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Full length Research paper

Effects of diets on carcass and meat of confined lambs in North of Brazil

***Paulo D. Firmino, Coelho Lachowski and Garrincha Ambrosio**

Department of Animal Science, Federal Rural University of Amazon, PA 275, km 13, Parauapebas, Pará, 68515-000 Brazil.

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This study was untaken to evaluate the effects of diets based on elephant grass or sugarcane as roughage and corn meal or rice bran as energy concentrate on carcass characteristics, meat quality, and the rack of lamb cut characteristics. Thirty-six lambs of undefined breed initially weighing 19.77±1.99 kg were used. A completely randomized design with eight treatments in a 2×2×2 factorial arrangement: two roughage (elephant grass or sugarcane), two concentrates (rice bran or corn meal), and two feeding levels (*ad libitum* or 60% of *ad libitum*) was performed. The nutrient intake was greater (P<0.05) in treatments with corn meal and elephant grass and at 4.96% of body weight feeding level. No interactions between roughage sources, concentrate sources, and feeding level was observed (P<0.05). The intake of dry matter was greater in lambs fed corn meal (P<0.05). No difference was observed on quality meat parameters (P>0.05), except for collagen solubility (P<0.05). Corn meal provided a noticeably greater percentage of protein (P<0.05), while rice bran promoted a greater fat deposition (P<0.05) in the rack of lamb. The use of sugarcane and rice bran as alternative foods for feedlot sheep is a viable strategy, because they do not decrease the quantitative and qualitative traits of sheep carcass and meat.

Key words: Elephant grass, performance, rice bran, sugarcane.

INTRODUCTION

Lamb production in Brazil is based on natural or cultivated pastures (Costa et al., 2011). The seasonality in forage production affects the output supply of uniform carcass to the industry, resulting in an inconstant lamb production scale throughout the year (Cutrim et al., 2012). Fluctuation on dry matter availability and forage quality may modify lambs performance, such as weight gain and fat composition in lamb's body and consequently meat quality, due to the uncertain amount of nutrients offered. Thus, the use of energy feed sources and adapted forages to drought conditions are necessary to meet the nutrient requirements of lambs during the shortage period of pasture. The reduction on intake during dry season affects carcass composition, because it

*Corresponding Author. Email: Paulo.firmino@yahoo.com

modifies drip loss and fat distribution (Somasiri et al., 2015). Consequently, it is essential to measure the effects of restricted and *ad libitum* feeding on meat quality of lambs under grazing conditions.

Elephant grass (*Pennisetum purpureum* Schum) and sugarcane (*Saccharum officinarum* L.) are suitable roughage sources to be used during seasonality periods. Both have high productivity, easy availability, and considerable nutritional value. The high soluble carbohydrate content of sugarcane and its ability to maintain nutritional value for long periods result in high amounts of digestible energy per hectare of production. Recently, Rotta et al. (2014) found that replacing partially corn silage by sugarcane in crossbred bulls Holstein × Zebu finishing diets altered the proportion of fatty acids in the *Longissimus dorsi* muscle.

However, because of the inferior nutritional quality of these roughages, compared to seasonal pasture, the nutrient intake of lambs consuming these forage sources is lower and must be complemented with concentrate sources. In this context, traditional and alternative feeds must be used as source of additional energy and protein in ruminant diets (Cavali et al., 2010). Corn meal and rice bran are viable concentrate energy sources and their price vary through the harvesting period, so it is essential to evaluate the performance of lambs fed energy concentrates to avoid excessive production costs.

In order to add value to meat from sheep, it is common to divide the carcass into smaller cuts to explore cuts that have greater commercial value. Among these specific cuts, the rack of lamb (in French "carré d'agneau"), which is a classic French cut composed of the *Longissimus dorsi* muscle, some ribs, and the subcutaneous fat can be considered. The rib bones are exposed by cutting off the fat and meat covering them. Typically, eight centimeters of ribs are left on the rack, with the top 5 cm exposed (Costa et al., 2011). Despite its great acceptance in the culinary world and its high value added, limited research has been done on the effect of roughage and rice bran as energy concentrate on the eating quality of lamb.

