period.

The fecal production estimation was performed using indigestible neutral detergent fiber (iNDF) as internal marker. Feces, feed and leftover samples were incubated *in vitro* in an artificial rumen (DAYSE II; ANKOM Technology Coorp., Fairport, NY) based on methodology described by Tilley & Terry (1963). The amount of sample incubated was 0.8 g for diets (particles of 1 mm), leftovers (particles of 1 mm) and feces (particles of 2 mm) packed in non-woven textile bags (TNT-100 g/m^2) for a period of 240 hours (Casali, 2006). The remaining material was subjected to extraction with neutral detergent and the residue was considered iNDF.

Ingredients, leftovers and feces were subjected to analyses of dry matter (DM), crude protein (CP), ether extract (EE), mineral matter (MM), neutral detergent fiber (NDF), acid detergent fiber (ADF) and lignin (Silva & Queiroz, 2002). The determination of NDF and ADF was performed with an ANKOM device from Ankom Technology Corporation, using TNT bags (100 g/m^2). The correction of nitrogen compounds and mineral matter on the NDF and ADF were performed as recommended by

Table 1 - Nutritional composition (g/kg dry matter) of the ingredients of the experimental diets

Item	Ingredient					
	Soybean meal	Cottonseed meal	Cottonseed cake	Whole cottonseed	Corn meal[1]	Coast-cross hay
Dry matter	876.7	873.7	876.3	875.7	887.6	853.6
Organic matter	934.0	954.2	958.3	958.2	967.5	930.1
Protein	473.0	291.4	310.4	226.2	105.0	79.8
Lipids	22.4	33.8	70.8	195.6	114.9	21.1
NDFap	92.5	482.1	437.6	408.1	245.0	763.5
ADFap	60.2	364.8	430.3	377.2	93.8	509.5
Lignin	15.8	138.6	122.4	99.8	23.1	110.8
Total carbohydrates	478.3	608.8	712.0	512.4	767.3	836.6
Non-fibrous carbohydrates	385.8	126.7	274.4	104.3	522.4	73.1
Neutral detergent insoluble protein	57.8	36.2	30.9	47.3	21.5	34.5
Acid detergent insoluble protein	46.2	14.0	16.7	25.2	13.3	24.5

NDFap - neutral detergent fiber corrected for ash and protein; ADFap - acid detergent fiber corrected for ash and protein.
[1] Byproduct of the fabrication of cornflake.

Table 2 - Chemical-bromatological composition of the experimental diets

Item	Treatments				
	Soybean meal	Soybean meal + urea	Cottonseed meal + urea	Cottonseed cake + urea	Whole cottonseed + urea
	Ingredients (g/kg dry matter)				
Coast-cross hay	469.9	464.5	443.2	446.2	455.2
Soybean meal	166.8	110.5	0.0	0.0	0.0
Cottonseed meal	0.0	0.0	154.7	0.0	0.0
Cottonseed cake	0.0	0.0	0.0	145.7	0.0
Whole cottonseed	0.0	0.0	0.0	0.0	158.5
Corn meal[1]	346.6	399.2	373.9	374.2	358.3
Urea	0.0	7.2	10.0	10.2	14.2
Mineral supplement[2]	5.2	7.7	7.4	16.2	1.0
Calcitic limestone	11.6	10.9	10.7	7.5	13.0
	Chemical composition (g/kg dry matter)				
Dry matter[3]	871.1	872.6	872.5	873.4	872.4
Organic matter	928.1	921.5	921.6	916.7	921.8
Mineral matter	71.9	78.5	78.4	83.3	78.2
Protein	147.2	145.1	141.2	142.0	146.7
Lipids	53.4	58.1	57.5	62.7	81.7
NDFap	459.1	462.7	504.6	496.1	500.0
ADFap	281.9	280.8	317.3	325.1	325.3
Lignin	62.7	62.4	79.2	75.9	74.5
Total carbohydrates	727.5	718.3	722.9	712.0	693.4
Non-fibrous carbohydrates	268.3	268.5	236.4	234.2	218.9
Neutral detergent insoluble protein	33.3	31.0	29.0	28.0	30.9
Acid detergent insoluble protein	23.8	21.8	18.0	18.3	19.9
Total digestible nutrients	637.3	646.6	589.9	614.0	642.7

