

INGESTIVE BEHAVIOR OF FINISHING SANTA INÊS SHEEP USING BY-PRODUCTS FROM ETHANOL TO REPLACE CORN GRAIN IN THE DIET

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ABSTRACT

Research shows that the use of dry distiller grain in ruminant diets can improve daily weight gain and feed efficiency, being regarded as a promising feed source in intensive production systems. The objective was to evaluate the effect of different levels of dietary inclusion of dry distiller grain with high-fiber solubles (DDGS FS OURO[®]) on the ingestive behavior of confined sheep. Eight animals of the Santa Inês breed were used, males and castrated, with an initial body weight of 30 kg, aged 7 months. The animals were distributed in a double 4 x 4 Latin square design, with four experimental periods of 21 days each. For comparison of different fiber levels in DDGS, the regression test was adopted using mutually orthogonal contrasts. Ingestive behavior was determined on the 21st day of each experimental period by visual observation for 12 hours, with 5-minute intervals to determine the time spent on feeding, rumination, idleness, and water intake. Ingestive behavior (min/day and/or %), referring to the time spent in idleness, rumination, feeding, and water intake, was not influenced by the inclusion of high-fiber DDGS in DM of the diet. The increased inclusion of dry distiller grain with high-fiber solubles replacing corn grain had no effect on the ingestive behavior of confined sheep.

Keywords: Feed, distiller grain, idleness, rumination, sheep.

INTRODUCTION

In Brazil, the meat production market has intensified, with producers constantly seeking improvements to maintain competitiveness and profitability. In this context, special attention has been given to animal nutrition as feed accounts for the largest variable input cost in production. As a result, efforts are focused on reducing this cost and exploring options to efficiently and safely feed ruminants.

Ethanol production increased by 29.7% from the 2020/21 to the 2021/22 harvest in Brazil (CONAB, 2022). The volume of ethanol from corn grain generated around 2 million tons of a by-product called distiller grain, marking a 60% increase compared to the previous harvest. This by-product has been regarded as a valuable feed source for livestock, particularly ruminants, and has long been used in ruminant diets in countries such as the United States, Argentina, and Paraguay.

There are two types of distiller grains: dry distiller grain (DDG) with solubles (DDGS) and wet distiller grain with solubles (WDGS). The production of DDGS involves a six-stage process, including grinding, maceration, cooking, enzymatic hydrolysis, fermentation, and distillation. From this process, different types of DDGS are obtained, being classified according to their protein content and composition into: i) high-protein DDGS, with around 39% crude protein; ii) and high-fiber DDGS, with crude protein values below 18% (SINGH et al., 2005; GIBSON and KARGES, 2006).

The use of high-fiber DDGS could potentially have a less negative effect on animal acceptability when added to confinement diets. However, it is crucial to understand the ingestive behavior of animals, particularly with increasing levels of high-fiber DDGS, to ensure that this dietary inclusion does not interfere with the time spent eating and/or ruminating. Insights on this topic could significantly impact the formulation of animal diets. The use of corn grain in DDGS is of great relevance as it increases the efficiency of confined animals in the finishing phase (SWANSON et al., 2014).

Research on the incorporation of high-fiber DDGS into sheep diets has primarily focused on its effects on feed intake, rumination patterns, and overall digestive efficiency. A study carried out by Zhou et al., (2022) indicated that high-fiber DDGS can increase fiber intake, which may support the ruminal health of sheep by stimulating chewing and saliva production, thereby enhancing rumen function. Moreover, this by-product has been linked to longer rumination times, which may

contribute to improved fiber digestion, though excessive fiber intake can sometimes lead to lower dry matter digestibility or a reduction in the rate of feed intake (De Evan et al., 2020). However, the impact on overall productivity, such as growth rate and milk yield, remains variable and often dependent on fiber level and balance with other dietary nutrients.

With the emergence of corn-based ethanol industries, there was a high production of DDG with lower values than corn. Currently, with the increase in the use of DDG in animal diets, there has been an inversion of values, with the price of DDG being US\$ 0.31/kg and that of corn US\$ 0.21/kg.

