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Production and quality of Alpine goat milk by using urea in place of soybean meal

Produção e qualidade do leite de cabras Alpinas utilizando uréia em substituição ao farelo de soja

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Abstract

The study was conducted to evaluate the effect of partial substitution of soybean meal by urea in the ration of alpine milking does on the physico-chemical composition, fatty acid profile, and sensory characteristics of the milk. Ten multiparous alpine goats, distributed in a 5X5 Latin square and five levels of urea (0.0; 0.5; 1.0; 1.5 e 2.0%) were used in five experimental periods of 17 days each - 12 days for adaptation and 5 days for data collection. There was no effect on the density index (g/cm^3), acidity (˚D), protein (%), total dry extract (%), dry defatted extract (%), ashes (%) and sensory characteristics (odor and flavor). Substitution of soybean meal by urea increased the concentration of milk fat and short chain fatty acids. However, sensory characteristics of the milk were not altered and acceptable by the taste panel.
Key words: Dairy goats, chemical composition, non-protein nitrogen, milk production

Resumo

O objetivo do trabalho foi avaliar o efeito da substituição parcial do farelo de soja por uréia na alimentação sobre a composição físico-química, perfil lipídico e características sensoriais do leite de cabras alpinas. Foram utilizadas 10 cabras alpinas multíparas, distribuídas em quadrado latino (5X5), cinco níveis de uréia (0,0; 0,5; 1,0; 1,5 e 2,0%) e em cinco períodos experimentais, de 17 dias, sendo 12 de adaptação e 5 para coleta de dados. Não houve efeito para índice de densidade (g/cm^3), teor de acidez (˚D), proteína (%), extrato seco total (%), extrato seco desengordurado (%), cinzas (%) e características sensoriais (odor e *flavor*). A substituição do farelo de soja por uréia promoveu um incremento na concentração de gordura, bem como no teor de ácidos graxos de cadeia curta, sem, contudo, alterar as características sensoriais do leite.
Palavras-chave: Cabra leiteira, composição química, nitrogênio não protéico, produção de leite

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Introduction

Goat farming plays a relevant role as an important socio-economic factor for small farmers, as well as producing a good source of proteins. The usage of goat products and sub-products can be considered an efficient instrument for promoting development in the Northeast Region of Brazil.

The composition of milk has assumed a crescent importance because its quality is a direct requirement from dairy industries that want to guarantee higher yield of their products and overall acceptance by the final consumers who, in turn, search for good-quality nutritious products.

Goat milk is one of the most complete foods. Its importance is based on its high nutritious value, as well as high protein, vitamin, fat, and mineral content, and its easy digestibility. It is recommended for convalescent and elderly people and children, mainly when they are allergic to cow milk (HAENLEIN, 2004).

The feed given to the animals is a determining factor in the production and composition of the milk. Morand-Fehr et al. (2007) stated that feed can influence quality and quantity characteristics of animal milk, and that particularly the type of feed and breeding system used by the farmer can present effects on the composition and quality of the milk of small ruminants, not only due to nutritional factors, but also to modifications which begin in the physiological and metabolic aspects of the digestive process which can aid in the understanding and interpreting of the modifications of the milk quality.

There is a growing need to research alternative feed rich in protein and energy for the animals in an attempt to prevent competition for food between animals and humans. Thus, usage of sources of non-protein nitrogen (NPN) such as urea as a protein alternative is very common in milk production systems in Brazil. It can be valuable to take advantage of the potential of ruminants to convert these sources into essential amino acids in their metabolism. Furthermore, using urea in feed allows for savings on input and cost reducing on the animal diet, since the highest cost with animal production is with its feed.

The purpose of this study was to evaluate the effect of urea supplementation in milking goat diet on milk production, physico-chemical composition, fatty acid profile, and sensory traits of Alpine goats.

Material and Methods

Experimental testing, animals and diets

The experiment was conducted at the Federal University of Paraíba, Campus at Bananeiras - PB, whose geographic coordinates are 6º, 41’ and 11” south latitude, and 35º, 37’ and 41” longitude, west of Greenwich, at an altitude of 552 meters.

