Mesquite Pod (Prosopis Juliflora) meal on Meat Quality of Pasture-Finishing Lambs

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Research Article

Keywords: Byproduct, Nutrition, Pasture, Semiarid, Sheep, Supplementation

Posted Date: June 28th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-585210/v1

Abstract

This study was carried out to evaluate the best inclusion level and the effects of mesquite pod (*Prosopis juliflora*) meal on carcass characteristics and meat quality for lambs finished in pasture. Forty male, non-castrated, crossbred Santa Inês lambs, with an initial body weight (24.2 ± 3.1 kg), and approximately 120-days old. The animals were kept in a total area of 4 ha, divided in 4 paddocks of 0.62 ha each (10 animals/paddocks), on pastures of Massai (*Panicum maximum cv. massai*) with drinkers and feeders during the finishing phase. Dietary treatments based on levels of corn ground replacement for mesquite pod meal included: CON – Without mesquite pod meal; MPM25 – 250 g/kg of mesquite pod meal; MPM50 – 500 g/kg of mesquite pod meal; and MPM75 – 750 g/kg of mesquite pod meal. No treatment effects were detected (P> 0.05) for carcass measures, carcass characteristics, chemical composition of *longissimus thoracis* muscle, tissue composition, and lipid oxidation. Lamb meat color values, such as lightness (L*) and yellowness (b*) were not affected (P> 0.05) by mesquite pod meal replacement on the diets, whereas for redness (a*), HUE, and crhoma were influenced (P< 0.05). Palmitic acid had a quadratic effect, while oleic acid, eicosatrienoic acid, saturated fatty acids, monounsaturated fatty acids, and PUFA:SFA had a linear course (P< 0.05). In conclusion the mesquite pod meal can be used as an energy feed source up to 750 g/kg of dry matter in the diet, without changing the carcass characteristics and meat quality of lambs finished in pasture.

Introduction

Sheep meat production in Brazil has grown in the last ten years, as well as the demand for animal protein in the country's large urban centers; due to population growth, increased purchasing power of the population, and change in eating habits (FAO, 2012). This growing demand for healthy products, antibiotic free, care for animal welfare, consequently a product of higher quality, promotes the sheep meat chain to search alternatives that can meet the needs of consumers, without affecting animal productivity with a less impact on the environment, in addition to reducing production costs.

In this context, mesquite pod meal stands out as an ingredient with great potential in animal feed, adapting to the replacement of commonly used concentrated energy feeds. It is relevant that fruit collection is carried out in the dry season (autumn - winter), in the off-season of most grains, showing energy, dry matter and crude protein content close to grain corn.

Another positive point to be considered in this feed is presence of alkaloids in its composition, a substance that inhibits the growth of ruminal gram-positive bacteria, which are responsible for production of gases such as CO^2 and methane, in addition to promoting better animal performance and better quality of products obtained from these animals (Mazzuca et al., 2003; Nakano et al., 2004; Singh et al., 2011).

When considering the chemical composition and requirement to evaluate the potential of mesquite pod meal in the sheep diet kept in pasture on carcass characteristics and meat quality, the objective was to determine the best level of corn replacement in the diet.

Material And Methods

Locality, animal, and diets

The experiment was carried out at cattle sector of Centro de Ciências Agrárias, Ambientais e Biológicas (CCAAB) of Universidade Federal do Recôncavo da Bahia (Cruz das Almas, Bahia, Brazil). On day − 1, forty male, non-castrated, crossbred Santa Inês lambs, were weighed to determine the initial body weight (initial BW = 24.2 ± 3.1 kg), vaccinated and dewormed prior to start of experiment, which were allocated in an experimental area consisting in a total area of 4 ha, divided in 4 paddocks of 0.62 ha each (10 animals/paddocks), on pastures of Massai (*Panicum maximum cv.* Massai) with drinkers and using a rotated management during the finishing phase.

The animals were supplemented in an individual feeding trough (1.0%/body weight; NRC, 2007) once daily (0700 h), throughout the experimental period (Table 1). Posteriorly the animals were taken to the pasture area (*Panicum maximum cv*. Massai) where they remained grazing freely until 1700h, and then were directed to a collective pen of 5.0 x 5.0 m with concrete floor and free-choice access to water during the next day. The treatments were constituted by four different levels of corn ground replacement for mesquite pod meal included: CON – Without mesquite pod meal; MPM25–250 g/kg of mesquite pod meal; MPM50–500 g/kg of mesquite pod meal; and MPM75–750 g/kg of mesquite pod meal.

