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The effect of combinations of dried or ensiled corn and sorghum on the performance of feedlot lambs

Combinações de milho e sorgo secos e ensilados nas características de carcaça de cordeiros terminados em confinamento

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Abstract

The objective of this study was to evaluate the effects of combinations of dry and moist corn and sorghum grain on the carcass and cut characteristics of crossbred lambs Suffolk x Santa Inês produced in feedlots. The experimental design was a randomized block with four treatments and three replicates. Sixty uncastrated male lambs with an initial average weight of 15.5 kg were used in this experiment. Four combinations of grain were evaluated: dry sorghum milled + silage of high-moisture sorghum grain (DS: MS); dry corn milled + silage of high-moisture sorghum grain (DC:MS); dry corn milled + silage of high-moisture corn grain (DC:MC); dry sorghum milled + silage of high-moisture corn grain (DS:MC). There was no difference between treatments for carcass yield, warm and cold carcass weight and for cooling loss. The slaughtering weights of lambs fed DC:MS associations were higher (29.46 kg) than lambs fed DC: MC (24.17 kg), but both did not differ DS:MS (26.18 kg) and DS:MC (25.21 kg). There was influence of the grain associations on the yield of commercial cuts palette and shank. Combinations of corn and sorghum grain, dried and ensiled, can be used to feed lambs in confinement for meat production without affecting the quality of the carcass.
Key words: Commercial cuts. Fat thickness. Loin eye area. Silage of high-moisture grain.

Resumo

O objetivo deste estudo foi avaliar o efeito das associações de grãos secos e úmidos de milho e sorgo nas características de carcaça de cordeiros mestiços Suffolk x Santa Inês terminados em confinamento. O delineamento experimental foi em blocos casualizado com quatro tratamentos e três repetições. Foram utilizados 60 cordeiros machos não castrados, com média de 15,5 kg de peso corporal. Quatro associações de grãos na dieta foram avaliadas: sorgo seco triturado + silagem de grãos úmidos de sorgo (SS:SU); milho seco triturado + silagem de grãos úmidos de sorgo (MS:SU); milho seco triturado + silagem de grãos úmidos de milho (MS:MU); sorgo seco triturado + silagem de grãos úmidos de milho

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(SS:MU). Não houve diferença entre os tratamentos para rendimento, peso de carcaça quente e fria e para perda por resfriamento. Os pesos de abate dos cordeiros alimentados com associações MS:SU foram superiores (29,46 kg) aos dos cordeiros alimentados com MS:MU (24,17 kg) porém, ambos não diferiram SS:SU (26,18 kg) e SS:MU (25,21 kg). Houve influência das associações de grãos sobre rendimento dos cortes comerciais paleta e pernil. As associações de grãos de milho e sorgo, secos e ensilados, podem ser utilizadas na alimentação de cordeiros em confinamento para produção de carne.
Palavras-chave: Área de olho-de-lombo. Cortes comerciais. Espessura de gordura. Silagem de grãos úmidos.

Introduction

The intensification of sheep production systems has been accompanied by significant changes in feeding and nutritional management in order to maximize performance and productivity, thus reducing the time to slaughter. The type of system chosen to produce ovine meat affects two main characteristics of economic importance: carcass weight and age at slaughter (OSÓRIO et al., 2012). For these two reasons, the termination of animals in feedlot systems has received increased acceptance in recent years (LAGE et al., 2010).

The production of sheep meat supplies a small portion of Brazilian domestic meat consumption, in which lamb is the most demanded category (SILVA SOBRINHO et al., 2008). The ideal age of slaughter depends on several factors such as breed, animal weight and production system (ROCHA et al., 2010). Pursuing the goal of greater feed efficiency in the production of feedlot animals, sheep producers employ diets containing grain that are rapidly fermentable in the rumen to maximize energy intake (STEELE et al., 2009). The goal of Brazilian sheep farming today is greater competitiveness in lamb production systems, with viable production costs and the production of quality and healthy products. Lamb meat provides a good source of essential amino acids, proteins and low concentrations of lipids and saturated fat (ALVES et al., 2014). Under these conditions, there is an increasing demand for low-cost feed that supports good animal performance in intensive systems of lamb production.

According to Prado-Calixto et al. (2017), silage of high-moisture corn can maximize animal productivity since it contains high levels of total digestible nutrients (TDN) and in vitro dry matter digestibility (IVDMD). Precisely for this reason, this type of feed is of great economic importance, since its TDN content is greater than 80% and it has high IVDMD (JOBIM et al., 2010).

The importance stems from the need to seek nutritional alternatives that maximize the performance, productivity and meat quality of feedlot sheep, as the demand for quality in the sheep meat market has increased significantly. The raising of feedlot sheep using humid corn and sorghum grain in the form of silage combined with dry grain is an innovative and little studied alternative, differing from conventional nutritional strategies by the better quality of the diet and the possibility of reducing food costs.

The objective of this study was to evaluate the effects of combinations of dry and moist corn and sorghum grain on the carcass and cut characteristics of crossbred lambs Suffolk x Santa Inês produced in feedlots.

Materials and Methods

The experiment was conducted at the experimental feedlot of the Department of Improvement and Animal Nutrition of the Faculty of Veterinary Medicine and Animal Science of Unesp, Câmpus of Botucatu-SP. The experimental period was 75 days. Prior to the experimental period, the animals were adapted to the experimental diets and the facilities for 15 days.

