Carcass characteristics of lambs fed spineless cactus as a replacement for sugarcane

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Objective: Fresh sugarcane has been a new roughage source for ruminant’s in semi-arid regions, a function of the decline of sugar and alcohol industry in recent years. However, there is little data published regarding lambs fed sugarcane associated with spineless cactus. This study evaluated the effect of sugarcane replacement with spineless cactus (0%, 33%, 66%, and 100%) in the diet of Santa Inês lambs on carcass characteristics.

Methods: Thirty-six non-castrated Santa Inês lambs at four months of age and an initial body weight of 22±2.3 kg were assigned in a randomized block design and slaughtered after 70 days of confinement. The effects of spineless cactus as a replacement for sugarcane in the diet of the lambs on the carcass characteristics, commercial cut weight and yield, leg tissue composition, and carcass measurements were studied.

Results: The study revealed quadratic behavior in slaughter body weight, and hot and cold carcass weight, with maximum values of 38.60, 18.60, and 18.11 kg and replacement levels of 40.18%, 44.42%, and 43.14%, respectively. The cold carcass yield presented an increasing linear behavior. The compactness index of carcass and leg presented a quadratic effect, with estimated maximal values of 0.28 and 0.57 kg/cm and replacement levels of 43.37% and 45.5%, respectively. The weights of commercial cuts of leg, loin, shoulder, and breast showed quadratic behavior, with maximum values of 2.79, 0.852, 1.46, and 1.30 kg and replacement levels of 49.5, 45.32, 39.0, and 40.7, respectively. For tissue composition, quadratic behavior was verified for leg weight, subcutaneous fat, and total fat.

Conclusion: The replacement of sugarcane by spineless cactus at level 44% is recommended for finishing lambs considering that this level improved most of the carcass characteristics, weights, and yields of commercial cuts and leg tissue composition.

Keywords: Carcass Characteristics; Roughage; Spineless Cactus

INTRODUCTION

Whether due to socioeconomics, culture, or even the adaptability of small ruminants, the northeastern semi-arid region naturally has a vocation to the development of meat sheep production. However, the significant importation of sheep meat from Uruguay, Chile, and Argentina indicates that there are still problems that interfere with the productive efficiency of the region. Although there are other points to be worked on in the establishment of the productive chain, nutritional problems due to seasonality in the roughage supply are mainly responsible for the insufficient and irregular supply of sheep meat to the market [1,2].

Increasing the herd turnover rate requires intensification and shortening of the production cycle, which can be achieved in the short and medium term through the implementation of production systems in confinement. However, the low availability of food resources during...
the dry season and the high prices applied when reselling the few available ingredients in these periods [3] compromise the economic viability of production systems. Thus, the search for regionally adapted, less costly, and more accessible ingredients is seen as a strategy to produce carcasses with a differentiated quality pattern that will be obtained through the slaughter of young animals.

In this context, spineless cactus emerges as a potential solution due to its adaptation to semi-arid regions, its high dry matter (DM) production per unit area (40 ton DM/ha/yr), and, especially, its high energy content (58.68% of non-fibrous carbohydrates) [4,5]. However, its use by ruminants is limited by its low content of neutral detergent fiber (NDF), making it necessary to associate it with a source of fiber with high effectiveness [6]. This source could be sugarcane, which, as a result of the sugarcane industry crisis in recent years, has been used on a large scale by farmers in the semi-arid region of the Brazilian Northeast due to its greater availability and lower cost when compared to other roughages.

Considering that reports dealing with fresh sugarcane use in sheep feeding are scarce, there is a need for studies that evaluate the influence of the diet on confined lamb carcass quality and the impacts on sheep meat [7,8], aiming at finding alternative feeding systems adaptable to arid and semi-arid regions’ growing conditions.

It was hypothesized that there may be a sugarcane/spineless cactus ratio that could maximize carcass characteristics and leg tissue composition. Therefore, the aim of this study was to evaluate the effect of replacing sugarcane by spineless cactus (Nopalea cochenillifera Salm Dyck) in lamb feeding on the leg tissue composition, carcass characteristics, commercial cut weight and yield.

