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High Levels of Sunflower Crushed in Diets for Feedlot Lambs Depress the Performance and Carcass Quality

Research Article

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ABSTRACT

This study aimed to evaluate the performance, some carcass characteristics from feedlot lambs receiving sunflower crushed (SC) in the diet on partial replacement of soybean meal. The experimental design was randomized block with four levels of SC in the diet (0, 10, 20 and 30% of dry matter (DM)). There was a linear reduction of 0.02; 0.003; 0.003 and 0.17% for each percentage unit of added SC in the diet, respectively, for the intake of dry matter, crude protein, daily weight gain and feed conversion ratio. There was a significant linear decrease of 0.15; 0.11 and 0.12% in slaughter weight, hot carcass and cold carcass, respectively, when increased 1% in the inclusion of SC in the diet. The use of SC did not influence the biological yield and characteristics of marbling, texture and color of the meat. The use of SC can be used in supplements for lambs in intensive production systems in partial replacement of soybean meal by up to 20%.

KEY WORDS carcass yield, co-products, marbling, performance, sunflower crushed.

INTRODUCTION

Intensive production system presents many onerous factors in animal production, like the animal feed. Many of the alternative feeds vary widely in nutrient content, making an analysis or some assessment of the feed value necessary. Producers must know the energy, protein and major mineral levels of these feeds to develop balanced, least-cost diets for livestock (Bosa *et al.* 2012). The low availability of food, especially those high in protein and energy is a limiting factor to livestock production in developing regions, making the production be susceptible to changes in market, so the use of regional food is recommended (agro industries byproducts) because they are inexpensive and easy to purchase and transport (Azevedo *et al.* 2012).

The inclusion of co-products in the formulation of rations for animals in production, replacing conventional foods, is an alternative whose potential is still little explored. Sunflower crushed (SC) can be considered as a protein food (greater than 20% of crude protein (CP)), with high ruminal degradation protein, besides being rich in unsaturated fatty acids. The products of the agroindustry of sunflower, can be characterized as protein concentrates and can be used to feed ruminants (Habib *et al.* 2013; Zagorakis *et al.* 2015). The SC presents average levels of crude protein, ethereal extract, corrected neutral detergent fiber, non-fibrous carbohydrates, non-protein nitrogen, rumen degraded protein and *in vitro* digestibility of 28.77%; 21.00%; 39.00%; 23.52%; 9.18%; 41.42%; 60.87%, respectively (Abdalla *et al*. 2008; Carrera *et al*. 2012). The inclusion of up to 28% of SC in lamb diets reduced weight gain and loin eye area (Rodrigues *et al*. 2006). However, there are few studies on the use of this for lambs and therefore research is needed to evaluate the effect of the use upon the performance of the animals. Feedlotting is a management practice which lamb producers frequently use in an effort to achieve a consistent supply of quality lamb that meets market specifications for weight and fat score (Carvalho *et al*. 2003). While feedlotting gives producers the flexibility to finish lambs irrespective of seasonal conditions, other options may be more profitable, and should be considered (Ribeiro *et al*. 2011). Based on the above, the aim of this experiment was to assess the performance and some carcass and meat characteristics of feedlot lambs receiving SC in the diet.

MATERIALS AND METHODS

The experiment was conducted at the agricultural sciences college -FCA, Federal University of Grande Dourados - UFGD, in Dourados-MS. Twenty eight crossbred Suffolk lambs, four months of age with an average weight of 21.35 ± 0.38 kg, were used. The experimental design was randomized block with four levels of SC in the diet (0 (control), 10, 20 and 30% of DM). The control consisted in mixture of corn and soybean meal. All the diets were isonitrogenous, with a 18.0% of dry matter in a proportion of roughage: concentrated of 50:50 (Table 1).

All the treatments possessed, as roughage a proportional mixture of *Cynodon* spp. hay, by Tifton 85, Tifton 68 and Jiggs. The concentrated was composed of corn, soybean meal, minerals and SC (Table 1), according to the NRC (2007), to gain 200 g/day. SC was obtained from the mechanical grain-free press obtained at Embrapa Agropecuária Oeste, the material was all rendered in a single period on a single machine (MUE-100 cold). The amount of feed was offered according to individual intake obtained during the early experimental phase.

