High Sulfur Content in Distillers Grains with Solubles May Be Deleterious to Beef Steer Performance and Carcass Quality

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Introduction

Distillers grains with solubles are becoming an increasingly important staple of cattle diets because of rapid expansion of the fuel ethanol industry. Sulfuric acid often is used in ethanol production processes to clean and control the pH of fermenters. Consequently, distillers grains with solubles can occasionally contain high sulfur concentrations. Within the rumen, sulfur is converted to hydrogen sulfide gas by ruminal microbes. Hydrogen sulfide is eructated from the rumen and subsequently aspirated into the lungs; excess amounts of hydrogen sulfide can cause polioencephalomalacia (brainers). Polioencephalomalacia is characterized by increased respiration, decreased feed intake, listlessness, muscular incoordination, progressive blindness, and necrosis of brain tissue. Elevated sulfur levels also may have deleterious effects on cattle growth performance and carcass characteristics. The objective of this study was to evaluate effects of sulfur content in dried distillers grains with solubles on ruminal gas concentrations, feedlot performance, and carcass characteristics of finishing steers fed diets based on steam-flaked corn or dry-rolled corn.

Experimental Procedures

Crossbred yearling steers (n = 80; 904 ± 6 lb initial weight) were fed diets based on steam-flaked or dry-rolled corn. All diets included 30% dried distillers grains with solubles (dry matter basis) and contained (dry matter basis) a moderate (0.42%) or high (0.65%) dietary sulfur level. The four experimental diets were: dry-rolled corn with high sulfur, dry-rolled corn with moderate sulfur, steam-flaked corn with high sulfur, and steam-flaked corn with moderate sulfur. The 0.42% sulfur level was obtained from the sulfur content of ration ingredients, and the 0.65% level was attained by adding sulfuric acid to dried distillers grains with solubles before mixing rations.

On arrival at the feedlot, steers were allowed free access to ground alfalfa hay and municipal water. One day after arrival, steers were individually weighed and implanted with Revalor 200 (Intervet, Inc., Millsboro, DE) and received Phoenectin pour-on IVX (Animal Health, St. Joseph, MO), Bovishield – 4 (Pfizer Inc., New York, NY), and Fortress – 7 (Pfizer Inc.). Steers were assigned randomly to experimental diets and pens within weight block. Steers were housed in one of four barns containing 20 individual partially covered concrete pens per barn; each pen measured 5 × 19.8 ft. Steers were moved up stepwise to the finishing diets (Table 1) through four gradual step-up diets, each fed for 5 days. Animals were evaluated daily for symptoms of polioencephalomalacia. On day 28 of the study, one animal fed steam-flaked corn with high sulfur presented symptoms of polioencephalomalacia including blindness. This animal was

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removed from the study and treated. No other animals experienced any health-related problems. Three animals were fed the wrong diet for approximately 1 week as a result of a clerical error. Data from all three misfed animals and the sick animal were excluded from analysis.

On days 69, 83, 90, 97, and 104, ruminal gas samples were collected from ruminal gas cap and analyzed for hydrogen sulfide concentrations. Steers were weighed every 14 days, and final live weights were measured on day 140 before steers were shipped to a commercial abattoir in Holcomb, KS. Carcass weights and incidence of liver abscesses were recorded at slaughter, and other carcass characteristics were measured following a 48-hour chill.

Results and Discussion

There were no interactions ($P \geq 0.15$) between grain processing method and dietary sulfur level for growth performance or carcass characteristics. Feeding high levels of sulfur decreased dry matter intake ($P < 0.01$), average daily gain ($P < 0.01$), and final body weight ($P < 0.01$) but had no effect ($P = 0.25$) on feed efficiency (Table 2). Steers fed diets containing high sulfur had 9% less dry matter intake and gained 13% less daily compared with their counterparts fed diets with moderate sulfur. Steers fed high sulfur were 4.3% lighter than steers fed moderate sulfur.

Grain processing method had no effect ($P = 0.30$) on average daily gain, but steers fed dry-rolled corn had greater ($P < 0.01$) dry matter intake than steers fed steam-flaked corn. Conversely, cattle fed steam-flaked corn tended ($P = 0.07$) to have better feed efficiency, and diets based on steam-flaked corn provided more ($P < 0.01$) dietary net energy for maintenance and net energy for gain than diets based on dry-rolled corn. High sulfur decreased ($P < 0.01$) hot carcass weight by 4.3%; decreased kidney, pelvic, and heart fat by 16.2% ($P < 0.01$); and tended ($P = 0.13$) to decrease marbling score (Table 2). Cattle fed high sulfur yielded carcasses with lower ($P = 0.04$) yield grades than carcasses from cattle fed moderate sulfur content. There were no differences among treatments with respect to dressing percentage, fat thickness over the 12th rib, ribeye area, liver abscesses, or USDA quality grades (Table 2). Grain processing method had no effects ($P > 0.15$) on carcass characteristics.