MATERIALS AND METHODS

Animal care
All procedures were conducted in accordance with the guidelines set out by the Ethics Committee on Use of Animals for Research (CEUA) of the UFRPE under license number 009/2015.

Animals, experimental design and experimental diets
The experiment was conducted at the Animal Science Department of the Federal Rural University of Pernambuco (UFRPE), Recife, Brazil. Thirty-six castrated, four-month-old, male Santa Inês lambs with an average initial body weight of 22±2.3 kg were used in a feedlot. The experimental design included randomized blocks with four treatments and nine replicates, and the animals’ initial weight was the criterion for block formation. Prior to the trial, the lambs were weighed, identified, and distributed in individual pens (1.2×1.6 m) with a feeder and drinker. In addition, the lambs were vaccinated against clostridial diseases and received treatments against endoparasites and ectoparasites, as well as vitamin supplements containing vitamin A, D, and E.

The experimental diets consisted of four levels (0%, 33%, 66%, and 100% on DM basis) of spineless cactus in replacement of sugarcane. The roughage:concentrate ratio was 48:52 on a DM basis with sugarcane (Saccharum officinarum L) and spineless cactus cv. Miúda (Nopalea cochenillifera Salm Dyck) as roughage (Tables 1, 2). The diet without spineless cactus was formulated to be isonitrogenous and to meet the nutritional requirements of lambs with 25 kg of body weight and an average daily gain of 200 g, according to the National Research Council [9].

The spineless cactus used in the experiment was from the Agronomic Institute of Pernambuco Experimental Station located in the city of São Bento do Una (harvested every 7 days with a maturity of 2 years) and sugar cane (harvested daily with a maturity of 1 year) from the Sugarcane Experimental Station from Carpina, Federal Rural University of Pernambuco, located in the municipality of Carpina. The spineless cactus and the sugarcane were processed in specific fodder processor before the supply to the animals.

Experimental procedures and sampling
The experiment lasted for 100 days, of which 30 days were for adaptation to the diets and installations, and 70 days were for data and sample collection. The animals were fed twice daily (at 08:00 and 15:00). The amount of feed supplied was corrected daily to generate 5% to 10% of orts. Feeds and orts

Table 1. Chemical composition of ingredients used in the experimental diets (g/kg of DM)

| Item                        | Sugarcane | Spineless cactus | Ground corn | Soybean meal | Wheat bran |
|-----------------------------|-----------|------------------|-------------|--------------|------------|
| Dry matter                  | 311       | 109              | 882         | 887          | 886        |
| Organic matter              | 979       | 844              | 986         | 929          | 947        |
| Crude protein               | 14.6      | 44.6             | 81.0        | 477          | 160        |
| Ether extract               | 10.2      | 14.7             | 38.7        | 13.7         | 32.4       |
| aNDF(n)                     | 488       | 243              | 119         | 134          | 363        |
| Non-fiber carbohydrates     | 450       | 534              | 576         | 296          | 383        |
| Acid detergent fiber        | 335       | 146              | 280         | 94.7         | 131        |
| Lignin                      | 58.6      | 25.1             | 6.6         | 16.2         | 38.0       |

DM, dry matter; aNDF(n), neutral detergent fiber assayed with a heat stable amylase and corrected for ash and nitrogenous compounds.
The carcasses were chilled for 24 hours in a 4°C cold room. The commercial yield was calculated as

\[ \text{CY} = \frac{\text{CW} \times 100}{\text{HCW}} \]

where CW is carcass weight and HCW is hot carcass weight. The carcasses were then sectioned into six anatomic regions [10], originating the following cuts: neck, shoulder, leg, loin, ribs, and breast. We recorded the individual weights of each cut and then calculated the yield of each cut coming from the left half of the carcass compared to its reconstituted weight.

