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Potential of elephant grass genotypes silages as exclusive roughage on tissue composition and meat quality of lambs: a preliminary study

[Potencial de silagens de genótipos de capim-elefante como volumoso exclusivo sobre a composição tecidual e a qualidade da carne de cordeiros: um estudo preliminar]

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ABSTRACT

This study aimed to evaluate the effects of diets containing elephant grass genotypes silages as exclusive roughage on leg tissue composition, and physicochemical characteristics of meat of lambs. Twenty-four crossbred male lambs with an average initial body weight of 20.29 ± 2.66kg were distributed in a complete randomized design with three treatments and eight replicates. The treatments consisted of three silages of elephant grass genotypes (IRI-381, Elephant B or Mott), without additives or wilting, as the only roughage. The diets did not affect (P>0.05) the dry matter (898.70 ± 60.10 g/day), crude protein (128.93 ± 6.91g/day), total digestible nutrients (690.20 ± 91.82g/day) intakes, body weight at slaughter (24.83 ± 2.79kg), and carcass yields (P>0.05). The tissue composition of the leg did not differ significantly between silages of elephant grass genotypes (P>0.05). No difference (P>0.05) for the physicochemical characteristics of meat from lambs fed diets tested was observed. Therefore, our results indicate that diets containing 50% elephant grass genotypes silages (IRI-381, Elephant B or Mott), harvested at 60 days of growth, have potential for use in lambs feeding.

Keywords: carcass yield, feedlot sheep, grass silage, meat production, physicochemical parameters

RESUMO

Este estudo teve como objetivo avaliar os efeitos de dietas contendo silagens de genótipos de capim-elefante como volumoso exclusivo sobre a composição tecidual da perna e nas características físico-químicas da carne de cordeiros. Vinte e quatro cordeiros machos mestiços, com peso corporal inicial médio de 20,29±2,66kg, foram distribuídos em delineamento inteiramente ao acaso, com três tratamentos e oito repetições. Os tratamentos consistiram de três silagens de genótipos de capim-elefante (IRI-381, Elephant B ou Mott), sem aditivos ou emurchecimento, como único volumoso. As dietas não afetaram (P>0,05) os consumos de matéria seca (898,70 ± 60,10g/dia), proteína bruta (128,93±6,91g/dia) e nutrientes digestíveis totais (690,20 ± 91,82g/dia), peso corporal ao abate (24,83 ± 2,79kg) e rendimentos de carcaça (P>0,05). A composição tecidual da perna não diferiu significativamente entre as silagens dos genótipos de capim-elefante (P>0,05). Não foi observada diferença (P>0,05) para as características físico-químicas da carne dos cordeiros alimentados com as dietas testadas. Portanto, os resultados indicam que dietas contendo 50% de silagens de genótipos de capim-elefante (IRI-381, Elephant B ou Mott), colhidos aos 60 dias de crescimento, têm potencial para uso na alimentação de cordeiros.

Palavras-chave: ovinos confinados, parâmetros físico-químicos, produção de carne, rendimento de carcaça, silagem de capim

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INTRODUCTION

The lamb meat production does not meet Brazilian demand, mainly regarding the qualitative characteristics of meat, and thus, imported lamb is needed (Abreu *et al*., 2021). Lamb feedlot is an alternative to reduce the influence of the tropical climate on sheep meat production and to increase productivity rates (Lima *et al*., 2021), and to meet the demand for sheep meat, with positive effects on the quality and product offering in the off-season (Ferreira *et al*., 2009). According to Santos-Cruz *et al*. (2013), lamb production can be improved in quality and profitability, using alternative feeding resources with considerable nutritional value, allowing positive changes in meat physicochemical composition.

