



# Sugarcane bagasse or elephant grass hay in diets for goats: Performance, feeding behavior and carcass characteristics

*Bagazo de caña de azúcar o heno de pasto elefante en la dieta de cabras: Rendimiento, comportamiento de consumo y características de la canal*

*Bagaço de cana de açúcar ou feno de capim elefante na dieta de caprinos: Desempenho, comportamento ingestivo e características de carcaça*

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## Abstract

**Background:** Novel feeding strategies should be developed to produce high-quality meat in current goat production systems. **Objective:** To evaluate the effects of castration and the association of spineless cactus with sugarcane bagasse or elephant grass hay on nutrient intake, digestibility, performance, feeding behavior and carcass traits of feedlot kids. **Methods:** A total of 24 male kids (12 castrated and 12 intact), with an average initial weight of  $18.5 \pm 3.8$  kg were allotted to a completely randomized 2 x 2 factorial design (sugar cane bagasse or elephant grass hay; intact or castrated), and confined for 70 days. **Results:** Nutrient intake and animal performance were similar between treatments. Sugarcane bagasse increased, when compared to elephant grass hay, the digestibility of dry matter (66.12 vs 62.88;  $p=0.005$ ), crude protein (74.26 vs 70.95;  $p=0.029$ ) and non-fibrous carbohydrates (91.94 vs 83.07;  $p<0.001$ ). The forage source affected the time spent resting, ruminating and total chewing time, but there was no effect of diet on feeding and rumination efficiencies. Elephant grass hay increased, when compared to sugarcane bagasse, hot carcass weight (9.87 vs 10.79;  $p=0.025$ ) and hot carcass yield (43.81 vs 46.87;  $p=0.013$ ). Intact kids produced heavier hot carcasses when compared with castrated kids (10.80 vs 9.86;  $p=0.014$ ). **Conclusion:** Feeding intact or castrated kids with sugar cane bagasse or elephant grass hay do not affect nutrient intake and performance. Feedlot goats have improved carcass traits if kept intact and fed elephant grass hay.

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**Keywords:** carcass yield; caprine; castration; elephant grass hay; feedlot; fiber source; goat meat; roughage; small ruminants; sugarcane bagasse.

## Resumen

**Antecedentes:** Se requiere desarrollar nuevas estrategias de alimentación para producir carne de alta calidad en los sistemas actuales de producción de cabras. **Objetivo:** Evaluar el efecto de la castración y asociación de palma forrajera con bagazo de caña de azúcar o heno de pasto elefante sobre la ingesta de nutrientes, digestibilidad, rendimiento, comportamiento de alimentación y características de la canal de cabritos de engorde. **Métodos:** Un total de 24 cabritos (12 castrados y 12 intactos) con peso inicial promedio de  $18,5 \pm 3,8$  kg fueron asignados a un diseño factorial 2 x 2 completamente al azar (bagazo de caña de azúcar o heno de pasto elefante; castrados o intactos) y confinados durante 70 días. **Resultados:** La ingesta de nutrientes y el rendimiento animal fueron similares entre tratamientos. El bagazo de caña de azúcar aumentó, en comparación con el heno de pasto elefante, la digestibilidad de la materia seca (66,12 vs 62,88;  $p=0,005$ ), de la proteína cruda (74,26 vs 70,95;  $p=0,029$ ) y de los carbohidratos no fibrosos (91,94 vs 83,07;  $p<0,001$ ). La fuente de forraje afectó el tiempo de descanso, de rumia, y el tiempo total de masticación, pero no hubo efecto de la dieta sobre la eficiencia alimenticia y de la rumia. El heno de pasto elefante aumentó, en comparación con el bagazo, el peso de la canal caliente (9,87 vs 10,79;  $p=0,025$ ) y el rendimiento de la canal caliente (43,81 vs 46,87;  $p=0,013$ ). Los animales intactos produjeron canales calientes más pesadas en comparación con los castrados (10,80 vs 9,86;  $p=0,014$ ). **Conclusión:** La alimentación de cabritos enteros o castrados con bagazo de caña de azúcar o heno de pasto elefante no afecta la ingesta de nutrientes y el rendimiento. Los cabritos tienen mejores características de canal si se alimentan con heno de pasto elefante y se dejan enteros.

**Palabras clave:** bagazo de la caña de azúcar; carne de cabra; caprino; castración; confinamiento; forraje; fuente de fibra; heno de pasto elefante; rendimiento de carcasa; pequeños rumiantes.

