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Feeding of DDGS in lamb rations

Feeding dried distillers grains with solubles as 60 percent of lamb finishing rations results in acceptable performance and carcass quality[1]

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Summary

Little scientific documentation is available that evaluates maximum levels of dried distiller grain with solubles (DDGS) in lamb-finishing rations. The objective of this research was to evaluate the effect of feeding increasing levels of DDGS in lamb-finishing rations on lamb performance and carcass characteristics. Two-hundred forty Western, white-faced Rambouillet wether and ewe lambs (31.7 ± 0.6 kg BW) were stratified by weight and sex, randomly allotted to one of 16 pens, and assigned to treatment (n = 4). Diets were balanced to meet CP, energy, and Cu requirements; however, treatments were not formulated to be isocaloric or isonitrogenous. The basal diet consisted of alfalfa hay, soybean meal, barley, and a trace mineral supplement. Dried distillers grains with solubles replaced barley and soybean meal at 0 percent, 20 percent, 40 percent, and 60 percent of the diet, respectively (DM basis). Sulfur concentrations of diets were 0.22 percent, 0.32 percent, 0.47 percent, and 0.55 percent for the 0 percent, 20 percent, 40 percent, and 60 percent diets, respectively. Thiamin was included at 142 $mg \cdot hd^{-1} \cdot d^{-1}$ (DM basis) in all rations for the prevention of polioencephalomalacia. Rations were mixed, ground, and provided ad-libitum. Lambs were weighed on day 0, 32, 56, 83, and 111. Lambs were harvested after the 111 d feeding trial and carcass data collected. Performance and carcass data were analyzed as a completely randomized design. The model included the fixed effect of DDGS treatment and the random effect of pen nested in treatment. Contrast statements included 1) 0 percent vs DDGS inclusion; 2) linear effect of DDGS inclusion; and 3) quadratic effect of DDGS inclusion. Final weight, ADG, G:F, mortality, hot- carcass weight, leg score, carcass conformation score, fat depth, body wall thickness, ribeye area, quality and yield grade, and boneless closely trimmed retail cuts were not affected by treatment ($P \geq 0.15$). Feed intake increased in a linear manner ($P < 0.001$) as level of DDGS inclusion increased. Additionally, flank streaking increased quadratically ($P = 0.09$) as level of DDGS inclusion increased. Dried distillers grains with solubles maintained lamb performance and had no negative effect on lamb carcass traits. Maximizing the use of DDGS may become economically feasible for lamb feeders when prices become favorable compared to conventional dietary ingredients; however, the level of use of supplemental thiamin for the prevention of potential S-induced polioencephalomalacia in lambs needs to be further evaluated.

Key Words: dried distillers grains with solubles, lamb, sulfur, thiamin

Introduction

Co-products from the ethanol industry are increasingly available in the northern Great Plains. A primary ethanol industry co-product, dried distillers grain with solubles (DDGS), is an excellent source of energy and protein for beef cattle and sheep (Lardy, 2003). Historically, research conducted in beef-cattle diets report that DDGS can be fed as a source of both supplemental protein and energy to cattle during backgrounding and finishing, with optimum inclusion levels at approximately 20 percent of the diet-dry matter (Lardy, 2003). A trend to formulate ruminant-finishing diets at higher inclusion levels of DDGS will continue, due to favorable economic substitution for conventional feedstuffs and animal performance responses. However, DDGS are high in potassium, phosphorus, and sulfur; therefore, caution is needed when formulating DDGS into diets to avoid nutritional health disorders.

To prevent polioencephalomalacia in sheep, current recommendations are to keep dietary concentrations of S below 0.3 percent DM when animals are fed concentrate diets or below 0.5 percent DM when fed high-forage diets (NRC, 2007). Recent research results in cattle indicate the diet may include up to 50 percent DDGS (DM basis) when 150 $mg \cdot hd^{-1} \cdot d^{-1}$ supplemental thiamin is provided (Huls et al., 2008). Little research has evaluated the inclusion of DDGS as a replacement for concentrate in lamb finishing rations, especially as inclusion rates rise to the point where S becomes potentially toxic. Schauer et al. (2005, 2006) and Huls et al. (2006) reported that DDGS can be included at levels up to 22.5 percent of a finishing ration with no negative effect on lamb performance or carcass traits. Thus, the objectives for this trial were to evaluate the influence of increasing levels of DDGS in lamb finishing rations on performance and carcass characteristics, specifically when S concentrations become potentially toxic.

