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Summary

A metabolism study was conducted to evaluate dietary sulfur (S) in beef cattle finishing diets formulated with wet and dry distillers grains with solubles (DGS) containing low (0.82%) and high (1.16%) S concentration. There was no interaction between moisture and S for intake, DM digestibility, or hydrogen sulfide (H_2S). Steers fed low S DGS consumed more feed than steers fed high S DGS. Subtle differences were observed for ruminal pH variables. Propionate and butyrate concentrations decreased when high sulfur DGS was fed. Sulfur of DGS impacts intake, VFA, and ruminal H_2S concentration. Wet DGS may be more prone to conversion of S to H_2S in the rumen than dry DGS.

Introduction

In recent growth performance study (*2011 Nebraska Beef Cattle Report*, pp. 62-64), steers fed high sulfur DGS diets showed lower DMI and ADG, even though total sulfur concentration in the diets was not greater than the threshold for polio. A possible hypothesis for this effect is that ruminal H_2S concentration, after being absorbed, can negatively impact energy metabolism. Likewise, the impact of elevated dietary sulfur on ruminal fermentation is unknown. Therefore, the objective of this study was to determine the effects of dietary sulfur in beef cattle finishing diets on intake, ruminal pH, H_2S, and volatile fatty acids concentration when cattle are fed wet or dry distillers grains with solubles.

Procedure

Diets, Feeding, and Experimental Design

Six ruminally fistulated crossbred beef steers (840 ± 68 lb BW) previously used in a 42-day adaptation trial were assigned to one of the five treatments. A 5x6 unbalanced Latin square design (six steers and five diets) was used. Steers were fed once daily *ad libitum* through five periods (14 days each), totaling 70 days. Treatments were arranged as a 2x2+1 factorial treatment design, with factors being moisture (wet or dry DGS included at 40% of diet DM), sulfur (S) concentration (0.82 and 1.16% in the co-product for low and high, respectively), and a diet (Match) containing wet DGS from high S provided at 31.44% of diet DM, to match the low S wet DGS treatment (Table 1).

Measurements and Statistical Analysis

All periods were 14 days, with seven days for adaptation and seven days for collection. Intakes were calculated based on DM offered after subtracting DM refused, and analyzed for the last seven days of each period. On day eight, pH probes were calibrated to take measures at each minute, introduced through the cannula into the rumen. Ruminal gas samples were collected on days 12, 13, and 14 of each period, once daily, 8 hours post feeding, through devices inserted in the ruminal cannula prior to feeding on day 12, and H_2S concentration analyzed with a spectrophotometer. On day 14, ruminal fluid was collected through a manual vacuum pump at 8, 13, and 22 hours post feeding, and frozen immediately for VFA. Chromium oxide (7.5g in gel capsules) was added into the rumen twice daily, every day, and spot fecal samples were collected twice daily on the last five days of each period to estimate fecal output and DM digestibility (DMD). Data were analyzed using the GLIMMIX procedures of SAS. Interaction between sulfur and moisture was tested. If not significant, the main effects

Table 1. Dietary treatments and chemical composition of diets containing wet or dry distillers grains with solubles, and with high or low sulfur concentration in the co-product.

Ingredients, % DM[3]	Low Sulfur[1]		High Sulfur		Match[2]
	Wet	Dry	Wet	Dry	Wet
DDGS	—	40.0	—	40.0	—
WDGS	40.0	—	40.0	—	31.44
High moisture corn	24.0	24.0	24.0	24.0	29.13
Dry rolled corn	16.0	16.0	16.0	16.0	19.42
Corn silage	15.0	15.0	15.0	15.0	15.0
Supplement[4]	5.0	5.0	5.0	5.0	5.0
Diet composition, % DM					
CP	16.14	15.12	17.67	16.62	15.62
Fat	6.99	7.78	6.89	8.16	6.36
NDF	23.67	21.01	21.35	19.12	19.63
Sulfur	0.40	0.40	0.54	0.54	0.40

[1]Low and High sulfur co-products being 0.82 and 1.16% S, respectively.
[2]Match: Diet containing high sulfur wet distillers grains with solubles, in amount to equal low sulfur diet sulfur content.
[3]DDGS = Dry distillers grains with solubles and WDGS = wet distillers grains with solubles.
[4]Supplements: All supplements were formulated to provide 30 g/ton of DM of Monensin, 90 mg/steer/day of Tylosin, and 150 mg/steer/day of thiamine.

Table 2. Dry matter digestibility, pH variables and volatile fatty acids of diets containing wet or dry DGS with high or low sulfur concentration.