## Resumo

**Antecedentes:** Novas estratégias de alimentação devem ser desenvolvidas para produção de carne de qualidade nos atuais sistemas de produção de caprinos. **Objetivo:** Avaliar o efeito da castração e da associação da palma forrageira com o bagaço de cana de açúcar ou feno de capim elefante no consumo de nutrientes, digestibilidade, desempenho, comportamento ingestivo e características de carcaça de cabritos confinados. **Métodos:** Um total de 24 caprinos (12 castrados e 12 não castrados), com peso inicial médio de  $18,5 \pm 3,8$  kg, distribuídos em um delineamento experimental inteiramente casualizado, em arranjo fatorial 2 x 2 (bagaço de cana de açúcar ou feno de capim elefante; inteiros ou castrados), confinados durante 70 dias. **Resultados:** O consumo de nutrientes e o desempenho dos animais foram semelhante entre os tratamentos. O bagaço de cana elevou, quando comparado com o feno, a digestibilidade da matéria seca (66,12 vs 62,88;  $p=0,005$ ), proteína (74,26 vs 70,95;  $p=0,029$ ) e carboidratos não fibrosos (91,94 vs 83,07;  $p<0,001$ ). As fontes de fibra afetaram os tempos de ócio, ruminação e mastigação total, mas não houve efeito para as eficiências de alimentação e ruminação. O feno de capim elefante aumentou, quando comparado com o bagaço, o peso de carcaça quente (9,87 vs 10,79;  $p=0,025$ ) e o rendimento de carcaça quente (43,81 vs 46,87;  $p=0,013$ ). Os animais inteiros produziram carcaças quentes mais pesadas em comparação aos castrados (10,80 vs 9,86;  $p=0,014$ ). **Conclusão:** Alimentar caprinos inteiros ou castrados com bagaço de cana ou feno de capim-elefante não interfere no consumo de nutrientes e desempenho. Caprinos confinados terão as características de carcaça melhoradas se mantidos intactos e alimentados com feno de capim elefante.

**Palavras-chave:** bagaço de cana de açúcar; carne caprina; caprino; castração; confinamento; fonte de fibra; forragem; palma forrageira; pequeno ruminante; rendimento de carcaça.

## Introduction

Goat farming stands out as an activity of cultural, social and economic relevance in the northeast region of Brazil. However, goat-derived products still lack standardization. The unsatisfactory productivity rates in the region caused by the seasonality of forage production make feedlot a reasonable strategy to intensify production of high-quality meat (Urbano *et al.*, 2015). Nutritional plans and techniques available in feedlot systems to enhance nutrient intake and animal performance allow reducing the age at slaughter and obtaining carcasses with high commercial value.

Feedlot diets are typically expensive due to the cost of concentrate feeds. However, the beneficial effects of dietary fiber cannot be neglected. Fiber maintains adequate ruminal conditions and promotes greater absorption of nutrients (Alves *et al.*, 2016), especially when correctly associated with sources of non-fibrous carbohydrates such as spineless cactus (Ferreira *et al.*, 2012). Correct associations between feed sources tend to enhance animal performance and, when the combination involves alternative feed sources, the beneficial effects also extend to the economics of the system.

Carcass is the most crucial element in the production chain of livestock systems focused on meat production since it contains the edible part with the highest economic value. As a result, farmers have sought increasing carcass weight under commercial conditions. According to Gois *et al.* (2018), carcass weight is highly dependent on growth speed, which is strongly influenced by age at slaughter and nutritional management. Therefore, diets play a key role in improving performance of young animals and production of carcasses with high yield and attractive sensory and organoleptic properties (Osório *et al.*, 2013).

We hypothesized that different sources of fiber and sexual condition could improve the results of confined goats. Therefore, this study aimed to evaluate the effects of castration and

the association of spineless cactus with elephant grass hay or sugarcane bagasse on nutrient intake, digestibility, performance, feeding behavior, and qualitative (pH and temperature) and quantitative (weights and yields) carcass traits of feedlot kids.

## Materials and Methods

### *Ethical considerations*

All procedures followed recommendations of Conselho Nacional de Controle de Experimentação Animal (CONCEA) under protocol No. 054/2017, approved by the Ethics Committee on Animal Use of Universidade Federal do Rio Grande do Norte (UFRN).

### *Location and animals*

The experiment was carried out at the experimental station of Grupo de Estudos em Forragicultura e Produção de Ruminantes (GEFORP) - Academic Unit of Agricultural Sciences/UFRN, located in Macaíba city in the eastern mesoregion of the State of Rio Grande do Norte, Brazil.

Twenty-four mixed breed male kids, of which 12 were castrated and 12 intact, with a mean initial age of five months ( $18.5 \pm 3.8$  kg) were allotted to a completely randomized 2 x 2 factorial design with two forage sources and two sexual conditions, totaling six replicates per treatment and 24 plots. The kids were castrated with rubber rings when they were 15 days old.

The kids were confined in individual pens equipped with feeders and waterers. The animals were weighed, identified, treated for endo and ectoparasites, and vaccinated for *Clostridium* spp. before starting the experimental period. Then, the kids went through a 30-day period of adaptation to handling and experimental diets.

The experimental diets were formulated to be isonitrogenous and contained the same proportion of NDF in order to meet maintenance requirements of 18 kg kids gaining 120 g day<sup>-1</sup>, as set by the National Research Council (2007).

The concentrate was composed of ground corn, soybean meal, mineral mix, sodium chloride and urea. The forage source was spineless cactus chopped in a stationary forage chopper, associated with sugarcane bagasse (SB) or elephant grass hay (EGH) (Table 1). To obtain elephant grass hay, the green material was cut (180 days after planting), then the forage was chopped in a stationary forage and exposed to the sun, on a clean surface, for the haying process. When the hay point was reached, the hay was packed in nylon bags and stored in a ventilated and moisture-free environment. The stationary forage produced particles of hay, sugarcane bagasse and spineless cactus with a size of 1.5 cm<sup>2</sup>.