The design used was a 5 x 5 Latin square, 10 Alpine female goats (at 31±6 kg of live weight and 26± 6 days of lactation), five treatments (0.0; 0.5; 1.0; 1.5; 2.0% urea) and five experimental periods, in which the animals were randomly distributed. The experimental period was 85 days, divided into five periods of 17 days, the first 12 days of each period being used for the adaptation of the animals to the diets and the last 5 days for sample collections.

The animals were handled in an intensive system placed in a covered shed in individual stalls. The diets contained an average of 12.7% CP formulated to attend to the maintenance and lactation requirements for 45 Kg goats, producing 1.5 L/day of milk (NRC, 1981). The furnishing of feed was performed twice a day, at 7:30 and at 15:30, immediately after milking, in quantities adjusted to proportion 15% leftovers, calculated on their daily consumption. Water was freely available for the animals. The chemical composition of the ingredients used in the experimental diets is found in Table 1. The diets furnished to the animals were composed of ground corn, soybean meal, Tifton hay, cactus pear, urea and mineral supplement (Table 2).

Collection and Analysis of samples

The goats were milked manually, twice a day, at 7:00 and 15:00 o'clock, in a milking parlor, for the registration of milk production, in which milk samples were collected at the 5 experimental periods on the 5 days of sample collection. The milk production was corrected for 3.5% fat (FCM) according to the equation suggested by Adams et al. (1995): FCM 3.5% = (0.4255 X milk production (Kg/day)) + [16.425 x (milk fat (%) / 100) x milk production (Kg/day)].

Table 1. Chemical composition of the ingredients based on the dry matter.

Indicators*	Ground Corn	Soybean Meal	Tifton Hay	Prickly Pear
DM	88.84	91.24	96.02	9.51
OM	97.34	92.84	93.45	80.26
MM	2.65	7.16	6.54	19.74
CP	7.56	51.48	5.83	5.79
EE	6.06	4.07	5.16	5.77
NDF	16.25	13.55	64.00	29.85
ADF	5.87	9.76	35.38	18.43
TCH	87.81	37.29	82.47	68.70
NFC	71.56	23.74	18.47	38.85

**Dy matter (DM), organic matter (OM), mineral matter (MM), crude protein (CP), ether extract (EE), neutral detergent fiber (NDF), acid detergent fiber (ADF), total carbohydrates (TCH) e non-fibrous carbohydrates (NFC).*

Source: Elaboration of the authors.

Table 2. Percentage composition of the ingredients in the diets (% in the DM), according to the levels of urea used.

Ingredients	Levels of Urea (%)				
	0	0.5	1.0	1.5	2.0
Soybean Meal	14	11	8	5	2
Urea	0	0,5	1,0	1,5	2,0
Prickly Pear Forage	26.5	27.5	28.5	29.5	30.5
Ground Corn	29	30.5	32	33.4	35
Tifton Hay	29	29	28.9	28.9	28.7
Mineral Supplement	1.5	1.5	1.6	1.7	1.8
Chemical composition (%)					
Dry Matter	27.91	27.06	26.51	25.49	24.75
Organic Matter	89.71	89.19	88.58	87.95	87.37
Mineral Matter	10.28	10.30	10.41	10.54	10.62
Crude Protein	12.62	12.66	12.69	12.71	12.75
Ether extract	5.35	5.38	5.40	5.40	5.44
Neutral Detergent Fiber	33.08	33.21	33.28	33.60	33.43
Acid Detergent Fiber	18.21	18.19	18.14	18.23	18.02
Total Carbohydrates	72.80	73.70	74.50	75.27	76.10
Non-Fibrous Carbohydrates	39.73	40.47	41.21	41.67	42.67
Metabolizable Energy (Kcal)	2.55	2.53	2.50	2.47	2.44

Source: Elaboration of the authors.

Aliquots for each animal were obtained constituting composite samples proportional to the production of milk for each milking shift. These aliquots were packaged in 200 mL polyethylene bottles and maintained frozen (-18 °C) for later analyses of the chemical composition, of the fatty acid and sensory profile of the milk.

