Influence of Thiamin Supplementation on Feedlot Performance and Carcass Quality of Lambs Fed a 60% Distillers Dried Grain plus Solubles Finishing Ration[1]

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The objective of this research was to evaluate the influence of thiamin supplementation on feedlot performance and carcass characteristics of lambs fed a 60% dried distillers grain plus solubles finishing ration. Level of thiamin supplementation may influence performance and dry matter intake; however thiamin supplementation did not have an effect on the incidence of PEM in feedlot lambs. Feeding dried distillers grains plus solubles at 60% of dietary dry matter provided acceptable lamb performance and carcass composition.

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Introduction

Recent research indicates sheep can be fed higher levels of dried distillers grains plus solubles (DDGS) than previously considered optimal without affecting carcass characteristics (Schauer et al., 2008). This provides an opportunity for increase utilization of dried distillers grains plus solubles in lamb finishing rations, potentially resulting in cheaper feed costs for lamb finishers. One potential problem with feeding increased levels of dried distillers grains plus solubles is the high dietary sulfur levels which result. These can potentially lead to neurological problems (polioencephalomalacia; PEM) in ruminants. Polioencephalomalacia is thought to result from a thiamin deficiency induced by the conversion of sulfate to sulfite in the rumen. To avoid problems with PEM, supplementation of 100-500mg/d thiamin (McDowell, 2000) in diets containing more than 0.4% S in high concentrate diets and 0.5% S in higher roughage diets (NRC, 2005) has been adopted. However, no research has examined if level of thiamin in these diets will affect feedlot performance, carcass characteristics, and incidence of PEM in feedlot lambs. Therefore, our objective was to determine the influence of thiamin level on feedlot performance, carcass characteristics, and incidence of PEM in lambs fed 60% dried distillers grains plus solubles.

Procedures

The objective of this study was to determine the influence of thiamin level on feedlot performance, carcass characteristics, dry matter intake, and incidence of PEM. Two-hundred forty western white-face lambs (wethers and ewes) were utilized in a randomized complete design to evaluate the influence of level of thiamin supplementation in lamb finishing diets containing 60% dried distillers grains plus solubles. Lambs were assigned to one of sixteen pens and each pen assigned to one of four treatment diets (4 pens per treatment). The final finishing diet was balanced to contain 60% dried distillers grains plus solubles (DM basis), which resulted in a dietary S concentration of 0.72%. The NRC maximum tolerable level of S is 0.40% S (preliminary analysis of these diets are presented in Table 1).Treatments diets differed in the amount of supplemental thiamin supplied; these levels were: 1) **CON** (no supplemental thiamin), 2) **LOW**

(15.8 mg/hd/d thiamin), 3) **MED** (48.4 mg/hd/d thiamin), or 4) **HIGH** (53.0 mg/hd/d thiamin). Rations were mixed in a grinder-mixer and provided ad-libitum via bulk feeders. Content of feeders (feed refusals) were collected and weighed at the end of the study. Lambs were weighed on days 0, 27, 56, 84, and 110. Initial and final weights were the average of two -day weights. Following the 110 d finishing period, lambs were transported for harvest and subsequent carcass data collection to Iowa Lamb Corp, Hawarden, IA. One hundred eighty five lambs of the original 240 (77.08%) were shipped. Lambs with a live weight less than 110lbs 28d prior to slaughter were not shipped. Treatment distributions were as follows; 49 head of the CON treatment, 48 head of the LOW treatment, 44 head of the MED treatment, and 44 head of the HIGH treatment. Feedlot performance and carcass trait data were analyzed as a randomized complete design using the GLM procedures of SAS (SAS Inst. Inc., Cary, NY) with pen serving as the experimental unit. Carcass data was analyzed similarly, with missing data points from underweight lambs not included in the data set, but with pen still serving as experimental unit. The model included treatment. Linear, quadratic, and cubic contrasts for increase level of thiamin supplementation were evaluated.

Table 1. Ingredient and nutritional composition of diets fed to feedlot lambs.

