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Evaluation of non-carcass components of goat grazing in Caatinga rangeland supplemented with spineless cactus and native plants

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ABSTRACT. The objective of this study was to evaluate non-carcass components of goats submitted to grazing in the Caatinga rangeland and supplemented with spineless cactus (*Nopalea cochelinifera* Salm Dick), Jitirana hay (*Merremia aegyptia* L. Urban) and Mororó hay (*Bauhinia cheilanta* Bong Stend). Thirty male goats (castrated), with no defined breed, with an initial mean body weight of 19 ± 0.35 kg and approximately 90 days of age were used. The treatments consisted of grazing without supplementation (GWS), grazing + Jitirana hay (GJ); grazing + Jitirana hay + spineless cactus (GJSC); grazing + Mororó hay (GM); grazing + Mororó hay + spineless cactus (GMSC). The means of the variables were tested by Tukey's test at 5% probability. The goats fed GWS, GJSC, GM and GMSC presented higher weights and yields of the diaphragm, and the spleen weight ($p < 0.05$). The highest yield of omasum ($p < 0.05$) occurred with goats fed GJ treatment. There were treatments ($p < 0.05$) on omental fat weight and leg yield, with the highest values for goats, fed GWS, GJSC, GM, and GMSC. The "Buchada" EBW^{-1} yield was higher ($p < 0.05$) for animals fed GWS. Feeding supplementation of goats grazing in the Caatinga had few influences on weights and yields of non-carcass components.

Keywords: semi-arid; supplementation; herd; organs.

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Introduction

Goat farming plays an important role in the agricultural sector, especially in the Brazilian semi-arid region, being an alternative for income generation through the sale of live animals, milk, meat, and its by-products. The main source of forage resources in this region is the Caatinga vegetation (Andrade et al., 2016).

This Biome is complex and consists of trees, shrubs and herbaceous species with great potential for use in animal feeding (Silva et al., 2016; Silva et al., 2017). However, in this region the irregular distribution of rainfall occurs, promoting seasonality in the production of fodder resources, with greater supply during the rainy season. It is then necessary to carry out the conservation and storage of the surplus fodder produced, either in the form of hay or silage for the most critical periods, in order to guarantee the survival of the herds and to maintain the productive indexes.

With the increase in the competitiveness of the markets, in addition to goat carcass, it was necessary to take advantage of the by-products generated during the production process, among them, non-carcass components, which are an important alternative to increase the profitability of production systems (Moreno et al., 2011). According to Pompeu et al. (2013), the processing of these organs should be performed in order to add value to the product, increasing revenues of small farmers it becomes a more profitable activity. As well as internal fat deposits due to their lipid profile have been used in formulations of meat products, aiming to improve their appearance, texture, and palatability (Ribeiro et al., 2016; Costa et al., 2017).

The level of dietary supplementation, type of food and energy level of the diets may influence the weights and yields of the non-constituent components of the carcass in small ruminants (Bezerra et al., 2010; Souza et al., 2015; Ribeiro et al., 2017). Thus, the objective of this work was to evaluate the weights and yields of the non-carcass components of goats submitted to grazing in the Caatinga supplemented with spineless cactus and native plants.

Material and methods

The management and care of the animals were carried out in accordance with the guidelines and recommendations of the Ethics Committee on the Use of Animals (CEUA) of UFRPE, under the license number (104/2014).

The experiment was conducted at the Center for Training and Professionalization in Goat and Sheep of the Instituto Agronômico de Pernambuco (IPA), located in the city of Sertânia, whose geographical coordinates of position are: Latitude 08º04'25 "south and Longitude 37º15'52", in the micro-region of Sertão of Moxotó, 600 m above sea level, in a Caatinga ecosystem, with a regional climate of the hot semi-arid type. The average rainfall in the experimental period was 107.5 mm/month.

Thirty male goats (castrated), with no defined breed, with an initial mean body weight of 19 ± 0.35 kg and approximately 90 days of age were used. At the start of the experiment, all animals were weighed, identified, treated against endo and ectoparasites with ivermectina 0.08% (oral solution) at the dose of 200 mcg of ivermectina/kg of body weight as indicated by the manufacturer. The experimental period lasted 105 days, with 15 days for adaptation to the experimental conditions.