Materials and Methods

Animals and Treatments

This trial was conducted at the North Dakota State University Hettinger Research Extension Center, Hettinger, N.D. All procedures were approved by the North Dakota State University Institute for Animal Care and Use Committee. Two-hundred forty Western, white-faced Rambouillet wether and ewe lambs (31.8 ± 0.6 kg initial BW) were stratified by weight and sex and assigned randomly to 16 outdoor pens (15 lambs/pen) with continuous access to water and shade. Pens were then assigned randomly to one of four dietary treatments, with pen serving as experimental unit (n = 4 per treatment): dried distillers grains with solubles replaced barley and soybean meal at 0 percent, 20 percent, 40 percent, and 60 percent of the diet, respectively (DM basis). Diets were balanced to meet or exceed crude protein, energy, and copper requirements (NRC, 2007); however, they were not formulated to be isocaloric or isonitrogenous as the level of DDGS inclusion increased (Table 1). The 0 percent diet was balanced to have equal CP concentration to the 20 percent diet (Table 1). The basal diet consisted of alfalfa hay, soybean meal, barley, and a trace mineral supplement (Table 1). The calcium (Ca):phosphorous (P) ratio was 1.77:1 or higher in all diets and ammonium chloride (0.5 percent, DM basis) was added to all diets to aid in the prevention of urinary calculi resulting from increasing concentrations of P in the

Table 1. Dietary ingredient and nutrient composition of lamb finishing diets.

	Diets[1]			
Item	**0%**	**20%**	**40%**	**60%**
Ingredient		DM basis		
Barley, %	76.5	61.5	41.5	21.5
DDGS, %	---	20.0	40.0	60.0
Alfalfa hay, %	12.5	12.5	12.5	12.5
Soybean Meal, %	5.0	---	---	---
Ammonium Chloride, %	0.5	0.5	0.5	0.5
Trace Mineral[2], %	5.0	5.0	5.0	5.0
CTC[3], %	0.5	0.5	0.5	0.5
Nutrient Concentration				
CP, %	20	20	25	27
$NE_{maintenance}$, Mcal/kg[4]	1.87	1.94	2.02	2.02
NE_{gain}, Mcal/kg[4]	1.25	1.30	1.34	1.34
Crude Fat, %	2.50	4.03	6.69	8.34
ADF, %	10.20	9.72	10.90	12.50
Sulfur, %[5]	0.22	0.32	0.47	0.55
Calcium, %	2.14	1.77	1.17	1.38
Phosphorus, %	0.48	0.55	0.66	0.67
Calcium:Phosphorus	4.46	3.09	1.77	2.06
Copper, ppm	12	10	11	10
Zinc, ppm	73	75	86	63
Thiamin, $mg \cdot hd^{-1} \cdot d^{-1}$	142	142	142	142

[1] 0% = 0% replacement of barley with dried distillers grains with solubles; 20% = 20% dried distillers grain with solubles in ration replacing barley and SBM; 40% = 40% dried distillers grain with solubles in ration replacing barley and SBM; 60% = 60% dried distillers grain with solubles in ration replacing barley and SBM.

[2] Trace mineral: 0.12 % S, 0.31% P, 1.2% K, 1.45% Mg, 17.47% Ca, 2.82% Na, 509 ppm Fe, 375 ppm Mn, 50 ppm Cu, 715 ppm Zn, 5 ppm Se, 1960 mg/kg Thiamine, 95.15 KIU/kg Vitamin A, 9.46 KIU/kg vitamin D3, 9504 IU/kg Vitamin E, 946 mg/kg lasalocid.

[3] CTC (chlorotetracycline - 4G) was formulated to provide 48 g/ton chlortetracycline.

[4] Calculated analysis.