	Diets[1]			
Item	CON	LOW	MED	HIGH
Ingredient	DM basis			
Alfalfa Hay, %	15.00	15.00	15.00	15.00
Corn, %	21.38	21.38	21.38	21.38
DDGS, %	60.00	60.00	60.00	60.00
Ammonium Chloride, %	0.50	0.50	0.50	0.50
Limestone, %	2.25	2.25	2.25	2.25
Bovetec, %	0.085	0.085	0.085	0.085
TM package[2], %	0.78	0.78	0.78	0.78
Copper Sulfate, %	0.002	0.002	0.002	0.002
Thiamin, %	0.00	0.004	0.007	0.011
Nutrient composition				
CP, %	23.70	23.30	23.40	23.60
TDN, %	84.50	84.40	84.50	85.10
NEm, Mcal/lb	0.92	0.92	0.92	0.93
NEg, Mcal/lb	0.61	0.61	0.61	0.62
Crude Fat, %	7.41	7.38	7.51	7.71
Acid Detergent Fiber, %	10.50	10.50	10.90	11.10
Sulfur, %	0.74	0.69	0.71	0.72
Calcium, %	1.33	1.59	1.17	1.08
Phosphorus, %	0.68	0.69	0.70	0.72
Copper, ppm	11.00	12.00	9.00	11.00
Zinc, ppm	71.00	67.00	63.00	59.00
Thiamin, ppm[3]	0.90	8.88	24.42	30.46

[1] Treatments abbreviations CON (no supplemental thiamin) LOW (15.8 mg/hd/d thiamin), MED (48.4 mg/hd/d thiamin), and HIGH (53.0 mg/hd/d thiamin).
[2] TM package contained: 11.7%Ca, 10.0% P, 14% salt, 0.1% K, 0.1% Mg, 20ppm Co, 100ppm I, 2,450ppm Mn, 50ppm Se, 2,700ppm Zn, 300,000 IU/lb Vitamin A, 30,000 IU/lb Vitamin D_3, and 600 IU/lb Vitamin E.
[3] Thiamin supplementation calculated based on laboratory analysis of premixed supplement multiplied by %composition of supplement in diet.

Results

Based on preliminary analysis of feedstuffs and dry matter intake calculated daily intake of thiamin were 1.6, 15.8, 48.4, and 53.0 mg/hd/d for CON, LOW, MED, and HIGH respectively. Results for feedlot lamb performance and carcass quality are reported in Table 2. There was a tendency for quadratic ($P = 0.08$) increases in final BW; specifically the CON, LOW, and MED treatment lambs finished heavier than the group fed the HIGH level of thiamin. Average daily gain exhibited a similar response, although cubic ($P = 0.08$) in nature with the CON, LOW, and MED treatment groups gaining weight at a faster rate than the HIGH treatment group.

Feed dry matter intake (DMI) as well as F:G or G:F were also affected cubically (P<0.03) by level of thiamin supplementation.

Mortality was not affected (P = 0.43) by level of supplemental thiamin. Hot carcass weight (HCW) decreased quadratically (P = 0.05), while leg score had a quadratic tendency (P = 0.06) for a lower score with increased thiamin supplementation. Fat depth, body wall thickness, ribeye area, flank streaking, quality grade, yield grade, and percent boneless closely trimmed retail cuts (%BCTRC) were all unaffected (P > 0.16) by level of supplemental thiamin. However, there was a cubic tendency (P = 0.10) for differences in conformation score.

Table 2. Influence of thiamin supplementation on feedlot lamb performance and carcass characteristics

