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K.L. Kessler

South Dakota State University

K.C. Olson

South Dakota State University

C.L. Wright

South Dakota State University

K.J. Austin

South Dakota State University

P.S. Johnson

South Dakota State University

See next page for additional authors

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Authors

K.L. Kessler, K.C. Olson, C.L. Wright, K.J. Austin, P.S. Johnson, and K.M. Cammack



Copper supplementation of grazing yearling steers supplemented with molybdenum while consuming high-sulfur water¹

K. L. Kessler*², K. C. Olson†³, C. L. Wright†³, K. J. Austin*⁴, P. S. Johnson†⁵, and K. M. Cammack*⁶

*Department of Animal Science, University of Wyoming

†Department of Animal and Range Sciences, South Dakota State University

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SUMMARY

There has been on-going research conducted by South Dakota State University in the area of the consumption of high-sulfur (S) water by steers grazing rangeland. During the summer of 2009 a trial was conducted in cooperation with the University of Wyoming on the effects of copper supplementation of grazing pasture steers supplemented with molybdenum (Mo), while drinking high-sulfur water. The main purpose of this experiment was to gather data that may aide in the formulation of a method to counteract the negative effects of high-S water consumed by ruminant livestock species in areas where sulfur concentrations in water sources causes risk to animal health and performance. Yearling steers (n=120) were assigned randomly to 9 replicate groups, 3 replicates of 3 treatments for a 52 d experiment. All groups were provided with high-S water containing on average 2,201 mg•kg⁻¹ of sulfate. Additionally, all treatment groups received 100 mg•kg⁻¹ of supplemental Mo as an antagonist that would bind excess S. Unfortunately, Mo also binds copper (Cu), indicating that supplemental Cu may be necessary. Therefore treatments differed in level of supplemental copper: treatments 1 through 3 received 0, 75, or 150 mg•kg⁻¹ of supplemental Cu, respectively. Prior to the trial, mid-trial and at the conclusion of the trial, ruminal H₂S gas cap levels were collected. Animal weights were recorded d -2, -1, 28, 52 and 53. Over the entire course of the experiment there was a significant difference in ADG due to treatment ($P < 0.001$). There were no differences in water consumption as a result of treatment ($P = 0.618$). No differences were observed in ruminal H₂S due to treatment. No animal losses occurred due to the consumption of high-S water in this trial.

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 problems in the quality of their livestock water sources because of high-S content. Drought conditions result in higher concentrations of minerals of which sulfur has been reported to be most problematic, especially for ruminant species. Excess intake of S in ruminants causes an overproduction of free sulfide in the rumen that can interfere with cellular membranes and can bind with hydrogen to form the toxic gas, hydrogen sulfide (H₂S). Of primary concern with high-S water intake is its association with the neurological disorder, sulfur-induced

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² Graduate student.

³ Associate professor.

⁴ Senior research scientist.

⁵ Professor.

⁶ Assistant professor.

polioencephalomalacia (sPEM). This disorder is diagnosed by the presence of cerebrocortical lesions in the gray matter of the brain. If a supplement can be formulated that is successful in reducing sPEM, it could provide producers with a way to reduce animal and profit losses from the detrimental effects of livestock consumption of high-S water. This study was part of an effort to determine whether the addition of Mo to the diet could aid in the binding of the free S so that it would be unable to form sulfide or H₂S gas or damage cellular membranes. If supplemental Mo successfully binds excess S, it will probably also bind dietary Cu, causing a copper deficiency. This specific experiment was designed to evaluate a range of supplemental copper levels for steers receiving supplemental Mo while consuming high-S drinking water.

MATERIALS AND METHODS

The study was conducted at South Dakota State University's Cottonwood Range and Livestock Research Station, near Philip, SD in the summer of 2009. The pasture trial length was 52 days using 120 yearling steers that were assigned randomly to nine pasture groups. Steers were composed of British breeds (Angus and Angus by Hereford crossbreds) with an initial body weight of 574±110 lb. Three replicate groups were each assigned to 1 of 3 treatments. All steers in the 9 pastures were provided with high-S water containing on average 2,201 mg•kg⁻¹ of sulfate. All steers also received 100 mg Mo•kg⁻¹ of estimated feed DM intake. The differences between the treatments were in varying levels of copper provided in the supplement. Treatment 1 received 0 mg•kg⁻¹ Cu (0Cu), treatment 2 received 75 mg•kg⁻¹ Cu (75Cu), and treatment 3 received 150 mg•kg⁻¹ Cu (150Cu).