The experimental design was randomized blocks with 4 treatments and 3 replicates (bays) with five lambs per bay. The blocks were defined based on the weight of the animals. A total of 60 uncastrated lambs, crossbred Suffolk x Santa Inês with an average body weight (BW) of 15.5 kg of and 60 days old, were used in the experiment. Twelve groups of five lambs based on BW were formed: four groups of light lambs (14.2 kg), four groups of lambs of medium weight (16.4 kg) and four groups of heavy lambs (20.3 kg). These groups were randomly distributed in the bays.

The treatments corresponded to combinations of corn and sorghum grain, dried and ensiled. These combinations resulted in the following treatments: dry sorghum milled + silage of high-moisture sorghum grain (DS: MS); dry corn milled + silage of high-moisture sorghum grain (DC:MS); dry corn milled + silage of high-moisture corn grain (DC:MC); dry sorghum milled + silage of high-moisture corn grain (DS:MC). The facilities were composed of 12 bays of six m² each, covered, with concrete floors and a bed composed of sugarcane residue, equipped with drinking fountains and troughs in order to feed the animals. The diets were provided at will, twice a day, with 40% of the total diet offered in the morning (8 am) and 60% in the afternoon (4 pm). The food leftovers were removed before feeding in the morning and weighed to control consumption and adjusting the amount of food to be provided, with average leftovers of 10%.

The volume used was the whole plant corn silage processed according to the recommendations of Factori et al. (2008). The criterion adopted to define the cutting time for ensiling was the maturity of the grain, measured by the appearance of the black layer of the grain (40-45% dry matter of the ensiled mass). Bunker-type silos were used, and the cutting done at 20 cm above the ground using a John Deere 7300-22 combine harvester equipped with an attachment to process the grain, regulated in this case to standardize the size of the particles at 2.0 cm.

For the preparation of the silage of high-moisture com and sorghum, the grain was harvested at a mean moisture content of 29%, milled in a medium sieve and stored in 200-liter plastic drums with a lid. Dry corn and sorghum grain was harvested at 15 and 17% moisture, respectively, dried in the sun on concrete floor terracing and bagged at 11% moisture in polyethylene bags. The grain was ground in a sieve (3 mm) for use in the dry form. The diet was composed of a source of roughage (40%) (whole plant corn silage processed) and concentrated ingredients (60%): 39% corn and/or sorghum dried and triturated and silage of high-moisture corn and sorghum grain, 41% of soybean meal, 19% of wheat bran and 1% of mineral core, as shown in Table 1.

Table 1. Composition of the diet offered to lambs.

Ingredients (%)	DS:MS	DC:MS	DC:MC	DS:MC
Whole plant corn silage	40	40	40	40
Soybean bran	41	41	41	41
Wheat bran	19	19	19	19
Silage of high-moisture sorghum grain	19.5	19.50	0	0
Silage of high-moisture corn grain	0	0	19.5	19.5
Dry Sorghum Grain	19.5	0	0	19.50
Dry Corn Grain	0	19.5	19.5	0
Mineral Supplement	1	1	1	1

DS: MS = Dry sorghum milled + silage of high-moisture sorghum grain; DC:MS = Dry corn milled + silage of high-moisture sorghum grain; DC:MC = Dry corn milled + silage of high-moisture corn grain; DS:MC = Dry sorghum milled + silage of high-moisture corn grain.

Experimental diets were formulated according to the NRC (2007), as seen in Table 2. The analyses of dry matter (DM), crude protein (CP), crude fiber (CF) and starch were performed according to the techniques described by AOAC (1995). Neutral detergent fiber (NDF) and acid (NDA) were determined as described by van Soest et al. (1991), adapted by Mertens (2002). Total digestible nutrient (TDN) values were calculated according to the equation proposed by Weiss, adopted by the NRC (2001).

Table 2. Average values of dry matter content (%) and nutritional composition (%) of diets.

Treatments[1]	DM	CP	NDF	NDA	CF	TDN	Starch
DS: MS	85.63	14.52	24.08	23.92	9.64	78	36.39
DC:MS	85.26	14.89	24.16	23.91	8.81	83	34.59
DC:MC	88.33	16.20	25.61	25.61	10.84	86	37.13
DS:MC	86.72	15.46	25.20	25.57	11.59	81	36.79

[1]DS: MS = Dry sorghum milled + silage of high-moisture sorghum grain; DC:MS = Dry corn milled + silage of high-moisture sorghum grain; DC:MC = Dry corn milled + silage of high-moisture corn grain; DS:MC = Dry sorghum milled + silage of high-moisture corn grain. [2]Dry Matter (DM); Crude Protein (CP); Neutral Detergent Fiber (NDF), Neutral Detergent Acid (NDA), Crude Fiber (CF); Total Digestible Nutrient (TDN).

TDN = 0.98 x (100 - FDFap - CP - Ashes - EE - 1) + 0.93 x CP + 2.25 x EE + 0.75 x (FDFap - lignin) x [1 - (lignin / FDFap) 0.667] – 7

where:

FDNap = Neutral detergent fiber corrected for ash and protein;

EE = Ethereal extract.

