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Carcass characteristics of lambs fed diets containing silage of different genotypes of sorghum

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ABSTRACT - Thirty-five feedlot lambs (without defined breed, aged between 5 and 7 months, with average live weight of 17.7±3.7 kg) were used in a completely randomized design to evaluate the effect of diets containing different genotypes of sorghum on morphometric measurements and qualitative characteristics of carcass and yields of primal cuts. The animals stayed in individual indoor pens for 42 days and slaughtered at an average weight of 26.24 kg. No significant differences were observed on morphometric measurements, hot (11.67 kg) and cold (11.39 kg) carcass weight, hot (44.46%) and cold (43.37%) carcass yields, biological yield and on cooling losses. There was also no significant effect of silages of different genotypes of sorghum on the weights and yields of retail cuts (neck, shoulder, rib, loin and leg) and on the subjective evaluation of carcasses. It is possible to finish sheep without defined breed feeding them diets based on silages of sorghum, resulting in carcasses with high yield and good conformation.

Key Words: feedlot, primal cuts, production systems, sheep

Introduction

The Brazilian Northeast has the largest sheep flock in the country, and sheep are a species that represents an important activity in the development of that region. However, the problems with the seasonality of forage production are factors that contribute to a smaller development of this activity, which may compromise the animal-performance indexes achieved.

The use of high supplementation during both the rainy and dry seasons has been one of the mechanisms used by producers to solve the problem of forage shortage throughout the year; hence the importance of choosing fodder species and management systems that solve the problems faced by farmers in these regions.

Because sorghum presents anatomical and physiological characteristics that make it a species highly resistant to sites that show irregularities in the distribution of rainfall, it has been one of the most used species by producers in the Brazilian Northeast.

Despite its yield potential and adaptability to the Brazilian semiarid climate, there is availability of seed from cultivars of different purposes in the market, some fodder and others with a higher proportion of grain, making it necessary to evaluate whether the morphological characteristics of the plant influence the quality of the diet, and thus, the carcass characteristics of feedlot sheep.

In spite of being more productive, the forage sorghum presents few grains, which could result in less energy in the formulated diets. On the other hand, is spite of its higher nutritional value, grain sorghum is less productive than forage sorghum, resulting in more expensive silages. Thus, it is very important to evaluate not only agronomic characteristics but also animal response, as well carcass characteristics of animals to indicate the most appropriate form of sorghum for a given production system.

According to Ribeiro et al. (2002), finishing lambs in feedlot is viable when low-cost forage is available during the dry season. In the Brazilian Northeast, this practice is more recommended for semi-arid areas during the dry season, where there is a great lack of forage on pastures, allowing the producers in these regions to supply animals for slaughter throughout the year. Therefore, knowledge of diets that influence carcass characteristics of feedlot sheep is important so that they can deliver good-quality products that meet the demands of various consumer markets.

This study was conducted to evaluate the morphometric measurements and qualitative characteristics of carcass and yields of primal cuts of feedlot lambs without defined breed fed diets containing different genotypes of sorghum.

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Material and Methods

Thirty-five non-castrated lambs without defined breed (WDB) aged between 5 and 7 months, with average weight of 17.7±3.7 kg, were used. The animals were initially vaccinated against clostridial diseases and treated against ecto- and endoparasites and, then, were distributed into indoor individual pens (0.80 × 1.20 m), with free access to feed and water. The adaptation period lasted 11 days and the animals were weighed every 14 days to control their weight development.

The experiment was conducted in a completely randomized design, with five total-mixed-ration (TMR) treatments (Table 1). Five genotypes of sorghum were evaluated, in the form of silage: BRS 610, 655, 800 and 810, and Ponta Negra – the first four being developed by the breeding program of EMBRAPA Milho e Sorgo and the last of them by EMPARN – Empresa de Pesquisa Agropecuária do Rio Grande do Norte. The genotypes have the following characterizations: hybrids BRS 610, BRS 655, Ponta Negra are forage type, and hybrids BRS 800 and BRS 810 are of dual purpose (grain and/or forage). All genotypes were chosen because they present yield potential and adaptability to the region of study as demonstrated in previous research.

The total mixed rations were formulated based on the NRC (2007), predicting gains of 200 g/day, with forage proportion ranging from 45.11 to 50.98%; values adjusted as a function of crude protein content. After previous analysis of the crude protein content of feedstuffs (Table 1), their proportion in the experimental diets was elaborated as described in Table 2. The intake of feed and water was *ad libitum*. Animals were fed twice a day (at 07.30 and 14.30 h) and feed offered and refused were recorded daily to adjust feed offered for 0.10 refusal.