In the left half of the carcass, a cross-section between the 12th and 13th ribs was made to measure the longissimus muscle area (LMA) of the longissimus dorsi muscle by tracing the muscle’s contour on a transparent plastic sheet for later area determination using the average of three readings from a digital planimeter (Haff, Digiplan model, Pfroment, Baviera, Germany). Additionally, a caliper was used to measure the thickness of the subcutaneous fat on the longissimus dorsi muscle section (between the last thoracic vertebra and the first lumbar) at two-thirds the total length of the LMA [10].

The left fillet of each animal was vacuum-packed in a high-density polyethylene bag and frozen at –10°C to evaluate its tissue composition. The composition was determined using the methodology described by [11], in which the 36 left fillets, which had previously been stored and were then gradually thawed while being kept at a temperature of approximately 4°C for 24 hours, were dissected. During the dissections, the five main muscles associated with the femur (biceps femur, semimembranosus, semitendinosus, quadriceps femoris, and adductor) were removed intact and then weighed to calculate the leg muscularity index according to the following formula: LMI = \[ \sqrt{\frac{W5M}{FL}} / FL \] , where W5M represents the weight of the five muscles (g) and FL is femur length (cm) [12].

### Statistical analysis

The experimental design was complete randomized blocks and the animals’ initial weight was the criterion for block formation. The variables studied were analyzed with the PROC MIXED option in SAS software (version 9.1), adopting 0.05 as the critical level of probability for type I error considering fixed effect, the treatment and random effects, the block and treatment×block variables according to the following model:

\[ Y_{ijk} = \mu + \tau_i + \beta_j + \tau\beta_{ij} + e_{ijk} \]

Where, \( Y_{ijk} \) is the experimental response measured on the treatment \( i \), block \( j \), and repetition \( k \); \( \mu \) is the general mean; \( \tau_i \) is the treatment effect \( i \), where \( i = 1, 2, 3, \) and \( 4; \) \( \beta_j \) is the block effect \( j \); \( \tau\beta_{ij} \) is the interaction effect of treatment \( i \) and block \( j \); and \( e_{ijk} \) is the random error with mean 0 and variance \( \sigma^2 \).
RESULTS AND DISCUSSION

Nutrient intake and carcass characteristics

The intakes of DM, crude protein, and digestible organic matter presented quadratic behavior with estimated maximum values of 1.320, 0.219, and 0.845 kg/d with 45%, 38.80%, and 44.93% of replacement of sugarcane by spineless cactus, respectively (Table 3). As a consequence and following the nutrient intake, the SBW, HCW, and CCW showed quadratic behavior, with estimated maximum values of 38.60, 18.70, and 18.11 kg for 40.18%, 44.42%, and 43.14% of replacement (Table 3), respectively.

The digestible organic matter quadratic behavior (44.93% of replacement) reflected the similar behavior of the parameters that determine tissue deposition in the carcass, verifying maximum values for SBW, HCW, and CCW when spineless cactus replaced sugarcane in 40.18%, 44.42%, and 43.14%, respectively. These results evidenced the influence of energy intake on tissue deposition in sheep, with consequent gains in carcasses [13,14]. The maximum values for HCW and CCW found in this study (18.70 and 18.11 kg, respectively) meet the minimum values for carcass characterization with good quality, with HCWs equal to or greater than those obtained in studies using conventional diets with corn, soybean, and Tifton grass hay in their composition [15,16].

The CY increased linearly as a function of the increase of spineless cactus in the diets (Table 3). It can be inferred that this happened due to the linear decrease observed for the GTC according to sugarcane replacement by spineless cactus, and because they are inversely proportional, the linear increase of the yield was verified. The result observed for GTC is a direct consequence of fiber intake, since sugarcane, an ingredient with low ruminal degradation fiber, low digestibility, and high retention in the tract was replaced by spineless cactus, which has low NDF content, high non-fiber carbohydrates content, and high ruminal degradation. It is likely that the replacement caused an increased passage rate in the gastrointestinal tract, since the consumption of diets with high fiber content is controlled by physical factors such as passage rate and ruminal filling [17,18].

Uniformity was observed for subcutaneous fat thickness (SFT), whose mean value was 0.84 mm. Although below the 1 to 2 mm range established by [19] for the “low fat” category, subcutaneous fat was sufficient to ensure adequate values of Cl %, which were not influenced by the replacement and showed an average of 3%, remaining within the range of 2% to 4% recommended by [20].

