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Diets Composed of Tifton 85 Grass Hay (*Cynodon* sp.) and Concentrate on the Quantitative and Qualitative Traits of Carcass and Meat from Lambs

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Abstract: The high intake of fermentable carbohydrates may cause nutritional disorders and negatively affect animal performance. Thus, the research study aimed to determine the better roughage: concentrate ratio to improve the carcass traits and physicochemical quality of meat from feedlot-finished Santa Ines lambs. Diets were composed of Tifton 85 grass hay (*Cynodon* sp.) and concentrate (soybean meal, corn meal, urea, and mineral mixture) and consisted of five roughage: concentrate ratios of 88:12 (C12), 69:31 (C31), 50:50 (C50), 31:69 (C69), and 12:88 (C88). After 63 days the animals were slaughtered and carcass traits, the yield of commercial cuts, and physicochemical properties of meat were evaluated. The higher percentage of concentrate on roughage provided higher DM intake, better feed conversion, higher conformation, finishing, and carcass yield that resulted in heavier commercial cuts with higher fat content in the meat. The addition of 50% concentrate to the roughage improved the carcass traits, commercial cuts, and physicochemical parameters of the meat in a similar way to the diet with 88% concentrate, but with leaner meats, meeting the demands of the current consumer market.

Keywords: carcass yield; commercial cuts; low cost; neutral detergent fiber; non-fiber carbohydrate

1. Introduction

Young lambs with high potential for body weight gain are usually finished between 60 and 150 days of age and need diets with high protein and energy content according to the NRC [1]. However, in Brazil, the ruminant's production usually uses forages as exclusive feed because it has a lower cost, but longer periods are required for finishing animals under these conditions, even when well-managed, it cannot fully meet the animal's nutritional demands, resulting in slower body development, animals with lighter carcass weight and consequently, low yield and decreased producer's revenue [2].

In contrast, feedlot systems for finishing use diets based on high concentrates ratio with a greater non-fiber carbohydrates (NFC) content and have short-term finishing periods resulting in rapid body development, reduced time to slaughter, heavier carcasses with better quality, and a higher percentage of marbling fat. Although, the high expense of feed provided to the animals do not always provide greater profitability to the producer [3,4].

However, the ruminal microbiota need availability of energy and protein in synchrony for growth and replication, resulting in better use of nutrients and SCFA production, which will provide a better performance, especially in parameters of carcass traits and meat quality. The intake of substantial amounts of readily fermentable carbohydrates can lead to changes in the ruminal fermentation pattern, resulting in increased production of short-chain fatty acids (SCFA), especially lactic acid that cause a drop in ruminal pH, directly affecting the ruminal microbiota [5] that may cause the animal to experience clinical or subclinical acidosis. SCFA production is closely related to the availability and synchronicity of nutrients which provide the proliferation and growth of the ruminal microbiota [6].

In view of the above for finishing lambs, it is believed that the addition of concentrate to the roughage will improve the synchronicity of rumen microorganisms, resulting in better performance, carcass traits, and meat physicochemical quality.

Thus, the present research aimed to determine the better roughage: concentrate ratio to improve the carcass traits and physicochemical properties of meat from feedlot-finished Santa Ines lambs.

2. Materials and Methods

The experiment was conducted at the Experimental Farm of Veterinary Medicine and Animal Science of the Federal University of Bahia, which is located at 174 km from the BR 101 highway, at 12°23′58″ S and 38°52′44″ W, Bahia State, Brazil. The research was approved by the ethics committee for the use of animals (CEUA), under protocol number 68/2018.

2.1. Animals, Diets, and General Procedures

Sixty intact Santa Ines sheep were used, with an initial average body weight (IBW) of 25.84 ± 0.53 kg, identified with numbered ear tags, dewormed, weighed, randomly assigned to their treatments, and housed in individual pens of 1.0 × 1.0 m, that were equipped with slatted wood floors, containing feed troughs and water troughs. The experiment lasted 78 days (15 for adaptation and 63 days for data collection). During the adaptation period, all animals were treated for internal and external parasites with ivermectin (Ivomec gold; Merial, Salvador, Bahia, Brazil) and vaccinated against clostridiosis using Polivalente (Sintoxan; Merial, Sao Paulo, Brazil). The animals received water ad libitum and the diets were supplied twice a day (8:00 and 15:00) i.e., 50% of the diet was allocated in the morning and the other half in the afternoon. Feed refusals were collected and weighed daily, and the amount of feed offered was adjusted to allow an approximate 20% refusal. Before the experiment, the feed components were chemically analyzed (Tables 1 and 2) separately with triplicate samples.

Table 1. Chemical composition of feed ingredients.

Items (g/kg DM)	Ingredient			
	Tifton Hay 85	**Soybean Meal**	**Corn Meal**	**Urea**
Dry matter, g/kg as fed	890	918	917	99.0
Organic matter	850	865	865	-
Crude protein	44.7	471	75.3	281
Ether extract	18.5	26.1	45.9	-
Neutral detergent fiber	762	144	134	-
Neutral detergent fiber$_{ap}$ [1]	682	101	118	-
Acid detergent fiber	346	77.4	36.0	-
Non-fiber carbohydrate	21.5	34.9	70.9	-

[1] Corrected to ash and protein.

Table 2. Ingredient proportions and chemical composition of experimental diets.

Items	Experimental Diets				
	C12	**C31**	**C50**	**C69**	**C88**
Ingredients (g/kg DM)					
Tifton hay	880	690	500	310	120
Soybean meal	80.0	80.0	76.0	74.0	72.0
Corn meal	10.0	200	394	586	778
Urea	15.0	15.0	15.0	15.0	15.0
Mineral mixture [1]	15.0	15.0	15.0	15.0	15.0
Chemical Composition (g/kg DM)					
Dry matter (g/kg as fed)	896	901	906	911	916
Ash	55.0	57.2	60.5	62.8	64.1
Organic matter	826	829	832	834	837
Crude protein	120	126	130	135	140
Ether extract	18.8	24.0	29.3	34.6	39.8
Neutral detergent fiber	683	564	445	325	206
Neutral detergent $fiber_{ap}$ [2]	609	502	395	288	181
Acid detergent fiber	311	252	193	134	75.1
Non-fiber carbohydrate	224	318	413	508	602
Metabolizable energy (MJ/kg)	8.75	9.50	9.88	10.2	12.5

[1] Guaranteed levels (for active elements): 120 g calcium, 87 g phosphorus, 147 g sodium, 18 g sulfur, 590 mg copper, 40 mg cobalt, 20 mg chrome, 1800 mg iron, 80 mg iodine, 1300 mg manganese, 15 mg selenium, 3800 mg zinc, 300 mg molybdenum, and maximum 870 mg fluoride. Solubility of phosphorus citric acid: 2–95%. [2] Corrected to ash and protein.