The animals were allocated in five treatments: grazing without supplementation (GWS), grazing + Jitirana hay (*Merremia aegyptia* L. Urban) (GJ); grazing + Jitirana hay + spineless cactus (*Nopalea cochelinifera* Salm Dick) (GJSC); grazing + Mororó hay (*Bauhinia cheilanta* Bong Stend) (GM); grazing + Mororó hay + spineless cactus (GMSC) (Table 1).

Table 1. Chemical composition of experimental diets ingredients.

Nutrients	Jitirana hay	Mororó hay	Spineless cactus	G (extrusa)	GJ	GJSC	GM	GMSC
DM (g kg^{-1} NM)	837.6	844.1	135.6	135.4	115.4	150.7	116.0	139.96
OM[1]	893.7	898.8	870.9	863.0	695.4	714.3	670.4	693.54
Ash[1]	106.2	101.1	129.1	136.9	110.0	111.0	106.2	109.19
CP[1]	86.6	106.6	39.3	152.9	112.5	118.1	118.0	117.00
EE[1]	17.8	24.7	15.4	33.6	26.9	26.1	25.9	25.90
NDF[1]	625.8	601.2	302.1	617.0	497.0	497.5	478.7	484.14
ADF[1]	369.9	491.7	182.5	490.2	393.7	385.9	380.5	383.50
TC[1]	789.9	769.2	816.4	676.3	545.8	569.8	526.4	550.54
NFC[1]	164.1	168.0	514.3	59.3	48.7	72.3	47.7	66.38
IVDMD (g g^{-1} DM)	0.51	0.44	0.79	0.55	0.45	0.46	0.43	0.45

[1]g kg^{-1} of DM, G = grazing without supplementation, GJ = grazing + Jitirana hay, GJSC = grazing + 51% Jitirana hay + 49% spineless cactus, GM = grazing + Mororó hay, GMSC = grazing + 51% Mororó hay + 49% spineless cactus, DM = dry matter, NM = natural matter, OM = organic matter, CP = crude protein, EE = ether extract. NDF = neutral detergent fiber, ADF = acid detergent fiber, NFC = non-fibrous carbohydrates, TC = total carbohydrates, IVDMD = *in vitro* dry matter digestibility.

The pasture was constituted by a Caatinga area corresponding to 37 hectares. The animals were released at 6:00 am and at 4:00 pm they returned to the management base. The animals of the treatment without supplementation were collected in a collective bay, in a shed measuring 18 m in length and 6 m in width, equipped with collective salt shaker and drinker. While the animals receiving supplementation were housed in individual stalls (2.1 m x 1.5 m), equipped with salt shakers and individual drinkers, where supplementation was provided, which was estimated in the amount of 1% of the initial body weight of the animals.

However, during the adaptation period, it was observed that the animals were not consuming the supplements in the previously stipulated amount of 1% of the initial body weight. All animals received 0.5% of the body weight until the end of the experiment, thus avoiding wastage of the supplement, with 59% of hay (Jitirana or Mororó) and 41% of spineless cactus based on dry matter being supplied. All animals received 10 g of mineral salt mixed with supplementation, mixed daily.

An experiment conducted during this same period determined the composition of the grazing samples using the extrusa collected in six goats (rumen fistulated) with a body weight of approximately 25 kg. In order to collect the extrusa, all ruminal contents were removed and stored in buckets, duly identified by the animal. The animals were then free in the experimental area for 40 minutes. After this period, they were confined to collect the extrusa, which in turn was packed in plastic bags, properly identified and frozen.

Samples of the feed and leftovers were collected, weighed, identified and stored under freezing (-20ºC) conditions and at the end of each period, a composite sample was formed for chemical composition analyzes. These samples were pre-dried in a forced ventilation oven at 55°C for a period of approximately 72 hours. After this process, they were ground in a Willey type mill in sieves with 1 mm sieves and packed in polyethylene bottles, identified and hermetically sealed for the analysis.