Feeding was carried out twice a day (7 am and 3 pm) as total mixed ration, *ad libitum*, allowing for refusals of 5 - 10% of offered feed (DM basis). Refused feed was collected and weighed

daily to adjust the feed offered and calculate dry matter intake.

Forage, concentrate ingredients, refusals and feces were sampled weekly for further analysis, which was carried out at the Laboratory of Animal Nutrition at UFRN. The analyses of dry matter (DM; method 934.01), ash (method 930.05), crude protein (CP; method 968.06), and ether extract (EE; method 920.39) were carried out according to the Association of Official Analytical Chemists (AOAC, 2012). NDF was determined using heat-stable alpha-amylase according to the methodology described by Mertens (2002). Total carbohydrates (TC) were calculated using the equation proposed by Sniffen *et al.* (1992), and the contents of non-fibrous carbohydrates (NFC) were calculated according to Mertens (1997).

**Table 1.** Ingredients and chemical composition of experimental diets.

Ingredient (g/kg DM)	Diets	
	Spineless cactus + SB <sup>3</sup>	Spineless cactus + EGH <sup>4</sup>
Spineless cactus	300	250
Sugarcane bagasse	296.3	0
Elephant grass hay	0	350
Soybean meal	180	180
Ground corn	200	200
Sodium chloride	5	5
Mineral Mix	10	10
Urea	8.7	5
Dry matter (DM, %) <sup>1</sup>	200.5	230.2
Organic Matter (OM)	914.2	921.3
Crude Protein (CP)	139.7	133.9
Ether Extract (EE)	21.8	20.7
Ash	77.1	73.7
Neutral Detergent Fiber (NDF)	398.1	394.6
Acid Detergent Fiber (ADF)	335.5	332.1
Total Carbohydrates (TC)	772.6	774.9
Non-fibrous carbohydrates (NFC)	368.9	374.9
Lignin (LIG)	69.4	72.4
Total digestible nutrientes (TDN) <sup>2</sup>	76.01	68.5

<sup>1</sup>% as organic matter, <sup>2</sup>Determined by the digestibility test, <sup>3</sup>Sugarcane bagasse, <sup>4</sup>Elephant grass hay.

Total digestible nutrients (TDN) were estimated by a digestibility test carried out 48 days after beginning the experiment. Feces were collected directly from the rectum of animals once a day for five days, at different times (6 am, 8 am, 10 am, 12 pm and 2 pm). An internal marker (iNDF - indigestible neutral detergent fiber) was used to estimate fecal output (FO) on DM basis. Samples of leftovers, feed, and feces were placed in non-woven fabric bags and incubated in the rumen of cannulated sheep for 288 hours (Valente *et al.*, 2015). The remaining incubation material was submitted to neutral detergent extraction for iNDF determination. The FO was calculated as follows:  $FO = ([\text{marker consumed}]/[\text{marker in feces}])$ . Dietary TDN was estimated using the equation of Weiss (1999). Chemical composition of the diets is shown in Table 1.

Feeding behavior analysis was performed on the 40th experimental day to assess times spent feeding, ruminating, resting, and total chewing time. Instant scan sampling was used to evaluate feeding behavior for 48 hours at 10-min intervals (Johnson and Combs, 1991). Feeding time (FT, h/day), and total chewing time (TCT, h/day) were evaluated following the methodology of Bürger *et al.* (2000).

The kids were weighed every 14 days after solid fasting for 16 hours. Total weight gain (TWG) was obtained by the difference between final weight (FW) and initial weight, while average daily gain (ADG) was obtained by the ratio of TWG over the number of days in feedlot until slaughter, not including the adaptation period:  $ADG = (WG/70)$ . After 70 days in feedlot, in addition to the 30 of adaptation, the kids were individually weighed to obtain final weight (FW) after solid fasting of 16 hours. At slaughtering, the animals were stunned by concussion to cause unconsciousness and then bled with bilateral severance of the carotid arteries and jugular veins.

At the end of skinning and evisceration, the head and legs were removed for determination of hot carcass weight (HCW), which was then used to calculate hot carcass yield [ $HCY(\%) = HCW/FW \times 100$ ]. Full and empty gastrointestinal tract (GIT), urinary bladder and gallbladder were weighed to determine empty body weight (EBW) and biological yield [ $BY(\%) = HCW/EBW \times 100$ ].

The pH and carcass temperature were measured at 0 and 24 hours *postmortem* in the semimembranosus muscle using a pH meter equipped with glass electrode and a temperature probe (Testo®, model 205). Carcasses were placed in a cold chamber ( $\pm 4^\circ\text{C}$ ; 24 hours) and the chilled carcasses were weighed to obtain cold carcass weight (CCW).

The data were analyzed using the PROC GLM of SAS (version 9.4, SAS Institute Inc., Cary, NC, USA, 2013) after testing for residual normality and homogeneity of variance. Given the high probability of Type II error, a significance level of  $\alpha = 0.05$  was used. When necessary, the means were compared by the F-test. The initial body weight was included as a covariate, as follows:

$$Y_{ijk} = \mu + F_i + S_j + (F*S)_{ij}\beta(X_{ijk} - X) + e_{ijk},$$

where:

$Y_{ijk}$  = Observed value of the dependent variable;

$\mu$  = Overall mean;

$F_i$  = Effect of forage source;

$S_j$  = Effect of sexual condition;

$(F*S)_{ij}$  = Effect of interaction (forage source x sexual condition);

$\beta(X_{ijk} - X)$  = Effect of the covariate (initial body weight);

$e_{ijk}$  = Experimental error.

