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Prediction of Body and Carcass Weight of Sheep Fed with Increasing Levels of Spineless Cactus (*Nopalea cochenillifera* Salm Dyck): Carcass Characteristics, Tissue Composition, Non-Carcass Constituents †

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Simple Summary

Spineless cactus, recognized for its resilience to heat and minimal water requirements, was evaluated as a sustainable alternative to Tifton hay in lamb diets. Forty male lambs were fed diets with varying levels of cactus inclusion (0%, 15%, 30%, and 45%) and assessed for body weight, carcass traits, and tissue composition. Among the variables analyzed, only empty body weight showed a significant difference between the control group and those receiving cactus, while carcass cuts such as neck, shoulder, and leg exhibited a quadratic response to cactus inclusion. No significant changes were observed in non-carcass components or biometric measurements, yet body measurements showed a strong correlation with slaughter weight and carcass traits. The optimal replacement level was identified at 24.25% to 27.50%, suggesting that partial substitution of Tifton hay with spineless cactus can maintain animal performance while reducing feed costs and water usage. These findings are particularly relevant for farmers in semi-arid regions, where water scarcity and forage availability are major challenges. Incorporating spineless cactus into sheep diets offers a practical, cost-effective strategy to enhance sustainability in livestock production without compromising carcass quality. This approach supports more resilient farming systems and contributes to resource-efficient meat production.

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Abstract

Spineless cactus, known for its high heat tolerance and low water requirements, offers a sustainable alternative for animal feed in regions where conventional crops struggle to thrive. This study aimed to evaluate the carcass characteristics, leg tissue composition, and non-carcass constituents of lambs fed increasing levels (0, 15, 30, and 45% based on dry matter) of spineless cactus as a replacement for Tifton hay. Additionally, we estimated body

weight and carcass traits using biometric measurements (BM). Forty male lambs, with an average initial body weight of 23.6 ± 2.58 kg, were subjected to a feedlot regime. Empty body weight was the only variable that showed a significant orthogonal contrast between the control group (0%) and those fed spineless cactus ($p < 0.05$). A quadratic regression effect ($p < 0.05$) was observed for the weights of the cold half carcass, neck, shoulder, and leg cuts. No significant effects were found on non-carcass components or biometric measurements. Biometric measurements showed strong positive correlations with slaughter weight and carcass characteristics. Based on these findings, replacing 30% of Tifton hay with spineless cactus is recommended as the optimal level, as it maintains carcass quality, tissue composition, and non-carcass traits. Moreover, biometric measurements prove to be effective tools for predicting slaughter weight and carcass characteristics, offering practical value for farmers seeking efficient and sustainable production strategies. The inclusion levels of 24.25% to 27.50% of spineless cactus in the diet of confined sheep appear to be the most efficient, promoting high-value commercial cuts without compromising carcass quality parameters. These levels balance productive performance and sustainability, especially in semi-arid regions.

Keywords: carcass characteristics; carcass prediction; climate-resilient crop; *Nopalea cochenillifera*; tissue composition

1. Introduction

In any production system, the primary consideration should be ensuring that consumers receive a high-quality product that is healthy, visually pleasing, and palatable. Within meat production, one way of assessing what is being produced is through quantitative and qualitative characteristics of the carcass, the aim of which is to meet the needs of the consumer market [1,2].

With the growing consumption of sheep meat, several alternatives have been researched to meet market demand and reduce production costs. Among these, feed management stands out as one of the most critical and costly components, especially in intensive systems where animals are confined to shorten the production cycle and provide faster economic return [3,4].

In semi-arid regions—which cover approximately 15% of the Earth's surface and are home to around 14% of the global population—agriculture remains the main source of household livelihood. However, the irregular distribution of rainfall through time and space poses significant challenges to animal production. In this scenario, the use of biological elements (plant and animal) compatible with and adapted to the semi-arid environment is a promising alternative to produce food for vulnerable populations inhabiting these areas [5–7].

Spineless cactus has stood out as a sustainable feed source for sheep, especially in semi-arid regions, due to its adaptive capability, associated with its productive potential and low demand for water resources (water-use efficiency). In ruminant feeding, in addition to contributing to the supply of water to the animals, it provides an excellent source of energy, rich in non-fiber carbohydrates and total digestible nutrients. Despite having low levels of crude protein and neutral detergent fiber compared to other bulky feeds, it has high dry matter digestibility. Many studies have been conducted using cactus in the diet of sheep [8,9]. However, most existing research has focused on performance and digestibility, with limited attention to carcass traits and tissue composition. This study adds new insights

by evaluating how different levels of spineless cactus inclusion affect carcass quality and leg tissue composition, which are key parameters for consumer acceptance and market value.

The hypothesis is that partial replacement of hay with spineless cactus in the diet of confined sheep improves carcass characteristics, tissue composition, and commercial cut yields without compromising meat quality or productive parameters, and these traits can be estimated through biometric measurements.

The objective of this study was to evaluate the effects of increasing levels of spineless cactus replacing Tifton hay on sheep carcass characteristics, leg tissue composition, and non-carcass constituents. Additionally, we aimed to estimate carcass traits based on biometric measurements of the animals, providing practical tools for producers to predict carcass quality without slaughter.

2. Materials and Methods

2.1. Animals and Experimental Location

The experiment was conducted at the Experimental Station of the National Semiarid Institute (INSA), which is located in Campina Grande, Paraíba, Brazil (latitude: 7°16′37″ S and longitude: 35°58′07″ W) and presents average annual rainfall of 492.4 mm. According to Thornthwaite's classification, the local climate is tropical with an average annual temperature of 24.6 °C. The study was approved by the Animal Ethics Committee of the Federal University of Paraiba—UFPB, Brazil (Protocol number 2305/14).

Forty uncastrated male sheep, 5 months old and without a defined racial standard, were used in the experiment. The animals had an average initial and final body weight expressed as 23.69 ± 3.08 kg and 37.34 ± 3.69 kg, respectively. The experimental period lasted 78 days, including 14 days for adaptation to the diets and facilities, followed by 64 days of data collection. Lambs were housed individually in slated floor pens (1.5 m^2). Lambs were assigned to dietary treatments (8 lambs/treatment) in a completely randomized design.

The animals were identified, weighed and treated for ecto and endoparasites; then, they were randomly allocated to individual stalls with cemented floor measuring 1.0 × 2.20 m, equipped with feeding, drinking and salt troughs.

