Journal of Agricultural Science; Vol. 9, No. 7; 2017
ISSN 1916-9752 E-ISSN 1916-9760
Published by Canadian Center of Science and Education

Meat Quality of Dairy Steers Fed Mesquite Pod Meal in Semi-Arid

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Received: April 25, 2017 Accepted: May 25, 2017 Online Published: June 15, 2017

doi:10.5539/jas.v9n7p155 URL: https://doi.org/10.5539/jas.v9n7p155

Abstract

The exploitation of dairy steers for meat production is an alternative to improve production rates, but feed alternatives to cereal grains like corn used in animal feed should be researched. In this study, we aimed to evaluate performance, carcass characteristics, and meat quality of dairy steers consuming different levels (0, 250, 500, 750, and 1000 g/kg, dry matter basis) of mesquite pod meal replacing corn. Twenty-five intact Holstein-Zebu dairy steers at approximately 18 months of age and with an initial body weight of 219±22 kg were used. A completely randomized design with five treatments (replacement levels) and five replications (animals) was adopted, and data were analyzed using PROC GLM for analysis of variance and PROC REG for regression analysis. There was no significant influence of the levels of replacement of corn by the mesquite pod meal as regards dry matter intake, final body weight, weight gain, carcass weight, or carcass yield ($P > 0.05$). The meat quality of the cattle was not significantly affected by the different levels of replacement ($P > 0.05$). Mesquite pod meal can fully replace corn in diets for dairy steers.

Keywords: alternative feedstuff, feedlot, semi-arid regions, tenderness

1. Introduction

The dairy agribusiness is a prominent growing sector in the global economy. Of a total of 1.03 billion cattle heads in the world, 251.9 are intended for milk production. In this context, it is clear that a large portion of calves born in the world originate from dairy-purpose herds, and part of these animals is kept in arid and semi-arid regions (United States Department of Agriculture [USDA], 2014). The exploitation of dairy steers for meat production is an alternative to improve production rates of both the beef and dairy cattle farming industries.

In cattle production systems, the expenses incurred from feeding can account for 70 to 90% of total operating costs. The grains and cereals used in cattle diets do not always achieve expressive production levels in many parts of the world, which elevates their price in arid and semi-arid regions, especially during dry periods. Therefore, it is essential for the beef cattle industry that alternative feedstuffs be introduced to eliminate or at least lessen these effects.

Among the forage resources, the mesquite pod (*Prosopis juliflora* (SW) D.C.) stands out for being found in low-fertility and rocky soils. The mesquite bears fruit even in the driest period of the year, and its pods have a high nutritional value and good palatability. It is more interesting to utilize the mesquite fruit as a meal, because the use of the mesquite pod meal (MPM) helps to control possible thermolabile factors, in addition to eliminating risks of intestinal perforation.

Considering the great participation of dairy cattle in the world herd the scarcity of results for body composition, carcass characteristics and feed efficiency of dairy steers used for meat production; and the high prices and the low availability of grains and cereals utilized in the formulation of diets, we conducted this study to evaluate the meat quality of dairy steers fed mesquite pod meal replacing corn.

2. Materials and Methods

2.1 Location, Facility and Animals

The experiment was undertaken in the cattle section of the Academic Unit of Serra Talhada, at the Rural Federal University of Pernambuco (Pernambuco State, Brazil) from May to September of 2013. The region is characterized by irregular rainfall, with an average annual precipitation of 700 mm, 108 mm of which occurred between May and September of 2013. The climate of the region is characterized by high temperatures, with maximum value of 31 ºC (National Institute of Meteorology [INMET], 2013).

Animals were kept in individual stalls (3 × 9 m) surrounded by a smooth wire with fibre-cement tile floors. Each stall had a feeder (1.0 m long). The water dispenser was replaced by a waterer. The study included 25 crossbred Holstein-Zebu bulls, with an initial body weight of 219±22 kg and a mean age of 18 months. Initially, the animals were weighed, identified and treated against endo and ectoparasites. All applicable international, national, and/or institutional guidelines for the care and use of animals were followed (Federal Rural University of Pernambuco, license: 041/2013).

2.2 Experimental Period, Treatments and Diets

The experimental period lasted 99 days, consisting of 15 days for the animals to adapt to experimental conditions and 84 days that were subdivided into three 28-day periods for data collection and sampling. After the adaptation period, animals were weighed and distributed at random into facilities and treatments.