This study was undertaken to evaluate the effects of diets, based on elephant grass or sugarcane as roughage and corn meal or rice bran as energy concentrate, on carcass characteristics, meat quality, and the rack of lamb cut characteristics.

MATERIALS AND METHODS

The experimental procedures were approved by the Ethics Committee on Animal Use - CEUA/UFRA, Para, Brazil (001/2012). The experiment was conducted in the small ruminants feedlot barn at the Universidade Federal Rural da Amazônia.

Lambs, experimental design, and diets

Thirty-six undefined breed male lambs average 19.77±1.99 kg (average ± standard deviation) of body weight and four-month years old were used. The lambs were purchased from local farms and housed in individual stalls (2.0 × 2.5 m) equipped with feeders and water.

The experimental diets consisted of elephant grass (*P. purpureum* Schum) or sugarcane (*Saccharum* spp.) as sources of roughage and corn meal or rice bran energy concentrates sources (Table 1). Diets were fed at two dry matter intake feeding levels: *ad libitum* level (4.96% of body weight) and 60% of *ad libitum* level (3.40% of body weight) for a total of eight treatments according to a 2×2×2 factorial arrangement. Six replicates were used for the *ad libitum* level and three replicates were used for the 60% of *ad libitum* level. The restricted treatment was used to simulate a condition of animals on low quality forage. The number of lambs in the restricted level was purposely reduced due to the stress caused by dietary restriction. Lambs were fed total mixed rations diets in a roughage:concentrate ratio diet of 60:40 with 16% of crude protein. The dry matter intake (DMI) (g/day) of the *ad libitum* treatment was calculated as the difference between the DMI offered and the orts remained in a 24-h period. Orts were weighed daily to calculate DMI. To ensure an *ad libitum* intake in the 4.96% of body weight feeding level treatment, the amount of orts allowed daily, based on the fed in the previous day, was 15%. A feed restriction of 30% compared to the *ad libitum* treatment was calculated weekly to constitute the 60% of *ad libitum* treatment.

The lambs were weighed every 14 days to assess the daily weight gain, with intermediate weighing to control the slaughter weight. The weighing was preceded by a fasting period of 18 hours. The animals for *ad libitum* treatments were slaughtered when they established 30 kg of body weight. It was preconized that one lamb from the restricted treatment was slaughtered for every two in the *ad libitum* treatment. The slaughter body weight were 30.24±0.78 kg of body weight for the *ad libitum* feeding level and 20.97±2.22 kg of body weight for the restricted feeding level.

Feed samples (orts and individual ingredients) were collected every 14 days, dried in a oven at 55°C and were processed in knife mill (1 mm) and analyzed for dry matter, organic matter, crude protein, ethereal extract contents according to the methods of the Association of Official Analytical Chemists (AOAC, 1990) and lignin for acid detergent fiber (Van Soest and Robertson, 1985) and neutral detergent fiber (Mertens, 2002).

Slaughter, carcass evaluation, and meat quality

Previously, the slaughter, lambs were fasted (solid food only) for 18-h up to the established slaughter body weight (SBW). Lambs were desensitized by stunning, followed by bleeding of carotid arteries and jugular veins. The head, skin, gut, and legs were removed. Carcasses were longitudinally split in two half-carcasses and weighed. After the slaughter, the carcasses were cooled at 4°C for 24 h. After this period, the cold carcass weight (CCW) was recorded. The carcass yield corresponded to the ratio of CCW to SBW, expressed as a percentage.

In the left carcass side, a sectional cut was made on the 13th rib to exposure the *L. dorsi* muscle. The perimeter of the *L. dorsi* muscle was measured by drawing its outline in a transparency sheets. A caliper was used to measure the *L. dorsi* muscle fat thickness (FT). The *L. dorsi* muscle was completely removed from the left carcass side. Samples were removed and stored in a freezer at -20°C for the subsequent analyzes: myofibrillar fragmentation index (MFI), colorimetric, thawing losses, cooking losses, shear force, total collagen, collagen solubility, and sarcomere length.

MFI were determined on fresh muscle. The protein concentration of the myofibril suspension was determined by the Biuret method (Gornall et al., 1949). Aliquots of themyofibril suspension were diluted with an isolating medium to reach a protein concentration of 0.5±0.05 mg/ml. The diluted myofibril suspension was stirred and

Table 1. Ingredient and nutrient composition of experimental diets.