NDFap - neutral detergent fiber corrected for ash and protein; ADFap - acid detergent fiber corrected for ash and protein.
[1] Byproduct from the fabrication of cornflake.
[2] Mineral supplement (nutrient/kg of the supplement): vitamin A - 135,000.00 IU; vitamin D3 - 68,000.00 IU; vitamin E - 450.00 IU; calcium - 240 g; phosphorus - 71 g; potassium - 28.2 g; sulfur - 20 g; magnesium - 20 g; copper - 400 mg; cobalt - 30 mg; chromium - 10 mg; iron - 2,500 mg; iodine - 40 mg; manganese - 1,350 mg; selenium - 15 mg; zinc - 1,700 mg; maximum fluorine - 710 mg; solubility of phosphorus (P) in citric acid - 2% (min).
[3] g/kg of the natural matter.

Licitra et al. (1996) and Mertens (2002), respectively. For the estimation of non-fiber carbohydrates (NFC), the equation proposed by Hall et al. (2000) was used (Equation 1):

$$NFC(\%) = 100 - MM - EE - NDFap - (CP - CPu + U) \quad [1]$$

The milk yield was calculated daily by individual weighing during the five days of collection, after milking the goats twice daily (07h00 and 04h00). On the 1st, 3rd and 5th days of the collection period, milk was collected for physicochemical analyses and grouped into composite samples, proportional to the weight of each milking for each animal.

In the physicochemical analyses of milk, protein was determined using methods 991.20 and 991.23; total dry extract using method 925.23; and acidity, expressed in Dornic degrees (°D), using method 947.05 of AOAC (1998). For the determination of fat and lactose, methods 433/IV and 432/IV of IAL (2005) were used, respectively.

The correction of milk production for fat percentage of 0.04 (FCMY) was performed according to NRC (2001) (Equation 2) and the correction of milk production for total solids (TSCMY) was performed according to Tyrrell & Reid (1965) (Equation 3):

$$FCMY(0.04)(kg/day) = 0.4\ x\ milk\ yeld\ (kg/day) + 15\ x\ fat\ (kg/day) \quad [2]$$

$$TSCMY(kg/day) - (12.3\ x\ g\ of\ fat) + (6.56\ x\ of\ fat\ solids) - (0.0752\ x\ milk\ yeld\ in\ kg) \quad [3]$$

Feed efficiency was determined by dividing the milk production corrected for fat percentage (0.04) by the dry matter intake verified over the sampling period.

At the calculation the nitrogen balance, the amounts of nitrogen (g/day) consumed and excreted in milk, urine and feces were considered. The nitrogen use efficiency was obtained by dividing the nitrogen contained in the milk by the nitrogen consumed.

On the first day of the collection period, spot urine samples were collected approximately 4 hours after feeding, during spontaneous urination. Aliquots of 30 mL of pure urine were collected and stored at -20 °C for nitrogen analysis using method 984.13 (AOAC, 1990) and 10 mL of samples were diluted into 40 mL of 0.036 N H_2SO_4, and kept at pH lower than 3, and then subjected to creatinine analysis using a commercial kit (Labtest) to estimate the urinary volume. The urine volume was obtained for each animal by multiplying body weight by the average daily creatinine excretion of 26.05 mg/L (Fonseca et al., 2006) and dividing this product by the creatinine concentration (mg/L) in the spot urine sample.

