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Goat milk production and quality on Tanzania-grass pastures, with supplementation

Marcelo de Oliveira Alves Rufino[1*], Arnaud Azevedo Alves[1], Marcônio Martins Rodrigues[1], Raniel Lustosa de Moura[1], Ana Clara Rodrigues Cavalcante[2] and Marcos Cláudio Pinheiro Rogério[2]

*[1]Programa de Pós-graduação em Ciência Animal, Universidade Federal do Piauí, Campus Agrícola da Socopo, s/n, 64049-550, Teresina, Piauí, Brazil. [2]Empresa Brasileira de Pesquisa Agropecuária, Centro Nacional de Pesquisa de Caprinos, Sobral, Ceará, Brazil. *Author for correspondence. E-mail: moarufino@yahoo.com.br*

ABSTRACT. It was evaluated the production and quality of milk produced by goats grazing *Panicum maximum* Jacq cv. Tanzania (Guineagrass) and receiving four levels of concentrate supplementation. Eight Anglo Nubian goats, aged between two and four years, 43.6 kg in average body weight and between the 2nd and 4th lactation were distributed into two 4 x 4 balanced Latin square design. The supplementation levels were: 0.0, 0.5, 1.0 and 1.5% of body weight. The concentrate was composed of corn and soybean meal. The intake of dry matter and nutrients, and the daily production of milk, 4% fat-corrected milk, fat, protein, lactose and total solids had increased ($p < 0.05$) with supplementation, whereas fat and total solids percentage were reduced ($p < 0.05$). The concentrate supplementation up to 1.5% of live weight in Tanzania-grass pasture raises the intake of dry matter and nutrients, resulting in a linear increase in milk production and of its components.

Keywords: Anglo Nubian breed, intake, efficiency, fat.

Produção e qualidade do leite de cabras em pasto cultivado de capim-Tanzânia suplementadas com concentrado

RESUMO. Avaliou-se a produção e qualidade do leite de cabras em pasto cultivado de *Panicum maximum* Jacq cv. Tanzânia sob níveis de suplementação com concentrado. Foram utilizadas oito cabras da raça Anglonubiana, com idade entre dois e quatro anos, peso médiode 43,6 kg, entre a 2ª e 4ª ordem de lactação, distribuídas em duplo quadrado latino balanceado 4 x 4. Os níveis de suplementação avaliados foram: 0,0; 0,5; 1,0 e 1,5% do peso vivo. O concentrado, foi composto por grão de milho e farelo de soja. O consumo de matéria seca e de nutrienteseas produçõesdiárias de leite, de leite corrigido a 4% de gordura, gordura, proteína, lactose e sólidos totais aumentaramcom a suplementação, enquanto que os teores de gordura e sólidos totais reduziram. A suplementação com concentrado em até 1,5% do peso vivo em pasto cultivado de capim-tanzânia promove aumento no consumo de matéria seca e de nutrientes da dieta, do que resulta o aumento linear na produção de leite e de seus constituintes.

Palavras-chave: raça Anglonubiana, consumo, eficiência, gordura.

Introduction

Dairy goat farming can contribute to food security of farming families and become an income source through commercialization of raw milk and dairy products. The characteristics of goat milk, both from a nutritional and social standpoint, are important and encourage studies to evaluate its production and quality (FERNANDES et al., 2008).

Cultivated pastures are important tool for the adequate feeding of goats. Researches have indicated that several factors, such as the availability and quality of forage, management of pasture, intake level and concentrate supplementation, should be observed to increase the effectiveness of milk production of goats on-pasture (LEFRILEUX et al., 2008).

Under tropical conditions, the seasonality of forage production causes fluctuations in the production and quality of forage throughout the year, which usually leads to the seasonality in animal production, when the farming is performed in extensive regime (SANTOS et al., 2004). Among all available technologies to overcome the seasonality in production and quality of the forage, stands out the use of high-yield grasses, in intensively managed pastures (OLIVEIRA et al., 2005).