	Treatment[1]						*P*-value[3]		
Item	CON	LOW	MED	HIGH	SEM[2]	*P*-value	Linear	Quad	Cubic
Initial Wt, lbs	71.76	71.60	71.45	71.63	0.34	0.94	0.73	0.63	0.83
Final Wt, lbs	137.07	138.22	137.44	133.03	1.43	0.10	0.07	0.08	0.79
ADG, lbs/d	0.59	0.61	0.60	0.56	0.01	0.08	0.09	0.04	0.08
Intake, lbs/hd/d	3.90	3.92	4.36	3.83	0.08	0.001	0.49	0.004	0.002
F:G, lbs DMI: lbs gain	6.60	6.48	7.29	6.86	0.19	0.05	0.09	0.45	0.03
G:F, lbs gain; lbs DMI	0.15	0.15	0.14	0.15	0.004	0.05	0.08	0.57	0.03
Mortality, %	1.67	0	0	0	0.83	0.43	0.20	0.34	0.66
HCW, lbs	68.98	70.66	69.84	68.06	0.81	0.18	0.35	0.05	0.68
Leg Score[4]	11.32	11.48	11.60	11.05	0.17	0.16	0.36	0.06	0.41
Conformation score	11.50	11.42	11.57	11.23	0.09	0.09	0.12	0.17	0.10
Fat Depth, in[5]	0.31	0.34	0.30	0.33	0.02	0.59	0.96	0.96	0.18
Body Wall Thick, in	1.07	1.10	1.00	1.05	0.04	0.32	0.39	0.83	0.11
Ribeye Area, in^2	2.42	2.40	2.43	2.43	0.06	0.98	0.77	0.92	0.81
Flank Streaking[6]	336.92	340.25	353.33	336.36	6.74	0.29	0.71	0.16	0.21
Quality Grade	11.34	11.33	11.47	11.18	0.08	0.17	0.36	0.13	0.15
Yield Grade[7]	3.48	3.75	3.42	3.66	0.18	0.55	0.82	0.94	0.17
%BCTRC[8]	44.66	44.33	45.01	46.81	0.21	0.18	0.24	0.75	0.06

[1]Treatments abbreviations CON (no supplemental thiamin) LOW (15.8 mg/hd/d thiamin), MED (48.4 mg/hd/d thiamin), and HIGH (53.0 mg/hd/d thiamin).
[2]Standard Error of Mean; n = 4.
[3]*P*-value for linear, quadratic, and cubic effects of increasing level of thiamin supplementation.
[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 (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)).

Discussion

The tendency for quadratic decrease in final weight with increasing level of thiamin was an unexpected result. Given that excess thiamin is cleared by the kidneys (McDowell, 2000), and that intake of upwards of 1000 times requirement are thought to be safe (NRC, 1987) it is difficult to attribute the decreased performance to thiamin toxicity at the levels fed in the present study. Further, it is unclear if the differences in performance are due to a negative effect of the 53 mg/hd/d thiamin intake or if the optimal level of supplementation is closer to 15.8 mg/hd/d. Palatability could be another possible cause for the differences in intake. Carcass characteristics with the exception of leg score and hot carcass weight were unaffected by treatment. The data from the present study as well as that of (Schauer et al., 2008) are largely comparable. Differences in HCW and leg score are more than likely driven by the similar differences observed in final BW.

As previously stated no differences (P = 0.43) in mortality were observed due to level of thiamin supplementation. During the course of this study one lamb did die; however the cause of death, as determined by a veterinarian, was chronic respiratory illness. Of further interest is that no (0) cases of polioencephalomalacia were observed during the entire 110 d feeding period; even with dietary S levels (0.72% S DM basis) nearly twice the maximum tolerable level of sulfur 0.4% for high concentrate diets reported by the NRC (2005). Contrary to the present study Krasicka et al. (1999) reported that all lambs fed a low fiber-high starch diet containing 0.72% S died from PEM after 12 weeks. Loneragan et al., (2005) hypothesized that the therapeutic effects of thiamin in PEM-affected animals is either due to an increased requirement for thiamin or a beneficial effect of thiamin on impaired brains. The present research discounts the proposed increased requirement; at least in feedlot lambs fed distillers grains as the sulfur source, In fact, our data suggests that thiamin was not required to prevent PEM. However, we cannot support or dismiss the second theory, relating to the beneficial effect of thiamin on impaired brains, as no cases of PEM occurred in our study.