Treatments were represented by the following levels of mesquite pod meal replacing ground corn: 0, 250, 500, 750, and 1000 g/kg of diet, on a dry matter basis. Experimental diets were composed of Tifton-85 hay grass, soybean meal, ground corn, mesquite pod meal, and a mineral mix (Table 1).

Table 1. Chemical composition of ration and food

Composition of ration	Replacement levels (g/kg DM)				
	0	250	500	750	1000
Tifton 85 hay (g/kg DM)	73.5	73.5	73.5	73.5	73.5
Soybean meal (g/kg DM)	8.0	8.0	8.0	8.0	8.0
Corn grains (g/kg DM)	18.0	13.5	9.0	4.5	0.0
Mesquite pod meal (g/kg DM)	0.0	4.5	9.0	13.5	18
Mineral mix (g/kg DM)	0.5	0.5	0.5	0.5	0.5
Chemical composition of ration	Nutritional composition				
Dry matter (g/kg FM)	942.0	943.9	945.9	952.3	949.8
Organic matter (g/kg DM)	931.6	930.8	929.9	929.0	928.2
Crude protein (g/kg DM)	120.0	120.6	121.2	121.8	122.4
Total carbohydrates (g/kg DM)	781.9	782.4	783.0	783.5	784.0
Neutral detergent fiber (g/kg DM)	591.1	595.6	600.0	604.5	608.9
Non-fiber carbohydrates (g/kg DM)	190.8	186.8	182.9	179.0	175.1
Total Digestible Nutrients (g/kg DM)	549.9	547.6	537.3	542.1	548.0
Chemical composition of ingredients	Tifton 85 hay grass	Soybean meal	Corn grains	Mesquite pod meal	
Dry matter (g/kg FM)	956.20	905.14	902.24	943.51	
Organic matter (g/kg DM)	913.40	933.99	983.74	962.55	
Crude protein (g/kg DM)	87.78	510.80	81.20	94.26	
Total carbohydrates (g/kg DM)	814.10	405.90	839.30	851.30	
Neutral detergent fiber (g/kg DM)	755.10	120.51	146.92	245.70	
Non-fiber carbohydrates (g/kg DM)	589.00	285.40	692.30	605.60	

Note. DM = dry matter; FM = fresh matter.

Recommendations of the NRC (2000) were utilized for diets formulations for a 1 kg/day gain. Feed was supplied twice daily, at 8:00 and 16:00, *ad libitum*, and adjusted daily so as to allow around 5% of the dry matter supplied as refusals.

2.3 Intake and Performance

Dry matter intake was obtained as the difference between the amount of feed supplied and refusals. During the experiment, every morning before the feed was supplied, refusals were collected and weighed, and data were recorded for a daily control. Every 28 days, on the first and last experimental days, animals were deprived of solid food for approximately 16 h to be weighed, and thus the initial and final body weights were obtained and the weight gain during the experimental period was determined. Samples of feces and the supplied food were collected in the last three last day of each experimental period, while samples of refusal were collected daily, and then composite samples were formed per week. These samples were pre-dried in a forced-air oven at 55±5 °C for 72 h and ground in Wiley knife mills with 1 mm sieves for analyses of the dry matter (DM) (method 967.03), mineral matter (MM) (method 942.05), ether extract (method 920.29), and crude protein (CP) (method 988.05), following recommendations of the AOAC (1990). Neutral detergent fiber (NDF) was determined according to Van Soest, Robertson and Lewis (1991). To estimate the total digestible nutrients, we used the equation proposed by Weiss (1999).

2.4 Slaughter, Carcass Characteristics, pH, and Samples Processing

At the end of the experiment, the cattle were slaughtered (after a solid-food deprivation period of 16 h), in the Municipal Slaughterhouse of Serra Talhada, PE. Pre-slaughter procedures complied with good animal welfare practices and the slaughter was carried out conforming the Regulation of Industrial and Sanitary Inspection of Animal Products (Anonymous, 1997).

Following slaughter, the empty body weight (EBW) was estimated by adding the weights of washed gastrointestinal tract, heart, lungs, liver, spleen, kidneys, internal fat, industrial meat, mesentery, tail, and trimmings (esophagus, trachea, and reproductive tract) and other parts of the body (carcass, head, leather, feet, and blood).

