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Morphometry and carcass characteristics of goats submitted to grazing in the Caatinga[1]

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ABSTRACT - The objective of this study was to evaluate morphometric measures, carcass yields, absolute weights and yields of commercial cuts of carcass of kids with no defined breed. Eighteen castrated male goats, with average weight of 15 kg were used. The experimental period lasted 105 days. The experimental design was completely randomized; animals were allocated to three treatments: free grazing without supplementation; restricted grazing without supplementation and free grazing with supplementation. Animals were supplemented (1% of body weight) with forage cactus (*Opuntia ficus - indica*, Mill) and soybean meal (*Glycine max*). The feeding consisted of continuous grazing on caatinga. Supplemented animals had higher live slaughter weight and body score, and consequently higher morphometric measures *in vivo* and in carcasses. The supplementation provided carcasses with higher body weight and body score. For yields of carcass, there was no difference between treatments restricted grazing and grazing with supplementation; supplementation provided carcasses with higher yields. Supplemented animals had higher absolute weights for commercial cuts. Supplementation of grazing goats raised in the caatinga provides animals with higher body weight at slaughter, greater morphometric measures *in vivo* and in carcass and better body conformation. Therefore, for supplementation, the level used in this experiment is a good alternative in the creation of small ruminants during the dry period in the semi-arid region.

Key Words: body score, commercial cuts, conformation, morphometric measures, supplementation, yields

Introduction

Meat goat breeding represents a traditional activity in the states of the Northeast of Brazil. Data from the Instituto Brasileiro de Geografia e Estatística (IBGE, 2007) indicate that about 91.4% of the Brazilian goats are located in this region, primarily consisting of animals with undefined breed (UB). It is a prominent socio-economic activity by being source of income especially for small producers through the production of meat, leather and use of edible components not constituents of the carcass in the preparation of regional dishes such as “buchada”.

According to Gonzaga Neto et al. (2006), carcass characteristics are directly influenced by the nutritional composition of the diet. In the Northeastern semi-arid region, the diet of goats is based on the use of caatinga vegetation (Santos et al., 2010), which often does not meet the nutritional requirements of animals, generating the need for the use of food supplementation. Carvalho Junior et al. (2009), when evaluating carcass characteristics of crossbred (Boer × UB) goats subjected to three supplementation levels concluded that animals supplemented with up to 1% body weight had heavier carcass and commercial cuts. However, Bezerra et al. (2010) observed that protein-energy supplementation to UB kids in the Caatinga during the dry season provided animals with higher body weight at slaughter and increased absolute weights of organs and viscera. Thus, the use of supplementation during the dry season is considered a good alternative to provide, in quantity and quality, nutrients that native pasture cannot supply and thus, increase the productivity of animals in order to meet market demands.

Evaluations in the housing are important to observe the performance achieved by the animal during its development. Thus, the use of supplementation during the dry season is considered a good alternative to provide, in quantity and quality, nutrients that native pasture could not supply and thus, increase the productivity of animals in order to meet market demands.

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Evaluations performed in the carcass are important to observe the performance achieved by the animal during its development. These evaluations are carried out objectively and subjectively. In the meat production system, carcass quantitative traits are essential in the production process, since they are directly related to the final product and are determined by yield, regional composition (commercial cuts), tissue composition and carcass muscularity. The proportion of muscle in the carcass can also be assessed using objective (body weight and biometrics) and subjective (body score) parameters *in vivo* or carcass. Yáñez et al. (2004) state that biometric measurement allow predicting some quantitative carcass traits. This research aimed to evaluate the morphometric and quantitative characteristics of SPRD kid's carcass submitted to grazing in the caatinga being held in restricted grazing or freely grazing, with or without supplementation.

Material and Methods

The experiment was conducted during the dry season (September-December 2008) at the Centro de Treinamento e Profissionalização em Caprino-Ovinocultura of Instituto Agronômico de Pernambuco (IPA) located in the city of Sertânia, at 08°04' 25" South latitude and 37°15' 52" west longitude in the microregion Moxotó, 600 m above the sea level with hot semi-arid climate and 25 °C average annual temperature (Santos et al., 2009).