Table 1

Composition of ingredients and the diets fed to Santa Inês lambs (g/kg of DM)[a]

Ingredients	DM[b]	OM[c]	CP[d]	EE[e]	NDF[f]	CELL[g]	HEMI[h]	LIG[i]	Ash	NFC[j]	TDN[k]
Massai Grass	368	915	95.4	16.1	748	298	380	69.1	85.3	54.7	573
Soybean meal	909	932	386	15.0	118	14.5	87.4	15.8	67.5	414	846
Ground corn	908	980	102	44.8	109	34.8	52.3	22.0	20.1	723	826
Mesquite pod meal	909	932	386	15.0	118	14.5	87.4	15.8	67.5	414	846
Mineral salt[l]	974	61.1	913	-	-	-	-	-	-	-	-
CON	912	924	237	72.6	148	26.3	148	59.0	75.9	466	840
MPM25	919	922	194	68.1	188	56.3	188	65.4	77.7	473	837
MPM50	926	910	215	568	229	81.6	229	70.5	90.3	408	838
MPM75	933	905	185	50.8	270	110	270	76.6	94.5	399	836

[a]CON = Without mesquite pod meal; MPM25 = 25 g/kg of mesquite pod meal; MPM50 = 50 g/kg of mesquite pod meal; MPM75 = 75 g/kg of mesquite pod meal.

[b]Dry matter; [c]Organic matter; [d]Crude protein; [e]Ether extract; [f]Neutral detergent fiber; [g]Cellulose; [h]Hemicellulose; [i]Lignin; [j]Non-fiber carbohydrates; [k]Total digestible nutrients.

[l]Mineral salt composition (kg): calcium, 50 g; magnesium, 57 g; sodium, 81 g; sulfur, 3.75 g; cobalt, 20 mg; copper, 500 mg; iodine, 25 mg; manganese, 1.500 mg; selenium, 10 mg; zinc, 2.000 mg; vitamin A, 400.000 UI; vitamin D3, 50.000 UI; vitamin E, 750 UI.

The lambs were finished on their respective diets for 84-days experimental period until the animals reached a mean final body weight of 32.2 ± 4.8 kg. Upon arrival the at the slaughterhouse, animals were kept in resting pens and were subsequently stunned using electro narcosis in compliance with the slaughter standards of the State Inspection Service legislation in Brazil (Brazil, 2000). After slaughter, the carcasses were identified, weighed, and chilled for 24 h at 4°C, for posteriorly data collection, such as carcass measures, carcass characteristics, chemical composition of *longissimus thoracis* muscle, tissue composition, color, and lipid oxidation.

Carcass measures

Thoracic depth, rump width, external carcass length, internal carcass length, shank thickness, internal leg length, external leg length were obtained according to the methodology described by Osório and Osório (2005). Through these measures, the carcass compactness index and the leg compactness index were calculated (Osório and Osório, 2005), using to the equations described below:

CCI = CCW/ ILL

LCI = RW/BL (1)

where: *CCI*, *CCW*, *ILL*, *LCI*, *RW*, and *BL* are Carcass compactness index; Cold carcass weight; Internal leg length; Leg compactness index; Rump width; and Body length, respectively.

Carcass characteristics

At slaughter time and 24 h post-mortem, the *Longissimus thoracis* pH was measured using a digital pH meter (Hanna – HI99163, Romania - Europe) with a penetration electrode placed at the point of the 3rd lumbar vertebra. The phMeter was calibrated at 20°C using standard pH 4.0 and 7.0 buffers (Valero et al., 2014).

Longissimus thoracis muscle area and thickness of subcutaneous fat were measured at 24 h post-mortem in the 12th rib by photographic images. Images were taken with aid of a digital camera in a straight line over the samples, forming an angle of 90 °. An object of known length was placed next to samples, to aid analysis by the ImageJ software.

Texture measurement of the previously cooked steaks was analyzed using a Stable Micro Systems TA.XTplus (Texture Technologies Corp., Serial Number 41288, Godalming, Surrey, UK) texture analyzer with a Warner-Bratzler blade, according to Honikel (1998). The meat was cut into rectangular pieces of 1 cm^2 cross-section, which were cut perpendicular to the direction of the muscle fibers.