## Results

Fiber sources and sexual conditions did not affect ( $p>0.05$ ) nutrient intake (kg/day): dry matter intake (DMI), crude protein (CPI), neutral detergent fiber (NDFI) and non-fibrous carbohydrates (NFCI) (Table 2).

The fiber source influenced ( $p<0.05$ ) feeding behavior. The TSR was higher for animals fed SB, whereas the TSRU and TCT were higher for animals fed elephant grass hay (Table 3).

Final weight (FW), average daily gain (ADG), total gain (TG) and empty body weight

(EBW), as well as qualitative carcass traits (pH and temperature at 0 and 24 hours post mortem) were not affected by diet, sexual condition, or their interaction ( $p>0.05$ ) (Table 4). Hot carcass weight (HCW) and cold carcass weight (CCW) were affected ( $p<0.05$ ) by sexual condition and fiber source, and were higher for intact animals, animals fed elephant grass hay (Table 4), respectively. There was a significant effect of diet ( $p<0.05$ ) on hot carcass yield (HCY) and biological yield (BY), with better results for animals fed elephant grass hay (Table 4).

**Table 2.** Dry matter intake, nutrient intake and coefficients of digestibility of diets for kids fed sugarcane bagasse and elephant grass hay as forage source.

Items	Diets		Sexual condition		CV	P-value		
	SB <sup>10</sup>	EGH <sup>11</sup>	INT <sup>12</sup>	CAST <sup>13</sup>	(%)	D <sup>14</sup>	SC <sup>15</sup>	D X SC
DMI (kg/day) <sup>1</sup>	0.567	0.670	0.663	0.573	18.51	0.071	0.088	0.063
CPI (kg/day) <sup>2</sup>	0.078	0.088	0.089	0.077	19.19	0.189	0.083	0.071
NDFI (kg/day) <sup>3</sup>	0.219	0.258	0.256	0.222	18.68	0.074	0.083	0.065
NFCI (kg/day) <sup>4</sup>	0.209	0.247	0.245	0.211	18.02	0.059	0.071	0.060
DMD (%) <sup>5</sup>	66.12	62.88	64.51	64.49	3.23	0.005	0.966	0.795
CPD (%) <sup>6</sup>	74.26	70.95	72.50	72.71	4.16	0.029	0.818	0.410
NDFD (%) <sup>7</sup>	41.00	40.04	40.83	40.21	11.36	0.608	0.815	0.608
NFCD (%) <sup>8</sup>	91.94	83.07	86.58	88.43	3.12	<0.001	0.160	0.825
TDNI (kg/day) <sup>9</sup>	0.431	0.459	0.471	0.412	16.91	0.364	0.104	0.065

<sup>1</sup>Dry matter intake, <sup>2</sup>Crude protein intake, <sup>3</sup>Neutral detergent fiber intake, <sup>4</sup>Non-fibrous carbohydrates intake, <sup>5</sup>Dry matter digestibility, <sup>6</sup>Crude protein digestibility, <sup>7</sup>Neutral detergent fiber digestibility, <sup>8</sup>Non-fibrous carbohydrates digestibility, <sup>9</sup>Total digestible nutrients intake, <sup>10</sup>Sugarcane bagasse, <sup>11</sup>Elephant grass hay, <sup>12</sup>Intact, <sup>13</sup>Castrated, <sup>14</sup>Diet, <sup>15</sup>Sexual condition.

**Table 3.** Feeding behavior of kids fed sugarcane bagasse and elephant grass hay as forage source.

Items	Diets		Sexual condition		CV	P-value		
	SB <sup>5</sup>	EGH <sup>6</sup>	INT <sup>7</sup>	CAST <sup>8</sup>	(%)	D <sup>9</sup>	SC <sup>10</sup>	D X SC
TSR (min) <sup>1</sup>	1812.20	1539.00	1651.71	1699.50	11.16	0.006	0.499	0.167
TSRU (min) <sup>2</sup>	865.62	1100.58	999.44	966.45	17.25	0.008	0.573	0.130
FT (min) <sup>3</sup>	202.17	240.43	228.84	213.76	20.14	0.099	0.480	0.991
TCT (min) <sup>4</sup>	1067.80	1341.00	1228.29	1180.51	15.53	0.006	0.498	0.167

<sup>1</sup>Time spent resting, <sup>2</sup>Time spent ruminating, <sup>3</sup>Feeding time, <sup>4</sup>Total chewing time (FT + TSRU), <sup>5</sup>Sugarcane bagasse, <sup>6</sup>Elephant grass hay, <sup>7</sup>Intact, <sup>8</sup>Castrated, <sup>9</sup>Diet, <sup>10</sup>Sexual condition.