Item	Elephant grass		Sugarcane	
	Corn meal	**Rice bran**	**Corn meal**	**Rice bran**
Ingredient composition (g/kg of DM)				
Elephant grass	600.0	600.0	-	-
Sugarcane	-	-	600.0	600.0
Corn meal	189.8	-	129.7	-
Soybean meal	155.2	134.1	215.3	201.3
Rice bran	-	212.7	-	143.7
Urea	10.0	10.0	10.0	10.0
Soybean Oil	28.0	30.0	30.0	30.0
Mineral Suplement[1]	10.0	10.0	10.0	10.0
Di-calcium phosphate	2.0	-	4.0	4.0
Limestone	3.0	-	-	-
Potassium chloride	2.0	-	-	-
Calcite limestone	-	3.2	1.0	1.0
Diet chemical composition (% of DM)				
Dry matter, % of total	51.03	50.97	49.75	49.72
Crude protein	17.87	17.64	15.72	15.56
Extract ether	5.32	7.25	4.77	5.93
NDFap	42.84	43.84	37.33	37.99
NFCap	27.28	24.52	39.89	37.92

[1]Mineral supplement: sodium 132 g/kg; calcium 82 g/kg; phosphorus 60 g/kg; sulfur 11.7 g/kg; zinc 2600.0 mg/kg; manganese 1200.0 mg/kg; iron 700 mg/kg; cupper 350 mg/kg; molybdenum 180 mg/kg; iodine 50 mg/kg; cobalt 30 mg/kg; selenium 15 mg/kg; chromium 11.7 mg/kg.

poured into a cuvette and the absorbance of this suspension was measured immediately at 540 nm. Absorbance was multiplied by 200 to give a MFI for each sample. Colorimetry was assessed using a colorimeter (Konica Minolta®, CIELab) measuring the luminosity (L*) and color intensities red (a*) and yellow (b*) of *Longissimus dorsi* muscle, according to method described by Houben et al. (2000).

Tenderness was evaluated through shear force strength (kgf/cm^2). Cylindrical samples were sheared perpendicularly to the orientation of the muscle fibers using a Warner-Bratzler device. Thawing losses were measured as the difference between the frozen and thawed sample weight (g), after a 12 h thawing process in a refrigerator at 2 to 5°C.

The method to determine total and soluble collagen was derived from method 990.26 (AOAC, 2000). A 1 cm thick steak was homogenized using an industrial blender to quantify the total and soluble collagen. The values of total and soluble collagen were calculated as the following equations:

% Total collagen = % Collagen in the sediment + % Collagen in the supernatant
Collagen solubility (%) = % Collagen in the supernatant x 100/% Total collagen

The sarcomere length was assessed laser diffraction technique (Cross et al., 1981) using the following equation:

$$S\ (\mu m) = (0.6328 \times D \times \sqrt{[(T/D)^2 + 1]\}}/T$$

where S = sarcomere length (μm), D = distance between the muscle and the A4 paper sheet, and T = distance between two diffraction bands: zero and the first maximum band (mm).

Physical and chemical composition of the rack of lamb cut

In the left carcass side, the rack of lamb cut was sectioned, comprising the section between the ninth and eleventh thoracic ribs, was used to analyze the tissue composition. The ribs were sectioned in 8 cm to proportionally standardize all carcasses evaluated. The cut was dissected into bone, muscle and fat, weighed separately and the proportion expressed as a weight of the cut. After dissection, samples were thawed in the refrigerator for 24 h and placed in a forced ventilation oven at 55°C for 72 h. Muscle and bone samples were then pre-defatted by successive washings in petroleum ether. Only the edible part of the cut was considered, which was the fat and muscle, excluding the bones. The proximal analysis of crude fat, crude protein, and moisture were made on edible cuts using the following the AOAC (1990) methods.