Data were subjected to analysis of variance using the mixed model (PROC MIXED) of the Statistical Analysis System (SAS, version 9.2), and the treatment means were compared by Tukey's test, adopting α = 0.05, using the following mathematical model:

$$Y_{ijkl} = \mu + A_{(k)i} + P_j + Q_k + T_l + QT_{kl} + \xi_{ijkl}$$

where: Y_{ijkl} = Observation of animal i (random effect), in period j (random effect), on square k (random effect), subjected to treatment l (fixed effect); μ = overall effect of the mean; $A_{(k)i}$ = effect of animal i on square k, with i = 1, 2, 3, 4, 5; Pj = effect of period *j*; Q_k = effect of the Latin square, with k = 1, 2; T_l = effect of treatment l, with l = 1, 2, 3, 4, 5; QT_{kl} = interaction of the effect with the Latin square × treatment l; and ξ_{ijkl} = random error associated with each observation Y_{ijkl}.

Results and Discussion

There was influence of the studied diets on the dry matter intake (kg/day and g/kg$^{0.75}$ BW) by goats (P<0.05) (Table 3). Diets containing cottonseed cake with urea (CC+U) and whole cottonseed with urea (WC+U) provided animals with lower intake values (P<0.05) compared with control diet (SBM) when DMI was expressed in kg/day; however, when it was expressed in g/kg$^{0.75}$ BW, only the diet containing WC+U showed significant difference. The dry matter intake observed for animals fed SBM, SBM+U and CM+U was similar to the 2.02 kg/day recommended by the NRC (2007) for animals with an average 45 kg body weight and production of 2 kg/day of milk corrected for a fat percentage of 0.04.

Although whole cottonseed is an oilseed rich in unsaturated fatty acids and cottonseed cake also contains a high content of this component, which may interfere with the intake of ruminants (Jenkins, 1993; Allen, 2000), the EE values in diets CC+U and WC+U, of 62.7 and 81.7 g/kg DM, respectively, in this experiment, are similar to those of Brown-Crowder et al. (2001), who worked with levels up to 80.0 g/kg EE in the DM of diets for Alpine goats in early lactation and reported no reduction in DM intake. Thus, the lower DM intake by goats fed diets CC+U and WC+U when compared with SBM may be more associated with psychogenic factors such as the physical form of whole cottonseed and cottonseed cake than the EE content of diets, and according to Mertens (1994), psychogenic factors involving animal behavior in response to stimulatory or inhibitory factors in the diet may adversely impact feed intake.

The CP, NDF and NFC intake by animals was also influenced by diet (P>0.05), but no difference in the EE intake was found (P<0.05). The diet with SBM promoted higher CP intake (P<0.05) than diets with CC+U and WC+U; however, for the NDF intake, only the diet with WC+U differed from control diet. The CP intake of 0.31 kg/day by goats that received diet with SBM; 0.30 kg/day from SBM+U; and 0.28 kg/day from CM+U, as well as DM intake, were similar to the 0.28 kg/day recommended by the NRC (2007), showing that these diets are able to meet the CP requirements for lactating goats.

The average value for NDF intake by animals of 18.4 g/kg body weight found in this study is higher than that suggested by Mertens (1992), who proposed an average NDF intake of 12.0 g/kg body weight, representing an intake level regulated by physical mechanisms, when stating that the filling limitation can be correlated to the level of neutral detergent fiber (NDF) of a diet. However, recommended caution when using this calculation, especially for goats raised in tropical regions, because, according to Van Soest (1994), the low energy content of forage produced in these regions, can causing the animals to consume greater amounts of feed to meet their requirements.

Diets with SBM and SBM+U promoted higher NFC intake (P<0.05) when compared with cotton-derived diets. When using feed with a high percentage of nitrogen and rumen-degraded protein such as soybean meal and urea, it is necessary to have the contribution of carbohydrate of rapid fermentation, allowing the availability of energy and carbon skeletons for microbial protein production (Russell et al., 1992), which may explain the higher NFC intake by animals fed diets containing SBM and SBM+U.