The feeding was carried out twice a day to 08:00 and 14:00 hours. The amount offered was adjusted daily, being controlled to be 10% of the amount offered. For determining the intake of nutrients, amount of feed provided and their orts were determined. Dry matter (DM), crude protein (CP), mineral matter (MM) and ether extract (EE) were analyzed according to methods described by AOAC (1990). For determination of neutral (NDF) and acid (ADF) detergent fiber, the methodology of Van Soest *et al*. (1991) was used.

The residual feed intake (RFI) or net feed efficiency was estimated by the difference between an animal's actual feed intake and its expected feed requirements for growth (Sainz *et al*. 2006).

The animals were weighed every 14 days. Previously of weighing the animals were subjected to fasting of solid and liquid, by 12 hours.

The animals were slaughtered based in the individual body condition (conducted by three trained raters), on a scale from one (very thin) to five (very fat), with intervals of 0.5. The evaluation of body condition was performed through palpation along the spinous dorsal, lumbar and tail base according to the methodology described by Osório and Osório (2005). The animals which their score was between 2.5-3.5 were slaughtered.

The animals were kept in a feedlot for period of 90 days, preceded by 30 days for adaptation to management and four periods of 15 days for data collection. The animals were kept in individual stalls of 1.5 m^2 in 2 warehouses covered concrete floor lined with shavings, which was replenished daily, with curtains for temperature control, with fountain and trough.

Then, the animals were insensibilized by electronarcosis and then suspended by its hind legs and then made bloodletting. Shortly after, the jugular veins were sectioned and carotid arteries, collecting the blood on previously tared container (Santos *et al*. 2013).

After bleeding and skinning, the gastrointestinal contents were removed for determination of empty body weight (EBW), obtained from the difference between weight at slaughter (SW) and the gastrointestinal content. The carcasses without skin, viscus, head, legs and genitals were weighted for determination of hot carcass weight (HCW) and transported to refrigeration chamber at 4 ˚C, where they were kept for 24 hours.

After cooling, the carcasses were weighed to obtain the weight of the cold carcass weight (CCW), by calculating the percentage of loss by cooling (LC) by the formula (PR %)= HCW – CCW / HCW × 100. Then it was determined the yields of hot carcass weight (HCW) and cold carcass weight (CCW) and biological yield (BY), respectively, by the following formulas: WHR (HCW/SW) × 100, RCF= (CCW/SW) × 100 and BY= (HCW/EBW) × 100, where the EBW is the empty body weight. The carcass compactness index was calculated according to the ratio between the HCW and the internal carcass length.

After cooling the carcasses were divided longitudinally. The left half carcasses were sectioned in commercial cuts of palette, shank, side cut (containing the muscle portions of the ventral region) and neck, and these subsequently weighed.

Table 1 Ingredients and composition of the experimental diets

Ingredients (%)	Inclusion level of sunflower crushed			
	0%	10%	20%	30%
Cynodon hay	50.00	50.00	50.00	50.00
Sunflower crushed	0.00	10.00	20.00	30.00
Ground grain corn	29.65	22.71	15.77	8.83
Soybean meal	19.41	16.37	13.33	10.29
Mineral premix[1]	0.20	0.20	0.20	0.20
Limestone	0.70	0.70	0.70	0.70
Chemical composition (%)				
Dry matter	87.24	87.26	88.37	88.77
Crude protein	17.98	18.15	17.97	17.66
Fat	1.27	3.43	5.63	7.18
Neutral determination of neutral (NDF)	60.22	61.96	62.54	60.33
Acid determination of neutral (ADF)	30.51	29.83	29.51	26.80
Total digestible nutrients (TDN)	56.60	55.60	55.30	56.54
Ash	6.63	7.01	6.50	6.72

[1] Cálcium (mín): 111.00 g/kg; Cobalt: 50.00 mg/kg; Sulphur: 11.99 g/kg; Iron: 4.42 mg/kg; Phosphorus (mín): 72.00 g/kg; Iodine: 75.00 mg/kg; Magnesium: 9.00 g/kg; Manganes: 1.550.00 mg/kg; Selenium: 13.50 mg/kg; Sodium: 174.00 g/kg; Zinc: 7.200.00 mg/kg and Fluor (máx): 720.00 mg/kg.

