

## SOYBEAN MOLASSES: AN ALTERNATIVE TO SHEEP'S SUPPLEMENTATION

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### Abstract

The objective was to evaluate soybean molasses as supplement for sheep at crescent levels. Five-crossbred ½ Dorper - Santa Inês ewes with initial body mass of  $45 \pm 3.5$  kg and  $12 \pm 2$  months of age were used. Treatments consisted of 0, 3, 6, 9 and 12% of soybean molasses inclusion to a basal corn silage diet, which fed exclusively supports the nutritional requirements of ewes at maintenance. The treatments were assigned into 5×5 latin square design. Five experimental periods, of 12 days each (1st to 5th day: diet adaptation period; 6th to 12th: data collection and sampling), was adopted. The statistical analysis performed were regression analysis with 5% of significance. Crude protein and water intakes increase as increase the supplementation levels of soybean molasses increased allowing the fit of linear regressions ( $P < 0.05$ ). Supplementation up to 12 % did not affect the intake of dry matter, energy and neutral detergent fiber or the digestibility of dry matter, protein and neutral detergent fiber ( $P > 0.05$ ). Also, ingestive behavior and blood variables, as metabolic mineral profile, was not affected ( $P > 0.05$ ). Soybean molasses can be used as supplement for sheep until 12 % of daily ration without affect feed digestibility, ingestive behaviour and metabolic profile.

### Keywords

co-product, digestibility, feed quality, ruminant nutrition

## MELAÇO DE SOJA: UMA ALTERNATIVA DE SUPLEMENTAÇÃO PARA OVINOS

### Resumo

Objetivou-se avaliar o melaço de soja como suplemento em níveis crescentes para ovinos. Foram utilizadas cinco ovelhas ½ Dorper-Santa Inês com massa corporal de  $45 \pm 3,5$  kg e  $12 \pm 2$  meses de idade. Os tratamentos consistiram na inclusão de 0, 3, 6, 9 e 12 % de melaço de soja a uma dieta basal composta de silagem de milho, a qual como alimento exclusivo atende os requerimentos nutricionais de ovelhas em manutenção. Os tratamentos foram distribuídos em delineamento quadrado latino  $5 \times 5$ . Cinco períodos experimentais de 12 dias foram adotados do 1º ao 5º dia: período de adaptação das dietas; do 6º ao 12º dia: coleta de dados e período de amostragem. As análises estatísticas foram realizadas por regressão considerando 5 % de significância. A ingestão de proteína bruta e água aumentou à medida que aumentaram os níveis de suplementação de melaço de soja, permitindo o ajuste de regressões lineares ( $P < 0,05$ ). A suplementação de até 12% não afetou o consumo de matéria seca, energia e fibra em detergente neutro ou a digestibilidade da matéria seca, proteína e fibra em detergente neutro ( $P > 0,05$ ). Também o comportamento ingestivo e as variáveis sanguíneas de perfil metabólico e mineral, não foram afetados ( $P > 0,05$ ). O melaço de soja pode ser utilizado como suplemento para ovinos até 12% da ração diária, sem afetar a digestibilidade dos alimentos, o comportamento ingestivo e o perfil metabólico e mineral.

### Palavras-chave

co-produto, digestibilidade, nutrição de ruminantes

## INTRODUCTION

The worldwide soybean production achieved 334 million tons in April of 2018 according to USDA (2018). Soybean is used, mainly, in human and animal feeding. Ruminants can consume diversity sources of food that not compete with human food. One way to feed these animals is using agro industry co-products as cakes, hulls, molasses and oils (Romanzini et al., 2018).

Soybean processing generates as co-products of oil extraction, hulls, meal and molasses. Soy molasses is viscous syrup produced through degreasing process of soymeal with 60 to 70% of ethanol and 30 to 40% of water (Siqueira et al., 2008). According to Barnes et al. (1994), soy molasses contains in its composition approximately 34.6% of carbohydrates, 3.2% of protein, 3.1% of fat and 4.2% of minerals.

It is estimated that to each ton of soymeal degrease, 250 kg of soy molasses is produced according to Siqueira et al. (2008), resulting in interest as co-product since soy molasses is discarded at industrial level. Since concerns about environmental impacts are important in the sustainability system, the use of residual products or co-products in animal diet is a positive point that contributes to the environment quality and production profitability.