The carcass of each animal was divided into two half-carcasses, which were weighed and then chilled in a cold room at 4 °C for 24 h. After the chilling time, carcasses were weighed again for obtaining the cold carcass weight and respective yield. The pH of the hot and cold carcasses was determined using a digital pH meter equipped with a penetration electrode coupled to a cutting blade with a thermometer (pH meter HI-99163 meat model). The set was inserted in a 2-4 cm-deep cut in the 12th rib, in the right half-carcass, and the pH was read at 0, ½, 1, 2 and 4 h after slaughter, as well as after 24 h of chilling. Hot or cold carcass yields were considered as the percentage relationships between the hot (HCW) or cold (CCW) carcass weights and the final body weight, respectively; and cooling loss as the difference between HCW and CCW, expressed as percentage.

A transverse section was made on the *Longissimus thoracis* muscle of the left half-carcass, at the 12th rib, to measure *Longissimus* muscle area, by outlining the muscle on a transparency sheet to determine the area using a planimeter. Rib fat thickness was taken at ¾ of the length of the *Longissimus thoracis* muscle (Greiner, Rouse, Wilson, Cundiff, & Wheeler, 2003).

2.5 Carcass and Empty Body Composition

The physical and chemical composition of the carcass and the chemical composition of the empty body were estimated by making a cut between the 9th and 11th ribs in the left carcass. Tissues were separated (muscle, bone, and adipose) for the estimate of body composition, according to equations proposed by Hankins and Howe (1946). Muscle, bone, and adipose tissues were lyophilized and ground. After lyophilization, the tissues were pre-defatted. After this process, samples were ground in a ball mill for analyses of DM, MM, CP and EE (AOAC, 1990). The chemical composition of carcass and empty body was estimated according to equations proposed by Valadares Filho, Paulino and Magalhães, (2006) and Valadares Filho, Paulino and Chizzotti (2010).

2.6 Meat Qualitative Evaluation

For the quantitative evaluation of the meat, a posterior section of the *Longissimus thoracis* muscle was collected and vacuum-packed at -20 °C. The meat color was evaluated using a Minolta Chroma Meter (model CR-400) on the surface of each sample, sliced with approximately 3 cm thickness and exposed to a refrigerated environment for 30 min, at approximately 4 °C (Ramos & Gomide, 2007), Three records for L*, a*, and b* were made, indicating lightness, redness, and yellowness of the meat samples, respectively (Muchenje et al., 2009). For the analysis of weight loss from cooking, the afore-mentioned steak was weighed and packed in aluminum foil and then cooked in a conventional oven under constant monitoring until the internal temperature reached 71 °C, measured with a thermometer attached to the steak (Ramos & Gomide, 2007). After cooking, samples were carefully dried, allowing the excess water to drain. Subsequently, they were exposed to room temperature for about one hour and weighed again to determine cooking losses. Shear force was measured using Warner Bratzler shear device (G-R Manufacturing CO., Model 3000) with 25 kgf load cell and crosshead speed of 20 cm/min. Three cylindrical pieces with 1.27 cm diameter were taken from the entire extension of each stake, cut in parallel to the orientation of the fibers. The water holding capacity (WRC%) was determined according to the modified methodology proposed by Sierra (1973), in which the meat sample with approximately 300 mg is placed in a previously weighed (W1) folded filter paper and then pressed for five minutes, using a 3.4 kg weight. After pressing, the meat sample is removed and the paper is immediately weighed (W2). The water holding capacity is then calculated by the following formula:

$$WRC\ (\%) = 100 - [(W2 - W1)/S \times 100] \quad (1)$$

Where, "S" represents the weight of the sample. The meat pH was measured according to the method described by Beltrán et al. (1997). Approximately 3 g of the *Longissimus thoracis* were homogenized with 20 mL distilled water for 15 s. Next, the pH was determined using a pH meter (model TEC3MP).

2.7 Statistical Design

The experimental design utilized was a completely randomized design with five replacement levels of corn by mesquite pod meal and five animals per treatment were utilized. The statistical model utilized for the analyses was

$$Y_{ij} = \mu + T_i + \varepsilon_{ij} \quad (2)$$

Where, Y_{ij} is the response variable; μ is the overall mean; T_i is the treatment effect; and ε_{ij} is the random error. The Shapiro-Wilk test was utilized for observe the data normality. For verification of statistical effect, analysis of variance (General Linear Model Procedure of the statistical analyses systems, SAS versão 9.1) and regression (Regression Procedure of the SAS), using a significant level of 0.05, were performed.

3. Results

Mesquite pod meal (MPM) replacing corn did not influence (P > 0.05) the performance and male bovine carcass traits of dairy steers (Table 2).