Even under situations with high supply of pasture, milk production can be limited by the nutritional quality of the forage (MIN et al., 2005). The forages have low energy density and slow rate of degradation and passage, which limit the forage intake (CARVALHO et al., 2006). In situations where the amount of nutrients necessary for milk production is higher than supplied by the pasture, it is of paramount importance the supplementation with concentrate, allowing the animals to express their production potential.

The supply of concentrate in diets for lactating goats has been the strategy used to increase milk production in pasture production systems (LEFRILEUX et al., 2008; MACEDO et al., 2002; MIN et al., 2005). Nevertheless, there is little information about systems of milk production of goats in cultivated pastures in tropical regions, which use the supplementation with concentrate as an additional source of nutrients.

The addition of concentrate food into the diet is used to stimulate the intake of nutrients. However the concentrate has been the responsible for the high cost of feeding of dairy goats, making interesting the maximization of using nutrients of the diet, and the determination of the optimal level of supplementation for lactating goats (FONSECA et al., 2006).

This study aimed at evaluating levels of concentrate supplementation on the production and quality of the milk, on intake and efficiency of nutrient use for milk production by goats grazing on a cultivated pasture of Tanzania-grass (*Panicum maximum* Jacq cv. Tanzania).

Material and methods

The experiment was conducted between April 23th to June 22th 2010, in the Sector of Goat Farming of DZO/CCA/UFPI, in Teresina municipality, Piauí State. The climate is typical of sub-humid transition zone, with two marked seasons, rainy and dry. The average temperature during the experimental period was 28.5°C.

The Tanzania-grass pasture area had 0.30 ha and was divided into ten paddocks of equal size, with water drinkers and artificial shade made with material of the region. The area receives annual fertilization based on N, P and K, at ratio 120-80-50. It was adopted rotational stocking, with three days of occupation and 27 resting days. The grass was watered with fixed spray sprinklers, with round watering every four days. Aiming to keep the grass at 27 days of growth after cutting, when the animals entered into each paddock, it was performed a sequential mowing every three days in the ten paddocks.

The pre-grazing forage mass was measured by gathering 40 samples using a frame of 0.5 m^2 (1.0 x 0.5 m) in ten paddocks chosen at random (in two cycles of grazing). The frames were positioned in four sites where the grass had the average height of the paddock at the moment of the sampling. The forage inside the frame was cut to an average height of 20 cm, similar to the height set for post-grazing residual stubble.

It was collected 20 points of the pasture height at pre- and post-grazing, by means of a graduated scale, in the same paddocks destined to assessment of forage mass.

The forage supply, in kg of DM 100 kg^{-1} of live weight, was estimated by dividing the average yield of dry matter of forage in each paddock in pre-grazing, by the product between the amount of grazing animals, their average live weight and the number of days of paddock occupation.

Two aliquots were taken from the samples gathered for determining the forage mass in pre-grazing. These aliquots were separated into two portions, one full and another of which it was separated the living and dead material, which was then divided into leaves and stem. The fractions, full material, dead material, leaves and stem were placed in paper bags, weighed, identified, and submitted to pre-drying in an air-forced oven at 65°C for 72h, to determine pre-dried material, in the Laboratory of Animal Nutrition (LANA) from the DZO/CCA/UFPI. From the obtained data, it was estimated the dry mass of green leaf, dry mass of stem, leaf/stem ratio, and forage dry matter.

Pasture samples, simulating the grazing by the animals in the pre-grazing, were collected in the same paddocks used to determine the production and morphological components of the forage. These samples were submitted to pre-drying in an air-forced oven at 65°C for 72h, milled using a Willey-type mill with 1 mm-sieve and subjected to determination of the contents of dry matter (DM) and crude protein (CP), as described by Silva and Queiroz (2002); neutral detergent fiber (NDF) and acid detergent fiber (ADF), according to Van Soest method, described and modified by Souza et al. (1999); and it was also determined the *in vitro* digestibility of dry matter (IVDDM) as proposed by Tilley and Terry (1963). This methodology was also adopted to concentrate samples (Table 1).

