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Effect of replacing Tifton Hay with Guandu Hay on intake, digestibility and ingestive behavior of dairy goats

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ABSTRACT. The purpose was to evaluate the effect of replacement of Tifton 85 hay with Guandu hay on the intake, digestibility and ingestive behavior of dairy goats. Five Saanen goats with average milk production of 2.26 ± 0.10 kg d^{-1}, around 123 ± 4 days of lactation were assigned to a 5 x 5 Latin square design. The treatments consisted of five levels of replacement with Guandu: 0, 8.4, 16.8, 25.2, or 36.4 %. We sampled the food offered, leftovers and feces to calculate intake and digestibility, and the ingestive behavior was monitored for 24 hours. Regression analysis was applied with 5% significance. The nutrient intake and the digestibility of dry matter, organic matter and protein decreased linearly with increasing levels of Guandu hay in the diet ($p < 0.05$). On the other hand, the neutral detergent fiber digestibility increased linearly, without change the water intake and ingestive behavior with replacement levels of Tifton hay with Guandu hay in the diet ($p < 0.05$). The replacement of up to 36.4% Tifton hay with Guandu hay in the dairy goat diet reduces the intake and digestibility of dry matter, organic matter and protein, and increasesfiber digestibility, without changing the ingestive behavior and water intake.

Keywords: legumes; *Pigeon pea*; small ruminants.

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Introduction

Legumes have an essential role in agriculture due to their significant nitrogen-fixing capacity, and also for livestock, providing feed with high nutritional value and reduced methane emissions (Mueller-Harvey et al., 2019). Among the legumes used for animal feed, stands out the Pigeon pea, known as Guandu.

Guandu is a legume of the species *Cajanus cajan* grown in semi-arid tropical and subtropical areas of the world, such as Asia, Africa, and Brazil. This species calls farmers attention for tolerance to acid and low fertility soil, hydric scarcity, besides supplying grains for human food, as well as branches and leaves for animal feed (Chen et al., 2019).

In branches and leaves of Guandu, there are about 152 (g kg^{-1} Dry matter (DM)) of crude protein, 631 (g kg^{-1} DM) of neutral detergent fiber, 465 (g kg^{-1} DM) of acid detergent fiber, 23 (g kg^{-1} DM) of ether extract and 955 (g kg^{-1} DM) of organic matter (Berardo, Dzowela, Hove, & Odoardi, 1997). As in another legume, Guandu has a greater concentration of protein compared to grasses, therefore reducing the need for dietary protein supplementation (i.e. soybean meal) to improve animal performance.

In addition, as for fiber content, legumes compared to grasses have lower cell wall lignification, which facilitates fiber breakage and ensures greater digestibility (Wilson, 1994). When fiber is more digestible, the fiber residence time in the rumen decreases, reducing rumen fill effect and leading to the possibility of making another meal (Van Soest, 1994). The disturbance in the number and frequency of meals can affect in the feeding behavior.

However, it is worth mentioning that in contrast to reduce of cell wall, legumes containanti-nutritional substances, such as tannin. Tannins are phenolic compounds with the ability to complex proteins and other macromolecules reducing diet digestibility (Cordão, Bakke & Bakke, 2010).

Some studies showed an increase *in vitro* degradability when Guandu was used in place of grasses, and as a supplement, it improved performance of growing goats (Tekle, Gebru, & Redae, 2018). However, there is little information on the use of Pigeon Peaas a substitute of grasses for dairy goats. Thus, the goal was to evaluate the levels of replacementof Tifton 85 with Guandu hay in the diet on intake, digestibility and ingestive behavior of dairy goats.

Material and methods

The study was conducted at Universidade Federal Rural do Rio de Janeiro (UFRRJ), in Seropédica, State of Rio de Janeiro, Brazil. Analyses were carried out at the Laboratory of the Department of Animal Nutrition and Pasture on the Institution of Animal Science of the same Institution, with partnership with the Laboratory of Animal Nutrition at Faculdade de Medicina Veterinária e Zootecnia of the Universidade Federal de Mato Grosso do Sul (UFMS). All animal procedures were approved by the ethics committee on animal use of the UFRRJ, according to the protocol 23083.015949/2017-93.

