Physicochemical and sensory characterization of meat from Santa Ines sheep fed with cactus forage (*Opuntia ficus indica* mill)

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ABSTRACT

Forty non-castrated male lambs were randomly assigned to groups fed with cactus forage (0, 17.6, 35.3, 53.2 or 71.1%) in place of buffelgrass hay to evaluate the effects on physicochemical and sensory properties of sheep meat. There was no influence of weight loss by cooking, shear force, moisture, lipids and ash ($P>0.05$). Effects were observed for protein ($P<0.05$), initial lightness ($P<0.01$) and final color ($P<0.05$) when increasing the level of cactus forage in the diet. Reduction in saturated fatty acids was found, mainly myristic acids, and increased levels of monounsaturated fatty acids and oleic acids, due to biohydrogenation. The use of cactus forage in the diet as a replacement for buffelgrass significantly influences the content of fatty acids in Santa Ines sheep meat, improving the lipid profile, without influencing sensory attributes.

Keywords: *Opuntia*, fatty acids, carcass, meat quality, flavor

INTRODUCTION

In recent decades, consumers in developed countries have tended towards “healthier habits”, improving the quality of life and life expectancy. Nutrition represents one area of changing habits and is critical to health. When it comes to quality of animal products, saturated fatty acid and cholesterol found in meat receive attention due to their association with coronary heart disease and atherosclerosis (Silva-Sobrinho, 2006). Foods high in saturated fat, such as animal fats, have been linked with a large number of metabolic disorders such as cancer, diabetes, hypertension and, particularly, cardiovascular disease (Belury, 2002).

Studies have been conducted that identify sheep meat as possessing moderate levels of fat and low in calories while having a soft texture, mild flavor and easy preparation. Its consumption in recent years has increased throughout Brazil (at the expense of other meats). Because of its nutritional value and acceptability, sheep meat has become the focus of studies designed to enhance production as well as physicochemical and sensory attributes.

Consumers require well-defined cuts that are tender, low in fat and affordable. Meat with high fat content discourages purchase. Meat should contain small amounts of fat as this is frequently removed before cooking or during a meal, especially amongst younger individuals (Sañudo *et al*. 2000).

In Brazil, new trends are emerging in the meat industry, influenced by the production methods of agribusiness. This is a response to consumer requirements that have expanded due to the inclusion of sheep meat in the diets of higher income groups. This is particularly prevalent in major cities with bars, restaurants and other services related to tourism and leisure (Medeiros *et al*. 2009). The aim of this study was to evaluate the physicochemical composition (fatty acid content) and the sensory evaluation of meat from sheep fed with cactus forage in place of buffelgrass.

MATERIALS AND METHODS

Location, animals and nutritional management

The experiment was conducted at the Experimental Station of São João do Cariri belonging to the Federal University of Paraíba. There were used a total of 40 male Santa Ines sheep, with an average weight of 22.10 kg. Animals were individually identified and randomly assigned to individual pens (1.3 X 0.60 m), provided with food and water. Sheep had an adaptation period of 15 days, during which they were dewormed. The weightings occurred every seven days, starting from the beginning of the experiment until slaughter.

Corn, soybean meal and wheat bran were used as concentrate feed together with a mineral supplement. Due to differences in protein content between the cactus forage and buffelgrass, we used urea to adjust the diet (Table 1). Diets were formulated to meet the 250 g day^{-1} requirements, according to NRC (2007). Feed was offered twice daily (50% in the morning and 50% in the afternoon) with a leftover level of 10%.

Slaughter, physical and sensory evaluation of meat

The experiment consisted of five experimental diets, all presenting forage:concentrate ratios of 70:30. We added increasing levels of cactus forage (0, 17.6, 35.3, 53.2, and 71.1%) together with buffelgrass diets are referred to as T1, T2, T3, T4 and T5, respectively.