The experimental diets were formulated according to the requirements recommended by National Research Council [1] and consisted of five Tifton hay (*Cynodon* sp.) to concentrate ratios of 88:12 (C12), 69:31 (C31), 50:50 (C50), 31:69 (C69), and 12:88 (C88) (Table 2). The concentrates were composed of soybean meal, corn meal, urea, and mineral mixture. The Tifton-85 hay was chopped into short lengths (2–3 cm) and mixed with the concentrate before offering.

Samples ingredients, refusals, and feces were pre-dried in a forced-air ventilation oven at 55 °C for 72 h and ground in a Wiley knife mill with a sieve size of 1 mm for ingredients and refusal samples and 3 mm for feces samples.

2.2. Diet Composition Actually Consumed and Growth Performance

After a period 15 days for animals' adaptation to diets and stables, the animals were weighed to obtain the initial body weight (IBW).

The dry matter intake (DMI) was calculated by the difference between the dry matter (DM) present in the offered diet and the DM obtained from the animals' refusals. In the same way, metabolizable energy intake (ME intake) was calculated.

The diet composition actually consumed (DCC) by lambs was estimated based on the ratio of the intake of each nutrient by the equation:

$$DCC = (Nutrient/DMI) \times 100 \quad (1)$$

After the experimental period (63 days), the animals were weighed (body weight at slaughter—BWS) after 16 -h solid fasting. Total weight gain (TWG) was calculated as the difference between BWS and IBW. Average daily gain (ADG) for individual lambs was calculated using the sum of average daily divided by the number of days that the animals were confined. Feed conversion ratio (FCR) for each lamb was calculated as a ratio of daily DMI to ADG.

2.3. Slaughter Procedures

Animals arrived at the slaughterhouse and were fasted for solids for 16 h, with water *ad libitum*, placed in a duly covered and walled corral. The slaughter was carried out in

the slaughterhouse and meat packing plant of the Cooperativa Agroindustrial de Pintadas (COOAP) in the municipality of Pintadas, state of Bahia, according to the standards of the State Inspection Service (SIE) of Bahia, according to the standards for humane slaughter, stunning animals by electronarcosis, followed by bleeding, by cutting the jugular veins and carotid arteries, then the animals were skinned and eviscerated. Head, limbs, and tail were removed, carcasses were identified, washed, and weighed to obtain the hot carcass weight (HCW).

After weighing, the carcasses were transferred to a cold room at ±4 °C and stored under chilling for 24 h hung by the common Achilles tendon, with appropriate hooks, keeping 17 cm between the tarsometatarsal joints.

2.4. Carcass Traits and Commercial Cuts

During the chilling period, the pH of the carcass was recorded 24 h *postmortem*, using a portable pH meter coupled to a penetration electrode previously calibrated with buffer solutions of pH 4.00 and 7.00. Afterwards, carcasses were weighed to obtain the cold carcass weight (CCW) and the weight loss by cooling (WLC) was calculated using equation:

$$\text{WLC} = ((\text{HCW} - \text{CCW})/\text{HCW}) \times 100 \quad (2)$$

Then, the following carcass morphological measurements were evaluated: internal and external carcass length; leg length; chest and rump width; chest depth; thoracic and rump perimeter. All length and perimeter measurements were taken using a measuring tape, and width and depth measurements were taken with the aid of a handmade compass, whose registered opening was measured with a ruler. The carcass compactness index (CCI) was calculated by the equation:

$$\text{CCI} = \text{CCW}/\text{ICL} \quad (3)$$

Then, the subjective assessment of the conformation and the state of fatness (marbling, pelvic-renal fat, and fattening degree) was carried out on the carcass, following the methodology of Cezar and Sousa [7], considering the conformation index varying from 1 = poor (concave) to 5 = excellent (convex); pelvic-renal fat of 1 = little fat to 3 = much fat; fattening degree of 1 = very thin to 5 = very fat; and marbling of 1 = nonexistent to 5 = abundant.

After the subjective assessment of the carcass pelvic-renal fat, the kidneys and pelvic renal fat were removed, whose weights were recorded and subtracted from the hot and cold carcass weights. Then, the hot carcass yields (HCY) and cold carcass yields (CCY) were calculated by equations:

$$\text{HCY (\%)} = (\text{HCW}/\text{BWS}) \times 100 \quad (4)$$

$$\text{CCY (\%)} = (\text{CCW}/\text{BWS}) \times 100 \quad (5)$$

The cold carcasses were sawed into two symmetrical sides along the backbone and the left sides from the carcasses were cut into five commercial cuts (leg, loin, rib, shoulder, and neck) and weighed separately. The weight of reconstituted half carcass was obtained by the sum of five commercial cuts weights and used to calculate commercial cuts yield, as proposed by Cezar and Sousa [7].

2.5. Physicochemical Properties from the Proximate Composition of Meat

In the left half carcass, a cross section was made between the 12th and 13th ribs, and using a digital caliper, the cover fat thickness was measured on the *Longissimus lumborum* muscle.

The *Longissimus lumborum* samples were dissected with the aid of a scalpel to remove the subcutaneous fat and epimysium, individually packaged, identified, and stored at −20 °C until the physicochemical analyses. Loins were thawed under chilling (8 °C) the night before the beginning of the analyses.

Two samples that were 2.5 cm thick from *Longissimus lumborum* muscle were used to evaluate the cooking weight loss (CWL). The samples were weighed before and after cooking and recorded.