To obtain the chemical composition of the goat milk, 50 samples corresponding to 10 goats and the five experimental treatments were analyzed. The analyses were performed according to the following methodologies: the lipid content was analyzed by using Gerber lactobutirometer (INSTITUTO ADOLFO LUTZ, 2005); Protein was determined by the Micro-Kjedahl method, by multiplying 6.38 by the nitrogen percentage - methods AOAC, 991.20 and 991.23 (AOAC, 2000); the lactose percentage was determined by using the reduction method of Fehling (INSTITUTO ADOLFO LUTZ, 2005); the acidity analysis was performed by titillation, and the result expressed in °D - method AOAC 947.05 (AOAC, 2000); Total dry extract, obtained by drying in oven at 105 °C until constant weight was obtained - method AOAC, 925.23 (AOAC, 2000); the defatted dry extract was determined by subtracting the lipid content from the dry defatted extract and the percentage of ashes was performed in muffle at a temperature of 550 a 570 °C (INSTITUTO ADOLFO LUTZ, 2005); the density was determined by reading lactodensimeter 15 °C (INSTITUTO ADOLFO LUTZ, 2005).

For extraction and esterification of the fatty acids, the samples were homogenized with glass rods and aliquots of 100 mL of milk were taken out and submitted to centrifugation for 5 minutes to separate the fat from the other nutrients. From these samples, 2 g aliquots were obtained for the extraction, saponification, and esterification processes (FOLCH; LEES; SLOANNE STANLEY, 1957). Then, methylation was performed according to the methodology of Hartman and Lago (1973) to obtain the esters that were produced, and then they were packed in (10 mL) glass containers, identified and closed to be sent for gas chromatography analysis.

Methyl esters from the fatty acids were separated and quantified in a gás chromatograph (CG-MASTER, Shimadzu, Brasil), equipped with a fused silica capillary column (MEGABORE, J and W Scientific, United States), polyethylene glycol stationary phase, with dimensions of 30 m in length, 0.53 mm internal diameter and 0.25 mm film thickness, using hydrogen as carrier gas, at the flow rate of 5 mL/min. Methyl ester samples of 1 μL were introduced in a *split/splitless* type injector at a temperature of 200 °C. The chromatograms with the data on the retention times and the area percentages of the methyl esters of the fatty acids were registered in Peaksimple (ARI Instruments - USA) type software. The identification and quantification of the fatty acids were performed according to European Norm EN 14103:2001.

For the sensory analysis, the samples were pasteurized, at 65 °C for 30 minutes, and put into sterile polyethylene containers. The analyses were conducted according to the methodology described by Stone and Sidel (1993), in individual booths, at pre-established hours, considering a 2-hour period after the last meals of the tasters.

The sensory panel was formed by 10 trained tasters, who performed a Quantitative Descriptive Analysis (QDA), for the attributes of characteristic odor, characteristic flavor, fruity taste, rancid flavor and global evaluation, according to methodology described by Faria and Yotsuyanagi (2002), using a structured scale of intensity of nine points, varying from extremely weak to extremely strong. Each judge received the samples of milk in (50 mL) polyethylene cups at a temperature of 7 °C, coded with three digits corresponding to each experimental treatment, according to the methodology of Ferreira, Almeida and Pettinelli (2000).

Statistical Analysis

The results of the physico-chemical characteristics and from the fatty acid analyses were submitted to analysis of variance and regression, and also to orthogonal contrast: control versus levels of urea in lactation, by using the SAS program, version 8.0 (SAS, 1996). The statistical model used on the physico-chemical data and the fatty acids was the following: $Y_{ijk} = \mu + a_i + pj + trat_k + \xi_{ijk}$; where: Y_{ijk} = Observation of the animal i, in period j, receiving treat k; μ = general average; a_i = effect of animal i; pj = effect of period i; $treat_k$ = effect of treat k; e ξ_{ijk} = random error associated to each observation Y*ijk*.

For the sensory analyses, the statistical model used was the following: $Y_i = \mu + T_i + \xi_{ij}$; where: Y_i = treatment i; μ = general effect of the average; T_i = effect of treatment i, being i = 1, 2, 3, 4, 5; ξ_{ij} = random error.

