Factors Affecting Ruminal Hydrogen Sulfide Concentration of Cattle

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Summary and Implications

Ruminal hydrogen sulfide concentrations may be a useful tool to determine risk of cattle developing sulfur-induced polioencephalomalacia. In this study, steers were fed a low sulfur (0.2% S) or a high sulfur diet (0.7% S) and ruminal hydrogen sulfide concentrations were measured. Although differences in ruminal hydrogen sulfide due to sulfur intake were maintained throughout the day, concentrations within treatment varied greatly throughout the day. Ruminal hydrogen sulfide concentrations peaked during the period from 6 to 10 hours after feeding. More research is needed to develop a threshold of ruminal hydrogen sulfide that may cause polioencephalomalacia. Additionally, time of sampling after feeding will need to be standardized for this risk assessment method to be successful.

Introduction

Sulfur content is one of the major limiting factors of ethanol co-product inclusion in beef feedlot diets. When large amounts of sulfur are fed to ruminants, the compound can be reduced to toxic hydrogen sulfide (H_2S) by ruminal bacteria. The ruminal H_2S is then eructated and subsequently inhaled by cattle, which can lead to polioencephalomalacia (PEM), commonly referred to as polio or brainers. PEM is characterized by aimless wandering or circling, blindness, head-pressing, ataxia, muscle tremors, and, in severe cases, convulsions and death. The term PEM describes the lesions that can be observed in the brain of sick animals; unfortunately, these lesions and symptoms also can be caused by lead poisoning, water deprivation and thiamine deficiency. Therefore, diagnosing sulfur-induced PEM can be difficult and there are currently no tests available that can be performed to quantify the risk for sulfur-induced PEM, or to definitively diagnose sick animals with sulfur-induced PEM. It has been suggested that ruminal H_2S concentrations could be used as a tool to assess risk of cattle developing sulfur-induced PEM and as a diagnostic tool for veterinarians. However, little is understood about how ruminal H_2S varies throughout the day and thus how time of sampling would affect potential conclusions drawn from this measurement. Additionally, ruminally cannulated cattle provide an excellent opportunity to gather information about ruminal effects of dietary sulfur. It is, however, unclear if rumen cannulation affects H_2S production and retention. Therefore, the objectives of this study were to determine the effects of dietary sulfur intake, time of sampling relative to feeding, and rumen cannulation on ruminal H_2S.

Materials and Methods

Sixteen steers (8 cannulated; 781 lbs; and 8 unmodified; 849 lbs) were used in a 2x2 factorial design with the two factors being cannulation status and dietary treatment (trt). Dietary trt consisted of a low sulfur (0.2% S; LS) wheat midd-based pellet or the same ingredients plus sodium sulfate to achieve a high sulfur (0.7% S; HS) pellet. Steers were blocked to pairs by cannulation status and body weight (BW) and pair-fed between trt to eliminate differences in intake among trt. During the first 7 days of adaptation to the new diet, the amount of diet offered was based on initial BW. On day 1 of diet adaptation, steers were fed 1% of BW and for the next 6 days the amount fed was increased by 0.25% BW each day. Then, starting on d 8, the HS steers were fed 110% of their previous day's intake of pellets and the LS steers were pair-fed 105% of their HS counterpart. All steers were fed chopped bromegrass hay at 5% of pellet intake. Eight steers (4 pairs) at a time were housed in stalls with individual feeders and water cups. Ruminal gas was sampled from all cattle on d 8, 11, 15, 22, 27, and 29 at 8 h post-feeding. Serial H_2S measures were collected from cannulated steers pre-feeding and 2, 4, 6, 10, 12, 16, and 20 h post-feeding on d 22. Kitagawa detector tubes were used to measure H_2S. Results were analyzed using PROC MIXED of SAS (SAS Inst. Inc., Cary, NC).

Results and Discussion

As designed, daily DM intake did not differ ($P = 0.80$) between trt (13.38 vs 13.53 lbs/hd for LS and HS, respectively). Timing of sampling relative to feeding affected ($P = 0.01$) ruminal H_2S (Table 1). Based on these, data samples taken prior to feeding will have much lower concentrations than those taken after feeding. Hydrogen sulfide peaked around 6 to 10 hours after feeding. Hydrogen sulfide was not affected by cannulation ($P = 0.35$). There was a tendency for trt by day ($P = 0.07$) interaction for H_2S measured at 8 h post-feeding (Table 2). Hydrogen sulfide at 8 hr post-feeding did not differ ($P > 0.05$) between dietary trts on the first day of full feed. However, H_2S was greater ($P < 0.05$) for HS than LS on the rest of the sampling days.

The mean 8 hr post-feeding concentration of H_2S for HS was 6005 ± 614 ppm and was 1639 ± 168 ppm for LS.

It has been suggested by other researchers that H_2S concentrations above 2000 ppm in the rumen are associated with PEM. In this study, ruminal H_2S concentrations of the LS steers were at or above 2000 ppm at several time points during the day (Table 1) and HS steers were consistently above this threshold (Table 1 and 2). However, only one steer fed the HS diet developed clinical signs of PEM during this trial. This steer had H_2S concentration of 12,000 ppm several days prior to the onset of PEM. The H_2S concentration of this steer after the onset of clinical signs of PEM was only 1,000 ppm, suggesting that ruminal H_2S would not be a good diagnostic tool to definitively diagnose sick animals. More research is needed to develop a threshold of ruminal H_2S that will induce PEM. Additionally, a standard time after feeding at which the samples are taken will need to be used in order to reduce variation in the measurement.

Acknowledgments

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Table 1. Concentration of ruminal hydrogen sulfide (ppm) over the course of a day of steers fed a low sulfur (0.2% S) or a high sulfur (0.7%) pelleted diet.

	Hour relative to feeding							
Treatment	0	2	4	6	10	12	16	20
Low sulfur	307^{e}	1938de	2388de	2300de	2238de	2233de	1208de	713^{e}
High sulfur	2589^{cd}	5938^{b}	7813^{ab}	8597^{a}	8375^{a}	7625^{ab}	1950^{cde}	3712^{cd}
SEM[1]	1035	1011	1011	1035	1297	1011	1011	1035

$^{a-e}$ means lacking common superscripts differ ($P < 0.05$)
[1]SEM is standard error of the mean

Table 2. Ruminal hydrogen sulfide (ppm) concentrations of steers fed a low sulfur (0.2% S) or a high sulfur (0.7%) pelleted diet for 29 days[1].

	Treatment	
Day of Trial	Low sulfur	High sulfur
8	704^{d}	2271^{cd}
11	825^{d}	4500^{bc}
15	1119^{d}	8813^{a}
22	2273^{cd}	5459^{ab}
25	2152^{cd}	5173^{ab}
29	2133^{cd}	7102^{ab}
SEM[2]	168	614

$^{a-d}$ means lacking common superscripts differ ($P < 0.05$)
[1]Trt ($P < 0.01$); Day ($P = 0.02$); Trt x Day ($P = 0.07$)
[2] SEM= standard error of the mean