Meta-Analysis of the Effect of Dietary Sulfur on Feedlot Health

Cody A. Nichols
Virgil R. Bremer
Andrea K. Watson
Crystal D. Buckner
Jana L. Harding
David R. Smith
Galen E. Erickson
Terry J. Klopfenstein[1]

Summary

A meta-analysis of University of Nebraska–Lincoln finishing trials was conducted to evaluate the effect of dietary sulfur on feedlot health. An interaction between level of dietary sulfur and forage NDF ($P = 0.07$) affected the incidence of polioencephalomalacia (PEM) cases. For a given level of dietary sulfur the relative risk for PEM decreased as forage NDF increased. Rumen degradable sulfur (RDS) was estimated for feedstuffs fed to cattle included in the analysis. As level of RDS increased in the diet, the incidence of PEM increased ($P < 0.01$). Rumen degradable sulfur is a better measure of PEM risk because it accounts for the dietary sulfur that contributes to hydrogen sulfide production.

Introduction

One of the challenges with using distillers grains plus solubles at large dietary inclusions is the potential for increased level of sulfur (S) in the ration (*Journal of Animal Science* 88:2444).

Polioencephalomalacia (PEM), or cerebrocortical necrosis, is a disease of ruminants that can occur sporadically.

The National Research Council (2000) suggests diets fed to feedlot cattle should not exceed 0.40%. Vanness et al., (2009 *Nebraska Beef Report*, p. 79) calculated the risk for PEM at increasing dietary S levels and concluded that incidence of PEM was low (0.14%) in diets containing 0.46% or less S. It also has been suggested that roughage level in high-byproduct diets may reduce the level of H_2S present in the rumen due to its ability to increase ruminal pH (2009 *Nebraska Beef Report*, pp. 81)

The objectives of the current study were to determine 1) effect of dietary S, 2) other dietary components, 3) or rumen degradability of sulfur on PEM risk, as well as 4) the relationship between other feedlot illnesses (i.e., respiratory, foot rot, bloat, and coccidiosis) and S.

Procedure

Data were compiled from finishing trials conducted at the University of Nebraska–Lincoln Agricultural Research and Development Center research feedlot (Mead, Neb.) from 2002-2009. The feedlot research program utilizes spring-born steers that are weaned in the fall. After the initial receiving period, the larger cattle are fed as calf-feds from approximately November to May, the medium weight steers are fed as short yearlings from May to October after grazing cornstalks in the winter and drylotting, and the smaller steers are fed from September to February as long yearlings after being wintered on cornstalks and grazing pasture in the summer.

Steers (n = 17,080) in these studies consisted of primarily black, crossbred steer calves or yearlings. Cattle included in the analysis were fed diets ranging from 0.120 to 0.723% S (DM). Sulfur undegradability was estimated for feedstuffs utilized in experiments included in the analysis. Sulfur undegradability was calculated by estimating % organic sulfur from sulfur containing amino acids (methionine and cysteine). This value was multiplied by undegradable intake protein (UIP) which yielded % undegradable intake S. Total S of the feedstuff was subtracted from rumen undegradable S which produced rumen degradable sulfur (RDS). Neutral detergent fiber (NDF) was measured for all forage sources. In the current analysis, we tested the effect of dietary S and NDF from forage on the incidence of PEM. The model tested three levels of forage NDF which were 0 NDF (no forage), 4% NDF (normal), and 8% NDF (2X normal). Most of the trials where byproducts were fed, cattle were supplemented with 150 mg/steer daily thiamine.

Computerized health records were maintained on all cattle. Feedlot illnesses of particular interest to the current study included PEM, respiratory disease, footrot, and bloat. Cattle were determined to be PEM cases if they were diagnosed by the feedlot health crew as exhibiting signs of PEM (poor coordination, disoriented, and blindness). Cattle suspected of suffering from PEM were treated with an intravenous injection of 5,000 mg thiamine. The cattle that did not recover from the PEM insult and/or died were necropsied and confirmed as having PEM if brain lesions were present.

Dietary sulfur, RDS, and NDF values were compared to health records to test for a relationship between level of S, RDS, NDF, and feedlot illnesses (PEM, respiratory, footrot, coccidiosis, and bloat).

The Proc GENMOD procedure of SAS (SAS Inst., Inc., Cary, N.C.) was used to test the effect of S level, NDF level, S x NDF level, RDS, or RDS x NDF level on PEM incidence, respiratory illness, foot rot, bloat, and cocci. Significance was declared at $P < 0.10$.

Results

Of the 17,080 cattle included in the current analysis, only 28 were diagnosed with or died due to PEM.