Table 1. Bromatological and percentage compositions of experimental diets based on dry matter (DM)

Variables	Replacement Levels (%)				
	0	17.6	35.3	53.2	71.1
Ingredients, % DM					
Buffelgrass, hay	70.00	57.50	45.00	32.50	20.00
Cactus forage	0.00	12.30	24.60	36.90	49.20
Corn	10.80	10.80	10.80	10.80	10.80
Soybean meal	13.30	13.30	13.30	13.30	13.30
Wheat bran	4.50	4.50	4.50	4.50	4.50
Urea	0.00	0.20	0.40	0.60	0.80
Mineral supplement	1.40	1.40	1.40	1.40	1.40
Composition, g kg^{-1} DM					
Dry Matter, DM	891.56	561.71	410.02	322.83	266.23
Crude protein, CP	127.28	129.31	131.35	133.37	135.41
Ether extract, EE	13.47	14.35	15.23	16.10	16.97
Neutral detergent fiber, NDF	616.16	565.86	515.55	465.24	414.93
Acid detergent fiber, ADF	396.69	365.53	334.37	303.21	272.05

Animals were sent to slaughter at 49 days after fasting solid foods for 15 hours with free access to water. The animals were killed by stunning and bleeding, followed by skinning and gutting. Subsequently, carcasses were kept in cold storage for 24 hours at 4°C; after which they were cut in half with an electric saw. The anatomical left half of the carcass was divided into five commercial cuts: shoulder, neck, rib, loin and leg according to the methodology described by Osorio *et al*. (1998). The *Longissimus* muscle was separated from bone, other muscle groups and all external fat in order to be used in physicochemical analysis.

Samples were individually wrapped with aluminum foil, identified and frozen at -20°C until use for analysis. Meat was defrosted in a refrigerator (± 4°C) 24 hours before analysis (Ramos & Gomide, 2009) and performed in triplicate (Madruga *et al*. 2001). Color of the *Longissimus* muscle was evaluated 45 minutes and 24 hours after slaughter employing the CIELAB L*, a*, b* system by colorimeter (Minolta Chroma Meter CR-400), with L* for lightness, a* for redness and b* for yellowness (Ramos & Gomide, 2009). pH was determined at 45 minutes (initial pH) and 24 hours after slaughter (final pH) by pH meter/thermometer (TESTO® Model pH 205), which was introduced into the *Longissimus lumborum* muscle of the whole carcass, between the fourth and fifth lumbar vertebrae.

Weight loss by cooking (WLC) was determined according to Duckett *et al*. (1998). There was used a digital thermometer to confirm temperature when cooking (Ternmars®, model Termometer TM-362). The WLC was calculated from the weight difference of the samples before and after cooking and expressed in percentage (g 100^{-1} g).

Texture was evaluated by shear force (SF). There was used the Warner-Bratzler Shear Force (WBSF) method with single blades, as described by Ramos & Gomide (2009). Muscle toughness (shear force) was measured as the maximum force (kg cm^{-2}) required for shearing through perpendicular to the muscle grain. The average peak shear force was considered as a force needed to shear through a particular muscle.

Sensory evaluation of the meat was performed in the Department of Nutrition of the Federal University of Paraíba, by a trained panel, composed of nine panelists (four women and five men). The team was previously selected and trained according to the methodology detailed by stone *et al*. (1974). During the training, a glossary of descriptive terms and reference samples was developed (Table 2).

The panelists were allocated to individual booths. The intensity of the attributes of hardness, juiciness, flavor and overall acceptability were evaluated on an unstructured 9-point scales with word anchors at the edges were used to rate the appraisals (1 = “do not like”; 9 = “like very much”), in three test sections. For sensory tests there was used the *Longissimus* muscle, cut into cubes of approximately 2 cm, that were baked on an electric grill at 170ºC until the temperature in the geometric center of the meat reached 71°C. There was no addition of salt or flavorings. After cooking, samples were placed in laboratory glassware, sealed with aluminum foil and kept in a water bath at 55°C.

Table 2. Glossary of sensory attributes with their respective reference samples

Attributes	Definition	Reference samples (beef)	
		Little	Lot
Hardness	Force required when compressing a piece of meat between the molars, assessed at first bite.	Filet mignon	Brisket
Juiciness	Perception of the amount of fluid released from the sample of meat in the mouth, after chewing 5 times.	Eye round	Filet mignon
Flavor	Characteristic flavor of sheep meat.	-	-

In each session, an evaluator received two cubes of cooked meat (from each treatment group) in disposable plastic containers with lids, coded with three-digit random numbers. Each booth was prepared with the following materials: evaluation form, pen, water, cracker biscuits (to avoid cross sample taste confusion), fork and napkins.