Given the importance of DDGS in animal nutrition, particularly in the context of increasing meat production efficiency, this study aims to evaluate the effect of different levels of dietary inclusion of dry distiller grain with high-fiber solubles (DDGS FS OURO®) on the digestive behavior of confined sheep. The evaluated diets could potentially replace corn grain.

MATERIAL AND METHODS

The experiment was conducted from August 2022 to July 2023 in a sheep farming sector located at the Federal Institute of Science and Technology (IFRO), Municipality of Colorado do Oeste/RO (13° 07'39" S; 60° 29'68" W), Brazil. The site is located at an elevation of 410 m, with a tropical wet-dry climate classified as Awa in the Köppen climate classification system, being characterized by high temperatures year-round and a distinct dry season (April to September) and wet season (October to March).

The animal experimentation protocol was approved by the Animal Use Ethics Committee (CEUA) of the Federal Institute of Rondônia, registered under number 306/21, in accordance with the precepts of Law N. 11,794 of October 8, 2008, and following the standards issued by the National Council for the Control of Animal Experimentation (CONCEA).

Eight castrated males of the Santa Inês breed, 7 months old, and with an initial body weight of 30 kg, were used to evaluate the inclusion levels of dry distiller grain with high-fiber solubles (DDGS FS OURO®) in the High concentrate feedlot sheep diet. The animals were distributed in a double 4x4 Latin square design, with four experimental periods of 21 days each (14 days of adaptation and 7 days of data collection).

Before starting the experiment, the animals were weighed, marked with numbered collars, and treated with endo and ectoparasites with administration of Ivermectin (Ivomec®,

Merial, Paulínea, BR). They were subsequently distributed in eight pens of 5 m² (one animal per pen), and provided with drinking fountains and feeders (unilateral access of 0.5 m for each animal).

The treatments consisted of the inclusion of 20, 40, 60, and 80% of high-fiber DDGS in dry matter in high concentrate sheep diets (Table 1). The diets were formulated to meet the energy and protein demands of a sheep with an average body weight of 30 kg, for a performance of 300 g/animal/day, according to NRC (2007).

Observation of the animals' ingestive behavior was carried out by trained people on the 21st day of each experimental period. This included minutes of feeding, rumination, idleness, and water intake, which were carried out every 5 min during a period of 12 h, starting at 7:00 h and ending at 19:00 h (Robles et al., 2007).

The analyses referring to the variables evaluated were in accordance with a double 4x4 Latin square design, with four treatments and eight replications. The results were interpreted statistically using analysis of variance. For comparisons of high-fiber DDGS levels, the regression test was adopted using mutually orthogonal contrasts, and utilizing the Mixed procedure of the Statistical Analysis System, version 9.1.3 (SAS, 2008), with 5% significance.

RESULTS AND DISCUSSION

The time spent on idleness, intake, rumination, and water intake was not influenced ($P>0.05$) by the inclusion of high-fiber DDGS in the diet, with average values of 498 min/day, 151 min/day, 77 min/day, and 23 min/day, respectively (Table 2).

The average time spent on idleness in confinement was more significant than that spent on rumination and water intake. This can be explained by the fact that animals spent more time ruminating than ingesting feed when increasing the levels of DDGS in the diet. As the animals received a diet with a higher level of concentration and with the use of bulky sources other than forage, the time spent on feeding activities and rumination was shorter. Notably, the use of diets with a higher level of concentration in confinement may result in lower energy expenditure if we consider that the animals spent most of their time in idleness.

As the time spent on intake activity did not change, there may have been a reduction in dry matter consumption with the increased levels of inclusion of high-fiber DDGS in the diet, thus not influencing rumination time. Another factor that can be observed is that more than the increased inclusion of DDGS, high fiber was needed to increase rumination time, even though high-

Table 1. Composition (% of DM) ingredients in the diet of confined sheep.