Variables	Low Sulfur[1]		High Sulfur		Match[2]	P- values			
						Main effects		Inter.	Contrast
	Wet	Dry	Wet	Dry	Wet	Moisture	Sulfur	MxS	Match x Low S Wet
Intake, lb/day									
Dry matter	22.0	24.2	18.9	21.8	19.5	< .01	< .01	0.21	< .01
Hydrogen sulfide concentration, µmol/L of ruminal gas									
H_2S	7.09	0	17.2	4.95	1.87	0.06	0.13	0.81	0.15
In vivo *Digestibility, %*									
Dry matter	70.1	69.3	66.7	69.7	72.4	0.38	0.32	0.16	0.20
pH variables									
Average	5.72[b]	5.84[a]	5.86[a]	5.75[b]	5.74	0.37	0.43	< .01	0.86
Variance	0.08	0.08	0.07	0.08	0.1	0.48	0.59	0.16	0.03
Time below 5.6[3]	705[a]	408[b]	499[b]	571[a]	628	0.76	0.55	< .01	0.48
Area below 5.6[3]	114[a]	68[b]	66[b]	103[a]	121	0.76	0.55	< .01	0.56
Volatile fatty acids, mMol/100 mMol of total VFA									
Total, mMol/mL	111.7	115.8	119.5	112.7	119.7	0.50	0.69	0.14	0.19
Acetate	54.3	55.4	55.6	54.7	56.4	0.95	0.89	0.64	0.49
Propionate	22.9	23.9	20.7	21.9	20.2	0.18	0.01	0.92	0.23
A:P ratio	2.41	2.49	2.72	2.60	2.83	0.88	0.13	0.47	0.16
Butyrate	16.9	14.8	18.6	17.0	18.4	0.10	0.08	0.82	0.89

[1]Low and High sulfur co-products being 0.82 and 1.16% S, respectively.
[2]Match: Diet containing high sulfur wet distillers grains with solubles, but just in amount enough (31.44%) to target low sulfur diet content.
[3]Time below pH 5.6, min; Area below pH 5.6, min*pH.

were studied. Day was accounted as a repeated measure for pH and intake. Period was a repeated measure for DMD, and time point for VFA data. A single degree-of-freedom contrast was used to compare the Match diet with low sulfur wet DGS diet.

Results

No interaction ($P > 0.16$) was observed between moisture and S for DMI, DMD, or H_2S concentration. Steers fed dry DGS had greater DMI ($P < 0.01$) than steers fed wet DGS. Likewise, steers fed low S DGS consumed more ($P < 0.01$) than steers fed high S DGS (Table 2). Similar effects for DMI were also observed for steers fed identical diets in a growth study (*2011 Nebraska Beef Cattle Report*, pp. 62-64). Lower intake observed for steers fed wet DGS was probably due to greater energy for wet DGS compared to dry DGS. Steers fed high S DGS also had lower DMI than steers fed low S DGS. Dry matter intake was greater ($P < 0.01$) when wet low S DGS at 40% was compared to wet high S at 31.44% inclusion (Match). Lower level of co-product inclusion and more corn (8.56%), not dietary S, may cause the DMI effect.

Greater ($P = 0.06$) H_2S concentration was observed for wet DGS compared to dry DGS (Table 2). Diets containing wet DGS appear to provide greater availability of sulfur for microorganism fermentation and subsequent H_2S production. This observation matches with the lower DMI and ADG observed by steers fed high sulfur wet DGS in the growth performance study (*2011 Nebraska Beef Cattle Report*, pp. 62-64). When included at 40% of diet DM, high S DGS tended ($P = 0.13$) to increase ruminal H_2S concentration compared to low S DGS.

An interaction between moisture and S was observed for average of ruminal pH ($P < 0.01$). Steers fed high S wet and low S dry DGS had greater average pH compared to low S wet and high S dry DGS. Also, greater time and area below pH 5.6 were observed for steers fed low S wet and high S dry DGS, but these differences were subtle. Dry matter digestibility was not affected by sulfur concentration or types of DGS (Table 2), which does not explain performance differences.

No difference was observed for acetate molar proportion in ruminal fluid samples. However, steers fed high sulfur diets showed lower ($P = 0.01$) propionate concentration and tended ($P = 0.13$) to show greater A:P ratio compared to low sulfur diets. There was no interaction of sulfur x moisture for butyrate concentration. However, steers fed wet DGS and high sulfur diets showed greater ($P \leq 0.10$) concentration of this VFA compared to dry and low sulfur treatments (Table 2).

Sulfur of DGS impacts DMI and ruminal H_2S production, which may be more pronounced with wet DGS. Ruminal propionate and butyrate concentrations were also affected by high sulfur DGS diets.

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