Statistical analysis

Statistical analyses were performed using SAS (SAS Institute Inc., Cary, NC) as the following statistical model:

$$Y_{ijk} = \mu + R_i + C_j + FL_k + (R \times C)_{ij} + (R \times FL)_{ik} + (C \times FL)_{jk} + (R \times C \times FL)_{ijk} + \varepsilon_{ijk}$$

where Y_{ijkl} is the measured variable; μ is the overall constant; R_i is the fixed effect of ith roughage; C_j is the fixed effect of jth concentrate; FL_k is the fixed effect of kth feeding level; $(R \times C)_{ij}$ is the fixed effect of the interaction between ith kind of R and jth kind of C; $(R \times FL)_{ik}$ is the fixed effect of the interaction between

Table 2. Intake and quantitative carcass traits of lambs fed two roughage and concentrate sources at different feeding levels.

Item	Feeding level (FL)								P-value[1]			
	ad libitum				60% of *ad libitum*							
	Elephant grass		Sugarcane		Elephant grass		Sugarcane					
	Corn meal	Rice bran	Corn meal	Rice bran	Corn meal	Rice bran	Corn meal	Rice bran	C	R	FL	C × R × FL
Dry Matter Intake, g/d	1,458 ± 77.38	1,286 ± 68.25	1,185 ± 62.89	1,009 ± 53.55	798 ± 4.19	716 ± 3.77	635 ± 3.34	800 ± 0.53	.02	<0.01	<0.01	0.83
Crude Protein Intake, g/d	276 ± 14.59	240 ± 12.69	201 ± 10.63	66 ± 3.49	135 ± 7.14	117 ± 6.19	106 ± 5.60	96 ± 5.08	.01	<0. 01	<0.01	0.83
NDF Intake, g/d	585 ± 31.14	531 ± 28.27	388 ± 20.66	349 ± 18.58	397 ± 21.13	385 ± 20.50	283 ± 15.07	280 ± 14.91	.18	<0.01	<0.01	0.94
Confinement time, day	120 ± 10.58	149 ± 13.10	130 ± 11.45	152 ± 13.36	110 ± 9.73	117 ± 10.36	109 ± 9.58	147 ± 12.95	.02	0.32	0.11	0.35
Body weight slaughter, kg	30.47 ± 0.60	30.48 ± 0.60	29.59 ± 0.58	30.34 ± 0.60	21.54 ± 0.42	22.16 ± 0.44	19.48 ± 0.38	20.83 ± 0.41	.15	0.02	0.01	0.99
Carcass weight, kg	12.49 ± 0.40	12.55 ± 0.40	13.37 ± 0.42	13.19 ± 0.42	8.38 ± 0.27	8.16 ± 0.26	7.99 ± 0.25	8.40 ± 0.27	.95	0.28	<0.01	0.49
Carcass yield, %	40.99 ± 1.18	41.17 ± 1.18	45.18 ± 1.30	43.47 ± 1.25	38.90 ± 1.11	36.82 ± 1.06	41.00 ± 1.18	40.32 ± 1.16	.31	<0.01	0.02	0.45
Fat thickness, mm	1.74 ± 0.32	2.48 ± 0.46	1.87 ± 0.35	3.01 ± 0.56	0.75 ± 0.14	0.88 ± 0.16	1.12 ± 0.21	0.42 ± 0.08	.28	0.64	0.01	0.31
Loin eye area, cm^2	12.84 ± 0.86	11.88 ± 0.79	12.48 ± 0.84	10.96 ± 0.73	9.76 ± 0.65	10.46 ± 0.70	8.81 ± 0.59	10.20 ± 0.68	.88	0.35	0.02	0.64

[1]There were interaction for dual parameters (R x FL) to Crude protein intake (P=0.01) and NDF intake (P=0.04). To others variables there were no interaction for dual parameters. C = effect of concentrate, R = effect of roughage, FL = effect of feeding level, C × R × FL = effect of interaction between C, R and FL.

ith kind of R and kth level of FL; $(C \times FL)_{jk}$ is the fixed effect of the interaction between jth kind of C and kth level of FL; $(R \times C \times FL)_{ijk}$ is the fixed effect of the interaction between ith kind of R, jth kind of C and kth level of FL and ε_{ijk} is the residual error.

RESULTS

Interactions between roughage sources, concentrate sources, and feeding level was not significant (P>0.05) to any parameters evaluated in this experiment (Tables 2, 3, and 4).