Through a trained assessor notes referring were attributed the conformation of carcasses on a scale of one (excessively thin) to five (excessively unusable), with intervals of 0.5.

All subdivisions and the measurements performed on the carcasses followed the recommendations of Sañudo (2008). On the right half carcass, was measured the internal length of the carcass with the help of measuring tape, which was divided by the weight of the cold carcass to determine carcass compactness index (CCI). In a transversal cut between the 12th and 13th ribs, exposing the measure of the longissimus muscle to fat thickness obtained in the third quarter of this muscle from the spine with a caliper was performed. Through tracing of the perimeter of the muscle in vegetable parchment the area of loin eye was measured subsequently by planimetry using AutoCAD R14 software, as described by Oliveira *et al.* (2010).

Three samples of Longissimus muscle were taken between the 11th, 12th and 13th rib with approximately 2.5 cm thickness and immediately sent to the laboratory for analysis of meat color.

The determination of the meat color was performed as described by Houben *et al.* (2000), using a colorimeter (Konica Minolta®). Thirty minutes before the evaluations, a transverse incision was made to the muscle to expose the myoglobin to oxygen, as described by Abularach *et al.* (1998). In sensorial analysis, the meat samples received an addition of 1.5% salt in relation to their weights and roasted in a preheated oven at 175 ˚C, remaining until the internal temperature of the meat reached 75 ˚C.

Data were subjected to SAS (2004), verifying the normality of residuals and homogeneity of variances using PROC UNIVARIATE. Data were analyzed by PROC MIXED according to the following model:

$$Y_{ijyk}= \mu + B_i + A_j + P_y + T_k + e_{ijyk}$$

Y_{ijyk}: dependent variable.
μ: general mean.
B_i: effect of block (i=1 to 4).
A_j: animal's effect (j=1 to 28).
P_y= effect of period (y=1 to 4).
T_k= effect of treatment (k=1 to 4).
e_{ijk}: error.

Random effect= A_j and P_y. The degrees of freedom were defined according to the method satterthwaite (ddfm=satterth). Data were subjected to analysis of variance and polynomial regression by command PROC MIXED of SAS, version 9.0 (SAS, 2004), adopting a significance level of 5%.

RESULTS AND DISCUSSION

The addition of SC in diets for lambs negatively influenced ($P<0.05$) intake of DM (kg/day and % BW), CP, fat, NDF (kg/day and % BW), total digestible nutrients (TDN), final weight, average daily gain (ADG), protein efficiency (PE) and feed conversion ratio (FCR) (Table 3). The dry matter intake (DMI) results decreased as it has increased the inclusion of SC (TG), ranging from 0.981 the 0.523 g per animal daily between 0 and 30% treatment ($P<0.05$) of inclusion of SC in the concentrate.

Table 2 Intake and productive performance

Item	Inclusion level sunflower crushed (%)				SEM	P-value	
	0	10	20	30		L	Q
Intake (g/day)							
Dry matter	1.04	0.79	0.56	0.46	0.04	0001	0.543
Crude protein	0.20	0.16	0.12	0.10	0.01	0.003	0.560
Fat	0.01	0.03	0.04	0.04	0.02	0.005	0.765
Neutral determination of neutral (NDF)	0.67	0.55	0.44	0.35	0.03	0.040	0.321
Total digestible nutrients (TDN)	1.07	0.86	0.71	0.60	0.05	0.001	0.731
Intake (% BW)							
Dry matter	2.91	2.18	1.75	1.38	0.05	0.002	0.409
Neutral determination of neutral (NDF)	2.01	1.54	1.24	0.93	0.08	0.004	0.543
Live weight (kg)							
Initial	21.85	21.42	21.00	21.10	0.07	-	-
Final	37.04	34.15	34.55	31.55	0.42	0.028	0.721
Body condition score							
Initial	1.50	1.50	1.50	1.50	0.01	0.876	0.445
Final	3.00	3.00	2.50	2.50	0.02	0.543	0.437
Average daily gain (ADG) (g/d)[3]	118	83	56	28	7.54	0.001	0.432
Feed conversion (FC)	5.33	5.50	5.60	7.96	0.43	0.654	0.326
Protein efficiency (PE)	0.60	0.50	0.34	0.30	0.02	0.002	0.332
Residual feed intake (RFI)	0.07	-0.01	-0.03	-0.05	0.01	0.086	0.876