A stain-less-steel thermocouple (Gulterm 700; Gulton do Brazil, Brazil) was placed into the geometric center of each sample to check and record its internal temperature. The samples were cooked on a grill (George Foreman Jumbo Grill GBZ6BW, Rio de Janeiro, Rio de Janeiro, Brazil) until the internal temperature reached 71 °C. Upon reaching the temperature, the samples were taken, placed into a plastic bag, and cooled to 10 °C in an ice water bath. The cooking weight loss of each sample was obtained by the difference between the weights before and after cooking and expressed as a percentage.

These same samples were kept at 4 °C overnight for instrumental texture analysis conducted according to the method of the AMSA [8].

On the following day, the samples were brought to room temperature before Warner-Bratzler Shear Force (WBSF) analysis and using a cork borer at least three cores of 1.27 cm in diameter and 2.0 cm in length, parallel to the muscle fibers, were removed from each sample.

The WBSF was measured using a texture analyzer (Texture Analyzer TX-TX2; Mecmesin, NV, USA) fitted with a Warner ± Bratzler-type shear blade with a load of 25 kgf (kilogram-force) and a cutting speed of 20 cm/min [9] that sheared each core perpendicular to the fiber direction and was expressed in Newtons (N).

Meat color was evaluated with a Minolta CR300 colorimeter, operating in the CIE system (L*, a*, b*), where L* is lightness, a* is redness, and b* is yellowness. The colorimeter was calibrated with a white tile and the illuminant used was C and the observation was at 2°. Before analysis, samples were exposed to room temperature for 30 min for the formation of oxymyoglobin, the main pigment responsible for the bright red color of meat [10]. After this time, and as described by Miltenburg et al. [11], L*, a* and b* were measured at three different points on the muscle surface, and the average of the triplicates of each coordinate per animal sample was subsequently calculated.

The saturation index (Chroma) and Hue angle (h_{ab}) were determined using a* as (a) and b* as (b) data according to the equations determined by Hunt and King [12]:

$$\text{Chroma} = \sqrt{(a^*)^2 + (b^*)^2} \quad (6)$$

$$h_{ab} = tan^{-1}\left(\frac{b^*}{a^*}\right).\left(\frac{180}{x}\right) \quad (7)$$

Longissimus lumborum muscle samples for proximate composition analysis were ground and homogenized in a food processor. The moisture, ash, and protein contents were evaluated according to AOAC [13], in procedures 985.41, 920.153, and 928.08, respectively. Total lipids were extracted according to the methodology described by Folch et al. [14] by extraction with chloroform: methanol (2:1) solution, followed by evaporation of the solvent in an oven at 105 °C.

2.6. Experimental Design and Statistical Analysis

Animals were distributed in a completely randomized experimental design, with 5 treatments and 12 replications, totaling 60 animals. The following mathematical model was used:

$$Xij = \mu + Ti + \varepsilon ij \quad (8)$$

where Xij = observation of treatment i, in repetition j; μ = overall mean; Ti = effect of treatment i; εij = effect of uncontrolled factors in the plot.

Data obtained were tested by analysis of variance and the means compared using the Tukey test at 5% significance, according to the forage:concentrate ratio in the diet for lambs finished in feedlot, using the software Statistical Analysis System [15] (SAS, version 9.1). The subjective assessment of the carcass also included the Levene test to verify the variance homogeneity using the "HOVTEST" command.

3. Results

3.1. Diet Composition Actually Consumed and Growth Performance

Effective consumption of nutritional fractions and performance of Santa Ines lambs are presented in Table 3.

Table 3. Composition of the diet actually consumed by Santa Ines lambs who received different forage-to-concentrate ratios.

Item	Experimental Diets [1]					SEM [2]	*p*-Value [3]
	C12	C31	C50	C69	C88		
Initial body weight, kg	25.17	25.53	26.28	25.78	26.45	0.99	-
Dry matter intake, kg	1.07c	1.23bc	1.44ab	1.70a	1.51ab	0.08	<0.01
ME intake, MJ/day	9.34d	11.71cd	14.28bc	17.43ab	18.88a	0.81	<0.01
Composition of the diet actually consumed [4]							
Crude protein	14.16b	14.24a	14.15c	14.13d	14.10e	<0.01	<0.01
Ether extract	2.37e	2.69d	3.02c	3.34b	3.66a	<0.01	<0.01
Neutral detergent fiber	68.05a	56.05b	43.99c	32.02d	20.06e	0.01	<0.01
Non-fibrous carbohydrate	15.3e	26.91d	38.7c	50.41b	62.12a	0.01	<0.01
Body weight at slaughter, kg	29.68b	33.33b	38.88a	42.08a	39.91a	1.35	<0.01
Total weight gain, kg	4.51d	7.80c	12.60b	16.30a	13.46b	0.61	<0.01
Average daily gain, kg	0.07d	0.12c	0.20b	0.26a	0.21b	0.01	<0.01
Feed conversion ratio, kg/kg	15.06a	10.05b	7.27c	6.63c	7.27c	0.40	<0.01

[1] C12, C31, C50, C69, and C88 refer to diets with Tifton-85 hay to concentrate ratios of 88:12, 69:31, 50:50, 31:69, and 12:88, respectively. [2] Standard error of the mean. [3] Significance at $p < 0.05$. Averages followed by different letters on the line differ among themselves by Tukey's test ($p < 0.05$). [4] Value expressed as the percentage of each nutrient ingested in relation to DMI.

The dry matter intake differed between treatments ($p < 0.01$), with higher DMI in the treatment with 69% concentrate, but not statistically different from the treatments with 50% and 88% concentrate. The lowest DMI was observed for the treatment with 12% concentrate.

There was greater metabolizable energy (ME) intake ($p < 0.01$) observed for the C88 treatment, but it did not differ statistically from the treatment with 69% concentrate. The lowest ME intake was observed for the C12 treatment.

The effective consumption of CP ($p < 0.01$) was higher in the treatment with 31% concentrate and lower in the treatment with 88% concentrate. The effective consumption of EE ($p < 0.01$) and NFC ($p < 0.01$) showed the same behavior, with higher averages for the treatment with 88% and lower averages for the treatment with 12% concentrate. The effective consumption of NDF ($p < 0.01$) had the highest average for the treatment with 12% concentrate and the lowest average for the treatment with 88%.