The dry matter (DM), crude protein (CP), ether extract (EE), ash and organic matter (OM) were determined according to the methodology described by the Association of Official Analytical Chemists (AOAC, 1997). The determination of neutral detergent fiber (NDF) and acid detergent fiber (ADF) was carried out according to the method proposed by Van Soest, Robertson, and Lewis (1991). Total carbohydrates (TC) were estimated by the equations described by Sniffen, O'Connor, Van Soest, Fox, and Russell (1992): TC = 100 - (% CP + % EE + % Ash). To obtain non-fibrous carbohydrates (NFC), the equation described by Hall, Hoover, Jennings, and Webster (1999) was used, where NFC = % TC -% NDF.

To estimate intake, fecal dry matter production (FDMP) was used and obtained by using a LIPE® external indicator (Modified and enriched hydroxyphenylpropane: P2S2, Florestal, Minas Gerais, Brazil), in daily, single doses of 250 mg, given orally from the seventh day of each experimental period. The feces were collected for five consecutive days directly from the rectal ampulla, before allowing the animals access to the pasture (Saliba et al., 2015).

At the end of the experimental period, the animals were weighed (final body weight) and submitted to a fasting for approximately 16 hours. After this time the animals were again weighed to obtain body weight at slaughter (BWS).

At slaughter, the animals were stunned by a concussion in the atlas-occipital region, followed by bleeding, for approximately four minutes, through the carotid and jugular section. The blood was collected in a previously tared container, for later weighing. Skinning and evisceration were performed, with the head, paws and tail removed, each of these components individually weighed and their weights recorded. The components of the gastrointestinal tract (GIT) were weighed full and then emptied, washed and reweighed to obtain the content of the GIT, and the empty body weight (EBW) was determined, according to the following formula: $\mathrm{EBW} = (\mathrm{GIT\ content} - \mathrm{BWS})$.

The non-carcass components were composed of organs (tongue, lungs + trachea, heart, liver, full gallbladder, pancreas, thymus, kidneys, spleen, diaphragm, testicles + penis, bladder + glands attached); viscera (esophagus, rumen, reticulum, omasum, abomasum and small and large intestines) and by-products (blood, skin, head, legs and fatty deposits: omental, mesenteric, pelvic + renal fat). As constituents of the "Buchada" were considered blood, liver, kidneys, lungs, spleen, tongue, heart, omentum, rumen, reticulum, omasum and small intestine (Medeiros et al., 2008).

The experimental design was completely randomized, with five treatments and six replicates. The analysis of variance and Tukey's test, at a 5% probability level, were performed using the Statistical Analysis System (SAS, 2015).

Results and discussion

There was an effect of treatments ($p < 0.05$) on a total dry matter (DM) of grazing intake, supplement intake, neutral detergent fiber (NDF) and non-fibrous carbohydrates (NFC) intakes. However, the intakes of crude protein (CP) and total digestible nutrients (TDN) did not differ ($p > 0.05$) among treatments (Table 2).

Body weight at slaughter, empty body weight, gastrointestinal tract content, absolute weights of TOTL (Tongue + Oesophagus + Trachea + Lungs), heart, liver and TOTL, heart, spleen, and liver yields were not significantly influenced by treatments ($p > 0.05$, Table 2).

However, there was a significant difference ($p < 0.05$) for the diaphragm weight and for its yield, and the grazing animals supplemented with jitirana hay had the lowest values for these variables (Table 2). The diaphragm is a muscle responsible for breathing and ranged from 0.04 to 0.07 kg. Jenkins and Leymaster (1993) argue that organs essential to vital processes of respiration and metabolism have a higher development at birth, while those associated with locomotion and storage of nutrients show later development, one may consider that despite the animals used in this experiment, on average the same age at slaughter, it can be suggested that the development of the organs did not occur in a similar way, since the animals have very particular metabolism and physiology.

The respective absolute weight and yield in relation to EBW did not differ among treatments, probably due to the fact that feed intake, in the treatment as grazing plus bulk supplementation, in the experimental conditions, in the Caatinga, did not provide an increase in the metabolic rate of this organ, even when the selectivity of goats on grazing is taken into account. Liver weight generally reflects the metabolic rate of the animals, because this organ is closely linked to the metabolism of the animal, the size and growth of this organ is related to the greater intake of nutrients of the diet by the animal, especially protein and energy, therefore, as the intakes of CP and TDN were not influenced by diets the weight of this organ also did not vary. Bezerra et al. (2010) and Souza et al. (2015) observed significant differences in liver weights of grazing goats according to the level of dietary supplementation or type of diet.