2.2. Experimental Diets

The treatments consisted of increasing levels of spineless cactus variety Baiana in the proportions of 0, 15, 30 and 45%. Tifton grass hay, corn and soybean were the other ingredients of the feed, whose chemical compositions are shown in Table 1.

Table 1. Chemical composition of the feed ingredients.

	Ingredients			
Nutrients	**Spineless Cactus**	**Tifton Hay**	**Ground Corn**	**Soybean Meal**
Dry matter, DM (g kg^{-1} as fed)	251	838	879	889
Organic matter (g kg^{-1} DM)	916	923	984	931
Crude protein (g kg^{-1} DM)	41.3	120	117	470
Ether extract (g kg^{-1} DM)	22.8	35.6	56.5	24.0
Neutral detergent fiber (g kg^{-1} DM)	175	742	143	149
Acid detergent fiber (g kg^{-1} DM)	131	385	44.9	107.8
Ash (g kg^{-1} DM)	82.3	76.2	15.4	68.8

Water was supplied at will and the intake was measured daily by weighting the water supplied and the water left 24 h later. Water loss due to evaporation was assessed by measuring the volume of water lost from an identical bucket placed out of reach of the

lambs [10]. Water intake was determined by the difference between supply and surplus, corrected for the evaporation rate.

Experimental diets were formulated according to the recommendations of NRC [11] to meet nutritional requirements, aiming for gains of 250 g/day, in a 50:50 roughage/concentrate ratio (Table 2). The experimental diets were offered ad libitum at 08 h 30 min and 16 h 00 min, in the form of total diet.

Table 2. Ingredients and chemical composition of experimental diets.

Ingredient (g kg^{-1} Dry Matter, DM)	Levels of Inclusion (%)			
	0.00	**15.0**	**30.0**	**45.0**
Ground corn	306	289	271	256
Soybean meal	175	192	210	225
Tifton hay	500	350	200	50.0
Spineless cactus	0.00	150	300	450
Urea	4.00	4.00	4.00	4.00
Mineral supplement	10.0	10.0	10.0	10.0
Calcite limestone	5.00	5.00	5.00	5.00
Chemical composition				
Dry matter (g kg^{-1} as fed)	860	633	500	414
Organic matter (g kg^{-1} DM)	926	924	922	920
Crude protein (g kg^{-1} DM)	189	183	178	171
Ether extract (g kg^{-1} DM)	39.3	36.8	34.3	31.9
Neutral detergent fiber (g kg^{-1} DM)	441	356	271	186
Acid detergent fiber (g kg^{-1} DM)	225	188	151	114
Total Carbohydrates (g kg^{-1} DM)	708	714	720	728
Non-fiber carbohydrates (g kg^{-1} DM)	267	358	449	541
Ash (g kg^{-1} DM)	69.0	71.0	73.0	74.9
Metabolizable energy (Mcal/kg DM)	2.50	2.54	2.58	2.63

The determined nutrient content [Association of Official Analytical Chemists (AOAC)] [12] of ingredients and diets are shown in Tables 1 and 2, respectively. The DM (method AOAC 934.01), crude protein (Kjeldahl method, method AOAC 984.13), ether extract (method AOAC 920.39), neutral detergent fiber (method AOAC 2002.04), acid detergent fiber (method AOAC 973.18) and ash content (method AOAC 942.05) were analyzed. Total carbohydrates were analyzed by capillary electrophoresis with ultraviolet radiation and derivatization pre-column with 250 mmolL^{-1} *p*-amin obenzoic acid (PABA) and 20% of acetic acid at 40 °C.

2.3. Slaughter and Carcass Evaluation

When the animals reached the end of the confinement period, they were weighed to obtain their final live weight, and then fasted for 16 h and weighed to obtain their body weight at slaughter (BWS).

The slaughter of all animals was carried out in the slaughterhouse within the Experimental Station of the National Semiarid Institute (INSA). Slaughter was carried out in accordance with the current RIISPOA standards [13] as follows: the animals were stunned using a captive dart gun with cerebral concussion, followed by bleeding for four minutes by sectioning the carotid and jugular arteries. The blood was collected in a pre-weighed container for later weighing.

After skinning and evisceration, head (section at the atlanto-occipital joint) and feet (section at the metacarpal and metatarsal joints) were removed and the hot carcass weight (HCW) was recorded. After obtaining the HCW, the carcasses were taken to the cold room, with an average temperature of 4 °C, where they remained for 24 h suspended on hooks by

the calcaneal tendon, and then the cold carcass weight (CCW) was obtained, according to the methodology of Cezar and Sousa [14]. Those records were used to calculate the yields:

$$\text{Hot carcass, HCY} = \text{HCW}/\text{BWS} \times 100; \quad (1)$$

$$\text{Cold carcass, CCY} = \text{CCW}/\text{BWS} \times 100; \quad (2)$$

$$\text{Cooling loss, CL (\%)} = (\text{HCW} - \text{CCW})/\text{HCW} \times 100. \quad (3)$$

Gastrointestinal tract (GIT), bladder and gallbladder were weighed full and empty to determine the empty body weight (EBW), using the following equation:

$$\text{EBW} = \text{BWS} - [(\text{FGIT} - \text{EGIT}) + \text{urine} + \text{bile}] \quad (4)$$

Empty body weight is a variable used as a basis for calculation of biological yield.

$$\text{Biological yield, BY(\%)} = \text{HCW}/\text{EBWz} \times 100. \quad (5)$$

All the non-carcass constituents, whether edible or not, were weighed and the viscera were emptied, washed and weighed again to determine the yields of buchada and panelada. Blood, liver, kidneys, lungs, spleen, tongue, heart, omentum, rumen, reticulum, omasum and small intestine were considered as constituents of the buchada [15].

The carcasses were sectioned at the ischio-pubic symphysis, following the body and spinous apophysis of the sacrum, lumbar and dorsal vertebrae. The carcass was then cut lengthways. The left half carcass was weighed and then the internal carcass length and leg length were measured, according to the methodology proposed by Cezar and Sousa [14]. Based on these measures, it was possible to calculate the carcass compactness index using Equation (6).

$$\text{CCI (kg/cm)} = \text{CCW}/(\text{Carcass internal length}) \quad (6)$$

And the leg compactness index (LCI), based on the ratio between croup width and leg length [14], was calculated.