At trial initiation, mid-trial and at the conclusion of the trial, rumen gas cap H₂S levels were collected using a similar method as described by Loneragan et al. (1998) on days -2, 28 and 52. It has been indicated by Loneragan (1998) that high H₂S levels in the rumen are associated with high levels of S intake and lead to an increased incidence of sPEM. Steer weights were recorded d -2, -1, 28, 52 and 53.

High-S water was mixed for the trial using a Dosatron® injection pump with sodium sulfate (Na₂SO₄) as the source of additional S added to rural water. A 50 gallon batch of high-S water concentrate was made daily and used for dilution using the Dosatron to the target sulfate concentration of 2,500 mg•kg⁻¹ (actual concentration achieved was 2,201 mg•kg⁻¹). The high-S water for the livestock was mixed into a large water storage tank and hauled for distribution to each pasture. Water samples also were collected from each batch and analyzed to confirm sulfate levels achieved.

High-S water was administered once, and sometimes twice, daily to each pasture. Water consumption was calculated by the daily change in water depth in each stock tank and adjusted for precipitation and evaporation for each given day. These measurements were recorded at the on-site weather station.

Pellets containing 100 mg•kg⁻¹ Mo and varying levels of Cu (0, 75 and 150 mg•kg⁻¹) were delivered daily during mid to late morning to each pasture in the quantities of 2 lbs per head per day. There were no supplement refusals from any of the treatment groups.

Animals were monitored daily for general health and symptoms of sPEM at the time of feed and water distribution. If animals were not near bunks or tanks, they were found in the pasture and evaluated for health. The physical symptoms that are associated with sPEM and used for animal evaluation in the pastures include blindness, staggers, head pressing, repetitive chewing with the grinding of teeth, muscle tremors and seizures. Footrot was a recurring problem that was treated as necessary.

The preliminary results for this trial were analyzed using the MIXED procedure in SAS (Statistical Analysis Software) to detect differences among levels of copper supplementation. Significance was indicated by *P*-values with alpha less than 0.05 and trends by *P*-values less than 0.10.

RESULTS AND DISCUSSION

No differences in water intake were observed by steers as a result of treatment (*P*= 0.618). Overall means for 0Cu, 75Cu, and 150Cu were 9.73, 9.60 and 10.09 ± 0.35 gallons per head per day, respectively.

Analysis of average daily gain (ADG) (Table 1) revealed that there was a significant treatment by period interaction (*P* = 0.038), meaning that the response to Cu treatments was different in period 1 than period 2. During period 1, ADG increased (*P* = 0.035) in a quadratic fashion as level of supplemental Cu increased, meaning that it increased from the 0 to 75 mg•kg⁻¹, then decreased slightly from 75 to 150 mg•kg⁻¹. However, in period 2, ADG increased in a linear fashion (*P* = 0.002) as Cu supplementation increased, meaning that ADG continually increased with each increment of additional supplemental Cu.

Table 1. Treatment means for ADG (lb/d) for each period

Item	Treatment ¹			<i>P</i> -value ⁵	
	0 mg•kg ⁻¹ Cu	75 mg•kg ⁻¹ Cu	150 mg•kg ⁻¹ Cu	Linear	Quadratic
1 st period ²	0.75 ± 0.33 ^a	2.07 ± 0.14 ^b	1.93 ± 0.18 ^b	0.035	0.035
2 nd period ³	1.87 ± 0.09 ^a	2.31 ± 0.01 ^a	3.16 ± 0.15 ^b	0.002	0.077

¹Level of Cu in each treatment

²1st period is time between initial and mid-trial weights.

³2nd period is time between mid-trial and final weights.

⁴Overall is the overall length of the trial from initial to final weights.

⁵Probability of a greater F.

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

Statistical analysis of ruminal H₂S revealed no differences due to treatment (*P*= 0.361). No animal losses were seen due to the consumption of high-S water.

This trial revealed that the addition of Mo with varying levels of Cu had no effect on the production of H₂S in the rumen gas cap. Additionally, analysis revealed that ADG was reduced in animals that were not provided with supplemental Cu in the presence of supplemental Mo.

LITERATURE CITED

Loneragan, G. H., D. H. Gould, R. J. Callan, C. J. Sigurdson, and D. W. Hamar. 1998 Association of excess sulfur intake and an increase in hydrogen sulfide concentrations in the ruminal gas cap of recently weaned beef calves with polioencephalomalacia. *J. Am. Vet. Med. Assoc.* 213:1599-1604.