Results and Discussion

The average values of production and centesimal composition of the goat milk are found on Table 3. The protein, the Total dry extract (TDE), the defatted dry extract (DDE), and ash contents, and the density and acidity did not present difference (P>0.05) between urea levels.

Table 3. Milk production and centesimal composition of the milk of goats fed diets with levels of partial substitution of soybean meal for urea.

Characteristic	Urea levels (%)					Effect
	0.0	0.5	1.0	1.5	2.0	
MP (Kg/day)[1]	2.059±0.67	2.072±0.58	1.955±0.53	1.833±0.51	1.781±0.60	*
FCM (Kg/day)[2]	1.940±0.59	1.999±0.50	1.900±0.48	1.780±0.46	1.800±0.56	*
Fat (%)[3]	3.2±0.42	3.3±0.50	3.4±0.27	3.4±0.38	3.6±0.48	*
Protein (%)	3.00±0.45	3.16±0.35	3.18±0.51	3.03±0.35	3.19±0.35	ns
Lactose (%)[4]	3.66±0.57	3.56±0.60	3.53±0.49	3.52±0.49	3.49±0.44	*
TDE (%)	11.16±0.66	11.28±0.82	11.12±0.63	11.14±0.59	11.46±0.70	ns
DDE (%)	7.97±0.39	7.98±0.42	7.75±0.52	7.69±0.54	7.88±0.50	ns
Ashes (%)	0.74±0.07	0.75±0.07	0.76±0.08	0.77±0.05	0.72±0.10	ns
Density (g/cm^3)	1031.3±1.51	1031.7±1.55	1031.6±0.87	1030.7±2.02	1030.4±1.42	ns
Acidity (^{o}D)	15.6±1.98	15.6±1.24	15.5±1.88	15.2±1.65	14.6±2.00	ns

[1] *Regression:* $\hat{Y} = 2.099-0.159x$ / r^2 =0.97.
[2] *Regression:* $\hat{Y} = 2.029-0.049x$ / r^2 =0.74.
[3] *Regression:* $\hat{Y}=3.2+0.18x$ / r^2 =0.91.
[4] *Regression:* $\hat{Y}=3.63-0.076x$ / r^2 =0.95 ;
[*] *P<0.05; ns - not significant.*
Source: Elaboration of the authors.

Addition of urea in the diet provoked a linear reduction (p<0.01) in the production of milk (MP) of the goats and 3,5% fat-corrected milk (FCM) whose averages diminished from 2.059 to 1.781 kg/day and from 1.940 to 1.800 kg/day, respectively. This reduction must have occurred because the diets used reduced the proportion of propionate:acetate. Propionate is an important precursor for the production of milk, and, consequently, reflected by decreasing production. Since cactus pear was used in the diets, the high content of pectin, which is a rapid ruminal degradation carbohydrate (VAN SOEST; ROBERTSON; LEWIS, 1991), in this cactus, improved the digestion of fiber, creating a favorable ruminal environment, and consequently, increasing the production of acetate and decreasing the propionate (VAN SOEST, 1994; MÜLLER; PRADO, 2005).

The fat content of the milk increased linearly ($P<0.05$) with the levels of urea. The lowest fat content (3.2%) was for the treatment without urea, while the highest content (3.6%) was observed in the level of 2.0% urea.

To this fat increase, it is possible that a beneficial effect of the urea occurred in the ruminal pH. The alkalinizing power of urea could aid in the maintenance of a higher ruminal pH in this diet, and this could favor digestion of fiber in the rumen (CARMO et al., 2005). These same authors observed a higher content of fat in the milk of cows receiving a diet with 2% urea and the explanation could be a greater availability of acetate precursor, as well as a lower concentration of inhibiting factors such as trans fatty acids, in the fat synthesis in the mammary glands (GAYNOR et al., 1994). Fat is the constituent which most suffers variations due to breed, seasons, lactation period and mainly feed (SANZ SAMPELAYO; CHILLIARD; SCHMIDEL, 2007).

