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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 semiarid 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 Ines 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 (*Nopallea 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 non-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 (*Nopallea 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.

Table 2. Proportion of ingredients and chemical composition of the experimental diets

Ingredients (g/kg)	Replacement levels (%)			
	0	33	66	100
Sugarcane	477	318	159	0
Spineless cactus	0	159	318	477
Ground corn	190	200	211	221
Soybean meal	187	177	166	156
Wheat bran	121	121	121	121
Urea/AS[1]	10	10	10	10
Salt	5	5	5	5
Mineral[2]	10	10	10	10
CP %	15.7	15.8	15.9	15.9
Diet composition (g/kg of DM)				
Dry matter	473	326	249	201
Organic matter	942	921	901	880
Matéria mineral	56.6	77.6	98.6	119
Crude protein	157	157	158	159
Ether extract	18.7	19.7	20.7	21.6
aNDF(n)	324	285	246	207
Non-fiber carbohydrates	425	441	458	474
Acid detergent fiber	246	218	190	162
Lignin	48.1	43.3	38.5	33.7

CP, crude protein; DM, dry matter; aNDF(n), neutral detergent fiber assayed with a heat stable amylase and corrected for ash and nitrogenous compounds.

[1] 9 parts of urea and 1 part of ammonium sulphate (AS).
[2] Nutrients/kg of product: Vit. A, 135.000 UI; Vit. D₃, 11,868.000 UI; Vit. E, 450 mg; Ca, 240 g; P, 71 g; K, 28.2 g; S, 20 g; Mg, 20 g; Co, 30 mg; Cu, 400 mg; Cr, 10 mg; Fe, 2,500 mg; I, 40 mg; Mn, 1,350 mg; Se, 15 mg; Zn, 1,700 mg; F (max.), 710 mg.

were weighed daily throughout the experimental period to calculate the voluntary intake.

After 70 days, the animals were solid fasted 12-hour pre-slaughter with only water access. Then, immediately before slaughter, they were weighed to obtain their slaughter body weight (SBW). At the time of slaughter, the animals were stunned by trauma to the head and were then bled at the carotid artery and the jugular vein.

The gastrointestinal tract content (GTC) was quantified by the difference between weights of the full and empty gastrointestinal tract. After skinning and evisceration, the head and the feet were removed from each animal and the hot carcass weight (HCW) was registered. Also, carcass pH readings were taken at 0 and 24 hours *post mortem* from the *Semimembranosus* muscle with the aid of a pH meter/insertion thermometer.

The carcasses were chilled for 24 hours in a 4°C cold room and hung on hooks, with the metatarsal joints spaced at 17 cm. After cooling, the carcasses were weighed, deducting the weight of the kidney and perirenal fat, to obtain the cold carcass weight (CCW) and to calculate the chilling losses (CL [%] = HCW–CCW/HCW×100). The commercial yield was calculated as CY (%) = CCW/SBW×100. After the cooling period, the following measures were taken on the whole carcass: internal length, leg length, and rump width. Subsequently, the leg compactness index (LCI), the ratio between rump width and leg length, the carcass compactness index (CCI), and the ratio between the CCW and the carcass inner length were calculated [10].

After the measurements, the carcasses were cut in half, and half of each carcass was weighed. The left half was 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, Pfronten, 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° 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 femures, semimembranosus, semitendinosus, quadriceps femoris,* and *adductor*) were removed intact and then weighed to calculate the leg muscularity index according to the following formula: LMI = $\sqrt{(W5M/FL)}$ / 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:

$$Y_{ijk} = \mu + \tau_i + \beta_j + \tau\beta_{ij} + \varepsilon_{ijk}$$

Where, Y_{ijk} is the experimental response measured on the treatment i, block j, and repetition k; μ is the general mean; τ_i is the treatment effect i, where i = 1, 2, 3, and 4; βj is the block effect j; $\tau\beta_{ij}$ = the interaction effect of treatment i and block j; and ε_{ijk} is the random error with mean 0 and variance σ²).

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	
	0	33	66	100		L	Q
Daily intake (kg/d)							
Dry matter[1]	1.10	1.350	1.198	0.974	0.056	0.009	< 0.0001
Crude protein[2]	0.189	0.235	0.191	0.162	0.009	0.002	0.0001
DOM[3]	0.716	0.832	0.820	0.648	0.039	0.166	0.0003
Carcass characteristcs							
GTC (kg)	6.43	5.68	5.30	3.84	0.346	< 0.0001	0.234
SBW (kg)[4]	35.77	39.24	36.65	32.78	1.642	0.027	0.002
HCW (kg)[5]	17.17	19.06	17.90	16.62	0.898	0.333	0.019
CCW (kg)[6]	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)[7]	0.26	0.29	0.27	0.25	0.011	0.189	0.004
LCI (cm/cm)[8]	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 área; CCI, carcass compactness índex; LCI, leg compactness índex.

[1] $Y = 1.117+0.009x-0.0001x^2$. [2] $Y = 194.42+1.2883x-0.0166x^2$. [3] $Y = 714,74+5.7972x-0.0645x^2$. [4] $Y = 36.022+0.1286x-0,0016x^2$.
[5] $Y = 17.322+0.0622x-0.0007x^2$. [6] $Y = 16.812+0.0604x-0.0007x^2$. [7] $Y = 262.6+0.963x-0.0111x^2$. [8] $Y = 551.09+1.2207-0.0134x^2$.

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[2]	0.549	0.749	0.653	0.455	0.065	0.104	0.0001
Renal-pelvic fat[3]	0.329	0.462	0.380	0.296	0.047	0.236	0.003
Total internal fat[4]	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] $Y = 1.3066+0.0159x-0.0002x^2$.

also have contributed to the low SFT values.

The LMA was not influenced by the replacement, presenting an average of 12.90 cm^2, similar to the values reported by [14], who found average values of 12.56 cm^2 of LMA in Santa Inês sheep carcass, and [23], who obtained an average value of 11.20 cm^2 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 muscularity 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 meat after slaughter [24], indicating that the pre-slaughter management techniques were applied efficiently, avoiding the occurrence of animal stress. Normal pH values suggest that other indicators of 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 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] $Y = 764.79+3.8528x–0.0425x^2$. [3] $Y = 1.3889+0.0039x–0.00005x^2$. [4] $Y = 1.8866+0.0057x–0.00007x^2$.

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		L	Q
Leg (g)[1]	2,525.9	2,772.4	2,652.4	2,401.3	140.60	0.329	0.034
Muscles (g)[2]	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)[3]	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)[4]	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 (%)[5]	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:boné	3.49	3.26	3.81	3.01	0.319	0.541	0.382
Muscle:fat[6]	8.78	6.64	7.38	7.65	0.505	0.266	0.028
LMI[7]	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] $Y = 2537.6+9.634x–01112x^2$. [2] $Y = 1650.1+7.6676x–0.0858x^2$. [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] $Y = 8.6079–0,0619x+0.0005x^2$.
[7] $Y = 35.903+0.1022x–0.0009x^2$.

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 56.77% of replacement, following the energy intake. In the present study, the deposition of adipose tissue in the leg followed the quadratic behavior of the digestible organic matter intake. Similar behavior was observed by [29], who evaluated cassava wastewater in replacement of corn and found that when energy intake decreased, fat deposition in the leg also decreased. The author attributed this to the high energy requirement for adipose tissue deposition.

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 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.

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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