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ANIMAL PRODUCTION

Carcass characteristics of Canindé goats subjected to feed restriction

Andreia Batista Bezerra[1*] Severino Gonzaga Neto[1] Ariosvaldo Nunes de Medeiros[1] Francisco Fernando Ramos de Carvalho[2] Safira Valença Bispo[1] Anaiane Pereira Souza[3] José Maurício dos Santos Neto[4] Luana Paula dos Santos Ribeiro[5]

[1]Universidade Federal da Paraíba (UFPB), 58397 000, João Pessoa, PB, Brasil. E-mail: andreiabatist10@hotmail.com. *Corresponding author.
[2]Universidade Federal Rural de Pernambuco (UFRPE), Recife, PE, Brasil.
[3]Universidade Estadual Paulista (UNESP), Jaboticabal, SP, Brasil.
[4]Universidade de São Paulo (USP), Piracicaba, SP, Brasil.
[5]Universidade Federal da Bahia (UFBA), Salvador, BA, Brasil.

ABSTRACT: *This study aimed to evaluate the effects of feed restriction on the carcass characteristics of castrated Canindé goat kids. A randomized block design was used, in which 21 goat kids with a body weight (BW) of 15.9±1.0kg were allocated to three levels of feed restriction: ad libitum, 20% and 40% restriction related to the ad libitum intake. The diet consisted of 55% forage (Tifton) and 45% concentrate. All animals were slaughtered when the kids fed ad libitum reached a BW of 25kg. After slaughter, the carcasses were chilled for 24 hours and subsequently measured. Kids fed ad libitum and subjected to 20% feed restriction showed similar morphometric carcass measurements, except for the chest circumference. Goat kids fed ad libitum exhibited greater values for warm and cold carcass yields compared with those subjected to 40% feed restriction and did not differ from the kids under 20% feed restriction. Weights of the commercial cuts showed decreasing mean values according to the intensity of feed restriction. Castrated Canindé goat kids subjected to 20% feed restriction presented similar carcass yields and proportion of commercial cuts to those fed ad libitum.*
Key words: *carcass yield, commercial cuts, native breed.*

Características de carcaça de caprinos Canindé submetidos à restrição alimentar

RESUMO: *Objetivou-se com o presente estudo avaliar os efeitos da restrição alimentar sobre as características de carcaça de cabritos Canindé castrados. Foi utilizado um delineamento em blocos casualizados, no qual 21 cabritos com peso corporal (PC) de 15,9±1,0kg foram distribuídos por três níveis de restrição alimentar: ad libitum, 20% e 40% de restrição alimentar. A dieta consistiu de 55% de volumoso (Tifton) e 45% de concentrado. Os animais foram abatidos quando os cabritos alimentados ad libitum atingiram PC de 25kg. Após o abate, as carcaças foram resfriadas por 24 horas e, subsequentemente, mensuradas. Os cabritos alimentados ad libitum e submetidos à restrição alimentar de 20% apresentaram medidas morfométricas semelhantes, exceto para a circunferência do peito. Os cabritos alimentados ad libitum apresentaram maiores valores para rendimento de carcaça quente e fria em comparação àqueles submetidos à restrição alimentar de 40% e não diferiram entre os cabritos com restrição alimentar de 20%. Os pesos dos cortes comerciais apresentaram médias decrescentes com a intensidade da restrição alimentar. Cabritos Canindé castrados submetidos à restrição alimentar de 20% obtém rendimento de carcaça e proporção dos cortes comerciais similares aos alimentados ad libitum.*
Palavras-chave: *cortes comerciais, raças nativas, rendimento de carcaça.*

INTRODUCTION

Arid and semiarid regions cover an area of approximately 48 million km^2 and are found in 2/3 of the world's countries. Droughts are characteristic of the ecosystem of these regions and result in losses to the agricultural sector (OLIVEIRA et al., 2010). Raising of goats occurs in many semi-arid regions (ANDRADE-MONTEMAYOR et al., 2011), since they show adaptability to regions with a low rainfall index and scarce forage availability. During the dry season, the goats consume low-quality feed as a consequence of low forage availability, thus resulting in a low productive performance. To make goat farming more profitable, especially during the long period of forage shortages, the feedlot farming system is presented as an alternative for improving production rates.

