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Meat quality of lambs fed silk flower hay (*Calotropis procera* SW) in the diet

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ABSTRACT - The objective of this work was to evaluate the influence of using silk flower hay replacing corn and soybean meal on physical-chemical and sensorial traits of lamb meat. It was used 32 intact Morada Nova male lambs (12.7 ± 2 kg initial body weigth) on feedlot system, distributed in a completely randomized design with four levels (0, 15, 30 and 45% on dry matter basis). The use of silk flower hay in the diet influenced quality of meat and carcass, leg weight, tissue composition, moisture, juiciness and flavor. Replacing corn (26.67%) and soybean (3.33%) with silk flower hay does not affect the tissue composition, ratios and muscularity index of leg and physical-chemical parameters of *semimembranosus* muscle of Morada Nova lambs.

Key Words: carcass, flavor, Morada Nova, muscularity, native breed

Qualidade de carne de cordeiros alimentados com feno de flor-de-seda (*Calotropis procera SW*) na dieta

RESUMO - Objetivou-se avaliar a influência do uso de feno de flor-de-seda em substituição ao milho e ao farelo de soja nas características físico-químicas e sensoriais da carne de cordeiros. Utilizaram-se 32 cordeiros Morada Nova, machos não-castrados (12,7 ± 2 kg de peso vivo inicial), em confinamento, distribuídos em delineamento inteiramente ao acaso com quatro níveis (0, 15, 30 e 45% com base na MS). A utilização de feno de flor-de-seda na dieta influenciou a qualidade da carcaça e da carne, o peso da perna, a composição tecidual, a umidade, a suculência e o sabor. A substituição do milho (26,67%) e da soja (3,33%) pelo feno de flor-de-seda não altera composição tecidual, relação e índice de muscularidade da perna e os parâmetros físico-químicos do músculo *semimembranosus* de cordeiros Morada Nova.

Palavras-chave: carcaça, *flavour*, Morada Nova, muscularidade, raça nativa

Introduction

Sheep and goat breeding activities are promising alternatives to the Brazilian Northeastern region, mainly because of the adaptability of animals to the adverse climatic conditions in the region. In northeastern Brazil, especially in semi-arid regions, some breeds began to develop features adapted to the climatic conditions that enabled them to reproduce in these environments and in others. An example is Morada Nova (Silva et al., 2007), which is considered a promising race in meat production.

The conventional diet for sheep under feedlot system is generally composed of corn grains, soybean meal, and hay or silage of good quality. However, in the Brazilian northeastern region, these inputs, mainly concentrated, may increase the feeding costs and, consequently, the economic viability of the sheep breeding activity with respect to the meat production. Alternatives of roughage such as silk flower hay (SHF, *Calotropis procera* SW.) are a key resource in maintaining the meat production, especially in times of food shortage. In addition, the need for high-quality food in the dry season is a constant, particularly in the semiarid region which presents deficiency in forage production due to the low rainfall levels. Among the plants that compose the vegetative potential of the *Caatinga* biome, *Calotropis procera* SW., has high digestibility and protein content, ranging from 13.6 to 19.4 % (Abbas et al., 1992). The use of SFH in feeding small ruminant animals,

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i.e., sheep, goats, camels, was reported to be suitable in the semi- arid areas of Brazil and India (Madruga et al., 2008; Nehra et al., 1987). These studies showed no suppressive effects on meat quality of animals. Torres et al. (2010) reported that the corn and soybean found in the concentrate can be partially replaced by silk flower hay up to 30% without compromising the performance and nutrient consumption in Morada Nova sheep.

Marques et al. (2007) concluded that the level of replacement of up to 33% of forage sorghum hay can be used in the diet of Santa Inês sheep without altering the performance and the carcass quality.