Table 2. Intake, weights, and yields of the organs of goats grazing in the Caatinga rangeland supplemented with spineless cactus and native plants.

Item	Treatments					SEM*	P-value
	G	GJ	GJSC	GM	GMSC		
Intake (g kg^{-1} BW ^{0,75} day^{-1})							
DM of grazing	73.79ab	78.21a	71.81ab	74.84ab	71.37b	0.774	0.036
DM of supplement	-	0.87c	9.26a	1.51c	7.34b	0.375	<.0001
Total DM	73.80b	79.09ab	81.06a	76.36ab	78.72ab	0.788	0.037
Crude protein	12.00	12.74	11.64	12.23	11.61	0.163	0.159
NDF	45.24ab	48.01a	44.01b	45.90ab	43.78b	0.448	0.018
NFC	28.32ab	24.00b	30.26a	27.21ab	30.57a	0.623	0.005
TDN	42.54	38.48	43.13	42.70	43.61	0.736	0.180
Weights (kg)							
BWS	23.65	22.78	24.68	23.55	24.85	0.539	ns
EBW	17.44	17.22	18.69	18.03	18.64	0.382	ns
Content of GIT	6.20	5.55	5.98	5.51	6.20	0.225	ns
TOTL	0.42	0.36	0.39	0.37	0.40	0.011	ns
Diaphragm	0.07a	0.04b	0.07a	0.07a	0.07a	0.003	0.001
Heart	0.09	0.08	0.09	0.08	0.10	0.003	ns
Spleen	0.38a	0.23b	0.37a	0.41a	0.40a	0.012	0.001
Liver	0.46	0.43	0.47	0.45	0.44	0.011	ns
Yields (%)							
TOTL	2.33	2.13	2.10	2.04	2.10	0.040	ns
Diaphragm	0.38a	0.23b	0.37a	0.41a	0.40a	0.012	0.001
Heart	0.50	0.43	0.47	0.46	0.55	0.012	ns
Spleen	0.11	0.12	0.13	0.12	0.13	0.007	ns
Liver	2.55	2.50	2.45	2.35	2.47	0.042	ns

G = grazing without supplementation, GJ = grazing + Jitirana hay, GJSC = grazing + Jitirana hay + spineless cactus, GM = grazing + Mororó hay, GMSC = grazing + Mororó hay + spineless cactus, NDF = neutral detergent fiber, NFC = non-fibrous carbohydrates, TDN = total digestible nutrients, TOTL = Tongue + Oesophagus + Trachea + Lungs; BWS = body weight at slaughter; EBW = empty body weight, *SEM = Standard error of the mean; Means followed by the same letter in the line do not differ by the Tukey test at the 5% probability level.

For the absolute heart weight, mean values of approximately 0.09 kg were found. Souza et al. (2015) reported that the level of feeding does not influence the weight of the heart indicating that these organs maintain their integrity and are a priority in the use of nutrients, which would explain the similarity between the treatments observed in this study.

In relation to the GIT content, it was not influenced by the treatments ($p > 0.05$). This similarity is probably due to the fact that the same type of feeding (roughage) was consumed, and being slightly influenced by the supplements, which may have contributed to this behavior, even though there were significant differences in NDF intake, with higher intakes observed for the animals fed only grazing and for those supplemented with Jitirana and Mororó hay (Table 2). However, in addition to diet, other factors such as slaughter weight, breed, sex and age influence the weights and proportions of the non-carcass components (Camilo et al., 2012).

Spleen weight was significantly influenced by the treatments ($p < 0.05$), possibly influenced by the difference in total DM and NFC intakes, with the highest values observed for grazing-only animals and those supplemented with Jitirana and Mororó hay, and their associations with the spineless cactus. The spleen is an organ of high metabolic rate because it actively participates in the metabolism of nutrients (Camilo et al., 2012), this variation is probably due to differences in nutrient utilization of these animals since each animal has particularities in its metabolism.

