



Soybean silage in the diet for beef cattle

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ABSTRACT. This experiment evaluated the effect of molasses with or without microbial additive on soybean silage regarding the intake, digestibility and growth performance of beef cattle. The experimental design used was randomized blocks with four treatments (diets with soybean silage (SS), SS with microbial inoculant, SS with molasses and SS with microbial inoculant and molasses) and seven replications. Animals were feedlot fed for 99 days. Diets contained forage: concentrate ratio of 70:30, the forage consisted of 40% soybean silage and 30% corn silage. There was lower intake of nutrients in the diet containing SS in relation to the SS diet added with inoculant and molasses. The diet containing SS with inoculant and molasses presented higher apparent digestibility for DM, CP, NDF, ADF, and NFC. Feed conversion, average daily gain and carcass gain were not influenced by the diets, with mean values of 5.90; 1.49 and 0.91 kg day⁻¹ respectively. The addition of molasses combined or not with bacterial inoculant to soybean at the time of ensiling has no effect on the performance of beef cattle, although favoring the intake and digestibility of nutrients.

Keywords: digestibility, feedlot, intake, microbial inoculant, molasses.

Silagem de soja na dieta de bovino de corte

RESUMO. Objetivou-se avaliar o efeito de melaço e ou aditivo microbiano na ensilagem de soja sobre o consumo, digestibilidade dos nutrientes e desempenho produtivo de bovinos de corte. O delineamento experimental utilizado foi o em blocos casualizados com quatro tratamentos (dietas com silagem de soja (SS), SS com inoculante microbiano, SS com melaço e SS com inoculante microbiano e melaço) e sete repetições. Os animais foram confinados por um período de 99 dias. As dietas continham relação volumoso:concentrado de 70:30, sendo o volumoso 40% de silagem de soja e 30% de silagem de milho. Observou-se menor consumo de nutrientes na dieta contendo SS em relação à dieta SS com inoculante e melaço. Na dieta contendo SS com inoculante e melaço, foram observadas maiores digestibilidades aparentes para MS, PB, FDN, FDA e CNF. A conversão alimentar, o ganho médio diário e o ganho de carcaça não foram influenciados pelas dietas, registrando-se valores médios de 5,90; 1,49 e 0,91 kg dia⁻¹, respectivamente. Conclui-se, que a adição de melaço na presença ou não de inoculante bacteriano à soja por ocasião da ensilagem, não afeta o desempenho de bovinos de corte, embora favoreça o consumo e a digestibilidade de nutrientes.

Palavras-chave: digestibilidade, consumo, confinamento, aditivo microbiano, melaço.

Introduction

Brazil became the largest exporter of soybeans in the world, surpassing the US according to estimates of FAPRI (2014). Grain is the main form of marketing soybeans, but there is wide variation in price, since it is a commodity. Thus, it is important to search for new ways to use the plant when the price of grain is not economically viable. There has been a growing interest in adopting soybean silage for animal feeding in several countries such as United States (Seiter et al., 2004), United Kingdom (Koivisto et al., 2003), Costa Rica (Tobía & Villalobos, 2004), Vietnam (Chinh & Tao, 1993) and

also Brazil (Gobetti et al., 2011). In this way, the use of soybean silage represents an alternative for increasing the protein content of the diet, providing greater amounts of calcium and phosphorus, thereby reducing production costs through reduced need for supplementation with protein concentrate (Marchezan et al., 2002). Nevertheless, there are factors that hinder the conservation of soybeans as silage, as the low concentration of dry matter and high content of protein, oil and mineral matter at the time of harvest, which characterize it as difficult ensiling forage because of its high buffering capacity. The use of additives such as molasses and microbial

inoculants are an option for improving fermentation profile and reducing losses during the fermentation process (Lima et al., 2013; Yokota et al., 1992). However, the effect of additives on animal performance has not been evidenced (Zopollatto et al., 2009). In this context, this study aimed to evaluate the intake, digestibility and growth performance of beef cattle fed diets containing soybean silage with and without additives.