In this context, it is expected that the inclusion of silk flower hay in the diet of Morada Nova sheep will improve the quantity and quality aspects of their carcass and meat. The objective of this work was to evaluate the effect of different levels of silk flower hay (*Calotropis procera SW)* as a partial replacement for ground corn and soybean meal on the tissue composition, physical-chemical and sensorial characteristics of the meat of Morada Nova lambs.

Material and Methods

It was selected for this experiment 32 intact Morada Nova male lambs born in the same herd of the Estação Experimental de Terras Secas da Empresa de Pesquisa Agropecuária do Rio Grande do Norte (EMPARN), with an initial weight of 12.7 ± 2 kg, at about five months of age and similar body condition, raised in a semi-extensive system in the native caatinga grassland. After selection, the lambs were identified, weighed and distributed in semi-open sheds with total area of 120 m^2, composed of 20 individual stalls (2.5 × 5 m), equipped with feeders and water troughs.

The animals were fed *ad libitum* a total mixed ration (TMR) balanced in accordance with recommendations of NRC (1985) twice a day. The experimental diets contained an average of 16.0% crude protein (CP), constituted by 40% of elephant Grass hay and 60% of concentrate (ground corn, soybean meal and cottonseed meal) and by different levels of silk flower hay. The total dry matter intake was determined by the daily control of the food supplied and rejected, so as to provide daily food surplus of about 10%.

Table 1 - Chemical composition of ingredients used in the experimental diets[1]

Nutrient	Ground corn	Soybean meal	Cottonseed meal	Elephant grass hay	Silk flower hay
Dry mater (%)	90.45	89.16	93.34	91.75	87.15
Organic matter (% DM)	98.01	92.75	95.08	88.62	84.20
Mineral matter (% DM)	1.99	7.25	4.92	7.30	15.80
Crude protein (% DM)	8.67	47.03	25.77	7.96	12.89
Ether extract (% DM)	4.27	2.70	9.60	1.71	5.24
Neutral detergent fiber (% DM)	16.33	16.35	54.31	74.78	41.95
Acid detergent fiber (% DM)	5.52	11.38	31.62	48.67	31.23
Lignin (% DM)	0.61	1.07	4.18	7.58	6.63
Total carbohydrate (% DM)	85.07	43.02	59.71	83.03	66.07
Non-fibrous carbohydrate (% DM)	68.77	26.27	5.40	18.25	24.12

[1] Torres et al. (2010).

Table 2 - Ingredient and chemical compositions (%) of the experimental diets, % of DM

	Silk flower hay level in the diet (%, DM basis)			
	0	15	30	45
Ingredient (% w/w)				
Silk flower hay (*Calotropis procera* SW)	0.0	9.0	18.0	27.0
Elephant grass hay (*Pennisetun purpureum* Schum)	40.0	40.0	40.0	40.0
Ground corn	37.5	29.5	21.5	13.5
Soybean meal	19.5	18.5	17.5	16.5
Cottonseed meal	3.0	3.0	3.0	3.0
Nutritional composition				
Dry mater (DM, %)	89.5	89.0	88.7	88.9
Crude protein (% of DM)	16.50	16.48	16.35	16.54
Ether extract (% of DM)	4.9	5.0	5.0	4.8
Mineral matter (% of DM)	3.6	5.6	7.3	10.8
Total carbohydrate (% of DM)	74.9	71.8	71.1	67.8
Neutral detergent fiber (NDF, % of DM)	37.9	40.3	41.1	46.4
Acid detergent fiber (ADF, % of DM)	5.2	10.4	12.5	15.0
Non-fibrous carbohydrate (% of DM)	36.9	31.5	29.9	21.4
Organic matter (% of DM)	96.3	94.3	92.2	89.2
Metabolizable energy (Mcal of ME/kg of DM)	2.13	2.07	2.01	1.95

The replacement of corn and soybean meal by silk flower hay consisted of the following levels: 0, 15; 30 and 45% of SFH (Tables 1 and 2).