Ingredients	High-fiber DDGS inclusion levels			
	20%	40%	60%	80%
Capulio of cotton	10.00	10.00	10.00	10.00
Ground corn	67.00	47.00	27.00	7.00
High-fiber DDGS ¹	20.00	40.00	60.00	80.00
Urea	1.00	1.00	1.00	1.00
Mineral core ²	2.00	2.00	2.00	2.00
Nutritional composition ³				
DM, %	88.98	89.68	90.39	91.11
CP, %DM	13.05	15.13	17.2	19.28
RDP, %DM	6.9	7.3	7.71	8.11
RNDP, %DM	6.79	8.27	9.75	11.23
NFD, %DM	23.48	29.6	35.73	41.85
EE, %DM	4.83	6.07	7.31	8.54
TDN, %DM	80.15	80.01	79.87	79.74

¹DDGS dry distiller grain with solubles. ² Mineral composition: 187 g/kg calcium, 90 g/kg chlorine, 80 g/kg copper, 32 g/kg sulfur, 750 mg/kg iron, 720 mg/kg fluorine, 72 g/kg phosphorus, 70 mg/kg iodine, 50 g/kg magnesium, 500 mg/kg manganese, 8 mg/kg selenium, 62 g/kg sodium, 90.000 UI/kg vitamin A, 20.000 UI/kg vitamin D3, 300 UI/kg vitamin E, 1.450 mg/kg zinc. ³DM: dry matter, CP: crude protein, RDP: rumen degradable protein, RNDP: rumen non-degradable protein, NDF: Neutral detergent insoluble fiber, EE: ether extract, TDN: total digestible nutrients.

Table 2. Ingestive behavior of finishing sheep fed with dry distiller grain with high-fiber solubles replacing corn grain.

Variables	Inclusion of high-fiber DDGS ¹				EPM	TREAT	P-value		
	20%	40%	60%	80%			linear	quadratic	cubic
Idleness, min ²	502	482	495	494	23.161	0.64	0.93	0.95	0.22
Intake, min ²	160	157	145	145	13.364	0.76	0.37	0.93	0.7
Rumination, min ²	58	81	80	81	13.114	0.35	0.12	0.44	0.48
Water intake, min ²	23	19	29	24	6.67	0.67	0.71	0.91	0.36
Idleness %	69.81	67.01	71.73	68.62	3.216	0.64	0.93	0.95	0.21
Intake %	22.11	21.91	20.37	20.18	1.715	0.77	0.37	0.93	0.7
Rumination %	8.02	11.85	11.14	12.33	1.625	0.36	0.13	0.44	0.49
Water intake %	3.33	2.78	4.03	3.37	0.904	0.67	0.71	0.93	0.36

¹ High-fiber DDGS– dry distiller grain with high-fiber solubles. ² Min – minutes in a 12-hour period.

fiber DDGS would increase fiber in the diet. However, the particle size of high-fiber DDGS is similar to that of ground corn grain (Berger and Singh, 2010), providing support for maintaining rumination time.

According to Klopfenstein et al. (2008), when analyzing inclusion levels of up to 40% of distiller grains, dry matter intake increased up to a level of 30% inclusion, with a reduction in consumption at higher values. In the present study, no difference was observed in the time of ingestion (min/day), probably because high-fiber DDGS does not have a negative effect on the acceptability of the diet or because there was a reduction in the volume of feed consumed per minute.

Swanson et al. (2014) evaluated the effects of processing dry-rolled corn with the inclusion of 20 to 40% more soluble dried distiller grains and indicated that the inclusion of DDGS did not influence rumination or feeding time. The authors only observed an increase in the number of daily meals, which could contribute to a better distribution of animal consumption throughout the day, reducing conditions of metabolic disorders such as ruminal acidosis.

CONCLUSION

The increased inclusion of dry distiller grains with high-fiber solubles replacing corn grain in the diet showed no effect on the ingestive behavior of confined sheep. However, further research is needed to evaluate higher concentrations of inclusion and their value as alternative sources of ruminant feed.

Author contributions

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da Freiria. Methodological design: Lucien Bissi da Freiria, Wagner Viana Andreatta, Pedro Ivo José Lopes da Rosa e Silva. Writing, revision and discussion of the manuscript: Ellen Cristina Silva Marques, Mateus Ferreira Lucas, Lucien Bissi da Freiria, Wagner Viana Andreatta, Fagton de Mattos Negrão, Luciano da Silva Cabral, Pedro Ivo José Lopes da Rosa e Silva. All co-authors reviewed the final version and approved the manuscript before submission.

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