Parasitological monitoring of the animals was performed every 15 days using the Famacha method (MOLENTO et al., 2004). An anthelmintic drug (moxidectin 0.2% - 1 mL/10 kg; and nitroxynil 34% - 2 mL/50 kg) was administered to animals with a Famacha grade equal to or greater than 3.

To monitor changes in live weight and weight gain, the animals were weighed individually at the beginning of the experiment and every 15 days. Before each weighing, the animals were fasted for 12 hours.

The lambs were weighed at the end of the experiment (75 days) to obtain slaughter weight (SW) and slaughtered in a commercial slaughterhouse using a procedure of desensitization and subsequent bleeding by section of the jugular veins and carotid arteries (CEZAR; SOUZA, 2007) followed by evisceration of the lambs. The carcasses were hung from the tarsal-metatarsal joints on hooks with a 17 cm opening then weighed to record the hot carcass weight (HCW), cooled in a cold room at 5 ºC for 24 hours and again weighed to obtain the cold carcass weight (CCW). The time for lambs to be slaughtered and for carcass cooling was standardized, and the temperature of the cold room was strictly monitored. We determined the hot carcass yield HCY = (HCW/SW) x 100) and the cold or commercial CCY = (CCW/SW) x 100), and cooling losses CL = [(HCW - CCW)/HCW]x100.

The carcasses were subjectively evaluated for the degree of fat cover and evaluated by the harmonic distribution of the fat in the carcasses, one for very lean and five for very fat (CEZAR; SOUZA, 2007).

The use of the left half carcass was standardized for the evaluations. The half carcass was sectioned into seven anatomical regions or commercial cuts (COLOMER-ROCHER et al., 1988): 1-neck, 2-rib uncovered, 3-true rib, 4-ribeye, 5-legged, 6-low, and 7-trowel. The weights of all cuts were recorded, and then the percentages of each cut were calculated in relation to the left half carcass.

pH and temperature readings were performed at 0 and 24 hours *post mortem* in the *longissimus dorsi* muscle with the aid of a Digmed® model DM 20 portable potentiometer with a penetration electrode and a resolution of 0.01 pH units.

Measurements of the *longissimus lumborum* muscle included the width (or measurement A; cm), the depth (or measure B; cm), the loin eye area (LEA; cm²) and the minimum subcutaneous fat thickness (or measure C, SFT_{MIN}; mm), maximum (or measure J, SFT_{MAX}; mm) and average (SFT_{AVE}; mm). The width and depth were obtained with a ruler, tracing two straight lines on the LEA image, one measuring the maximum distance of the *longissimus lumborum i*n the mediolateral (width) direction and another one perpendicular to the anterior one, which measures the distance in the dorso-ventral direction (depth).

These measures were used in the LEA calculation, which followed the formula: LEA = (A/2 x B/2) x ω, where ω = 3,1416. SFT_{MIN} and SFT_{MAX} were determined with a caliper. SFT_{AVE} corresponded to the mean obtained from SFT_{MIN} and SFT_{MAX}, as described by Cezar and Souza (2007).

The data were compared using analysis of variance by the general linear model (GLM), and the means were compared by the Tukey test at a 5% significance level. Statistical analysis was performed using the statistical package SAEG (SISTEMAS PARA ANÁLISES ESTATÍSTICAS, versão 9.1).

Results and Discussion

Lambs fed with combinations of dry corn milled + silage of high-moisture sorghum grain (DC:MS) differed in slaughter weight (P<0.05) from lambs fed with dry corn milled + silage of high-moisture corn grain (DC:MC) (Table 3); however, these treatments did not differ (P>0.05) from those fed with dry sorghum milled + silage of high-moisture sorghum grain (DS: MS) or dry sorghum milled + silage of high-moisture corn grain (DS:MC).

Table 3. Average and mean standard error for carcass characteristics of lambs fed four combinations of maize and sorghum grain.

Variables [2]	Treatments [1]				*SEM	P
	DS:MS	DC:MS	DC:MC	DS:MC		
SW	26.18 ab	29.46 a	24.17 b	25.21 ab	1.88	0.0284
FCS (1-5)	2.76 ab	3.1 a	2.63 b	2.65 b	0.16	0.0312
HCW (kg)	11.68	13.77	11.31	11.38	0.97	0.0666
CCW (kg)	11.31	13.37	11.01	11.04	0.95	0.0621
HCY (%)	44.83	46.63	46.59	44.88	0.89	0.4317
CCY (%)	43.43	45.28	45.35	43.51	0.89	0.3844
CL (%)	3.13	2.92	2.69	3.07	0.21	0.3822

[1]DS: MS = Dry sorghum milled + silage of high-moisture sorghum grain; DC:MS = Dry corn milled + silage of high-moisture sorghum grain; DC:MC = Dry corn milled + silage of high-moisture corn grain; DS:MC = Dry sorghum milled + silage of high-moisture corn grain. [2] SW = Slaughter Weight, FCS= Fat Coverage Score, HCW = Hot Carcass Weight, CCW = Cold Carcass Weight, HCY= Hot Carcass Yield, CCY= Cold Carcass Yield, CL = Cooling Losses. Averages followed by lower case letters on the same line differ by Tukey test (P <0.05). *SEM = Mean Standard Error.