Feed analysis was conducted according to standard procedures: dry matter (item number 930.15), crude protein (item number 984.13), mineral matter (item number 942.05) of the AOAC (2000). The acid and neutral detergent fiber contents were determined according to the methodology of Van Soest et al. (1991).

The lambs had an adaptation period for the experimental diet of 15 days and they were weighed individually every seven days. The total experimental period had duration of 75 days, and the animals were slaughtered after this period, at an average slaughter weight of 19.3 ± 2.2 kg.

The lambs were slaughtered after an 18-hour fast. However, during this period water was made available to the animals. The carcasses were identified according to animal and treatment, and transported to a cold room, where they remained for 24 hours at a temperature of 4ºC, hung on appropriate hooks. The pH, temperature and color parameters were measured in *M. semimembranosus* just before refrigeration (0 hour), and after the refrigeration period (24 hours).

For the qualitative and quantitative evaluations of the lamb meat, the leg was dissected to obtain the tissue composition, being separate into bone, muscle and fat. After the separation of tissues, the muscularity index (MUSC) proposed by Purchas et al. (1991) was calculated by using the weight of the five main muscles surrounding the femur (*M. biceps femoris, M. semitendinosus, M. semimembranosus, M. adductor femoris, M. quadriceps femoris*) and femur length, through the following formula:

$$MUSC = \left\{\sqrt{((5M_{WT})/(F_L))}\right\}/(F_L)$$

where: $5M_{WT}$ = five-muscles weight (*g*), and F_L = femur length (cm)

The *M. semimembranosus* was vacuum packed and frozen in a commercial freezer at -18ºC for 60 days, before chemical and sensory evaluation. All lamb meat analyses were performed in triplicates.

For pH and temperature measures (0 and 24 hours), a digital portable potentiometer was used, according to methodology of the AOAC (2000). Surface color of *M. semimembranosus* was measured after a 30-minute bloom at room temperature (Minolta Chromameter 200, Minolta, Japan). Color measurements were taken in the CIE–L*, a*, b* system, with the average of three measurements taken across the same cross section of muscle, avoiding areas of connective tissue or intramuscular fat. The chromameter was calibrated on a red tile (Y = 15.6, X = 0.446, Y = 0.313) before measuring color. The measuring head had D_{65} lighting with a second standard observer and 8-mm aperture.

Moisture, ash and protein contents were determined by using the methodology described in item numbers 985.41, 920.153 and 928.08, respectively (AOAC, 2000). Total fat was determined by following the procedure of Folch et al. (1957).

The *M. semimembranosus* were thawed at 4ºC for 12 hours, and cut into cubes of 3 cm of edge. The meat cubes were submitted to dry cooking process in electric grill at 170ºC until the temperature, monitored through a digital thermometer (Delta OHM, model HD9218, Italy), reached 71ºC in the geometric center of the meat, which took approximately eight minutes. There was no addition of salt or seasonings. After cooking, the samples were transferred to beakers coded according to treatment (0, 15, 30, 45% of SFH), covered with foil and kept in water bath at 55°C to avoid loss of volatiles.

A panel composed of nine tasters trained through non-structured scales of 9 cm was used, with measurement of intensity of the sensory attributes, which ranged from the least favorable condition to the most favorable condition. Three repetitions per group of sample were carried out, and in each repetition, four coded samples corresponding to the different treatments were offered, according to Amarine et al. (1965), Larmond (1977) and Madruga et al. (2000). For the sensory attribute "color *in natura*," the tasters observed fresh meat, so that they could visually rank it.

In addition to the variance analysis, regression analysis was performed according to the SFH levels in the diet. The criteria used for choosing the equations were: biological behavior, coefficient of determination (r^2) and significance, for the regression parameters, obtained by the "t" test, for the level 5% probability. Statistical analyses were performed by the PROC GLM and PROC REG procedures of the SAS (1996).