The half carcasses were sectioned into six anatomical regions that made up the commercial cuts, neck, shoulder, ribs, flank, loin and leg, according to the methodology of Cezar and Sousa [14]. The individual weight of each cut was recorded to calculate its proportion in relation to the sum of the reconstituted half carcass, thus obtaining the yield of the carcass cuts.

From the left half carcass, a cross section was made between the 12th and 13th ribs, exposing the cross section of the Longissimus thoracis muscle, whose area was traced by means of a permanent marker, with an average tip size of 2.0 mm, on a transparent plastic film for loin eye area (LEA) determination.

Additionally, subcutaneous fat thickness (SFT) was measured on the Longissimus thoracis using a caliper, taken at the insertion of the 12th and 13th ribs, which have high and positive correlation with fat distribution in the carcass [16].

The left legs of each animal were packed in a high-density polyethylene bag and frozen at −18 °C to assess their tissue composition. To determine this composition, the left leg of each animal was dissected according to the methodology described by Brown and Williams [17], and then previously gradually thawed and kept at a temperature of approximately 4 °C for 24 h.

Using a scalpel, tweezers and scissors, the following tissue groups were separated: subcutaneous fat, intermuscular fat (all the fat located below the deep fascia, associated with the muscles), muscle (total weight of the dissected muscles after completely removing all the adhered intermuscular fat), bone (total weight of the leg bones) and other tissues

(all the unidentified tissues, consisting of tendons, glands, nerves and blood vessels). By dissecting the leg, the weights and yields of the dissected tissues were obtained, and the percentage of tissue components was calculated in relation to the reconstituted weight of the leg after dissection. The muscle/bone, muscle/fat and subcutaneous fat/intermuscular fat ratios were then obtained.

To calculate the leg muscularity index (LMI), the five main muscles surrounding the femur (Biceps femoris, Semimembranosus, Semitendinosus, Quadriceps femoris and Adductor) were dissected, removed in their entirety and then weighed. LMI was calculated according to the following equation:

$$LMI = \sqrt{(5MW/FL)/FL}, \quad (7)$$

where MW represents the weight of the five muscles (g) and FL is the femur length (cm) [18].

2.4. Biometric Measures

Biometric measures (BM) were taken on all lambs 24 h before slaughter, as described by Cezar and Sousa [14]. Body length (BL), croup height (CRH), chest width (CW), croup width (CRW), leg perimeter (LP), chest perimeter (CP), leg length (LL), external height (EH), withers height (WH) and body condition score (BCS) were measured. A flexible fiberglass tape (Truper®) and a 65 cm wide caliper (Haglof®) were used for all measurements. BM were expressed in cm, which was considered to be related to carcass composition [19].

After slaughter, the carcass was weighed (HCW) and divided by the dorsal midline into two halves and refrigerated for a period of 24 h at 4 °C. Subsequently, the viscera and organs (VIS: blood, liver, heart, kidneys, lungs, empty intestines, gallbladder, tongue and spleen) were removed and weighed. The internal fat (IF) consisted of the pelvic fat (around the kidneys and pelvic region) and the fat around the gastrointestinal tract (omental and mesenteric). The gastrointestinal tract (GIT) was weighed full and empty. Empty body weight (EBW) was calculated as the body weight at slaughter minus GIT, urine and bile. The waste parts of the carcass (OFF) were added together (skin, head, feet, tail, internal fat, testicles and blood).

2.5. Statistical Analysis and Model Development

The data obtained was evaluated using analysis of variance. When significant by the F test, the effect of spineless cactus in replacement of Tifton hay was analyzed by first-degree regression: $yij = \beta0 + \beta1 * x + \varepsilon ij$, and second degree: $yij = \beta0 + \beta1 * x + \beta2 * x^2 + \varepsilon ij$; yij: observed value; β0, β1 e β2: parameters of the equation; x: levels of spineless cactus; εij: random error, associated with each observed value i and j. The equations that showed significant effect ($p < 0.05$) and higher coefficient of determination (R^2) were selected.

Contrast analysis is a practical approach to analyze experimental data regarding the main, interaction and nested effects. Contrast analysis can be used on experimental designs that do not fit into defined structures and also to obtain more precise and specific comparisons between groups of means (control vs. treatments at different levels, for instance). The significance of the contrast was determined by comparing the Fcontrast (Fcontrast = MScontrast/MSerror) with the Fcritical at 5% of significance. Animal was used as the experimental unit.

Additionally, equations were created to estimate BWS, EBW, HCW, CCW and LEA using biometric measurements. A descriptive statistical analysis was performed using PROC SUMMARY. The PROC CORR command estimated Pearson's correlation coefficients among variables. The STEPWISE and Mallow's Cp options were used in the SELECTION statement to select the variables included in the model. The goodness of fit of the developed

equations was assessed based on R^2 and RMSE. All statistical procedures were performed by SAS OnDemand software 8.3.

3. Results

Carcass characteristics were not affected ($p > 0.05$) by the increasing levels of spineless cactus (Table 3). However, EBW showed an orthogonal contrast. Carcass morphometric measures (Table 4) showed no significant effect ($p > 0.05$) with the inclusion of spineless cactus in the diet. The weight and yield of the cuts, except for the weight of the shoulder, neck and leg, showed no significant effect ($p > 0.005$) (Table 5). The weight of the cold half carcass, shoulder, neck and leg showed quadratic regressive response.

Table 3. Carcass characteristics of lambs fed increasing levels of spineless cactus (*Nopalea cochenillifera* Salm Dyck) variety Baiana.