A significant interaction (P<0.05) between roughage sources (Table 2) and feeding levels was found on crude protein (CP) and neutral detergent fiber (NDF) intake. Nutrient intake of CP and NDF were greater (P<0.05) for lambs fed *ad libitum* dry matter intake (DMI) and elephant grass as roughage source. No significant difference (P>0.05) was observed in nutrient intake for different roughages at restricted feeding level. The intake of dry matter was greater in lambs fed corn meal (P<0.05). Diets with rice bran resulted in greater crude fat intake (P<0.05). The confinement time was different between the concentrates kinds (P < 0.05); it was lower for animals fed corn (Table 2).

No interaction (P > 0.05) occurred between roughage sources, concentrate source or feeding level for qualitative characteristic (Table 3). There was no interaction for dual parameters (P>0.05). No difference was observed on quality meat parameters (P>0.05), except for collagen solubility (P<0.05). Lambs fed sugarcane had higher percentages of collagen solubility (Table 3). There was no effect of the treatment on MFI (P>0.05), meat color (P>0.05), and shear force strengthen (P>0.05). MFI value is related to the tenderness of the meat.

No interactions effects (P>0.05) among roughage sources, concentrate sources or feeding level were found on the physical and chemical composition of the rack of lamb cut (Table 4). Elephant grass stimulated fat deposition in the cut. The feeding level affected (P<0.05) all variables, with greater weights in treatments with dry matter intake at 4.96% of body weight. Concentrate sources had no impact on bone, muscle, and fat components (P>0.05). Lambs fed sugarcane had greater fat accumulation (P<0.05).

DISCUSSION

The use of different concentrate sources in ruminant diets alters dietary chemical composition, due to the particular characteristics of each supplement.

In this experiment, replacing corn meal by rice bran caused variations in nutrient intake. Related to the concentrate source, the dry matter intake was greater for lambs fed with corn meal diets

Table 3. Qualitative carcass traits of lambs fed two roughage and concentrate sources at different feeding levels.

Item	Feeding level (FL)								P-value[1]			
	ad libitum				60% of *ad libitum*							
	Elephant grass		Sugarcane		Elephant grass		Sugarcane					
	Corn meal	Rice bran	Corn meal	Rice bran	Corn meal	Rice bran	Corn meal	Rice bran	C	R	FL	C × R × FL
MFI [2]	88.70 ± 3.10	78.11 ±11.54	77.71 ± 1.48	68.47±10.11	62.01 ±9.16	76.98 ± 1.37	72.59 ± 0.72	76.82 ± 1.35	0.99	0.81	0.55	0.77
Shear force, kgf/cm2	2.91 ± 0.48	2.96 ± 0.49	2.44 ± 0.40	2.97 ± 0.49	2.72 ± 0.45	3.13 ± 0.51	3.12 ± 0.51	2.55 ± 0.42	0.81	0.71	0.89	0.41
Total collagen, %	1.08 ± 0.20	0.66 ± 0.12	0.68 ± 0.13	1.13 ± 0.21	1.39 ± 0.26	1.46 ± 0.28	0.89 ± 0.17	1.12 ± 0.21	0.64	0.28	0.07	0.31
Total collagen, mg/g	10.75 ± 2.03	6.58 ± 1.24	6.81 ± 1.29	11.27 ± 2.13	13.91 ± 0.63	14.58 ± 2.75	8.89 ± 1.68	11.17 ± 2.11	0.64	0.27	0.07	0.32
Collagen solubility, %	19.80 ± 4.98	22.26 ± 5.59	27.46 ± 6.90	28.79 ± 7.23	16.54 ± 0.16	13.64 ± 3.43	21.97 ± 5.52	24.60 ± 6.18	0.47	0.04	0.54	0.38
Drip loss, %	13.57 ± 1.53	12.62 ± 1.42	9.34 ± 1.05	9.53 ± 1.07	8.43 ± 0.95	12.56 ± 1.41	6.22 ± 0.70	10.67 ± 1.20	0.19	0.06	0.23	0.89
Cooking loss, %	23.49 ± 1.51	21.35 ± 1.38	23.40 ± 1.51	26.10 ± 0.68	23.76 ± 0.53	23.33 ± 1.50	22.31 ± 1.44	19.29 ± 1.24	0.65	0.90	0.38	0.25
Sarcomere, µm	1.45 ± 0.10	1.57 ± 0.11	1.53 ± 0.10	1.73 ± 0.12	1.78 ± 0.12	1.61 ± 0.11	1.52 ± 0.10	1.73 ± 0.12	0.37	0.82	0.37	0.45
CIE L	39.11 ± 0.64	38.48 ± 0.63	39.91 ± 0.66	39.68 ± 0.65	38.20 ± 0.63	40.31 ± 0.66	39.91 ± 0.66	40.01 ± 0.66	0.53	0.35	0.55	0.32
CIE a*	6.66 ± 0.46	6.38 ± 0.44	5.98 ± 0.41	6.10 ± 0.42	7.11 ± 0.49	6.14 ± 0.43	6.53 ± 0.45	5.89 ± 0.41	0.39	0.38	0.79	0.97
CIE b*	4.71 ± 0.44	4.64 ± 0.44	4.79 ± 0.45	4.72 ± 0.44	5.49 ± 0.52	4.07 ± 0.38	4.97 ± 0.47	4.64 ± 0.44	0.37	0.91	0.88	0.59

