The effect of overprocessing dried distillers grains on the growth of finishing lambs

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Abstract

Dried distiller's grains (DDG) are a popular by-product used in the livestock feed industry as it is a cost-effective feedstuff that is rich in crude protein and minerals. However, it is also well reported that as the concentration of DDG in the diet increases, animal dry matter intake decreases, thus extending the feeding period. To further investigate this challenge, my project involved feeding two different diets, diet A (control DDG) and diet B (processed DDG), and observing the differences in average daily gain (ADG), dry matter intake (DMI), and gain to feed ratio (G:F) in finishing lambs. Both diets were the same except for the processing of DDG; whereas diet A used a commercial DDG source directly from the mill and diet B contained the same commercial DDG source that differed through additional heat processing. For DDG processing (diet B), 40% moisture was added to the DDG and heated at 150°C for 70 minutes. After the heating process, diet B was placed in a second oven at 56°C for two days to allow for humidity evaporation. Lambs, blocked by sex and weight, were housed in pens (2 to 3 lambs per pen, 6 pens per treatment) and were fed for 42 days. Lamb DMI was measured daily, and body weight was measured every 14 days. Data were analyzed using a mixed model in SAS considering diet as the fixed effect and pen and block as random effects. The results of this study showed that there were no treatment differences ($P \geq 0.13$) in ADG, DMI, and G:F in growing, finishing lambs. Although no differences were reported under the conditions of the current study, producers should remain cautious when incorporating this ingredient into finishing diets as changes in by-product processing may negatively impact feed quality, and thus animal intake and growth.

Keywords: Lamb, sheep, dried distillers grains, average daily gain, dry matter intake, gain to feed ratio

Introduction

According to the United States Department of Agriculture (USDA) National Agriculture Statistics Service (NASS), there are approximately 5.02 million head of sheep and lambs in the United States today (USDA NASS, 2023). As the cost of feedstuffs increase, investigating the potential use and benefit of incorporating by-products into livestock diets, such as dried distillers grains (DDG) or dried distillers grains with solubles (DDGS), is one practice that may be implemented on-farm to reduce operating costs. Dried distillers grains are a by-product of the ethanol industry, which currently utilizes approximately 45% of all corn produced in the U.S. to produce ethanol fuel (Ates, 2023). With this volume of ethanol being produced, a substantial amount of nutrient dense DDG is available for use in the livestock feed industry. In general, DDG contains approximately three times the amount of crude protein (CP), fat, and phosphorus (P) as corn (Klopfenstein et al., 2008) and thus is commonly incorporated into livestock diets as a protein source. Providing enough CP in a diet is critical to ensure livestock receive the proper proportion of essential amino acids required for development and growth.

In terms of minerals, the concentration of P in DDG is important to note as P is antagonistic to calcium (Ca) utilization. Therefore, excess P in the diet can negatively affect the absorption of Ca in ruminants (*i.e.,* cattle, sheep, and goats). Additionally, excess P in the diet is also linked to osteodystrophy and urinary calculi which raise concern for additional challenges for growing animals (Pugh, 2022). Furthermore, sulfur (S) concentration increase after the production of DDG. This is partly because of the cleaning process used in ethanol plants where sulfuric acid is used to clean the fermentation vats (Shurson, 2018). When incorporating DDG into a diet, nutritionists should make note of the increased S concentrations as too much S in a ruminant diet can lead to Polioencephalomacia (PEM), a noncontagious, neurologic disease resulting in brain swelling accompanied by neuron destruction (Lèvy, 2022). Rumen microbes convert S into hydrogen sulfide (H_2S) and is believed to be primarily responsible for the development of PEM (Drewnoski, 2014). In severe cases, PEM symptoms may include blindness, depression, head pressing, loss of body coordination, neck arching, and muscle contractions (Lutnicki et al., 2014; Gammon et al., 2010).

From a production standpoint, it is important to note that not all distillers grains are produced similarly. Differences of interest include fermentation type and length of time as well as distillation and drying methods (Nuez, Ortin, and Yu, 2009). As a result, the Mailliard reaction may occur, making proteins and sugars less digestible. As heat is applied, the chemical composition of DDG begins to change, thus making it more difficult for the rumen microbes to breakdown and digest. As more water is introduced to DDG, the greater the Maillard reaction. Mauron (1990) suggests this may be in part due to how the protein molecules change during the reaction or by the creation of compounds that block digestive enzymes. Therefore, differing degrees of the Maillard reaction in DDG processing is one factor that can negatively impact the quality of the final product.