The diet with WC+U provided the highest EE percentage in the composition (81.7 g/kg DM); however, the intake of lipids by the group fed this feed, of 0.13 kg/day, was similar to the others (P>0.05), possibly due to the selectivity and consequent rejection of whole cottonseed by animals, raising the EE content in the leftovers. According to the concept postulated by Van Soest (1994), goats are classified as intermediate selectors, being able to select the more nutritive parts of feeds.

There was an effect of diets on DM, OM, CP and NFC digestibility coefficients (P<0.05); however, for EE and NDF, treatments did not differ (P>0.05) (Table 3). The diet with CM+U promoted the lowest DM and OM digestibility coefficients, with 0.543 and 0.558, respectively, when compared with diets with SBM and SBM+U (P<0.05). Beran et al. (2005), evaluating the ruminal degradability *in situ* of concentrated supplements in cattle feed, found that the heating during the oil extraction process for obtaining cottonseed meal can cause changes in the protein constitution, thereby decreasing its degradability, which contributes to lower digestibility and to the lower DM and OM digestibility coefficients of the diet with CM+U, compared with the control diet (P<0.05).

Also in relation to OM digestibility coefficient, the 0.576 for the diet with WC+C was also lower than the control diet (0.635). The behavior of the low OM digestibility in diet with WC+U when compared with the control diet can be explained by the high lipid concentration of whole cottonseed, which may have hindered the access of microorganisms to this diet and consequently affected digestibility (Palmquist, 1991). At the same time, Silva et al. (2007) suggested that the peculiar characteristics of oilseeds should be considered when provided in its whole form, since due to the presence of fiber, mostly in the hulls, they decrease the rate of passage of solids and this increase in permanence time reduces digestibility and energy value of the diet. Silva et al. (2010) studied the effect of fat supplementation in the diet of lactating goats and observed reduction in OM digestibility when the animals received 128.9 g/kg DM from whole cottonseed in the total diet.

The CP digestibility coefficient of the diet with CM+U was 0.662, with no statistical difference for the coefficient 0.699 of diet with CC+U, but lower (P<0.05) than the digestibility coefficients of 0.738, 0.729 and 0.725 of diets with SBM, SBM+U and WC+U, respectively. Cottonseed meal showed 138.6 g/kg DM in the lignin diet (Table 1), and according to Van Soest (1994), a high lignin content can also affect the digestibility of nutrients including protein.

In this study, there was no influence of different sources of protein on EE and NDF digestibility, although diets with CM+U and WC+U provided higher EE concentrations in the diet: 62.7 and 81.7 g/kg DM, respectively, contrasting with results of Silva et al. (2010), who found higher EE digestibility when supplementing lactating goats with faveleira (*Cnidoscolus phyllacanthus*) and cottonseed cake, obtaining EE percentage in the diets of 0.066 and 0.084, in addition to greater NDF digestibility for the animals that received whole cottonseed.

There were significant effects of diets (P<0.05) on production data and physicochemical composition of goat milk (Table 4), in which goats fed the diet with SBM showed higher amount of milk produced, with no statistical difference when compared with the group fed SBM+U (P>0.05), but the feed efficiency (FE) of the animals was not affected by diet (P>0.05).

The high results for milk production by animals that received diets with SBM, SBM+U and CM+U were due to the high DM intake (kg/day) and CP values (kg/day) by animals. Increased feed intake implies more supply of nutrients to the animal. Furthermore, Goetsch et al. (2011) reported that the effect of dietary crude protein on milk production depends on the nature of nitrogenous compounds due to their influence on the metabolizable protein intake. Milk production by animals fed diets containing CM+U differed in relation to control only when expressed in kg/day (P<0.05).