Table 2. Effects of corn replacement by mesquite pod meal on performance and male bovine carcass traits of dairy origin

Variables	Replacement Levels (g/kg DM)					$\hat{Y}$	*P*-Value	SEM
	0	250	500	750	1000			
Initial body weight, kg	218.6	219.4	219.0	219.0	221.5	219.4	0.9999	5.80
Final body weight, kg	321.8	318.4	327.8	324.0	326.0	323.5	0.9944	6.61
Empty body weight (EBW), kg	258.57	262.66	264.74	262.28	258.17	261.28	0.9952	5.25
Dry matter intake, kg	6.95	6.78	7.05	7.06	7.16	6.99	0.8102	0.09
Crude protein intake, kg	0.82	0.81	0.84	0.82	0.87	0.83	0.5508	0.01
Total digestible nutrients intake, kg	4.13	4.01	3.90	3.94	4.03	3.99	0.9629	0.09
Total weight gain, kg	103.2	101.3	108.8	105.0	104.5	104.7	0.9311	2.53
Average daily gain, kg/day	1.040	0.922	1.096	1.062	1.066	1.04	0.1619	0.02
Feed Conversion	6.84	6.47	6.54	6.69	6.77	6.67	0.9860	0.21
Hot carcass weight, kg	161.30	161.28	168.56	160.96	160.16	162.45	0.9509	3.46
Hot carcass yield, g/kg EBW	500.3	517.3	516.4	499.4	513.7	509.4	0.9902	1.37
Cold carcass weight (CCW), kg	158.84	159.16	165.92	158.84	157.76	160.10	0.9587	3.47
Cold carcass yield, g/kg EBW	492.6	510.5	508.3	492.8	506.1	502.0	0.9907	1.36
Forequarter, g/kg CCW	489.5	483.7	494.7	480.7	489.9	487.7	0.7798	3.55
Hindquarter, g/kg CCW	511.5	518.7	502.3	516.5	510.3	511.8	0.7109	3.72
Cooling loss, g/kg CCW	15.8	13.4	15.6	13.2	15.2	14.6	0.5843	0.63
Carcass initial pH	6.47	6.57	6.48	6.54	6.53	6.51	0.9736	0.05
Carcass ultimate pH	5.39	5.15	5.31	5.41	5.48	5.34	0.2981	0.05
Longissimus muscle area, cm²	49.31	45.09	51.31	52.52	50.46	49.74	0.5367	1.39
Rib fat thickness, mm	3.25	3.40	3.25	3.13	3.17	3.25	0.9970	0.23

Note. DM = dry matter.

The pH values decreased gradually with the measurement time (P < 0.05), with an average initial value of 6.51 and ending at 5.34 at 24 h of chilling (Figure 1).

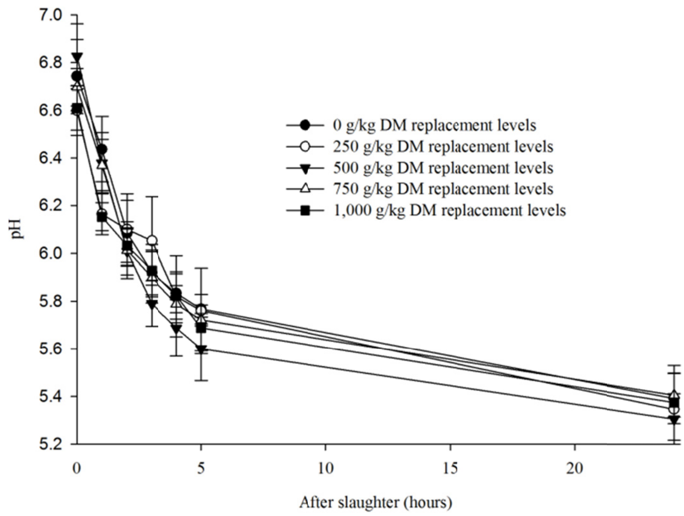

Figure 1. Carcass pH behavior after slaughter

The physical and chemical composition of carcass and empty body weight of the dairy steers were not significantly affected (P > 0.05) by the replacement of corn by MPM (Table 3).