The daily weight gain ($p < 0.01$) and consequently the total weight ($p < 0.01$) of the animals, presented greater means for the treatment with 69% concentrate and the lowest for the treatment with 12% concentrate in the diet.

The worst feed conversion ($p < 0.01$) was obtained for the treatment with 12% concentrate and there was no significant difference for treatments with 50%, 69% and 88% concentrate.

3.2. Carcass Traits and Commercial Cuts

The data of morphometric measurements and carcass traits of Santa Ines lambs are presented in Table 4.

Most morphometric measurements ($p < 0.05$) of the carcass had a significant difference between treatments except leg length ($p = 0.25$).

Regarding the development of the carcass, we can observe through the morphometric measures, that there was no significant difference ($p < 0.05$) between treatments with 50%, 69%, and 88% concentrate. The animals receiving 12% concentrate had lower carcass development. This behavior can also be evaluated using the CCI variable.

Table 4. Effect of dietary forage-to-concentrate ratios on morphometric measurements and carcass traits of lambs.

Item	Experimental Diets [1]					SEM [2]	*p*-Value [3]
	C12	C31	C50	C69	C88		
Morphometric measurements, cm							
Chest width	13.93b	14.92b	16.43a	17.29a	17.31a	0.33	<0.01
Rump width	20.42b	22.15ab	22.71ab	24.00a	24.02a	0.64	<0.01
Thoracic perimeter	64.5c	68.79b	73.25a	74.68a	74.68a	0.98	<0.01
External length	59.17b	61.75ab	64.08a	63.55a	64.18a	0.96	<0.01
Internal length	49.08b	51.5ab	53.42a	54.18a	53.54a	0.76	<0.01
Leg length	39.33	40.67	41.25	40.64	40.20	0.61	0.25
Chest depth	17.33b	18.33ab	19.04a	17.86ab	17.95ab	0.30	<0.01
Rump perimeter	49.08c	52.83bc	55.79ab	57.82a	58.14a	1.08	<0.01
Carcass compactness index [4], kg/cm	0.22c	0.27b	0.32a	0.34a	0.34a	0.01	<0.01
Hot carcass weight, kg	10.83c	13.98b	17.08a	18.30a	18.32a	0.67	<0.01
Cold carcass weight, kg	10.78c	13.93b	17.03a	18.27a	18.26a	0.67	<0.01
Hot carcass yield, %	36.47d	41.95c	43.91b	43.88bc	45.90a	0.47	<0.01
Cold carcass yield, %	36.33c	41.80b	43.78a	43.81a	45.76a	0.47	<0.01
Fat thickness, mm	0.84	1.04	1.14	1.21	1.13	0.09	0.07
Carcass conformation index [5]	2.77c	3.52b	4.02ab	4.18a	4.14ab	0.16	<0.01
Carcass fattening degree [6]	2.54c	3.63b	4.06ab	4.25ab	4.48a	0.17	<0.01
Pelvic-renal fat [7]	1.17b	1.75ab	2.25a	2.35a	2.36a	0.16	<0.01
Marbling [8]	1.00	1.25	1.25	1.36	1.64	0.13	0.06

[1] C12, C31, C50, C69, and C88 refer to diets with Tifton-85 hay to concentrate ratios of 88:12, 69:31, 50:50, 31:69, and 12:88, respectively. [2] Standard error of the mean. [3] Significance at $p < 0.05$. Averages followed by different letters on the line differ among themselves by Tukey's test ($p < 0.05$). [4] Carcass compactness index. [5] Carcass conformation index (1 = Poor (concave) to 5 = Excellent (convex)). [6] Fattening degree (1 = very thin to 5 = very fat). [7] Pelvic-renal fat (1= little fat to 3 = much fat). [8] Marbling (1= nonexistent to 5= abundant).

Body weight at slaughter did not present a significant difference ($p < 0.05$) between treatments with 50%, 69%, and 88% concentrate and animals receiving 12% concentrate in their diet presented lower weight ($p < 0.01$). The same behavior can be observed for hot carcass weight ($p < 0.01$) and cold carcass weight ($p < 0.01$).

Hot ($p < 0.01$) and cold ($p < 0.01$) carcass yields presented greater averages for treatment with 88% concentrate and lower yield for the carcass for the animals that received 12% concentrate in their diet.

The fat thickness presented an average of 1.07 cm and did not differ statistically ($p = 0.07$) between the treatments.

Within the subjective assessments of carcasses only marbling ($p = 0.06$) did not show a significant difference between treatments and obtained an average of 1.30.

The carcass conformation index ($p < 0.01$) showed the highest average for the treatment with 69% concentrate; however, it did not differ statistically from the treatments with 50% and 88% concentrate.

The highest average for carcass finishing degree ($p < 0.01$) was obtained by treatment with 88% concentrate, but it did not differ statistically from the treatments with 50% and 69% concentrate. The lowest carcass finishing degree was obtained by the C12 treatment.

When evaluating pelvic-renal fat ($p < 0.01$), it was observed that the lowest average obtained was for the treatment with 12% concentrate. The other treatments did not differ statistically.

The weight and yield of commercial cuts are presented in Table 5.

The reconstituted half carcass ($p < 0.01$) showed the same behavior as the CCW (Table 4), not differing between treatments C50, C69, and C88 with a lower average for treatment C12.

The neck, shoulder, loin, and leg cuts showed a lower average for treatment with 12% concentrate and did no differ between treatments C50, C69, and C88.

Table 5. Effect of dietary forage-to-concentrate ratios on weight and yield of commercial cuts from ambs.