The concentrate based on milled corn and soybean meal was formulated to contain 16% of crude protein (%DM). The supplementation levels assessed were: 0% of LW, corresponding only to grazing on Tanzania-grass; 0.5, 1.0 and 1.5% of LW per animal per day. The supplied amount of concentrate was corrected after each 15 days according to individual weight of each animal. The concentrate was given to each animal in two equal meals, at the moment of milking. The mineral mixture was provided *ad libitum* when the goats were in the fold.

Table 1. Mean values of bromatological composition and *in vitro* digestibility of dry matter of Tanzania-grass and of concentrate.

Parameters (%)	Tanzania-grass	Concentrate
Dry matter	20.4	88.3
% in DM		
Crude protein	11.9	16.2
Neutral detergent fiber	70.1	22.1
Acid detergent fiber	37.6	5.2
Total digestible nutrients[1]	70.2	88.0
In vitro digestibility of dry matter	75.3	94.6

[1]Estimated according the equation of Cappelle et al. (2001): TDN = 6.12 + 0.851DMD, for green fodder, and TDN = 9.6134 + 0.8294DMD, for concentrate.

Twelve grazing goats were used, only eight test animals and four equilibrium animals, all of Anglo Nubian breed, aged 2-4 years, average live weight (LW) 43.55 ± 3.25 kg, between 2nd and 4th lactation, with 30 days of lactation, and wormed 15 days postpartum. Throughout the experimental period it was kept a stocking rate of 3.87 AU ha^{-1}.

The eight goats were assigned into two 4 x 4 balanced Latin square design to evaluate the effect of four levels of concentrate supplementation. Each experimental period lasted 15 days, of which 10 days were used for adaptation to the management and diet, and five days to collect data.

The hand milking was made twice a day, at 7am and 5pm. After morning milking, the goats were driven to pasture, where they remained until 5pm, when they were driven back to milking parlor for the afternoon milking. After this, the goats were driven to the fold to spend the night where they had access only to mineral salt and water.

The daily milk production was the sum of the two milkings. During the milking, 300 mL milk samples were collected to determine the content of fat, protein, lactose and total solids, using the ultrasonic milk analyzer EKOMILK total®, in the Center for Studies, Research and Processing of Foods (NUEPPA) from the UFPI.

The correction of milk production to 4% fat was made according to NRC (2001), by using the formula: FCM 4% (kg day^{-1}) = 0.4 x milk (kg day^{-1}) + 15 x fat (kg day^{-1}). To estimate the efficiency between milk production and nutrient intake, we adopted the methodology proposed by Rodrigues et al. (2007).

Fecal production was obtained from an external indicator, the hydroxyphenylpropane - LIPE®[1] (SALIBA et al., 2003). The LIPE® was given to animals at dose of 250 mg, before the first meal of the day, with two days for adaptation and five days to collect the feces. The feces were collected directly from the rectum of animals, at 6:30am and 4:30 pm, and homogenized, forming one composite sample per animal per period. Then the samples were pre-dried, milled, and we determined the DM (SILVA; QUEIROZ, 2002), packed in labeled vials, and sent to the Chemistry Department of the Institute of Exact Science of the UFMG, for estimates of fecal production through infrared spectrometer, using the formula: FP = (Amount of administered LIPE/concentration of LIPE in the feces)*100.

In order to estimate the intake of dry matter (DMI) and of Tanzania-grass (TGI) we adopted the methods proposed by Paciullo et al. (2008). It was estimated the fecal production determined by the intake of concentrate using the formula: FPC = DMCI* (1–IVDMDC), where FPC is the fecal production determined by the intake of concentrate; IDMC is the intake of dry matter of the concentrate, and IVDDMC, is the *in vitro* digestibility of dry matter of the concentrate. By subtracting the FPC of the total FP, we obtain the fecal production determined by the intake of Tanzania-grass (FPT). Afterwards, the intake of dry matter of Tanzania-grass (ITG) per day was estimated using the equation: ITG (g day^{-1}) = FPT/(1-IVDDM). The digestibility coefficient used to estimate the intake of grass was determined by the *in vitro* digestibility of dry matter (IVDDM) of the samples from the simulated grazing.