Variables	Inclusion Levels (%)				SEM	*p*-Value	
	0	15	30	45		L	Q
IW (kg)	24.4	23.9	24.1	22.4	3.08	0.1735	0.5113
FW (kg)	37.4	37.6	38.1	36.3	3.69	0.7179	0.6365
BWS (kg)	33.56	34.78	36.55	33.40	3.61	0.800	0.063
EBW (kg)	28.97 *	31.05	32.91	30.86	3.56	0.144	0.074
HCW (kg)	17.41	18.03	19.35	17.96	1.71	0.229	0.072
CCW (kg)	17.02	17.64	18.92	17.51	1.70	0.261	0.066
HCY (%)	52.58	51.73	53.04	53.81	3.82	0.360	0.507
BY (%)	61.32	58.00	58.86	58.29	5.19	0.270	0.407
CCY (%)	51.38	50.62	51.86	52.45	3.79	0.409	0.575
CL (%)	2.29	2.17	2.24	2.53	0.42	0.194	0.129
LEA (cm^2)	12.20	13.16	13.51	12.76	2.00	0.471	0.184
SFT (mm)	2.00	1.75	2.09	1.77	0.49	0.748	0.891

IW—Initial weight; FW—Final weight; BWS—Body weight at slaughter; EBW—Empty body weight; HCW—Hot carcass weight; CCW—Cold carcass weight; HCY—Hot carcass yield; BY—Biological yield; CCY—Cold carcass yield; CL—Cooling loss; LEA—Loin eye area; SFT—Subcutaneous fat thickness. * orthogonal contrast = control vs. cactus pear inclusion levels ($p < 0.001$); SEM—Standard error of the mean; L—Linear; Q—Quadratic.

Table 4. Morphometric measures, indices and carcass fat thickness of lambs fed increasing levels of spineless cactus.

Variables	Inclusion Levels (%)				SEM	*p*-Value	
	0	15	30	45		L	Q
External length (cm)	57.16	57.56	59.34	56.78	3.56	0.899	0.196
Internal length (cm)	60.30	61.11	60.22	59.89	2.86	0.603	0.531
Leg Length (cm)	39.35	40.00	39.78	39.94	1.98	0.581	0.702
Croup width (cm)	19.11	21.58	21.82	21.81	3.17	0.070	0.224
Chest width (cm)	21.84	21.90	21.64	22.10	1.85	0.842	0.737
Leg perimeter (cm)	35.90	35.67	35.17	38.44	2.74	0.074	0.050
Croup Perimeter (cm)	60.35	60.30	60.63	62.16	4.07	0.324	0.545
Chest Perimeter (cm)	70.10	72.50	73.62	71.70	3.97	0.298	0.093
Chest depth (cm)	27.95	28.67	28.67	28.28	1.12	0.536	0.125
CCI (kg/cm)	0.28	0.29	0.31	0.29	0.03	0.179	0.116
LCI (cm^2)	0.49	0.54	0.55	0.55	0.09	0.111	0.303

CCI = Carcass compactness index; LCI = Leg compactness index; SEM—Standard error of the mean; * orthogonal contrast = control vs. cactus pear inclusion levels ($p < 0.001$); L—Linear; Q—Quadratic.

Tissue composition variables, ratios and muscularity indices, except for the cooled leg, showed no significant effect ($p > 0.005$) (Table 6). The weights of non-carcass constituents used as ingredients for the preparation of "buchada" were not affected ($p > 0.05$) by the increasing levels of inclusion of spineless cactus in the lambs' diet (Table 7).

Table 5. Weight and yield of commercial cuts of lambs fed with increasing levels of spineless cactus (*Nopalea cochenillifera* Salm Dyck) variety Baiana.

Variables	Inclusion Levels (%)				SEM	Regression	
	0	15	30	45		L	Q
Cold half-carcass weight (kg)	8.04	8.36	8.84	8.19	0.75	0.382	0.048 [1]
Neck (kg)	0.91	0.96	1.01	0.90	0.11	0.987	0.036 [2]
Shoulder (kg)	1.34	1.43	1.51	1.41	0.13	0.127	0.026 [3]
Flank (kg)	1.25	1.26	1.34	1.28	0.14	0.414	0.413
Ribs (kg)	1.36	1.30	1.43	1.29	0.22	0.750	0.546
Loin (kg)	0.80	0.81	0.87	0.81	0.11	0.513	0.229
Leg (kg)	2.41	2.60	2.65	2.49	0.24	0.380	0.025 [4]
Cuts yield (%)							
Neck	11.28	11.45	11.42	10.98	0.96	0.497	0.318
Shoulder	16.64	17.12	17.13	17.33	0.94	0.124	0.646
Ribs	15.50	15.11	15.28	15.62	0.98	0.699	0.244
Flank	16.85	15.55	16.12	15.70	1.92	0.298	0.474
Loin	9.87	9.68	9.90	9.89	0.87	0.829	0.752
Leg	29.87	31.09	30.15	30.48	1.58	0.691	0.377

[1] $y = -0.0011x^2 + 0.0547x + 7.9755$ $R^2 = 0.77$; [2] $y = -0.0002x^2 + 0.0081x + 0.902$ ($R^2 = 0.83$); [3] $y = -0.0002x^2 + 0.0109x + 1.333$ ($R^2 = 0.92$); [4] $y = -0.0004x^2 + 0.0194x + 2.4065$ ($R^2 = 0.99$) * orthogonal contrast = control vs. cactus pear inclusion levels ($p < 0.001$); SEM—Standard error of the mean; L—Linear; Q—Quadratic.

Table 6. Tissue composition, ratios and muscularity index of lamb's leg as a function of inclusion levels of cactus pear.

Variables	Inclusion Levels (%)				SEM	*p*-Value	
	0	15	30	45		L	Q
Cooled leg (kg)	2.32 *	2.54	2.61	2.38	0.24	0.458	0.005 [1]
Bones (%)	13.99	14.77	14.09	15.32	1.79	0.200	0.693
Muscle (%)	61.68	62.48	62.45	64.08	5.23	0.340	0.693
Fat (%)	20.10	17.54	18.81	16.25	5.23	0.235	0.998
Other tissues (%)	4.23	5.21	4.65	4.38	1.45	0.948	0.177
Muscle/Bone	4.53	4.27	4.47	4.24	0.68	0.500	0.941
Muscle/Fat	3.70	3.96	3.62	4.05	1.29	0.708	0.830
LMI (g/cm)	0.41	0.42	0.43	0.41	0.04	0.757	0.168

LMI = Leg muscularity index. * orthogonal contrast = control vs. cactus pear inclusion levels ($p < 0.001$). [1] $y = 2.3125 + 0.0242x - 0.0005x^2$ ($R^2 = 0.98$); SEM—Standard error of the mean; L—Linear; Q—Quadratic.

Table 7. Weights and yields of non-carcass constituents used to produce "buchada".