Cattle fed high sulfur had greater ($P < 0.01$) concentrations of hydrogen sulfide in the ruminal gas cap than cattle fed moderate sulfur (Figure 1), and hydrogen sulfide was inversely related ($P < 0.01$) to average daily gain ($r = -0.42$), dry matter intake ($r = -0.43$), and feed efficiency ($r = -0.20$). Production of hydrogen sulfide may compromise energy efficiency, resulting in poorer growth performance and lower marbling scores. Additionally, hydrogen sulfide gas is a causative factor in sulfur-induced polioencephalomalacia.

Implications

Feeding distillers grains that are high in dietary sulfur may increase the concentration of hydrogen sulfide in the ruminal gas cap, which may decrease intake and compromise growth performance, carcass characteristics, and health of feedlot cattle regardless of the grain processing method used.

Table 1. Composition of finishing diets based on steam-flaked corn or dry-rolled corn containing dried distillers grains with moderate or high dietary sulfur (S) concentrations

	Dry-rolled corn		Steam-flaked corn	
Item	0.42% S	0.65% S	0.42% S	0.65% S
Ingredients, % of dry matter				
Steam-flaked corn	---	---	51.1	50.6
Dry-rolled corn	51.3	50.8	---	---
Dried distillers grains with high sulfur	---	30.4	---	30.6
Dried distillers grains with moderate sulfur	29.9	---	30.1	---
Alfalfa hay	8.6	8.6	8.6	8.6
Cane molasses	6.2	6.2	6.2	6.2
Supplement[1, 2]	4.0	4.0	4.0	4.0
Analyzed composition, % of dry matter				
Dry matter	87.2	86.6	86.5	83.4
Starch	38.3	38.4	38.8	38.9
Crude protein	15.6	15.4	15.2	15.0
Crude fat	5.8	5.8	5.8	5.8
Neutral detergent fiber	12.6	12.2	12.5	12.1
Calcium	0.7	0.7	0.7	0.7
Phosphorus	0.4	0.4	0.4	0.4
Potassium	0.7	0.7	0.7	0.7
Sulfur	0.42	0.65	0.42	0.65

[1] Formulated to provide 300 mg/day Rumensin (Elanco Animal Health, Greenfield, IN); 90 mg/day Tylan (Elanco Animal Health); 1,000 IU/lb vitamin A; 10 IU/lb vitamin E; 10 ppm copper; 60 ppm zinc; 60 ppm manganese; 0.5 ppm iodine; 0.25 ppm selenium; and 0.15 ppm cobalt.

[2] Zilmax (Intervet/Schering-Plough Animal Health, Millsboro, DE) was fed the last 21 days at 7.56 g/ton (dry matter basis) with a 3-day withdrawal period.

Table 2. Growth performance and carcass characteristics of steers fed finishing diets based on steam-flaked corn or dry-rolled corn containing dried distillers grains with moderate or high dietary sulfur (S) concentrations