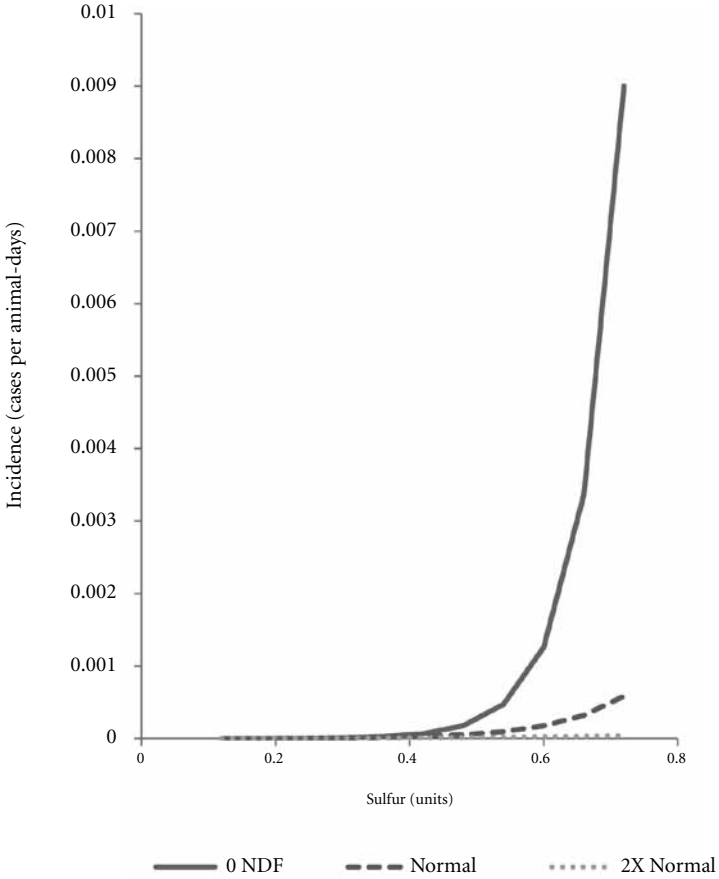

Figure 1. Effect of sulfur and forage NDF level on polioencephalomalacia (PEM) incidence. A dietary sulfur x forage level NDF interaction ($P = 0.07$) was observed. For a given level of forage NDF, the incidence of PEM increased as level of sulfur increased in the diet; however, for a given level of dietary sulfur the relative risk for PEM decreased as forage NDF increased.

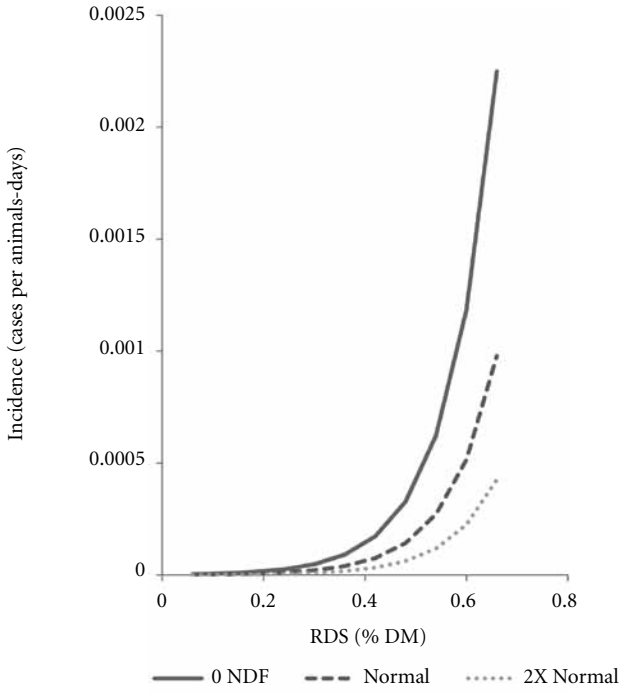

Figure 2. Effect of rumen degradable sulfur (RDS) and forage NDF level on polioencephalomalacia (PEM) incidence. A significant relationship was detected between RDS and PEM ($P < 0.01$). As level of RDS increased in the diet, the incidence of PEM increased. There was no RDS x forage level NDF interaction ($P > 0.10$).

Data indicate cattle started to exhibit signs of PEM about halfway through the feeding period. The relationships between dietary S and footrot, respiratory disease, and bloat were not significant ($P > 0.05$); therefore these feedlot illnesses did not appear to be related to diet S.

As the level of sulfur increased in the diet, the relative risk of cattle contracting PEM also increased (Figure 1; $P = 0.02$). According to the current model, cattle fed diets containing 0.42% S with normal forage level NDF would cause 0.56 cases per day in a 20,000 head feedlot. This diet would be considered a low PEM risk diet; therefore, the PEM cases resulting from this diet will be considered our baseline. Incidence of PEM for cattle consuming finishing rations containing 0.42% S and no forage was 0.00022 (cases per animal days), equivalent to about 2 cases per day in a 20,000 head commercial feedlot. Polioencephalomalacia increased to 23 cases per day (based off of a 20,000 head feedlot) when cattle consumed diets containing 0.60% S and no supplemental forage compared to the 0.42% S level (two cases per day).

There was an interaction between forage NDF and dietary S ($P = 0.07$). The addition of forage in finishing diets containing 0.40% S (DM) or more reduced PEM cases (Figure 1). Cattle fed diets containing normal forage NDF (DM) and 0.60% S (DM) had a reduction in incidences of PEM compared to cattle fed similar dietary S levels with no forage NDF. As the level of dietary S increased, forage level became increasingly important. In finishing diets containing more than 0.40% S and 2X normal forage NDF, risk of cattle contracting PEM was almost completely eliminated (Figure 1).