The body weight, age and the body score of the animals are factors directly linked to obtaining quality carcasses with a minimum weight value of 27 kg (BUENO et al., 2000; LEMES; ROLL, 2013). This value is close to the mean observed in this work, 26.25 kg; however, this requirement can vary according to the needs and demands of the consumer market. Such differences can be explained by the lower potential for weight gain of the Santa Inês breed, selected for meat that is characterized by a lower growth rate, being considered more rustic as verified by Barros et al. (1999); however, the weights reached by the animals in the other treatments (Table 3), were higher than those described in the literature for crossbred animals (22.2 kg on average) by Villarroel et al. (2006).

For the evaluation of carcass fat coverage score (FCS), there was a difference (P>0.05) only for the treatment consisting of dry corn milled + silage of high-moisture sorghum (DC:MS). Our evaluation resulted in classification three. Grain combinations resulted in lower average carcass fat content, 2.78 for SFT. This value is considered close to intermediate or medium finish. These results were associated with slaughter weight, but they serve the consumer market, which requires carcasses with low fat deposition. The increase in slaughter weight and increase in crude protein in the diet implies higher FCS due to the greater deposition of fat in the carcass. In this context, it is emphasized that the irregular finishing of the carcasses comes from the racial characteristics of the animals and slaughter weight, demonstrating that the grain combinations were satisfactory for the finishing of crossbred animals.

The cooling loss expresses the difference in weight after the cooling of the carcass, mainly due to the amount of cover fat and the loss of moisture. The cooling weight losses (CL) were on average 2.9% and were not influenced (P> 0.05) by grain combination (Table 3). The fat cover was not sufficient to avoid causing exudation losses in the cold chamber, although the fat cover values were within acceptable standards.

Although the highest carcass fat cover score was observed in carcasses of lambs finished with the combination of milled dry corn + silage of high-moisture sorghum grain (Table 3), this did not influence the reduction of cooling losses (P> 0.05), which averaged 3.02%. In research with lambs of F1 Santa Inês x without defined racial pattern (WDRP) and F1 Somalis Brasileiro x WDRP, values of 3.60 and 3.80% were verified for weight by cooling (OLIVEIRA et al., 2014). This value is among the maximum scores of 3 to 4% considered acceptable according to the Almeida Júnior et al. (2004). This is desirable from the productivity and qualitative perspective, as it indicates low weight loss by dripping during the cooling of the carcasses. According to McManus et al. (2013), the carcasses must have a good distribution of cover fat to avoid weight loss from the cold.

There were no differences (P> 0.05) in the weight and yield of hot and cold carcasses depending on the type of combination used (Table 3). The warm carcass weights averaged 12 kg and yields averaged 44.4%. Selaive-Villarroel and Sousa Júnior (2005) and Villarroel et al. (2006) observed the lack of significant differences between crossbred sheep. In general, the observed values for carcass yield are adequate, as they may represent 40-50% or more of live weight (PÉREZ; CARVALHO, 2007). In addition, factors related to the carcass itself such as weight and finish affect the yield (PÉREZ; CARVALHO, 2007).

Treatments with higher slaughter weights showed similar carcass yields. It is known that there is a high and significant correlation between live weight at slaughter and carcass yield. It is emphasized that confined animals receiving nutrient-rich foods, according to Papi et al. (2011), increases the carcass yield as well as other attributes of the carcass.

Cartaxo et al. (2017), working with fledged animals, did not observe an effect (P> 0.05) of the genotype on carcass weights and yields. Their lambs had average weights of hot and cold carcasses of 14.71 kg and 14.57 kg, respectively. The average yields of warm carcasses, cold and biological carcasses were 50.80%, 50.30% and 59.55%, in the same order. These carcass yields can be considered good and should be attributed to the average lamb slaughter weight of 30.35 kg.

The pH of the meat is an important parameter that influences the color, water retention capacity, shear force, weight loss by cooking, among other meat qualities, and is of fundamental importance to standards of acceptability (ASSIS et al., 2015). No significant difference (P> 0.05) was observed in the pH results (Table 4), indicating that carcass cooling standards were observed and the resulting values were found to be consistent with recommendations. The mean pH value (5.77) for the carcasses of the animals throughout the treatments is considered normal for ovine meat. This parameter is related to the increase in the concentration of hydrogen protons and the accumulation of lactic acid from postmortem glycolysis in the muscle (GOMIDE et al., 2013), which causes an accelerated decrease in muscle pH, making it more acidic. pH is one of the factors that interferes with the transformation of meat muscle, varying with the age and, mainly, the stress undergone by the animal before slaughter (LISBOA et al., 2010).

Table 4. Average and mean standard error (SEM) for carcass pH and temperature (T) of lambs fed four combinations of maize and sorghum grain.

Variables [2]	Treatments [1]				*SEM	P
	DS:MS	DC:MS	DC:MC	DS:MC		
pH 0	6.54	6.43	6.43	6.43	0.05	0.0974
pH 24	5.75	5.75	5.83	5.75	0.04	0.5272
T 0 ºC	28.18 a	28.46 a	28.07 a	27.53 b	0.20	0.0023
T 24 ºC	10.05	8.00	11.73	10.88	0.81	0.1122

[1] DS: MS = Dry sorghum milled + silage of high-moisture sorghum grain; DC:MS = Dry corn milled + silage of high-moisture sorghum grain; DC:MC = Dry corn milled + silage of high-moisture corn grain; DS:MC = Dry sorghum milled + silage of high-moisture corn grain. [2] T0 = Initial temperature; T24 = Temperature after 24 hours; pH 0 = initial pH; pH 24 = final pH Averages followed by lower case letters on the same line differ by Tukey test (P <0.05). *EPM = Mean Standard Error.