The steaks were thawed at 4°C for 24 h. They were then weighed and the thawing losses were calculated as the percentage difference between the fresh and thawed weights (Rivaroli et al., 2016). For cooking losses, the steaks were weighed and wrapped in aluminum foil. Each sample was cooked in a pre-heated grill (Grill Philco Jumbo Inox, Philco SA, Brazil) at 200°C until an internal temperature of 72°C was reached, which was monitored using an internal thermocouple (Incoterm, 145 mm, Incoterm LTDA, Brazil). The sample was then removed from the heat and left at ambient temperature to cool. Once the steaks reached 25°C, each steak was weighed and the cooking losses calculated as the percentage difference in weight before and after cooking.

The water-holding capacity was determined by the methodology described by Nakamura (1985), which the samples were packed on filter paper (approximately 1 grams), and centrifuged for 4 minutes at 1500 G. Subsequently, the filter paper was discarded and the samples were oven dried at 70 ° C for 12 hours. The water-holding capacity was determined by the equation:

*WHC = (SWC-DSW/IW)*100* (2)

where: *SWC*, *DSW*, and *IW* are Sample weight after centrifugation; Dry sample weight; and Initial weight, respectively.

Chemical analysis of meat samples

To determine chemical composition, the samples were homogenized in a multiprocessor until a homogeneous mass was obtained. Moisture (ID 950.46B) content was determined by drying in an oven at 105°C until a constant weight was obtained (AOAC, 2005); Ash content was measured by combustion at 550°C for 16h according to method ID 942.05 (AOAC, 2005); Total fat were extracted by the Soxhlet method ID 960.39 (AOAC, 2005); and the crude protein was measured using the Kjeldahl method ID 992.15 (AOAC, 2005).

Carcass tissue composition

Carcass composition was determined/estimated by dissection between the 12th and 13th ribs according to the methodology of Menezes et al. (2015). Muscle, fat (subcutaneous and inter-muscular), and bone were separated.

Instrumental meat color

The color was evaluated after 30 min of exposure to oxygen at 1-day of display, by using the CIELab system with a Minolta CR-400 Chroma meter (Japan) (with a 10° view angle, D65 illuminant, 8 mm of aperture with a close cone). Six measurements at randomly selected points were recorded per sample (*longissimus dorsi* muscle, between the 12th and 13th ribs), obtaining lightness (L*), redness (a*) and yellowness (b*). Chroma and hue values were determined according to the methodology described by Ramos and Gomide (2012), using to the equations described below:

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

$$H^0 = (\arctan (b^*/a^*)) \quad (3)$$

where: $a*^2$, $b*^2$, and h^0 are redness; yellowness; and hue angle, respectively.

Lipid oxidation

The malondialdehyde (MDA) content in meat was quantified using the thiobarbituric acid reactive substances (TBARS) assay as was adapted by Vital et al. (2016). The sample (5 g) was mixed with trichloroacetic acid (10 mL), homogenized using an Ultra-Turrax, and then centrifuged (4000 rpm) at 4°C for 15 min. The supernatant was filtered and mixed with TBARS reagent (1:1 v/v). The mixture was boiled (100°C) for 15 min, cooled then the absorbance measured at 532 nm against an MDA standard. Results were expressed as mg MDA/kg of meat. The assay was performed at 1, 7, and 14 days of display.

Fat acid profile

Fatty acid methyl esters by transesterification of triglycerides acids were obtained in a solution of n-heptane and KOH/methanol (ISO, 1978). The analysis of the methyl esters of the fatty acid were carried out in the gas chromatograph 14-A (Shimadzu Corp, Nakagyoku, Kyoto, Japan) equipped with a flame ionisation detector and fused silica capillary column with 100-m length, 0.25-mm inner diameter and 0.20 mm in polisiloquixanocyanoalkyl, CP-Sil 88 (Chrompack, Santa Clara, CA, USA). To record the concentrations of fatty acids, the device was coupled to a GC-300 Processor Integrator (CG Scientific Instruments, Woburn, MA, USA). The conditions adopted in chromatographic separation process, and the

quantification of fatty acids were performed using correction factors for peak area, according to Goes et al. (2018).