The concentration of carbohydrates, mainly sugar, and protein draws attention to soy molasses potential to use on ruminant nutrition. Different sources of non-fibrous carbohydrates can alter the amount of microbial protein and ruminal passage rates (HALL et al., 2001). The knowledge about a new feed is important to evaluate their applicability in production systems. There are few studies using soy molasses (Miletić et al., 2017). Therefore, the aim of this research was to elucidate the effect of soybean molasses in the intake, digestibility, ingestive behavior and metabolic profile to sheep supplementation.

## MATERIALS AND METHODS

All procedures were conducted in accordance with the Ethics Committee on Use of Animal for Research of the Federal University of Uberlandia, under license number 069/14. The experiment was conducted in the period between august and october 2014 at Uberlandia, Minas Gerais, Brazil. Regional Köppen (1948) climatic classification is Aw, hot and humid tropical with an average annual temperature of 21.4°C and an average annual rainfall 1479 mm.

Five cross-bred in maintenance ½ Dorper - Santa Inês ewes with an average body mass of 45 ± 3.5 kg and 12 ± 2 months of age were assigned into a 5×5 latin square design. The animals were housed in individual pens of 2 m<sup>2</sup> with individual feeders and drinkers.

Treatments consisted of 0, 3, 6, 9 and 12% of soybean molasses in the dry matter to a basal corn silage diet, which fed exclusively supports the nutritional requirements of ewes at maintenance (NRC, 2007). Composition and energy content of diet ingredients are in table 1.

**Table 1.** Composition and energy content of diet ingredients

Item	Soybean Molasses	Corn Silage
Dry matter (DM) (g/kg)	650	260.1
Crude protein (g/kg of DM)	110.0	70.4
Neutral detergent fiber (g/kg of DM)	0	350.4
Ash (g/kg of DM)	160.8	60.2
Gross energy (kcal/kg)	4.1	3.9
Ca (g/kg of DM)	3.9	-
Cu (mg/L)	19.6	-
Fe (mg/L)	55.3	-
K (K <sub>2</sub> O) (g/kg of DM)	20.2	-
Mg (g/kg of DM)	2.1	-
Na (mg/L)	160.6	-
P (P <sub>2</sub> O <sub>5</sub> ) (g/kg of DM)	80.5	-
Zn (mg/L)	52.2	-

The experimental period was 60 days in total, divided into five 12 days periods. From the 1st to 5th day was the adaptation period; from 6th to 12th day was the data collection period: blood, feed, water and feces samples. Ingestive behavior was observed at 11th and 12th day. Lastly, on 12th day, the animals were weighted.

The diets were offered twice a day (08h00 and 16h00 h). The amount of supplied feed was corrected daily to generate 10% of leftovers as fresh matter. Samples of offered and leftovers feed were collected daily and stored in plastic bags at -20 °C. Six liters of water, per animal, was offered once a day at 08h00 h. Water leftovers were daily measured through graduated test tube.

Total feces were collected daily and stored in plastic bags at -20°C. Blood samples were collected every day from 6th to 12th of each experimental period before first feed by jugular vein puncture, into tubes without anticoagulant. After collection, the blood samples were immediately centrifuged at 2.700×g for 20 min. The plasma samples were frozen at -18°C for later analysis of total protein (TP), creatinine (CRE), urea (U), aspartate aminotransferase (AST), gammaglutamyltransferase (GGT), phosphorous (P), calcium (Ca) and magnesium (Mg) concentrations.

Samples of feeds, leftovers, and feces were analyzed to determine the concentrations of ashes, crude protein, dry matter, and gross energy (Detmann, 2012). The concentration of neutral detergent fiber was based on the Van Soest et al. (1991) method. Soy molasses mineral

composition was analysed through liquid chromatography.

Plasma samples were analysed with Bio-2000 semi-automatic specific with commercial kits Labtest. The creatinine and urea were made with Labtest Diagnóstica S.A. by the colorimetric enzymatic method. The enzymes evaluated were aspartate Aminotransferase by the UV kinetic method (AST/GOT Liquiform Labtest Diagnóstica® S.A.) and gammaglutamyltransferase. The total serum proteins and serum albumin by the bromocresol green method (Labtest Diagnóstica® S.A.). Regarding the mineral profile, the serum calcium was measured by the method of purple Phthalein (Labtest Diagnóstica® S.A.); inorganic phosphorus by the ammonium molybdate method (Labtest Diagnóstica® S.A.) and serum magnesium by the sulphonated magon method (Labtest Diagnóstica® S.A.).