Items	Experimental Diets [1]					SEM [2]	*p*-Value [3]
	C12	C31	C50	C69	C88		
Reconstituted half carcass, kg	5.06c	6.40b	7.90a	8.24a	8.32a	0.33	<0.01
Commercial cut weight, kg							
Neck	0.53c	0.65b	0.78a	0.77a	0.76a	0.03	<0.01
Shoulder	1.10c	1.37b	1.68a	1.77a	1.78a	0.06	<0.01
Rib	1.42b	1.87b	2.49a	2.62a	2.68a	0.12	<0.01
Loin	0.25c	0.32b	0.38a	0.41a	0.42a	0.01	<0.01
Leg	1.76c	2.2b	2.57a	2.68a	2.69a	0.09	<0.01
Commercial cut yield, %							
Neck	10.47	10.11	9.87	9.32	9.10	0.49	0.33
Shoulder	21.74	21.41	21.27	21.44	21.33	1.14	0.99
Rib	28.06	29.20	31.52	31.80	32.20	1.85	0.57
Loin	4.94	5.00	4.81	4.94	5.05	0.26	0.98
Leg	34.78	34.31	32.53	32.50	32.31	1.76	0.77

[1] C12, C31, C50, C69, and C88 refer to diets with Tifton-85 hay to concentrate ratios of 88:12, 69:31, 50:50, 31:69, and 12:88, respectively. [2] Standard error of the mean. [3] Significance at $p < 0.05$. Averages followed by different letters on the line differ among themselves by Tukey's test ($p < 0.05$).

The treatments with 12% and 31% concentrate did not differ statistically for the loin cut. Additionally, there was no significant difference between treatments with 50%, 69% and 88% concentrate.

No significant differences ($p > 0.05$) were observed between treatments for commercial cuts yields, with means of 9.16%, 20.05%, 28.57%, 4.63%, and 31.24% for yields of neck, shoulder, rib, loin, and leg, respectively.

3.3. Physicochemical Properties from the Proximate Composition of Meat

The physicochemical composition of the *Longissimus lumborum* muscle is presented in Table 6. Most of the variables evaluated showed no significant difference ($p > 0.05$).

Table 6. Effect of dietary forage-to-concentrate ratios on physicochemical composition of the *Longissimus lumborum* muscle from lambs.

Item	Experimental Diets [1]					SEM [2]	*p* Value [3]
	C12	C31	C50	C69	C88		
pH_{0h}	7.33a	7.28ab	7.23ab	7.04b	7.02b	0.07	<0.01
pH_{24h}	6.17	5.98	6.03	6.16	6.01	0.08	0.37
Color parameter							
L* (lightness)	38.97	37.54	38.30	37.14	38.19	0.47	0.08
a* (redness)	22.70	22.11	22.29	21.61	22.21	0.35	0.34
b* (yellowness)	6.19	5.58	5.83	5.18	5.63	0.38	0.53
Chroma (saturation)	23.53	22.80	23.04	22.22	22.91	0.416	0.35
Hue (h_{ab})	15.25	14.16	14.66	13.48	14.22	0.761	0.65
Cooking weight loss, %	19.02	22.75	24.55	28.39	30.52	2.957	0.09
Shear force, N	20.99	21.39	16.28	24.53	20.21	2.060	0.14
Chemical composition, %							
Moisture	74.48a	73.51ab	72.95bc	72.83bc	71.95c	0.44	<0.01
Ash	1.07	1.12	1.12	1.09	1.14	0.02	0.39
Protein	21.93	22.55	22.97	22.51	22.92	0.45	0.37
Lipid	2.43d	2.41d	2.55c	2.63b	2.82a	0.01	<0.01

[1] C12, C31, C50, C69, and C88 refer to diets with Tifton-85 hay to concentrate ratios of 88:12, 69:31, 50:50, 31:69, and 12:88, respectively. [2] Standard error of the mean. [3] Significance at $p < 0.05$. Averages followed by different letters on the line differ among themselves by Tukey's test ($p < 0.05$).

The pH_{0h} showed a significant difference ($p < 0.01$) between treatments, with the highest average for the treatment with 12% concentrate. There was no significant difference between treatments for pH_{24h} ($p = 0.37$), presenting a mean value of 6.07.

For the color parameters, none of the variables showed a significant difference between treatments, presenting mean values of 38.03, 22.18, 5.68, 22.90, and 14.35 for lightness, redness, yellowness, Chroma, and Hue angle, respectively.

Cooking losses and shear force did not differ statistically between treatments and presented averages of 25.05 and 2.11, respectively.

The moisture showed a significant difference ($p < 0.01$) between treatments, with the highest average for the treatment with 12% concentrate and lower mean for C88 treatment.

Ash and protein did not differ statistically between treatments and presented averages of 1.11% and 21.86%, respectively.

The lipids content in the muscle showed the highest mean for the treatment with 88% concentrate and the lowest mean for the C12 treatment.

4. Discussion

4.1. Diet Composition Actually Consumed and Growth Performance

The lower DMI was observed for the animals receiving 12% concentrate, due to the high concentration of NDF that this diet presented (88%). This possibly limited DM intake by physical factors in the gastrointestinal tract, which reduced the passage rate of digesta and prevented the emptying of the gastrointestinal tract (GIT) that caused a distension of the rumen-reticulum, resulting in a decreased DMI [16–18] and inability to ingest more feed to nourish themselves.

The metabolizable energy (ME) intake by animals was greater than ME offered by the diets, in this way, it is confirmed that the reduction in DMI was not limited by the energy density of the ration and rather limited by physical factors in the gastrointestinal tract.

The diet effectively consumed allows us to observe the behavior of animal selectivity in relation to their offered, that is, we can observe through the DMI the amount of each nutrient that was consumed per day. In this way, it was observed that the research animals were selective because the diet actually consumed (Table 3) was not equal to that offered (Table 2).

According to the chemical composition of diets, the CP content ranged from 14.0% to 12.0%, EE of 3,98% to 1.88%, NFC of 60.2% to 22.4% and NDF of 18.1% to 60.9% for treatments with 88%, 68%, 50%, 31%, and 12% concentrate, respectively. When the composition of the diet effectively consumed was observed, the CP contents ranged from 14.10% to 14.24%, EE of 3.66% to 2.37%, NFC of 62.12% to 15.3%, and NDF of 20, 06% to 68.05%. This difference between the offered and actually consumed diet indicates that there was a preference of animals to the concentrate, since the concentrate has a higher percentage of CP, EE, and NFC and lower NDF in relation to forage.

Although these animals received diets with different roughage: concentrate ratio, they depend, in common on the amount of DM ingested and the levels of protein and energy satisfactory [19] for the development and efficiency of the rumen microbiota. These satisfactory levels result in higher synthesis of microbial protein and a better use of energy and protein by the animal so that they can achieve greater growth performance through development of muscle and adipose tissue, and consequently increase the BWS [20] resulting in a better feed conversion ratio. This can be observed for animals receiving 69% concentrate in diet.