Results and Discussion

Levels of silk flower hay in diet affected slaughter weight ($P<0.01$), muscle and adipose tissue (Table 3), weight of the five muscles surrounding femur bone and the muscularity index ($P<0.05$). It also increased linearly the muscle: fat ratio ($P<0.01$) and linearly decreased leg weight ($P<0.05$). Increase on the dietary levels of silk flower hay decreased approximately 3 g in the leg weight for each percentage unit of hay estimated.

There was a quadratic effect on the level of SFH in the diet in relation to the slaughter weight. The maximum point was 15.75% of inclusion of SFH, in which the slaughter weight reached 20.28 kg. The diet of 45% of

Table 3 - Tissue composition, ratios and muscularity of the leg index of Morada Nova sheep fed diets containing different levels of silk flower hay (SFH)l

Variable	SFH levels in the diet (%, DM basis)				Effect
	0	15	30	45	
Initial live weight (kg)	12.8 ± 2.1	12.5 ± 1.5	12.8 ± 2.3	12.8 ± 2	-
Final Slaughter weight (kg)	19.4 ± 2.1	19.9 ± 1.6	19.5 ± 2.8	16.2 ± 2.5	**[1]
Leg (kg)	1.4 ± 0.2	1.3 ± 0.1	1.4 ± 0.2	1.2 ± 0.2	*[2]
Bone (%)	20.5 ± 1.2	20.4 ± 2.1	19.4 ± 2.1	21.1 ± 2.8	ns
Muscle (%)	63.8 ± 1.9	67.2 ± 4.8	65.2 ± 2.5	63.9 ± 1.9	*[3]
Fat (%)	6.2 ± 0.8	6.7 ± 1.3	6.2 ± 1.1	4.8 ± 0.9	*[4]
Remaining tissues (%)	6.9 ± 1.1	7 ± 1.1	6.4 ± 0.9	6.9 ± 1.1	ns
Muscle:bone	3.1 ± 0.2	3.3 ± 0.3	3.4 ± 0.5	3.1 ± 0.5	ns
Muscle:fat	6.0 ± 0.8	5.9 ± 1.2	6.3 ± 1.2	8.0 ± 1.4	**[5]
Muscularity (g/cm)	0.4 ± 0.01	0.4 ± 0.01	0.4 ± 0.03	0.3 ± 0.02	*[6]

[1] $Y = 19.29 + 0.126X - 0.004X^2$ ($R^2 = 0.97$).
[2] $Y = 1.409 - 0.003*X$ ($R^2 = 0.54$).
[3] $Y = 64.08 + 0.22X - 0.005X^2$ ($R^2 = 0.74$).
[4] $Y = 6.203+0.063X-0.002X^2$ ($R^2 = 0.99$).
[5] $Y = 5.615 + 0.041X$ ($R^2 = 0.72$).
[6] $Y = 0.356+0.001X-0.00004X^2$ ($R^2 = 0.60$).
**; * Significant at 1% and 5% level at probability by "t" test, respectively.
ns – not significant.

SFH promoted a decrease in the slaughter weight of the animals of around 16.2 kg. These results are related to the lowest development of the animals due to a reduction in the intake to dry matter (0.739; 0.728; 0.755 and 0.625 kg/day), and consequently, of protein intake (0.122; 0.120; 0.123; 0,103 kg/day) and energy intake (1.57; 1.51; 1.52 and 1.22 Mcal of ME/day), with the increase of SFH in the diet.

The average values for bone, muscle, fat and other tissues were similar to those reported by Marques et al. (2007), studying Santa Ines lambs fed with different SFH levels.

Although the animals had not completed physiological maturity, they presented reduction in the leg fat content, after the addition of 15% of SFH in the diet, and a quadratic effect was verified ($P<0.05$). The ratio of muscle:fat increased linearly ($P<0.05$) varying from 6.0 to 8.0, between the levels of 0 and 45% of SFH in the diet, respectively. The low consumption of metabolizable energy in the diet with 45% of SFH did not permit a greater deposition of fat tissue in the body of the sheep, mainly in the leg region, which presented low quantities of fat. Gonzaga Neto et al. (2006) observed similar results in Morada Nova sheep. The relation muscle:fat (8.82) was greater in the sheep which received less concentrate in the diet.