Evaluated behaviors were eating, ruminating and idling time of all ewes each every five minutes for 48 hours, according to methodology proposed by Fischer et al. (1998). The eating and rumination efficiencies (kg of DM/h) were calculated by dividing the dry matter intake by the total eating and rumination times. The digestibility coefficients (DC) of dry matter (DM), crude protein (CP) and neutral detergent fiber (NDF) were calculated as follows:  $DC (\%) = (intake - excreted) / intake$ . The digestible energy was estimated according to Sniffen et al. (1992).

The statistical model was:

$$Y_{ijkl} = \mu + \tau_i + P_j + A_k + \varepsilon_{ijkl}$$

Where:  $Y_{ijkl}$  = observation ijkl;  $\mu$  = general mean;  $\tau_i$  = treatment, fixed effect i;  $P_j$  = period, fixed effect j;  $A_k$  = animal, random effect k;  $\varepsilon_{ijkl}$  = random error. Comparisons between diets were conducted by the sum decomposition of squares in or-thogonal contrasts to linear, quadratic and cubic effects ( $P < 0.05$ ). Statistical analyzes were performed using the R software (R Core, 2018).

## RESULTS AND DISCUSSION

Crude protein intake increased linearly as soybean molasses supplementation increased ( $P < 0.05$ ). However, there were no significant differences in the dry matter, neutral detergent fiber, and gross energy intakes between the levels proposed for supplementation with molasses ( $P > 0.05$ ) ([Table 2](#)). Similarly, the dry matter, crude protein and neutral detergent fiber digestibility were not influenced by soy molasses ( $P > 0.05$ ).

The increased of crude protein intake is explained by supplement composition ([Table 1](#)). The soybean molasses accord to CQBAL (2019) has crude protein concentration like cornmeal (80 g/kg), thus  $A_k$  protein intake is the consequence of increasing amount of protein in the ration.

**Table 2.** Nutrient intake and digestibility with increased soybean molasses in the lamb diet

Item	Soymolasses (%)					p value			SEM
	0	3	6	9	12	L	Q	C	
<b>Intake</b>									
DMI (g/d)	1319.9	1255.9	1365.7	1258.6	1225.4	0.48	0.43	0.23	29.7
CPI (g/d)	25.0	25.6	26.9	26.8	28.2	0.01	0.06	0.30	0.02
NDFI (g/d)	62.9	63.7	61.7	62.6	62.9	0.30	0.68	0.88	0.01
GEI (kcal/d)	10.6	10.5	10.7	10.4	10.7	0.95	0.88	0.90	0.03
WI (ml/d)	1387.1	1536.7	1686.2	1835.7	1985.7	0.04	0.13	0.10	105.75
<b>Digestibility</b>									
DMD (%)	67.4	70.7	68.9	68.0	68.9	0.95	0.82	0.31	0.56
CPD (%)	52.2	53.1	50.2	49.2	50.0	0.10	0.33	0.27	0.73
NDFD (%)	65.3	68.2	66.2	65.4	66.0	0.77	0.81	0.36	0.52

DMI: dry matter intake, BM: body mass, GEI: gross energy intake, NDFD: neutral detergent fiber digestibility, NDFI: neutral detergent fiber intake, CPD: crude protein digestibility, CPI: crude protein intake, L: linear effect, Q: quadratic effect, C: cubic effect and SEM: standard error of the mean.

Although it has increased protein content, the intake and digestibility of other nutrients were not changed because of the basal diet composition be of corn silage, which is a fibrous feed, while molasses supplement has a non-fibrous feed profile (Table 1). The degradation of the fibrous carbohydrate profile presents a low digestion rate when compared to non-fibrous carbohydrates (VAN SOEST, 1994). Therefore, as Clark et al. (1992) showed in order to optimize the use of carbohydrates and proteins in the diet, there must be synergism in the degradation of the ingredients which did not occur when used corn silage as basal diet and soy molasses supplementation.

Lack of synergism between basal and supplementation sources of diet is asserting in works as Johnson and McClure (1968), which showed that mature corn silage to sheeps could have values approximately 68% and 51%, respectively, to DM and CP digestibility. That is, similar values found in this study, proving that even with the increase of soybean molasses in the diet the digestibility of the same remained close to expected for the basal diet.