Chemical analysis

Dry matter, crude protein and ether extract contents were determined according to the methodology described by AOAC (2000). Moisture, ash and protein were also quantified by the same methodology. Neutral Detergent Fiber (NDF) and Acid Detergent Fiber (ADF) were determined according to Van Soest *et al*. (1994).

Total lipids were measured according to Folch *et al*. (1957). Fat extracts were esterified (Hartmann & Lago, 1973) for chromatographic analysis to identify the fatty acid profile. Methyl esters of fatty acids were separated and quantified by gas chromatograph (Master GC) coupled to a flame ionization detector. The separation was performed on a CARBOWAX 20M Fused-Silica Capillary Column, polyethylene glycol stationary phase, with dimensions of 30 m by 0.53 mm inner diameter and 0.25 µm film thickness. There was used hydrogen as a gas carrier at a flow rate of 5 mL min^{-1}. Samples of 1 µL of methyl esters were introduced in the split/splitless injector at 170°C with split ratio of 1:10. For temperature settings, there were used the following chromatographic conditions, initial column temperature of 70°C for 2 minutes. Column temperature increased at a rate of 15°C min^{-1} up to 175°C for 12 minutes, totaling 21 minutes of analysis. The temperature of the flame ionization detector was maintained at 190°C. Chromatograms, with retention times and fatty acid percentages were recorded with the PeakSimple software (SRI Instruments - USA).

Statistical Analysis

Analysis of variance and regressions were used for statistical analysis, depending on the levels of cactus forage in the diet (SAS, 2001). We used a complete randomized design with five treatments and 8 replicates. For sensorial data, the model included also the random effect of panelist. Means comparison was performed by LSMEANS procedure. Significances were estimated at a 0.05 probability level in error type I.

RESULTS AND DISCUSSION

Weight loss from cooking (WLC) was not affected (P>0.05) by replacing buffelgrass with cactus (Table 3). Average body weight at slaughter was ~30 kg. When there is an increase in slaughter weight, lower WLC values are usually found, inverse to values observed in younger animals, since they have more water in the muscles, and likely greater water loss during the cooking process (Bonagurio *et al*. 2003).

Shear force (SF) values were lower than those reported in the literature, even compared to chicken, as described by Ramos & Gomide (2009), in which values less than 3.62 Kgf. Our data can be related to the age of the animal, estimated at less than 12 months, according to dental chronometry (milk teeth only), suggesting they are young animals (Cezar & Sousa, 2007). Meat of lambs contain less fat, greater softness and milder aromas than meat from older animals (Silva-Sobrinho, 2006).

The mean values for moisture, lipids and ash were not affected, possibly due to the short period of confinement (49 days) and slaughter weights (29.45 to 31.32 kg). This was likely insufficient for fat deposition, especially the intramuscular fat (marbling) even with the highest energy intake. This was also reported by Madruga *et al*. (2008b) in Santa Ines sheep that were confined for 70 days and slaughtered at weights between 30.41 and 33.50 kg suggesting the lambs did not reach physiological maturity.

Table 3. Effect of the replacement levels of buffelgrass by cactus forage on physicochemical composition of Santa Ines sheep meat.

Variables	Replacement levels (%)					Mean ± SEM	Effect
	0	17.6	35.3	53.2	71.1		
Protein, %	23.07	23.29	23.52	23.64	24.22	23.55±1.08	*1
Moisture, %	76.06	76.44	75.54	76.03	75.53	75.92±1.06	ns
Lipids, %	2.98	2.64	3.42	3.19	3.47	3.14±0.89	ns
Ash, %	0.99	1.04	1.02	1.02	1.06	1.02±0.06	ns
WLC[1], g/100g	31.31	27.25	29.13	30.21	27.61	29.10±5.11	ns
SF[2], kgf/cm^2	1.76	1.74	1.65	2.11	1.85	1.82±0.38	ns

^{ns} (P>0.05); * (P<0.05); **(P<0.01); sem= standard error of the mean;
WLC = weight loss by cooking; SF = shear force;
[1] $Y=23.02 + 0.0149X$ (r^2 = 92)

Conversely, there was a significant effect on protein, which was increased as dietary cactus forage was increased. The likely explanation for this is a possible increase in microbial protein synthesis due to higher energy consumption in the rumen, as well as a likely increase in tissue energy for the protein synthesis (Santos, 2006).