Further links between sulfur induced PEM and ruminal pH change have been explored (Gould, 1998). Gould (1998) concluded that in diets with levels of sulfur exceeding 0.3 percent the combination of dietary sulfur, ruminal sulfide production, and increased thiaminase production may increase incidence of PEM. Alves de Oliveria et al. (1996) reported that decreasing ruminal pH did not decrease microbial production of thiamin; however, the decrease in rumen pH has been found to favor thiaminase producing bacteria (Morgan and Lawson, 1974; Boyd and Walton, 1977; Thomas et al., 1987). In the present study lambs were previously adapted to high concentrate diets prior to receiving the 60% dried distillers grains plus solubles diet which contained presumed toxic levels of sulfur. This along with the fact that no measurements of ruminal sulfide or thiaminase were conducted does not allow for a comparison of the present study to the previous data. However, in a second portion of this study (unpublished data) lambs which were individually fed the same diets presented here were adapted from a medium concentrate diet to a high concentrate diet while increasing the amount of dried distillers grains plus solubles and thus sulfur content of the diet. While this portion of the study is on-going no incidences of PEM have occurred even with the suspected increased susceptibility to PEM during diet adaptation.

A review of literature reporting the amount of S fed to ruminants in corn by-product based rations further demonstrates the inconsistencies in the amount of sulfur required to cause neurological problems, such as PEM. Similar to the present study (Schauer et al., 2008) fed lambs a finishing diet which contained 0, 20, 40, or 60% dried distillers grains plus solubles. In this study no differences in animal performance were reported; further, the 60% dried distillers grains plus solubles diet which contained 0.55% S (DM basis) did not cause any incidence of PEM. Contrary to the present study, (Niles et al., 2002) reported that 10 of 14 calves fed a corn gluten feed based diet exhibited PEM; those calves affected were fed diets that contained either 0.554 or 0.701% S (DM basis). Both authors reported water sulfate values; the water consumed by the lambs (Schauer et al., 2008) contained 141 ppm S, while the water consumed by the steers (Niles et al., 2002) contained 56ppm S. Unfortunately, Niles et al, (2002) did not report how much, if any, supplemental thiamin was provided to the steers in their study; however, Schauer et al, (2008) did report that their lambs did receive 142 mg/hd/d of supplemental thiamin. Huls et al. (2008) fed 50 percent modified dry distillers grains plus solubles while supplementing 150 mg/hd/d thiamin without affecting performance when compared to steers fed control diets. Contrary to these results Buckner et al. (2007) discontinued a 50 percent dried distillers grains plus solubles when multiple steers exhibited polioencephalomalacia while receiving 150 mg/hd/d thiamin.

Sulfur from water has also been implicated as a cause of PEM in ruminants. Ward and Paterson (2004) evaluated thiamin supplementation as a method of preventing PEM in steers consuming high sulfate (4000 ppm) water. Two steers on high sulfate water and one steer from high sulfate water supplemented with 1g/hd/d thiamin died; however, only one case from the unsupplemented group was confirmed to have died from PEM. Although no incidences of PEM occurred, (Loneragan et al, 2001) reported that steers consuming water of increasing sulfate concentrations negatively impacted performance and carcass characteristics. However, this decrease in performance was not observed in lambs fed dried distillers grains diets containing increasing amount of sulfur (Schauer et al, 2008). The fact that the lambs fed 60% dried distillers grains plus solubles from (Schauer et al., 2008) as well as the lambs fed 60% dried distillers grains plus solubles in the present study did not develop PEM, even when not given supplemental thiamin, demonstrates repeatability of our results. Further, this data appears to indicate that either the NRC maximum tolerable level of S, or the need for supplemental thiamin, is in question. At a minimum Schauer et al. (2008) and the present study illustrate the need for additional research to further determine the interactive affects of sulfur, thiamin supplementation, and dietary grain concentration in finishing rations, and the effect they collectively have on the incidence of polioencephalomalacia.

Implications

The current research as well as previous work has demonstrated that dried distillers grains plus solubles can be included in lamb finishing rations at levels up to 60% of dietary dry matter in limited situations. Feeding dried distillers grains plus solubles at 60% of dietary dry matter does not appear to increase the incidence of polioencephalomalacia in lambs when water with low sulfur (141 ppm sulfate) is available. Further, the use of thiamin as a dietary additive to aide in the prevention of polioencephalomalacia does not appear to be necessary in feeding environments with similar sulfur present in the feed and water as observed in the present study. However, the authors still strongly advise producers to have feed samples as well as water samples tested before determining their livestock's risk to developing PEM due to sulfur toxicity.

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