Tropical grass silages, despite not having high quality, when compared to traditional silages, such as corn, become important sources of fiber for the adequate functioning and health of the rumen environment. Considering that roughage foods can represent 20 to 60% of the diets of animals in feedlot, the amount of forage to be produced must be high, which suggests the use of forage plants with high productive potential. In this scenario, elephant grass (*Pennisetum purpureum* Schum.) presents itself as one of the main options for forage production, given its potential to produce forage mass, combined with its nutritional value and acceptability by ruminant animals (Dubeux Jr. and Mello, 2010; Cunha *et al*., 2011; Dourado *et al*., 2019; Souza *et al*., 2021). This forage grass is grown in tropical, subtropical, and even in semiarid zones worldwide (Pereira *et al*., 2017).

According to Silva *et al*. (2021), when investigating which grass would be most recommended for cut-and-carry: tall-sized (Elephant B and IRI-381) or dwarf (Taiwan A-146 2.37 and Mott) elephant grass cultivars for sheep feeding, concluded that animals fed dwarf elephant grass have greater weight gain. However, few studies have evaluated the effects of the use of elephant grass genotypes silages, of different sizes, on lamb finish, carcass traits and meat quality. One of the important steps in breeding programs of forage cultivars is the evaluation of the productive performance and quality of the products of the animals that receive the material as a dietary ingredient, which highlights the need for scientific investigations on the subject.

We hypothesized that diets containing dwarf or tall elephant grass genotypes silages as the only roughage do not compromise the carcass characteristics and meat quality of sheep. Therefore, the objective of this study was to determine the effects of diets containing elephant grass genotypes silages as exclusive roughage on leg tissue composition, and physicochemical characteristics of meat of lambs.

MATERIAL AND METHODS

This study was conducted according to ethical standards and approved by the Animal Use Ethics Committee of the Federal Rural University of Pernambuco (UFRPE) (License N^{o}. 010/2010). The experiment was conducted at the research station of Agronomy Institute of Pernambuco (IPA), in Itambé, located in the coastal region of Pernambuco State, Brazil (7º23’S and 35º10’W).

Twenty-four crossbred male lambs, uncastrated, with an initial weight of 20.29 ± 2.66kg and aged 8 months, were distributed in a complete randomized design with three treatments and eight replicates. The animals were allocated in individual stalls, provided with feeders and drinkers. Before starting the experiment, the animals were identified, vaccinated against clostridial diseases, and treated against endoparasites and ectoparasites. The experiment (a preliminary study) lasted for 38 days, being 15 days for adaptation to the diets and installations, and 23 days for data and sample collection.

The ingredients used were elephant grass genotypes silages (*Pennisetum purpureum* Schum. cv. Mott, IRI-381, and Elephant B), corn meal, soybean meal, and mineral mix (Table 1).

Table 1. Chemical composition of ingredients of experimental diets (g/kg dry matter, unless stated)

Item	Elephant grass silage			Corn meal	Soybean meal	Mineral mix †
	Mott	IRI-381	Elephant B			
Dry matter [a]	131.0	148.0	155.9	898.0	897.1	990.0
Organic matter	836.7	887.1	873.2	981.5	931.3	-
Crude protein	115.3	103.6	102.3	87.4	494.3	-
Ether extract	32.4	29.9	33.7	67.2	28.9	-
apNDF [b]	462.6	543.7	543.7	144.7	191.5	-
Total carbohydrates	689.0	753.5	737.1	826.8	408.1	
NFC [c]	226.3	209.8	205.8	682.0	216.5	-
Lignin	62.0	69.3	65.7	3.9	3.0	-

[a] g/kg natural matter; [b] neutral detergent fiber assayed with a heat stable amylase and corrected for ash and nitrogenous compounds; [c] non-fibrous carbohydrates; (-) not determined. † Nutrients/kg of product: Ca = 110g; Ca (max.) = 135g; P = 87g; S = 18g; Na = 147g; Mg = 20g; Co = 15mg; Cu = 590mg; Cr = 20mg; I = 50mg; Mn = 2000mg; Mo = 300mg; Se = 20mg; Zn = 3800mg; F = 870mg (max.); Fe = 1800mg.

