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Effects of soybean silage on feeding behavior, performance, and meat quality of lambs

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ABSTRACT

The objective of this study was to evaluate the performance, feeding behavior, carcass traits, and meat quality of feedlot lambs using 2 types of silage, sorghum or soybean. Twenty-eight male non-castrated market lambs weighting 20 ± 2 kg were used. Diets were formulated to be isonitrogenous and isocaloric. The animals were slaughtered after 50 days of experiment, with 32.13 ± 5.09 kg of body weight. Lambs fed with soybean silage showed increased time for feed intake ($P = 0.01$). There was no difference for allowed daily gain, dry matter intake, feed conversion, and carcass traits between diets. Meat from lambs fed with soybean silage showed decreased shear force ($P = 0.001$) compared to sorghum silage, with no differences ($P > 0.05$) for chemical composition, color, and cooking loss. The intake of sorghum silage increased ($P < 0.05$) C6:0, C16:0, C20:0, C14:1, and C16:1 fatty acids content of *Longissimus lumborum* intramuscular fat. The intake of soybean silage showed an increased ($P < 0.05$) content of C18:1ω9t, C18:2ω6c, and sum of ω6 fatty acids. The feed cost and profit from the use of sorghum and soybean silage were US$ 0.12 and US$ 0.13/Lamb/d, US$ 16.68 and US$ 16.97/Lamb, respectively. The use of soybean silage provides the same performance and carcass traits of lambs compared with sorghum silage, and it shows the benefit of decrease shear force and the proportion of hypercholesterolemic fatty acids C16:0 and C16:1.

1. Introduction

Sorghum (*Sorghum bicolor*, (L.) Moench) is a tropical crop widely used for silage production, with high dry matter (DM) production, low buffering capacity, and high content of water-soluble carbohydrates (Fribourg, 1995; Kempton et al., 1984; McDonald, 1981; Rooney et al., 2007). Campanili et al. (2017) found that the use of sorghum silage does not prejudice the feeding behavior and improves fiber digestibility and grain ruminal degradability. Cattani et al. (2017) highlight, in general, that sorghum silage does not present any impairment in animal performance, however, sorghum silage based diets should be supplemented with grains to compensate for the low starch content. In Brazil, sorghum silage is the third type of roughage most used in ruminant feedlot.

Soybean is commonly used as a grain crop worldwide, with a significant impact in many economies. However, in some countries, such as Canada and US, soybean first use was as forage crop, which shows an increased interest in livestock production systems. Soybean silage can supply the protein requirements of the animals, reduce the feed costs, improve the profitability, and benefit the soil fertility and structure when intercropping with others grains crops (Vargas-Bello-Pérez et al., 2008; Spanghero et al., 2015; Nkosi et al., 2016).

For the production of soybean silage, it is recommended that the crop be harvested between the growth stages R5 and R7. Under these conditions, silage generally presents the best combination of low fiber, high protein content, and digestible energy (Açiköz et al., 2013; Darmosarkoro et al., 2001; Fehr et al., 1971; Hintz and Albrecht, 1994; Lee et al., 2014; Munoz et al., 1983; Sheaffer et al., 2001; Zhai et al., 2008). In this study, the objective was to evaluate the feeding behavior, performance, carcass traits, and meat quality of feedlot lambs fed with soybean silage, compared to sorghum silage.

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2. Material and methods

2.1. Animals

All procedures carried out in the experiment followed the ARRIVE guidelines (Kilkenny et al., 2013) and EU Directive 2010/63/EU for animal experiments (European Union, 2010). The experiment was approved by the Ethics Committee on the Use of Animals (CEUA) of the School of Veterinary Medicine and Animal Science (FMVZ/UNESP), with the protocol n° 04/2014-CEUA.

The experiment was conducted at the Lageado Experimental Farm of FMVZ/UNESP, in Botucatu-SP (22°51′01"S 48°25′28"W, and altitude of 777 m). In the feedlot, there were 28 individual covered pens of 2.9 m^2 with ground floor, with *ad libitum* access to water and individual feed bunk.

Twenty-eight male market lambs, with mean BW (± SD) of 20 ± 2 kg and 60 days of age, were randomly allocated into 2 treatments (sorghum silage or soybean silage), with 14 repetitions. At the beginning of the experiment, the animals received prophylactic management against internal parasites (3 mL/animal of levamisole chloride).

2.2. Soybean silage and diets

For the production of soybean silage, the cultivar used was BMX Potência RR (Seeds Lazarotto, Entre Ijuís, Rio Grande do Sul, Brazil), from the semi-mature maturation group (6.6). Seeding was carried out at 3 cm depth, with a density of 400,000 seeds/ha and a spacing of 0.45 m. The plants were harvested at growth stage R7 (beginning of grain maturation and 50% yellowish leaves), at 10–15 cm height, with the material being chopped into 4 mm average particles. A portion of the harvested material was used in the preparation of the experimental silos for evaluations of the chemical composition of the silages; the remaining material was stored in 200 L capacity drums.