	Dry-rolled corn		Steam-flaked corn			P-values[1]		
	0.42% S	0.65% S	0.42% S	0.65% S	SEM	G	S	G × S
Number of steers	18	19	20	19	---	---	---	---
Growth performance								
Days on feed	140	140	140	140	---	---	---	---
Initial weight, lb	903	902	905	904	6	0.15	0.43	0.59
Final weight[2], lb	1409	1334	1374	1330	24	0.34	<0.01	0.46
Average daily gain, lb/day	3.61	3.09	3.35	3.04	0.16	0.30	<0.01	0.48
Dry matter intake, lb/day	23.5	21.6	21.3	19.2	0.59	<0.01	<0.01	0.97
Feed:Gain	6.41	6.94	6.33	6.29	0.28	0.07	0.25	0.27
Diet NE_m, Mcal/100 lb	103.4	100.7	109.8	109.3	2.3	<0.01	0.50	0.63
Diet NE_g, Mcal/100 lb	72.1	69.9	77.6	77.6	1.8	<0.01	0.50	0.61
Carcass characteristics								
Hot carcass weight, lb	896	847	873	845	16	0.34	<0.01	0.45
Dressed yield, %	66.1	65.4	65.1	65.5	0.40	0.19	0.61	0.15
Ribeye area, sq. in.	14.4	14.3	14.8	14.6	0.32	0.19	0.51	0.91
12th rib fat, in.	0.64	0.54	0.40	0.58	0.18	0.58	0.82	0.41
Kidney, pelvic, and heart fat, %	1.88	1.45	1.76	1.60	0.12	0.82	<0.01	0.24
Liver abscess[3], %	5.9	0	15.0	0	5.4	---	---	---
Marbling score[4]	SL[94]	SL[82]	Sm[3]	SL[69]	16	0.91	0.13	0.48
Yield grade	2.34	2.00	2.15	1.79	0.19	0.23	0.04	0.95
Choice, %	41.2	31.6	50.0	31.6	12.0	0.70	0.23	0.70
Select, %	52.9	57.9	25	57.9	11.9	0.23	0.10	0.23
Standard, %	5.9	10.5	25	10.5	8.3	0.23	0.54	0.23

[1] G, Effect of grain processing method; S, Effect of dietary sulfur level; G × S, interaction between grain processing method and dietary sulfur level.
[2] Final weight was calculated by dividing carcass weight by a common dressing percentage (63.5%).
[3] Chi-square test = no treatment effect (P=0.15).
[4] SL, Slight; Sm, Small. Numbers indicate degrees of marbling (0 to 99) within a marbling score.

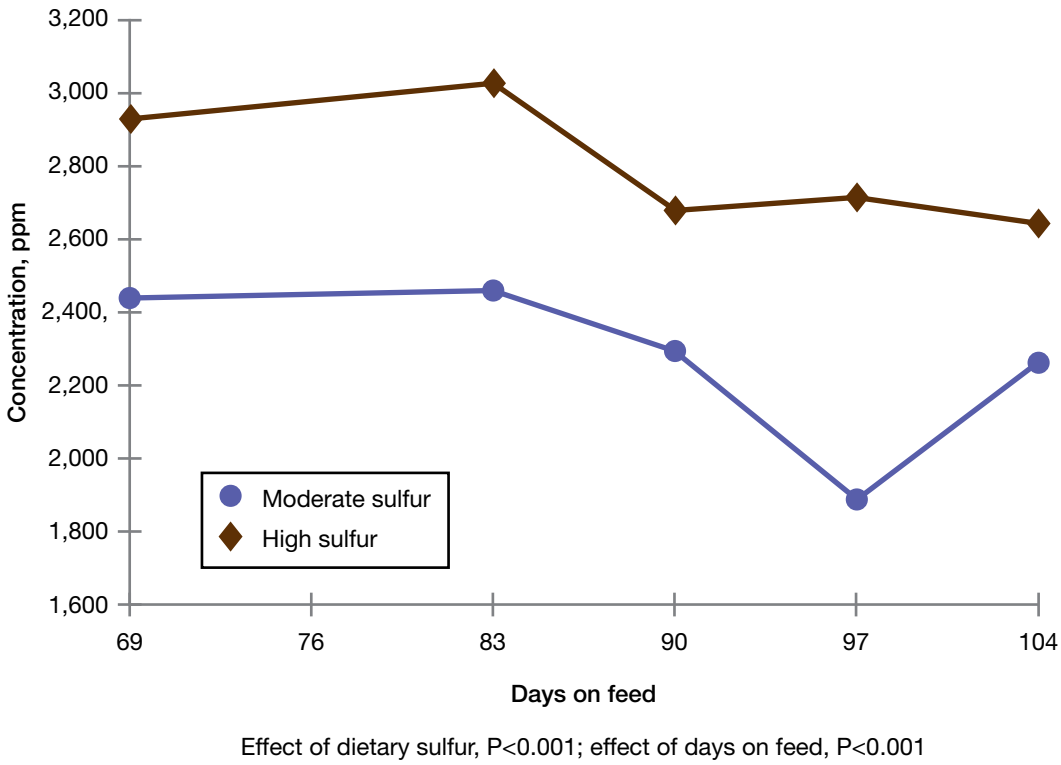

Figure 1. Effect of days on feed on ruminal hydrogen sulfide concentration in steers fed finishing diets containing dried distillers grains with moderate or high dietary sulfur concentrations.