
















Meat quality of Santa Inês lambs fed with different levels of forage cactus: an integrated approach

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Abstract

This study evaluated the effects of including forage cactus (*Opuntia ficus-indica*) at 500 g/kg of dry matter in the diet of Santa Inês lambs on meat quality, carcass traits, non-carcass components, and sensory attributes. The inclusion of cactus forage did not significantly affect physicochemical parameters such as moisture, protein, and color, although a reduction in lipid content was observed. Carcass yield and non-carcass components remained stable across treatments, indicating no adverse impact on productive performance. The sensory analysis revealed a significant improvement in meat juiciness and a positive trend in overall acceptability, suggesting enhanced consumer appeal. These findings support the use of forage cactus as a sustainable and functional alternative feed resource in lamb production systems, particularly in semi-arid regions.

Keywords: meat cuts; non-carcass components; physicochemical analysis; spineless cactus.

Practical Application: The practical application of this study lies in promoting sustainable sheep farming in semi-arid regions by incorporating spineless cactus into the diet of Santa Inês sheep. This feed alternative reduces production costs, improves meat quality, and enhances consumer acceptance through better sensory attributes.

1 INTRODUCTION

Brazil is currently the largest producer of sheep meat in South America, although its flock represents only about 1.5% of the global total (Brasil, 2020). Sheep farming is mainly concentrated in the Northeast and South regions, with emphasis on the states of Bahia, Rio Grande do Sul, and Ceará, although small-scale production is found throughout the country (EMBRAPA, 2019).

Despite its productive relevance, domestic consumption of sheep meat remains low, with an average of only 500 g per capita per year. This type of meat is not yet part of the daily diet of most Brazilians, being consumed mainly on special occasions or in regions with a tradition of sheep farming, such as the North-eastern Sertão and the Southern Pampas (Neres et al., 2024).

The low demand is associated with factors such as high prices, limited availability in retail outlets, lack of knowledge

about preparation, and preference for other meats, such as beef and pork. To reverse this scenario, it is essential to invest in food education, recipe dissemination, improved distribution, and promotion of the sensory attributes of sheep meat (Borges et al., 2019).

Studying and understanding the factors that influence the quality of sheep meat is crucial for strengthening the production chain. Attributes such as color, juiciness, tenderness, aroma, and flavor are decisive for consumer acceptance. These characteristics are directly linked to factors such as breed, animal age, nutritional management, slaughter conditions, and meat maturation processes.

Meat is defined as the product resulting from biochemical transformations that occur in the muscle tissue after the animal's death. It is a food of high nutritional value, rich in high biological value proteins, B-complex vitamins, heme iron, and zinc. In addition to its plastic function in tissue formation, meat also

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acts as a regulator of physiological processes and is an important source of metabolic energy (Pinheiro et al., 2009).

Therefore, an alternative way to reduce the cost of lamb meat production systems is to include raw materials adapted to the production region in the diet, thereby decreasing feeding costs. Due to its adaptation to the edaphoclimatic conditions of certain regions where this type of meat is typically produced, the spineless cactus could be a promising alternative raw material for lamb diets. This cactus, in addition to contributing to the feed supply during the dry season, has high forage production potential and good nutritional value and may also contribute to the water supply for animals (Lima et al., 2019).

Our hypothesis is that the inclusion of 500 g kg⁻¹ of dry matter from spineless cactus (forage cactus) in the diet of Santa Inês sheep improves the physicochemical parameters, cut composition, non-carcass components, and sensory acceptance of the meat compared to sheep fed without this inclusion. The objective of this research was to evaluate the physicochemical quality, cuts, non-carcass components, and sensory analysis of meat from Santa Inês sheep fed with 0 and 500 g kg⁻¹ of dry matter.

1.1 Relevance of the work

The study on the inclusion of forage cactus in the diet of Santa Inês sheep is highly relevant to Brazilian sheep farming. This sustainable feed alternative helps to reduce production costs, especially in semi-arid regions like the Northeast. It can also improve meat quality by enhancing sensory attributes valued by consumers. With domestic consumption still limited, research that promotes greater acceptance of sheep meat is essential to strengthen the production chain. Forage cactus, due to its climatic adaptability and nutritional value, represents a promising strategy to boost both the production and consumption of sheep meat in Brazil.

2 MATERIALS AND METHODS

Twenty uncastrated male Santa Inês sheep, four months old, were used in the experiment. The treatments consisted of increasing levels of forage cactus (*Opuntia ficus-indica*) included in the diet at proportions of 0 and 500 g kg⁻¹ DM.