The mean weights, as well as the yields of viscera (Table 3), did not differ statistically ($p > 0.05$) among treatments, except for omasum yield in relation to empty body weight; this variable may have been influenced by the intake of NDF.

For the rumen/reticulum absolute weight, values between 0.75 to 0.83 kg and yields 4.29% to 4.45% were found (Table 3). The development and weight of these organs are influenced by the type of diet, especially the level of fiber (Cardoso et al., 2016; Lima et al., 2019). Therefore, the rumen-reticulum volume is associated with its function during fermentation, that is, the size will be larger depending on the number of solid foods, especially the roughage, which could explain the similarity among the treatments, since the diet of the animals was composed only of roughage foods, and the fiber values in the diets were very close between the treatments that had supplementation. Thus, the viscera can serve as an additional source of income for the producers and refrigeration industries with the commercialization of these components, besides the possibility of being used in human food (Camilo et al., 2012).

Table 3. Weights and yields of the viscera of goats grazing in the Caatinga rangeland supplemented with spineless cactus and native plants.

Item	Treatments					SEM*	*P*-value
	G	GJ	GJSC	GM	GMSC		
Weights (kg)							
Rumen/Reticulum	0.80	0.75	0.82	0.79	0.83	0.020	ns
Omasum	0.06	0.07	0.06	0.07	0.06	0.002	ns
Abomasum	0.11	0.11	0.11	0.11	0.12	0.003	ns
Small intestine	0.43	0.39	0.49	0.41	0.44	0.012	ns
Large intestine	0.29	0.23	0.27	0.28	0.27	0.008	ns
Yields (%)							
Rumen/Reticulum	4.45	4.43	4.33	4.29	4.46	0.062	ns
Omasum	0.35ab	0.40a	0.32b	0.39ab	0.32b	0.009	0.001
Abomasum	0.60	0.67	0.55	0.61	0.62	0.018	ns
Small intestine	2.37	2.28	2.55	2.24	2.41	0.058	ns
Large intestine	1.63	1.36	1.42	1.51	1.43	0.628	ns

*SEM = Standard error of the mean; G = grazing without supplementation, GJ = grazing + Jitirana hay, GJSC = grazing + Jitirana hay + spineless cactus, GM = grazing + Mororó hay, GMSC = grazing + Mororó hay + spineless cactus. Means followed by the same letter in the line do not differ by the Tukey test at the 5% probability level.

For the values of the by-products (Table 4), no significant difference was observed for the analyzed variables, except for the absolute weight of the omentum and for the yield of the legs.

The weight of the omentum may have been influenced by the intake of NFC, which was higher for the animal supplements based on the spineless cactus associated with Jitirana and Mororó hay. According to Brand, Van Der Merwe, Swart, and Hoffman (2019), goats have a greater physiological ability to deposit fat around the internal organs, constituting, in one aspect, an energy reserve for the animal during the dry season. The deposited fat is the non-carcass component that presents greater variation as a function of the nutritional level ingested (Asizua et al., 2014; Souza et al., 2015; Luz et al., 2017). Although it's over accumulation is not desired. But according to Costa et al. (2017), internal fat deposits have the potential for use in the formulation of meat products.

Table 4. Weights and yields of by-products of goats grazing in the Caatinga rangeland supplemented with spineless cactus and native plants.

Item	Treatments					SEM*	*P*-value
	G	GJ	GJSC	GM	GMSC		
Weights (kg)							
Blood	1.04	0.88	1.07	1.05	0.97	0.025	ns
Skin	1.14	1.20	1.27	1.23	1.22	0.026	ns
Head	1.38	1.37	1.50	1.41	1.46	0.025	ns
Feet	0.74	0.53	0.75	0.73	0.73	0.021	ns
Omental fat	0.04a	0.03b	0.06a	0.04a	0.05a	0.005	0.02
Mesenteric fat	0.12	0.12	0.14	0.14	0.15	0.007	ns
Yields (%)							
Blood	5.98	5.13	5.74	5.87	5.24	0.096	ns
Skin	6.57	7.00	6.80	6.87	6.58	0.084	ns
Head	7.96	7.99	8.00	7.88	7.92	0.105	ns
Feet	4.24a	3.16b	4.04ab	4.08ab	3.98ab	0.113	ns
Omental fat	0.22	0.18	0.36	0.23	0.28	0.025	ns
Mesenteric fat	0.68	0.69	0.79	0.81	0.80	0.035	ns