Five non-pregnant Saanen goats with an average body weight (BW) of 48.0 ± 1.48 kg, with 123 ± 4 days of lactation and production of 2.26 ± 0.10 kg day^{-1} were dewormed with albendazole, using 1 mL for 10 kg body weight before the experimental period. The experimental design was a 5×5 Latin square (five treatments and five periods), where each experimental period lasted 11 days divided into seven days for adaptation to the diets and four days for sample collection.

Animals were housed in individual stalls with slatted floors provided with feeders and drinkers. The diets were isonitrogenous containing 13.5% crude protein according to the requirements calculated by the National Research Council (NRC, 2007) for dairy goats producing 2.5 kg milk per day and 3.5% fat milk. The roughage: concentrate ratio was 70:30 (DM basis) as a complete mixed ration at 08:00 and 17:00 h and, mineral mix were offered *ad libitum*. The concentrate consisted of soybean and corn meal, and the hay of Guandu (*Cajanus cajan*) and Tifton 85 (*Cynodon dactylon*). The amount of supplied feed was corrected to produce 20% leftovers in the dry matter. The treatments were: 0; 8.4; 16.8; 25.2 or 36.4% proportions of Guandu hay (*Cajanus cajan*) replacing the Tifton 85 hay (*Cynodon dactylon*) in the roughage fraction. The ingredients and chemical composition of the diets are listed in Table 1.

Table 1. Proportion of the ingredients and chemical composition of the experimental diets.

Item	Replacement level				
Ingredients (g kg^{-1})	0	8.4	16.8	25.2	36.4
Tifton 85 hay	70.00	61.60	53.20	44.80	33.60
Guandu hay	0.00	8.40	16.80	25.20	36.40
Ground corn	22.20	23.00	23.80	24.60	25.70
Soy bean meal	7.80	7.00	6.20	5.40	4.30
Diet composition (g kg DM^{-1})	Replacement level				
Crude protein	135.46	135.38	135.31	135.23	135.00
Ether extract	21.60	23.50	25.40	27.30	30.00
Ash	76.63	78.55	70.48	68.70	63.70
Non-fiber carbohydrates	175.20	173.57	181.92	183.97	188.51
Neutral detergent fiber	591.11	589.00	586.90	584.80	582.80

DM: dry matter.

The total of feces was collected through plastic collectors below each individual stall, weighed and samples daily in each experimental period, in the same way, samples of feed and leftovers were stored in plastic bags at −18°C. Samples of feeds, leftoversand feces were analyzed to determine the concentrations of dry matter (DM), organic matter (OM), crude protein (CP), and neutral detergent fiber (NDF).

Samples of feeds, leftovers and feces were pre-dried in a forced ventilation oven at 55°C for 72h and ground to 1-mm particles (Wiley mill, Marconi, MA- 580, Piracicaba, Brazil). Samples were analyzed for DM, OM and CP (Detmann et al., 2012). NDF was determined according to Van Soest, Robertson, & Lewis, (1991).

For water intake, daily in each experimental period measured through graduated test tube the offered placed in 20 liter buckets that replacement when necessary and leftovers to estimated drinking water intake by difference between offered and leftovers.

The apparent digestibility coefficient (AD) was estimated by difference between intake and feces and divided by intake, as

$AD = (\frac{(Intake - Feces)}{Intake}) \times 100.$

Ingestive behavior was evaluated according to the methodology proposed by Fischer, Deswysen, Dèspres, Dutilleul, & Lobato (1998). The feeding and rumination efficiencies were calculated by dividing the intake of dry matter by the total eating and rumination times.

Data were tested by regression analysis in the R Development Core Team (2018) (version 3.5.0). The statistical model was:

$Y_{ijkl=\mu+\tau_i+P_j+A_k+\varepsilon_{ijkl}}.$

where: y_{ijkl}= observation ijkl; μ = overall mean; τ_i= fixed effect of treatment i; P_j= fixed effect of period j; A_k= random effect of animal k; ε_{ijkl}= random error. Comparisons between Guandu replacement levels in the diets were conducted by the sum decomposition of squares in orthogonal contrasts to linear and quadratic effects with 5% significance ($p < 0.05$).

