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Effects of molybdenum supplementation on performance of forage-fed steers receiving high-sulfur water ¹

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SUMMARY

There has been on-going research in the area of the consumption of high-sulfur (S) water by steers grazing rangeland as well as forage-fed steers in a feedlot setting. During the summer of 2009, a trial was conducted on the effects of high-S water in finishing steers supplemented with molybdenum (Mo). The main purpose of the research was to gather data that may aid in the formulation of a supplement to counteract the negative effects of high-S water consumed by ruminant livestock species in areas where sulfur concentration in water sources is a risk to animal health and performance. The specific focus of this trial was to determine whether the feeding of supplemental Mo would improve animal health and performance by decreasing the formation of hydrogen sulfide gas (H₂S) in the rumen. Yearling steers (n=96) were used for a 56-d trial. The trial consisted of 3 treatment groups; a low-S water group and two high-S water groups. One high-S water treatment group received the same pellet that the low-S group was given and the other high-S water treatment group received a pellet with supplemental Mo included. Rumen gas cap H₂S was collected on d -1, 29 and 57. Weights were recorded on d -2, -1, 29, 56 and 57. There were no differences between treatments in water intake ($P= 0.719$), but feed intake was reduced in the steers receiving the supplemental Mo ($P < 0.001$). There was a significant difference in ruminal H₂S due to treatment ($P= 0.014$), with higher ruminal H₂S in the steers receiving the supplemental Mo. Steers receiving the Mo supplement had lower ADG than steers in the other treatments ($P= 0.009$). Throughout the duration of the trial, two steers were removed from the trial due to advanced symptoms of sulfur-induced PEM (sPEM) from the high-S treatment with no supplemental Mo.

INTRODUCTION

Reliable drinking water sources are important and necessary for success in any livestock production. Many parts of the United States including South Dakota have recently seen problems in the quality of their livestock water sources due in large part to increasing and sustained drought conditions. Drought conditions result in higher concentrations of mineral salts in surface and ground water. In the western high plains, sulfur has been found to be problematic, especially for ruminant species. Excess intake of sulfur in ruminants causes over production of free sulfide in the rumen that can interfere with cellular membranes and can bind with hydrogen to form the toxic gas, H₂S. Of primary concern with high-S

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water intake is its association with the neurological disorder, sulfur-induced polioencephalomalacia (sPEM). This disorder is diagnosed by the presence of cerebrocortical lesions in the gray matter of the brain. The purpose of this study was to determine if the addition of Mo to the diet could aid in the binding of sulfur so it would not be reduced to sulfide. If this supplement is successful, it could provide producers with a way to reduce animal and profit losses from the detrimental effects of livestock consumption of high-S water.

MATERIALS AND METHODS

This study was conducted at South Dakota State University's Cottonwood Range and Livestock Research Station, near Philip, SD in the summer of 2009. Yearling steers (n=96) used in this experiment were composed of British breeds (Angus and Angus by Hereford crossbreds) with an initial body weight of 636 ± 87 lb. Steers were stratified by weight to one of three treatment groups (n=32), four pens with eight steers per pen for each treatment group, for a 56-d trial: low-S water (LS, $375 \text{ mg} \cdot \text{kg}^{-1}$), high-S water (HS, $2,218 \text{ mg} \cdot \text{kg}^{-1}$) and high-S water (HSMO, $2,218 \text{ mg} \cdot \text{kg}^{-1}$) with $100 \text{ mg Mo} \cdot \text{kg}^{-1}$ of feed DM. All steers received $10 \text{ mg} \cdot \text{kg}^{-1}$ of supplemental Cu as tribasic copper chloride (TBCC). Copper was included in treatments because its availability to the animal has been shown to be decreased in the presence of Mo and S (Engle, 2005).

On d -1, 29 and 57, rumen gas cap H_2S levels were collected. A modified method described by Loneragan et al. (1998) was used for the collection of these data. Also, it has been indicated by Loneragan et al. (1998) that high sulfide levels in the rumen are associated with high levels of sulfur intake and lead to an increased incidence of sPEM. Hydrogen sulfide concentrations were collected to determine the changes in rumen gas production in the presence of high-S water. Weights were recorded d -2, -1, 29, 56 and 57.

Feed was offered at 105% of the average of consumption for the previous 3 days. Feed refusals were collected and weighed each morning. Feed supplements were provided following refusal collection and at the same time hay was delivered to each bunk. The diet consisted of 50:50 ground hay and pellet supplement. The pellet formulation was primarily wheat middlings plus the supplemental minerals. The hay was grass hay, with the goal of mimicking the nutritive value of summer pasture.