No RDS x forage NDF interaction ($P > 0.10$) was detected. As level of RDS increased in the diet, risk for cattle contracting PEM increased as well ($P = 0.0072$; Figure 2). Cattle fed diets containing 0.28% RDS and no forage had a greater risk for contracting PEM than cattle fed diets containing

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only 0.18% (DM basis) RDS and no forage. Finishing diets with no forage and a RDS level of 0.60% increased the number of PEM related cases in feedlot cattle compared to cattle fed a similar diet with 0.28% RDS. Risk of contracting PEM increased as dietary RDS level increased for all three forage NDF levels scenarios (no forage, normal, 2X normal; Figure 2).

Dietary NDF from forage decreased ($P = 0.10$) the risk of PEM in feedlot cattle in the RDS model. Unlike total dietary S, there was no interaction between RDS and forage NDF ($P > 0.10$). Rations containing 0.28% RDS and normal forage NDF exhibited a lower risk (0.34 cases per day) of inducing PEM than similar diets (0.28% RDS) with no forage (0.77 cases per day). A feedlot diet containing 0.28% RDS (26.9 DRC, 26.9 HMC, 41.3 WDGS, and 5 cornstalks; %DM) would have a total dietary S equivalent of 0.42% (Table 1). Data indicated that as level of RDS increased in finishing rations, PEM risk increased as well but, as forage NDF values increased, the risk of PEM decreased.

Our current recommendation for dietary S level is to not exceed 0.46% (assuming water sulfate is low). If cattle are drinking water containing 1,000 ppm sulfate during the summer, the dietary S equivalent would be about 0.13% S and 100% rumen degradable. A diet formulated to provide 0.46% S could contain 47.6% corn, 47.3% wet distillers grains plus solubles, and 5% cornstalks (DM). This diet would contain 0.31% RDS (DM). If cattle water source contains high levels of sulfate (1,000 ppm), then the diet can only contain 0.18% RDS or about 23% WDGS.

Results from this study confirm that as level of dietary S or RDS increase in finishing diets, risk of inducing PEM increased as well.

Table 1. Nutrient composition (% of DM) for UNL research feedlot trials summarized for 2002-2009.

Feed[1]	Sulfur	Rumen Degradable Sulfur (% of dietary DM)	Neutral Detergent Fiber
Protein Feeds			
WDGS	0.81	0.56	34.0
MDGS	0.78	0.53	34.0
DDGS	0.76	0.52	34.0
WDG	0.46	0.22	42.5
Dakota Bran Cake	0.41	0.39	30.3
CCDS	1.12	1.08	3.0
Sweet Bran®	0.50	0.44	37.8
ADM WCGF	0.47	0.41	37.8
Steep	0.58	0.38	2.0
Corn Bran	0.22	0.21	72.2
Brewers Grits	0.34	0.26	34.0
CGM	0.72	0.21	5.0
Energy Feeds			
SFC	0.14	0.06	10.8
HMC	0.13	0.09	10.8
DRC	0.14	0.06	10.8
FGC	0.14	0.06	9.0
Whole Corn	0.14	0.06	10.8
Reconstituted Corn	0.14	0.10	10.8
Roughage Sources			
Alfalfa	0.21	0.19	55.5
Brome	0.20	0.18	75.5
Cornstalks	0.20	0.18	81.3
Soyhulls	0.26	0.23	61.8
Sorghum Silage	0.10	0.08	62.2
Corn Silage	0.08	0.06	43.9
Wheat Straw	0.13	0.11	80.4
Grass Hay	0.18	0.16	76.0

[1]WDGS = wet distillers grains plus solubles.
MDGS = modified distillers grains plus solubles.
DDGS = dry distillers grains plus solubles.
WDG = wet distillers grains.
CCDS = condensed corn distillers solubles.
ADM WCGF = Archer Daniels Midland wet corn gluten feed.
CGM = corn gluten meal.
SFC = steam-flaked corn.
HMC = high-moisture corn.
DRC = dry-rolled corn.
FGC = fine-ground corn.

When a roughage source was included in the diet, PEM risk was reduced and continued to decrease as more roughage was added to the ration. It appears that roughage is an important factor in reducing PEM related illness in feedlot cattle, which may be due to its ability to regulate rumen pH. Dietary S level does not appear to be connected to other common feedlot diseases (respiratory, foot rot, and bloat). These data indicate that RDS is a better measure of PEM risk than diet S.

[1]Cody A. Nichols, graduate student; Virgil R. Bremer, former research technician; Andrea K. Watson, research technician; Crystal D. Buckner, former research technician; Jana L. Harding, research technician; David R. Smith, professor; University of Nebraska–Lincoln (UNL) School of Veterinary Medicine and Biomedical Sciences, Lincoln, Neb.; Galen E. Erickson, professor; Terry J. Klopfenstein, professor; UNL Department of Animal Science, Lincoln, Neb.