Variables (kg)	Inclusion Levels (%)				SEM	*p*-Value	
	0	15	30	45		L	Q
Tongue	0.09	0.08	0.09	0.08	0.02	0.221	0.792
Liver	0.60	0.64	0.66	0.67	0.12	0.122	0.712
Heart	0.14	0.15	0.15	0.15	0.02	0.693	0.221
Spleen	0.06	0.08	0.06	0.06	0.03	0.782	0.257
Blood	1.34	1.41	1.41	1.40	0.21	0.585	0.552
Kidneys	0.11	0.11	0.11	0.11	0.01	0.943	0.633
Lungs	0.30	0.32	0.31	0.31	0.06	0.789	0.402
GIT	1.92	2.12	2.13	1.94	0.38	0.895	0.105
Head	1.82	1.86	2.03	1.84	0.19	0.381	0.078
Feet	0.75	0.79	0.82	0.80	0.09	0.181	0.302
"Buchada" yield: EBW (%)	18.95	18.46	17.81	18.25	2.47	0.438	0.560

GIT = Gastrointestinal tract, EBW = Empty body weight; SEM—Standard error of the mean; * orthogonal contrast = control vs. cactus pear inclusion levels ($p < 0.001$); L—Linear; Q—Quadratic.

The average, maximum and minimum values for the biometric measures and carcass characteristics are shown in Table 8. In this study, the biometric measures (BM) were used to predict carcass characteristics of the crossbred lambs through equations (Table 9). Among the biometric measures and carcass characteristics analyzed, the internal fat was the measure that showed the greatest variation (44.75%). The prediction equations for the variables BWS and EBW showed R^2 ranging from 0.49 to 0.88 and 0.47 to 0.63, respectively. The BM included in the models to predict the weight variables were LP, CW, LL, CRH, WH and CRW. Equation (1) (R^2 = 0.49), which includes LP, was correlated with BWS. Equations (6) and (7) presented R^2 = 0.85 and 0.88 and showed good correlation between CW and CRW with LL.

Table 8. Descriptive analysis of the data measured on the lambs.

Variables	μ ± SD	Maximum	Minimum
Biometric measures			
Body length (BL)	64.38 ± 5.19	75.20	54.00
Withers height (WH)	61.58 ± 3.10	68.70	56.50
Croup height (CRH)	64.60 ± 3.73	71.10	55.10
Croup width (CRW)	20.18 ± 1.91	25.50	17.50
Chest width (CW)	18.99 ± 1.51	22.00	17.10
Leg perimeter (LP)	41.74 ± 4.61	49.00	30.00
Chest perimeter (CP)	76.76 ± 2.98	81.80	70.00
Croup perimeter (CRP)	79.77 ± 2.98	88.70	62.00
Leg length (LL)	46.31 ± 3.45	54.30	38.60
Body condition score (BCS)	2.94 ± 0.51	4.00	2.00
Carcass characteristics			
Hot carcass weight (HCW)	17.28 ± 1.77	21.32	14.14
Cold carcass weight (CCW)	16.87 ± 1.74	20.90	13.78
Hot carcass yield (HCY)	53.28 ± 4.72	69.68	47.76
Cold carcass yield (CCY)	52.00 ± 4.63	67.93	46.48
Loin eye area (LEA)	12.57 ± 1.37	16.84	10.79
Internal fat (IF)	1.66 ± 0.74	3.99	0.66
Viscera (VIS)	4.58 ± 0.79	6.63	3.42
OFF	8.55 ± 1.07	11.01	6.52

OFF = skin, head, feet, tail, internal fat, testicles and blood; SD—standard deviation.

Table 9. Regression equations to predict some in vivo characteristics of lambs fed increasing levels of spineless cactus.

No.	Equation	Equation	R^2	RMSE	*p*-Value
BWS					
1	BWS (kg) = −7.40 (±8.33) + 0.92 (±0.38) CW + 0.54 (±0.12) LP		0.62	2.48	<0.0001
2	BWS (kg) = −21.48 (±10.93) + 0.96 (±0.36) CW + 0.54 (±0.12) LP + 0.29 (±0.15) LL		0.69	2.32	<0.0001
3	BWS (kg) = −5.62 (±12.24) + 0.60 (±0.36) CW + 0.67 (±0.12) LP − 0.53 (±0.24) WH + 0.71 (±0.24) LL		0.76	2.09	<0.0001
4	BWS (kg) = −19.98 (±13.39) + 0.79 (±0.35) CW + 0.64 (±0.11) LP + 0.390 (±0.20) WH − 0.71 (±0.24) CRH + 0.70 ± (0.22) LL		0.81	1.91	<0.0001
5	BWS (kg) = −29.02 (±13.50) + 0.43 (±0.24) CRW + 0.61 (±0.34) CW + 0.640 (±0.10) LP + 0.45 (±0.19) WH − 0.77 ± (0.22) CRH + 0.78 (±0.21) LL		0.85	1.78	<0.0001
6	BWS (kg) = −21.05 (±13.52) − 0.17 (±0.10) BL + 0.49 (±0.23) CRW + 0.44 (±0.33) CW + 0.75 (±0.12) LP + 0.33 (±0.19) WH − 0.73 (±0.19)		0.88	1.67	<0.0001
EBW					
7	EBW (kg) = −12.24 (±8.29) + 1.01 (±0.38) CW + 0.56 (±0.12) LP		0.63	2.47	<0.0001

BWS: body weight at slaughter, EBW: empty body weight, LP: leg perimeter, CW: chest width, LL: leg length, CRH: croup height, WH: withers height, CRW: croup width, BL: body length.

Hot carcass weight and CCW showed R^2 ranging from 0.65 to 0.90 (Table 10), and the BM included in the models were CP, BCS, LL, LP and WH. The equation with CP showed R^2 = 0.65 with a good fit for estimation of CCW. The R^2 value of the prediction equations for HCY and CCY was low (0.19) and of the BM, the only one included was CRP (Table 10).

Table 10. Prediction equations for the carcass characteristics of lambs fed increasing levels of spineless cactus.