Material and methods

The study was conducted at the Center for Experimentation, Research and Extension of the Triângulo Mineiro (CEPET), Federal University of Viçosa (UFV). CEPET is located in the municipality of Capinópolis, with average altitude of 620.2 m, 18,41° South latitude and 49,34° West longitude. According to the Koppen classification, the climate is Aw, hot and humid, with temperature in the coldest month above 18°C, annual rainfall between 1,400 and 1,600 mm, rainy summer and dry winter. Soybean DM 339 (Pioneer) was planted in January, in an area of approximately 6 ha, using a SHM M13 seeder (Semeato). The crop was harvested when the plants reached the R6 stage, as recommended by (Coffey et al., 1995) using a JF-92 Z10 forage harvester. Before ensiling, the chopped material was subjected to the following treatments: 1 - exclusive soybean silage (SS) (control); 2- soybean silage with microbial inoculant (SSI); 3- soybean silage with microbial inoculant and molasses (SSIM) and 4 - soybean silage with molasses (SSM). We used 2.5% powdered molasses on a dry matter basis for the treatments 3 and 4. The inoculant (SIL-ALL C4, Alltech Brazil) was applied with the aid of a backpack sprayer of 20 liters upon ensiling. This microbial inoculant contains the following assurance levels: *Streptococcus faecium* (*Enterococcus faecium*), *Lactobacillus plantarum* e *Lactobacillus salivares* (10 billion CFU g⁻¹), hemicellulase and cellulase at 5%. Four surface silos were manufactured with a capacity of about 25 tons each. Planting of corn (AG 1051) was conducted in an area of 3 ha following the recommendations of the seed producer, using a SHM M13 seeder (Semeato). Corn was harvested and ensiled when grains reached the hard-dough stage. The treatments were isonitrogenous diets with 13.0% crude protein and forage: concentrate ratio of 70:30, the forage consisted of 40% soybean silage and 30% corn silage, on a DM basis. The proportion of the ingredients of the concentrate is shown in Table 1.

In this study, 32 crossbred (H x Z) animals, non-neutered, with an average initial weight of 360 kg were weighed and dewormed and distributed in individual pens of approximately 10 m² with covered trough and drinking fountain, in a randomized block design with four treatments and seven animals per treatment.

Table 1. Ingredients used in the concentrate, percentage of natural matter.

Ingredients	(%)
Ground corn	98.97
Dicalcium phosphate	0.32
Limestone	0.03
Common salt	0.65
Micronutrients ¹	0.03

¹(zinc sulfate: 50%; copper sulfate: 42.86%; cobalt sulfate: 2.86%; sodium selenite: 2.86% and potassium iodate 2.86%).

After an adaptation period of 15 days, three experimental periods of 28 days each were performed, totaling 99 experimental days. The animals were weighed after fasting for 16h, at the beginning and end of the experiment, and periodically every 28 days, without prior fasting, at the end of each experimental period. Food was given daily at 7h00 am and 15h00 pm, allowing leftovers up to 10% of the supplied.

During the experiment, we collected on a daily basis samples of food provided and leftovers to comprise a composite sample for each period, which were placed in labeled plastic bags and stored in a freezer. From the day 39 to the 45, fecal samples were taken directly from the floor, at different times during the day, to estimate fecal output, using the indigestible acid detergent fiber (ADFi) as an indicator. Also in this period, we collected samples of food and leftovers. At the end of the experimental period, all samples were subjected to preliminary drying at 55°C for 72 hours, ground in a Wiley knife mill with 1mm mesh and stored in a glass container with polyethylene cap, for subsequent laboratory analysis.