L: linear and Q: quadratic.
SEM: standard error of the means.

Table 3 Carcass characteristics

Item	Inclusion level of sunflower crushed (%)				SEM	P-value	
	0	10	20	30		L	Q
Slaughter weight (kg)	37.04	34.16	35.79	31.47	0.45	0.001	0.450
Hot carcass weight (kg)	16.95	15.49	15.00	13.27	0.29	0.002	0.423
Cold carcass weight (kg)	16.21	14.69	14.26	12.34	0.30	0.003	0.453
Hot carcass yield (%)	45.74	45.38	41.91	42.38	0.38	0.020	0.165
Cold carcass yield (%)	43.74	43.08	39.86	39.34	0.42	0.002	0.342
Biological yield (%)	54.15	54.67	52.90	53.54	0.14	0.325	0.765
Coolin glosses (%)	4.37	6.01	5.65	5.51	0.13	0.106	0.004
Internal length of carcass	53.86	55.43	55.14	53.14	0.20	0.102	0.043
Compactness index (kg/cm)	0.32	0.28	0.27	0.25	0.01	0.502	0.658
Loin eye area (cm²/kg)	0.80	1.08	0.94	0.84	0.02	0.901	0.013
Fat thickness (mm)	1.11	1.22	1.43	0.86	0.04	0.827	0.032
Conformation	3.29	2.93	3.14	2.64	0.05	0.001	0.654
Texture	3.79	3.79	3.50	3.57	0.03	0.600	0.432
Color	3.21	3.21	3.14	3.57	0.04	0.170	0.654
Marbling	1.79	1.64	1.71	1.50	0.02	0.245	0.765

L: linear and Q: quadratic.
SEM: standard error of the means.

When we analyze the intake in relation to the percentage of live weight in that the value is adjusted in the light of changes in live weight of animals, with values of 2.91; 2.18; 1.75 and 1.38% live weight for the control and the levels of 10, 20 and 30% of inclusion of SC, respectively. Dry matter, crude protein, neutral detergent fiber intake by inclusion of SC, decreasing with inclusion of SC.

The addition of SC in diets reduces the average daily gain (Table 2). The animals fed without SC were heavier 9.20% in those fed diets containing SC. Witch alter the final body weight (Table 3).

Animals not receiving sunflower diet had a residual food intake (RFI) positive, indicating less efficiency. The FCR ranged from 5.33 to 7.96 and was negatively (P>0.05) influenced by levels of SC in the diets, which can be justified by the reduction in DMI.

There was no influence (P>0.05) of diets on body condition (BC) of the animals for the experimental period (Table 2). The inclusion of 30% of SC in the diet of lambs negatively affected carcass characteristics (Table 3). There was a significant linear decrease of 0.15; 0.11; 0.12 and 0.002% on the SW, HCW, CCW and compactness index

(CI), respectively while increased 1% in the inclusion of SC in the diet. The hot carcass yield (HCY) and cold (CCY) presented reduction with the increase of SC, where the averages were adjusted with the linear regression model. There was a reduction of 0.13% and 0.16% on the water holding resistence (WHR) and CCY for each percentage unit of added SC in the diet, respectively. The variation between groups receiving high dietary level and without the addition of the crushed was 7.36% for WHR and 10.05% for the CCY. These reductions in yield occurred due to oscillation between the absolute values of SW, HCW and CCW with increment of SC in the diet.