Results and discussion

With increasing levels of Guandu hay replacing Tifton 85 hay in the diet, the dry matter, organic matter (OM), crude protein (CP), and neutral detergent fiber (NDF) intake decreased linearly ($p < 0.05$) (Table 2). The reduced dry matter intake influenced the intake of all nutrients (OM, CP, and NDF). In agreement with the result shown by Brown, Salim, Chavalimu, and Fitzhugh (1988), which observed that the use of pigeon pea reduced the intake and increased the refusal and selection by dairy goats. The dry matter intake DMI is mainly controlled by nutritional requirements, rumen capacity and fill effect (Mertens, 1987). Thus, when increasing the levels of replacement of grasses with legumes, there was a reduced amount of fiber carbohydrates (Table 1), consequently, providing more energy per gram of dry matter to meet the nutrient requirements.

However, different from Lopes et al. (2017), who showed that replacing grasses (Tifton hay) with legumes (Alfafa hay) for dairy goats resulted inhigher DM intake, explained by the chemical composition and palatability of Alfafa hay. It is important to consider the legume species when making recommendations for replacing grasses.

According to Park, Reynolds and Stratton (1989), Alfalfa was superior to Guandu in the dry matter, crude protein, and fiber digestibility in goats. This is because Guandu contains a considerable amount of tannins (Sekhon, Grewal, Singh, & Kaur, 2017). Tannin is a secondary compound known to have low palatability for small ruminants, thus reducing intake (Baumont, Prache, Meuret, & Morand-Fehr, 2000).

Table 2. Nutrient intake of lactating goats on diets with replacement of Tifton 85 hay with Guandu hay.

	Replacement level						p-value	
Item	0	8.4	16.8	25.2	36.4	SEM	L	Q
Dry matter (kg Day^{-1})[1]	2.147	2.513	2.191	1.984	1.947	0.061	0.014	0.089
Organic matter (kg Day^{-1})[2]	0.771	0.744	0.750	0.728	0.666	0.057	0.012	0.092
Crude protein (kg Day^{-1})[3]	0.292	0.365	0.297	0.277	0.270	0.009	0.038	0.117
Neutral detergent fiber (kg Day^{-1})[4]	1.348	1.593	1.380	1.180	1.169	0.042	0.004	0.072
Water (L Day^{-1})	4.60	6.51	5.68	5.86	5.42	0.386	0.623	0.122

SEM: standard error of the mean; L: linear effect; Q: quadratic effect; $Y^1 = 2.435 - 0.093x$; $Y^2 = 0.799 - 0.022x$; $Y^3 = 0.340 - 0.013x$; $Y^4 = 1.565 - 0.077x$.

Although increasing levels of inclusion of Guandu reduces nutrient intake, the percentage intake in relation of body weight (BW) for Tifton Hay and Guandu replacement 8.4% to 16.8% were 4.47, 5.23, 4.56 % of BW, maintain within recommended of 4.26% of BW for the goats production level by NRC, (2007). But the treatments with 25.2 and 36.4 % Guandu obtained 4.12 and 4.04% BW, respectively, lower than recommended by the NRC (2007), due to intake considerations or bias in the requirement system that were made differently to tropical conditions.

For water intake, there was no difference ($p > 0.05$) when Tifton hay was replaced with Guandu hay in the diet (Table 2). This is because both forage sources are hay, therefore, has the same water precondition to forage particle hydration. In mid-lactation as well as in the studied goats, the water requirements is estimated by the NRC (2007) as nearly 165mL kg^{-1} BW$^{0.75}$, equivalent to 3.08 L day^{-1}, but the average consumption was 5.61 L. day^{-1}. The difference between estimated and observed water intake was because the water requirement equations do not account for production levels and environmental conditions. Therefore, it is necessary accurate equations to contrast water intake.