Samples of feces, food and leftovers, relative to digestibility estimation, were incubated in non-woven bags (TNT), in situ, for a period of 240 hours. Material from incubation was subjected to digestion in acid detergent, and the residue was considered ADFi. With the completion of the experimental period, animals were slaughtered (Frigorífico Bertim), and we evaluated carcass yield (CY) expressed by dividing hot carcass weight by the respective final body weight (FBW) of each animal subjected to fasting for 16 hours. For the calculation of carcass gain, four reference animals were slaughtered after the period of adaptation to experimental diets. The relationship between carcass

weight and body weight of the reference animal was used to estimate initial carcass weight for the other animals. At the end of the experiment, all samples were transported to the Laboratory of Forage, Department of Animal Science, UFV, Viçosa. Analyses of dry matter (DM), ether extract (EE), nitrogen compounds (N), organic matter (OM) and lignin were performed according to procedures of AOAC (1998); the crude protein (CP) was obtained by multiplying the total nitrogen content by the factor 6.25. Total nutrients digestibility (TND) of the diets was calculated following the equation proposed by NRC (2000): $TND = CPD + 2.25 \times EED + NDFD + NFCD$, where: CPD, EED, NDFD and NFCD mean respectively, digestible crude protein, digestible ether extract, digestible neutral detergent fiber and digestible non-fiber carbohydrates. For the calculation of non-fiber carbohydrates (NFC), we used the equation suggested by Weiss (1993). Data were subjected to analysis of variance, comparing the means by Tukey test at 5% probability using the software SAS (2004).

Results and discussion

The mean pH of 4.58 observed for soybean silage is considered high, compared to the value of 3.91 recorded for corn silage (Table 2).

Table 2. Chemical composition of silages and the concentrate used in the experimental diets.

Item	Silages					Concentrate
	SS ³	SSI ⁴	SSIM ⁵	SSM ⁶	SM ⁷	
Dry matter (%)	25.61	24.84	28.14	27.11	30.76	88.01
Crude protein ¹	20.10	19.83	19.90	19.36	7.93	8.90
Ether extract ¹	9.00	8.94	8.70	9.81	3.29	4.65
Neutral detergent fiber ¹	52.52	52.65	52.23	52.13	54.42	11.67
Acido detergent fiber ¹	36.17	35.97	36.48	35.77	29.99	4.00
Non-fiber carbohydrates ¹	10.04	10.82	10.31	9.55	29.55	71.23
Lignin ¹	9.03	10.01	8.35	8.70	4.01	1.09
pH	4.69	4.66	4.55	4.43	3.91	-
Ammonia nitrogen	21.64	15.75	12.58	12.38	4.57	-

¹Percentage in the DM; ² Percentage in the CP; ³ Soybean silage (control); ⁴ Soybean silage with inoculant; ⁵ Soybean silage with inoculant and molasses; ⁶ Soybean silage with molasses; ⁷ Corn silage.

It is known that the pH of legume silages stabilizes at a higher value, as observed by Touno et al. (2014), who evaluated the quality of soybean silage and verified a mean value of 4.78. This can be attributed to the high buffering capacity of soybean, which is promoted by residual amino acids and the presence of cations, such as K⁺, Ca²⁺ and Mg²⁺, which neutralize the organic acids formed by fermentation, preventing a decrease in pH. Another likely explanation is the high CP content of soybean, which through the release of nitrogenous compounds by protein breakdown, neutralizes part

of the lactic acid formed. The high concentration of ammonia nitrogen in soybean silage may result from the high pH, since the proteolytic microorganisms develop at higher pH ranges (McDonald, 1981).

The probable reason for the lower values of pH and ammonia nitrogen (N-NH₃) in silages containing molasses with or without a microbial inoculant is the supply of soluble sugars, which stimulates lactic fermentation, supporting a higher growth of lactic acid bacteria. The chemical composition of the experimental diets was similar, i.e. they have the same proportion of ingredients, varying only soybean silage with or without molasses and inoculant (Table 3).

Table 3. Chemical composition of the experimental diets.