For the BY, there was no significant difference between treatments, with an average of 43.72%. The CI of the carcass of lambs decreased linearly with an increase of SC in the diet, with marginal variation of 21.87% observed, which can be explained by the decrease in CCW lambs and internal carcass length. Cooling loss, the internal length of the carcass, the loin eye area (REA) and back fat thickness of the animals showed a quadratic response with increasing level of dietary SC, with the maximum point level obtained in 18.25; 13.33; 15.00 and 12.50%, respectively.

The conformation of carcasses reduced ($P<0.05$) linearly with the addition of SC in the diet, and for each unit of SC added in the diet, found a decrease of 0.01% in conformation. No differences ($P>0.05$) were observed in the major quality attributes related to the sensory characteristics of the meat. The texture and color of the meat had averages of 3.66 and 3.28, respectively. The intramuscular fat content characterized as fat marbling were not affected ($P>0.05$) with the increase of SC in the diet of lambs with an average of 1.66. The evaluated diets had ($P>0.05$) significant effects on the weights of the major commercial cuts of crossbred lambs Suffolk finished in feedlot (Table 4). The addition of SC in the diet induced a reduction of 0.007; 0.01 and 0,009% by weight on the palette, leg and ribs of lamb pie for each unit increased in the diet DM, a fact that could be related with the carcass weights (Table 4). The weight of the neck did not differ ($P>0.05$) between the treatments with a mean of 0.53 kg.

All of the animals present a lower intake to the recommended by NRC (2007), of 2.9-3.5% for growing and finishing lambs with weights between 20 and 30 kg. The inclusion of SC limited the intake, which did not allow the expression of the potential for weight gain of animals. Ahmed and Abdalla (2005), who assessed the SC as protein source for feedlot lambs, reported average intake of dry matter equivalent to 3.49% of body weight close to the average observed in the present study.

The reduction in dry matter intake of animals can be explained by the high level of fat in the diet (Table 2), which causes rumen repletion effect consequently lower rate of degradation of the fiber due to the toxic action of unsaturated fatty acids on gram-positive microorganisms. This result is consistent to Bosa *et al.* (2012) that evaluated the DMI in lambs receiving different levels (25; 50 and 75%) of coconut crushed in the diet, and found 54.49% of decreased by 25 and 75% of coconut crushed.

Unsaturated fatty acids have anfilic nature, being soluble in both organic solvents and in water and therefore toxic to fibrolitic bacteria, decreasing the rate of passage due to increased residence time of the roughage in the rumen, limiting the intake of raw drought (Mizubuti *et al.* 2011). The highest concentration of oil can lead to astringency due to lipid oxidation by altering the structure and affecting patterns as odor, flavor and texture (Ramalho and Jorge, 2006), and unsaturated fatty acids structures more susceptible to oxidative process.

Crude Protein intake (CPI), supplying the minimum need of ruminal flora; with average of 148.75 g per animal per day, similar to the value recommended to NRC (2007), to growing sheep (137 g per animal per day). The crude protein content in a diet is one of the factors that can affect the dry matter intake, values under 70 g/kg of dry matter reduces the degradation of fibers, limiting voluntary food intake, decreasing the efficiency of food utilization.

The concentration of NDF in diet is inversely related to dry matter intake. In this experiment, the NDF intake (Table 3) was higher than the proposed by Van Soest (1994), of 160 to 360 g per animal per day for sheep. It is important to note that high levels of NDF in diet could limit the DMI (Hübner *et al.* 2008), which did not occur in this work; because the physical processing of SC may have reduced the effectiveness of fiber and its effect on the dry matter intake.

According to Van Soest (1994), the voluntary dry matter intake is related to NDF diet content, since the fermentation and the passing rate of the fibrous fraction by rumen are slower than other dietary constituents. In this sense, the DMI and INDF, expressed as a percentage of body weight was higher in the control group.

The nutrient intake is the function of the animal that is directly associated with the body weight, body weight variation, level of production and physiological condition, beyond the kind of diets and feeding conditions (Mertens, 1983). The fat intake increased significantly with the SC in diet, being observed levels of 14.2; 40.0; 63.7 and 78.9 g for kg of dry matter for the 0, 10, 20 and 30% of SC, respectively.