Composite samples of dietary ingredients offered and refused were analyzed for contents of dry matter, organic matter, ash, crude protein (CP) and ether extract, according to methodologies cited by Silva and Queiroz (2002), and neutral detergent fiber corrected for ash and protein

Table 1 - Chemical composition of the ingredients utilized in the experimental diets

Items	Feedstuffs						
	BRS 610 silage	BRS 655 silage	BRS 800 silage	BRS 810 silage	Ponta Negra silage	Ground corn grain	Soybean meal
Dry matter (DM), g/kg	224.6	271.2	269.5	266.7	251.2	867.3	880.8
Organic matter, g/kg DM	932.2	944.9	944.9	941.6	952.4	945.0	945.0
Ash, g/kg DM	67.8	55.1	55.1	58.4	47.6	55.1	55.0
Crude protein, g/kg DM	35.8	54.7	53.3	55.3	44.0	89.8	454.4
Ether extract, g/kg DM	56.0	59.1	44.4	61.1	68.8	41.5	35.1
NDF corrected for ash and protein, g/kg DM	519.7	467.2	477.1	481.2	545.0	118.4	138.6
Non-fibrous carbohydrates, g/kg DM	320.7	364.0	370.1	344.0	294.7	695.3	316.9
Total carbohydrates, g/kg DM	840.4	831.1	847.2	825.3	839.7	813.7	455.5

NDF - neutral detergent fiber.

Table 2 - Proportion of ingredients and average chemical composition of experimental diets

Items	Experimental diets[1]				
	610	655	800	810	PN
Sorghum silage, g/kg DM	451.1	496.2	509.8	508.5	501.5
Ground corn grain, g/kg DM	390.7	378.3	362.5	36.18	346.6
Soybean meal, g/kg DM	111.7	80.5	83.8	85.9	108.0
Urea, g/kg DM	6.9	6.3	6.2	6.2	6.4
Ammonium chloride, g/kg DM	10.1	9.3	9.0	9.0	8.1
Trace mineral salts[2], g/kg DM	22.6	21.4	20.6	20.7	20.2
Limestone, g/kg DM	8.9	8.1	8.1	7.9	9.2
Dry matter (DM), g/kg	381.6	417.0	409.1	406.4	390.9
Organic matter, g/kg DM	895.2	902.5	903.5	901.9	907.2
Ash, g/kg DM	104.8	97.5	96.5	98.1	92.8
Crude protein, g/kg DM	165.4	166.1	164.0	167.1	162.9
NDF corrected for ash and protein, g/kg DM	296.1	287.7	297.7	299.4	329.3
Non-fibrous carbohydrates, g/kg DM	451.7	469.1	467.3	453.7	423.0
Total carbohydrates, g/kg DM	747.8	756.9	765.1	753.2	752.3
Ether extract, g/kg DM	45.4	47.9	40.6	49.1	52.7

NDF - neutral detergent fiber.

[1] 610 - Silage of sorghum BRS610; 655 - silage of sorghum BRS655; 800 - silage of sorghum BRS800; 810 - silage of sorghum BRS810; PN - silage of sorghum Ponta Negra.

[2] Each 1,000 g contains: vitamin A - 135,000.00 IU; vitamin D3 - 68,000.00 IU; vitamin E - 450.00 IU; Ca - 240 g; P - 71 g (solubility in citric acid at 2% [min.]); K - 28.2 g; S - 20 g; Mg - 20 g; Cu - 400 mg; Co - 30 mg; Cr - 10 mg; Fe - 2,500 mg; I - 40 mg; Mn - 1,350 mg; Se - 15 mg; Zn - 1,700 mg; maximum Fl - 710 mg; excipient q.s. - 1,000 g.

(NDFap) by the method of Van Soest et al. (1991) with modifications proposed by the manual of Ankon (Ankon® Technology Corp.), corrected for the content of ash and crude protein.

After 42 days in the feedlot, the animals were deprived of solids and received only water for 16 hours. After this time, they were weighed to obtain the slaughter weight (SW). The slaughter was carried out in accordance with the standards of Regulamento de Inspeção Industrial e Sanitária dos Produtos de Origem Animal (Brasil, 2007). The animals were desensitized by stunning with brain concussion through a captive bolt pistol, followed by sticking, bleeding, dressing and evisceration. The blood was collected in previously tared container for later weighing.