The treatments consisted of three experimental diets: 1) diet with elephant grass Mott silage as exclusive roughage (short size); 2) diet with elephant grass IRI-381 silage as exclusive roughage (tall size); and 3) diet with elephant grass Elephant B silage as exclusive roughage (tall size); and were formulated to provide weight gain of 150 g/day (Nutrient…, 2007), with roughage:concentrate ratio of 50:50 (Table 2).

Table 2. Ingredients proportion and chemical composition of the experimental diets

Ingredients (g/kg)	Diets		
	Mott silage	IRI-381 silage	Elephant B silage
Elephant grass Mott silage	50	0	0
Elephant grass IRI-381 silage	0	50	0
Elephant grass B silage	0	0	50
Corn meal	40.7	40.5	40.3
Soybean meal	9.3	9.5	9.7
Diet composition (g/kg dry matter, unless stated)			
Dry matter [a]	514.4	522.9	526.4
Organic matter	904.4	929.5	922.4
Crude protein	139.2	134.2	134.3
Ether extract	46.3	44.9	46.7
apNDF [b]	308.1	348.7	348.8
Total carbohydrates	719.0	750.4	741.4
NFC [c]	410.9	401.7	398.8
Total digestible nutrients	746.0	780.0	776.0

[a] g/kg natural matter; [b] neutral detergent fiber assayed with a heat stable amylase and corrected for ash and nitrogenous compounds; [c] non-fibrous carbohydrates.

Three elephant grass genotypes (Mott - short size; IRI-381 and Elephant B - tall size) were harvested at 60 days of growth and ground in a stationary forage machine and used to obtain the silages. The chopped material was compacted in 200-L plastic barrels, without using additives or practice of wilting, and remained sealed for 150 days. The diets were offered *ad libitum* in total mixed ration, twice daily (at 08:00 am and 03:00 pm). The adjustment of intake was based on the intake of the previous day, guaranteeing leftovers around 10% of the total dry matter (DM) offered. The DM intake was calculated based on the difference between the quantities offered and leftovers. Water and mineral mix for sheep were offered *ad libitum* throughout the experimental period.

Weekly, feeds, leftovers and feces samples were collected and for each animal, one composite sample was pre-dried in a forced ventilation oven at 55 °C for 72 h, ground in a Wiley mill with a 1-mm sieve screen and submitted to bromatological analysis. For *in situ* rumen incubation, 2-mm screen was used in samples. The chemical analyses of DM, ash, crude protein (CP), and ether extract (EE) were performed according to the AOAC (Official…, 2000). Neutral detergent fiber (NDF) was determined according to the methodology proposed by Van Soest *et al*. (1991), adapted by Detmann *et al*. (2012). NDF levels were corrected for residual ash according to Detmann *et al*. (2012) and for nitrogen compounds according to Licitra *et al*. (1996).

The levels of non-fibrous carbohydrates (NFC) were estimated according to Hall (2000). Total carbohydrates (TC) were estimated according to Sniffen *et al*. (1992). The lignin was determined by treating the acid detergent fiber residue with 72% sulfuric acid (Silva and Queiroz, 2002). To estimate the total digestible nutrients (TDN), samples of feed, leftovers and feces were collected. To estimate the production of fecal dry matter, indigestible dry matter was used (Soares *et al*., 2011). For the TDN estimation, the equation described by Weiss (1999) was used: TDN = DCP + DEE x 2.25 + DNFC + DapNDF. Average daily gain was calculated according to the following formula = (total weight gain/days of the experimental period).

At the end of the experimental period, the lambs were randomly distributed in a slaughter order, submitted to solid fast for 16h, to obtain body weight at slaughter (BWS), and slaughtered following the current recommendations (Brasil, 2000). The animals were stunned by non-penetrative brain percussion with the aid of a pistol, suspended by the hind limbs and bled. The body of the slaughtered, bled, skinned, and gutted animal, free of the limbs, kidneys, and perirenal fat, was the hot carcass weight (HCW), to determine the hot carcass yield [HCY (%) = HCW/BWS × 100]. The gastrointestinal tract was weighed full, then emptied, washed, and reweighed to obtain the gastrointestinal tract content (GITC). The empty body weight (EBW) was calculated using the formula EBW = (BWS − GITC), and the biological yield (BY) was calculated using the formula BY (%) = HCW/EBW × 100. After weighing, the carcasses were taken to a cold chamber at 4ºC, where they remained suspended by hooks for 24 h. After this period, the carcasses were weighed again to obtain the cold carcass weight (CCW). To determine the commercial yield, the formula was used: CY (%) = CCW/BWS × 100 (Cezar and Sousa, 2007).