No. Equation	Equation	R^2	RMSE	*p*-Value
HCW				
1	HCW = −19.53 (±6.30) + 0.48 (±0.08) CP	0.66	1.07	<0.0001
2	HCW = −16.53 (±5.35) + 0.39 (±0.07) CP + 1.31 (±0.44) BCS	0.77	0.89	<0.0001
3	HCW = −20.42 (±5.28) + 0.36 (±0.07) CP + 0.11 (±0.06) LL + 1.48 (±0.41) BCS	0.82	0.81	<0.0001
4	HCW = −17.42 (±4.98) + 0.10 (±0.05) LP + 0.27 (±0.08) CP + 0.12 (±0.05) LL + 1.40 (±0.37) BCS	0.87	0.74	<0.0001
5	HCW = −12.28 (±5.12) + 0.12 (±0.04) LP + 0.25 (±0.07) CP − 0.12 (±0.06) WH + 0.18 (±0.05) LL + 1.50 (±0.33) BCS	0.90	0.66	<0.0001
CCW				
6	CCW = −19.43 (±6.22) + 0.47 (±0.09) CP	0.65	1.05	<0.0001
7	CCW = −16.22 (±5.24) + 0.38 (±0.07) CP + 1.31 (±0.43) BCS	0.78	0.87	<0.0001
8	CCW = −20.18 (±5.18) + 0.36 (±0.07) CP + 0.11 (±0.05) LL + 1.48 (±0.40) BCS	0.82	0.80	<0.0001
9	CCW = −17.26 (±4.89) + 0.10 (±0.05) LP + 0.26 (±0.08) CP + 0.12 (±0.06) LL + 0.14 (±0.37) BCS	0.86	0.72	<0.0001
10	CCW = −12.03 (±5.12) + 0.12 (±0.04) LP + 0.24 (±0.07) CP − 0.12 (±0.06)WH + 0.18 (±0.05) LL + 1.50 (±0.33) BCS	0.90	0.65	<0.0001
LEA				
11	LEA = 0.43 (±3.02) + 0.10 (±0.04) BL + 1.91 (±0.04) BCS	0.60	0.92	<0.0001

HCW = hot carcass weight, CCW = cold carcass weight, LEA = loin eye area, LP: leg perimeter, BL: body length, CRH: croup height, WH: withers height, BCS: body condition score, CP: chest perimeter, LL: leg length.

4. Discussion

The inclusion of spineless cactus resulted in a higher empty body weight in the animals of the control group, probably due to the higher fiber content in the diet of this treatment (Table 2), which influenced digestibility and reduced the passage rate, increasing gastrointestinal content at the time of slaughter. This result reinforces the importance of diet composition in the digestive dynamics of ruminants, especially in intensive systems [20,21].

The absence of a significant effect on carcass yield may be related to the similarity in live weight and age of the animals, intrinsic factors that directly influence this parameter. The average cold carcass yield (51.54 ± 3.70%) falls within the range recommended in the literature (40–60%) [22], and the biological yield values (58.92 ± 4.87%) were higher than those normally found (40–50%) [23], suggesting good feed conversion efficiency even with partial replacement of hay by cactus. These results are relevant, as carcass yield is directly related to meat production and the commercial value of the product.

Cooling loss (2.31 ± 0.415%) was not affected by the treatments, indicating uniformity in fat cover and good handling and storage conditions of the carcasses. Lower losses are associated with better fat coverage, indicating protection against dehydration during cooling [22–24].

Loin eye area and subcutaneous fat thickness did not show significant variations, which may be explained by the similarity in body weight at slaughter. However, fat thickness is highly variable and depends on factors such as breed, sex, nutritional plan, and carcass weight [25,26]. A minimum fat cover is essential to protect the carcass during cooling and freezing processes.

The carcass compactness index was higher than those reported in the literature [11,27], suggesting greater deposition of muscle tissue per unit area. This may be related to the

energy composition of cactus, which is rich in non-fiber carbohydrates and digestible nutrients [7], favoring muscle development [28,29].

The commercial cuts (shoulder, loin, and leg) accounted for 57.41% of the carcass, a value close to the ideal 60% for specialized breeds [30,31]. This indicates that even crossbred animals fed with cactus can present competitive commercial performance. The proportion of these cuts is an important parameter for assessing carcass commercial quality [32].

The average tissue composition (62.67% muscle, 14.54% bone, and 18.17% fat) indicates high-quality carcasses. These results may be related to the efficiency of ruminal microorganisms in synthesizing amino acids, due to the greater supply of fermentable energy provided by cactus [7]. However, statements such as "greater microbial protein may have a positive impact on tissues" are speculative and should be interpreted with caution, as they were not directly measured in this study [33,34].

The estimated "buchada" yield in relation to empty body weight varied among treatments, and although the organs have low individual commercial value, they can add value when used in traditional dishes or sausages [35,36].

In predicting carcass traits based on biometric measurements, R^2 values varied widely (0.49 to 0.90). Although high values indicate good fit, R^2 above 0.85 may suggest overfitting, especially in small samples. Therefore, it is necessary to validate the models with external data and apply methods such as cross-validation to ensure robustness.

The generated equations should be compared with previously published models to assess their external validity. For example, studies such as those by Alphonsus et al. [35] and Hernandez-Espinoza et al. [37] have already identified measurements such as withers height and chest perimeter as good predictors of body weight and carcass yield. Including these comparisons strengthens the applicability of the proposed models.

The prediction equation for loin eye area showed an R^2 of 0.60, and the biometric measurements included were body length and body condition score [17]. The prediction of hot and cold carcass yield showed low R^2 values, with chest perimeter being the only correlated measurement. Although Hernandez-Espinoza et al. [37] reported an association between yield and withers height, our results indicated correlation only with chest perimeter.

5. Conclusions

The inclusion levels of 24.25% to 27.50% of spineless cactus in the diet of confined sheep appear to be the most efficient, promoting high-value commercial cuts without compromising carcass quality parameters. These levels balance productive performance and sustainability, especially in semi-arid regions.

Partial replacement of hay with spineless cactus in the diet of confined sheep proved to be a viable and sustainable alternative for semi-arid regions, promoting satisfactory carcass and commercial cut performance, with emphasis on carcass compactness index and muscle tissue proportion. Although no significant changes were observed in some parameters, such as carcass yield and fat thickness, the results indicate that cactus can be used without compromising carcass quality.

The prediction equations based on biometric measurements showed potential for estimating carcass traits, although it is necessary to validate these models with external populations to ensure their applicability in different production systems. Furthermore, complementary data on meat quality, already published in a parallel study, reinforce the benefits of spineless cactus in sheep feeding.

Therefore, spineless cactus stands out as a strategic resource for animal production in environments with low water availability, contributing to food security and the enhancement of local production. Future studies are recommended to include economic

analyses, diet digestibility assessments, and validation of predictive models, expanding the applicability of the results in commercial and scientific contexts.