[5] Sulfur may be toxic at levels of 0.30% of diet (DM basis; NRC, 2007).

ration. Thiamin was included at 142 mg·hd^{-1}·d^{-1} (DM basis) in all rations for the possible prevention of polioencephalomalacia. Lambs were adapted to a 75 percent barley and 25 percent alfalfa-based ration prior to the initiation of the trial. Rations were mixed and ground through a grinder-mixer and provided ad libitum via bulk feeders. Weight of each feed delivery and feed remaining at the end of the trial was recorded for the determination of feed intake and gain efficiency (G:F). Feeders were checked daily and cleaned of contaminated feed (fecal contamination, moisture contamination, etc.). Lambs were observed twice daily for the symptoms of acidosis, urinary calculi, and polioencephalomalacia. Grab samples of the ration were collected on d 0, 56, and 111, dried at 55° C for 48 h, and analyzed by a commercial laboratory (Midwest Laboratories Inc., Omaha, Neb.) for DM, CP, calculated energy, crude fat, ADF, S, mineral concentrations, and thiamin (Table 1). Sulfur concentrations of diets were 0.22 percent, 0.32 percent, 0.47 percent, and 0.55 percent for 0 percent, 20 percent, 40 percent, and 60 percent, respectively. Water was sampled on d 56, and samples were analyzed by a commercial laboratory (Stearns DHIA, Sauk Centre, Minn.) for sulfate (141 ppm), nitrate-N (0.07 ppm), pH (8.90), calcium (47.86 ppm), Mg (10.34 ppm), Na (54.28 ppm), Fe (0.18 ppm), Mn (< 0.13 ppm), Cu (< 0.02 ppm), water hardness (162 ppm, calculated value), chloride (12.60 ppm), and total dissolved solids (296 ppm).

Feedlot Performance and Carcass Data Collection

Lambs were fed the treatment diets for 111 d. Lambs were weighed on d 0, 32, 56, 83, and 111. Initial and final weights were an average of two-day weights, with lambs having continuous access to feed and water. Gain efficiency (G:F) was calculated as the ratio of weight gain to DMI. Lambs, regardless of treatment, were marketed at a common time endpoint, when the average weight of the wethers reached a market weight of 60 kg; if lambs did not reach the 60 kg market weight, carcass data was not collected. Following the 111-d finishing period, lambs were transported 805 km for harvest and subsequent carcass data collection at Iowa Lamb Corp, Hawarden, Iowa. Of the original 240 lambs 205 lambs (85.42 percent) were shipped for slaughter. Treatment distributions were as follows; 46 head of the 0-percent treatment, 53 head of the 20-percent treatment, 51 head of the 40-percent treatment, and 55 head of the 60-percent treatment. Hot-carcass weight (HCW) was recorded on the day of slaughter. Leg score, conformation score, fat depth, body wall thickness, longissimus muscle area, and USDA quality and yield grades were recorded after carcasses were chilled at 4°C for 24 h. Percent boneless, closely trimmed, retail cuts (%BCTRC) were calculated (Savell and Smith, 1998).

Statistical Analysis

Feedlot-performance data were analyzed as a completely randomized design using the GLM procedure of SAS (SAS Inst. Inc., Cary, N.Y.) with pen serving as the experimental unit. Because pen served as the experimental unit, we did not test for differences between ewe and wether lambs. Carcass data were analyzed similarly, with missing data points from the underweight lambs not included in the data set, but with pen still serving as experimental unit. The linear model included the fixed effect of treatment, and the random effect of pen nested in treatment. Contrast statements included 1) 0 percent vs DDGS inclusion; 2) linear effect of DDGS inclusion; and 3) quadratic effect of DDGS inclusion.

Results and Discussion

The effects of treatment on feedlot performance and carcass traits are shown in Table 2. Final weight, ADG, G:F, mortality, HCW, leg score, conformation score, fat depth, body wall thickness, ribeye area, quality grade, yield grade, and %BCTRC were not affected by treatment ($P \geq 0.15$). Intake increased in a linear manner ($P < 0.001$) as level of DDGS inclusion increased. While a significant difference was not observed for G:F, it appears that G:F is trending downward as level of DDGS inclusion increases. This trend is supported by the increase in DM intake with no change in ADG as DDGS inclusion increased. Additionally, flank streaking increased ($P = 0.09$) in a quadratic relationship to the 0-percent dietary treatment as level of DDGS inclusion increased, with all DDGS treatments having greater ($P = 0.02$) flank streaking than 0-percent treatment. During the 111-d finishing trial, lambs were not observed to exhibit symptoms of acidosis, urinary calculi, or polioencephalomalacia, regardless of dietary treatment (data not shown). The mortality cases were attributed to the following: two lambs with chronic rectal prolapses and three lambs with pneumonia-respiratory complications. These mortality cases do not appear to be treatment related.