Water was administered once, and sometimes twice, daily to each pen according to treatment. Water consumption was calculated by the daily change in water depth in each tank and adjusted for precipitation and evaporation for each given day. These measurements were taken at the onsite weather station.

High-S water was mixed for the trial using a Dosatron® injection pump with sodium sulfate (Na_2SO_4) as the source of additional S added to rural water. High-S water was mixed into large water storage tanks and distributed to each pen receiving high-S water. A large water storage tank also was filled with rural water for those pens receiving low-S water.

Animals in the feedlot were monitored 3 times daily for general health and symptoms of sPEM. Physical symptoms associated with sPEM include blindness, staggers, head pressing, repetitive chewing with the grinding of teeth on palate, muscle tremors and seizures. Steers were removed from the trial and treated when they displayed staggers or any three other early symptoms including separation from herd, anorexia, diarrhea, and muscle tremors. Steers exhibiting blindness, head pressing, repetitive chewing or star gazing were removed and treated immediately. Steers that were removed in this trial were provided with low-S water, hay and pellets from the treatment they were in. They were

administered thiamine at 5 ml per lb IM, twice daily, dexamethasone and B-complex each at 2 ml per 100 lb IM, once daily and drenched with 5 gallons of water once daily. In days 2-7 of treatment thiamine and dexamethasone were administered at the same level as the first day of treatment. Drenching continued, however; the B-complex was stopped and Probios[®] was given on alternate days starting on day 3.

The preliminary results for this trial were analyzed using the MIXED procedure in SAS (SAS Institute, Cary, NC). Significance was indicated by *P*-values with alpha less than or equal to 0.05 and trends by *P*-values less than 0.1.

RESULTS AND DISCUSSION

The data collected from this trial were analyzed for treatment, period, and treatment by period interactions to detect changes that may have occurred early on in the trial and then dissipated or changes that occurred later in the trial. The periods were as follows: first period is the length of time from initial to mid-trial data collection day and the second period is the length of time from the mid-trial to the final data collection day.

Overall there were no significant differences in water intake between treatments (*P*= 0.719), with similar response within periods (Table 1). However, there was a significant difference in feed intake due to treatment (*P* < 0.001). Overall, from initial to final feeding there was a significant difference between LS and HSMO (*P*= 0.0004) and between HS and HSMO (*P*= 0.002) steers. Overall (across both periods), there were differences seen in ADG with comparisons of LS and HSMO (*P*= 0.0002) and HS and HSMO (*P*= 0.0004) being significant.

Table 1. Treatment means for water intake, feed intake, ADG, and ruminal H₂S

Treatment ¹	LS	HS	HSMO	SEM	<i>P</i> ²
Water intake, gal/hd/d	13.0	12.5	12.8	0.4	0.719
Feed intake (as fed basis), lbs/hd/d	23.9 ^a	22.7 ^a	17.1 ^b	0.77	<0.001
ADG, lb/d	2.48 ^a	1.50 ^{ab}	0.91 ^b	0.36	0.009
H ₂ S, mg•kg ⁻¹	54 ^a	150 ^a	400 ^b	58.1	0.014

¹ Treatments include: low-S water (LS), high-S water (HS), and high-S water with Mo (HSMO)

² Probability of a greater F

^{a,b} Means (in a row) without a superscript in common are different (*P* < 0.05)

Differences in hydrogen sulfide concentration in the ruminal gas cap among treatments were compared across sample dates (initial, midpoint, and final). There was a significant overall increase in the amount of H₂S gas accumulated in the rumen of HSMO steers (*P*= 0.014) compared to the LS and HS steers (Table 1). These differences among treatments were not different among the sample dates. These results were opposite to our expectation of lowering ruminal H₂S with the use of supplemental Mo.

Two steers were removed from the trial from the HS treatment group due to advanced symptoms of sPEM including blindness, anorexia and staggers. Out of these two steers, one died and we were able to confirm sPEM based on postmortem diagnostic evaluation of brain tissue at the Animal Disease

Research and Diagnostic Laboratory at South Dakota State University. The report concluded that the brain revealed multiple areas of cell death and softening in the gray matter characteristic of sPEM. In addition, we observed incidences of diarrhea in those pens supplemented with Mo, suggesting potential toxicity from the supplemental Mo.

These preliminary results suggest the use of a Mo supplement was not effective to bind S in the rumen. In addition, there were no differences in water consumption between treatments but there was a marked decline in feed consumption in animals on high-S water with the Mo supplement. Also, ADG in HSMO steers was greatly inhibited. Mo did not provide relief from the negative effects of high-S consumed by forage-fed steers.

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