Item	Diets			
	SS ²	SSI ³	SSIM ⁴	SSM ⁵
DM ¹	45.87	45.57	46.89	46.48
CP ¹	13.09	12.98	13.01	12.79
EE ¹	5.98	5.96	5.86	6.30
NDF ¹	40.83	40.89	40.72	40.68
ADF ¹	24.67	24.58	24.79	24.51
NFC ¹	34.25	34.56	34.35	34.05
ADFi ¹	11.14	11.62	8.99	11.50
LIG ¹	5.14	5.53	4.87	5.01

¹(%) in the DM; ²Soybean silage (control); ³ Soybean silage with inoculant; ⁴ Soybean silage with inoculant and molasses; ⁵ Soybean silage with molasses. Values followed by different letters in the row are significantly different by Tukey's test (5%).

The increased intake of nutrients found in diets containing soybean silage with inoculant and molasses is probably due to better fermentation of this silage in relation to others, thus resulting in greater acceptability, especially in relation to the control treatment, which showed strong odor of acetic acid and ammonia, characteristics of undesirable fermentation (Table 4).

Table 4. Mean values of nutrient intake of different diets and respective coefficients of variation (CV).

Item	Silages				CV (%)
	SS ¹	SSI ²	SSIM ³	SSM ⁴	
	Intake (kg day ⁻¹)				
Dry matter	7.60b	8.46ab	9.55a	9.05ab	12.29
Crude protein	0.80b	1.05a	1.24a	1.14a	12.78
Ether extract	0.42b	0.50ab	0.56a	0.56a	12.80
Neutral detergent fiber	3.03b	3.36ab	3.86a	3.65ab	12.65
Non-fiber carbohydrates	2.74b	3.09ab	3.33a	3.17ab	11.70
Total digestible nutrient	4.72b	5.29b	6.60a	5.77b	11.45
	Intake (% Body weight)				
Dry matter	1.83b	2.00ab	2.16a	2.10ab	9.54
Neutral detergent fiber	0.73b	0.79ab	0.87a	0.85ab	9.98

¹Soybean silage (control); ²Soybean silage with inoculant; ³Soybean silage with inoculant and molasses; ⁴ Soybean silage with molasses. Values followed by different letters in the row are significantly different by Tukey's test (5%).

The intake of DM and NDF (% BW) were higher in the treatment containing soybean silage with inoculant and molasses compared to control diet. Values ranging from 1.83 to 2.16 kg are close to that observed for by Azevêdo et al. (2010) in a meta-

analysis to determine the equation to estimate dry matter intake in feedlot animals. These authors observed mean intake (% BW) of 2.16 kg for daily weight gain of 1.20 kg. These values demonstrate the quality of the diet formulated with soybean silage, not compromising the performance or consumption of animals. Considering that the requirement of beef cattle weighing 350 kg and gain of 1.0 kg day⁻¹ is 0.849 kg CP and 4.93 kg TND (NRC, 2000) except the diet containing exclusively soybean silage, which met 95% of the CP requirement, it can be stated that the other diets met the requirements of energy and protein of the animals.

There was a higher total apparent digestibility of DM, CP, NDF and NFC in the diet containing soybean silage with inoculant and molasses (SSIM) compared with other diets evaluated (Table 5).

Table 5. Mean values of total apparent digestibility of nutrients of the different diets and respective coefficients of variation (CV).

Item	Silages				CV (%)
	SS ¹	SSF ²	SSIM ³	SSM ⁴	
Dry matter	59.10b	60.24b	67.02a	58.40b	4.43
Crude protein	56.26b	55.76b	65.00a	55.37b	5.77
Ether extract	74.07a	70.91a	70.39a	73.39a	7.78
Neutral detergent fiber	49.74b	49.66b	59.85a	51.15b	5.10
Non-fiber carbohydrates	71.66bc	74.90ab	78.60a	68.42c	5.66

¹Soybean silage (control); ²Soybean silage with inoculant; ³Soybean silage with inoculant and molasses; ⁴ Soybean silage with molasses. Values followed by different letters in the row are significantly different by Tukey's test (5%).

