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Effect of Source and Level of Sulfur on Rumen Metabolism and Finishing Performance

Cody A. Nichols
University of Nebraska-Lincoln

Kelsey Rolfe
University of Nebraska - Lincoln, krolfe2@unl.edu

Crystal D. Buckner
University of Nebraska - Lincoln, cbuckner2@unl.edu

Galen Erickson
University of Nebraska - Lincoln, gerickson4@unl.edu

Terry Klopfenstein
Universitiy of Nebraska - Lincoln, tklopfensein1@unl.edu

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Summary

Five ruminally fistulated steers fitted with rumen gas extraction cannula plugs were utilized to quantify ruminal pH and hydrogen sulfide (H_2S) levels produced at different times post feeding. Diets consisted of 1) 28.5% WDGS, 37.5% Sweet Bran®, 4% corn bran, 0% alfalfa hay; 2) 28.5% WDGS, 37.5% Sweet Bran, 7.5% alfalfa, 4% corn bran; 3) 44% WDGS, 44% Sweet Bran, 7.5% alfalfa; 4) 50% WDGS, 37.5% DRC, 7.5% alfalfa; and 5) 87.5% Sweet Bran, 7.5% Aafalfa. Dry matter intake was different ($P = 0.05$) across treatments. Steers fed diets containing 44% WDGS and 44% Sweet Bran had greater ($P < 0.01$) levels of H_2S compared to other diets; however, cattle fed 87.5% Sweet Bran produced less ($P < 0.05$) H_2S compared to the other four dietary treatments.

Introduction

In past finishing studies, feedlot cattle fed diets containing corn milling byproducts with dietary sulfur levels of 0.45% (2010 Journal of Animal Science, 88:1061-1072) and 0.48% (Wilken et al., *2009 Nebraska Beef Report*, pp. 76-78) have been shown to induce polioencephalomalacia (polio); however, other diets with similar % sulfur did not. A summary of byproduct research (Vanness et al., *2009 Nebraska Beef Cattle Report*, pp. 79-80) conducted at the University of Nebraska–Lincoln concluded cattle can tolerate up to 0.46% sulfur with minimal risk of polio (0.1% polio). Vanness et al. (*2009 Nebraska Beef Cattle Report*, pp. 81-83) observed a negative correlation between ruminal pH and ruminal H_2S concentration and concluded that dietary roughage level is important in order to minimize the risk of polio. The objective of our study was to determine impact of source and level of sulfur on ruminal pH, continuous DMI, and H_2S in beef cattle finishing diets.

Procedure

Five ruminally cannulated crossbred yearling steers (initial BW=739±40 lb) were used in a 5x5 Latin square designed experiment. The five diets consisted of 1) 28.5% wet distillers grains plus solubles (WDGS), 37.5% Sweet Bran (Cargill; Blair, Neb.), 25% dry-rolled corn (DRC), and 4% corn bran; 2) 28.5% WDGS, 37.5% Sweet Bran, 17.5% DRC, 7.5% alfalfa, and 4% corn bran; 3) 44% WDGS, 44% Sweet Bran, and 7.5% alfalfa; 4) 50% WDGS, 37.5% DRC, and 7.5% alfalfa; and 5) 87.5% Sweet Bran and 7.5% alfalfa (DM basis; Table 1). All diets included 5% supplement which provided 30 g/ton Rumensin (Elanco Animal Health; Greenfield, Ind.), 90 mg/steer daily Tylan (Elanco Animal Health), and 130 mg/steer daily thiamine. Steers were fed for *ad libitum* intake once daily at 0800. Periods were 14 days long with an 11 day adaptation to the diet and a 3 day collection period.

Steers were housed in individual pens with bunks suspended from load cells. Feed amounts were determined and feed refusal weighed, if present, before the 0800 feeding. Wireless pH probes were inserted before the 0800 feeding on the first collection day. The probes were used to collect continuous ruminal pH measurements every minute. Ruminal pH data were recorded onto a data logger, which was downloaded before the start of the 0700 period.

Gas samples were collected twice daily (8 and 12 hours post feeding) on the last three days of each period. Rumen gas collection was achieved by inserting a 21-inch artificial insemination pipette straw into a specially equipped cannula plug. Twenty mL of rumen gas was extracted from the rumen by use of a 35-mL syringe. Five mL of gas was injected into a 30-mL glass serum bottle with a rubber stopper. The rumen gas samples were later analyzed for H_2S. This process was replicated six times per animal.