**Table 4.** Performance of goats fed sugarcane bagasse or elephant grass hay as forage source.

Items	Diets		Sexual condition		CV	P-value		
	SB <sup>10</sup>	EGH <sup>11</sup>	INT <sup>12</sup>	CAST <sup>13</sup>	(%)	D <sup>14</sup>	SC <sup>15</sup>	D X SC
FW (kg) <sup>1</sup>	22.40	22.95	23.46	21.89	8.84	0.529	0.079	0.062
ADG (kg/day) <sup>2</sup>	0.055	0.071	0.072	0.055	38.70	0.173	0.125	0.117
TWG (kg/day) <sup>3</sup>	3.89	4.92	5.03	3.78	39.18	0.211	0.104	0.097
HCW (kg) <sup>4</sup>	9.87	10.79	10.80	9.86	7.70	0.025	0.014	0.057
CCW (kg) <sup>5</sup>	9.69	10.52	10.56	9.64	8.55	0.050	0.023	0.067
EBW (kg) <sup>6</sup>	17.91	16.70	18.45	16.16	22.87	0.581	0.171	0.073
HCY (%) <sup>7</sup>	43.81	46.87	45.69	44.99	5.16	0.015	0.515	0.767
BY (%) <sup>8</sup>	55.32	59.76	57.84	57.23	6.00	0.020	0.781	0.357
pH <sup>0h</sup>	6.84	6.79	6.86	6.77	2.58	0.463	0.306	0.789
pH <sup>24h</sup>	5.67	5.62	5.67	5.62	1.64	0.163	0.380	0.351
T <sup>9h</sup> (°C)	34.98	34.03	33.84	35.17	4.35	0.184	0.056	0.052
T <sup>24h</sup> (°C)	6.77	6.73	6.89	6.61	9.20	0.823	0.351	0.999

<sup>1</sup>Final weight, <sup>2</sup>Average daily gain, <sup>3</sup>Total weight gain, <sup>4</sup>Hot carcass weight, <sup>5</sup>Cold carcass weight, <sup>6</sup>Empty body weight, <sup>7</sup>Hot carcass yield, <sup>8</sup>Biological yield, <sup>9</sup>Temperature, <sup>10</sup>Sugarcane bagasse, <sup>11</sup>Elephant grass hay, <sup>12</sup>Intact, <sup>13</sup>Castrated, <sup>14</sup>Diet; <sup>15</sup>Sexual condition.

## Discussion

The DMI was lower than that recommended by the NRC (2007) for kids (820 g/day), which may be related to the feeding habit of goats. Despite being versatile, goats are classified as intermediate feeders (Hoffmann, 1989) and require longer periods for adaptation to new conditions, especially when removed from the Caatinga environment and allocated in individual pens with totally different diets, not only in terms of feed offered but also in terms of composition and assimilation. Garcez *et al.* (2020) report that even in feedlot systems, goats express selectivity and spend most of the time searching and selecting food, which influences both quality and quantity of the feed consumed besides chemical composition of leftovers causing variation in nutrient intake. Therefore, the typical feeding habit of goats not adapted to feedlot systems seems to have a greater influence on DMI than fiber source and sexual condition. Moreover, moisture content of diets, which contained 25 and 30% of spineless cactus, also contributed to the low DMI. Goats prefer less moist and more nutrient-rich feedstuffs, such as grasses, shrub and tree plants, due to their intrinsic selective capacity (Costa *et al.*, 2015; Pinho *et al.*, 2019).

The study of Lima Júnior *et al.* (2015) corroborates our argument when they calculated DMI of feedlot goats fed diets containing 30% spineless cactus associated with Tifton 85 hay (415 g DM/day) and cassava hay (544 g DM/day), reporting values lower than those obtained in the present study (567 and 670 g DM/day for BS and EGH, respectively).

The literature reports that DMI in ruminants can be physically limited by rumen filling, which is regulated by the proportion of total dietary NDF (Mertens, 1997, Alves *et al.*, 2016). Goats, in turn, have a high intake capacity of forages with high NDF content (Formiga *et al.*, 2020). When assessing fiber levels for goats, Branco *et al.* (2011) indicated a limitation in DMI from 35% of NDF in the diet, lower than the present study. However, diets had comparable NDF levels (40%), which led to similar NDF and DMI. The lack of effect of treatments on DM led to similar intakes of CP, NFC and TDN.

According to Pessoa *et al.* (2013), the carbohydrates present in the spineless cactus have high degradation rates, which may favor diet digestibility. An increase in dietary NFC concentration changes the microbial environment in the gastrointestinal tract of goats

by increasing the amount of energy available in the rumen for bacterial growth (Ma *et al.*, 2014; Ma *et al.*, 2015; Pinho *et al.*, 2019). This can increase nutrient digestibility. Thus, a greater inclusion of spineless cactus in sugarcane bagasse-based diets increased the digestibility of DM, CP and NFC in this treatment.

Muniz *et al.* (2012) evaluated the ruminal kinetics of the fibrous fraction of roughages, finding that an increase of approximately 3% lignin content in the feed, as found in the present study, decreases nutrient digestibility, justifying the lower values for EGH. Lignin is considered a limiting factor for fiber degradation due to its barrier effect that prevents microbial adhesion and colonization (Cabral *et al.*, 2020).