According to Abbasi et al. [21] working with dietary energy levels of goat kids, and Cui et al. [22] working with dietary energy and protein levels of lambs, the low dietary energy level (9.1 vs. 10.7 MJ ME/kg and 10.9 vs. 8.6 MJ ME/kg, respectively) can reduce the average daily gain and worsen the feed conversion ratio. This was observed for the 12% concentrate treatment.

4.2. Carcass Traits and Commercial Cuts

Measurements and evaluations performed on the carcass allow us to understand the body development of animals, seeking to obtain a deposition maximum of muscle and intermediate fat in the carcasses. In view of the data obtained, the animals from the treatments with 50%, 69%, and 88% concentrate showed similar and better body development than the animals from the treatments C12 and C31. This is probably related to DMI for those animals that received diets above 50% roughage, preventing them from expressing their production potential, because with the high NDF content in these diets, the passage of digesta through the gastrointestinal tract was reduced, limiting DMI from animals by filling [17,20].

Within the measurements and evaluations carried out on the carcass, the carcass compactness index and carcass conformation index stand out as being parameters that estimate the amount of muscle deposited in the carcass, which is the edible part with the highest financial return for the producer. The animals from treatments C50, C69, and C88 did not differ statistically; this indicates that all animals from these treatments were similar in body performance with similar muscle composition and carcass conformation. This resulted in higher hot and cold carcass weight, and better cold carcass yield (also known as commercial yield). The same behavior was observed by Brand et al. [23] evaluating carcass characteristics and fat deposition of Merino, South African Mutton Merino, and Dorper lambs housed in a feedlot.

Lower weights and yields of carcass obtained for the animals that received 12% concentrate can be explained by the NDF and ADF content in the diet, which is higher than the other treatments. This fiber content provided the animals with a longer digesta retention time due to reduced passage rate, resulting in a greater volume/weight of the gastrointestinal tract. As the carcass yield calculation is obtained through the ratio between the carcass weight and the final body weight of the animal, the volume/weight of the GIT and its content are considered only in the final weight of the animal, which reduces the weight and consequently the carcass yield. With higher energy availability in feed, there is greater availability of nutrients for the development of muscle and adipose tissue, resulting in higher carcass weights, and consequently heavier commercial cuts [18].

Regarding the deposition of fat in the carcass, the fat thickness and marbling did not differ between treatments, indicating that this distribution occurred in a similar way, regardless of the roughage:concentrate ratio that the animal received. However, the subjective evaluation of carcass finishing indicated that animals from treatments C50, C69, and C88 had better distribution of fat in the carcass than animals that received 12% and 31% concentrate. This divergence may be related to the measured and/or visualized location, as the fat thickness is measured only between the 12th and 13th ribs, while the fat finish assessment examines the complete carcass.

Regarding the deposition of pelvic-renal fat, tropical animals have the physiological ability to deposit intra-abdominal fat, which occurs with maturity and acts as energy reserves that are mobilized during the period of feed shortage to reduce their energy deficit [18]. Renal pelvic fat has a high correlation with carcass fattening degree; that is, the greater the deposition of fat in this region, the greater the carcass fattening degree [7,24].

Carcass fattening degree is interesting because it protects carcasses from cold drying [25] and keeps meat with optimal concentrations of moisture, providing, together with the fat, a greater juiciness in the meat [26,27]. However, it is necessary to consider to what extent the amount of fat is interesting in the carcass fattening. Because it is highly correlated with the pelvic-renal fat, indicating feed energy waste, it fails to convert the energy absorbed from the food into muscle and/or marbling fat (edible part of the carcass) to convert it into a type of fat that is neither commercialized nor used in cooking. The animals that received 31%, 50%, 69% and 88% concentrate showed similar pelvic-renal fat deposition.

4.3. Physicochemical Properties from the Proximate Composition of Meat

As can be seen by pH_{0h}, diets with different roughage:concentrate ratios provided different amounts of muscle glycogen reserve during the animals' development. The diet with the lowest proportion of concentrate (C12) had a higher pH_{0h} compared to the other treatments. This was due to the high NDF and ADF content in the diet, which reduced the passage rate of digesta, distended the rumen-reticulum, and limited the intake of animals due to physical factors of the gastrointestinal tract. This probably prevented the animals from having their energy demand fully satiated, resulting in less muscle glycogen deposition.

The muscle pH in live animals is between 7.08 and 7.30, soon after slaughter the pH reduces to 7.0 and continues to reduce until reaching values between 5.4 and 5.8 for sheep meat [7,27]. This reduction in pH occurs due to the accumulation of lactic acid produced, via anaerobic mechanism, which is inversely proportional to the concentration of muscle glycogen present at the time of slaughter. The pH_{24h} did not differ between treatments and presented an average of 6.07, above the expected for sheep meat. The animals were probably subjected to some stress during transport and/or at the slaughterhouse, which made them use muscle glycogen for energy production via aerobic mechanism, resulting in lower lactic acid production and higher pH_{24h} [28].

In this research, the pH_{24h} obtained was higher than the isoelectric point of muscle proteins (5.2–5.3), which indicates that because it is above the neutral charge of proteins, these meats had an excessive negative charge in their fibers, which provided repulsion of the filaments, in this way, increased the space for the water molecules to bind, contributing to greater juiciness, less mechanical force when cutting, and smaller proportional losses of water during cooking. The mean values of CL were within the acceptable range of up to 35% [29].

The shear force did not differ between treatments, which was expected, since this variable is more affected by the age, physical activity, and sex of the animal [18]. The shear force is directly related to the connective tissue protein, that is, the size of the fiber bundles, the quantity and size of the fibers, the collagen solubility, if there is a presence of cross-links, among others. The mean values indicate that the meat obtained for most treatments was considered tender (<22.27 N), except the meat from animals that received a diet with 69% concentrate, which had an average value of 24.50 N, but was considered with medium tenderness (22.27 and 35.61 N) [7].