Replacing up to 60 percent of the ration in a barley and alfalfa-hay-based finishing diet with DDGS had no effect on lamb-growth performance. Water did not significantly contribute to S intake of feedlot lambs. Feed intake increased linearly as level of DDGS inclusion increased. The increase in intake was surprising, as crude fat was 8.34 percent of the diet for the 60-percent treatment, well above industry recommendations for fat concentrations in feedlot diets. Although intake increased, a significant increase in ADG was not observed. However, a numerical increase in ADG of approximately 6 percent was observed for all DDGS treatments when compared to the 0-percent-DDGS inclusion diet. Other researchers suggest that DDGS can be an effective replacement of concentrate with no adverse effect on livestock performance compared to control diets. Erickson et al. (1989) provided up to 28 percent of a finishing diet as DDGS and observed no negative affects on lamb performance. Similarly, Schauer et al. (2005) incorporated DDGS at levels up to 15 percent of the total diet and Huls et al. (2006) substituted up to 22.9 percent of the finishing diet with DDGS and found no difference in lamb performance or carcass traits. However, Schauer et al. (2006) reported an increase in performance from increasing DDGS levels up to 22.5 percent of the diet. In both Schauer et al. (2006) and the current trial, CP levels of the DDGS diets are in excess of the requirements for lambs (NRC, 2007). This, combined with a trend for increasing intake and increased caloric density of the diets containing DDGS due to increasing fat concentrations may

Table 2. The influence of dried distillers grains with solubles (DDGS) on feedlot lamb performance and carcass characteristics.

	Treatment[1]						*P*-value[3]		
Item	0%	20%	40%	60%	SEM[2]	P-value	Linear	Quadratic	0% Vs. DDGS
Initial Weight, kg	31	32	32	32	0.6	0.55	0.47	0.22	0.22
Final Weight, kg	60	62	62	62	0.9	0.27	0.15	0.25	0.06
ADG, kg/d	0.26	0.28	0.28	0.28	0.01	0.21	0.11	0.41	0.05
DM Intake, $kg \cdot hd^{-1} \cdot d^{-1}$	1.68	1.78	1.83	1.91	0.03	0.001	< 0.001	0.71	< 0.001
G:F	0.16	0.16	0.15	0.15	0.005	0.53	0.20	1.00	0.39
Mortality, %	0.75	0.25	0.25	0	0.30	0.38	0.12	0.68	0.12
Hot Carcass Weight, kg	30	32	31	31	0.45	0.27	0.19	0.16	0.06
Leg score[4]	10.3	10.5	10.5	10.5	0.3	0.89	0.56	0.66	0.45
Conformation score[4]	10.3	10.3	10.5	10.5	0.27	0.83	0.42	1.0	0.60
Fat Depth, cm[5]	0.74	0.81	0.76	0.81	0.05	0.57	0.36	0.69	0.24
Body Wall Thickness, cm	2.44	2.16	2.57	2.59	0.08	0.47	0.13	0.87	0.22
Ribeye Area, cm^2	14.96	15.35	15.16	15.42	0.32	0.72	0.43	0.83	0.35
Flank Streaking[6]	324	357	342	345	8	0.08	0.19	0.09	0.02
Quality Grade[4]	10.3	10.8	10.8	11	0.2	0.15	0.04	0.57	0.04
Yield Grade[5, 7]	3.26	3.57	3.42	3.55	0.18	0.63	0.39	0.65	0.26
%BCTRC[8]	45.1	44.9	44.9	44.8	0.21	0.76	0.35	0.70	0.31