Statistical analyses

Data were analyzed by using the ANOVA procedure of SAS (SAS, 2004) to perform a randomized complete experiment with four treatments and ten replications, using the model:

$Yij = \mu + ai + \varepsilon(i)j$ (4)

where: Yij, μ, ai, and $\varepsilon(i)j$ are Dependent variables; Constant general; Effect related to the replacement level i (i = 1, 2, 3, and 4); and random error, respectively.

For each studied variable, the mean and standard error of the mean (SEM) were calculated and linear and quadratic regression tests were performed between the supplement treatments ($P \leq 0.05$).

Results

Carcass measurements and compactness indexes (carcass and leg) were not affected ($P > 0.05$) by the levels of mesquite pod meal in the supplement (Table 2). There were no differences ($P > 0.05$) in *Longissimus thoracis* muscle area, thickness of subcutaneous fat, initial pH (at the time of slaughter), final pH (pH 24h), shear force, losses (cooking and thawing losses), and water-holding capacity (Table 3). Corn ground replacement for mesquite pod meal in the diet did not affect ($P > 0.05$) the chemical composition of lamb meat (Table 4). Carcass tissue composition (% muscle, fat, and bone) based on dissection between the 12th and 13th ribs from the carcass were not affected ($P > 0.05$; Table 5). Lightness (L*) and yellowness (b*) were not influenced ($P > 0.05$), whereas the redness (a*) presented decreasing values with the replacement of mesquite pod meal in the diet ($P < 0.05$). However, chroma and h^0 values showed a linear course ($P < 0.05$; Table 6). Meat lipid oxidation at 1, 7, and 14 days of display was not affected ($P < 0.05$; Table 7) at none of maturation times. Fatty acid profile, the palmitic acid (C16:0) had a quadratic effect, while oleic (C18:1) and eicosatrienoic (C20:3ω3) acids had a linear effect ($P < 0.05$). However, sum of fatty acids - saturated fatty acids, monounsaturated fatty acids, and PUFA:SFA had a linear course ($P < 0.05$; Table 8).

Table 2
Carcass measures from Santa Inês lambs supplement or not with mesquite pod meal during the finishing phase on pasture[a]

						p-value	
Parameters	CON	MPM25	MPM50	MPM75	SEM	L	Q
External carcass length (cm)	54.7	48.5	52.6	52.8	1.31	0.137	0.114
Internal carcass length (cm)	52.6	51.5	51.5	46.1	1.26	0.167	0.393
External leg length (cm)	42.2	42.2	41.8	42.3	0.19	0.996	0.804
Internal leg length (cm)	40.7	40.5	40.5	40.6	0.19	0.626	0.754
Thoracic depth (cm)	17.5	17.3	16.7	16.8	0.14	0.383	0.759
Rump width (cm)	15.5	15.6	16.3	15.3	0.17	0.809	0.242
Shank thickness (cm)	12.1	11.6	12.2	11.8	0.13	0.521	0.089
CCI[b] (kg/cm²)	0.22	0.24	0.26	0.26	0.07	0.211	0.718
LCI[c] (kg/cm²)	0.38	0.38	0.40	0.37	0.07	0.665	0.296

[a]CON = Without mesquite pod meal; MPM25 = 25 g/kg of mesquite pod meal; MPM50 = 50 g/kg of mesquite pod meal; MPM75 = 75 g/kg of mesquite pod meal.

[b]Carcass compactness index.

[c]Leg compactness index.

Table 3
Carcass characteristics from Santa Inês lambs supplement or not with mesquite pod meal during the finishing phase on pasture[a]

						p-value	
Parameters	CON	MPM25	MPM50	MPM75	SEM	L	Q
pH abate	7.38	7.39	7.32	7.33	0.04	0.612	0.873
pH 24h	5.54	5.51	5.52	5.56	0.03	0.259	0.189
LMA[b] (cm^2)	3.90	4.34	4.45	4.16	0.13	0.713	0.582
Fat thickness (cm)	0.10	0.12	0.15	0.13	0.02	0.296	0.858
Shear force (kgf/cm^2)	2.36	2.34	2.38	2.34	0.03	0.632	0.538
WHC[c] (mL.100/g)	53.2	53.8	53.3	54.1	0.38	0.834	0.393
Cooking losses (%)	22.5	20.6	20.5	21.0	0.61	0.562	0.396
Thawing losses (%)	4.14	4.70	4.56	4.37	0.05	0.186	0.695

[a]CON = Without mesquite pod meal; MPM25 = 25 g/kg of mesquite pod meal; MPM50 = 50 g/kg of mesquite pod meal; MPM75 = 75 g/kg of mesquite pod meal.