In feedlot systems, feed planning is essential to reduce costs. Use of feed restriction is an interesting alternative to reduce feed waste because it leads to greater profitability of the production system. Feed restriction is a strategy that has been investigated in some studies on meat goat production as well (PEREIRA FILHO et al., 2007; YÁÑEZ et al., 2007).

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However, studies on the farming of native goat breed in semi-arid regions, which present differentiated growth and physiological characteristics, are scarce.

In this context, this study aimed to evaluate the effects of feed restriction on the carcass characteristics of castrated Canindé goat kids.

MATERIALS AND METHODS

The experiment was conducted at the Experimental Station at Universidade Federal da Paraíba (UFPB), located in the municipality of São João do Cariri (Paraíba-Brazil). Humane animal care and handling procedures were followed according to the university's animal care committee.

We used 21 castrated Canindé kids, at approximately five months of age, with a body weight (BW) of 15.9±1.0kg. Animals were weighted, identified, treated for ecto and endoparasites and vaccinated against clostridiosis, after which they were randomly distributed in stalls. Treatments consisted of three levels of intake: *ad libitum*; 20% of feed restriction; and 40% of feed restriction. These levels were based on the feed intake of the goat fed *ad libitum*, in each block of three goats where the daily intake of the restricted-fed goats within a block was determined by the dry matter intake (DMI) of the goat fed *ad libitum* within the same block on the previous day. Experimental diet was formulated as recommended by the NRC (2007) based on an average daily gain of 100g. A ratio of 55% roughage to 45% concentrate was used, and the ingredients were Tifton hay chopped in a forage chopper with a 10-mm mesh sieve, corn meal, soybean meal, limestone and a mineral supplement. Crude protein (CP) and metabolizable energy (ME) contents of diets were 164.7g kg^{-1} and 2.5Mcal kg^{-1} ME. Feed was supplied twice a day as totally mixed ration and the quantity was adjusted to maintain the amount of orts at approximately 20% of the feed supplied to the animals subjected to the *ad libitum* level. Water was provided *ad libitum* for all animals.

Each group was slaughtered when the animal fed *ad libitum* reached BW of approximately 25kg. Kids were stunned via cerebral concussion with a captive bolt pistol, after which bleeding was performed for four minutes by severing the carotid and jugular veins. After skinning and gutting, the head (sectioned at the atlanto-occipital joint) and feet (sectioned at the carpal and tarsal-metatarsal joints) were removed to determine the carcass weight including the kidneys and perinephric-pelvic fat.

All non-carcass constituents were separated. The gastrointestinal tract (GIT), bladder (B) and gallbladder (GB) were emptied, washed and weighted again to determine the empty BW (EBW), which was obtained based on the difference between the fasting weight at slaughter (FW) and weights of contents (GIT, B and GB).

Carcasses were kept in refrigeration for 24h at 4ºC, where they were hung by the tarsal-metatarsal joints, and spaced 17cm apart on average. At the end of this period, the carcass weight including the kidneys and perinephric-pelvic fat was recorded. The kidneys and the perinephric-pelvic fat were separated and weighted, and their values were subtracted from the carcasses to determine warm carcass weight (WCW), as well as cold carcass weight (CCW). These weights were used to calculate the cold carcass yield (CCY) (%) = (CCW/FW)×100 and warm carcass yield (WCY) (%) = (WCW/FW)×100. Then, the percent chilling loss (LC) was determined using the following equation: LC = [(WCW - CCW)/WCW]×100. Biological yield was calculated based on the EBW as described by CEZAR & SOUSA (2007).