The dry matter, organic matter and crude protein digestibility decreased linearly with the inclusion of Guandu in the diet (Table 3). This decrease in DM, OM, and CP digestibility is related to the same factors influencing the nutrientintake. Because, besides the presence of tannin in Guandu, around 5%, which results in a low palatability and high protein complexity with the disadvantage and making nutrient breakdown available, mainly the protein fraction (Ferreira, Nogueira, Souza & Batista, 2004). Consequently, according to Piñeiro-Vázquez et al. (2015), this secondary component affects microbial activity, impacts fermentation and leads to reduced digestibility.

Table 3. Apparent digestibility of nutrients of lactating goats on diets with replacement of Tifton 85 hay with Guandu hay.

	Replacement level (%)						p-value	
Item	0	8.4	16.8	25.2	36.4	SEM	L	Q
Dry matter (kg day^{-1})[5]	0.770	0.744	0.750	0.727	0.666	0.011	0.001	0.181
Organic matter (kg day^{-1})[6]	0.782	0.754	0.761	0.738	0.681	0.011	0.001	0.209
Crude protein (kg day^{-1})[7]	0.796	0.777	0.759	0.744	0.668	0.013	0.001	0.171
Neutral detergent fiber (kg day^{-1})[8]	0.588	0.745	0.712	0.711	0.678	0.014	0.001	0.236

SEM: standard error of the mean; L: linear effect; Q: quadratic effect; $Y^5 = 0.799 - 0.022x$; $Y^6 = 0.809 - 0.021x$; $Y^7 = 0.835 - 0.028x$; $Y^8 = 0.643 + 0.014x$.

Despite the reduced digestibility of dry matter, the neutral detergent fiber digestibility increased with the inclusion of Guandu in the diet (Table 3). As already shown, grasses fiber has a more lignified cell wall in contrast to legumes, thus, when replacing the forage source of grasses with legumes, it is available fiber with higher digestibility.

As for DM, OM, and CP digestibility, the diet composition should also be considered (Table 1), since when Guandu hay replaced Tifton hay, the concentrate protein source was replaced with roughage. Although legumes have a substantial amount of protein, this is related to the fiber fraction, which has a lower degradation rate compared to non-fiber protein sources such as soybean meal consequently decreasing the digestibility of this nutrient (Broderick, 1995).

The ingestive behavior, feeding and ruminating efficiencies did not differ with increasing levels of replacement of Tifton hay with Guandu hay in the diet ($p > 0.05$) (Table 4). Results similar to Lopes et al. (2017), in which replacement of grasses with legumes for goats also did not change the ingestive behavior.

Table 4. Ingestive behavior of lactating goats on diets with replacement of Tifton 85 hay with Guandu hay.

	Replacement level (%)						p-value	
Item	0	8.4	16.8	25.2	36.4	SEM	L	Q
Ruminating (min Day^{-1})	440	448	444	410	414	9.85	0.190	0.640
Feeding (min Day^{-1})	402	438	408	384	386	10.26	0.109	0.318
Idle (min Day^{-1})	598	554	582	646	638	17.02	0.151	0.436
Feeding efficiency (g DM min^{-1})	5.43	5.75	5.45	5.17	5.09	0.140	0.097	0.361
Rumination efficiency (g DM min^{-1})	4.92	5.63	5.01	4.85	4.76	0.142	0.178	0.230

SEM: standard error of the mean; L: linear effect; Q: quadratic effect.

The fact that goats are selective explains the ingestive behavior, as the animals spend time in feed selection to reduce variation in intake composition as much as possible in relation to diet composition, leading to the same pattern of ingestive behavior (Baumont et al., 2000). In this sense, this selection was possible up to 36.4% replacement with Guandu because it remained 50 % to the Tifton in relation to the forage proportion.

Conclusion

The replacement of Tifton hay with Guandu hay in up to 36.4 % reduces the intake and digestibilityof dry matter, organic matter and crude protein, and increases neutral detergent fiber digestibility, however without changing the water intake and ingestive behavior.

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