For chemical analysis, values were similar to other reports such as Costa *et al*. (2009), found average protein, moisture, lipid and ash of 22.93, 74.41, 2.22 and 0.98, respectively, in Santa Ines sheep fed with varying levels of fiber. Similarly, Madruga *et al*. (2008a) observed 21.5 to 22.2% for protein, 72.7 to 75.0% for moisture content, 2.3 to 5.3% for lipids, and 1.1 to 1.2% for ash in Santa Ines sheep fed with silk flower.

Despite pH_{24h} not being affected by diet (Table 4), after complete glycolysis, this should have values below 6.0, according to Miranda-de la Lama *et al*. (2009).

Table 4. Effect of cactus forage in the physical composition of Santa Ines sheep meat.

Variables	Replacement levels (%)					Mean ± SEM	Effect
	0	17.6	35.3	53.2	71.1		
pH_{45min}	6.99	7.09	7.09	6.94	8.96	7.4 ±2.54	ns
pH_{24h}	5.93	6.12	5.98	6.04	5.98	6.0 ±0.30	ns
L^*_{45min}	19.16	21.52	23.00	21.84	20.36	21.2 ±2.44	**1
L^*_{24h}	18.76	19.70	21.87	21.60	20.42	20.5 ±3.97	ns
a^*_{45min}	4.41	4.35	5.05	6.69	4.72	5.0 ±1.74	ns
a^*_{24h}	4.57	4.75	4.75	5.17	6.59	5.2 ±1.45	*2
b^*_{45min}	20.25	19.70	20.65	21.87	21.75	20.8 ±2.87	ns
b^*_{24h}	19.64	23.04	27.58	23.71	25.85	23.9 ±5.45	ns

^{ns} (P>0.05); * (P<0.05); **(P<0.01); SEM= Standard Error of the Mean;
[1] $Y= 19.17 + 0.1811X - 0.0023X^2$ (r^2 = 0.97); [2] $Y= 4.28 + 0.0251X$ (r^2 = 0.73)

Meat from sheep fed with cactus forage had higher initial lightness (L^*_{45min}). Lightness may vary depending on factors, including pH. Lower values suggest brighter meat (Cezar & Sousa, 2007). Madruga *et al*. (2008a) found levels of 30 for lightness in sheep meat. And comparing this work and that of Costa *et al*. (2009) with the aforementioned, they also observed proximity to the measured level of 18.79 after 24 hours, even with lower values at 45 minutes after slaughter, having a darker meat in both cases. The a* index represents the intensity of red with higher values indicating a redder meat (Ramos & Gomide, 2009). In the present study, it was observed increasing red (a^*_{24h}) according to quantity of dietary cactus forage. This can be explained by young animals in the study, with low myoglobin concentration, which increases with age, intensifying the color (Lawrie, 2005). In summary, Santa Ines sheep meat was more light (19.16 to 23.00), redder (4.5 to 7.4) and less pale (19.7 to 21.8) relative to Morada Nova lambs, also a native Brazilian breed (Costa *et al*. 2011).

It was identified seven saturated fatty acids, two monounsaturated and two polyunsaturated (Table 5). It was observed a reduction in myristic acid (C14:0), as dietary cactus forage was increased. Interestingly, C14:0 has been associated with elevation of total cholesterol and LDL (low density lipoprotein) in plasma, increasing the risks to human health (Scollan *et al*. 2006).

The high concentration of oleic acid (C18:1) in sheep fat has been reported in the literature (Sañudo *et al*, 2000; Madruga *et al*. 2008b; Jerónimo *et al*. 2010). This unsaturated fatty acid was the largest contributor to the fatty acid profile, while stearic acid (C18:0) and palmitic acid (C16:0) were the most prominent saturated acids. Similar profiles have previously been reported (Joy *et al*. (2008); Madruga *et al*. (2008a); Atti, *et al*. (2009), Berthelot *et al*. (2010); Scerra *et al*. (2011)).

Most unsaturated fatty acids released by lipolysis are rapidly hydrogenated (saturated) by ruminal bacteria, in which the sequential isomerase and reductase activities convert both the linoleic (C18:2) and linolenic (C18:3) acids to stearic acids (C18:0) (Kozloski, 2009). However, in this study we observed a growing increase in oleic acid (C18:1), according to dietary cactus forage levels. This suggests that increased dietary cactus forage may lead to decreased ruminal pH, modifying hydrogenation. As a consequence incomplete hydrogenation may occur, leading to an accumulation of unsaturated fatty acids in the rumen i.e. C18:1 (Palmquist *et al*. 2006).