The protein content of the goat milk was not influenced by the levels of substitution of soybean meal for urea, and the average found was 3.11%. In relation to composition, this absence of significance can be explained by the correct balance of the fibrous and non-fibrous carbohydrates, as well as by the adequate levels of CP, since these are the main responsible for the nutritional factors which modify such contents (FREDEEN, 1996). According to Mendes et al. (2010), the absence of alteration in the milk protein content indicates that there was no limitation in the metabolizable protein by providing diets containing source of non-protein nitrogen.

The protein contents and the lipid composition are of the most important components of the technological and nutritional quality of goat milk, for they imply in yield and firmness of the cheese, as well as in the color, taste and odor of goat products (CHILLIARD et al, 2003). These values can be very useful, for they aid in the selection of the best animals (higher productions, production of milk with a greater fitness for cheese making - yield of cheeses).

The values found for lactose in the milk (Tabela 3) were reduced in all of the treatments, with com values below the minimum limit (4.0%) determined by legislation (BRASIL, 2000). Working with cactus pear forage in substitution for corn in the diet of milking goats, Beltrão Filho (2008) found results similar to those found in this study, which also found averages in the treatments (3.85 to 3.54%) below those determined by the legislation.

It is possible that the diets used may have reduced the production of propionate, which is an important precursor of glucose, and may have contributed to reduce lactose synthesis in the mammary gland, a fact stated by Silva et al. (2007). Since cactus pear forage was used in this study (Table 2), ruminal fermentation may also have occurred from the pectin that increments the production of acetic acid with reduction of the concentration of propionic acid (DUSKOVÁ; MAROUNEK, 2001). Lactose is directly related to the regulation of osmotic pressure, so that a larger production of lactose determines a greater production of milk, that is, milk production is directly proportional to lactose production(QUEIROGA et al., 2007).

The composition of the fatty acid profile obtained from the goat milk in relation to the increasing levels of urea, expressed in area percentage (%), is found in Table 4. Eleven fatty acids were identified and quantified, being 8 saturated fatty acids and 3 unsaturated fatty acids (two monounsaturated and one polyunsaturated). The percentage of lauric acid (C12:0), presented a linearly decreasing effect ($p<0.05$) in relation to the elevation of urea levels in the diet. Probably, no differences were found in the other fatty acids due to the contribution of nutrients (energy and protein) to the mammary gland have been sufficient to maintain the quality of the goat milk.

Table 4. Percentage composition of fatty acids in the goat milk according to the crescent levels of urea in the diet.

Fatty Acid	Urea Levels (%)					Effect
	0.0	0.5	1.0	1.5	2.0	
C6:0	1.98±0.42	2.15±0.92	2.03±0.23	2.34±0.81	1.70±0.72	ns
C8:0	5.03±1.14	5.66±0.76	4.52±0.50	4.55±0.50	4.95±1.08	ns
C10:0	19.47±2.67	20.11±2.09	17.45±1.77	16.80±1.01	17.81±2.72	ns
C12:0	7.52±1.60	7.84±0.79	6.84±0.92	6.17±0.35	6.48±0.98	*
C14:0	13.25±1.48	12.99±1.79	12.80±1.46	12.52±0.99	12.61±1.34	ns
C15:0	0.97±0.08	1.11±0.19	1.10±0.26	0.98±0.12	0.95±0.26	ns
C16:0	23.76±3.08	23.84±2.65	25.95±3.47	27.73±2.19	26.85±3.49	ns
C16:1	0.87±0.18	1.10±0.78	1.04±0.88	0.77±0.10	0.74±0.08	ns
C18:0	6.80±1.11	5.59±0.90	6.06±1.06	7.18±1.71	6.85±1.27	ns
C18:1	16.81±2.04	14.97±1.99	17.17±0.76	17.70±1.26	17.20±1.47	ns
C18:2	2.65±0.42	2.70±0.69	3.23±0.76	2.50±0.26	2.71±0.47	ns
Others	0.84±0.54	1.92±0.87	1.79±0.80	0.76±0.14	1.11±0.38	ns
Saturated	81.06±2.43	81.23±3.19	79.27±1.86	79.19±1.43	79.35±1.91	ns
Unsaturated	18.89±2.43	18.77±3.19	20.73±1.86	20.81±1.43	20.65±1.91	ns
MUFA[1]	19.68±2.17	16.07±2.53	17.91±1.21	18.39±1.18	17.94±1.52	ns
U/S[2]	0.24±0.04	0.21±0.05	0.27±0.03	0.27±0.02	0.28±0.03	ns
DAG[3]	25.48±3.12	24.36±4.08	27.53±1.79	28.21±3.04	27.51±2.37	ns
AI[4]	4.83±0.80	4.89±1.39	4.22±0.54	4.19±0.50	4.24±0.62	ns