Carcasses were subjectively evaluated using the visual method described by CEZAR & SOUSA (2007) to estimate their degree of conformation, fat cover, and perinephric-pelvic fat score. In the evaluation of the carcass conformation, e proportion and distribution of muscle mass deposited on the skeleton were estimated assigning a value of 1 to the poorest conformation and 5 to an excellent conformation; for the fat cover, a value of 1 was assigned to the poorest cover and 5 to excellent cover.

The perinephric-pelvic fat score was determined by evaluating the amount of fat in the pelvic and abdominal cavities around the kidneys. The classification scale comprised three classes, according to the methodology of CEZAR & SOUSA (2007): score 1 = left kidney not fully covered with fat and pelvic cavity coated with a layer of fat; score 2 = left kidney fully covered with fat and right kidney without any fat cover or partially covered and pelvic cavity with a median layer of fat; score 3 = both kidneys fully covered with fat and pelvic cavity coated with a thick layer of fat.

In the carcasses, the following measurements were performed with a tape measure and a caliper (cm), according to the methodology described by YÁÑEZ et al. (2004): carcass external length; rump width; rump circumference; thigh circumference; chest circumference; chest width. Carcass was divided longitudinally into two halves: the right and left. In the left half, the following measurements were performed according to the methodology described by CEZAR & SOUSA (2007): chest depth, leg length and carcass internal length.

Leg compactness index (LCI) was calculated from the ratio between the carcass leg weight and length. Carcass compactness index (CCI) was calculated from the ratio between the CCW and the carcass internal length. After performing the morphometric measurements, carcass halves were sectioned into five anatomical regions (neck, ribs, loin, leg, shoulder). The loin eye area (LEA) was determined from a cross-section between the 12th and the 13th thoracic vertebrae of the left half of the cooled carcass. The LEA was recorded by placing a clear plastic sheet on the *longissimus dorsi* muscle and outlining the contour of the muscle, for subsequent determination of the area using AutoCAD®.

The experimental design was a randomized block with three levels of intake and seven replicates, according to the following model:

$Y_{ij} = \mu + t_i + \beta_j + e_{ij}$,

where:

Y_{ij} = observed variable

μ = overall mean

t_i = fixed effect of the feed restriction level

β_j = random effect block

e_{ij} = random error associated with each observation

The data were analyzed using PROC MIXED. An orthogonal partition of treatment effects into linear and quadratic degree effects was obtained following an analysis of variance (P<0.05). Means were compared by the Tukey-Kramer, using the probability level *(P*<0.05) by the Statistical Analysis System software.

RESULTS AND DISCUSSION

Levels of feed restriction evaluated affected the carcass characteristics of Canindé goats because there was difference in DMI (*P*<0.05), where the values were 737, 557 and 444g day^{-1} for goat kids fed *ad libitum*, 20% and 40% feed restriction respectively.

The goat kids fed *ad libitum* responded similarly to those subjected to 20% feed restriction and better than the animals under 40% feed restriction for the following parameters: carcass internal length, chest depth, rump perimeter, thigh perimeter and leg length (*P*<0.05). Animals with a greater slaughter weight tended to exhibit greater values for carcass measurements (Table 1). MARTINS et al. (2014) observed that in Boer, Canindé and Moxotó kids fed *ad libitum*, there was an increase of the carcass internal length, chest depth and rump circumference in comparison with kids subjected to 25% and 50% feed restriction. DHANDA et al. (2003) also reported an increase of carcass length according to the increase in the weight at slaughter in distinct breeds (Boer, Angorá, Feral and Saanen), slaughtered at intervals of 14-22kg and 30-35kg.