Eighteen male kids of undefined breed (UB), 15 kg initial body weight and approximately 90 days old were used. At the beginning of the experiment, animals were weighed, identified, castrated by the burdizzo method, treated against endo and ectoparasites and submitted to a period of adaptation to the environment and management for 15 days. The experiment lasted 105 days.

Animals were divided into three treatment groups: grazing freely without supplementation, with access to pasture for nine hours/day; restricted grazing , with access to pasture for about four hours/day, or according to the intermediate weights performed weekly aiming the body weight maintenance; and grazing freely with supplementation, with access to pasture for nine hours/day and supply of supplementation in the late afternoon. Feeding consisted of grazing with continuous stocking in area corresponding to 37 hectares of caatinga. By late afternoon, animals in the first and secondtreatments were taken to a dirt collective stall, provided with waterer and salt trough. Animals from the third treatment were taken to a warehouse consisting of twenty individual stalls with 2.4 m^2 per animal, equipped with feeders and salt troughs to provide supplementation. Supplementation was added at 1% of the animal body weight, 50% cactus pear (*Opuntia ficus - indica* Mill) cut by hand and 50% soybean meal (*Glycine max* L.), on a dry matter basis. Weekly, animals were weighed after solids fasting for 18 hours to monitor the weight gain and adjust the supplementation. At the end of the experiment, animals were weighed (final weight) and fasted for solids for 18 hours, when they were weighed again to obtain the body weight at slaughter (WS).

Before slaughter, animal body condition was determined by spine palpation after the 13^{th} pair of thoracic ribs. The classification was performed using a scale from zero to five, where zero rates the cachectic animal, not possible to detect muscle or fat between skin and bone, and five rates animals deemed too fat (Silva Sobrinho & Gonzaga Neto, 2001).

Objectively, biometric measurements were determined *in vivo*, using methods described by Yáñez et al (2004): body length (BL), distance between cervical-thoracic articulation and tail base in the first inter-coccygeal articulation; anterior height (AH), distance between withers and distal forelimb region, posterior height (PH), distance between sacral tuberosity and distal hind limb, leg length (LL), distance between the largest femurtrochanter and edge of tarsal-metatarsal articulation, thoracic perimeter (TP), perimeter taking the sternum and withers as base, passing the tape after the palette; rump width (RW), distance between the largest trochanters of the femur and chest width (CW), distance between lateral sides of scapular-humeral articulations. Body compactness (COMPAC; kg/cm), objective index of *in vivo* conformation, was determined by the formula cited by Yáñez et al. (2004): COMPAC = WS/BL.

At slaughter, animals were anesthetized by stunning in the atlas-occipital region, followed by bleeding for about four minutes, through the section of carotid and jugular. Skinning and evisceration, withdrawal of head, feet and tail were performed in order to record the hot carcass weight (HCWkf), including kidneys and kidney-pelvic fat. The gastrointestinal tract was weighed full and empty to determine the empty body weight (EBW) aiming to determine the true yield: TY (%) = HCW/EBW × 100 (Cezar & Souza, 2007). Carcasses were cooled for 24 hours in refrigerator at approximately 4 °C. Afterwards, they were weighed to obtain the cold carcass weight (CCWkf), including kidneys and renal pelvic fat. The index of loss by cooling (ILC) was calculated using the formula described by Mattos et al. (2006): ILC (%) = HCWkf – CCWkf/HCWkf × 100. Subsequently, weights of kidney and pelvic and kidney fats were obtained and these values subtracted from the weights of hot and cold carcasses to calculate the hot carcass yield [HCY (%) = HCW/WS × 100] and cold carcass yield and/or commercial yield [YC (%) = CCW/WS × 100] (Mattos et al., 2006). After weighing, carcasses were evaluated subjectively, following the method described by Colomer - Rocher et al. (1988) to determine the degree of conformation (visual assessment of the state of the carcass muscularity), ranging from poor (1) to excellent (5); finishing (visual assessment of the fat proportion covering the carcass), ranging from very lean (1) to very fat (5) and amount of pelvic-renal fat, ranging from small (1) to big (3).