[*] *$P<0.05$;Regression: $\hat{y} = 8.095-0.375x/r^2 = 0.72$; ns -not significant*
[1] *MUFA: monounsaturated fatty acids.*
[2] *U/S:= relation unsaturated / saturated.*
[3] *AGD= desirable fatty acids (unsaturated + C18:0).*
[4] *AI= Atherogenesis index ((C12+4*C14+C16)/ (sum of the unsaturated)).*
Source: Elaboration of the authors.

A predominance of saturated fatty acids (77.25%) was observed, followed by unsaturated (20.43%). Desirable fatty acid content (DFA), whose average was 26.6%, did not present variation (p>0.05) and this is directly related to stearic acid content (C18:0).

The average of the atherogenic index (AI) (Table 4) was 4.47%. Possibly, this high average was due to an increase in the levels of saturated fatty acids (C12, C14 and C16) in relation to unsaturated fatty acids (C16:1; C18:1 e C18:2), whose AI calculation takes these fatty acids into consideration. The most atherogenic fatty acids are myristic acid (C-14) and palmitic acid (C-16). Stearic acid (C-18) is an exception because it is transformed into oleic acid (monounsaturated fatty acid) so rapidly that it has no cholesterol elevating effect (MATHERSON et al., 1996). According to Queiroga et al. (2007), lipid profile knowledge of foods is important to human nutrition, with relevant attention in the onset of cardiovascular pathologies.

Table 5 shows the averages of the sensory attributions. No variation was observed (p>0.05) for any of the variables analyzed. Within a scale from 1 to 9 points, characteristic odor presented an average of 3.19, representing milk with moderately weak odor; as to characteristic taste, an average of 6.06 was obtained, characterized as being a slightly strong milk; rancid flavor, an average of 4.44, which was characterized as being a slightly weak milk; fruity flavor, whose average was 3.51 was characterized as being a moderate to slightly weak milk; and global evaluation presented an average of 4.82, characterizing an intermediate acceptance.

Table 5. Scores for the sensorial characteristics of the goat milk according to crescent levels of urea in the diet.

Characteristic	Urea Levels (%)					Effect
	0.0	0.5	1.0	1.5	2.0	
Characteristic Odor	3.36±1.69	3.13±1.46	3.23±1.50	3.10±1.54	3.13±1.69	ns*
Characteristic Flavor	5.86±1.76	6.20±1.86	5.80±1.92	6.00±1.55	6.46±1.81	ns
Rancid Flavor	4.43±2.24	4.30±1.97	4.36±2.31	4.26±2.41	4.86±2.53	ns
Fruity Flavor	3.30±1.82	3.40±2.04	3.70±2.17	3.66±1.79	3.50±1.74	ns
Global Evaluation	4.76±1.98	4.63±1.90	5.06±1.82	4.86±1.98	4.80±2.41	ns

* *Not significant (P>0.05)*
Source: Elaboration of the authors.

The main reason for rejection of the goat milk by the consumers is for its characteristic peculiar flavor, and these results in the negative image of the products. According to Calvo and La Hoz (1992), the formation of volatile compounds which originate the flavor of the milk and its products is related to its chemical composition. Researches have referred to fat as being the main nutrient that affects the sensory characteristics of the milk (FROST; DIJKSTERHUIS; MARTENS, 2001). It should be noted that the use of milk with inadequate sensory characteristics, as well as its use in producing derivatives compromises their acceptance by the final consumer.

Conclusion

The use of urea in substitution for soybean meal in the feed of goats promoted a small decrease in milk production and an increase in its fat content, without altering the lipid profile and sensory characteristics, which makes it a well-accepted product by consumers.

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