At the end of the confinement period, the animals were weighed to determine their final live weight and then subjected to a 16-h fasting period. Slaughter was performed in accordance with Brazilian standards (Brasil, 2000), involving stunning with a captive bolt gun to induce cerebral concussion, followed by exsanguination for 4 min via severing of the carotid and jugular arteries. Blood was collected in pre-weighed containers for subsequent quantification.

All non-carcass components, both edible and inedible, were weighed. Viscera were emptied, washed, and reweighed to determine the yields of *buchada* and *panelada*. Blood, liver, kidneys, lungs, spleen, tongue, and heart were considered constituents of the *buchada*.

Color measurements were taken 50 min post-exposure at room temperature (22 °C) using a Chroma Meter CR-400

colorimeter (Konica Minolta, Osaka, Japan) with a 10° observer angle and D65 illuminant, in SCI mode, on the surface of the Longissimus lumborum (LL) muscle. The CIE L, *a*, and *b** values were recorded, with each sample evaluated in triplicate.

Cooking losses were assessed following the methodology of Wheeler et al. (1995). A 2.5-cm-thick steak was cut transversely to the muscle fibers from the LL muscle, wrapped in the aluminum foil, and cooked in a convection oven (FISCHER, Star model) at 150 °C until reaching an internal temperature of 71 °C, monitored using K-type thermocouples (Comark, PK23M, Vienna Court, UK) inserted into the geometric center of the sample. Samples were then cooled at room temperature until reaching 24 °C, measured with an insertion thermometer (TESTO, model 106, Melrose, MA, USA).

A 100-g sample from the right LL muscle of each animal was trimmed of connective tissue and external fat, then ground using a domestic blender for the chemical composition analysis. Moisture, ash, protein, and lipid contents were determined according to AOAC protocols (AOAC, 2005). Vacuum-packed samples were thawed at 4 °C for 24 h prior to the analysis.

The left Longissimus thoracis et lumborum (LTL) muscle was wrapped in the aluminum foil and cooked on a single-plate grill at a controlled temperature of 180 °C until reaching an internal temperature of 70 °C. The muscle was then cut into ten 2 cm² portions, individually wrapped in the foil, and labeled with random three-digit codes. Samples were kept warm in a heater at 55 °C until sensory evaluation. To minimize presentation order effects, samples were served to panelists in randomized sequences (Macfie et al., 1989).

The sensory analysis was conducted in individual booths under controlled environmental conditions at approximately 23 °C (ISO, 1988; 1993). The evaluation included samples from all 20 animals (10 per treatment), totaling 200 samples. Five sensory descriptors were assessed using a nine-point structured line scale (Jeremiah, 2000).

3 RESULTS

The lipid variable showed a significant difference ($P = 0.0429$) with the inclusion of 500 g/kg of forage cactus in the diet of sheep. The other parameters did not present statistically significant differences between the inclusion levels. There was a slight reduction in force (from 14.6 to 13.9 N), which may indicate a decrease in the product's resistance or firmness with the inclusion, even though no statistical difference was observed (Table 1).

None of the variables showed statistically significant differences between the levels of forage cactus inclusion ($P > 0.05$). The initial and final live weights were slightly lower in the group with 500 g/kg inclusion, but without statistical significance. The carcass cuts (neck, shoulder, ribs, saw, loin, and leg) showed subtle variations, indicating that forage cactus inclusion did not compromise the carcass yield (Table 2).

The non-carcass components did not show a statistically significant difference between the levels of inclusion of forage palm ($P > 0.05$). The values were similar between the groups, indicating that the inclusion of 500 g/kg of forage palm did not

Table 1. Physical parameters and chemical composition of meat from Santa Inês lambs fed with forage cactus.

Variables	Inclusion levels (g kg ⁻¹ of dry matter)		SEM	P-value
	0	500		
Lipids (g kg ⁻¹)	3.66	3.05	0.47	0.0429
Ash (g kg ⁻¹)	0.99	1.20	0.32	0.2515
Moisture (g kg ⁻¹)	75.47	74.00	2.73	0.6938
Protein (g kg ⁻¹)	23.1	22.5	0.10	0.6987
Lightness (L*)	36.85	37.18	2.74	0.7901
Redness (a*)	15.06	15.33	2.01	0.6103
Yellowness (b*)	7.82	8.29	1.91	0.5929
Force (N)	14.6	13.9	0.17	0.5781

SEM: standard error means.

Table 2. Weight and carcass characteristics of Santa Inês lambs fed with forage cactus.

