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EFFECTS OF INCREASING LEVELS OF SOYBEAN MOLASSES AS REPLACEMENT OF GROUND CORN IN SUGARCANE BAGASSE-BASED DIETS ON *IN VITRO* GAS PRODUCTION

Arianny dos Santos FIDELIS*, Franciele Caetano SAMPAIO, Matheus TOBALDINI, Juliana Maria de SOUZA, Vinícius Augusto MACHADO, Letícia Carolina Bortolanza SOARES, Dalton Henrique PEREIRA, Erick Darlisson BATISTA

*autor para correspondência: ariannydsfidelis@gmail.com
Universidade Federal de Mato Grosso, Mato Grosso, Sinop, Brasil

Abstract: Effects of graded levels of soybean molasses (SM) as replacement of ground corn in feedlot sugarcane bagasse-based diets were evaluated on *in vitro* gas production and digestibility. Four levels of SM (0, 50, 100, and 150 g kg^{-1} DM) were evaluated by replacement of ground corn. Gas production (GP) kinetics were evaluated during 24 h. At the end, incubation was stopped and the pH of the fluid was determined and filtrate used to determine *in vitro* dry matter (IVDMD) and organic matter digestibility (IVOMD). As dietary SM increased, GP tended linearly increased from 0 to 4 hours (P=0.09) and 20 to 24 hours (P=0.08). There was no SM effect ($P \geq 0.14$) on total GP, averaging 204 mL g^{-1} DM. There was a positive linear effect (P<0.001) of the levels of dietary SM on gas volume originated from the fraction of fast degrading pool of carbohydrates. In addition, lag time linearly decreased (P<0.01) and fraction rate of fast degrading pool tended (P=0.08) to linearly decrease as SM increased. The pH, IVDMD, and IVOMD did not differ among treatments. The IVDMD and IVOMD averaged 578 g kg^{-1} DM and 613 g kg^{-1} OM, respectively. The graded levels of SM replacing ground corn in feedlot sugarcane bagasse-based diets did not promoted effects on total GP and *in vitro* digestibility when replaced by ground corn.

Keywords: feedlot, *in vitro* digestibility, kinetic parameters, metabolizable energy, ruminant

Introduction

Mato Grosso State is in the lead position regarding to the possibilities of production and use of alternative foods in animal feed, especially the by-products from human food industry and biodiesel industry. In this scenario, soybean molasses can be inserted, a co-product of the soybean processing to obtain the oil and meal. Soybean molasses is a viscous liquid of brown color and bittersweet flavor, free of alcohol, formed mainly by sugars of glucose, fructose, sucrose, raffinose, and stachyose (Chajuss, 2004). This by-product have a high generation and low comercial cost. Its incorrect disposal can cause several enviromental problems, and its use to ruminant feeding can minimize this problem. Thus, to minimize these problems, alternatives have been proposed for the use of soybean molasses in ruminant feeding, as it also has an economic advantage. However, there was no experimental evaluation on its effects on ruminal fermentation.

Therefore, our objective was to determine the effects of increasing levels of soybean molasses as replacement of ground corn in feedlot sugarcane bagasse-based diets on *in vitro* gas production and kinetic parameters.

Material and Methods

All procedures involving animals were approved by the Animal Care and Use Committee of the Universidade Federal de Mato Grosso. Feed ingredients consisting of sugarcane bagasse, ground corn, cottonseed cake, urea and mineral-vitamin supplement were used to mix four substrates for *in vitro* fermentation studies. All substrates contained similar crude protein (CP) content (136 g CP kg^{-1} of dietary dry matter, DM) and were formulated to supply the requirements of Nellore steers in feedlot according to the Brazilian Nutrient Requirements for Zebu Beef Cattle system (Valadares Filho et al., 2010), based on a Nellore bull with 500 kg BW and daily gain of 1.2 kg day^{-1}, and a roughage:concentrate ratio of 150:850 (Table 1).The following treatments were evaluated: control – no soybean molasses (SM0) inclusion in the diet; SM50 – 50 g SM kg^{-1} DM; SM100 – 100 g SM kg^{-1} DM; SM150 – 150 g SM kg^{-1} DM. The SM inclusion concentrations are described on a DM basis. The averaged composition of the diets were: 151 g/kg of cottonseed cake; 150 g/kg sugarcane bagasse; 150 g/kg soy hulls; 20 g/kg mineral-vitamin and 12 g/kg urea. The ground corn (519, 469, 419, and 369 g kg^{-1}) was replaced by soybean molasses (0, 50, 100 and 150 g kg^{-1}) in the diets, respectively to SM0, SM50, SM100 and SM150.