Based on results from previous research (Dos Santos et al., 2024), my hypothesis for this experiment was that processing DDG (DDG heated at 150°C for 70 minutes) will decrease lamb dry matter intake (DMI) and average daily gain (ADG) by 5% and 10%; respectively, when fed a diet consisting of 20% DDG and compared with lambs fed a commercial DDG diet that was not heat processed. These values are based on the expected results from a linear regression at a 20% inclusion rate of processed DDG compared with the control of 0% DDG (Dos Santos et al., 2024). The objective of this study was to investigate how different heat processing methods of DDG affects the growth of finishing lambs. As we continue to search for outlets for energy produced by-products, understanding how to best incorporate products such as DDG into livestock diets without resulting in a reduction of feed intake and subsequent animal growth will continue to be at the forefront of the livestock feeding industry.

Materials and Methods

All experimental procedures for this project were approved by The Ohio State University Institutional Animal Care and Use Committee (#2023A00000070).

Thirty-four cross-bred lambs (Hampshire × Dorset × Ile de France × SAMM) located at The Ohio State University Small Ruminant Research Unit in Wooster, Ohio during the summer of 2023 were utilized for this experiment. Lambs were housed in pens measuring 3.66m × 1.6m and were approximately 100 days of age at the initiation of the feeding experiment. Lambs had an initial average body weight of 36.9 (± 1.71) kg. Three weeks before the start of the experiment, lambs (wethers = 18 and ewes = 16) were weighed and blocked by body weight and sex, then assigned to one of 12 pens. Ten of the pens contained 3 lambs while 2 pens contained 2 lambs each. Following the placement of lambs to their assigned pen, each pen was randomly assigned one of two treatments.

Treatments were diets containing 20% DDG, but differed in DDG processing, whereas diet A (control) contained commercial DDG whereas diet B (processed) contained the same commercial DDG that was further processed using heat. All commercial DDG used in this experiment were taken from the same batch to control variability between ethanol plants and batches within plant. For processing (diet B), I added 40% of water (w/w) and heated at 150°C for 70 minutes. This process was to enact the Maillard reaction, which is indicated by a darker colored DDG (Figure 1) compared with the commercial DDG that did not undergo heat processing. After heating, the heat processed DDG was placed in an oven at 56°C for two days to allow for humidity evaporation until it reached the same dry matter (DM) content as the commercial DDG that was not heat processed (89% DM). The remainder of the pelletized diet, as described in Table 1, consisted of ground corn (48.44%), soybean hulls (28.00%), minerals/salt (2.06%), and animal-vegetable fat blend (1.50%).

Lambs were offered water ad libitum throughout the duration of the experiment. Additionally, lambs were fed using slick bunk management. The bunk feeder was considered slick when there was no feed remaining in the bunk 24 hours post feeding. When this occurred for two consecutive days, the amount of feed offered increased by 0.34kg. If a pen left feed for two consecutive days, the amount of feed offered was decreased by 0.23kg.

Prior to beginning the experiment, all lambs were fed diet A for 10 days during an adaptation period. Lamb body weight (BW) was measured at the start of the experiment (day1), and every 14 days throughout the duration of the experiment (42 days). Lambs were fed once daily at 7:30 A.M. During lamb BW collection, feed was withheld until data collection was complete. Feed efficiency (G:F) was measured by converting the amount of feed fed to the amount of weight gained. Dry matter intake was recorded daily for each pen prior to feeding by weighing the previous day's feed refusals. At the conclusion of the experiment ADG was calculated.

Statistical analysis

Data were analyzed as a randomized blocked design using a mixed procedure (SAS, 9.4). The model included the fixed effect of treatment and the random effects of block and pen. Pen was considered the experimental unit. Treatment differences were considered with a P value ≤ 0.05.

Results and Discussion

As stated previously, the hypothesis for my experiment was that processing DDG (DDG heated at 150°C for 70 minutes) will decrease lamb DMI and ADG by 5% and 10%; respectively, when fed a diet consisting of 20% DDG and compared with lambs fed a commercial DDG diet that was not heat processed. Nutrient composition for each diet was calculated to evaluate crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), ether extract (EE), and ash as shown in Table 2. There were no differences ($P \geq 0.13$) in lamb ADG, DMI, or G:F (Table 3). This is of interest as I was expecting to see a decrease in lamb feed intake because of a suspected decrease in palatability in diet B because of heat processing resulting in the Milard reaction. As heat is applied, the chemical composition of a given substance changes and it becomes more difficult for the rumen microbes to break down the chemical bonds in the feed (Mauron, 1990). Further supporting that the Milard reaction had taken place, figure 2 illustrates the final pelletized product that was fed throughout the duration of this experiment.