The muscularity index (MUSC) presented quadratic effect according to the increase of SFH in the diet ($P<0.05$). However, it was adjusted to a maximum point at a level of 12.5%. The MUSC value obtained in this study was 0.35 g cm^{-1}, close to those found by Silva Sobrinho et al. (2002), which was 0.42 g cm^{-1}, when studying different forage: concentrate ratios in the diet of Ile de France × Ideal crossbred lambs.

There was no significant difference ($P>0.05$) for ash, proteins and lipids contents, with levels ranging from 1 to 1.1%, 23.2 to 24.9 % and from 2.3 % to 2.7 %, respectively, which corroborate the results found by Almeida Jr. et al. (2004; Table 4). Despite of not showing significant difference ($P>0.05$), there was a clear trend of reduction in the levels of lipids, according to the addition of SFH in the diet.

The chemical composition (fat percentage) was similar among the treatments; however, the physical composition indicated a lower percentage of adipose tissue for the animals fed a higher level of SFH diet. These results are caused by the methodology used to measure the adipose tissue. In the physical composition, it is performed the dissection and weighing of subcutaneous and intramuscular fat. In the chemical composition of the *M. semimembranosus*, the intramuscular fat content was determined by the extraction of lipids by organic solvents.

The moisture content differed among treatments ($P<0.01$), presenting a quadratic effect, which could be related to the live weight at slaughter, which was higher than that of treatments with 0% and 15%. Therefore, higher SFH levels in the diet promote increase in the moisture content of meat (Bonagurio et al., 2004).

There was no influence of diet on the physical characteristics of Morada Nova lamb ($P>0.05$). The pH values are higher than those determined by Madruga et al. (2008), who worked with different concentrate levels in the diet of Santa Inês lambs, and found in *M. semimembranosus*, the same value used in this study, i.e. average pH of 6.4.

In relation to the meat color, values from 31.4 to 38 for L*, from 12.3 to 18 for a*, and from 3.3 to 5.6 for b* were found in this study; the b* values were higher, whereas for

the red intensity and luminosity, these values were lower than those found by Silva Sobrinho et al. (2005). Even with no significant difference between treatments for L*, a* b* variables at 0 and 24 hours, the meat from Morada Nova lambs seemed to be darker (12.3), less red (0.9 to 1.3) and paler (16.9 to 17.2) when compared to Santa Ines lambs fed diets containing four levels of SFH, (Madruga et al., 2008), whose average values were L* = 35 to 37, a* = 12 to 15 and b* = 8 to 11.

The addition of SFH in the diet (Table 5) influenced the juiciness and flavor attributes of lamb meat (P<0.01). These results corroborate with those found by Madruga et al. (2005), who observed differences in these parameters in the meat from Santa Ines lambs fed four types of forages. There was a decreasing linear effect in the juiciness, flavor and overall acceptance parameters as the SFH content increased in the diet.

The diets with 0 and 15% of SFH presented better averages in juiciness and flavor and color (*in natura*). A greater intake of metabolizable energy in these diets permitted a better fat deposition in the carcass, which favored the sensorial attributes of the meat. Sheep meat was considered tender, presenting a average score of 3.4, in a scale from 1 to 9 regardless to the level of SFH.

Levels of silk flower hay influenced (P<0.01) the overall meat acceptance, with decreasing linear effect, showing that the higher the hay level added to the diet, the lower the meat acceptance. However, in general, the scores given to sensory parameters were similar to those found in literature, indicating the good quality of meat from all treatments.