[1]There was no interaction for dual parameters. C = effect of concentrate, R = effect of roughage, FL = effect of feeding level, C x R x FL = effect of interaction between C, R and FL.
[2] Myofibril fragmentation index (MFI).

Table 4. Physical and centesimal composition of edible part of rack cut of lambs fed two roughage and concentrate sources at different feeding levels.

Item	Feeding Level (FL)								P-value[1]			
	ad libitum				60% of *ad libitum*							
	Elephant grass		Sugarcane		Elephant grass		Sugarcane					
	Corn meal	Rice bran	Corn meal	Rice bran	Corn meal	Rice bran	Corn meal	Rice bran	C	R	FL	C × R × FL
Physical composition, g												
Total weight	236 ± 20.15	241 ± 21.23	235 ± 19.87	229 ± 19.68	146 ± 12.45	122 ± 11.29	129 ± 10.81	133 ± 11.07	0.74	0.23	<0.01	0.67
Bone	37 ± 3.53	43 ± 4.11	46 ± 4.39	47 ± 4.49	37 ± 3.53	32 ± 3.06	38 ± 3.63	33 ± 3.15	0.81	0.29	0.02	0.81
Muscle	131 ± 10.12	136 ± 10.51	142 ± 10.97	135 ± 10.43	92 ± 7.11	80 ± 6.18	78 ± 6.03	90 ± 6.96	0.94	0.82	< 0.01	0.27
Fat	68 ± 8.18	62 ± 7.46	47 ± 5.65	47 ± 5.65	17 ± 2.05	10 ± 1.20	13 ± 1.56	10 ± 1.20	0.34	0.03	< 0.01	0.85
Centesimal composition of edible part, %												
Humidity	47 ± 1.49	48 ± 1.52	52 ± 1.65	52 ± 1.65	60 ± 1.90	62 ± 1.96	65 ± 2.06	63 ± 2.00	0.94	0.01	< 0.01	0.68
Protein	19 ± 1.20	17 ± 1.08	19 ± 1.20	18 ± 1.14	26 ± 1.65	19 ± 1.20	20 ± 1.27	20 ± 1.27	0.02	0.46	0.02	0.22
Crude fat	32 ± 3.26	35 ± 3.57	27 ± 2.75	29 ± 2.96	10 ± 1.02	20 ± 2.04	13 ± 1.32	17 ± 1.73	0.03	0.27	< 0.01	0.54
Ash	1.2 ± 0.07	1.3 ± 0.05	0.9 ± 0.04	1.1 ± 0.07	1.2 ± 0.06	1.1 ± 0.10	1.4 ± 0.08	1 ± 0.07	0.32	0.88	0.41	0.88

[1]There was no interaction for dual parameters. C = effect of concentrate, R = effect of roughage, FL = effect of feeding level, C × R × FL = effect of interaction between C, R and FL.

(P<0.05). This decrease on intake rice bran may have been caused by the increase in ether extract content of the diet which provides a reduction in digestibility and use of nutrients.