There was a significant difference for chest perimeter, in which the animals fed *ad libitum* showed the greatest value (Table 1). According to YÁÑEZ et al. (2004), the chest circumference is a measurement influenced by the muscle and bone structure as well as by fat deposits. Thus, because the animals fed *ad libitum* ingested greater amounts of energy and protein than the groups subjected to 20% and 40% feed restriction; there were differences between the carcasses of these groups. An effect on the CCI (P<0.05) was observed, as the mean values decreased with increased feed restriction (Table 1). According to OSÓRIO & OSÓRIO (2005), compactness is a measurement used to evaluate the amount of tissue deposited per unit of length and is therefore an indicator of carcass conformation. Thus, animals subjected to feed restriction deposited less tissue, with a consequent decrease in the amount of carcass meat produced. Despite the differences between the restriction levels, the values are within the usual range for goat carcasses.

The FW, EBW, WCW, CCW were influenced (*P*<0.05) by the feed restriction levels (Table 2). Kids fed *ad libitum* exhibited the highest FW and; consequently, the highest carcass weights, which was associated with a greater average daily gain during the experiment (101.1, 73.3 and 48.4g day^{-1} for *ad libitum*, 20% and 40% feed restriction respectively). According to ZAMIRI et al. (2012), the weight at slaughter is one of the factors that may influence the amount of meat, fat and bone in the carcass.

The kids fed *ad libitum* showed greater WCY and CCY values than the animals subjected to 40% restriction (*P*<0.05). Biological yield was not affected by the feed restriction levels (Table 2), most likely because this parameter considers the EBW and, thus, eliminates the variations in GIT contents, which are material without any commercial value. These results are similar with the findings of MATTOS et al. (2006), who assessed the carcass yield in Canindé goats subjected to 0% and 30% feed restriction and did not report difference in biological yield, thus demonstrating that it was the GIT content that led to the differences in carcass yields.

There was an effect of the level of restriction on the carcass conformation, with lower values being observed for the animal carcasses subjected to feed restriction (*P*<0.05). A lower conformation value indicated a lower proportion

Table 1 - Morphometric measurements of the carcasses of Canindé goats subjected to levels of feed restriction.

Variables	----------Feed restriction----------			SEM[1]	----------*P*-value----------	
	0%	20%	40%		Lin	Quad
Final body weight (kg)	26.4a	23.2b	21.0c	0.381	<0.01	0.29
Carcass external length (cm)	47.5	46.0	45.7	0.584	0.04	0.41
Carcass internal length (cm)	56.9a	55.7ab	53.3b	0.765	<0.01	0.50
Rump perimeter (cm)	51.0a	48.6ab	46.6b	0.942	<0.01	0.85
Thigh perimeter (cm)	35.0a	34.3ab	31.8b	0.757	<0.01	0.37
Chest perimeter (cm)	64.6a	61.3b	58.4b	0.789	<0.01	0.79
Chest depth (cm)	26.9a	25.7ab	24.4b	0.356	<0.01	0.87
Leg length (cm)	38.1a	37.5ab	36.7b	0.429	0.03	0.84
Chest width (cm)	17.9	16.6	15.8	0.613	0.028	0.67
Rump width (cm)	18.3	18.00	17.21	0.371	0.056	0.59
LCI (kg cm^{-1})	0.48	0.48	0.47	0.0135	0.52	0.65
CCI (kg cm^{-1})	0.20a	0.18b	0.16c	0.0414	<0.01	0.65

LCI = leg compactness index; CCI = carcass compactness index.
[a-c]For level of feed restriction within row, means without a common superscript letter differ by Tukey-Kramer test (P<0.05).
[1]Standard error of mean (SEM).

of meat in the carcass because the conformation is directly related to the deposition of muscle mass on the skeleton. This result agreed with SILVA et al. (2012) that the carcass conformation is closely linked to the body condition.

The kids fed *ad libitum* presented similar mean values to the animals subjected to 20% feed restriction and greater values than those subjected to 40% feed restriction (P<0.05) for perinephric-pelvic fat (Table 2). The greater deposition of internal fat and reduced deposition of external fat in the goats may be likely associated with the adaptation of these native animals to the dry climate of the semi-arid region of Brazil, leading to the emergence of adaptive traits over time.

The absolute weights (kg) of the neck, ribs, shoulder, leg and loin decreased with increased feed restriction (P<0.05), as shown in table 3. The weight

Table 2 - Carcass characteristics of Canindé goats subjected to levels of feed restriction.