Usually, research carried out with whole cottonseed, either to lactating cows or goats, evaluates this ingredient as source of lipid and the results of the inclusion of whole cottonseed in milk production are controversial and in some

Table 3 - Average daily intake and apparent digestibility of nutrients by lactating goats as a function of the different sources of nitrogen in the diet

Item	Treatments						
	Soybean meal	Soybean meal + urea	Cottonseed meal + urea	Cottonseed cake + urea	Whole cottonseed + urea	P-value	Standard error of the mean
Intake							
Dry matter (kg/day)	2.05a	2.02ab	2.00ab	1.82bc	1.60c	0.0001	0.068
Dry matter (g/kg$^{0.75}$ BW)	113.02a	108.96a	105.34a	100.83ab	87.87b	0.0001	3.520
Protein (kg/day)	0.31a	0.30a	0.28ab	0.26b	0.23c	0.0001	0.008
Ether extract (kg/day)	0.12a	0.13a	0.12a	0.12a	0.13a	0.3762	0.003
NDFap (kg/day)	0.88a	0.86ab	0.96a	0.85ab	0.75b	0.0005	0.033
NDFap (g/kg$^{0.75}$ BW)	19.1a	18.4ab	20.3a	18.6a	15.7b	0.0006	0.070
Non-fibrous carbohydrates (kg/day)	0.59a	0.60a	0.51b	0.47b	0.40c	0.0001	0.013
Coefficients of digestibility							
Dry matter	0.608a	0.608a	0.543b	0.566ab	0.562ab	0.0092	1.592
Organic matter	0.630a	0.625ab	0.558c	0.580ab	0.576b	0.0021	1.490
Protein	0.738a	0.729a	0.662b	0.699ab	0.725a	0.0004	1.271
Ether extract	0.724a	0.709a	0.689a	0.715a	0.743a	0.5506	1.743
NDFap	0.408a	0.406a	0.379a	0.392a	0.382a	0.6183	2.029
Non-fibrous carbohydrates	0.885ab	0.892a	0.850a	0.875a	0.863a	0.0536	1.081

Means followed by different letters in the row differ by Tukey's test (P<0.05).
BW - body weight; NDFap - neutral detergent fiber corrected for ash and protein.

Table 4 - Milk yield (MY), feed efficiency and physicochemical composition of milk from goats receiving different sources of nitrogen in the diet

Item	Treatments						
	Soybean meal	Soybean meal + urea	Cottonseed meal + urea	Cottonseed cake + urea	Whole cottonseed + urea	P-value	Standard error of the mean
Yield							
Milk (kg/day)	2.05a	1.92ab	1.73bc	1.47cd	1.24d	0.0001	0.08
FCMY 0.04 (kg/day)[1]	1.88a	1.77a	1.62ab	1.42bc	1.25c	0.0001	0.08
TSCMY (kg/day)	1.92a	1.82a	1.67ab	1.44bc	1.27c	0.0001	0.08
Efficiency							
FE - MY/DM Intake (kg/kg)	0.93a	0.89a	0.90a	0.80a	0.80a	0.3202	0.06
Physicochemical composition of the milk (%)							
Total solids	0.1132b	0.1147b	0.1156b	0.1158b	0.1208a	0.0020	0.12
Non-fat solids	0.0789a	0.0794a	0.0796a	0.0781a	0.0796a	0.8832	0.14
Moisture	0.8868a	0.8853a	0.8844a	0.8842a	0.8792b	0.0020	0.12
Mineral	0.074a	0.073a	0.073a	0.072a	0.076a	0.3014	0.14
Fat	0.0343b	0.0353b	0.0360b	0.0377ab	0.0412a	0.0051	0.13
Protein	0.0353a	0.0338a	0.0339a	0.0334a	0.0343a	0.0970	0.05
Lactose	0.0436a	0.0438a	0.0437a	0.0436a	0.0429b	0.0063	0.03
Acidity (°D)	14a	14a	14a	14a	14a	0.7761	0.004

Means followed by different letters in the row differ by Tukey's test (P<0.05).
TSCMY - milk yield corrected for total solids; FE - feed efficiency.
[1] FCMY 0.04 - milk yield corrected for 0.04 percentage of the fat.

cases, there is reduction or increases, and in others cases, no interference (Fernandes et al., 2002; Queiroga et al., 2009).