It is possible that low-fat deposition is related to the intrinsic factor of the Santa Inês breed, which presents low deposition of subcutaneous fat but accumulates large amounts of internal fat [21], as observed in Table 4, where internal fat deposits followed the quadratic behavior of energy intake. Moreover, it is worth mentioning that the subcutaneous fat is deposited late when compared to other fatty deposits [22], which may

Table 3. Nutrient intake and carcass characteristics of lambs fed diets containing different replacement levels of sugarcane by spineless cactus

| Item                        | Replacement levels (%) | SEM     | p value |
|-----------------------------|------------------------|---------|---------|
| Daily intake (kg/d)         |                         |         |         |
| Dry matter                  | 1.10                   | 33      | 66      | 0.974   | 0.056 | 0.009 | <0.0001 |
| Crude protein               | 0.189                  | 0.235   | 0.191   | 0.162   | 0.009 | 0.002 | 0.0001 |
| DOM                         | 0.716                  | 0.832   | 0.820   | 0.648   | 0.039 | 0.166 | 0.0003 |
| Carcass characteristics     |                         |         |         |
| GTC (kg)                    | 6.43                   | 5.68    | 5.30    | 3.84    | 0.346 | <0.0001 | 0.234 |
| SBW (kg)                    | 35.77                  | 39.24   | 36.65   | 32.78   | 1.642 | 0.027 | 0.002 |
| HCW (kg)                    | 17.17                  | 19.06   | 17.90   | 16.62   | 0.898 | 0.333 | 0.019 |
| CCW (kg)                    | 16.67                  | 18.48   | 17.38   | 16.10   | 0.872 | 0.320 | 0.019 |
| CY (%)                      | 46.53                  | 47.00   | 47.41   | 49.15   | 0.589 | 0.002 | 0.264 |
| CL (%)                      | 2.89                   | 3.12    | 2.87    | 3.13    | 0.191 | 0.578 | 0.952 |
| SFT (mm)                    | 0.88                   | 0.87    | 0.78    | 0.83    | 0.063 | 0.417 | 0.639 |
| LMA (cm²)                   | 12.68                  | 13.54   | 13.21   | 12.20   | 0.602 | 0.478 | 0.102 |
| CCI (kg/cm)                 | 0.26                   | 0.29    | 0.27    | 0.25    | 0.011 | 0.189 | 0.004 |
| LCI (cm/cm)                 | 0.55                   | 0.58    | 0.57    | 0.54    | 0.012 | 0.828 | 0.035 |
| pH 0 hours                  | 6.81                   | 6.89    | 6.97    | 6.93    | 0.064 | 0.116 | 0.338 |
| pH 24 hours                 | 5.60                   | 5.57    | 5.61    | 5.56    | 0.017 | 0.259 | 0.496 |

SEM, standard error of the mean; L, linear effect; Q, quadratic effect; DOM, digestible organic matter; GTC, gastrointestinal tract content; SBW, slaughter body weight; HCW, hot carcass weight; CCW, cold carcass weight; CY, commercial yield; CL, chilling losses; SFT, subcutaneous fat thickness; LMA, Longissimus muscle area; CCI, carcass compactness index; LCI, leg compactness index.

\[ Y = 1.117 + 0.0009x - 0.0001x^2 \]
\[ Y = 194.42 + 1.2883x - 0.0166x^2 \]
\[ Y = 714.74 + 5.7972x - 0.0645x^2 \]
\[ Y = 36.022 + 0.1286x - 0.0016x^2 \]
\[ Y = 17.322 + 0.0622x - 0.0007x^2 \]
\[ Y = 16.812 + 0.0604x - 0.0007x^2 \]
\[ Y = 262.6 + 0.963x - 0.0111x^2 \]
\[ Y = 551.09 + 1.2207 - 0.0134x \]
also have contributed to the low SFT values.