After evaluations, external measurements were carried out in the carcass to determine the conformation: external carcass length (ECL): distance between cervical-thoracic articulation and 1st inter-coccygeal articulation; rump width (RW): maximum width between the trochanters of the femurs, rump perimeter (RP): perimeter of the rump region, based on the trochanters of the femur; chest perimeter (CP): perimeter measured behind the palette. Soon after, carcasses were cut in half and half-carcasses were weighed. In the left half-carcass, the following parts were measured: carcass inner length (CIL): distance between the front edge of the pubic bone and front edge of the first rib at its midpoint; chest depth (CD): distance between the sternum and withers and chest width (CW): maximum chest width. The carcass compactness index was also determined by the following formula: CCI (kg/cm) = HCW/CIL, described by Yáñez et al. (2004).

After completion of these measurements, right and left half-carcasses were sectioned into six parts individually, according to the methodology proposed by Cezar & Souza (2007) considering the following commercial cuts: palette (obtained by scapula disarticulation), leg (obtained by sectioning between the last lumbar vertebra and first sacral vertebra); loin (between the 1st and 6th lumbar vertebrae); ribs (between 1st and 13th thoracic vertebrae), saw (straight cutting, starting on the flank to the cranial end of the sternum manubrium) and neck (region encompassed by the seven cervical vertebrae). Cuts were individually weighed and their weights recorded for later analysis of yields. Cuts yields were estimated in relation to reconstituted cold carcass weight.

To measure the loin eye area (LEA), a cross-section was performed between the 12th and 13th thoracic vertebrae on the left half-carcass. After exposure of the *longissimus dorsi* muscle, a transparent plastic film was placed on it and with the aid of a suitable pen, the muscle outline was drawn for subsequent AOL measurement, using a plastic-checkered grid following the method described by Cezar & Souza (2007). The experimental design was completely randomized with three treatments; the treatment of animals grazing freely with supplementation with eight repetitions and the other treatments with five replicates. This was due to death of animals during the experimental period. Analysis of variance was performed and the Newman Keuls test was used for means comparison (SNK) at 10% probability. The SAEG statistical package (Statistical and Genetics Analysis System, version 9.1) was used.

Results and Discussion

Supplemented animals had higher final body weight and body weight at slaughter and thus higher values for rump width and anterior height (P<0.10); this is explained by larger and heavier animals presenting larger biometric measures. Biometric measurements anterior height, body length and leg length were not affected (P>0.10) by treatments (Table 1).

According to Yáñez et al. (2004), chest perimeter is a measure influenced by the bone base, muscle base and fat deposits, and the adipose tissue deposition mainly in the

Table 1 - Final body weight, body weight at slaughter and biometric measurements *in vivo* of kids with undefined breed pattern bred grazing on the Caatinga of Pernambuco

	Treatments				
Variables	PAS	PA	PR	CV (%)	Significance
Final body weight, kg	24.00a	18.40b	16.20b	11.9	0.0001
Body weight at slaughter, kg	22.74a	18.12b	16.00b	11.5	0.0002
Body length, cm	54.90	49.20	51.00	8.4	0.1149
Heart girth, cm	65.60a	62.20a	58.00b	5.8	0.0074
Chest width, cm	14.62a	13.90ab	13.10b	7.7	0.0061
Leg length, cm	34.10	31.90	32.40	11.7	0.2301
Rump width, cm	12.40a	11.20b	10.10b	9.5	0.0061
Posterior height, cm	57.50a	51.60b	51.40b	7.2	0.0181
Anterior height, cm	52.10	49.20	48.00	6.9	0.1791
Body score (1-5)	2.25a	1.40b	1.10b	18.0	0.0000
Carcass compactness (kg/cm)	0.41a	0.37a	0.31b	12.9	0.0105

PAS = grazing freely with supplementation; PA = grazing freely without supplementation; PR = restricted grazing; CV = coefficient of variation.
In rows, means followed by the same letter do not differ significantly from each other by the SNK test at 10% probability.

sternum region may explain the differences between treatments (P<0.10); animals kept on restricted grazing had lower values, (Table 2), regarding the finishing degree.

The fact that body length did not show differences between treatments can be explained by animals showing the same age and, therefore, approximate size. Since this is a measure that takes into account the bone base, it is not influenced by animal feeding.