The results were submitted to analysis of variance and regression analysis by means of the procedures GLM and REG of the SAS statistical software (SAS, 2000).

Results and discussion

The production of DM of Tanzania-grass was 3,292 kg ha^{-1} (Table 2), allowing the supply of 6.3 kg DM 100 kg^{-1} of animal LW. Coupled to this supply, the proportion of leaves (79%) in Tanzania-grass is considered high according to Santos et al. (2003), and the leaf/stem ratio above 3.0 (Table 2) in pre-grazing, were favorable to diet selection and to the intake of the most nutritious parts of the grass. The reduction of only 46% in grass height after grazing suggests higher intake of leaf.

Table 2. Structural characteristics of the Tanzania-grass pasture.

Parameters	Mean values
Forage mass (kg DM ha^{-1})	3,292.1
Live material (%)	84.6
Dead material (%)	15.4
Height at pre-grazing (cm)	90.5
Height at post-grazing (cm)	48.9
Leaf (%)	79.3
Stem (%)	20.7
Leaf/stem ratio	3.1

[1]Lipe–hydroxyphenylpropane modified and enriched: P2S2, Minas Gerais State.

Lefrileux et al. (2008) recommend a forage supply of 5-6 DM 100 kg^{-1} LW and proportion of leaves of 60-80% at pre-grazing, to achieve high milk production by goats in Southeast France, in a pasture cultivated with ryegrass and alfalfa. However there is very little information in literature about structural characteristics of the pasture that provides an increase in milk production by goats under tropical conditions.

The intake of DM and nutrients increased ($p < 0.05$) with the supplementation (Table 3), providing higher availability CP and TDN to the goats. The increased energy and protein in the diet provides an increase in the consumption of DM by the animals (RODRIGUES et al., 2007). Similar results were found by Fonseca et al. (2006) and Rodrigues et al. (2007), with positive response in DM intake by goats with increasing level of CP and protein/energy ratio in the diet.

The intake of NDF and ADF increased linearly ($p < 0.01$) with supplementation (Table 3). The concentrate supplementation, up to studied levels, may have favored the growth of fibrolytic bacteria, increasing the degradation rate of fibrous carbohydrates (COSTA et al., 2008) with consequent increase in the intake of NDF and ADF. A linear decreasing effect was observed for the intake of DM and a linear increase for the intake of NDF and ADF, when elevating the participation of NDF in the diet of lactating goats (CARVALHO et al., 2006). Branco et al. (2010) verified a reduction of 30% in the DM intake between the levels 20 and 48% of NDF from forage, without effect on the fiber intake.

No effect of supplementation was detected on daily intake of Tanzania-grass (Table 3), with mean 0.82 kg DM day^{-1} and 2.1% of LW. Different result was observed by Lima et al. (2001), when the supplementation with 0.5% of LW in concentrate had reduced in 23.5% the total intake of dry matter of Tanzania-grass by crossbred dairy cows Holstein x Gir, as a consequence of the high levels of NDF (78.8%) determined in the extrusa collected via esophageal fistula. The amount of grass used in this study, with 70% of NDF, 37% ADF and 75% of IVDDM, associated with the increase in degradation rate and intake of the fiber, enabled the maintenance of the consumption of pasture, with no substitution effect of the forage by the concentrate in the diet.

When the concentrate supplementation corresponded to 1.5% of LW, the intake of DM achieved the recommended by NRC (2007) for goats of non-specialized breeds for milk production, producing 0.89 kg of milk day^{-1}, at middle of lactation. Even for non-supplemented goats, the intake of CP met the daily demands for production, but, the TDN requirements were not met by supplementation. Thus, under the studied conditions, it could have been used only energy supplementation, since the CP of the grass had met the demands for milk production by goats.

Live weight has increased ($p < 0.05$) with supplementation (Table 3). It is estimated that the goats that were given more than 0.72% of concentrate, have increased body weight, as a function of the higher intake of DM. For the goats maintained only on pasture, and those supplied with up to 0.72% concentrate, there was greater mobilization of body reserves to meet the requirement for milk production, which was not balanced by the DM intake, as can be observed in the variation of live weight.