The LMA was not influenced by the replacement, presenting an average of 12.90 cm², similar to the values reported by [14], who found average values of 12.56 cm² of LMA in Santa Inês sheep carcass, and [23], who obtained an average value of 11.20 cm² for Santa Inês sheep fed Tifton grass hay and fresh spineless cactus. The average value verified for the LMA in this study is compatible with high muscular carcasses.

The CCI and LCI, variables highly correlated with carcass and leg musculature degree, respectively, also follow the quadratic behavior of energy intake. The CCI showed the maximum value of tissue storage estimated at 0.28 kg/cm with 43.37% replacement, whereas the highest LCI (0.57) was verified when spineless cactus replaced sugarcane by 45.5% (Table 3).

The replacement of sugarcane by spineless cactus did not affect the carcass pH values at 0 and 24 hours post mortem, and they were within the normal range of 5.5 to 5.8 for sheep [24], indicating that the pre-slaughter management techniques were applied efficiently, avoiding the occurrence of animal stress. Normal pH values suggest that the pre-mortem pH does not affect meat quality parameters, such as softness and color, tend to have good results, since they are directly linked to pH.

### Weights and yields of commercial cuts

The weights of the leg, loin, shoulder, and breast commercial cuts followed the energy intake, showing quadratic behavior with maximum values estimated at 2.79, 0.85, 1.46, and 1.30 kg with 49.5%, 45.3%, 39.0%, and 40.7% replacement of sugarcane by spineless cactus, respectively (Table 5). These cuts are those that accumulate a greater amount of muscular mass and, therefore, undergo stronger nutritional influence. Table 6 shows a higher proportion of muscles in the leg (67.82% on average). Higher proportions of muscle mass were also observed [25] in lambs slaughtered at 32 kg, with 67.89% for leg, 55.25% for shoulder, and 65.32% for loin. For this reason, the shoulder, leg, and loin are the most important cuts of the carcass because they are the noblest and of greatest commercial value [26].

Commercial cut yields were not influenced by replacement. The main commercial cuts of the carcass (leg, loin, and shoulder) in meat sheep breeds must show the sum of their yields close to 60% [27]. The average obtained in the sum of these cuts in the present study was 58.29%, demonstrating that the

### Table 4. Internal fat of the gastrointestinal tract of lambs fed diets containing different replacement levels of sugarcane by spineless cactus

| Items (kg)              | Replacement levels (%) | SEM  | p value |
|------------------------|------------------------|------|---------|
|                        | 0         | 33    | 66     | 100     | L | Q |
| Mesentery fat\(1\)     | 0.319     | 0.404 | 0.340  | 0.290   | 0.033 | 0.141 | 0.006 |
| Omentum fat\(1\)       | 0.549     | 0.749 | 0.653  | 0.455   | 0.065 | 0.104 | 0.0001 |
| Renal-pelvic fat\(1\)  | 0.329     | 0.462 | 0.380  | 0.296   | 0.047 | 0.236 | 0.003  |
| Total internal fat\(1\)| 1.279     | 1.719 | 1.496  | 1.136   | 0.138 | 0.147 | 0.0001 |

SEM, standard error of the mean; L, linear effect; Q, quadratic effect.
\(1\) \(Y = 327.43 + 2.5485x - 0.03x^2\). \(2\) \(Y = 559.33 + 7.7456x - 0.0889x^2\). \(3\) \(Y = 340.06 + 4.2905x - 0.0484x^2\). \(4\) \(Y = 1.3066 + 0.0159x - 0.0002x^2\). 

### Table 5. Commercial cut weight and yield of lambs fed diets containing different replacement levels of sugarcane by spineless cactus