Table 3. Effect of corn replacement by mesquite pod meal on physical and chemical composition of carcass and empty body of male dairy bovine

Variables	Replacement Levels (g/kg DM)					Ŷ	*P*-Value	SEM
	0	250	500	750	1000			
Carcass Physical Composition								
Muscle tissue	660.3	666.9	648.8	661.1	663.1	660.1	0.9608	7.17
Adipose tissue	224.5	227.3	241.1	236.4	231.9	232.2	0.9603	7.04
Bone tissue	134.6	127.9	131.0	125.5	127.3	129.2	0.8442	2.54
Carcass Chemical Composition								
Crude protein	186.5	188.4	178.2	194.4	170.6	183.1	0.8881	7.61
Ethereal extract	73.4	72.2	72.7	73.5	73.0	73.0	0.8660	0.41
Mineral matter	48.4	47.7	44.6	46.8	46.9	46.9	0.7039	0.82
Water	678.0	678.6	686.9	674.8	688.9	681.7	0.8744	4.77
Empty Body Chemical Composition								
Crude protein	191.9	193.7	183.7	199.6	176.4	188.6	0.8884	7.41
Ethereal extract	72.1	70.7	71.3	72.1	71.6	71.5	0.8710	0.45
Mineral matter	40.7	40.1	37.7	39.4	39.5	39.5	0.7045	0.64
Water	686.3	686.9	696.3	682.6	698.6	690.5	0.8747	5.41

Note. DM = dry matter.

The mesquite pod meal did not have a significant effect (P > 0.05) on meat qualitative characteristics (Table 4).

Table 4. Effects of corn replacement by mesquite pod meal on meat qualitative characteristics of male dairy bovine

Variables	Replacement Levels (g/kg DM)					Ŷ	*P*-Value	SEM
	0	250	500	750	1000			
Meat pH	5.48	5.50	5.49	5.48	5.47	5.48	0.9899	0.01
L* (lightness)	39.21	40.78	39.86	40.26	40.84	40.19	0.7008	0.39
a * (redness)	10.25	10.10	10.48	9.92	10.47	10.24	0.9066	0.20
b * (yellowness)	7.77	7.45	7.54	6.91	7.53	7.44	0.4455	0.14
CL, g/100g	33.90	35.45	35.06	37.10	33.27	35.14	0.9617	0.15
WHC, g/100g	25.08	26.22	27.04	26.70	24.29	25.93	0.8720	0.08
WBSF, kgf/cm²	3.34	3.20	3.63	3.58	3.75	3.49	0.9706	0.25

Note. DM = dry matter; CL = Cooking loss; WHC = water holding capacity; WBSF = Waner-Bratzler shear force.

4. Discussion

Our results demonstrate that mesquite pod meal can fully replace corn in diets for dairy steers in feedlot. These results indicate it as an important alternative for the livestock activity developed around the world, mainly in semi-arid regions, because corn is a product of great economic and social importance that can be used in human feeding and in ethanol production, and thus to use this noble food for animal feeding would be a discrepancy. Therefore, mesquite in meal form is a good alternative to replace corn in the production of feedlot cattle, helping to reduce feed costs in addition to being a reality for many semi-arid regions of the world.

Many aspects are involved in the cattle performance, among which are the sex condition, genetic group, production system (pasture or feedlot), feeding, and their interactions. Of these aspects, only feeding was variable in the present study. However, the similarity between the evaluated feedstuffs (Table 1) contributed to the lack of limitations to the intake of nutrients (Table 2). Hence, the maintenance and production requirements of the cattle were fully met, which resulted in the similar weight gain feed conversion, hot and cold carcass weights, and respective yields.

Despite having low starch levels, the mesquite pod meal contains a high percentage of organic acids and sugar, particularly sucrose, which represents a readily-available energy source. Additionally, its palatability promotes good acceptance by the animals (Alves et al., 2010). The high non-fibrous carbohydrates content of mesquite pods stems from higher proportions of the monosaccharides mannose and galactose: 62.52% and 35.92%, respectively (Rincón, Muñoz, Ramírez, Galán, & Alfaro, 2014). Figueiredo et al. (2007) reported a lower fraction A + B1 value for mesquite pod meal (59.92%) than corn (72.20%), but higher values for fractions B2 (16.52% vs. 12.0%) and C (10.57% vs. 0.38).

Although there is a higher content of neutral detergent fiber and lower non-fibrous carbohydrates content in MPM compared to corn (Table 1), these differences were not large enough to lead to significant differences in the proportions of fore- and hindquarter, *Longissimus* muscle area, and rib fat thickness. The genetic equivalence, sex condition, and performance of the animals evaluated here contributed to this response. Melo et al. (2007) concluded that the yields of prime cuts are aimed at balance, irrespective of the final body weight and the nutritional status of the animals.