There was a difference (P <0.05) for initial temperature (T0). This lower result for the combination of dry sorghum milled + silage of high-moisture corn grain is attributed to the organization of the slaughter line, where the carcasses were favored using the initial temperature measurement.

Similar results among the combinations were related to the best conformed carcasses and possibly were also explained by the sorghum grain processing, which, when ensiled and/or comminuted, reach optimum digestibility compared to corn grain and yielded 93-96% of the nutritional value of corn (OWENS; ZINN, 2005).

Grain combination influenced (P <0.05) the yield of the palette and shank commercial cuts (Table 5). Lambs fed with dry corn milled + silage of high-moisture corn grain (DC:MC) and dry sorghum milled + silage of high-moisture sorghum grain (DS:MS) showed a higher paddle yield (19.45% on average). The combination of dry sorghum milled + silage of high-moisture corn grain (DS:MC) did not differ (P> 0.05) from the combinations of dry sorghum milled + silage of high-moisture sorghum grain (DS:MS) and dry corn milled + silage of high-moisture sorghum grain (DC:MS). Other commercial cuts were not influenced (P> 0.05) by the grain combinations studied.

Table 5. Average and mean standard error (SEM) for yield of commercial carcass cuts of lambs fed four combinations of maize and sorghum grain.

Yield (%)	Treatments [1]				*SEM	P
	DS:MS	DC:MS	DC:MC	DS:MC		
Palette	19.38 ab	18.97 c	19.52 a	19.03 bc	0.09	0.0049
Neck	9.83	9.65	9.45	9.02	0.33	0.3593
Rib Discovery	6.27	6.27	6.26	6.35	0.09	0.8988
True rib	10.53	10.71	10.54	10.92	0.17	0.3285
Low	11.88	11.42	11.21	11.61	0.28	0.4681
Loin	9.52	9.89	9.77	8.98	0.30	0.2764
Shank	32.58 b	33.10 ab	33.27 ab	34.07 a	0.21	0.0164

[1]DS: MS = Dry sorghum milled + silage of high-moisture sorghum grain; DC:MS = Dry corn milled + silage of high-moisture sorghum grain; DC:MC = Dry corn milled + silage of high-moisture corn grain; DS:MC = Dry sorghum milled + silage of high-moisture corn grain. Averages followed by lower case letters on the same line differ by Tukey test (P <0.05). *SEM = Mean Standard Error.

The differences observed between grain combinations in the diet for loin characteristics are mainly related to the slaughter weight of the animals. Similar values (P> 0.05) for loin width were observed for the combinations. Loin depth was an observed effect of combination (P <0.05) as shown in Table 6. The grain combinations used did not influence loin eye area (P> 0.05). Rosa et al. (2002) reported that the growth of muscle and fat in the loin is late, more deposition of these tissues occurring with an increase in carcass weight. In addition to carcass weight, some crosses may favor such a measure, as observed by Cartaxo et al. (2017), with carcasses of Dorper crossbred lambs showing higher (P <0.05) loin eye area when compared to carcasses of Santa Inês lambs. The carcasses of ¾ Dorper × ¼ Santa Inês lambs measured 14.02 cm^2, those of ½ Dorper × ½ Santa Inês lambs, 14,28 cm^2, higher than the 12.43 cm2 observed for Santa Inês carcasses. A similar result was observed by Costa et al. (2010), who observed greater loin eye area for Dorper × Santa Inês lambs compared with Santa Inês.

Table 6. Average and mean standard error (SEM) for lamb loin characteristics fed with four grain combinations.

characteristic[2]	Treatments [1]				*SEM	P
	DS:MS	DC:MS	DC:MC	DS:MC		
Width (cm)	4.63	5.18	4.76	4.81	0.19	0.1379
Depth (cm)	2.71 ab	2.81 a	2.47 b	2.57 ab	0.07	0.0165
SFT_{MIN} (mm)	2.47	2.65	2.00	1.82	0.20	0.0928
$SFT_{MÁX}$ (mm)	3.97 ab	4.40 a	3.21 b	2.99 b	0.23	0.0190
SFT_{AGE} (mm)	3.22 ab	3.52 a	2.60 ab	2.41 b	0.19	0.0227
LEA (cm^2)	9.85	11.51	9.46	9.87	0.59	0.0973

[1]DS: MS = Dry sorghum milled + silage of high-moisture sorghum grain; DC:MS = Dry corn milled + silage of high-moisture sorghum grain; DC:MC = Dry corn milled + silage of high-moisture corn grain; DS:MC = Dry sorghum milled + silage of high-moisture corn grain. [2] SFT_{MIN}= Minimum Subcutaneous Fat Thickness; $SFT_{MÁX}$= Maximum Subcutaneous Fat Thickness; SFT_{AGE}= Average Subcutaneous Fat Thickness
LEA = Loin Eye Area. Averages followed by lower case letters on the same line differ by Tukey test (P <0.05). *SEM = Mean Standard Error.