The higher digestibility of the diet containing soybean silage with inoculant and molasses is possibly related to the better fermentation of silage, which can be proven by the best values of pH and ammonia nitrogen. The best fermentation of this silage possibly decreased the losses of the cellular content, which has a higher digestibility compared to cell wall constituents. Rice et al. (1990) argued that the improvement in digestibility of inoculated silages is due to the better fermentation and by reducing dry matter losses. Yokota et al. (1992) evaluated the effect of adding powdered molasses to elephant grass silage and found no difference in the digestibility of nutrients, but observed that the soluble carbohydrate content of the silage with molasses was higher than the control treatment, demonstrating that silage with molasses provides higher energy to animals.

The higher digestibility of the diet with molasses and inoculant positively affected the intake of dry matter and nutrients, justified by a higher rate of passage, thus causing lower ruminal fill in the animals.

Despite the differences in intake and digestibility of nutrients, this was not reflected in the growth performance of the animals, since the average daily gain, carcass yield and feed conversion were similar, regardless of diet (Table 6).

Table 6. Mean values of growth performance of beef cattle for different experimental diets.

Item	Silages				CV (%)
	SS ¹	SSF ²	SSIM ³	SSM ⁴	
Average daily gain (kg)	1.32	1.45	1.68	1.50	17.83
Carcass gain (kg)	0.84	0.87	0.99	0.96	15.70
Carcass yield (%)	54.41	53.62	53.59	54.69	2.54
Feed conversion	5.86	5.99	5.71	6.03	10.18

¹Soybean silage (control); ²Soybean silage with inoculant; ³Soybean silage with inoculant and molasses; ⁴ Soybean silage with molasses.

The weight gain varied from 1.32 (exclusive soybean silage) to 1.68 kg day⁻¹ (soybean silage with inoculant and molasses) and considered high for the type of animal. Zago et al. (1985) and Obeid et al. (1992) observed weight gains ranging from 560 to 680 g day⁻¹ for zebu steers receiving silage of soybean intercropped with corn, and from 248 to 265 g day⁻¹ for those fed only corn silage. The authors attributed the difference in gain to the highest protein content of the silage of soybean intercropped with corn in relation to the exclusive corn silage. Evangelista et al. (1991) examined the weight gain of steers fed diets containing soybean silage and registered that silage from corn-soybean intercropping (435 g animal day⁻¹) increased the weight gain of steers in 239 g animal day⁻¹ in relation to the exclusive corn silage (196 g animal day⁻¹). Lima et al. (2013) evaluated the replacement of concentrate with soybean silage in diets with sugarcane silage for lambs and reported no differences in daily weight gain and feed conversion, with average values of 7.9 and 6.2 kg animal day⁻¹, respectively. Moreover, Souza et al. (2014) studied the performance of beef cattle on diets with increasing levels of *Stylosanthes* cv. Campo Grande and also found no difference between treatments, with average weight gain of 1.25 kg day⁻¹.

The diets evaluated promoted similarity between the carcass gain, carcass yield and feed conversion. The average feed conversion was 5.89 between diets evaluated. Resende et al. (2001) assessed weight gain (AWG) and feed conversion (FC) of crossbred steers fed Tanzania grass hay and different levels of concentrate and observed AWG of 1.26 kg day⁻¹ and FC of 7.54 kg DM per kg weight gain in the 30:70 forage: concentrate ratio. The highest values of FC found in the literature confirm the high quality of diets containing soybean silage for feedlot beef cattle.

Conclusion

The addition of molasses combined or not with bacterial inoculant to soybeans during the ensiling process does not affect the performance of beef cattle, although favoring the intake and digestibility of nutrients.

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