Evaluating livestock performance using parameters such as ADG, G:F, and DMI are beneficial to ensure that a diet is meeting the nutritional requirements of a given species and formulated for its stage of production. In general, increased ADG results in a shorter number of days on feed. Previously, Dos Santos et al. (2024) concluded that increasing DDG in lamb diets resulted in decreased ADG. These authors fed diets consisting of 0%, 15%, 30%, 45%, and 60% DDG on a g/kg basis for 112 days. This resulted in an ADG for growing lambs of 244, 225, 213,170, and 141g/day; respectively. Results from my experiment refute these finding as heat processed DDG did not negatively impact lamb growth. In my experiment, lamb ADG for diet A was 0.35kg whereas diet B was 0.32kg. Furthermore, the finishing BW of lambs fed diet A was 51.3kg whereas those fed diet B had a final BW of 49.8kg. Results reported from Van Emon et al. (2013) also refute the findings by dos Santos et al. (2024) as their work showed an increase in lamb ADG that were fed rations with DDGS as compared to their control ration with 0% DDGS. While it is unclear why we see varying results in DDG inclusion studies, one possibility is because of a difference in raw materials used. Corn grain differing in nutrient composition may be a factor in the quality of a final DDG by-product produced. Another possibility may result from differences in DDG processing. While my study did not reveal any differences in DDG quality or lamb performance associated with differences in heat processing, it is possible heating at a greater temperature for a longer duration of time may account for these differences.

When evaluating livestock growth, DMI and G:F should also be considered. My experiment found that lamb DMI did not differ between treatments (1.81kg/day and 1.82kg/day for diets A and B; respectively). In calculating G:F, both diets had a G:F of 0.2. In the aforementioned study completed by dos Santos et al. (2024), the authors reported as the percentage of DDG in the diet increased, lamb DMI decreased linearly. These authors also reported a linear decrease in lamb feed efficiency as the percentage of DDG increases in the diet. These findings differ from those of Schauer et al. (2008), who focused on replacing barley with DDG at varying inclusion rates (0%, 20%, 40%, and 60%; respectively). Like my study, Schauer et al. (2008) found there to be no difference in lamb ADG or G:F regardless of treatment. While we do not have a definitive answer as to why these studies have varying results, again it is possible that the difference may be based on the variety of corn grain used. While the study by Schauer et al. (2008) occurred in the United States, the research by dos Santos et al. (2024) was completed in Brazil. Differences in climatic conditions may alter nutrient composition of the corn grain, thus further impacting the quality of DDG produced.

Conclusion

Completion of this experiment revealed that processing DDG at 150°C for 70 minutes does not affect lamb growth, ADG, DMI, or G:F. Further research should be conducted to focus on processing DDG at greater temperatures for longer periods of time**,** as well as the effects of how differing raw material nutrient composition affects DDG quality. By increasing the temperature of heating and duration, the greater the Mailliard reaction's effects may be. By understanding what affects the quality of DDG, ethanol plants can begin to make more consistent high-quality livestock feed by-products.

Conflicts of interest

None.

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Tables

Table 1. Diet composition and ingredient inclusion rates for commercial (diet A) and heat processed* (diet B) dried distillers grain (DDG) fed to finishing lambs in a feedlot setting.

Feed Ingredient	**percent (%) inclusion rate in the diet**
Ground corn	48.44
Soybean hulls	28.00
DDG	20.00
Minerals/salt**	2.06
Animal – vegetable fat blend	1.50

*DDG heat processing – 40% moisture was added to the DDG and heated at 150°C for 70 minutes. After the heating process, diet B was placed in a second oven at 56°C for two days to allow for humidity evaporation.

**(48.50% limestone, 24.30% salt, 19.40% ammonium chloride, 4.40% Vitavet selenium, 2.40% Vitamin E, 0.49% Vitamin A and D)

Table 2. Nutrient composition of commercial (diet A) and heat processed* (diet B) dried distillers grain (DDG) fed to finishing lambs, reported as a percent (%) on a dry matter basis.

Parameter	**diet A**	**diet B**
Neutral Detergent Fiber	27.17	27.38
Acid Detergent Fiber	16.59	15.39
Crude Protein	14.19	14.68
Ether extract	2.27	2.35
Ash	5.10	5.34

* DDG heat processing – 40% moisture was added to the DDG and heated at 150°C for 70 minutes. After the heating process, diet B was placed in a second oven at 56°C for two days to allow for humidity evaporation.