| Items              | Replacement levels (%) | SEM  | p value |
|--------------------|------------------------|------|---------|
|                    | 0         | 33    | 66     | 100     | L | Q |
| Commercial cuts (kg)|                       |      |        |         |   |
| Leg\(1\)           | 2.54      | 2.79  | 2.64   | 2.35    | 0.166 | 0.202 | 0.044 |
| Loin\(2\)          | 0.76      | 0.86  | 0.82   | 0.73    | 0.044 | 0.446 | 0.013 |
| Shoulder\(3\)      | 1.38      | 1.49  | 1.40   | 1.28    | 0.065 | 0.134 | 0.055 |
| Breast\(4\)        | 1.17      | 1.35  | 1.22   | 1.10    | 0.077 | 0.105 | 0.005 |
| Ribs               | 1.24      | 1.32  | 1.25   | 1.17    | 0.072 | 0.350 | 0.170 |
| Neck               | 0.92      | 0.96  | 0.98   | 0.91    | 0.066 | 0.992 | 0.373 |
| Commercial cut yield (%)|                  |      |        |         |   |
| Leg                | 31.68     | 31.62 | 31.63  | 30.54   | 0.934 | 0.423 | 0.584 |
| Loin               | 9.54      | 9.89  | 9.97   | 9.75    | 0.349 | 0.660 | 0.416 |
| Shoulder           | 17.37     | 17.04 | 16.91  | 17.30   | 0.602 | 0.895 | 0.512 |
| Breast             | 14.56     | 15.31 | 14.50  | 14.49   | 0.476 | 0.609 | 0.388 |
| Ribs               | 15.42     | 15.12 | 15.15  | 15.73   | 0.436 | 0.617 | 0.315 |
| Neck               | 11.42     | 10.99 | 11.81  | 12.17   | 0.414 | 0.108 | 0.348 |

SEM, standard error of the mean; L, linear effect; Q, quadratic effect.
\(1\) \(Y = 2.553 + 0.0099x – 0.0001x^2\). \(2\) \(Y = 276.49 + 3.8528x – 0.0425x^2\). \(3\) \(Y = 1.3889 + 0.0039x – 0.00005x^2\). \(4\) \(Y = 1.8866 + 0.0057x – 0.00007x^2\).
replacement did not compromise the quality of the noblest cuts.

**Leg tissue composition**

Among the leg tissue components evaluated (Table 6), the muscles presented the highest weight (1,618.80 g), followed by bones (391.09 g) and fat (326.09 g). These tissue components present different developmental orders, where, according to [28], the bone tissue presents earlier growth, followed by muscle and, finally, adipose tissue. Analyzing these values, especially the muscular weight, it is possible to verify the aptitude of Santa Inês sheep for meat production, especially considering the average percentage of muscular deposition of 67.82%.

For tissue composition, a quadratic effect was verified for the weight of the leg, muscles, subcutaneous fat, and total fat, with maximum values estimated at 2,743.79, 1,821.9, 163.75, and 266.46 g with 43.29%, 44.70%, 52.89%, and 51.18% of replacement, respectively, which was a probable consequence on the quadratic effect observed for nutrient intake, especially energy.

The leg muscularity index, which is one of the main indicators of the number of muscles in this section, showed quadratic behavior, with a maximum value estimated at 0.38% with 61.9% of replacement. The muscle:bone ratio was not influenced by the replacement, probably because the weight of the bones did not change.

The muscle:bone ratio is an objective measure often associated with increased muscle mass deposition [12]. However, [30] stated that, from the point of view of meat quality, the muscle:fat ratio can be considered the most important, since the presence of fat has great importance in the acceptance of meat, as it influences the characteristics of texture, juiciness, and flavor.

The combination of spineless cactus and sugarcane proved to be extremely promising for use in confined sheep diets. The 44% replacement showed much higher results than in other studies. Studies by [15] and [16] with Santa Inês animals fed conventional feeds composed of Tifton grass hay, corn, and soybean and using the same roughage:concentrate ratio [15] showed a SBW of 30.7 kg, HCW of 13.2 kg, and CCW of 12.7 kg. For SBW, HCW, and CCW, [16] found 34.7, 15.9, and 15.3 kg, respectively.

Observing Table 3 and comparing with the above-mentioned values, it may be asserted that sugarcane and spineless cactus are unconventional ingredients that are suitable for sheep feed, considering that the values obtained for referred variables were higher than the verified results with these conventional diets, with SBW, HCW, and CCW values of 38.60, 18.70, and 18.11 kg, respectively.