Body score is a subjective method that estimates the amount of energy stored as fat and muscle and therefore assessing the nutritional status or animal's energy condition. Supplemented animals had higher body score (P<0.10) compared with those without supplementation and those maintained on restricted grazing (Table 1). This difference can be attributed to the higher growth rate of muscle and adipose tissues promoted by higher energy and protein intake from supplementation.

The body score of 2.0, close to that obtained in supplemented animals (2.25), indicates that the animal is classified as having a lean body condition. According to Cezar & Souza (2007), this classification is overall used for goats. It is noteworthy that there is no record in the literature of a standard scale for body condition of native and/or UB goats, considering that the latter predominates in goat herd in the Northeast. According to Medeiros et al. (2009), body condition is related to factors such as weight at slaughter, finishing state, development degree and animal nutritional plan.

Body compactness is an index estimating objectively the conformation in live animals from two easy measurable values, body length and body weight at slaughter (Yáñez et al., 2004), which explains the superiority (P<0.10) of animals grazing freely on pasture with supplementation and on pasture *ad libitum* without supplementation compared with animals on restricted grazing, since they had lower live weights at slaughter.

Rump perimeter was the only variable that was different at the three treatments (P<0.10), demonstrating that when using a measure based on muscle, nutritional differences are more evident. This measure, according to Araújo Filho et al. (2007), indicates deposition of top quality meat. Carcasses from supplemented animals showed higher values (P<0.10) for carcass internal length, rump width, chest width and leg perimeter.

Supplemented animals had carcass compactness index (CCI) higher than those subjected to free grazing without supplementation and restricted grazing once supplemented animals had higher (P<0.10) cold carcass weight (Table 3), one of the parameters making up the CCI. This assessment is of great importance, since the higher the CCI, the higher the deposition of muscle tissue per unit area (cm^2) and therefore, better carcass quality (Amorim et al., 2008).

Supplementation affected (P<0.10) conformation and finishing of carcasses since it enables the slaughter of animals with higher weights, so these animals had a greater muscle development and increased fat deposition in the carcass (Table 2). The 3.0 body score obtained for UB animals and at semi-arid conditions is considered high, since, according to the classification of Colomer-Rocher et al. (1988), carcasses have good conformation when scoring 3.0, being medium shape and with sub-convex profile. Carcasses had little subcutaneous fat with 2.33 average score (3.0, 2.4 and 1.6 for treatments of animals grazing freely without supplementation, restricted grazing, and grazing freely with supplementation, respectively). Carcasses of goats are characterized as lean and low-fat cover, due to higher fat concentration in these animals does not occur in the carcass, but around the internal organs. However, it

Table 2 - Morphometric measurements on the carcass of goats of undefined breed in grazing in the Caatinga of Pernambuco

Variables	Treatments			CV (%)	Significance
	PAS	PA	PR		
Carcass internal length, cm	63.10a	58.80b	57.80b	4.4	0.0055
Carcass external length, cm	48.30a	45.70ab	43.80b	4.2	0.0034
Rump width, cm	12.70a	11.20b	10.50b	5.9	0.0002
Rump perimeter, cm	48.50a	43.90b	40.40c	5.5	0.0001
Chest width, cm	17.10a	14.90b	14.80b	7.9	0.0058
Chest depth, cm	19.60	22.00	22.90	5.8	0.3248
Leg perimeter, cm	24.90a	22.50b	21.30b	6.3	0.0019
Chest perimeter, cm	58.40a	56.10a	52.10b	4.9	0.0041
Carcass compactness index	0.146a	0.115b	0.098b	14.3	0.0009
Pelvic-renal score (score, 1-3)	2.0	2.0	1.6	31.2	0.1585
Finishing degree (score, 1-5)	3.0a	2.4b	1.6c	22.2	0.0015
Conformation degree (score, 1-5)	3.0a	2.2b	1.6c	21.6	0.0008
Loin eye area, cm^2	7.98a	6.71 ab	5.67b	19.6	0.0294

PAS = grazing freely with supplementation; PA = grazing freely without supplementation; PR = restricted grazing; CV = coefficient of variation.
In rows, means followed by the same letter do not differ significantly from each other by the SNK test at 10% probability.

should be noted that fat is an important carcass component of animals bred for meat production (Silva Sobrinho et al., 2008), since it has important roles such as carcass insulation reducing the temperature drop during post-mortem cooling and by being associated with the flavor, tenderness and juiciness of the meat. Regarding the amount of kidney-pelvic fat (Table 2), there was similarity between treatments (P>0.10), probably due to the intrinsic characteristic of goats of depositing more perirenal and pelvic fat than cover fat, even in supplemented animals. Within the range described by Colomer-Rocher et al. (1988), the score obtained is considered normal, where kidneys are partially covered with fat and fat deposited in the pelvic cavity is medium thick.