Total saturated fatty acids (SFA), monounsaturated fatty acid (MUFA) and MUFA/SFA was significantly influenced by diet. The highest level of dietary cactus resulted in lower SFA and greater MUFA and MUFA/SFA readings. A study conducted by the UK Department of Health (1994) found that MUFAs do not affect blood cholesterol levels in the same way as SFAs or PUFAs. However, when SFA is replaced with MUFA in the diet, levels of total cholesterol and LDL (low density lipoprotein) are reduced.

The fatty acid profile of meat is frequently reported as, PUFA/SFA ratio due to the impacts of all SFAs on cholesterol levels. This effect is smaller in ruminant's relative to monogastric animals because of the biohydrogenation of unsaturated fatty acids by rumen microorganisms (Banskalieva *et al*. 2000). Values in this data sets were lower than those reported by Joy *et al*. (2008) of 0.21 and 0.23 who evaluated diet in pastured and confined sheep, respectively. However, both data sets were below 0.40, which is the limit recommended by the UK Department of Health (1994) as being healthy.

Table 5. Effect of cactus forage on fatty acid composition (%) and the relationship between saturated (SFA), monounsaturated (MUFA) and polyunsaturated fatty acids (PUFA) of Santa Ines sheep meat.

Fatty acids	Replacement levels (%)					Mean ± SEM	Effect
	0	17.6	35.3	53.2	71.1		
Capric, C8:0	0.24	0.46	0.14	0.24	0.14	0.24±0.31	ns
Lauric, C12:0	0.90	0.82	0.44	0.26	0.72	0.63±0.92	ns
Myristic, C14:0	6.68	3.38	4.24	3.08	3.18	4.11±1.99	**[1]
Pentadecanoic, C15:0	0.74	1.08	1.38	0.84	1.52	1.11±0.80	ns
Palmitic, C16:0	27.80	26.18	27.24	27.20	27.02	27.08±1.99	ns
Palmitoleic, C16:1	2.12	2.38	2.62	2.68	2.54	2.47±0.29	*[2]
Heptadecanoic, C17:0	2.74	1.22	1.28	1.12	1.28	1.53±1.22	ns
Stearic, C18:0	16.26	16.62	15.12	14.26	14.52	15.36±1.79	*[3]
Oleic, C18:1	38.64	41.54	42.26	45.42	43.06	42.18±3.22	*[4]
Linoleic, C18:2	3.44	5.64	4.17	4.32	5.50	4.60±1.62	ns
Linolenic, C18:3	0.36	0.48	0.02	0.22	0.34	0.28±0.55	ns
Saturated, SFA	55.34	49.76	50.00	47.12	48.38	50.12±2.71	*[5]
Monounsaturated, MUFA	40.72	43.92	44.88	48.10	45.60	44.64±3.30	*[6]
Polyunsaturated, PUFA	3.80	6.12	4.14	4.54	5.84	4.89±1.98	ns
PUFA/SFA	0.07	0.13	0.08	0.09	0.12	0.10±0.04	ns
MUFA/SFA	0.75	0.89	0.90	1.02	0.94	0.90±0.10	*[7]
AI[9]	28.24	14.87	18.01	13.12	13.97	17.64±8.48	**[8]
(C18:0+C18:1)/C16:0	1.97	2.23	2.11	2.20	2.16	2.13±0.19	ns

ns (P>0.05); * (P<0.05); **(P<0.01); SEM= Standard Error of the Mean;
[1]$Y = 5.56 - 0.0409X$ ($r^2 = 0.58$); [2]$Y = 2.10 + 0.0223X - 0.0002X^2$ ($r^2 = 0.98$); [3]$Y = 16.52 - 0.0328X$ ($r^2 = 0.79$); [4]$Y = 39.65 + 0.0714X$ ($r^2 = 0.61$); [5]$Y = 54.93 - 0.2637X + 0.0024X^2$ ($r^2 = 0.90$); [6]$Y = 41.87 + 0.0782X$ ($r^2 = 0.61$); [7]$Y = 0.75 + 0.0082X - 0.00007X^2$ ($r^2 = 0.88$); [8]$Y = 23.67 - 0.1701X$ ($r^2 = 0.60$)
[9]Atherogenicity index = C12:0 + (4*C14:0) + C16:0 / sum of unsaturated.