However, the same digestibility between controls shows the possibility of using up to 12% of soybean content, because according to Oliveira et al. (2014), nutrient digestibility defines the nutritional quality of the diet, ascertaining the amount of the nutrients that will be effectively used by the animal.

For water intake, there was a linearly crescent effect ( $P < 0.05$ ) with increasing soybean molasses supplementation in the ewes diet (Table 2). These increases were 30.14% for 12% supplementation levels, confirming that voluntary water intake per sheep is related to dietary crude protein intake (NRC, 2007).

Already feeding behavior was not influenced by molasses supplementation, as well as the result of feed efficiency and rumination (Table 3). This happened because according to

Mertens (1996) changes in ingestive behavior are related to nutrient feedback, and the nutrient digestibility did not differ between treatments.

**Table 3.** Ingestive behavior of sheep fed soy molasses

Item	Soymolasses (%)					p value			SEM
	0	3	6	9	12	L	Q	C	
Feeding (min/d)	379	359	333	369	363	0.77	0.57	0.72	10.25
Ruminating (min/d)	512	547	524	520	513	0.81	0.85	0.90	14.63
Idle (min/d)	549	534	583	551	564	0.75	0.94	0.98	19.85
Feeding (kg of DM/h)	0.30	0.28	0.25	0.28	0.27	0.90	0.64	0.61	0.016
Ruminating (kg of DM/h)	0.40	0.44	0.39	0.39	0.38	0.96	0.99	0.61	0.013

L: linear effect, Q: quadratic effect, C: cubic effect, SEM: standard error of the mean.

Following the same pattern of digestibility and feeding behavior, the blood variables was not affected at the proposed supplementation levels of soybean molasses (Table 4).

**Table 4.** Mineral and metabolites profile of sheep fed soy molasses

Item	Soymolasses (%)					p value			SEM
	0	3	6	9	12	L	Q	C	
TP (g/dL)	6.13	6.10	6.20	6.28	6.05	0.978	0.86	0.81	0.079
Creatinine (mg/dL)	1.09	1.18	0.84	1.13	0.88	0.311	0.60	0.79	0.062
Urea (mg/dL)	16.96	17.61	15.58	17.46	16.84	0.896	0.92	0.98	0.427
AST (U/L)	66.60	72.04	69.48	74.24	73.60	0.100	0.24	0.42	1.393
GGT (U/L)	46.52	45.20	46.20	45.64	43.64	0.694	0.91	0.97	1.858
Ca (mg/dL)	8.28	8.25	8.23	8.22	8.19	0.722	0.94	0.99	0.085
P (mg/dL)	3.82	4.10	3.98	3.63	3.80	0.446	0.63	0.41	0.092
Mg (mg/dL)	2.25	2.19	2.24	2.21	2.28	0.675	0.67	0.85	0.025

TP: total protein, AST: aspartate aminotransferase, GGT: gammaglutamyltransferase, Ca: calcium, P: phosphorous, Mg: magnesium, L: linear effect, Q: quadratic effect, C: cubic effect, SEM: standard error of the mean.

Metabolites and mineral concentrations were not influenced by supplementation with molasses ( $P > 0.05$ ). These diagnoses allowing infer that the addition of soy molasses up to 12% in the sheep feed accord to recommend by Gonzalez and Hilario (2000) remained homeostatic balances in animal metabolism. According to Dallago et al. (2011) elevated concentrations of AST and GGT are related to hepatic injuries, when it happens hepatocellular damage overflows the hepatocytes by raising their serum concentration.

The values of protein, urea, AST and GGT were within reference intervals for sheep: 6.0 to 7.9 of total protein, 17 to 42.8 of urea, 60 to 280 of AST and 20 to 55 of GGT accord to Kaneko (2008), showing that there is no risk of intoxication when soy molasses are used as supplementation in sheep diet.

Minerals concentrations values of phosphorous, calcium and magnesium were within reference intervals for sheep: 3.9 to 6.19 of phosphorous, 7 to 13 of calcium and 1.7 to 2.67

according to Gonzalez and Hilario (2000), showing that addition of soy molasses did not cause disorder in the concentrations blood minerals.

## CONCLUSION

Soybean molasses can be used as supplement for sheep until 12% of daily ration without affect feed digestibility, ingestive behaviours and metabolic profile.

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