The pH_{24h} of the meat affects the load of the muscle proteins that alters the spacing between the fibers of the meat. This change in the structure affects how the light is reflected and absorbed and therefore affects the visual appearance of the meat, which is measured through the indices of brightness (L*), the intensity of yellow (b*), and intensity of red (a*). The different roughage:concentrate ratios did not affect the coordinates referring to color, which is important because it is the primary attribute considered at the time of purchase [30]. The averages obtained corroborate those in the literature for sheep meat, which are from 30.03 to 49.47 for L*, from 8.24 to 23.53 for a* and from 3.38 to 11.10 for b* [27]; also working with Santa Ines sheep, means similar to those of this study were found.

When evaluating the chemical composition of Santa Ines sheep meat, we observed that the different roughage:concentrate ratios did not provide a significant difference for the ash and protein contents and the averages obtained for the moisture and lipid contents were inversely proportional, as also described by Silva et al. [31]. The moisture and lipid contents in the meat are important for providing the consumer with the feeling of juiciness since the moisture in the meat is released at the time of mastication and the juiciness sensation persists due to the concentration of lipids in the meat, which stimulates salivation [26], ensuring the juiciness for longer.

The diet with 88% concentrate presented lower NDF content and higher NFC and ME content. This promoted greater use of the diet and energy supply to ruminants due to the production of ruminal propionic acid and a lower acetate:propionate ratio, which allows a higher concentration of circulating glucose, favoring insulin secretion and induction of

lipogenesis, which resulted in greater storage of energy in the form of adipose tissue [32]. In this way, the meats of the animals that received this treatment probably provided greater succulence to the consumer compared to treatments C12 and C31. This is because, despite the meat from these last two treatments having a higher moisture content, the prolonged sensation of juiciness is obtained with the concentration of lipids in meat, which for these treatments had a lower proportion.

The Santa Ines breed is specialized in producing lean meats [24]; however, total lipid contents obtained in meats were adequate to guarantee the desirable organoleptic properties of meat [33].

5. Conclusions

Higher levels of concentrate favored carcass traits, commercial cuts, and physicochemical parameters of the meat. However, considering the demands of the producer (higher production with lower cost) and the demand of market consumer, the addition of 50% of concentrate to the roughage presented animal performance and carcass traits similar to the highest level of concentrate tested, also presenting as the most interesting option.

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References

1. NRC (National Research Council). *Nutrient Requirements of Small Ruminants: Sheep, Goats, Cervids, and New World Camelids*; The National Academies Press: Washington, DC, USA, 2007.
2. Oliveira, K.A.; de Lima Macedo, G.; da Silva, S.P.; Araújo, C.M.; Varanis, L.F.M.; Sousa, L.F. Nutritional and metabolic parameters of sheep fed with extrused roughage in comparison with corn silage. *Semin. Cienc. Agrar.* **2018**, *39*, 1795–1804. [CrossRef]
3. Jacques, J.; Berthiaume, R.; Cinq-Mars, D. Growth performance and carcass characteristics of Dorset lambs fed different concentrates: Forage ratios or fresh grass. *Small Rumin. Res.* **2011**, *95*, 113–119. [CrossRef]
4. Papi, N.; Mostafa-Tehrani, A.; Amanlou, H.; Memarian, M. Effects of dietary forage-to-concentrate ratios on performance and carcass characteristics of growing fat-tailed lambs. *Anim. Feed Sci. Technol.* **2011**, *163*, 93–98. [CrossRef]
5. Issakowicz, J.; Bueno, M.S.; Sampaio, A.C.K.; Duarte, K.M.R. Effect of concentrate level and live yeast (Saccharomyces cerevisiae) supplementation on Texel lamb performance and carcass characteristics. *Livest. Sci.* **2013**, *155*, 44–52. [CrossRef]
6. Qiao, G.H.; Xiao, Z.G.; Li, Y.; Li, G.J.; Zhao, L.C.; Xie, T.M.; Wang, D.W. Effect of diet synchrony on rumen fermentation, production performance, immunity status and endocrine in Chinese Holstein cows. *Anim. Prod. Sci.* **2018**, *9*, 664–672. [CrossRef]
7. Cezar, M.F.; Sousa, W.H. *Carcaças Ovinas e Caprinas—Obtenção, Avaliação e Classificação*; Agropecuária Tropical: Uberaba, Brazil, 2007.
8. AMSA. *Research Guidelines for Cookery, Sensory Evaluation, and Instrumental Tenderness Measurements of Meat*; American Meat Science Association: Champaign, IL, USA, 2015.
9. Shackelford, S.D.; Wheeler, T.L.; Koohmaraie, M. Evaluation of slice shear force as an objective method of assessing beef Longissimus tenderness. *J. Anim. Sci.* **1999**, *77*, 2693–2699. [CrossRef]