The animals in the present study showed a higher percentage of hindquarter portion (average 51.18%), demonstrating the potential of dairy steers to be used for beef production, since the most valuable cuts of bovine carcasses are located in the hindquarter.

Longissimus muscle area averaged 49.73 cm^2, which is in line with the results found in the literature between 45.29 and 59.3 (Costa et al., 2007; Rotta et al., 2009). Rib fat thickness averaged 3.25 mm (Table 2), which is above the minimum limit (3.0 mm) required by meat-packing plants (Paulino et al., 2009). This value provided little cooling loss (Table 2) and low shear force values (Table 4). The rib fat thickness works as a thermal insulator during the carcass chilling, preventing drying, darkening, and reduction of the meat tenderness. In carcasses chilled too fast, before the onset of *rigor mortis*, the muscle sarcomeres shrink, and the meat tenderness is reduced.

The mesquite pod meal showed a similar glycolytic potential to that of corn, as it provided animals with an adequate reserve of muscle glycogen, resulting in initial and final pH as well as pH decline (Figure 1) compatible with good quality meat (Table 4), since the carcass initial pH remained close to neutrality, averaging 6.51 (Table 2), indicating that the animals were in adequate antemortem conditions, especially as regards any stress related to pre-slaughter management. When the pre-slaughter stress is intense, the muscle glycogen is rapidly consumed and the pH declines, because accumulation of lactic acid does not occur gradually, consequently generating poor quality meat. The carcass ultimate pH, which averaged 5.34 (Table 2), was in a range close to desirable of 5.5 to 5.8 (Mach, Bach, Velarde, & Devant, 2008).

The mesquite pod meal caused a similar growth rate in the animals of the present study to that obtained with corn (Table 2), which directly reflected in the development stage of the muscle, bone, and adipose tissues, thereby not changing the physical and chemical composition of the carcass or the chemical composition of the empty body (Table 3). The weight gain rate has a direct impact on the degree of maturation of cattle and consequently on the composition of the gain; therefore, as the animal growth rate increases, the sooner it will achieve the plateau for muscle tissue deposition, exponentially increasing the adipose tissue deposition rate. Souza et al. (2012) found an influence on the growth rate on the body composition of Zebu × Taurine crossbred cattle.

The similarity between experimental diets, as well as the conformity of the animals under study (breed group, age, and confinement), resulted in meat of excellent quality (Table 4). It is thus evident that the mesquite pod meal is an alternative for production of beef cattle in semi-arid regions, and that dairy steers can be exploited for meat production.

The mean values of 40.19 observed for lightness (L*) and 6.44 for yellowness (b*) are within the standards for cattle cited by Muchenje et al. (2009), which ranges from 33.2 to 41.0 for L* and from 6.1 to 11.3 for b*. However, the redness (a*) value of 10.24 was slightly below the interval described by the authors (between 11.1 and 23.6), which can be explained by the age of the animals, which were at early age (approximately 21 months), showing a lower myoglobin content in relation to older animals. This is because the meat color is a reflection of the amount of heme iron, which increases as the animal ages, and the amount of pigments during growth can be considered a measure of the physiological development of animals. When in contact with air, the meat undergoes a reaction on its pigmentation with the molecular oxygen, forming a relatively stable pigment called oxymyoglobin. This pigment is responsible for the bright red color that gives the attractive aspect to the consumer. The deoxygenation of oxymyoglobin results in reduced myoglobin, which is unstable. These conditions cause deoxygenation, also responsible for oxidation, forming the metmyoglobin, an undesired brown pigmentation.

The pH decline being within normal standards (Figure 1) resulted in good meat qualitative parameters such as color, cooking loss, water holding capacity, and shear force, because during *rigor mortis* development, the pH can influence these traits directly or indirectly.

The right amount of subcutaneous fat, the adequate pH decline, and the age of the animals used in the present study contributed to the production of meat of high tenderness, since its shear force was 3.47 kgf/cm². Taurine cattle of British origin yield tender meat when compared with the zebu, as the former have a greater collagen solubility and lower activity of calpastatin postmortem. However, the tenderness of meat from young animals is influenced mainly by the degree of muscle tissue contraction during the meat chilling. Thus, the incorporation of mesquite pod meal into diets of dairy steers can successfully promote the production of good quality meat in semi-arid regions.

5. Conclusion

Mesquite pod meal can fully replace ground corn in dairy steers diets without compromising their performance, carcass yield, or the physical and chemical composition of their carcass, maintaining the quality of the meat from these animals.

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