After dressing and evisceration, the head (section in atlanto-occipital joint) and legs (section in carpal and tarsal-metatarsal joints) were removed, later recording the hot carcass weight (HCW), and the pH and the internal temperature of the carcass (0 hours *post mortem*), in the *semimembranosus* muscle were measured. The gastrointestinal tract (GIT), bladder (B) and gallbladder (GB) were emptied and washed to obtain the empty body weight (EBW), which was estimated by subtracting the weights referring to the content of the GTI, B and GB from the weight at slaughter (WS), in order to determine the biological or true yield [BY = (HCW/EBW) × 100].

Then the carcasses were cooled in cold chamber for 24 hours at ±4 ºC, hanging by common calcaneal tendon. During the cooling period, at the *semimembranosus* muscle, the pH and carcass temperature were recorded 24 hours *post mortem*. After this period, the carcasses were weighed to obtain the cold carcass weight (CCW) and weight loss by cooling [LC = (HCW – CCW)/HCW × 100].

Subsequently, morphometric measures were taken of thoracic and hind widths; thoracic depth; thoracic, hind and leg perimeters; internal and external carcass lengths and leg length of carcasses, as shown by Garcia et al. (2003). After obtaining morphometric measures, the compactness index of carcass was determined by the ratio between weight and internal length of carcass.

The carcasses were subjectively evaluated, in which the conformation index [1 = Poor (concave), 2 = Regular (sub-concave), 3 = Good (straight), 4 = Very good (sub-convex), 5 = Excellent (convex)] and the degree of fattening (1 = Very thin, 2 = Thin, 3 = Median, 4 = Fat, 5 = Very fat) were determined, as proposed by Cezar and Sousa (2007). When assessing the renal-pelvic fat (RPF), a score varying from 1 to 3 was given, as follows: 1 = Low (two uncovered kidneys), 2 = Normal (one covered kidney), 3 = Excess (two covered kidneys) (Cezar and Sousa, 2007).

After subjective assessment of RPF of the carcass, the kidneys and pelvic + kidney fat were removed; their weights were recorded and subtracted from the hot and cold carcass weights. Then the hot [HCY = (HCW/LWS) × 100] and the cold carcass yields [CCY = (CCW/LWS) × 100] were calculated.

The carcasses were split longitudinally, at midline, and the left half-carcasses were weighed and sectioned into five regions (leg, loin, ribs, shoulder and neck) as presented by Colomer-Rocher et al. (1986).

The left half-carcass were cross-sectioned between the 12th and 13th thoracic vertebra, where the thickness of subcutaneous fat on the *longissimus* muscle was determined with a digital caliper. The marbling degree of the *longissimus* muscle was determined in a 1-5 scale according Osorio and Osorio (2005).

The data were subjected to analysis of variance (ANOVA), and when necessary, the means were compared by Tukey's test at 5% probability using the SISVAR statistical analysis program (Ferreira, 2008).

Results and Discussion

The silages of different genotypes of sorghum did not affect (P>0.05) the morphometric characteristics of the carcass (Table 3). This result is mainly due to the fact that the animals belonged to the same genetic group and were slaughtered at similar live weight, because all diets met the nutritional requirements of the animals. Thus, because these variables are influenced by genotypes of animals (Ribeiro et al., 2012), the probability of variations occurring due to diet modification is very low.

The silages of different genotypes of sorghum had no influence (P>0.05) on slaughter weight, empty body weight, and hot and cold carcass weights (Table 4), which may be related to the fact that different types of sorghum did not influence the nutritional value of diets, resulting in similar carcass and final weight between treatments.

With regard to the carcass yields, there was no difference (P>0.05) between treatments, and the animals showed average values of 58.47, 44.46 and 43.37% for biological, hot and cold carcass yields, respectively. Alves et al. (2012) found hot and cold carcass yields of 47.29 and 45.49%, respectively, in feedlot lambs fed diets containing sorghum silages with high tannin. According to Cezar (2004), the biological yield best represents the components of the carcass because it eliminates variations influenced by the abiotic content. The hot carcass yield is the most used by producers, while the cold carcass yield is the most feasible by cold storages and the most important for the sheep-meat production chain.

The average cooling loss found in this study was 2.45%, which is lower than the 4.18, 3.33 and 2.88% found by Dantas et al. (2008) in Santa Inês lambs on pasture, fed concentrate at 0.0, 1.0 and 1.5% of their live weigh, respectively. Cooling losses are inversely related to the fattening degree of the carcasses, since the fat thickness provides protection to carcasses during the cooling period, reducing losses. In this work, the cooling loss of the carcasses can be considered low, since, according to Sañudo et al. (1981), for beef lambs, acceptable values range from 3 to 4%, showing that, despite their undefined breed, the animals showed a good carcass fattening (Table 5), sufficient to provide protection to carcasses during cooling.