[b]LMALongissimus thoracis muscle area.

[c]Water holding capacity.

Table 4
Chemical composition of meat samples from Santa Inês lambs supplement or not with mesquite pod meal during the finishing phase on pasture[a]

						p-value	
Parameters (g/kg DM basis)	CON	MPM25	MPM50	MPM75	SEM	L	Q
Moisture	74.3	74.7	74.8	74.4	0.10	0.158	0.269
Ash	1.65	1.71	1.66	1.68	0.04	0.679	0.889
Ether extract	3.00	2.99	2.99	2.99	0.01	0.222	0.409
Crude protein	20.9	20.6	20.5	20.9	0.11	0.171	0.321

[a]CON = Without mesquite pod meal; MPM25 = 25 g/kg of mesquite pod meal; MPM50 = 50 g/kg of mesquite pod meal; MPM75 = 75 g/kg of mesquite pod meal.

Table 5
Carcass composition from Santa Inês lambs supplement or not with mesquite pod meal during the finishing phase on pasture[a]

						p-value	
Tissue, %	CON	MPM25	MPM50	MPM75	SEM	L	Q
Bone	43.8	43.3	42.9	43.7	1.05	0.842	0.429
Fat	6.06	5.68	5.88	5.47	0.19	0.216	0.856
Muscle	50.1	50.1	51.2	50.8	1.08	0.687	0.419

[a]CON = Without mesquite pod meal; MPM25 = 25 g/kg of mesquite pod meal; MPM50 = 50 g/kg of mesquite pod meal; MPM75 = 75 g/kg of mesquite pod meal.

Table 6
L*a*b*, chroma and hue values of meat sample from Santa Inês lambs supplement or not with mesquite pod meal during the finishing phase on pasture[a]

						p-value	
Parameters	CON	MPM25	MPM50	MPM75	SEM	L	Q
L*	42.3	43.7	44.1	43.6	0.33	0.123	0.812
a*[b]	11.9	11.7	11.6	10.4	0.13	0.001	0.736
b*	11.8	12.6	12.0	12.1	0.11	0.722	0.085
Chroma[c]	16.8	17.2	15.9	16.2	0.14	0.014	0.143
Hue[d]	48.4	49.2	47.4	44.8	0.34	0.001	0.273

[a]CON = Without mesquite pod meal; MPM25 = 25 g/kg of mesquite pod meal; MPM50 = 50 g/kg of mesquite pod meal; MPM75 = 75 g/kg of mesquite pod meal.

[b]Y=9.98707 + 0.45656x.

[c]Y=15.5102-0.4879x.

[d]Y=50.36282-1.11620x.

Table 7
Lipid oxidation (TBARS) expressed as mg malonaldehyde/kg of meat sample from Santa Inês lambs supplement or not with mesquite pod meal during the finishing phase on pasture[a]

						p-value	
Days	CON	MPM25	MPM50	MPM75	SEM	L	Q
1	0.59	0.55	0.61	0.57	0.02	0.738	0.167
7	0.57	0.54	0.54	0.61	0.02	0.991	0.162
14	0.56	0.58	0.52	0.59	0.02	0.438	0.760

[a]CON = Without mesquite pod meal; MPM25 = 25 g/kg of mesquite pod meal; MPM50 = 50 g/kg of mesquite pod meal; MPM75 = 75 g/kg of mesquite pod meal.