There was a difference ($P < 0.05$) for mean subcutaneous fat thickness (SFT_{AVE}). Dry corn milled + silage of high-moisture sorghum grain was higher (3.52 mm) than the dry sorghum milled + silage of high-moisture corn grain combination (2.41 mm), but remained between 2.4 and 3.5 mm (Table 6), indicating a good degree of finishing of the animals regardless of the combination of grain used in the diet. According to the classification of Silva Sobrinho (2001), the SFT_{AVE} should vary between 2 to 5 mm in young animals, which was observed in the present study. These values are above those obtained by Cunha et al. (2008), who recorded a mean of 1.1 mm of subcutaneous fat thickness in Santa Inês sheep finished in confinement with a mean of 32 kg at slaughter, this slaughter weight being higher than those of the present work and lower for SFT_{AVE}. For medium-weight carcasses of 12-15 kg of cold weight, small and inferior thicknesses were observed in this study, between 1-2 mm (PIRES et al., 2009; CARTAXO et al., 2009; BUENO et al., 2000; RODRIGUES et al., 2008).

Conclusions

Combinations of corn and sorghum grain, dried and ensiled, can be used to feed lambs in confinement for meat production without affecting the quality of the carcass.

Referências

ALMEIDA JÚNIOR, G. A.; COSTA, C.; MONTEIRO, A. L. G.; GARCIA, C. A.; MUNARI, D. P.; NERES, M. A. Desempenho, características de carcaça e resultado econômico de cordeiros criados em *creep feeding* com silagem de grãos úmidos de milho. *Revista Brasileira de Zootecnia*, v. 33, n. 4, p. 1048-1059, 2004. DOI: 10.1590/S1516-35982004000400025

ALVES, L. G. C.; OSÓRIO, J. C. S.; FERNANDES, A. R. M.; RICARDO, H. A.; CUNHA, C. M. Produção de carne ovina com foco no consumidor. *Enciclopédia Biosfera*, v. 10, n. 18, p. 2399-2415, 2014.

ASSIS, A. P. P.; LEITE, H. M. S.; MIRANDA, M. V. F. G.; LOPES, K. T. L.; PEREIRA, M. I. L. B.; MOURA, A. K. B.; SALGADO, R. L.; LIMA, P. O. Parâmetros físicos e químicos da carne de cabritos alimentados com diferentes dietas líquidas até os 60 dias. *Acta Veterinaria Brasilica*, Mossoró, v. 9, n. 4, p. 327-334, 2015.

ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS - AOAC. 15th ed. Association of Official Agricultural Chemists. Washington, DC. 1995.

BARROS, N. N.; FIGUEIREDO, E. A. P.; BARBIERE, M. Efeito do genótipo e da alimentação no desempenho de borregos de cruzamento industrial em confinamento. *Revista Científica de Produção Animal*, Brasília, v. 1, n. 1, p. 59-67, 1999. DOI: https: 10.15528/11

BUENO, M. S.; CUNHA, E. A.; SANTOS, L. E.; RODA, D. S.; LEINZ, F. F. Características de carcaça de cordeiros Suffolk abatidos em diferentes idades. *Revista Brasileira de Zootecnia,* v. 29, n. 6, p. 1803-1810, 2000. DOI: 10.1590/S1516-35982000000600029.

CARTAXO, F. Q.; CEZAR, M. F.; SOUZA, W. H.; GONZAGA NETO, S.; PEREIRA FILHO, J. M.; CUNHA, M. G. G. Características quantitativas da carcaça de cordeiros terminados em confinamento e abatidos em diferentes condições corporais. *Revista Brasileira de Zootecnia*, v. 38, n. 4, p. 697-704, 2009. DOI: 10.1590/S1516-35982009000400016.

CARTAXO, F. Q.; SOUSA, W. H.; CEZAR, M. F.; CUNHA, M. G. G.; MENEZES, L. M.; RAMOS, J. P. F.; GOMES, J. T.; VIANA, F. A. Desempenho e características de carcaça de cordeiros Santa Inês e suas cruzas com Dorper terminados em confinamento. *Revista Brasileira de Saúde e Produção Animal*, v. 18, v. 2, p. 388-401, 2017. DOI: 10.1590/s1519-99402017000200017.

CEZAR, M. F.; SOUZA, W. H. *Carcaças ovinas e caprinas:* obtenção, avaliação e classificação. Uberaba: Editora Agropecuária Tropical, 2007. 232 p.

COLOMER -ROCHER, F.; DELFA, R.; SIERRA, I. Métodos normalizados para el estudio do los caracteres cuantitativos de las canales ovinas producidas em el area mediterranea según los sistemas de producción. Ministerio de Agricultura, Pesca y Alimentación. In: COLOMER -ROCHER, F.; DELFA, R.; SIERRA, I. *Métodos normalizados para el estudio de los caracteres cuantitativos y cualitativos de las canales caprinas y ovinas*. Instituto Nacional de Investigaciones Agrarias, Madrid, España, 1988. p. 20-41. (Cuaderno INIA, n. 17).