The high digestibility of sugarcane bagasse-based diets reduced rumination and increased TSR since both DMI and NDFI, which could influence this characteristic, were similar between treatments. However, the low digestibility of elephant grass-based diets increased TSRU and, consequently, TCT, although feeding times were similar between diets.

In addition to the NDF level, fiber composition can influence behavioral activities, especially rumination due to physical barriers to the digestive action of microorganisms (Azevedo *et al.*, 2013; Ramos *et al.*, 2016). Thus, diets with similar NDF levels but composed of different feeds can predispose animals to different expenditures in daily activities (Carvalho *et al.*, 2011).

Similarity of DMI and nutrient intake between treatments resulted in similar animal performance. Feed intake affects animal performance, since the ingested nutrients are converted into animal products (Pompeu *et al.*, 2012).

Daily and total weight gain of kids were lower than the average 120 g/day expected by the NRC (2007). It is relevant to highlight that DMI did not reach the expected target (820 g/day), which would explain the low weight gain.

Regarding sex, it directly influences animal physiology. According to Pellegrini *et al.*

(2012), intact males have higher growth speed than castrated males due to the anabolic effects of testosterone (Paim *et al.*, 2011). It explains the higher results for HCW and CCW in intact animals (10.8 and 10.56 kg) in relation to castrated kids (9.86 and 9.64 kg). Both HCW and CCW are direct measures of body tissue composition (muscle, bone and fat).

Castration increases fat deposition in the carcass (Gois *et al.*, 2018). In goats, fat deposition occurs primarily in the form of visceral fat, which is lost during evisceration (Rodrigues *et al.*, 2013). Thus, it does not significantly influence the final carcass weight and yield.

The HCW and CCW results, although the highest for kids fed elephant grass hay, were similar to the findings of Lima Junior *et al.* (2015) for HCW (10.22 and 9.45 kg) and CCW (9.57 and 8.85 kg) for goats fed Tifton 85 hay and cassava hay associated with spineless cactus, respectively. This indicates that sugarcane bagasse and elephant grass hay are good alternatives to Tifton hay. The increase in hot carcass yield (HCY) and biological yield (BY) are in line with the increase in carcass weight. In a study with feedlot goats, Salles *et al.* (2013) reported lower BYs (50.95%) than those obtained in the present study for both forage sources (55.32 and 59.76% for SB and EGH, respectively). Biological yield was influenced by fiber source, most likely because when considering the empty body weight, this parameter is affected by variations in the gastrointestinal tract contents (Bezerra *et al.*, 2017), which depends on diet intake.

The pH at 24 hours *postmortem* averaged 5.6, which is within the recommended range of 5.5-5.8 for carcasses of small ruminants after cooling (Della Malva *et al.*, 2016). Therefore, it is possible that pre-slaughter handling procedures were carried out without animal stress. The temperature at 24 hours *postmortem* was high, possibly due to the cold chamber setup.

In conclusion, feeding intact or castrated kids with sugar cane bagasse or elephant grass hay



does not affect nutrient intake and performance. However, feedlot goats fed elephant grass hay improve carcass traits if kept intact, which is our recommend combination of strategies.

### Declarations

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#### *Conflicts of interest*

The authors declare they have no conflicts of interest with regard to the work presented in this report.

#### *Author contributions*

VH Campelo-Lima, PH Cavalcante-Ribeiro, JI Gomes-Bezerra were responsible for data collection. S Antas-Urbano, M Andrade-Ferreira coordinated the research. E Moreira-Aguiar, AH Nascimento-Rangel assisted in laboratory analysis. JC Cariri-Chagas analyzed the data.

### References

Alves AR, Pascoal LAF, Cambuí GB, Trajano JS, Silva CM, Gois GC. Fibra para ruminantes: Aspecto nutricional, metodológico e funcional. *Pubvet* 2016; 10(7):513–579.

AOAC, V. AOAC INTERNATIONAL. AOAC Official Methods of Analysis, 2012.

Azevedo RA, Rufino LMA, Santos ACR, Ribeiro Junior CS, Rodriguez NM, Gerasse LC. Comportamento ingestivo de cordeiros alimentado com torta de macaúba. *Arq Bras Med Vet Zootec* 2013; 65(2):490–496. DOI: <https://doi.org/10.1590/S0102-09352013000200027>

Bezerra AB, Gonzaga Neto S, Medeiros NA, Carvalho FFR, Bispo SV, Souza AP, Santos Neto JM, Ribeiro LPS. Carcass characteristics of Canindé goats subjected to feed restriction. *Cienc Rural* 2017; 47(8):e20160690. DOI: <https://dx.doi.org/10.1590/0103-8478cr20160690>

Branco RH, Rodrigues MT, Silva MMC, Rodrigues CAF, Queiroz AC, Araujo FL. Desempenho de cabras em lactação alimentadas com dietas com diferentes níveis de fibra oriundas de forragem com maturidade avançada. *R Bras Zootec* 2011; 40(5):1061–1071. DOI: <https://doi.org/10.1590/S1516-35982011000500018>

Bürger PJ, Pereira JC, Queiroz AC, Silva JFC, Valadares Filho SC, Cecon PR, Casali ADP. Comportamento ingestivo em bezerros holandeses alimentados com dietas contendo diferentes níveis de concentrado. *R Bras Zootec* 2000; 29(1):236–242. DOI: <http://dx.doi.org/10.1590/S1516-35982000000100031>