All experimental procedures involving animal feeding, ruminal fluid collection, and *in vitro* evaluation were described by Soares et al. (2018). The incubation period was chosen because in a preliminary study with the based substrates 85.6 ± 1.41% of gas production (GP) occurred in a 24-h incubation period. The experimental design was as follows: 4 incubation runs × 4 treatments × 2 replications (1 from each animal) plus 2 blank bottles per run (bottles containing only the rumen fluid and the buffer solution), for a total of 40 bottles.

Gas production data were fitted according to the bicompartmental model proposed by Schofield et al. (1994) using PROC NLIN of SAS, to provide parameters describing the gas volume originated from the fraction of fast and slow degrading pool (V_{1f} and V_{2f}, respectively); fraction rate of fast and slow degrading pool (h^{-1}; *k*1 and *k*2, respectively); and lag time (h^{-1}). It was used the interactive process of Marquadt algorithm for adjustments. Statistical analyses were performed as described by Soares et al. (2018).

Results and Discussion

As dietary SM increased, GP tended linearly increased from 0 to 4 hours (P=0.09) and 20 to 24 hours (P=0.08). There were not SM effect ($P \geq 0.14$) on GP from 4 until 20 hours, as well as total GP. In average, total GP was 204 mL g^{-1} DM.

Regarding the GP parameters, there was a positive linear effect (P<0.001) of the levels of dietary SM on V_{1f}, GP originated from the fraction of fast degrading pool of carbohydrates. In addition, lag time linearly decreased (P<0.01) and fraction rate of fast degrading pool (K_{1f}) tended (P=0.08) to linearly decrease as SM increased. The positive linear effect of the levels of dietary SM on GP from 0-4 hours and V_{1f} can be justified by the greater concentration of sugars rapidly fermentable in the SM as well as sugarcane bagasse (164 g kg^{-1} sugars; Pereira et al., 2009), such as sucrose, fructose, and glucose. These disappearance rates of sugar in the rumen can range from 0.19 to 0.69 h^{-1} (Henning et al., 1991).

The volume (V_{1f}) and fraction rate of slow degrading pool (K_{1f}) were not affected ($P \geq 0.12$) by SM levels. The pH, in vitro dry matter digestibility (DMD), and in vitro organic matter digestibility (OMD) did not differ among treatments. The DMD and OMD averaged 578 g kg^{-1} DM and 613 g kg^{-1} OM, respectively. The metabolizable energy (ME; MJ kg^{-1} DM) of a diet may be estimated considering the total GP and CP content, which are positively related with the EM of the diet (Menke et al., 1979). In this sense, as the diets evaluated in this study presented similar CP content and total GP, we can infer that diets with SM levels presented similar EM. Thus, it seems that SM can replace ground corn up to 150 g kg^{-1} without affect ruminal fermentation and ME in feedlot sugarcane bagasse-based diets.

Conclusion

Partial dry ground corn replacement by soybean molasses as an energy source in sugarcane based-diet for feedlot cattle exerted no changes on gas production and *in vitro* digestibility. The increasing amounts of SM linearly reduce the latency and increases accumulated gas production on initial times.

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Table 1 – Effects of graded levels of soybean molasses as replacement of ground corn in sugarcane bagasse-based diets on *in vitro* gas production.

	Soybean molasses level (g kg^{-1} DM)					P-value	
Item	0	50	100	150	SEM	Linear	Quadratic
Gas production (mL g^{-1} DM)							
0-4 h	34.7	37.3	41.9	41.0	3.80	0.092	0.544
4-8 h	37.7	39.0	41.3	44.8	5.50	0.141	0.748
8-12 h	41.1	37.5	34.0	38.6	3.67	0.415	0.170
12-16 h	36.7	32.4	27.7	32.6	3.38	0.209	0.122
16-20 h	28.8	28.5	25.2	26.3	1.96	0.142	0.662
20-24 h	20.4	20.0	17.7	18.0	1.53	0.081	0.742
Total	201.2	205.1	198.1	210.9	13.00	0.510	0.539
pH	6.88	6.94	6.91	6.86	0.078	0.568	0.077
Gas production parameters							
V_{1f} (mL g^{-1} DM)	24.6	30.8	40.2	51.2	9.27	<0.001	0.577
K_{1f} (h^{-1})	0.34	0.35	0.31	0.25	0.485	0.073	0.404
Lag (h^{-1})	3.34	2.85	2.52	2.47	0.288	0.005	0.318
V_{2f} (mL g^{-1} DM)	188.7	178.3	162.4	184.0	13.26	0.582	0.195
K_{2f} (mL g^{-1} DM)	0.059	0.058	0.058	0.054	0.005	0.119	0.425
pH	6.90	6.83	6.85	6.91	0.091	0.808	0.155
DMD (g kg^{-1} DM)	587	570	569	586	55.6	0.982	0.553
OMD (g kg^{-1} OM)	607	604	623	618	33.6	0.517	0.961

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