Silva et al. (2010) studied whole cottonseed as a source of lipid supplementation and found no difference in milk production when compared with the control diet (soybean meal), but when supplemented with faveleira cake, there was a decrease in milk production, and the values of 1.098 and 1.095 kg/day of milk for whole cottonseed and faveleira cake, respectively, shown by these authors are below those found in this study. It is noteworthy that the animals used in the experiment of these authors had average milk production of 1.20 kg/day, i.e., well below the 2.00 kg/day of animals used in this study, which leads us to infer that diets with CC+U and WC+U can be alternatives to animals with lower milk production.

The physicochemical composition of milk differed (P<0.05) for total solids (TS), moisture, fat and lactose, which were higher in the milk of animals receiving diets with WC+U, except for lactose, not differing only from goats fed the diet CC+U for fat percentage (P>0.05).

The fat percentage in the milk of goats fed diets containing WC+U and CC+U, of 0.0412 and 0.0377, respectively, were the highest, and these results corroborate those reported by Silva et al. (2010), who found that there is an increase in the TS and fat percentage in the milk of goats fed faveleira cake and whole cottonseed as lipid supplement in the diet with soybean meal. Smith et al. (1981) and Lubis et al. (1990) reported that diets with whole cottonseed decrease the synthesis of short-chain fatty acids in the mammary gland, but there is a transfer of long-chain fatty acids of whole cottonseed to the milk, which results in a net increase in the percentage and production of milk fat. Higher levels of fat and total solids in milk are desirable characteristics in the dairy industry, because they promote an increase in product yield (Santos et al., 2011).

The percentage of protein in milk did not differ among diets, with average percentage of 0.0341, above the 0.0299 found by Macedo et al. (2003), but similar to the 0.0369 observed by Araújo et al. (2010). It was expected that the different sources of protein would promote changes in the protein content, which was not observed in this study, since soybean meal, which is a food rich in rumen-degradable protein (RDP), was replaced by three sources of protein (cottonseed meal, cottonseed cake and whole cottonseed), with higher levels of rumen-undegradable protein (RUP). The quality of RUP from these sources compared with soybean meal may have contributed to these results (Goetsch et al., 2011). Laudadio & Tufarelli (2010) found higher values for protein percentage in the milk of goats fed diets containing high RUP levels, and according to these authors, this may occur as a result of better utilization of nutrients. However, Huston & Hart (2002) reported that the response of lactating goats to RUP supplementation is lower when compared with cows; moreover, the response to RUP supplementation is more evident in high-yielding animals (Chalupa & Sniffen, 1991). In extreme cases, the protein percentage in milk is around 0.004, while the fat percentage can vary from 0.02 to 0.03 (Carvalho, 2000).

Between protein and fat, fat is more strongly influenced by nutrition (Pulina et al., 2008).

The average percentage value of 0.0435 for lactose in the milk of animals in the present study is similar to 0.043, recommended by current Brazilian legislation for goat milk (Brasil, 2000) and equal to 0.0435 found by Macedo et al. (2003), who found no difference in lactose and protein levels when substituting up to 0.5 soybean meal by corn gluten in the diet of lactating goats, unlike animals fed a diet containing WC+U, which showed the percentage of 0.0429 for lactose in milk lower than the other treatments (P<0.05); the lower NFC consumption by these animals may have contributed to reduced production of propionate and consequently its availability in the mammary gland for use in the synthesis of lactose (Goestich et al., 2001). Like protein, the lactose content of milk can hardly be changed (Carvalho, 2000).

The titratable acidity value of 14 ºD, average for all treatments, is within the limits for goat milk, which ranges from 13 to 18 ºD (Brasil, 2000), demonstrating the milk quality regarding its collection and manipulation.