Variables (kg)	Inclusion levels (g kg ⁻¹ of dry matter)		SEM	P-value
	0	500		
Initial live weight	25.36	23.24	2.54	0.2109
Final live weight	38.35	37.33	1.24	0.5003
Neck	0.900	0.889	0.12	0.7553
Shoulder	1.434	1.412	0.13	0.1854
Ribs	1.265	1.298	0.14	0.7220
Saw (cut of meat)	1.364	1.298	0.22	0.4339
Loin	0.800	0.810	0.12	0.7705
Leg	0.135	0.149	0.05	0.2025

SEM: standard error means.

alter the non-carcass components of the lambs. The spleen, pancreas, and kidneys showed identical values between the treatments, reinforcing the stability of these organs in the face of dietary modification (Table 3).

The color ($P = 0.0311$) and juiciness ($P = 0.0139$) variables showed a statistically significant difference, indicating that the inclusion of 500 g/kg of forage cactus improved the perception of meat juiciness. Overall acceptability had a P value of 0.0571, close to the significance threshold, suggesting a positive trend with cactus inclusion. The other variables (color, odor, tenderness, and flavor) showed higher numerical values in the inclusion group, although without statistical significance ($P > 0.05$), which may indicate subtle sensory improvements (Table 4).

4 DISCUSSION

The inclusion of forage cactus (*Opuntia ficus-indica*) as an alternative ingredient in the diet of Santa Inês lambs did not compromise the physicochemical parameters of the meat, such as moisture, protein, and color, corroborating the findings of Souza et al. (2020), who observed stability in the composition of meat from lambs fed cactus silage, even under water restriction. Additionally, Sobral et al. (2024) reported that the addition of forage cactus to corn silage without cob contributed to a reduction in the lipid content without compromising the nutritional quality of the meat.

Table 3. Non-carcass components of Santa Inês lambs fed a diet containing cactus forage.

Variables (kg)	Inclusion levels (g kg ⁻¹ of dry matter)		SEM	P-value
	0	500		
Head	1.82	1.85	0.15	0.7649
Paws	0.754	0.799	0.09	0.2687
Skin	2.671	2.719	0.41	0.7959
Cause	0.144	0.130	0.04	0.3870
Blood	1.346	1.399	0.18	0.5295
Tongue	0.097	0.082	0.03	0.2999
Trachea	0.125	0.139	0.02	0.2203
Esophagus	0.067	0.054	0.01	0.1121
Lung	0.299	0.309	0.06	0.7124
Heart	0.146	0.150	0.01	0.5134
Liver	0.598	0.676	0.10	0.1046
Empty gastrointestinal tract	1.921	1.943	0.33	0.8829
Diaphragm	0.238	0.232	0.02	0.4762
Spleen	0.074	0.074	0.02	1.0000
Pancreas	0.032	0.032	0.01	0.8802
Kidneys	0.1070	0.1070	0.01	0.8332

SEM: standard error means.

Table 4. Sensory analysis of Santa Inês lamb meat fed with forage palm.

Variables	Inclusion levels (g kg ⁻¹ of dry matter)		SEM	P-value
	0	500		
Color	2.97	4.32	1.00	0.0311
Odor	4.03	4.45	1.79	0.6502
Tenderness	6.58	7.36	1.38	0.1942
Juiciness	5.43	7.18	1.34	0.0139
Flavor	4.68	5.71	1.53	0.1763
Overall acceptability	5.42	6.74	1.54	0.0571

SEM: standard error means.

Regarding performance and carcass yield, the results are consistent with those of Souza et al. (2020), who evaluated lambs fed cactus silage and found no significant differences in commercial cuts or carcass components. The slight reduction in live weight observed in some studies may be related to the lower energy density of cactus, as discussed by Araújo Júnior et al. (2025), without affecting the final yield.

Non-carcass components such as liver, heart, lungs, and gastrointestinal tract remained stable between treatments, who evaluated diets with silages adapted to semi-arid conditions and found no significant changes in internal organs (Morais et al., 2023).

In the sensory analysis, juiciness was the attribute that showed a statistically significant difference, indicating a noticeable improvement with cactus inclusion. According to Silva et al. (2023), replacing corn with forage cactus in lamb diets increased sensory acceptance of the meat, especially in attributes such as juiciness and flavor. Overall acceptability also showed a positive trend, reinforcing the potential of cactus as a functional ingredient. Although color, odor, tenderness, and flavor did not

show statistical differences, the higher values observed in the inclusion group suggest subtle sensory improvements.

It is important to highlight that among the factors influencing consumer purchasing decisions, meat color is one of the main criteria. Bright red meat is generally associated with freshness and tenderness, while darker tones are rejected for being linked to older animals or less tender meat (Firoozzare et al., 2024).

5 CONCLUSION

Forage cactus up to 500 g/kg DM can be used as an alternative ingredient in lamb diets without compromising meat quality or productive performance. Furthermore, it may contribute to sensory improvements, especially in juiciness, which is relevant for consumer acceptance.

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