*SEM = Standard error of the mean; G = grazing without supplementation, GJ = grazing + Jitirana hay, GJSC = grazing + Jitirana hay + spineless cactus, GM = grazing + Mororó hay, GMSC = grazing + Mororó hay + spineless cactus. Means followed by the same letter in the line do not differ by the Tukey test at the 5% probability level.

Blood was not influenced by the treatments ($p > 0.05$), this is probably due to the fact that the animals had the same weight at slaughter and consequently even blood supply since the weight of the blood is related to the weight of the animal.

The absolute skin weight ranged from 1.14 to 1.27 kg. The skin is the largest organ of the body, and grows as the animal grows in size, developing at the same speed of body weight (Brand et al., 2019), thus being a justification for non-variation of animal skin of the present study.

Feet yields in percentage values ranged from 3.16% to 4.24%, where the animals under grazing at will had higher yields when compared to animals supplemented with Jitirana hay, probably due to the fact that they were working with animals of the non-defined breed type, which possibly presented varied development for this characteristic. Stressing that the head and feet follow the same proportion of development, however, are components that present a lower variability and influence of the feeding in relation to the other parts of the body.

'Buchada' yields for body weight at slaughter were not influenced by treatments (p > 0.05, Table 5), yields observed in this study ranged from 16% to 18%. For the yield of the 'Buchada' in relation to the empty body weight, it was observed that the animals only under grazing had the highest mean (24.69%), in relation to the supplemented animals. Bezerra et al. (2010), working with no defined breed goats under grazing in the Caatinga, did not find a significant difference for 'Buchada' yield in relation to body weight at slaughter, as well as in relation to empty body weight, with mean values found by the author of 16.88% and 13.35%, for the respective variables. These values are lower than those found in this study, which may possibly be justified due to the lower occurrence of rainfall when compared to the present study since the author also evaluated these characteristics during the dry period of the year.

Table 5. Weights of constituents and yield of the "Buchada" of goats grazing in the Caatinga rangeland supplemented with spineless cactus and native plants.

Item	Treatments					SEM*	*P*-value
	G	GJ	GJSC	GM	GMSC		
"Buchada" (kg)	4.31	3.82	4.46	4.28	4.22	0.090	ns
Head + Feet (kg)	2.12ab	1.90b	2.25a	2.15ab	2.20ab	0.036	0.001
"Buchada" EBW^{-1} (%)	24.69a	22.15b	23.93ab	23.77ab	22.77ab	0.254	0.001
"Buchada" BWS^{-1} (%)	18.23	16.77	18.07	18.23	17.13	0.211	ns
Head + Feet EBW^{-1} (%)	12.20	11.14	12.05	11.97	11.90	0.157	ns
Head + Feet BWS^{-1} (%)	9.03	8.45	9.11	9.19	9.02	0.142	ns

G = grazing without supplementation, GJ = grazing + Jitirana hay, GJSC = grazing + Jitirana hay + spineless cactus, GM = grazing + Mororó hay, GMSC = grazing + Mororó hay + spineless cactus. BWS = body weight at slaughter; EBW = empty body weight, *SEM = Standard error of the mean, Means followed by the same letter in the line do not differ by the Tukey test at the 5% probability level.

Regarding the weight of the head + feet, the highest values were observed in the animals fed with the Jitirana hay and spineless cactus supplementation. However, no significant effect of treatments on head + leg yields was observed in relation to BWS and EBW, which presented averages of 8.96% and 11.85%, respectively.

It is worth mentioning that the "Buchada" yield, when expressed in relation to empty EBW, is higher when compared to BWS, showing the importance of eliminating the content of the gastrointestinal tract so that there is no overestimation of the results.

Conclusion

Supplementation with Jitirana and Mororó hay associated or not with spineless cactus exerted few effects on the weights and yields of the non - carcass components, as well as the "Buchada" yield.

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