The supplementation increased loin eye area (P<0.10) compared with animals on restricted grazing, but it did not differ statistically from animals on free grazing (Table 2). Supplemented animals had higher means for body weight at slaughter, empty body weight and weights of hot and cold carcasses (P<0.10). The differences in body weights at slaughter may be related to the greater input of nutrients from the supplement, which provided better performance of supplemented animals. This increased body weight at slaughter of supplemented goats influenced the difference between yields, since there is a direct correlation between body weight at slaughter and carcass yields.

Carvalho Junior et al. (2009), had higher carcass weights for F_1 goats (Boer × UB) finished in native pasture in the semi-arid region of Paraiba supplemented with 1% of body weight in relation to non-supplemented animals.

Carvalho Junior et al. (2009) had higher weights and yields of carcass for F_1 goats (Boer × UB) finished in native pasture in the semi-arid region of Paraiba, supplemented with 1% body weight compared with non-supplemented animals.

The gastrointestinal content varies depending on the nature of food, fasting duration and gastrointestinal tract development, which are influenced by age and nutritional history of animals (Osório et al., 2002). There were differences (P<0.10) between contents of gastrointestinal tract of supplemented animals and kept at pasture *ad libitum* without supplementation and restricted grazing, where those supplement showed higher content (Table 3).

Yields of hot and cold carcasses of animals under free grazing did not differ (P>0.10) from supplemented animals and animals subjected to restricted grazing (Table 3). This difference can be explained by the influence of fat deposition, carcass conformation and muscularity, in addition to age and animal's nutritional status on the carcass yield. The higher the yield, the greater the proportion of muscles and fat in the carcass (Yáñez et al., 2004); which can be confirmed by the results for finishing degree and conformation of carcass (Table 2).

The true yield or carcass biological yield is the most accurate, since it eliminates the changes in contents of the gastrointestinal tract from calculation, ranging from 35 to 60% in goats (Hashimoto et al., 2007). Values obtained remained within the acceptable range for goats with difference (P<0.10) between treatments, with means of 53.08, 50.19 and 47.40% for treatments of animals under free grazing with supplementation, without supplementation and restricted grazing, respectively.

Cooling losses are humidity losses from muscle surfaces that occur during the carcass cooling. In this study, carcasses lost on average 6.28% of their weights during cooling. Loss by cooling is directly related to fat coverage in the carcass, which explains the higher values found in this study compared with the values cited in the literature (3.9%, on average) (Amorim et al., 2008; Hashimoto et al., 2007; Oliveira et al., 2008), since carcasses had little subcutaneous fat as discussed in the finishing degree; and one must have in mind that the subcutaneous fat (coverage fat) acts as thermal insulator, reducing water losses during carcass cooling.

Absolute weights of commercial cuts were influenced (P<0.10) by treatments (Table 4), reflecting the difference

Table 3 - Characteristics and yields of kids carcass with undefined breed pattern bred on grazing in the Caatinga of Pernambuco

	Treatments				
Variables	PAS	PA	PR	CV (%)	Significance
Body weight at slaughter, kg	22.74a	18.12b	16.00b	11.6	0.0002
Empty body weight, kg	18.40a	14.34b	12.60b	12.5	0.0003
TIG content, kg	4.338a	3.779b	3.398b	14.1	0.0265
Hot carcass weight, kg	9.78a	7.22b	5.99b	15.2	0.0002
Cold carcass weight, kg	9.20a	6.74b	5.68b	15.7	0.0003
Hot carcass yield,%	42.93a	39.72ab	37.31b	5.6	0.0018
Cold carcass yield,%	40.38a	37.04ab	35.37b	7.1	0.0137
True yield,%	53.08a	50.19b	47.40c	4.1	0.0009
Loss index by cooling	5.83	6.46	6.54	23.2	0.1487