Variables	----------Feed restriction----------			SEM[1]	----------*P*-value----------	
	0%	20%	40%		Lin	Quad
Fasting live weight (kg)	24.2a	21.4b	19.1c	0.281	<0.01	0.571
Empty body weight (kg)	21.3a	18.7b	16.2c	0.294	<0.01	0.950
Warm carcass weight (kg)	11.6a	10.2b	8.84c	0.206	<0.01	0.851
Cold carcass weight (kg)	11.3a	9.90b	8.58c	0.199	<0.01	0.869
Chilling loss (%)	2.35b	2.46ab	2.76a	0.106	0.013	0.47
Warm carcass yield (%)	47.8a	47.4ab	45.5b	0.559	<0.01	0.32
Cold carcass yield (%)	46.6a	46.1ab	44.4b	0.557	<0.01	0.36
Biological yield (%)	54.5	54.3	54.6	0.638	0.91	0.78
Conformation (1-5 points)	3.43a	2.93b	2.71b	0.121	<0.01	0.35
Fat cover (1-5 points)	2.85	2.85	2.64	0.1429	0.30	0.55
Perinephric-pelvic fat (1-3 points)	2.36a	2.29a	1.64b	0.1579	<0.01	0.16
LEA (cm^2)	9.25	8.20	7.88	0.4170	0.033	0.49

LEA = loin eye area.
[a-c]For level of feed restriction within row, means without a common superscript letter differ by Tukey-Kramer test (P<0.05)
[1]Standard error of mean (SEM).

Table 3 - Commercial cuts in the carcass of Canindé goats subjected to levels of feed restriction.

Variables	----------Feed restriction----------			SEM[1]	----------*P*-value----------	
	0%	20%	40%		Lin	Quad
Neck (kg)	0.68a	0.59b	0.50c	0.0151	<0.01	0.82
Shoulder (kg)	0.97a	0.87b	0.79c	0.0170	<0.01	0.79
Rib (kg)	1.52a	1.29b	1.13c	0.0335	<0.01	0.47
Leg (kg)	1.69a	1.50b	1.33c	0.0350	<0.01	0.84
Loin (kg)	0.78a	0.67b	0.57c	0.0175	<0.01	0.97
Neck (%)	12.0	12.0	11.5	0.234	0.16	0.45
Shoulder (%)	17.2b	17.7ab	18.2a	0.222	<0.01	0.84
Rib (%)	26.9	26.2	26.2	0.265	0.065	0.29
Leg (%)	29.9	30.4	30.8	0.356	0.11	0.99
Loin (%)	13.8	13.7	13.2	0.285	0.13	0.62

[a-c]For level of feed restriction within row, means without a common superscript letter differ by Tukey-Kramer test (P<0.05).
[1]Standard error of mean (SEM).

of the leg, loin, rib and neck followed the same increasing trend as the CCW; however, the shoulder did not follow this trend (P<0.05).

The group of animals fed *ad libitum* showed a lower mean shoulder yield compared with those subjected to 40% feed restriction (P<0.05). The fact that only the shoulder exhibited differentiated growth is due to the greater amount of bones it contains; thus, the proportion will be greater in leaner carcasses. MARQUES et al. (2014) studied increasing levels of concentrate supplementation (0, 5, 10 and 15g kg^{-1} of BW) in Moxotó goats (with similar BW to our study) grazing in the semiarid region and observed that the weights of the neck, rib, shoulder and leg cuts also increased. The proportion of the shoulder was the only cut influenced by the feed restriction levels, as observed in the present study.

CONCLUSION

Castrated Canindé goat kids subjected to 20% feed restriction exhibited similar carcass yields and proportions of commercial cuts to animals fed *ad libitum*. Applying 20% feed restriction may represent an interesting alternative for native goat systems; however, future studies are needed mainly to focus on the cost-benefit analysis.

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