Data were analyzed as a 5x5 Latin square using the Glimmix procedure of SAS (SAS Institute, Cary, N.C.). Animal was treated as a random effect with treatment being a fixed effect.

Results

Dry matter intake was significantly impacted by dietary treatments ($P = 0.05$; Table 2). Steers fed Diet 2 (28.5% WDGS, 37.5% Sweet Bran, 7.5% alfalfa) consumed more feed (24.8 lb) compared to cattle fed Diet 3 (22.5 lb; 44% WDGS, 44% Sweet

Table 1. Diet compositions and dietary sulfur level of experimental diets (DM basis).

Item	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
WDGS	28.5	28.5	44.0	50.0	0
Sweet Bran®	37.5	37.5	44.0	0	87.5
DRC	25.0	17.5	0	37.5	0
Alfalfa	0	7.5	7.5	7.5	7.5
Corn Bran	4.0	4.0	0	0	0
Supplement[1]	5.0	5.0	5.0	5.0	5.0
Nutrient composition					
Sulfur, % DM	0.45	0.46	0.58	0.45	0.46

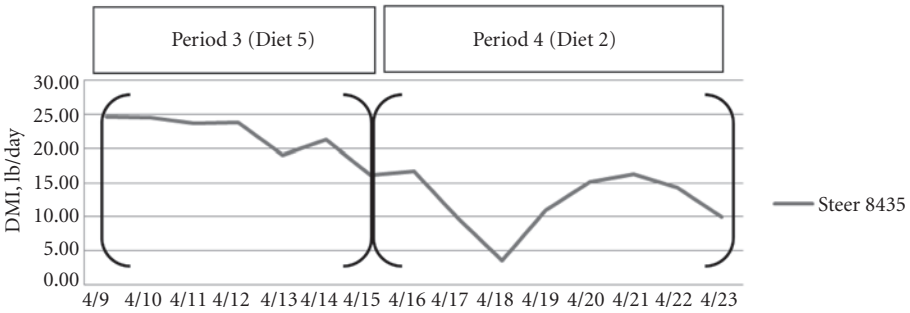
[1]Supplement formulated to provide 30 g/ton Rumensin, 90 mg/head/day Tylan, and 130 mg/head/day thiamine.

Table 2. Effect of source and level of sulfur on intake, ruminal pH, and H_2S[1].

Item	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	SEM	*P*-value
DMI, lb/day	23.5[ab]	24.8[a]	22.5[b]	23.9[ab]	24.4[a]	1.56	0.05
Average pH	5.67	5.90	5.96	5.89	6.11	0.13	0.22
Maximum pH	6.30	6.55	6.70	6.59	6.69	0.13	0.20
Minimum pH	5.28	5.38	5.48	5.36	5.61	0.09	0.11
pH variance	0.05	0.06	0.07	0.08	0.05	0.06	0.58
Time <5.6, min/day	656.7[a]	145.1[b]	150.9[b]	461.1[ab]	116.9[b]	133.5	0.03
Area <5.6, min/day[2]	90.3	11.3	15.8	84.7	16.8	28.0	0.10
H_2S[3]	46.2[a]	48.4[a]	61.1[b]	50.3[a]	32.3[c]	6.81	<0.01
Sulfur, g/day[4]	48.8	49.9	60.6	49.4	50.3		

[abc]Within a row means without a common superscript differ ($P < 0.05$).
[1]**Diet 1** = 28.5% WDGS, 37.5% Sweet Bran, no Alfalfa; **Diet 2** = 28.5% WDGS, 37.5% Sweet Bran 7.5% Alfalfa; **Diet 3** = 44% WDGS, 44% Sweet Bran, **Diet 4** = 50% WDGS, **Diet 5** = 87.5% Sweet Bran.
[2]Area under curve is magnitude of pH <5.6.
[3]Values are µmol hydrogen sulfide/L rumen gas collected.
[4]Grams of sulfur consumed per treatment diet per day.

Table 3. Dry matter intake of steer that had to be removed from trial due to polio.