Nitrogen intake (g/day) showed the same behavior as protein intake (Table 3), in which animals fed the diet containing SBM had higher nitrogen intake when compared with animals fed the diet containing CC+U and WC+U (P<0.05) (Table 5). The excretion of nitrogen in milk (g/day) was higher in animals that received the diet containing SBM than for those fed the diet containing CM+U, CC+U and WC+U (P<0.05) as a result of the difference in milk production among animals (Table 4). Among the diets, with the use of cotton-derived products associated with urea as sources of nitrogen, animals receiving CM+U had higher fecal nitrogen excretion (g/day) (P<0.05), not differing from the diets containing SBM and SBM+U (P>0.05). There was no difference in nitrogen excretion in urine and nitrogen balance (NB) in g/day between sources of nitrogen studied (P>0.05), and NB was negative regardless of the source of nitrogen used in the diet. Difference was detected (P<0.05) for nitrogen use efficiency (NE).

The higher nitrogen intake (g/day) and nitrogen excretion in milk (g/day) of animals fed diets containing SBM when compared with those fed CC+U and WC+U (P<0.05) was due to the difference between DM intake and milk yield; these variables were higher in animals fed diets containing SBM compared with animals fed diets containing CC+U and WC+U. Animals that received diet with CM+U had lower CP digestibility, which increases fecal nitrogen excretion (Van Soest, 1994) and explains the higher fecal nitrogen excretion (g/day), not differing from diets containing SBM and SBM+U (P>0.05).

As previously mentioned, CP intake by goats fed diets containing SBM, SBM+U and CM+U was close to values recommended by the NRC (2007), and all animals, regardless of the treatment, showed negative nitrogen balance; however, the presence of significance for NE shows that animals fed CC+U and WC+U were less efficient in the use of nitrogen for the synthesis of milk. The values observed in this study were lower than those reported by Jonker et al. (1998), who found an average coefficient of 0.283±0.037 (n = 70) for nitrogen use efficiency by analyzing data from 40 cows and 10 diets in the development of a model for predicting nitrogen use efficiency.

For Cordeiro et al. (2007), lower nitrogen use efficiency may be associated with the amino acid profile required for lactating animals, because from the moment they do not meet the requirements for milk production, amino acids supplied by diet and/or by rumen microorganisms are used in other metabolic pathways.

The use efficiency of nitrogen derived from rumen degradable protein depends on the level of energy intake from carbohydrates of high degradation rate (NFC) and animals fed diets containing CC+U and WC+U had the lowest NFC intake when compared with the control diet (Table 3). Chase (2003), cited by Pina et al. (2006), in

Table 5 - Nitrogen balance and use efficiency by lactating goats receiving different sources of nitrogen in the diet

Item	Treatments						
	Soybean meal	Soybean meal + urea	Cottonseed meal + urea	Cottonseed cake + urea	Whole cottonseed + urea	P-value	Standard error of the mean
Balance							
N intake (g/day)	49.6a	47.6a	45.5ab	42.3bc	37.1c	0.0001	0.001
N milk (g/day)	11.3a	10.0ab	9.2bc	7.7cd	6.6d	0.0001	0.000
N feces (g/day)	13.0ab	12.9ab	15.3a	12.7bc	10.2c	0.0001	0.000
N urine (g/day)	35.7a	37.6a	24.1a	30.7a	33.9a	0.2881	0.004
Nitrogen balance	-10.4a	-12.9a	-3.1a	-8.8a	-13.6a	0.4958	0.004
Efficiency							
NE - N milk/N intake (g/g)	0.22a	0.20ab	0.19ab	0.17b	0.17b	0.0012	0.008

Means followed by different letters in the row differ by Tukey's test (P<0.05).
NE - nitrogen use efficiency.

an attempt to identify the various factors that affect the nitrogen use efficiency, reported among other factors, the quantity and quality of dietary protein, as well as the source of carbohydrates.

Conclusions

The use of soybean meal and cottonseed meal associated with urea as main source of nitrogen in the diet for lactating goats does not compromise the milk performance and characteristics. This study recommends the use of cottonseed cake and whole cottonseed associated with urea when feeding animals in the period of low milk production.

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