COSTA, R. G.; ARAÚJO FILHO, J. T.; SOUSA, W. H.; GONZAGA NETO, S.; MADRUGA, M. S.; FRAGA, A. B. Effect of diet and genotype on carcass characteristics of feedlot hair sheep. *Revista Brasileira de Zootecnia*, v. 39, n. 12, p. 2763-2768. 2010. DOI: 10.1590/S1516-35982010001200029

CUNHA, M. G. G.; CARVALHO, F. F. R.; GONZAGA NETO, S.; CEZAR, M. F. Características quantitativas de carcaça de ovinos em Santa Inês confinados alimentados com rações contendo diferentes níveis de caroço de algodão integral. *Revista Brasileira de Zootecnia,* v. 37, n. 6, p. 1112-1120, 2008. DOI: 10.1590/S1516-35982008000600023.

FACTORI, M. A.; COSTA, C.; MEIRELLES, P. R. L.; OLIVEIRA, K.; ROSALES, L. A.; MORAES, G. J.; GOLÇALVES, H. C. Degradabilidade ruminal de híbridos de milho em função do estádio de colheita e processamento na ensilagem. *Boletim da Indústria Animal,* Nova Odessa, v. 65, n. 4, p. 259-273, out./dez., 2008.

GOMIDE, L. A. M.; RAMOS, E. M.; FONTES, P. R. A carne com alimento; propriedades da carne fresca. In: GOMIDE, L. A. M.; RAMOS, E. M.; FONTES, P. R. *Ciência e qualidade da carne*: fundamentos. Viçosa, MG: Editora UFV, 2013. p. 11-56.

JOBIM, C. C.; BRANCO, A. F.; GAI, V. F.; CALIXTO JUNIOR, M.; SANTOS, G. T. Qualidade da silagem de grãos de milho com adição de soja crua e parâmetros de digestibilidade parcial e total em bovinos. *Arquivos de Medicina Veterinária e Zootecnia*, v. 62, n. 1, p. 107-115, 2010. DOI: 10.1590/S0102-09352010000100015.

LAGE, J. F.; RODRIGUES, P. V.; PEREIRA, G. R.; VALADARES FILHO, S. C.; OLIVEIRA, A. S.; DETMANN, E.; SOUZA, N. K. P.; LIMA, J. C. M. Glicerina bruta na dieta de cordeiros terminados em confinamento. *Pesquisa Agropecuária Brasileira*, v. 45, n. 9, p. 1012-1020, 2010. DOI: 10.1590/S0100-204X2010000900011.

LEMES, J. S.; ROLL, V. F. B. *Avaliação da carcaça em animais de produção*. Pelotas: Ed. Carta. 2013. 147 p.

LISBOA, A. C. C.; FURTADO, D. A.; MEDEIROS, A. N.; COSTA, R. G.; QUEIROGA, R. C. R. E.; BARRETO, L. M. G.; PAULO, J. L. A. Avaliação da qualidade da carne de cabritos nativos terminados com dietas contendo feno de Maniçoba. *Revista Brasileira de Saúde e Produção Animal*, v. 11, n. 4, p. 1046-1055, 2010.

McMANUS, C.; PAIM, T. P.; LOUVANDINI, H.; DALLAGO, B. S. L.; DIAS, L. T.; TEIXEIRA, R. A. Avaliação ultrassonográfica da qualidade de carcaça de ovinos Santa Inês. *Ciência Animal Brasileira*, v. 14, n. 1, p. 08-16, 2013. DOI: 10.5216/cab.v14i1.12336

MERTENS, D. R. Gravimetric determination of amylase-treated neutral detergent fiber in feeds with refluxing in beakers or crucibles: collaborative study. *Journal of AOAC International*, v. 85, n. 6, p. 1217-1240. 2002.

MOLENTO, M. B; TASCA, C.; GALLO, A.; FERREIRA, M.; BONONI, R.; STECCA, E. Método Famacha como parâmetro clínico individual de infecção por *Haemonchus contortus* em pequenos ruminantes. *Ciência Rural*, Santa Maria, v. 34, n. 4, p. 1139-1145, 2004. DOI: 10.1590/S0103-84782004000400027.

NATIONAL RESEARCH COUNCIL - NRC. Nutrient requirements of dairy cattle. 7th ed. rev. Washington: National Academy Press, 2001.

NATIONAL RESEARCH COUNCIL - NRC. Nutrient requirements of small ruminants: sheep, goats, cervids and new world camelids. Washington: National Academy Press, 2007. 362 p.

OLIVEIRA, D. S.; ROGÉRIO, M. C. P.; BATISTA, A. S. M.; ALVES, A. A.; ALBUQUERQUE, F. H. M. A. R. de; POMPEU, R. C. F. F.; GUIMARAES, V. P.; DUARTE, T. F. Desempenho e características de carcaça de cordeiros SPRD cruzados com as raças Santa Inês e Somalis Brasileira terminados em confinamento. *Revista Brasileira de Saúde e Produção Animal*, v. 15, n. 4, p. 937-946, 2014. DOI: 10.1590/S1519-9940201400040002

OSÓRIO, J. C. S.; OSÓRIO, M. T. M.; FERREIRA, O. G.; VARGAS JUNIOR, F. M.; FERNANDES, A. R. M .; RICARDO, H. A.; ALVES, L. G. C.; ORRICO JÚNIOR, M. A. P. Avaliação da carcaça de caprinos e ovinos. *PUBVET*, Londrina, v. 6, n. 23, Ed. 209, Art. 1403, 2012.