The left leg of each animal was weighed, identified, packed in high-density polyethylene bags, and stored at −20°C for evaluation of tissue composition. The legs were previously stored and thawed gradually, being maintained at a temperature of about 4°C for 24 h. Throughout the dissection of leg, the weight of the five muscles that covered the femur (*Biceps femoris*, *Semimembranosus*, *Adductor*, *Semitendinosus* and *Quadriceps femoris*) were obtained. The leg muscle index (LMI) was calculated according to Purchas *et al*. (1991).

The qualitative analyzes of the meat were performed using the right loins of each animal. The chemical composition of the meat was performed in the *Semimenbranosus* muscle, according to methodologies recommended by AOAC (Official…, 2000). Cooking losses, shear force and color were determined according to the methodologies described by Wheeler *et al*. (1993). The water holding capacity was determined according to Sierra (1973).

The experimental design was completely randomized, considering initial body weight (IBW) as covariate, according to the model below:

$$Y_{ij} = \mu + T_i + \beta(X_{ij} - X) + e_{ij},$$

where: Y_{ij} = observed value of the dependent variable; μ = general mean; T_i = treatment effect i (i = 1 to 3); β (X_{ij} − X) = covariate effect (IBW); and e_{ij} = experimental error. The data were submitted to analysis of variance, using SAS statistical package (2009). The Tukey's test, at 5% probability, was used to compare the averages between treatments.

RESULTS

The diets did not affect (P>0.05) the DM (898.70 ± 60.10g/day), CP (128.93 ± 6.91g/day), TDN (690.20 ± 91.82g/day) intakes, body weight at slaughter (24.83 ± 2.79kg), and carcass yields (P>0.05) (Table 3).

Table 3. Nutrient intake, performance and carcass yield of lambs fed diets containing elephant grass genotypes silages

Item	Diets				
	Mott silage	IRI-381 silage	Elephant B silage	SEM [a]	P-value
Dry matter intake (g/day)	914.7	877.9	903.5	60.10	>0.05
Crude protein intake (g/day)	131.1	126.3	129.4	6.91	>0.05
TDN [b] intake (g/day)	683.0	685.8	701.8	91.82	>0.05
Average daily gain (kg/day)	0.211	0.185	0.189	0.06	>0.05
Body weight at slaughter (kg)	25.0	24.6	24.9	2.79	>0.05
Hot carcass yield (%)	42.04	41.52	41.84	1.70	>0.05
Commercial yield (%)	40.32	40.11	39.96	1.77	>0.05
Biological yield (%)	52.55	53.05	53.37	2.22	>0.05

[a] standard error of the mean; [b] total digestible nutrients. Averages in rows followed by different letters are statistically different by the Tukey's test at 5% probability.

The tissue composition of the leg did not differ significantly between silages of elephant grass genotypes (P>0.05), with means of whole leg weight (1532.47±192.40g), muscle (1055.36±164.65g), bone (385.93± 42.49g), subcutaneous fat weight (43.04 ± 12.52g), intermuscular fat (19.68±5.91g), total fat (64.14±14.27g) and other tissues (27.02±8.03g), as well the ratios of muscle:bone (2.73±0.40), muscle:fat (17.18±4.10), and LMI (0.33±0.03) (Table 4).