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References

1. Silva, N.V.; Silva, J.H.V.; Coelho, M.S.; Oliveira, E.R.A.; Araújo, J.A.; Amâncio, A.L.L. Características de carcaça e carne ovina: Uma abordagem das variáveis metodológicas e fatores de influência. *Acta Vet. Bras.* **2008**, *2*, 103–110. [CrossRef]
2. Liu, J.; Ellies-Oury, M.P.; Stoyanchev, T.; Hocquette, J.F. Consumer Perception of Beef Quality and How to Control, Improve and Predict It? Focus on Eating Quality. *Foods* **2022**, *11*, 1732. [CrossRef]
3. Ferro, D.A.C.; Aquino, L.M.; Ferro, R.A.C.; Silva, B.P.A.; Santos, K.J.G.; Santos, A.P.P.; Bueno, C.P.; Paula, R.S. Performance and carcass and meat quality of crossbred sheep confined with and without access to artificial shade. *Revista Rev. Bras. Saúde Prod. Anim.* **2022**, *23*, e22232022. [CrossRef]
4. Huang, J.Y.; Li, C.; Fu, F.; Chen, Q.; Fu, A.; Dai, M.; Shinoda, Z.; Ma, W.; Guo, Z.; Li, L.; et al. Dryland climate change: Recent progress and challenges. *Ver. Geophys.* **2017**, *55*, 719–778. [CrossRef]
5. Moura, M.S.C.M.; Guim, A.; Batista, A.M.V.; Maciel, M.V.; Cardoso, D.B.; Lima Júnior, D.M.; Carvalho, F.F.R. The inclusion of spineless cactus in the diet of lambs increases fattening of the carcass. *Meat Sci.* **2020**, *160*, 107975. [CrossRef] [PubMed]
6. Pereira, C.J.; Silva, J.O.; Rodrigues, P.M.S.; Cavalcanti, A.C. Consequences of land use changes on seed fate and demography in the palm tree Syagrus coronata (Mart.) Becc. (Arecaceae). *Folia Geobot.* **2021**, *56*, 227–239. [CrossRef]
7. Wanderley, W.L.; Ferreira, M.A.; Andrade, D.K.B.; Véras, A.S.C.; Farias, I.; Lima, L.E.; Dias, A.M.A. Replacement of Forage Cactus (Opuntia ficus indica Mill) for Sorghum Silage (*Sorghum bicolor* (L.) Moench) in the Dairy Cows Feeding. *R. Bras. Zootec.* **2002**, *31*, 273–281. [CrossRef]
8. Vasconcelos, A.G.V.; Lira, M.A.; Cavalcanti, V.L.B.; Santos, M.V.F.; Willadino, L. Seleção de clones de palma forrageira resistentes à cochonilha do carmin (Dactylopius opuntiae). *R. Bras. Zootec.* **2009**, *38*, 827–831. [CrossRef]
9. Bezerra, S.B.L.; Carvalho, F.F.R.; Véras, R.M.L.; Batista, A.M.V.; Cabral, A.M.D.; Lucas, L.C.O.; Pereira Neto, J.D. Morphometric Measurements of Carcasses of Sheep Fed Diets with Different Levels of Cactus Pear. *Rev. Cient. Prod. Anim.* **2012**, *14*, 231–234. [CrossRef]
10. Mdletshe, Z.M.; Chimonyo, M.; Marufu, M.C.; Nsahlai, I.V. Effects of saline water consumption on physiological responses in Nguni goats. *Small Rumin. Res.* **2017**, *153*, 209–211. [CrossRef]
11. NRC. *Nutrient Requirements of Small Ruminants: Sheep, Goats, Cervids, and New World Camelids*, 1st ed.; National Academy Press: Washington, DC, USA, 2007; 384p.
12. Brasil, Ministério da Agricultura; Pecuária e do Abastecimento (MAPA); Secretaria da Defesa Agropecuária (SDA); Departamento de Inspeção de Produtos de Origem Animal (DIPOA); Divisão de Normas Técnicas. *Instrução Normativa n°3, de 17 de Janeiro de 2000*; Lex: Diário Oficial da União de 24 de janeiro de 2000, Seção 1; Brasil, Ministério da Agricultura: Brasília, Brazil, 2000.
13. Association of Official Analytical Chemists (AOAC). *Official Methods of Analysis*, 17th ed.; AOAC: Arlington, VA, USA, 2005.
14. Cezar, M.F.; Sousa, W.H. *Carcaças Ovinas e Caprinas: Obtenção, Avaliação e Classificação*, 1st ed.; Editora Agropecuária Tropical: Uberaba, Brazil, 2007; 147p.
15. Medeiros, G.R.; Carvalho, F.F.R.; Ferreira, M.A.; Alves, K.S.; Mattos, C.W.; Saraiva, T.A.; Nascimento, J.F. Effect of concentrate levels on non carcass components of the Morada Nova hair sheep in feedlot. *R. Bras. Zootec.* **2008**, *37*, 1063–1071. [CrossRef]