There was no difference (P>0.05) between the carcass compactness (CC) of the animals, which had an average value of 0.20 kg/cm. This measurement is used to evaluate the production of muscles between animals of similar body weight. The data regarding the carcass compactness found in this experiment show good proportion of muscle per length unit, and a good homogeneity of the animals used in the experiment. Therefore, the CC and slaughter weight data showed the homogeneity of the animals used in the experiment.

The silage of different genotypes of sorghum did not influence (P>0.05) the initial and final temperature of the meat, and also did not affect the pH of the meat, which had

Table 3 - Carcass morphometric measurements of lambs WDB fed diets containing different genotypes of sorghum

Variables (cm)	Genotypes of sorghum[1]					P-value
	610	655	800	810	PN	
External carcass length	53.85	55.42	54.14	54.42	53.0	0.103
Internal carcass length	55.57	56.42	56.0	56.92	55.14	0.444
Thoracic width	17.71	17.92	17.64	16.92	18.28	0.717
Hind width	17.71	17.57	16.64	17.14	17.85	0.789
Thoracic depth	23.50	23.42	23.21	24.07	23.28	0.677
Hind perimeter	54.85	54.64	54.14	54.78	55.14	0.980
Thoracic perimeter	62.28	63.57	63.50	64.14	63.42	0.817
Leg perimeter	35.35	35.0	35.14	34.85	35.14	0.988
Leg length	38.35	38.21	38.64	38.92	39.28	0.706

[1] 610 - silage of sorghum BRS 610; 655 - silage of sorghum BRS 655; 800 - silage of sorghum BRS 800; 810 - silage of sorghum BRS 810; PN - silage of sorghum Ponta Negra.

Table 4 - Carcass characteristics of lambs WDB fed diets with different genotypes of sorghum

Variables	Genotypes of sorghum[1]					P-value
	610	655	800	810	PN	
Slaughter weight (kg)	25.68	26.77	26.28	26.54	25.91	0.925
Empty body weight (kg)	20.43	20.86	20.57	20.29	20.71	0.911
Biological yield (%)	58.3	57.59	57.44	61.02	58.02	0.345
Hot carcass weight (kg)	11.46	11.61	11.55	12.06	11.70	0.933
Hot carcass yield (%)	44.50	43.37	43.91	45.40	45.14	0.276
Cold carcass weight (kg)	11.13	11.38	11.29	11.74	11.43	0.946
Cold carcass yield (%)	43.24	42.51	42.91	44.15	44.06	0.507
Cooling losses (%)	2.85	1.97	2.30	2.76	2.38	0.432
Carcass compactness (kg/cm)	0.20	0.20	0.20	0.21	0.21	0.870
Temperature (ºC)						
0 hours	33.91	32.75	32.74	34.12	33.41	0.385
24 hours	4.14	4.14	3.98	4.05	4.01	0.580
pH						
0 hours	6.83	6.70	6.80	6.84	6.80	0.654
24 hours	5.62	5.65	5.63	5.61	5.69	0.961

[1] 610 - silage of sorghum BRS 610; 655 - silage of sorghum BRS 655; 800 - silage of sorghum BRS 800; 810 - silage of sorghum BRS 810; PN - silage of sorghum Ponta Negra.

Table 5 - Subjective and subcutaneous fat thickness evaluation of carcass of lambs WDB

Variables	Genotypes of sorghum[1]					P-value
	BRS 610	BRS 655	BRS 800	BRS 810	PN	
Conformation	2.57	2.57	2.35	2.21	2.57	0.718
Finishing	2.50	2.35	2.57	2.64	2.57	0.803
Marbling	1.85	1.71	1.85	1.85	2.00	0.940
Fat thickness (mm)	1.20ab	1.22ab	1.15ab	0.84b	1.61a	0.006
Renal-pelvic fat	2.28	1.92	2.14	2.21	2.07	0.701

a, b in the same row differ by Tukey's test (P<0.05).
[1] 610 - silage of sorghum BRS 610; 655 - silage of sorghum BRS 655; 800 - silage of sorghum BRS 800; 810 - silage of sorghum BRS 810; PN - silage of sorghum Ponta Negra.

an average of 6.79 and 5.64, for the initial and the final pH (fpH, 24 hours), respectively.

According to Rodrigues et al. (2004), the decrease in pH and temperature during *rigor mortis* of the animal carcasses directly influence the quality of the meat, having this decrease controlled mainly by glycogen reserve, pH and muscle temperature. The values of fpH found in this study show that there was a good settling of *rigor mortis* of carcasses during the cooling process, resulting in meat with more desirable sensory properties, ideal for both *in natura* consumption and for the processing industry.