10. Cañeque, V.; Sañudo, C. *Metodologia Para el Estúdio de la Calidad de la Canal y de la Carne en Ruminantes*; Instituto Nacional de Investigación y Tecnologia y Alimenticia: Madrid, Spain, 2000.
11. Miltenburg, G.A.J.; Wensing, T.H.; Smulders, F.J.M.; Breukink, H.J. Relationship between blood hemoglobin, plasma and tissue iron, muscle heme pigment, and carcass color of veal. *Sci. J. Anim. Sci.* **1992**, *70*, 2766–2772. [CrossRef]
12. Hunt, M.C.; King, A. *Meat Color Measurement Guidelines*; American Meat Science Association (AMSA): Champaign, IL, USA, 2012; Available online: https://meatscience.org/docs/default-source/publications-resources/hot-topics/2012_12_meat_clr_guide.pdf?sfvrsn=d818b8b3_0 (accessed on 10 January 2022).
13. Association of Official Analytical Chemists (AOAC). Humidity, Ash and Protein (crude) determination in animal feed (985.41; 920.15 e 928.08). In *Official Methods of Analysis*; AOAC: Gaithersburg, MD, USA, 2016.
14. Folch, J.; Lees, M.; Stanley, G.S. A simple method for the isolation and purification of total lipides from animal tissues. *J. Biol. Chem.* **1957**, *226*, 497–509. [CrossRef]
15. SAS-SAS Institute. *SAS User's Guide: Basics*; SAS Institute Inc.: Cary, NC, USA, 2014.
16. Salinas-Chavira, J.; Arzola, C.; García-Castillo, R.F.; Briseno, D.A. Approaches to the level and quality of forage in feedlot diets for lambs. *J. Dairy Vet. Anim.* **2017**, *5*, 96–97. [CrossRef]
17. Pinho, R.M.A.; Santos, E.M.; Oliveira, J.S.; Carvalho, G.G.P.; Silva, T.C.; Macêdo, A.J.D.S.; Corrêa, Y.R.; Zanine, A.M. Does the level of forage neutral detergent fiber affect the ruminal fermentation, digestibility and feeding behavior of goats fed cactus pear? *Anim. Sci. J.* **2018**, *89*, 1424–1431. [CrossRef]
18. Souza, A.F.N.; Araújo, G.G.L.; Santos, E.M.; Azevedo, P.S.; Oliveira, J.S.; Perazzo, A.F.; Pinho, R.M.A.; Zanine, A.M. Carcass traits and meat quality of lambs fed with cactus (*Opuntia ficus-indica* Mill) silage and subjected to an intermittent water supply. *PLoS ONE* **2020**, *15*, e0231191. [CrossRef]
19. Ríos-Rincón, F.G.; Estrada-Angulo, A.; Plascencia, A.; López-Soto, M.A.; Castro-Pérez, B.I.; Portillo-Loera, J.J.; Robles-Estrada, J.C.; Calderón-Cortes, J.F.; Dávila-Ramos, H. Influence of Protein and Energy Level in Finishing Diets for Feedlot Hair Lambs: Growth Performance, Dietary Energetics and Carcass Characteristics. Asian-australas. *J. Anim. Sci.* **2014**, *27*, 55–61. [CrossRef] [PubMed]
20. Sousa, W.H.; Cartaxo, F.Q.; Costa, R.G.; Cezar, M.F.; Cunha, M.G.G.; Pereira Filho, J.M.; Santos, N.M. Biological and economic performance of feedlot lambs feeding on diets with different energy densities. *Rev. Bras. Zootec.* **2012**, *41*, 1285–1291. [CrossRef]
21. Abbasi, S.A.; Vighio, M.A.; Soomro, S.A.; Kachiwal, A.B.; Gadahi, J.A.; Wang, G. Effect of different dietary energy levels on the growth performance of kamori goat kids. *Int. J. Agro Vet. Med. Sci.* **2012**, *6*, 473–479. [CrossRef]
22. Cui, K.; Qi, M.; Wang, S.; Diao, Q.; Zhang, N. Dietary energy and protein levels influenced the growth performance, ruminal morphology and fermentation and microbial diversity of lambs. *Sci. Rep.* **2019**, *9*, 16612. [CrossRef]
23. Brand, T.S.; Van der Westhuizen, E.J.; Van Der Merwe, D.A.; Hoffman, L.C. Analysis of carcass characteristics and fat deposition of Merino, South African Mutton Merino and Dorper lambs housed in a feedlot. *S. Afr. J. Anim. Sci.* **2018**, *48*, 477–478. [CrossRef]
24. Cartaxo, F.Q.; Sousa, W.H.; Costa, R.G.; Cezar, M.F.; Pereira Filho, J.M.; Cunha, M.G.G. Quantitative traits of carcass from lambs of different genotypes submitted to two diets. *R. Bras. Zootec.* **2011**, *40*, 2220–2227, (In Portuguese, with Abstract in English). [CrossRef]
25. Kannan, G.; Lee, J.H.; Kouakou, B. Chevon quality enhancement: Trends in pre-and post-slaughter techniques. *Small Rumin. Res.* **2014**, *121*, 80–88. [CrossRef]
26. Nute, G.R.; Richardson, R.I.; Wood, J.D.; Hughes, S.I.; Wilkinson, R.G.; Cooper, S.L.; Sinklar, L.A. Effect of dietary oil source on the flavour and the colour and lipid stability of lamb meat. *Meat Sci.* **2007**, *77*, 547–555. [CrossRef]
27. Lima, A.G.V.O.; Oliveira, R.L.; Silva, T.M.; Barbosa, A.M.; Nascimento, T.V.C.; Oliveira, V.D.S.; Ribeiro, R.D.X.; Pereira, E.S.; Bezerra, L.R. Feeding sunflower cake from biodiesel production to Santa Ines lambs: Physicochemical composition, fatty acid profile and sensory attributes of meat. *PLoS ONE.* **2018**, *13*, e0188648. [CrossRef]
28. Perlo, F.; Bonato, P.; Teira, G.; Tisocco, O.; Vicentin, J.; Pueyo, J.; Mansilla, A. Meat quality of lambs produced in the Mesopotamia region of Argentina finished on different diets. *Meat Sci.* **2008**, *79*, 576–581. [CrossRef] [PubMed]
29. Webb, E.C.; Casey, N.H.; Simela, L. Goat meat quality. *Small Rumin. Res.* **2005**, *60*, 153–166. [CrossRef]
30. Xazela, N.M.; Chimonyo, M.; Muchenje, V.; Marume, U. Effect of sunflower cake supplementation on meat quality of indigenous goat genotypes of South Africa. *Meat Sci.* **2012**, *90*, 204–208. [CrossRef]
31. Silva, T.M.; Medeiros, A.N.; Oliveira, R.L.; Neto, S.G.; Queiroga, R.C.R.E.; Ribeiro, R.D.X.; Leão, A.G.; Bezerra, L.R. Carcass traits and meat quality of crossbred Boer goats fed peanut cake as a substitute for soybean meal. *J. Anim. Sci.* **2016**, *94*, 2992–3002. [CrossRef] [PubMed]
32. Costa, J.B.; Oliveira, R.L.; Silva, T.M.; Ribeiro, R.D.X.; Silva, A.M.; Leão, A.G.; Bezerra, L.R.; Rocha, T.C. Intake, digestibility, nitrogen balance, performance, and carcass yield of lambs fed licuri cake. *J. Anim. Sci.* **2016**, *94*, 2973–2980. [CrossRef] [PubMed]
33. Wood, J.D. Consequences for meat quality of reducing carcass fatness. In *Reducing Fatness in Meat Animals*; Wood, J.D., Fisher, A.V., Eds.; Elsevier Applied Science: London, UK, 1990.