The experimental diets were isonitrogenous (Table 1) and were formulated based on nutritional requirements of growth for a lamb with 20 kg of BW (NRC, 2007). The adaptation to diet and facilities was realized during 14 days and the diet was individually offered on 2 schedules (0700 and 1600 h), with *ad libitum* access to water and individual feed bunk. Dry matter, crude protein (CP), and ether extract (EE) were determined according to AOAC (2007), while NDF and ADF determined according to Van Soest et al. (1991) adapted by Mertens et al. (2002). Total digestible nutrients (TDN) were estimated according to NRC (2007). Metabolizable protein (MP) and energy (ME) of the diets were calculated by Small Ruminant Nutrition System (Tedeschi et al., 2010).

Table 1
Ingredients and diets composition.

	Diet	
	Sorghum silage	Soybean silage
Ingredients, %		
Sorghum silage	24.96	0.00
Soybean silage	0.00	35.00
Grounded corn	63.70	26.91
Soybean meal	8.26	0.00
Wheat meal	0.00	34.84
Limestone	1.27	1.44
Mineral premix[a]	1.28	1.28
Ionophore[b]	0.03	0.03
Ammonium chloride	0.50	0.50
Composition		
Dry matter, %	62.71	54.40
Crude protein, % DM	11.89	19.33
Metabolizable protein, % DM	11.74	11.46
Ether extract, % DM	3.90	7.66
Neutral detergent fiber, % DM	22.32	32.12
Acid detergent fiber, % DM	10.50	13.96
Total digestive nutrients, % DM	79.90	77.50
Metabolizable energy, Mcal/kg DM	2.88	2.80

[a] Composition: 12.0% Ca, 0% P, 11.0% Mg, 21.0% S, 0.038% Se, 8.35% Zn, 2.63% Mn, 0.25% I, 0.25% Co.
[b] Rumensin®: 10 g of Sodic Monensin/100 g.

Table 2
Fatty acid composition of the diets (% of total FAME).

	Diet	
	Sorghum silage	Soybean silage
C4:0	0.21	3.16
C6:0	0.04	0.04
C8:0	0.01	0.01
C10:0	0.004	0.01
C11:0	0.00	0.002
C12:0	0.02	0.09
C14:0	0.12	0.16
C15:0	0.06	0.06
C16:0	15.37	14.93
C17:0	0.09	0.11
C18:0	2.15	3.04
C20:0	0.47	0.40
C21:0	0.009	0.01
C22:0	0.17	0.39
C23:0	0.14	0.22
C24:0	0.27	0.30
Σ SFA	19.12	22.92
C16:1	0.14	0.07
C17:1	0.03	0.03
C18:1ω7c	1.02	1.72
C18:1ω9c	30.68	19.78
C18:1ω9t	0.22	0.16
C20:1	0.21	0.57
C22:1ω9	0.005	0.003
C24:1	0.004	0.00
Σ MUFA	32.30	22.33
C18:2ω6c	46.09	49.33
C18:3ω3	1.93	4.78
C18:3ω6	0.008	0.003
C20:2	0.005	0.02
C20:3ω6	0.06	0.00
C20:4ω6	0.008	0.03
C20:5ω3	0.003	0.001
C22:5ω3	0.001	0.00
C22:6ω3	0.00	0.006
Σ PUFA	48.11	54.17
Σ ω6	48.10	54.15
Σ ω3	1.94	4.79
PUFA:SFA	2.52	2.36
ω6:ω3	24.86	11.31
NI	0.47	0.59

Σ SFA: sum of saturated fatty acid; Σ MUFA: sum of monounsaturated fatty acid; Σ PUFA: sum of polyunsaturated fatty acid; Σ ω6: sum of omega 6 fatty acid; Σ ω3: sum of omega 3 fatty acid; NI: fatty acids not identified.

The fatty acids profile from each diet is presented in Table 2, and was performed using the technique described by Rodríguez-Ruiz et al. (1998). Samples were put in test tubes with 1 mL of the methylation mixture (methanol/acetyl chloride, 20:1 v/v) and 0.5 mL hexane, and were heated at 100 °C for 10 min. After the formation of a single methanol/hexane phase, samples were cooled to room temperature, and 1 mL-distilled water was added. The hexanic phase was extracted and placed into the chromatograph vial for injection.

A GC Finnigan Focus model (Varian, Palo Alto, California), which was equipped with a flame (Sigma-Aldrich Corp., St. Louis, MO) ionization detector and a capillary column (CP-Sil 88, Varian) that was 100 m long with a 0.25 μm internal diameter and 0.20 μm film thickness was used. Hydrogen was used as the carrier gas at a flow rate of 1.8 mL/min. The initial oven temperature program was 70 °C, and a wait time of 4 min was used. The temperature was then raised to 175 °C (at 13 °C/min), with a wait time of 27 min, followed by another