### Table 6. Leg tissue composition of lambs fed diets containing different replacement levels of sugarcane by spineless cactus

| Component | Replacement levels (%) | SEM | p value |
|-----------|------------------------|-----|---------|
|          | 0  | 33  | 66  | 100 |       |
| Leg (g)  | 2,525.9 | 2,772.4 | 2,652.4 | 2,401.3 | 140.60 | 0.329 | 0.034 |
| Muscles (g) | 1,652.7 | 1,804.4 | 1,788.7 | 1,557.7 | 82.59 | 0.359 | 0.013 |
| Bones (g) | 494.1 | 549.3 | 497.5 | 517.2 | 32.87 | 0.900 | 0.578 |
| Subcutaneous fat (g) | 110.1 | 164.7 | 152.5 | 125.8 | 12.14 | 0.487 | 0.001 |
| Intermuscular fat (g) | 89.0 | 108.2 | 93.8 | 88.5 | 9.23 | 0.641 | 0.118 |
| Total fat (g) | 199.7 | 273.4 | 246.8 | 215.01 | 17.65 | 0.764 | 0.001 |
| Other tissues (g) | 54.1 | 65.93 | 60.81 | 60.81 | 8.50 | 0.701 | 0.495 |
| Muscles (%) | 69.67 | 66.92 | 68.48 | 66.23 | 0.990 | 0.060 | 0.803 |
| Bones (%) | 20.03 | 20.56 | 19.53 | 22.17 | 0.876 | 0.169 | 0.226 |
| Total fat (%) | 8.09 | 10.11 | 9.64 | 8.97 | 0.511 | 0.337 | 0.012 |
| Other tissues (%) | 2.21 | 2.41 | 2.36 | 2.58 | 0.271 | 0.383 | 0.963 |
| Muscle:bone | 3.49 | 3.26 | 3.81 | 3.01 | 0.319 | 0.541 | 0.382 |
| Muscle:fat | 8.78 | 6.64 | 7.38 | 7.65 | 0.505 | 0.266 | 0.028 |
| LMI | 0.36 | 0.38 | 0.39 | 0.37 | 0.008 | 0.449 | 0.019 |

SEM, standard error of the mean; L, linear effect; Q, quadratic effect; LMI, leg muscularity index.

1) $Y = 2537.6+9.634x-0.0858x^2$.
2) $Y = 199.0+7.6676x-0.0858x^2$.
3) $Y = 112.84+1.9253x-0.0182x^2$.
4) $Y = 204.63+2.416x-0.0236x^2$.
5) $Y = 8.2087+0.0668x-0.0006x^2$.
6) $Y = 8.6079-0.0619x+0.0005x^2$.

SEM: $Y = 35.903+0.1022x-0.0009x^2$. 

The tissue components of bone and other tissues were not influenced by the replacement of sugarcane with spineless cactus. The muscle:fat ratio was influenced by replacement, presenting quadratic behavior with a maximum value of 6.69% with 61.9% of replacement. The muscle:bone ratio was not influenced by the replacement, probably because the weight of the bones did not change.

The combination of spineless cactus and sugarcane proved to be extremely promising for use in confined sheep diets. The 44% replacement showed much higher results than in other studies. Studies by [15] and [16] with Santa Inês animals fed conventional feeds composed of Tifton grass hay, corn, and soybean and using the same roughage:concentrate ratio [15] showed a SBW of 30.7 kg, HCW of 13.2 kg, and CCW of 12.7 kg. For SBW, HCW, and CCW, [16] found 34.7, 15.9, and 15.3 kg, respectively.

Observing Table 3 and comparing with the above-mentioned values, it may be asserted that sugarcane and spineless cactus are unconventional ingredients that are suitable for sheep feed, considering that the values obtained for referred variables were higher than the verified results with these conventional diets, with SBW, HCW, and CCW values of 38.60, 18.70, and 18.11 kg, respectively.
CONCLUSION

The replacement of sugarcane by spineless cactus at level 44% is recommended for finishing lambs considering that this level improved most of the carcass characteristics, weights, and yields of commercial cuts and leg tissue composition.

CONFLICT OF INTEREST

We certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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