The daily yield of milk and the one corrected to 4.0% of fat increased ($p < 0.05$) and the levels of fat and total solids have reduced ($p < 0.05$) with supplementation (Table 4), whereas the content of protein and lactose had no variations ($p > 0.05$).

The greater intake of CP and TDN, when the grazing goats had been supplemented with concentrate, resulted in an increase of about 24, 50 and 60% in milk production for the supplementation levels 0.5, 1.0 and 1.5%, respectively, in relation to the production only on pasture.

Table 3. Intake of dry matter and nutrients and variation of live weight of goats of Anglo Nubian breed in Tanzania-grass pasture with supplementation.

Intake	Supplementation levels (%)				Regression equation	R^2
	0.0	0.5	1.0	1.5		
DMI[1] (kg day^{-1})	0.86	1.09	1.45	1.89	$\hat{y} = 0.69x + 0.81$	0.93
DMI (% LW[2])	2.1	2.6	3.2	3.8	$\hat{y} = 1.3x + 2.1$	0.91
DMI (g MW[3])	53.4	66.5	84.6	105.9	$\hat{y} = 35.0x + 51.4$	0.87
CPI (kg)[4]	0.10	0.13	0.17	0.22	$\hat{y} = 0.08x + 0.10$	0.92
TDNI (kg)[5]	0.60	0.77	1.00	1.30	$\hat{y} = 0.46x + 0.57$	0.91
NDFI (kg)[6]	0.60	0.63	0.73	0.87	$\hat{y} = 0.21x + 0.56$	0.84
ADFI (kg)[7]	0.32	0.33	0.36	0.43	$\hat{y} = 0.81x + 0.30$	0.76
TGI (kg day^{-1})[8]	0.86	0.88	1.01	1.19	$\hat{y} = \bar{y} = 0.82$	-
TGI (%LW)	2.1	2.1	2.2	2.3	$\hat{y} = \bar{y} = 2.1$	-
VLW (kg)[9]	-0.45	-0.21	0.30	0.42	$\hat{y} = 0.61x - 0.44$	0.76

[1]Intake of dry matter; [2]Live Weight; [3]Metabolic Weight; [4]Intake of crude protein; [5]Intakeoftotal digestible nutrients; [6]Intake of neutral detergent fiber; [7]Intake of acid detergent fiber; [8]Intake of Tanzania-grass; [9]Variation of live weight.

Table 4. Milk production and composition of Anglo Nubian goats on Tanzania-grass pasture, with supplementation.

Parameters	Supplementation levels (%)				Regression equation	R^2
	0.0	0.5	1.0	1.5		
MP (kg day^{-1})[1]	0.63	0.78	0.91	1.08	$\hat{y}$ = 0.288x + 0.629	0.96
MP 4.0% (kg day^{-1})[2]	0.81	0.98	1.07	1.25	$\hat{y}$ = 0.264x + 0.824	0.77
Fat (%)	5.9	5.6	5.2	4.9	$\hat{y}$ = -0.721x + 5.980	0.92
Protein (%)	2.4	2.5	2.5	2.5	$\hat{y}$ = $\hat{y}$ = 2.42	-
Lactose (%)	4.2	4.2	4.2	4.1	$\hat{y}$ = $\hat{y}$ = 4.18	-
TS (%)[3]	13.8	12.8	12.5	12.0	$\hat{y}$ = -1.072x + 13.55	0.90
Fat(g day^{-1})	37.6	44.3	47.1	53.0	$\hat{y}$ = 9.82x + 38.16	0.97
Protein (g day^{-1})	15.6	19.3	22.5	26.8	$\hat{y}$ = 7.47x + 15.70	0.91
Lactose (g day^{-1})	26.3	32.7	38.4	44.7	$\hat{y}$ = 12.75x + 26.54	0.93
TS (g day^{-1})[3]	82.2	100.5	112.9	129.7	$\hat{y}$ = 32.19x + 83.29	0.85

[1]Milk production; [2]Production of milk corrected to 4.0% fat; [3]Total solids.