Bran). Rumen H_2S levels were also impacted ($P < 0.01$) by dietary treatment. Diet 5 (87.5% Sweet Bran) produced the lowest (31.6 µmol H_2S/L, $P < 0.05$) level of H_2S compared to the other four treatments. Diet 3 (44% WDGS, 44% Sweet Bran) produced the greatest (61.1, $P < 0.05$) level of H_2S compared to the other treatments. Steers fed Diet 3 (44% WDGS, 44% Sweet Bran) ingested 60.6 g/day of sulfur which was about 10 g more than that of the 87.5% Sweet Bran diet (50.3 g/day). The dietary sulfur level of Diet 3 (44% WDGS, 44% Sweet Bran) was 0.58% (DM basis) compared to Diet 5 (0.46%). Treatments 1 (28.5% WDGS, 37.5% Sweet Bran, no alfalfa), 2 (28.5% WDGS, 37.5% Sweet Bran, 7.5% alfalfa), and 4 (50% WDGS) all had the same level ($P > 0.05$) of H_2S. Dietary sulfur levels were 0.45, 0.46, and 0.45% (DM basis) respectively for diets 1, 2, and 3. Grams of sulfur ingested per day were also relatively similar across the three treatments.

Results from the current study indicate H_2S level appears to be indicative of the sulfur level of the diet. However, when steers were fed a diet that contained 87.5% Sweet Bran which had a dietary sulfur level of 0.46%, the diet promoted lower H_2S levels compared to diets that contained similar levels of sulfur (Diets 1, 2, and 4).

Rumen pH was not affected by treatment (ave. pH, max pH, and pH variance); however, time < 5.6 was greater ($P = 0.03$) for Diet 1 compared to Diets 2, 3, and 5. Diet 1 (28.5% WDGS, 37.5% Sweet Bran, no alfalfa) was not different for time < 5.6 compared to diet 4 (50% WDGS). Area < 5.6 also tended ($P = 0.10$) to be greater for diet 1 (28.5% WDGS, 37.5% Sweet Bran, no alfalfa) compared to the other treatments.

The relatively high H_2S measurements observed for the 44% WDGS, 44% Sweet Bran diet may explain some of the polio cases noted for a similar diet fed in another experiment (Wilken et al., *2009 Nebraska Beef Cattle Report*, pp. 76-78). Wilken et al. (2009) removed four steers from the trial due to polio attributed to dietary sulfur (0.59%). Similar polio cases have been noted for Diets 1 (28.5% WDGS, 37.5% Sweet Bran, 25% DRC) and 4 (50% WDGS, 37.5% DRC). Both of these diets had similar H_2S levels (Diet 1 = 46.2 µmol /L, Diet 4 = 50.3 µmol /L); however, Diet 2 (28.5% WDGS, 37.5 Sweet Bran, 17.5% DRC, 7.5% alfalfa) also had similar H_2S levels. No polio cases have been noted for cattle consuming diets similar to Diet 2 (Loza et al., *2005 Nebraska Beef Cattle Report*, pp. 45-46). Also, the dietary sulfur for Diet 5 (87.5% Sweet Bran) was closely comparable (0.46%) to Diets 1, 2, and 4 but produced significantly less H_2S (32.2 µmol /L).

During the course of the study, a steer had to be removed from the trial due to polio-related illness. During Period 4 while the steer was on Diet 2 (28.5% WDGS, 37.5% Sweet Bran, 7.5% alfalfa) the animal began exhibiting signs considered typical of a steer suffering from polio (poor coordination, disoriented, and refusing to stand). The steer was removed from the trial, treated for the illness, and died due to polio (necropsy confirmed). During Periods 1, 2, 3, and 4, the steer's DMI averaged 21.1, 22.5, 24.8, and 12.5 lb respectively. Table 3 represents the steady decline in the steer's DMI for Periods 3 and 4. Average rumen pH during Periods 1, 2, and 3 were 5.58, 5.87, and 6.29 respectively. Hydrogen sulfide gas was also collected during periods 1, 2, and 3 and were 72.6, 75.7, and 29.5 µmol/L respectively. Unfortunately, H_2S measurements were not collected at time of polio onset. Also, the diet the steer was consuming at the time of the polio insult had not produced polio in previous feedlot experiments.

[1]Cody A. Nichols, graduate student; Kelsey M. Rolfe, research technician, Crystal D. Buckner, research technician; Galen E. Erickson, professor; Terry J. Klopfenstein, professor University of Nebraska–Lincoln Department of Animal Science.