Table 4 - Physical-chemical parameters of *M. semimembranosus* from Morada Nova lambs fed diets containing different levels of silk flower hay (SFH)

Variable	SFH levels in the diet (%, DM basis)				Effect
	0	15	30	45	
Moisture (%)	75.4 ± 1.5	75 ± 0.6	75.9 ± 1	78.5 ± 0.4	**[1]
Ash (%)	1 ± 0.1	1 ± 0.04	1 ± 0.05	1.1 ± 0.04	ns
Protein (%)	24 ± 1.3	24.9 ± 0.5	23.2 ± 0.8	23.7 ± 0.6	ns
Fat (%)	2.7 ± 0.6	2.6 ± 0.3	2.5 ± 0.4	2.3 ± 0.5	ns
pH (0 h)	6.5 ± 0.2	6.3 ± 0.1	6.4 ± 0.2	6.5 ± 0.2	ns
pH (24 h)	5.9 ± 0.3	5.9 ± 0.1	6.1 ± 0.3	5.9 ± 0.3	ns
Colour					
L* (0 h)	12.2 ± 1.4	11.5 ± 0.5	12.1 ± 0.8	11.9 ± 0.7	ns
L* (24 h)	12.5 ± 1	12.3 ± 0.9	12.9 ± 1.1	12.3 ± 0.5	ns
a* (0 h)	0.7 ± 0.3	0.7 ± 0.2	0.9 ± 0.3	0.7 ± 0.2	ns
a* (24 h)	1 ± 0.5	0.9 ± 0.2	1.3 ± 0.4	1.2 ± 0.6	ns
b* (0 h)	17.5 ± 0.6	17.2 ± 0.3	17.4 ± 0.6	17.5 ± 1.3	ns
b* (24 h)	17.2 ± 0.4	17 ± 0.3	17.2 ± 0.3	16.9 ± 1.4	ns
Temperature ºC (0 h)	33.7 ± 2.2	33 ± 1.5	32.8 ± 1.9	32.9 ± 0.9	ns
Temperature ºC (24 h)	7 ± 1.5	6.8 ± 1.7	6.8 ± 1.3	7.3 ± 1.6	ns

[1] $Y = 75.45 - 0.079X + 0.003X^2$ ($R^2 = 0.99$).
**Significant at 1% level at probability by "t" test.
NS – not significant.

Table 5 - Sensory attributes of the *M. semimembranosus* from Morada Nova lambs fed diets containing different levels of silk flower hay (SFH)

Variable	SFH levels in the diet (%, DM basis)				Effect
	0	15	30	45	
Hardness	3.86 ± 1.78	3.32 ± 1.52	3.27 ± 2.0	3.16 ± 1.72	ns
Juiciness	3.57 ± 1.54	3.04 ± 1.41	2.96 ± 1.46	2.98 ± 1.45	**[1]
Flavor	4.24 ± 1.77	3.73 ± 1.77	4.02 ± 1.86	3.63 ± 1.66	**[2]
Color	3.33 ± 1.37	3.05 ± 1.43	3.97 ± 1.54	3.23 ± 1.54	ns
Color (*in natura*)	4.83 ± 1.59	4.30 ± 1.88	4.96 ± 2.17	4.25 ± 2.0	ns
Overall acceptability	4.40 ± 1.78	3.69 ± 1.72	4.10 ± 2.03	3.71 ± 1.57	**[3]

[1] $Y = 3.415 - 0.012X$ ($R^2 = 0.67$); [2] $Y = 4.136 - 0.010X$ ($R^2 = 0.51$); [3] $Y = 4.226 - 0.011X$ ($R^2 = 0.40$).
**Significant at 1% level of probability by "t" test; ns – not significant.

Conclusions

The substitution of corn (26.67%) and soybean (3.33%) by silk flower hay does not affect the tissue composition, ratios and muscularity index of leg and physical-chemical parameters of *M. semimembranosus* of Morada Nova lambs. The sensory attributes of the meat from Morada Nova lambs fed levels above 30% SFH in the concentrate has lower juiciness, flavor and overall acceptability.

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