Table 4. Leg tissue composition of lambs fed diets containing elephant grass genotypes silages

Item	Diets				
	Mott silage	IRI-381 silage	Elephant B silage	SEM [a]	P-value
Whole leg (g)	1542.26	1523.26	1531.89	192.40	>0.05
Muscle (g)	1067.71	1037.91	1060.46	164.65	>0.05
Bone (g)	392.10	387.10	378.60	42.49	>0.05
Total fat (g)	56.97	70.10	65.35	14.27	>0.05
Subcutaneous fat (g)	37.71	47.46	43.96	12.52	>0.05
Intermuscular fat (g)	18.18	20.68	20.18	5.91	>0.05
Other tissue (g)	25.48	28.10	27.48	8.03	>0.05
Muscle:bone ratio	2.72	2.67	2.82	0.40	>0.05
Muscle:fat ratio	19.03	15.59	16.94	4.10	>0.05
Leg muscle index	0.33	0.34	0.33	0.03	>0.05
Yield (%)					
Muscle	69.10	67.71	69.12	3.11	>0.05
Bone	25.49	25.76	24.77	2.89	>0.05
Total fat	3.73	4.67	4.26	0.97	>0.05
Subcutaneous fat	2.48	3.15	2.85	0.78	>0.05
Intermuscular fat	1.17	1.40	1.34	0.45	>0.05
Other tissue	1.66	1.84	1.83	0.53	>0.05

[a] standard error of the mean. Averages in rows followed by different letters are statistically different by the Tukey's test at 5% probability.

No difference (P>0.05) for the physical characteristics (shear force, cooking loss, water-holding capacity, lightness, redness, and yellowness) of meat from lambs fed diets tested was observed (Table 5). Additionally, the values of moisture (77.42±0,96%), CP (18.21±0.89%), EE (1.59±0.22%), and ash (1.07±0.08%) of the meat were not influenced (P>0.05) by the treatments (Table 5).

Table 5. Physicochemical characteristics of meat from lambs fed diets containing elephant grass genotypes silages

Item	Diets				
	Mott silage	IRI-381 silage	Elephant B silage	SEM [a]	P-value
Shear force (kg/cm^2)	2.03	2.17	2.10	0.43	>0.05
Cooking loss (%)	33.08	30.91	31.30	4.90	>0.05
Water-holding capacity (%)	28.74	27.14	26.43	3.89	>0.05
Lightness, L^*	42.10	42.52	41.28	2.12	>0.05
Redness, a^*	7.91	7.57	8.06	1.06	>0.05
Yellowness, b^*	6.70	7.22	6.58	1.01	>0.05
Moisture (%)	77.36	77.30	77.61	0.96	>0.05
Crude protein (%)	18.14	18.23	18.26	0.89	>0.05
Ether extract (%)	1.52	1.59	1.65	0.22	>0.05
Ash (%)	1.08	1.09	1.05	0.08	>0.05

[a] standard error of the mean. Averages in rows followed by different letters are statistically different by the Tukey's test at 5% probability.

DISCUSSION

The silages used in the present study had a much lower DM content than the 30% recommended by literature (Table 1). However, as they accounted for 50% in the diet of feedlot sheep, they did not provide a reduction in DM intake, since sheep that received silages from tall sizes (IRI-381 and Elephant B) consumed 3.9% of BW and those that consumed the short size (Mott), 4% of BW. These results reflected positively on the values of average daily gain (0.195kg), which were higher than predicted in the diet formulation. Productive performance is a direct function of digestible DM intake, so that 60 to 90% of performance results from variation in intake, and 10 to 40% depends on fluctuations in digestibility. Therefore, intake is considered the most important factor in determining animal performance (Mertens, 1994; Gomes *et al*., 2017).