The silages from different genotypes of sorghum had no effect (P>0.05) on the degrees of conformation and fattening, RPF, and fat marbling, which averaged 2.37, 2.52, 2.12 and 1.85, respectively (Table 5). Visual determination of degree of fattening allows for providing carcasses with adequate fat cover for consumers, since, according Osorio and Osorio (2005), the ideal fat cover of the carcasses is defined by the consumer.

Andrade et al. (2009) found degrees of conformation of 3.07, 2.88 and 2.63 for Hampshire Down lambs fed only corn grain silage, 80% corn grain silage + 20% sunflower silage or 99% corn grain + 1% of urea, respectively. The marbling level of the carcasses was higher than the 1.42, 1.20 and 1.69 reported by Gutiérrez et al. (2005) for Pelibuey, Suffolk × Pelibuey and Rambouillet × Pelibuey lambs, respectively. It can be observed that the animals had carcasses with good conformation, indicating a proportional development of distinct anatomical regions comprising the carcass, and an average fattening degree, enough to protect the carcasses from excessive losses during the cooling process and to give the meat a nicer flavor.

The lowest subcutaneous fat thickness was observed in the carcass of the animals fed diet containing sorghum genotype BRS 810, although there was no difference in the composition of the diets or in the weight gain that would justify this purpose. Lombardi et al. (2010), working with lambs that received corn grain silage or corn grain silage with inclusion of sunflower or urea, found values close to those found in this study.

The weights and yields of retail cuts of the carcass were not affected (P>0.05) by the silage of different genotypes of sorghum (Table 6). The leg was the heaviest cut and, thus, had the highest yield in relation to the left half-carcass, 31.88%, which is because it is a region with greater muscularity and higher yield of the edible part. The average yields of loin and shoulder were of 12.54 and 18.34%, respectively. The leg and the loin are the cuts with the largest commercial value, named prime cuts, in view of their better muscle yield and higher meat tenderness (Cezar and Sousa, 2007).

According to Silva Sobrinho et al. (2005), in meat sheep breeds, the sum of yields of leg, loin and shoulder yield over 60%. In this study, the sum of the yields of these cuts was 62.76%. This value is close to that found by Paim et al. (2013) with crossbred Dorper × Santa Inês, and higher than that found by Pinto (2009). (59.37%), in research with Santa Ines lambs, showing that although the lambs have no defined breed, they had yields of prime cuts close to those observed in specialized breeds for meat production. This result highlights the possibility of producing lamb carcasses with high yield even exploiting the genetic resources of that region. For the other cuts, the averages were 7.92 and 29.42%, for the neck and ribs, respectively.

According to the results, it appears that, regardless of the genotype of sorghum used, forage or grain types, the experimental diets showed an excellent composition, meeting the nutritional requirements of the animals, allowing for a good yield of retail cuts.

Table 6 - Weight and yield of retail cuts of lambs WDB fed diets with different genotypes of sorghum

Variables	Genotypes of sorghum[1]					P-value
	610	655	800	810	PN	
Weight of the cold half-carcass (kg)	5.48	5.65	5.59	5.73	5.60	0.972
Neck (kg)	0.43	0.45	0.41	0.46	0.45	0.542
Shoulder (kg)	1.01	1.02	1.01	1.06	1.00	0.871
Ribs (kg)	1.62	1.66	1.69	1.68	1.61	0.969
Loin (kg)	0.67	0.69	0.72	0.69	0.69	0.941
Leg (kg)	1.73	1.80	1.74	1.82	1.83	0.833
Yield of retail cuts (%)						
Neck	8.01	7.99	7.43	8.11	8.10	0.514
Shoulder	18.64	18.26	18.23	18.60	18.00	0.585
Ribs	29.40	29.37	30.20	29.39	28.75	0.969
Loin	12.32	12.33	12.98	12.12	12.27	0.237
Leg	31.61	32.03	31.15	31.77	32.86	0.229

[1] 610 - silage of sorghum BRS 610; 655 - silage of sorghum BRS 655; 800 - silage of sorghum BRS 800; 810 - silage of sorghum BRS 810; PN - silage of sorghum Ponta Negra.

Conclusions

It is possible to finish sheep without defined breed feeding them diets based on silages of sorghum, regardless of its grain or forage purpose, because they meet the nutritional requirements of the animals, and result in carcasses with high yield and good conformation, likely to meet the market demand for sheep meat.

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