Lambs fed elephant grass showed greater dry matter intake compared to sugarcane diets (P<0.05). This may be related to its greater apparent digestibility results of an elevated ruminal retention time, which stimulates the satiety center and limits feed intake (Gomes et al., 2012). Additionally, sugarcane diets have high content of lignin which affects its degradability rate, decreasing dry matter intake as result of high ruminal transit time (Cutrim et al., 2012). Furthermore, elephant grass showed superior nutritional value compared to sugarcane as roughage (Table 1). Lambs fed elephant grass showed significantly (P<0.05) higher body weight slaughter associated with greater nutrient intake, what stimulated the accumulation of tissues on their carcass.

The characteristics related to carcass weight and yield (Table 2) did not differ between animals fed different roughage and concentrate. This result suggests that viscera are more involved in the differences in carcass weight and yield than body weight slaughter. This happened because the diet with elephant grass showed higher neutral detergent fiber intake (P<0.05; Table 2), increasing the amount of food at gastrointestinal tract.

The confinement time was lower for animals fed corn. Since there are the dry matters and crude protein intake was higher, it is understood that their diet was better balanced to energy and protein, having a consequent higher protein deposition in the carcass. Besides, a greater deposition of ether extract in rack of lambs cut of animals fed with rice bran was observed (Table 4), and a smaller dry matter intake thereof. It is understood that such a diet has a higher deposition of fat tissue which has lower deposition efficiency, justifying the longer period to achieve slaughter weight.

Carcass fat deposition is critical to ensure sensorial traits of the meat being directly correlated to feeding and lamb age. However, there is no minimum fat thickness established for lamb's carcasses to standardize an excessive or deficient fat accumulation (Fernandes et al., 2011). In the current study, lambs fed *ad libitum* (4.96% body weight) presented fat thickness greater than 1.4 mm. Lambs fed with no nutrient restriction, showed greater total digestible nutrient intake and consequently superior carcass quality.

Lambs fed sugarcane had higher percentages of collagen solubility (Table 3). Collagen solubility in the meat of lambs fed sugarcane was higher than in that of lambs fed elephant grass. This result may be associated with the lambs growth rate, as collagen synthesis is greater in lambs with high growth rates (Lage et al., 2014). Hopkins et al. (2015) found that newly formed collagen molecules dilute the old molecules, resulting in muscles with higher collagen solubility. These results indicate that sugarcane may have favored a higher growth rate of lambs and a higher rate of collagen synthesis.

MFI value is related to the tenderness of the meat. In our study, the average values founds for MFI ranged from 62.01 to 88.70, which is associated with higher ultra structural fragmentation, and high tenderness (Stanisz et al., 2015). Variations in meat color occur among animal species, age, muscle evaluated, production system, and feeding level (Muchenjea et al., 2009). The fact of no dietary effects on meat color possibly is due to same similarity in the production system and age of lambs evaluated in this study. Thus, animals that are slaughtered at similar ages and who are submitted to the same slaughter handling do not tend to present with differences in coloration of the muscle, except if there was an ingredient in the diet that can alter this characteristic; this was not observed in this study, since even though there was a scarce amount of subcutaneous fat (Table 2), the degree of yellow intensity did not differ among animals (Table 3).

Lambs fed sugarcane had greater fat accumulation in the rack of lamb cut. This finding may be related to the greater intake of TDN and therefore of energy in these lambs (Table 2). Fat is the tissue with greatest variability in the body lamb, it is important for meat quality because it maintains organoleptic traits such as juiciness, aroma and flavor. Corn meal provided a noticeably greater percentage of protein, while rice bran promoted a greater fat deposition in the rack of lamb. Lambs fed sugarcane had higher percentage of moisture in this cut. The feeding level had a significant effect on assessed components, with higher values observed in the *ad libitum* feeding level (4.96% of body weight).

Conclusion

The use of sugarcane and rice bran as alternative foods for feedlot sheep is a viable strategy because they do not decrease the quantitative and qualitative traits of sheep carcass and meat. However, the time required to achieve the slaughter weight is greater using rice bran. The use of rice bran as concentrated source increases fat and reduces protein concentration in the rack of lamb cut. The feeding level affects all variables, with greater weights in treatments with DMI at 4.96% of BW. Research to evaluate the fatty acid profile of the rack of lamb cut are recommended.

Conflict of Interests

The authors have not declared any conflict of interests.

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