The animals' body weight at slaughter also did not differ (P>0.05) as a function of the silages they received, a fact that reflected in the similarity of hot, commercial, and biological carcass yields (Table 3). The variables related to the leg tissue composition of the lambs were similar, regardless of the silages (Table 4), which can be explained by the lack of difference in the DM, CP and TDN intakes. Possibly, the high TDN intake contributed to the efficiency of utilization of available dietary protein for muscle growth. In addition, young and fully growing animals were used, a phase characterized by greater deposition of muscle tissue in relation to adipose tissue, which may have contributed to the results observed. The muscle:fat ratio is considered an important attribute of carcass quality, so diets can contribute to increasing this ratio. However, there was no dietary effect on muscle:bone and muscle:fat ratios, indicating that tissue deposition did not occur only by the addition of muscle tissue, but by the deposition of all tissues together. The leg tissues accompanied the carcass weight development of animals, result also observed by Cardoso *et al*. (2021).

According to Silva Sobrinho *et al*. (2005), the LMI suggests the amount of muscle present in each cut, and the higher this index, the higher the yields. The mean for LMI (0.33 ± 0.03) is below the value (0.39 ± 0.03) reported by Lima *et al*. (2021) for Dorper x Santa Inês crossbred lambs, with known aptitude for meat production. However, it was close to the value of 0.37 reported by Urbano *et al*. (2013), when working with undefined breed pattern lambs. Based on this information, it can be inferred that the crossbred lambs in the present study had the potential to produce carcasses with considerable yield. On the other hand, the percentage yield of tissue components (Table 4) indicates that the carcasses can be considered of quality and suitable for the market, since they had high proportions of muscle (68.64%), reduced percentage of tissues of low consumer interest, in addition to a low percentage of fat (4.22%).

The diet is a determining factor to characterize possible variations in the carcass and in the tissue and chemical composition of commercial cuts. Thus, among the factors that can determine variation in these compositions are the roughage:concentrate ratio (Kumari *et al*., 2013) and the feeding system, exclusively in grazing or in feedlot (Panea *et al*., 2011). Considering these, it is understood the similarity found in the chemical composition parameters of the *Semimembranosus* muscle recorded between the animals receiving the different silages as exclusive roughage (Table 5).

The silages did not provide differences in the qualitative aspects of the meat (Table 5). However, it should be noted that the color of sheep meat is more influenced by the production system than by the diet (Perlo *et al*., 2008). Animals in feedlot, as in the present study, are less susceptible to physical activities than those raised in extensive systems, which induces a lower synthesis of myoglobin, in view of the lower need for muscle oxygenation, favoring a less intense staining in the meat (Vestergaard *et al*., 2000).

According to Schmidt *et al*. (2013), meats that have shear force values lower than 2.75kg/cm^2 can be classified as tender. Other parameters indicating meat quality (water holding capacity, color and tenderness) can also be considered adequate. On the other hand, the water holding capacity (WHC) determines the meat's ability to retain water after the application of external forces (Muchenje *et al*., 2009), so that the higher the WHC of the meat, the greater its firmness and consistency, more uniform is the texture, due to the greater turgor of the fiber. In the same relationship, the cooking loss is associated with the meat yield at the time of intake, being a characteristic influenced by the WHC in the meat structures. The cooking process is a determining factor in the WHC of the meat (juiciness) and during the cooking of the meat up to temperatures of 71ºC, higher values of WHC also contributed to lower losses of exudate, which can vary from 25 to 40% (Gomide *et al*., 2013). Thus, in view of the physicochemical results of the meat (Table 5), it can be inferred that sheep fed diets containing silages of elephant grass genotypes had meat without compromising color, tenderness, and juiciness.

It is important to highlight that there is difference between the nutritional value of the different elephant grass genotypes (Silva *et al*., 2021). However, this variation did not impact the carcass and meat characteristics of sheep used in the present study. On the other hand, the length of the experimental period may have caused the non-significant results. Furthermore, it is recommended that a negative control (a lower quality standard forage) and/or a positive control (better quality forage or an additive) be tested.

CONCLUSIONS

Diets containing 50% elephant grass genotypes silages (IRI-381, Elephant B or Mott), harvested at 60 days of growth, have potential for use in lambs feeding. Additionally, future research is encouraged to assess the effects of diets containing elephant grass genotypes silages (tall-sized or dwarf) for a long-term, aiming to establish the real impact of silages on carcass characteristics and meat quality of lambs.

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