The atherogenicity index (AI) proposed by Ulbricht & Southgate (1991) has been used as an indicator of coronary heart diseases. This ratio is the sum of lauric acid (C12:0), palmitic acid (C16:0) and four times the ratio of the myristic acid (C14:0) (greatest hypercholesterolemic potential), divided by the sum of unsaturated. It was observed that AI was lower in diets with more cactus forage, which is desirable and favorable to human health.

Banskalieva *et al*. (2000), reported that the fatty acid composition, the ratio (C18:0 + C18:1): C16:0 is sufficient to describe possible beneficial effects of different lipids found in red meat, with values ranging from 2.10 to 2.80% in sheep meat. In the present study, values ranged from 2.11 to 2.23% for animals fed on cactus forage, confirming a good quality fraction in the Santa Ines sheep meat. This was similar to data from Costa *et al*. (2009). However, Madruga *et al*. (2005) found higher values (2.76%) in for Santa Ines sheep fed with cactus forage.

Sensory analysis (Table 6) showed was no effect on meat from sheep fed with cactus forage (*P*>0.05) with similar responses for all treatments. Responses were assessed on a scale from 0 to 9 cm (closer to zero means a more intense characteristic). Hardness ranged from 5.42 to 5.78; juiciness between 4.92 and 5.57; flavor between 5.01 to 5.28; and the overall acceptability was between 5.32 and 5.82. It was, therefore, classify the meat as tender, juicy, good tasting and with satisfactory acceptance by the panelists.

Hardness can be evaluated by ease of chewing (Muela *et al*. 2012) and/or by cutting the sample with instruments. In the shear force method, instruments imitate mastication, applying compression and tension forces on the meat (Ramos & Gomide, 2009). Thus, the two obtained experimental results were consistent, as noted by Sañudo *et al*. (2000) and Muela *et al*. (2012), when comparing both approaches (sensory vs. mechanical).

Juiciness suffered no significant effect of treatments. This fact was also observed by Sañudo *et al*. (2000), assessing the quality of sheep meat at different levels of fat, in the European classification system. Weight loss by cooking, moisture and lipids should be considered in the juiciness assessment, since together these parameters reflect the perception of water content during mastication (Muela *et al*. 2012). This sensation is caused by the release of juice and serum, stimulated by the effect of fat on salivary flow (Osório *et al*. 2009). Flavor has a direct relationship with lipid composition, which is influenced by the diet and age at slaughter (Sañudo *et al*. 1997). Since it was reported a no significant effect of diet, it is postulated that there were no observed changes in flavor.

Table 6. Effect of cactus forage on sensory analysis of Santa Ines sheep meat.

Variables	Replacement levels (%)					Mean ± SEM	Effect
	0	17.6	35.3	53.2	71.1		
Hardness	5.78	5.75	5.47	5.54	5.42	5.59±2.00	ns
Juiciness	5.54	5.57	5.10	5.08	4.92	5.24±1.48	ns
Flavor	5.03	5.01	5.28	5.01	5.27	5.12±1.65	ns
Overall acceptance	5.58	5.82	5.37	5.48	5.32	5.51±1.58	ns

^{ns} (P>0.05); SEM= Standard Error of the Mean

All meat was acceptable to the panelists (average of 5.51). This was also observed by Muela *et al*. (2010), when working with sheep carcasses weighing from 9.24 to 13.39 kg and Ekiz *et al*. (2009) that evaluated the meat quality of five different sheep breeds. Cultural and sensory habits are important for the acceptability of a product. Therefore, meat from sheep slaughtered at a young age had a good acceptance. However, this depends on the preferences and culinary habits of the sensory panel of each region or country (Sañudo *et al*. 1998).

CONCLUSION

The use of cactus forage in the diet as a replacement for buffelgrass significantly influences the content of fatty acids in Santa Ines sheep meat, improving its lipid profile. Considering that consumers, when deciding to purchase, prefer bright red meat, it is possible to say that the addition of cactus forage to the diet gives the meat acceptable features for the consumer, without influencing its sensory attributes.

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