OWENS, F. N.; ZINN, R. A. Corn grain for cattle: influence of processing on site and extent of digestion. In: ANNUAL SOUTHWEST NUTRITION CONFERENCE, 20., 2005. *Proccedings*... Phoenix: University of Arizona, 2005. p. 86-112.

PAPI, N.; MOSTAFA-TEHRANI, A.; AMANLOU, H.; MEMARIAN, M. Effects of dietary forage-to-concentrate ratios on performance and carcass characteristics of growing fat-tailed lambs. *Animal Feed Science and Technology*, v. 163, p. 93-98, 20114. DOI: 10.1016/j.anifeedsci.2010.10.010

PÉREZ, J. R. O.; CARVALHO, P. A. Considerações sobre carcaças ovinas. In: PÉREZ, J. R. O. (Org.). *Ovinocultura*: aspectos produtivos. Lavras: UFLA, 2007. p. 1-29

PIRES, C. C.; GALVANI, D. B.; CARVALHO, S.; CARDOSO, A. R.; GASPERIN, B. G. Características da carcaça de cordeiros alimentados com dietas contendo rações contendo farelo de babaçu. *Revista Brasileira de Zootecnia*, v. 38, n. 2, p. 392-398, 2009. DOI: 10.1590/S1516-35982009000200024.

PRADO-CALIXTO, O. P.; MIZUBUTI, I. Y.; RIBEIRO, E. L. A.; PEREIRA, E. S.; SILVA, R. T.; CORLETTO, L.; PEIXOTO, E. L. T., CARVALHO, L. N.; NIHEI, A. K.; MASSARO JÚNIOR, F. L.; SILVA, L. D. F.;

GALBEIRO, S. Comportamento ingestivo e parâmetros sanguíneos em ovinos que receberam dietas contendo aditivos à base de extratos de própolis em pó. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia*, v. 69, n. 2, p. 381-390, 2017. DOI: 10.1590/1678-4162-9065.

ROCHA, H. C.; BOTELHO VIEIRA, M. I.; STREINSTRASSER FONSECA, R.; OLIVEIRA DA COSTA, L.; CECCHETTI, D.; PASSOS NADAL, R. dos; SANTOS ROCHA, F. dos. Produção de carne e características da carcaça de cordeiros não castrados, castrados e induzidos ao criptorquidismo. *Semina: Ciências Agrárias*, v. 31, n. 31, p. 783-792, 2010. DOI: 10.5433/1679-0359.2010v31n3p783

RODRIGUES, G. H.; SUSIN, I.; PIRES, A. V.; MENDES, C. Q.; URANO, F. S.; CASTILLO, C. J. C.; Polpa cítrica em rações para cordeiros em confinamento: características da carcaça e qualidade da carne. *Revista Brasileira de Zootecnia*, v. 37, n. 10, p. 1869-1875, 2008. DOI: 10.1590/S1516-35982008001000022.

ROSA, G. T.; PIRES, C. C.; SILVA, J. H. S.; MÜLLER, L. Crescimento de osso, músculo e gordura dos cortes de carcaça de cordeiros e cordeiras em diferentes métodos de alimentação. *Revista Brasileira de Zootecnia,* v. 31, n. 6, p. 2283-2289, 2002. DOI: 10.1590/S1516-35982002000900017.

SELAIVE-VILLARROEL, A. B.; SOUSA JUNIOR, F. A. de. Crescimento e características de carcaça de cordeiros mestiços Santa Inês e Somalis x SRD em regime semi-intensivo de criação. *Revista Ciência e Agrotecnologia*, Lavras, v. 29, n. 5, p. 948-952, 2005. DOI: 10.1590/S1413-70542005000500005.

SILVA SOBRINHO, A. G. *Criação de ovinos*. Jaboticabal: Funep, 2001. 302 p.

SILVA SOBRINHO, A. G.; SAÑUDO, C.; OSÓRIO, J. C. S.; ARRIBAS, M. M. C.; OSÓRIO, M. T. M. *Produção de carne ovina.* Jaboticabal: FUNEP, 2008. 228 p.

SISTEMA PARA ANÁLISES ESTATÍSTICAS - SAEG. versão 9.1. Viçosa: UFV, 2007.

STEELE, M. A.; ALZAHAL, O.; HOOK, S. E.; CROOM, J.; MCBRIDE, B. W. Ruminal acidosis and the rapid onset of ruminal parakeratosis in a mature dairy cow: a case report. *Acta Veterinaria Scandinavica*, v. 59, n. 39, p. 1-6, 2009. DOI: 10.1186/1751-0147-51-39

VAN SOEST, P. J.; ROBERTSON, J. B.; LEWIS, B. A. Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. *Journal of Dairy Science*, v. 74. p. 3583-3597, 1991. DOI: 10.3168/jds.S0022-0302(91)78551-2

VILLARROEL, A. B. S.; LIMA, L. E. S.; OLIVEIRA, S. M. P.; FERNANDES, A. A. O. Ganho de peso e rendimento de carcaça de cordeiros mestiços Texel e Santa Inês × SRD em sistema de manejo semi-intensivo. *Ciência Agrotécnica*, v. 30, n. 5, p. 971-976, 2006. DOI: 10.1590/S1413-70542006000500022.