Table 8
Fatty acid profile and sum of fatty acids of meat sample from Santa Inês lambs supplement or not with mesquite pod meal during the finishing phase on pasture[a]

						p-value	
Items, %	CON	MPM25	MPM50	MPM75	SEM	L	Q
Fatty acid profile							
C10:0	0.36	0.35	0.35	0.35	0.01	0.473	0.206
C12:0	0.11	0.12	0.11	0.11	0.01	0.591	0.233
C14:0	2.26	2.29	2.26	2.27	0.02	0.989	0.681
C16:0[b]	23.2	23.5	23.4	23.7	0.10	0.003	0.014
C18:0	18.2	18.2	18.3	18.3	0.02	0.224	0.325
C20:0	0.11	0.11	0.11	0.11	0.01	0.581	0.712
C16:1	3.56	3.57	3.58	3.56	0.02	0.989	0.738
C18:1[c]	44.1	43.8	43.9	43.7	0.09	0.017	0.052
C18:2ω6	2.49	2.41	2.46	2.40	0.02	0.057	0.157
C18:2CLA	0.17	0.17	0.17	0.18	0.01	0.290	0.496
C18:3ω3	0.45	0.44	0.46	0.45	0.01	0.588	0.865
C20:3ω3[d]	0.11	0.11	0.11	0.10	0.01	0.028	0.089
C20:3ω6	0.10	0.10	0.10	0.10	0.01	0.575	0.704
C20:4ω6	0.17	0.18	0.17	0.18	0.01	0.480	0.776
Sum of fatty acids							
Saturated fatty acids[e]	44.3	44.6	44.6	44.8	0.09	0.008	0.113
Monounsaturated fatty acids[f]	47.7	47.5	47.6	47.4	0.09	0.018	0.058
Polyunsaturated fatty acids	3.50	3.43	3.47	3.42	0.03	0.159	0.356
ω-3	0.56	0.55	0.56	0.56	0.01	0.904	0.991
ω-6	2.94	2.87	2.91	2.86	0.03	0.106	0.257
ω-6:ω-3	5.26	5.21	5.16	5.14	0.09	0.323	0.611
PUFA:SFA[g]	0.079	0.077	0.076	0.08	0.01	0.039	0.109

	p-value
[a]CON = Without mesquite pod meal; MPM25 = 25 g/kg of mesquite pod meal; MPM50 = 50 g/kg of mesquite pod meal; MPM75 = 75 g/kg of mesquite pod meal.	
[b]$Y=23.22410 + 0.00812-0.0000328x^2$.	
[c]Y=44.02320-0.00401x.	
[d]Y=0.10980-0.000068x.	
[e]Y=44.34010 + 0.00612x.	
[f]Y=47.69480-0.00399x.	
[g]Y=0.07854-0.0000284x.	

Discussion

The similarity in the results for carcass measurements is associated with animals' homogeneity at the beginning of experiment until the slaughter period. These characteristics are directly related to slaughter weight, animal genotype, and the diet indirectly influences carcass measurements. (Bonvillani et al., 2010). Compactness indexes prove that the animals between treatments showed uniformity and a good muscle proportion, which according to Suassuna et al. (2015), the carcass compactness indexes must be equal to and/or greater than 0.20 kg/cm.

Longissimus thoracis muscle area and thickness of subcutaneous fat are used to predict the amount of muscle and fat present in the carcass, due to positive correlation between them. Thus, the thickness of subcutaneous fat of animals' carcass were considered scarce, which is recommended for Santa Inês sheep 0.3 cm (Silva Sobrinho, 2001). Whereas, the race factor is an explanation, since Santa Inês animals are poor subcutaneous fat (Araújo Filho et al., 2010). However, another characteristic that influences the qualitative characteristics of meat is the pH, modifying the appearance, conservation, tenderness, flavor, as well as the nutritional value of the meat (Gomide et al., 2013). Average values observed for the present study was 5.53, considered adequate, since the ideal for sheep meat are values between 5.5 and 5.8 (Gois et al., 2017).

Meat samples showed an average of 2.35 (kgf/cm²) for shear force, being considered as very tender meat, according to classification system mentioned by Boleman et al. (1997) in which meat with a shear force between 2.3 and 3.6 (kgf/cm²) is considered extremely tender. Cooking and thawing losses according to Costa et al. (2011), are important characteristics to be measured, as they are associated with the yield at the time of meat preparation, storage, and influenced by the water holding capacity. In its turn, this parameter according to Zeola et al. (2007), is indicative of losses, and thus, the lower the water holding capacity, the greater the losses due to cooking and nutritional value (soluble proteins, lipids and minerals).