Cabral AMD, Carvalho FFR, Santos GCL, Ferreira GC, Silva MJMS, Santos GRA, Belo Junior GS, Melo ND. Use of sugar cane to feed lactating dairy goats. *Arq Bras Med Vet Zootec* 2020; 72(6):2297–2307. DOI: <https://doi.org/10.1590/1678-4162-12022>

Carvalho GGP, Garcia R, Pires AJV, Detmann E, Ribeiro LSO, Chagas DMT, Silva RR, Pinho BD. Comportamento ingestivo em caprinos alimentados com dietas contendo cana-de-açúcar tratada com óxido de cálcio. *R Bras Zootec* 2011; 40(8):1767–1773. DOI: <https://doi.org/10.1590/S1516-35982011000800021>

Costa JV, Oliveira ME, Moura RMAS, Costa Júnior MJN, Rodrigues MM. Comportamento em pastejo e ingestivo de caprinos em sistema silvipastoril. *R Ciênc Agron* 2015; 46(4):865–872. DOI: <https://doi.org/10.5935/1806-6690.20150075>

Della Malva A, Albenizio M, Annicchiarico G, Caropese M, Muscio A, Santillo A, Marino RO. Relationship between slaughtering age, nutritional and organoleptic properties of Altamurana lamb meat. *Small Ruminant Res* 2016; 135:39–45. DOI: <https://doi.org/10.1016/j.smallrumres.2015.12.020>

- Ferreira MA, Bispo SV, Rocha Filho RR, Urbano SA, Costa CTF. The use of cactus as forage for dairy cows in semi-arid regions of Brazil. *Organic farming and food production*, 2012; 169p. DOI: <http://dx.doi.org/10.5772/53294>
- Formiga LDAS, Paulo PFM, Cassuce MR, Andrade AP, Silva DS, Saraiva EP. Ingestive behavior and feeding preference of goats reared in degraded caatinga. *Ciênc anim bras* 2020; 21:e-52435. DOI: <http://dx.doi.org/10.1590/1809-6891v21e-52435>
- Garcez BS, Alves AA, Oliveira ME, Moreira Filho MA, Azevedo DMMR, Lacerda MSB. Nutrient metabolism and ingestive behavior of goats fed diets containing palm tree fruit. *Rev Ciênc Agron* 2020; 51(2):e20196608. DOI: <https://doi.org/10.5935/1806-6690.20200034>
- Gois GC, Campos FS, Pessoa RMS, Silva AAF, Ferreira JMS, AGS Matias AGS, Nogueira GHMSMF, Santos RN. Qualidade da carne de ovinos de diferentes pesos e condição sexual. *Pubvet* 2018; 12(5):172–178. DOI: <https://doi.org/10.22256/pubvet.v12n5a97.1-9>
- Hoffmann RR. Evolutionary steps of ecophysiological adaptation and diversification of ruminants: a comparative view of their digestive system. *Oecologia* 1989; 78:443–457.
- Johnson TR, Combs DK. Effects of prepartum diet, inert rumen bulk, and dietary polyethylene glycol on dry matter intake of lactating dairy cows. *J Dairy Sci* 1991; 74(3):933–944. DOI: [https://doi.org/10.3168/jds.S0022-0302\(91\)78243-X](https://doi.org/10.3168/jds.S0022-0302(91)78243-X)
- Lima Junior DM, Carvalho FFR, Ferreira BF, Batista AMV, Ribeiro MN, Monteiro PDB, Monteiro S. Maniçoba hay feeding Moxoto goats. *Semin Ciênc Agrár* 2015; 36(3) 2211–2221. DOI: <http://doi.org/10.5433/1679-0359.2015v36n3Supl1p2211>
- Ma T, Deng KD, Tu Y, Jiang CG, Zhang NF, Li YL, Si BW, Lou C, Diao QY. Effect of dietary concentrate: forage ratios and undegraded dietary protein on nitrogen balance and urinary excretion of purine derivatives in dorper thin-tailed han crossbred lambs. *Asian-Australas J Anim Sci* 2014;27:161–168. DOI: <https://doi.org/10.5713/ajas.2013.13338>
- Ma T, Tu Y, Zhang NF, Deng KD, Diao QY. Effect of the ratio of non-fibrous carbohydrates to neutral detergent fiber and protein structure on intake, digestibility, rumen fermentation, and nitrogen metabolism in lambs. *Asian Australas J Anim Sci* 2015; 28:1419–1426. DOI: <https://doi.org/10.5713/ajas.15.0025>
- Mertens DR. Creating a system for meeting the fiber requirements of dairy cows. *Int J Dairy Sci* 1997; 80(7): 1463–1481. DOI: [https://doi.org/10.3168/jds.S0022-0302\(97\)76075-2](https://doi.org/10.3168/jds.S0022-0302(97)76075-2)
- Mertens DR. Gravimetric determination of amylase treated neutral detergent fiber in feeds with refluxing in beaker or crucibles: collaborative study. *JAOAC Int* 2002; 85(6):1217–1240.
- Muniz EB, Mizubuti IY, Pereira ES, Pimentel PG, Ribeiro ELDA, Pinto AP. Cinética ruminal da fração fibrosa de volumosos para ruminantes. *Revista Ciência Agronômica* 2012; 43(3), 604–610. DOI: <https://doi.org/10.1590/S1806-66902012000300025>
- National Research Council. Nutrient requirements of small ruminants. Washington, DC: National Academy Press. 2007; 362p.
- Osorio MTM, Bonacina MS, Osorio JCS, Rota EL, Ferreira OGL, Treptow RO, Gonçalves MS, Oliveira MM. Características sensoriais da carne de ovinos Corriedale em função da idade de abate e da castração. *Agrarian* 2013; 6(19):60–66.
- Paim TDP, Cardoso MTM, Borges BO, Gomes EF, Louvandini H, McManus C. Estudo econômico da produção de cordeiros cruzados confinados abatidos em diferentes pesos. *Ciênc Anim Bras* 2011; 12(1):48–57. DOI: <http://doi.org/10.5216/cab.v12i1.5894>
- Pellegrini LG, Pellegrini CRS, Monteiro ALG, Neumann M. Efeito do sexo no desempenho de cordeiros desmamados terminados em pasto de Azevém. *Synergismus scyentifica UTFPR*, 2012; 7(1):10–15.