16. McManus, C.; Paim, T.P.; Louvandini, H.; Dallago, B.S.L.; Dias, L.T.; Teixeira, R.A. Ultrassonography evaluation of Sheep carcass quality of Santa Inês Breed. *Ciênc. Anim. Bras.* **2013**, *14*, 8–16. [CrossRef]
17. Brown, A.J.; Williams, D.R. *Sheep Carcass Evaluation: Measurement of Composition Using a Standardized Butchery Method*; Agricultural Research Council: Langford, BC, Canada; Meat Research Council: Langford, BC, Canada, 1979; 16p, (Memorandum, 38).
18. Purchas, R.W.; Davies, A.S.; Abdukkah, A.Y. An objective measure of muscularity: Changes with animal growth and differences between genetic lives of South down sheep. *Meat Sci.* **1991**, *30*, 81–94. [CrossRef]
19. Fernándes, H.J.; Tedeschi, L.O.; Paulino, M.F.; Paiva, L.M. Determination of carcass and body fat compositions of grazing crossbred bulls using body measurements. *J. Anim. Sci.* **2010**, *88*, 1442–1453. [CrossRef]
20. Pinho, A.C.A.; Pessoa, R.A.S.; Batista, A.M.V.; Véras, A.S.C.; Cardoso, D.B.; Santos, K.C.; De Lima, D.M., Jr.; De Carvalho, F.F.R. Spineless Cactus-Based Diets Associated with Various Nitrogen Sources: Effects on Intake, Digestibility, Rumen Kinetics and Nitrogen Balance in Sheep. 2020. Available online: https://scielo.org.za/pdf/sajas/v51n6/08.pdf (accessed on 20 March 2025).
21. Ferraz, L.V.; Pessoa, R.A.S.; Milanês, T.O.; Maciel, M.I.S.; Suassuna, J.M.A.; dos Santos, K.C.; Cardoso, D.B.; de Lima, D.M., Jr.; Véras, A.S.C.; de Carvalho, F.F.R. Nitrogen Sources in Spineless Cactus-Based Diets for Sheep in Finishing. 2021. Available online: https://www.researchsquare.com/article/rs-547192/v1 (accessed on 20 March 2025).
22. Sañudo, C.; Sierra, I. Calidad de la canal en la espécie Ovina. *Ovino* **1986**, *1*, 127–153.
23. Oliveira, D.S.; Rogério, M.C.P.; Batista, A.S.M.; Alves, A.A.; Albuquerque, F.H.M.A.R.; Pompeu, R.C.F.F.; Guimarães, V.P.; Duarte, T.F. Performance and carcass characteristics of lambs SPRD crossbreed with Santa Inês and Somalis Brasileira feedlot finished. *Rev. Bras. Saúde Prod. Anim.* **2014**, *15*, 937–946. [CrossRef]
24. Martins, R.R.C.; Oliveira, N.M.; Osório, J.C.S.; Osório, M.T.M. *Peso Vivo ao Abate Como Indicador do Peso e das Características Quantitativas e Qualitativas das Carcaças em Ovinos Jovens da Raça Ideal*; Embrapa Pecuária Sul: Bagé, Brazil, 2000; Volume 29, (Boletim de Pesquisa, 21).
25. Pires, C.C.; Galvani, D.B.; Carvalho, S.; Cardoso, A.R.; Gasperin, B.G. Carcass characteristics of lambs fed diets with different neutral detergent fiber levels. *R. Bras. Zootec.* **2006**, *35*, 2058–2065. [CrossRef]
26. Louvandini, H.; McManus, C.; Dallago, B.S.; Machado, B.D.; Antunes, D.A. Evaluation of carcass traits, non-carcass components and 12 (th) rib analysis of hair sheep supplemented with phosphorus. *R. Bras. Zootec.* **2006**, *35*, 550–554. [CrossRef]
27. Cunha, E.A.; Santos, L.E.; Bueno, M.S.; Roda, D.S.; Leinz, F.F.; Rodrigues, C.F.C. Use of Meat Sheep Sire Breed on Fine Wool Ewe Flocks to Produce Fast-growing Lambs for Slaughter. *R. Bras. Zootec.* **2000**, *29*, 243–252. [CrossRef]
28. Medeiros, G.R.; Carvalho, F.F.R.; Batista, A.M.V.; Dutra Júnior, W.M.; Santos, G.R.A.; Andrade, D.K.B. Effect of concentrate levels on carcass characteristics of the Morada Nova breed sheep in feedlot. *R. Bras. Zootec.* **2009**, *38*, 718–727. [CrossRef]
29. Embrapa. Intake, Nutrient Digestibility, Nitrogen Balance, and Microbial Efficiency in Sheep Fed Ensiled Spineless Cactus. 2020. Available online: https://www.alice.cnptia.embrapa.br/alice/bitstream/doc/1130083/1/Intake-nutrient-digestibility-nitrogen-balance-2020.pdf (accessed on 20 March 2025).
30. Osório, J.C.S.; Oliveira, N.M.; Osório, M.T.M.; Jardim, R.D.; Pimentel, M. Meat Production in Male Lambs Derived from the Crossing Between Border Leicester Rams with Corriedale and Polwarth Ewes. *R. Bras. Zootec.* **2002**, *31*, 1469–1480. [CrossRef]
31. Silva Sobrinho, A.G.; Silva, A.M.A.; Gonzaga Neto, S.; Zeola, N.M.B.L.; Marques, C.A.T.; Miyagi, E.S. Feeding Systems and In Vivo and Carcass Traits of lambs in drylot. *ACSA* **2005**, *1*, 39–45.
32. Moreno, G.M.B.; Silva Sobrinho, A.G.; Leão, A.G.; Loureiro, C.M.B.; Perez, H.L. Carcass yield, tissue composition, and leg muscularity of lambs fed corn silage or sugar cane in two levels of concentrate, Arquivo Brasileiro de Medicina Veterinária e Zootecnia. *Arq. Bras. Med. Vet. Zootec.* **2010**, *62*, 686–695. [CrossRef]
33. Marques, R.O.; Menezes, J.J.L.; Gonçalves, H.C.; Medeiros, B.B.L.; Rodrigues, L.; Canizares, G.I.L.; Gomes, H.F.B.; Roça, R.O. Cut yields, carcass and tissue composition proportion in meat from young goats depending on the breed and slaughter body weight. *Arq. Bras. Med. Vet. Zootec.* **2013**, *65*, 1561–1569. [CrossRef]
34. Beitz, D.C. Metabolismo de proteínas e aminoácidos. In *Dukes—Fisiologia dos Animais Domésticos*; Reece, W.O., Ed.; Guanabara Koogan: Rio de Janeiro, Brazil, 2006; 926p.
35. Alphonsus, C.; Akpa, G.N.; Oni, O.O.; Rekwot, P.I.; Barje, P.P.; Yashim, S.M. Relationship of linear conformation traits with body weight, body condition score and milk yield in Friesian*Bunaji cows. *J. Appl. Anim. Res.* **2010**, *38*, 97–100. [CrossRef]
36. Yáñez, E.A.; Resende, K.T.; Ferreira, A.C.D.; Medeiros, A.N.; Silva Sobrinho, A.G.; Pereira Filho, J.M.; Teixeira, I.A.M.A.; Artoni, S.M.B. Utilization of Biometric Measures for Prediction of Saanen Goats Carcass Traits. *R. Bras. Zootec.* **2004**, *33*, 1564–1572. [CrossRef]
37. Hernandez-Espinoza, D.F.; Oliva-Hernández, J.; Pascual-córdova, A.; Hinojosa-Cuéllar, J.Á. Descripción de medidas corporales y composiciónde la canal en corderas Pelibuey: Estudio preliminar. *Rev. Científica* **2012**, *22*, 24–31.

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