Bosa *et al.* (2012) emphasizes that the inclusion of lipid source exceeding 5% of dry matter intake compromises the food intake, by regulatory mechanisms, either by the limited capacity of ruminants to oxidize fatty acids. Therefore, levels of inclusion of SC above 10% justify the low result obtained on dry matter intake.

Table 4 Commercial cuts

Variable	Inclusion level of sunflower crushed (%)				SEM	P-value	
	0	10	20	30		L	Q
Weight of pallet (kg)	1.38	1.31	1.27	1.13	0.02	0.001	0.765
Weight of ham (kg)	2.67	2.48	2.46	2.20	0.04	0.002	0.654
Rib weight (kg)	1.01	0.85	0.87	0.69	0.02	0.031	0.542
Neck weight (kg)	0.55	0.55	0.52	0.50	0.02	0.457	0.556

L: linear and Q: quadratic.
SEM: standard error of the means.

Supplementation with 5 to 10% has been used successfully in diets for animals confined in regions of high temperatures, in which intake is generally compromised. However, supplementation increases the power intake (Mizubuti *et al*. 2011).

According to Mizubuti *et al*. (2011), the microbial metabolism of triglycerides, which is the form of lipids found in seeds, begins with its hydrolysis (addition of hydrogen ion in dual-link), giving rise to galactose and glycerol, which are fermented to volatile fatty acid quickly. The action of fat as being a potent stimulator of colecistokinine (CCK) which contributes to satiety is a factor in evidence in the regulation of animal intake. One hypothesis is that the CCK reduces food intake, inhibiting gastric emptying. Diets high in fats in ruminant plasma CCK increase and the infusion of long chain fatty acids, saturated, not inhibit the motility of the rumen reticulum (RR) in sheep.

Another possible explanation for the reduction in the DMI would be that sunflower oil, rich in polyunsaturated fatty acids when by hydrogenated by bacteria and protozoa results in greater energy supply (Petit *et al*. 1997), thus reducing the intake of dry matter.

The smaller ADG values were observed in animals receiving diets containing 30% SC (74 g/animal/day) are more expressive, justified by the higher fat intake that could be negatively affecting the fiber degradability in the rumen, increasing the degree of repletion of the rumen and decreasing the use of diet (Sainz *et al*. 2006).

The addition of SC affect the TDN with direct influence on animal performance. In work conducted by Louvandini *et al*. (2007) the average daily gain (ADG) were 139.84; 101.53 and 82.12 g, respectively, to 0, 50, 100% replacement levels of soybean meal by sunflower meal, which is in accordance with the results obtained in this research, that is, as it has increased the amount of SC in the diet, average daily gain decreased. Thus, the authors suggest that the use of this by product should be subject to cost in relation to soybean meal, since there is performance reduction with the replacement of this food by meal or SC.

Animals not receiving sunflower diet had a residual feed intake (RFI) positive, indicating less efficiency.

For Archer *et al*. (1997) animals with low RFI showed lower dry matter intake, less abundant subcutaneous fat and similar or higher performance when compared to the high RFI. According to review carried out by Lanna and Almeida (2012), in beef cattle several authors estimated positive correlation between RFI and subcutaneous fat deposition. Knott *et al*. (2003) evaluating sheeps found a negative correlation between no fat carcass and negative RFI, demonstrating lower feed efficiency. In this work the animals receiving 10, 20 and 30% of SC presented less fat carcass deposition in function of DMI observed in relation DMI estimated, being more efficient in function of feed conversion (FC).

The feed conversion is an important parameter to be used for the economic evaluation of diets. In the present work, the effect of the inclusion of SC in the diets on the FC shows that animals needed to consume smaller amounts from diet, to convert it into 1 kg of body weight, reducing the cost of animal feed.

These results were compatible to Azevedo *et al*. (2012), which evaluated the performance of lambs fed with inclusion of macauba crushed in the diet, found food efficiency of 5.53 and 6.40, respectively, for the levels of 0 and 300 g/kg of dry matter of macauba crushed.