[1] 0% = 0% replacement of barley and SBM with dried distillers grains with solubles; 20% = 20% dried distillers grain with solubles in ration replacing barley and SBM; 40% = 40% dried distillers grain with solubles in ration replacing barley and SBM; 60% = 60% dried distillers grain with solubles in ration replacing barley and SBM.
[2] Standard Error of Mean; n = 4.
[3] *P*-value for 0% vs DDGS treatments and linear and quadratic affect of dried distillers grains with solubles inclusion.
[4] Leg score, conformation score, and quality grade: 1 = cull to 15 = high prime.
[5] Adjusted fat depth and yield grades.
[6] Flank streaking: 100-199 = practically devoid; 200-299 = traces; 300-399 = slight; 400-499 = small; 500-599 = modest.
[7] Yield Grade = 0.4 + (10 x adjusted fat depth).
[8] % Boneless closely trimmed retail cuts (% BCTRC) [49.936 - (0.0848 x Hot Carcass Weight, in.) - (4.376 x Fat Depth, in.) - (3.53 x BW, in.) + (2.456 x Ribeye Area, in^2)].

explain subtle increases in ADG as DDGS inclusion increased. Additionally, supplemental fat from the DDGS may have affected intake and performance in both trials. Future research is needed to determine if adequate lamb performance can be maintained while utilizing lower quality forages than alfalfa with DDGS replacing a portion of the concentrate in the diet.

The majority of carcass traits were not affected by increasing levels of DDGS in the ration. These results are supported in research conducted by Schauer et al. (2005, 2006) and by Huls et al. (2006). In the current trial only marginal increases in flank streaking were observed. This response could potentially be the result of the increased-energy density in the rations with higher levels of DDGS inclusion.

In this trial supplemental thiamin was provided to aid in the prevention of S-induced polioencephalomalacia. Current research suggests that S toxicity in lambs can be expected to occur when S concentration is greater than 0.3 percent DM in high-concentrate diets, and 0.5 percent DM in high-forage diets (NRC, 2007). As concentrate levels increase in lamb diets, ruminal pH decreases and excessive production of rumen sulfide can result (Gould, 1998). While decreases in ruminal pH have not been found to decrease the microbial production of thiamin (Alves de Oliveira et al., 1996), a lower ruminal pH favors bacteria that produce thiaminase—a compound that in turn destroys the thiamin (Morgan and Lawson, 1974; Boyd and Walton, 1977; Thomas et al., 1987). In diets containing greater than 0.3 percent sulfur, the combination of increased dietary-S concentration, increased-ruminal-sulfide production, and increased-thiaminase production may result in an increase in polioencephalomalacia (Gould, 1998). Sulfur toxicity may additionally result in decreased intake and performance, as well as health problems associated with S binding to copper, resulting in secondary copper deficiencies. One potential remedy for excessive dietary S is to include supplemental thiamin in the diet (NRC, 2007). Recent beef-cattle research has reported mixed results using supplemental, orally administered thiamin. Huls et al. (2008) successfully fed 50 percent of the diet as modified DDGS while supplementing with 150 $mg \cdot hd^{-1} \cdot d^{-1}$ thiamin, noting no change in performance when compared to control diets. However, a 50-percent DDGS treatment had to be discontinued by Buckner et al. (2007), when multiple steers exhibited signs of polioencephalomalacia, even though they were providing 150 $mg \cdot hd^{-1} \cdot d^{-1}$ supplemental thiamin. In this trial, no increases in mortality or morbidity were observed, indicating that the lambs on increasing levels of DDGS had no deleterious effects from increasing dietary-S concentrations. Additional research is needed to further quantify the supplemental-thiamin needs of lambs fed high- DDGS rations or to elucidate the reasons that lambs are less likely than cattle to develop polio based on S-induced affects in the rumen.

Conclusion

The expansion of the ethanol industry in the United States may result in an increase in the availability of dried distillers grains with solubles for lamb feeders. Maximizing the use of dried distillers grains with solubles may become economically feasible for lamb feeders, especially in relation to the current price trends for more traditional feedstuffs. When appropriately priced relative to energy feedstuffs, dried distillers grains with solubles supplemented with thiamin at 142 $mg \cdot hd^{-1} \cdot d^{-1}$ may effectively replace up to 60 percent of a lamb-finishing ration with no negative effects on feedlot performance or carcass traits.

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