- Pessoa RAS, Ferreira MA, Silva FMD, Bispo SV, Wanderley WL, Vasconcelos PC. Diferentes suplementos associados à palma forrageira em dietas para ovinos: consumo, digestibilidade aparente e parâmetros ruminais. *Rev Bra Saúde Prod Anim* 2013; 14(3):508–517. DOI: <https://doi.org/10.1590/S1519-99402013000300012>
- Pinho RMA, Santos EM, de Oliveira JS, de Carvalho GGP, Alves JP, Macêdo AJdaS, Pereira GA, Pereira DM, Perazzo AF, Zanine AdeM. Relationship between forage neutral detergent fiber and non-fibrous carbohydrates on ruminal fermentation products and neutral detergent fiber digestibility in goats. *Rev Colomb Cienc Pecu* 2019; 32(2):126–138. DOI: <https://doi.org/10.17533/udea.rccp.v32n2a06>
- Pompeu RCF, Cândido MJD, Pereira ES, Bomfim MAD, Carneiro MSDS, Rogério MCP, Sombra WA, Lopes MN. Desempenho produtivo e características de carcaça de ovinos em confinamento alimentados com rações contendo torta de mamona destoxicada em substituição ao farelo de soja. *R Bras Zootec* 2012; 41(3):726–733. DOI: <http://dx.doi.org/10.1590/S1516-35982012000300036>
- Ramos AFO, Pinho BD, Junior L, Silva AGM, Faturi C, Martorano LG, Manno MC, Souza LKR, Sousa LF. Ingestive behavior of sheep fed Brazil nut cake in the diet. *Comportamento ingestivo de ovinos alimentados com torta de castanha-do-pará na dieta*. *Semina: Ciências Agrárias* 2016; 37(4):2259–2268. DOI: <https://doi.org/10.5433/1679-0359.2016v37n4p2259>
- Rodrigues L, Gonçalves HC, Medeiros BBL, Menezes JLL, Maestá AS. Avaliação da somatotropina bovina recombinante (rbST) nos não-componentes da carcaça de cabritos de três genótipos. *Ci Anim Bras* 2013; 14(2):143–150. DOI: <https://doi.org/10.5216/cab.v14i2.8984>
- Salles FM, Zambom MA, Alcalde CR, Macedo FAF, Souza R, Gomes LC, Dias FB, Molina BSL. Carcass characteristics of goat kids in two finishing systems. *Arq Bras Med Vet Zootec* 2013; 65(6):1867–1875. DOI: <http://dx.doi.org/10.1590/S0102-09352013000600039>
- SAS<sup>®</sup>, Statistical Analysis System. SAS/STAT User's Guide. Versão 9.4. Cary, NC, USA: SAS Institute Inc; 2013.
- Sniffen CJ, O'Connor JD, Van Soest PJ, Fox DG, Russel JB. Anet carbohydrate and protein system for evaluating cattle diets: II. Carbohydrate and protein availability. *J Anim Sci* 1992; 70(11):3562–3577. DOI: <https://doi.org/10.2527/1992.70113562x>
- Urbano SA, Ferreira MA, Veras RML, Azevedo OS, Santos Filho HB, Vasconcelos GA, Oliveira JPF. Características de carcaça e composição tecidual de ovinos Santa Inês alimentados com manipueira. *Rev Bras Ciênc Agrár* 2015; 10(3):466–472. DOI: <http://doi.org/10.5039/agraria.v10i3a4812>
- Valente TNP, Detmann E, Sampaio CB. Recent advances in evaluation of bags made from different textiles used in situ ruminal degradation. *Can J Anim Sci* 2015; 95(4): 493–498. DOI: <https://doi.org/10.4141/cjas-2015-100>
- Weiss WP. Energy prediction equations for ruminant feeds. In: *Proceedings Cornell Nutrition Conference for Feed Manufacturers*. Ithaca, 1999; 176–185.