The result observed for Body Condition Score was expected due to the experimental methodology defined by body condition score. However, for Hammond (1966), as the sheep grows, changes occur in their body proportions, usually a wave of growth that begins in the head and extends along the trunk (primary waves) and other that start at the ends and ascend through the body, lying in the tenderloin with the last rib "least-developed region" (secondary waves) favoring an increase in body condition score (CC) of animals, which is a fundamental parameter for determine the best time for slaughter and for carcasses with smooth finish.

The results obtain for the slaughter weight (SW), hot carcass weight (HCW), cold carcass weight (CCW) and compactness index (CI) are according to Sañudo and Sierra (1986), lamb carcass yields ranging 40 to 60%, depending on the breed, the crosses and the build system.

Therefore, the values obtained in this study are consistent with those described by these authors.

According to Perez (1995), any of the three forms of evaluation of carcass yield are determinants of higher or lower cost of the meat for the consumer, in a way that it becomes relevant to the breeders who invest in this activity.

Urbano *et al.* (2013) also observed a linear decrease in CI lamb fed levels (0; 33; 66; 100% of DM) of castor beans bark replacing Tifton85 hay (*Cynodon* spp.). The authors explained that the lipid content of the diet increased as hay replaced by castor bean bark, consequently, reduced the CCW and did not alter the internal carcass length. Therefore, the HCW was the factor responsible for the reduction on the IC.

The result observed to cooling loss were, the internal length of the carcass, loin eye area and back fat thickness possibly correlated to linear decrease on the ADG and DMI. The measurement of loin eye area (AOL) performed on longissimus muscle has indicated a direct relationship to the total carcass muscle, while the thickness of subcutaneous fat to total carcass fat and indirectly to the amount of muscles, since the larger accumulation of fat, the lower the proportion of muscle (Lawrie, 2004).

The mean (3.00) observed for carcass conformation between treatments can be inferred that the carcasses were presented fatting in lean state, which is desirable by consumers and not desirable by the fridge, since it lean carcasses are positively correlated with low levels of subcutaneous fat, increasing losses during cooling, such as the shortening of the fibers (Fernandes *et al.* 2011). However, despite the reduction in carcass conformation with the supply of SC, the average carcass (1.15 mm) for the fat thickness verified in this study, is located inside the range recommended by the fridge that is at least 1 mm, indicating quality desired by consumers (Sousa *et al.* 2008).

The color has an important role in sensory meat quality and differentiates itself as the main factor considered when buying (Sousa *et al.* 2008). The meat of crossbred Suffolk lambs showed slightly light red color, which is characteristic of meat of lamb. This result may be related to the concentration of fat in the carcass of such animals since larger lipid levels in meat results in a lower concentration of myoglobin in the product and, consequently, less intense staining. These results corroborate those obtained by Cartaxo *et al.* (2011) who analyzed the effects of increasing dietary energy crossbred lambs (Dorper×Santa Inês) and observed no significant differences in the color and texture, with an average of 3.91 and 4.00, respectively.

This value of marbling is low, which possibly is characteristic of young animals. It is also reflective of the amount of external fat carcasses. The marbling is an important feature, because it is closely related to the sensory characteristics of the meat possible of being perceived as flavor and succulence, which are appreciated by the consumer (Fernandes *et al.* 2011). This observation can be confirmed by combining the results of quantitative evaluations, which showed no qualitative problem, were shown, with the scores given by the panelists.

The variation between the highest and the lowest level of inclusion was 18.11; 17.60 and 31.68%, respectively for the weight of the pallet leg and ribs. According to Osorio *et al.* (2002), when the animals show different body conformation, as in the case of mixed race and also differences in carcass weight and tissue composition of muscle and fat, as seen by the similar values of AOL and EGS in this study, the regional composition of carcasses may be different.

Fernandes *et al.* (2011) evaluating the performance of lambs fed in feedlot diets containing soybeans or protected fat found an average weight of 1.79 kg neck. This difference in weight of the neck in relation to the results of this research can be related to slaughter weight of animals and factors related to age and race.

CONCLUSION

The use of SC can be used in supplements for lambs in intensive production systems in partial replacement to soybean meal up to 20%.

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