Table 3. Growth, dry matter intake, and gain-to-feed ratio of finishing lambs consuming a diet with 20% dried distillers grain (DDG) that differ through heat processing.

Parameters[1]	**Control**	**Processed[2]**	**SEM**	***P*-value[3]**
BW, kg	51.3	49.8	0.68	0.14
ADG, kg	0.35	0.32	0.016	0.13
DMI, kg	1.81	1.82	0.042	0.84
G:F	0.2	0.2	0	0.15

[1]BW = body weight; ADG= average daily gain; DMI = dry matter intake; G:F = gain-to-feed ratio

[2]Processed = 40% moisture was added to the DDG and heated at 150°C for 70 minutes. After the heating process, DDG was placed in an oven at 56°C for two days to allow for humidity evaporation.

[3]All variables were analyzed as repeated measurements considering the fixed effects of treatment, day, and their interaction. Because of the lack of observed differences in the time by treatment interaction ($P \geq 0.36$) only the main effect of treatment are presented.

Figures

Figure 1. Comparison of dried distillers grain (DDG). The sample on the left (diet A) is commercial DDG source received from the mill that did not undergo additional heat processing. The sample of the right (diet B) is the same commercial DDG that was further processed using heat. Heat processing was conducted as follows: 40% moisture was added to the DDG and heated at 150°C for 70 minutes. After the heating process, DDG was placed in an oven at 56°C for two days to allow for humidity evaporation.

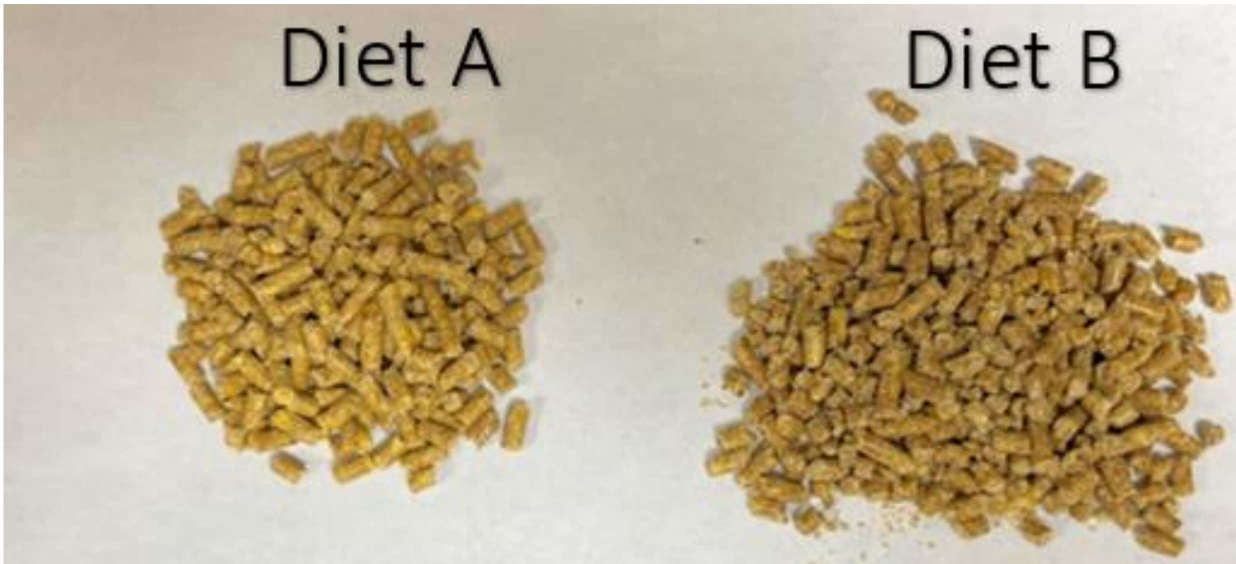

Figure 2. Comparison of pelletized diet fed to finishing lambs containing 20% DDG that differ in processing. The sample on the left (diet A) contains a commercial DDG source received from the mill that did not undergo additional heat processing. The sample of the right (diet B) is the same commercial DDG that was further processed using heat. Heat processing was conducted as follows: 40% moisture was added to the DDG and heated at 150°C for 70 minutes. After the heating process, DDG was placed in an oven at 56°C for two days to allow for humidity evaporation.