PAS = grazing freely with supplementation; PA = grazing freely without supplementation; PR = restricted grazing; TIG = gastrointestinal tract; CV = coefficient of variation.
In rows, means followed by the same letter do not differ significantly from each other by SNK test at 10% probability.

observed in relation to cold carcass weight, so that animals in the treatment of free grazing with supplementation showed heavier cuts, which certainly was due to the supplementation provided. Among the cuts, ham had higher weight regardless of treatment. According to Cezar & Souza (2007), ham is considered a first-class cut, and therefore has high muscle:bone and muscle:fat ratios, i.e., it has high muscle yield.

For cuts yields, expressed on the reconstituted cold carcass weight, only loin and neck showed statistical differences (P<0.10), unlike that observed for absolute weights of these cuts. These results confirm the law of anatomical harmony (Bocardo, quoted by Siqueira et al., 2001) from the observation that carcasses with different weights reflect cuts of varying weights, but in proportional terms the change in carcass does not always imply cut variation, which can be associated with possible differences in the growth of tissues, especially muscle and fat. Voltolini et al. (2008) also found no differences between yields of commercial cuts of goat of undefined breed pattern fed on cassava.

Cuts of ham, palette and ribs had the highest average yields (Table 4), similar to that observed by Carvalho Junior et al. (2009), who, working with F_1 goats (Boer × UB) with different levels of supplementation found higher values for ham, ribs and palette yields with averages of 30.07%, 24.31% and 21.79% , respectively. Monte et al. (2007) observed in crossbred Boer (½ Boer × ½ UB) and Anglo-Nubian (½Anglo-Nubian × ½ UB) goats slaughtered at 29 kg average weight, in which palette and ham correspond to 55% carcass. The sum of yields for palette and ham cuts of supplemented animals was 53.8% in this study; higher than that reported by Carvalho Junior et al. (2009) in F_1 goats (Boer × SPRD) supplemented with 1% body weight (50.3%). Prime cuts (ham and loin) accounted for 41.44% total carcass, whereas the choice cuts (palette) represented 21.3% and other cuts, considered of select grade, accounted for 37.7%.

Overall, responses found between treatments free grazing without supplementation and restricted grazing did not differ from each other, which can be explained by reports in the literature classifying goats as highly selected animals with “opportunistic” behavior, i.e., they change their feeding behavior according to food availability and time of year in order to achieve certain levels of intake, consistent with their nutritional requirements.

Table 4 - Absolute weights and yields of commercial cuts of goats of undefined breed grazing in the Caatinga of Pernambuco

	Treatments				
Variables	PAS	PA	PR	CV (%)	Significance
Palette, kg	1.909a	1.455b	1.219b	13.8	0.0002
Neck, kg	0.606a	0.480b	0.400b	15.3	0.0011
Ribs kg	1.818a	1.344b	1.094b	16.1	0.0002
Saw, kg	1.046a	0.752b	0.620b	23.3	0.0044
Loin, kg	0.773a	0.518b	0.418b	15.4	0.0000
Ham, kg	3.036a	2.203b	1.842b	15.9	0.0000
Cuts yields (%)					
Palette, kg	20.80	21.66	21.47	5.2	0.1152
Neck, kg	6.60b	7.20a	7.10a	6.6	0.0672
Ribs kg	19.76	19.95	19.27	4.3	0.1628
Saw, kg	11.29	11.04	10.93	10.3	0.1257
Loin, kg	8.44a	7.63b	7.32b	6.1	0.0024
Ham, kg	33.00	32.72	32.38	2.8	0.1398

PAS = grazing freely with supplementation; PA = grazing freely without supplementation; PR = restricted grazing; CV = coefficient of variation.
In rows, means followed by the same letter do not differ significantly by SNK test at 10% probability.

Conclusions

The energy-protein supplementation for goats of undefined breed pattern bred in caatinga grazing provides heavier animals at slaughter and, consequently, higher values of morphometric measurements *in vivo* and in carcass as well as better conformation. Supplementation with forage cactus and soybean meal at 1% body weight is a good alternative for animal feeding during the dry season in the semi-arid region, concerning animal performance.

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