The reason for similar values for chemical composition is most likely due to all animals that received a diet formulated to meet nutritional gain requirements, associated with the total digestible nutrients and crude protein intake that were similar between treatments. The values referring to moisture, crude protein, ether extract, and ash observed in the present study are match with the values presented by Madruga et al. (2008) and Gois et al. (2017) for lamb meat, which were ~ 73.5%, 23%, 3.5, and 111%, respectively. Studies carried out with lambs reported muscle, fat, and bone percentages (Azizi-shotorkhoft et al., 2015), befitting to values obtained in this study can be considered normal for these animal categories.

According to Pinheiro et al. (2009) the increase in weight and age at slaughter, promotes the color of lamb meat with a lower lightness (L*) value, due to the greater fat amount and less water contained in the animals' muscle. Therefore, the similarity between treatments for lightness and yellowness (b*) contents may have occurred due to the uniformity of animals at slaughter. Values observed in this study for lightness, redness (a*), and yellowness are within the standard for sheep breed, according to research described by Bressan et al. (2001), Rodrigues et al. (2008), and Jucá et al. (2016), who report values from 30.1 to 49.5, 8.24 to 23.5, and 3.34 to 13.1, respectively. Chroma and hue are variables influenced by redness value, and thus, we can claim that results found for these characteristics are directly related to effect of mesquite pod meal on redness meat color.

Lipid oxidation for all treatments showed indexes lower the maximum limits established for the perception of oxidative rancidity through the flavor present in the food, which is recommended in 1.0 mg of malonaldehyde/kg of sample.

Values of C20:3 and monounsaturated fatty acids remained within the standard for meat samples from ruminants fed with oilseeds or their by-products (Goes et al., 2018 and De Araújo et al., 2021). According to Goes et al. (2018) working with levels of replacement of soybean meal by sunflower cake in feeding ruminants, found high values for C16:0, while the values of mesquite pod meal treatments in the present study remained low. This is an important result, since C16:0 fatty acid has high cholesterol levels and provides less action on liver receptors for low-density lipoprotein, and consequently at high dosages in the bloodstream, it harms human health (Goes et al., 2018).

According to Sañudo et al. (2000) and Quiñones et al. (2019) the fatty acid profile in the *Longissimus thoracis* muscle presented a conduct similar to the present study, providing an increase of C18:1 in the meat as the mesquite pod meal was added. The explanation for this event is due to high levels of unsaturated fatty acids present in the mesquite pod meal; when consumed in a diet by ruminants go through the biohydrogenation process, consequently absorbed in the intestine, and incorporated into the tissues. Furthermore, there is a possibility that C18:1 fatty acid is related to action of lipogenic enzymes (Yeom et al., 2005; Quiñones et al., 2019).

De Araújo et al., 2021 working with castor bean meal from the biodiesel process did not observe any difference for saturated fatty acids from meat samples (ruminant animals), whereas, the present results indicate a significant increase in the saturated fatty acids content with addition of mesquite pod meal to lambs diet. However, care for human health has favored debates in recent years regarding the effect of

saturated fatty acids, so far there has been no evidence of any correlation with ratio of saturated fatty acids consumed and cardiovascular diseases (Astrup et al., 2011; Li et al., 2015; Praagman et al., 2016).

According to Aksoy et al. (2019) the contents of saturated fatty acids, monounsaturated fatty acids and polyunsaturated fatty acids are used as parameters in determining the nutritional quality of meat intramuscular fat. Consequently, the ratio of polyunsaturated fatty acids and saturated fatty acids is influenced positively or negatively, but according to Department of Health (1994) recommendations, this ratio must be equal to or less than 0.45; medium result of 0.077 found in the present study, proves the meat quality of lambs fed with mesquite pod meal.

In conclusion, the great potential of using mesquite pod (*Prosopis juliflora*) meal as an energetic ingredient in supplements for lambs finished in pasture can be considered, aiming that the carcass characteristics and meat quality were not affected with corn ground replacement for mesquite pod (*Prosopis juliflora*) meal.

Declarations

Ethics statement

The Committee for Ethics in the use of Animals (CEUA) of the Universidade Federal do Recôncavo da Bahia approved this experiment (no. 23007.004598/2016-17).

Conflict of interest

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

Funding

This work was supported by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – CAPES (Brasília, Brazil) for the scholarship, and the Conselho Nacional de Desenvolvimento Científico e Tecnológico – CNPq (Brasília, Brazil).

Informed consent

All authors have given their consent that this work is valid and represent their views of the study, and all authors have given their consent for this work to be published.

Data availability

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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