Even considering the low production potential of Anglo Nubian goats used herein, of mixed livestock type, and not specialized for milk production, the low level of pasture intake by the non-supplemented animals did not met the demand for TDN for production. Thus, the supplementation results in productive response from these herds; considering the need for provision of adequate amounts of nutrients and energy to meet the requirements for milk production, according to Min et al. (2005).

There was an increase of 288 g of milk for each one percentage point increase in supplementation level, corresponding to 72 g of milk per 100 g of concentrate. This result is superior to those registered by Lefrileux et al. (2008), for goats on pasture cultivated with ryegrass and alfalfa, of 46 g per 100 g of concentrate. This indicates that the supplementation in tropical pastures can results in a better response. In this way, the cost benefit may be the variable that will define the supplementation levels of the animals diets based on tropical forage.

An inverse relationship was observed between concentrate supplementation and fat content in the milk (Table 4) which can be related to the reduction of precursors for the synthesis of fat in the mammary gland (BAUMAN; GRIINARI, 2003). According to these authors, the increase in the production of propionic acid in diets with high content of grains promotes a glycemia increase through gluconeogenesis, which would result in a greater secretion of insulin. As a consequence, there would be a decrease in lipolysis, reducing the contribution of preformed fatty acids for fat synthesis in the mammary gland.

There was an increase ($p < 0.05$) of the daily production of fat, protein, lactose and total solids (Table 4), which may be due to the increased availability of nutrients with the increase in DM intake. The greater production of total solids in the milk can results in better performance in production of dairy products, like cheese, UHT milk, powdered milk, among others (MIN et al., 2005). The increased production of fat and protein with the supplementation is in accordance with Min et al. (2005) and Lefrileux et al. (2008).

The efficiency of using nutrients for milk production had decreased ($p < 0.05$) with the supplementation (Table 5).

The lower efficiency of milk production with supplementation may be due to the deposition of body reserves of goats, with positive variation of live weight during the experiment, as previously reported. In the goats that received more than 0.72% of concentrate, part of nutrients supplied by the diet was for weight gain, with reduction in production efficiency. This effect can be related to the low production potential of the goats used in the present study, which were not specialized for milk production.

A better efficiency between milk production and intake was observed by Zambom et al. (2005), when the metabolizable energy of feed increased from 2.46 to 2.95 Mcal of ME kg DM^{-1}, and by Rodrigues et al. (2007), for goats with an increase in the protein/net energy ratio, from 7.3 to 14.8.

A drop in the efficiency of nitrogen use was verified, indicating that the N not used for production of milk proteins may have been excreted in urine (FONSECA et al., 2008). A similar result was found by Rodrigues et al. (2007) who observed lower efficiency of using N when increased the intake of CP in the diet of dairy goats.

Table 5. Efficiency of using nutrients for milk production by Anglo Nubian goats on Tanzania-grass pasture, with supplementation.

Intake	Supplementation levels (%)				Regression equation	R^2
	0.0	0.5	1.0	1.5		
MP[1]/IDM[2] (kg kg^{-1})	0.73	0.71	0.62	0.56	$\hat{y}$ = -0.13x + 0.76	0.78
MP/ICP[3] (kg kg^{-1})	6.17	5.89	5.17	4.76	$\hat{y}$ = -1.09x + 6.34	0.73
MP/IDN[4] (kg kg^{-1})	1.04	1.02	0.90	0.84	$\hat{y}$ = -0.16x + 1.08	0.68
N of milk[5]/IN[6] (g g^{-1})[1]	0.96	0.92	0.80	0.74	$\hat{y}$ = -0.17x + 0.99	0.74

[1]Milk production; [2]Intake of dry matter; [3]Intake of crude protein; [4]Intake of total digestible nutrients; [5]Nitrogen of the milk; [6]Intake of nitrogen.

Conclusion

The concentrate supplementation, up to 1.5% live weight, for Anglo Nubian goats on Tanzania-grasspastures, promotes increased intake of dry matter and nutrients, resulting in increased live weight and production of milk and its constituents.

The cost benefit will be the variable that will define the supplementation levels with concentrate for goats not specialized for milk production in systems of milk production on pasture.

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