

# Comparison of Trace Mineral Repletion Strategies in Beef Cattle to Overcome a High Antagonist Diet

## A.S. Leaflet R3224

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### Summary and Implications

It was observed that diets with high sulfur and molybdenum decreased markers of copper, selenium, and manganese after 90 d. In a 62-d trace mineral repletion period, steers receiving an injection of Multimin90 had the most rapid improvement of copper and selenium status by d 14, while it took 28 d and 42 d for copper and selenium status to improve in steers supplemented with 150% of national recommended concentrations from either an inorganic and organic blend, or only inorganic trace minerals. Further research is needed to understand the optimal trace mineral supplementation strategy to overcome dietary antagonisms without creating economic loss for producers.

### Introduction

Greater inclusions of ethanol coproducts in feedlot diets have resulted in higher concentrations of dietary sulfur (S), which can antagonize trace mineral (TM) absorption in the rumen. This antagonism is especially powerful when molybdenum (Mo) is present. These ruminal interactions create the unique challenge of supplementing TM in a method that can effectively bypass ruminal antagonism for absorption in the small intestine. Previous research has suggested some organic TM are ruminally insoluble and more available than inorganic TM for absorption in the small intestine. Additionally, injectable TM have been shown to rapidly improve TM status by providing TM directly to the tissues through subcutaneous injection. The objective of this study was to compare the effectiveness of TM repletion strategies on TM status of steers fed diets containing the antagonists S and Mo.

### Materials and Methods

This study was conducted at the Beef Nutrition Farm of Iowa State University. Sixty-two Red Angus steers were blocked by body weight ( $560 \pm 14$  lbs) into a heavy and light group and assigned to one of two corn-silage based depletion diets (DEP) which were fed for the entirety of the trial. Depletion diets were either supplemented with Cu, Mn, Se, and Zn at NRC (1996) recommendations (control, CON), or not supplemented with these TM. The latter were supplemented with 0.3% S ( $\text{CaSO}_4$ ) and 2 mg of Mo/kg DM to deplete TM status (antagonist, ANT). Steers were housed

in pens (6 per pen) equipped with GrowSafe bunks. On d 89 steers were blocked within DEP to one of three trace mineral repletion strategies (REP). Strategies were as follows: 1) an injectable TM (Multimin90) containing Cu, Mn, Zn, and Se, and dietary TM supplemented at 100% of nationally recommended concentrations (NASEM, 2016) from strictly inorganic sources (ITM), 2) a sterilized saline injection and TM supplemented at 150% of NASEM (2016) recommendations from strictly inorganic sources (ING), or 3) a sterilized saline injection and TM supplemented at 150% of NASEM (2016) recommendations from a blend of 75% inorganic and 25% organic sources (BLEND). These treatments resulted in a  $2 \times 3$  factorial design consisting of 6 treatments for the 62 d TM repletion period ( $n = 12$  steers per treatment). Injections were administered subcutaneously at a rate of 1 mL per 150 lbs BW.

*Sample Collection.* Liver biopsies were collected at the start (d -2 or d -1) and end (d 79 or d 80) of the depletion period, and on d 14, d 28, and d 42 of the repletion period.

*Statistical Analysis.* Data for the depletion period were analyzed using the GLIMMIX procedures of SAS 9.4 with steer as the experimental unit ( $n = 36$  per treatment). Data for the repletion period were analyzed as a  $2 \times 3$  factorial design using the GLIMMIX procedures of SAS 9.4 with steer as the experimental unit ( $n = 12$  per treatment). Liver TM and RBCL enzyme activity data were analyzed as repeated measures using day as the repeated effect.

### Results

*Depletion Period.* Trace mineral status of Cu, Mn, Se, and Zn were not different at the start of the trial. At the end of the depletion period liver concentrations of Cu and Se were decreased in ANT compared to CON ( $P < 0.0001$ , **Table 1**). Regardless of initial status, liver Cu was decreased approximately 90% in ANT compared to CON, liver Se was decreased approximately 40%, liver Mn concentrations were also decreased in ANT compared to CON and liver Zn concentrations were unaffected at the end of depletion. At the end of depletion, plasma concentrations of Cu, Fe, Se, and Zn were decreased in ANT relative to CON ( $P \leq 0.03$ ), plasma Mo was greater in ANT than CON ( $P < 0.0001$ ), and Mn-dependent superoxide dismutase (Mn-SOD) tended to be lesser in ANT than CON ( $P \leq 0.09$ ).

*Repletion Period Liver TM.* There were no interactions between DEP diet and REP strategy ( $P \geq 0.15$ ), suggesting the pattern of TM repletion within a REP strategy was similar across diets, with or without antagonists. Although ANT had lesser Cu status at the start of repletion than CON, both treatments receiving ITM increased liver Cu by approximately 44 mg Cu/kg DM when measured 14 d post injection ( $P < 0.0001$ ). Liver Cu was improved by d 14 in

ITM, while it took 28 d and 42 d for Cu status to improve in steers supplemented with 150% of national recommended concentrations from BLEND and ING treatments, respectively ( $P < 0.0001$ , **Figure 1**). Similarly, liver Se was improved by d 14 in ITM, on d 28 ITM and BLEND were greater than ING, and there were no differences due to repletion treatment on d 42 ( $P < 0.0001$ , **Figure 1**). Due to random treatment assignments, steers assigned to receive ITM had lesser Mn concentrations at the start of the repletion period. Interestingly, while there was a decrease in liver Mn concentrations of BLEND and ING on d 14, steers receiving ITM maintained their status at this time (data not shown).

*Repletion Period Antioxidant Activity.* In the repletion period, Mn-SOD activity was lesser on d 14 and d 28 relative to other collection days ( $P < 0.0001$ ). A similar trend was noted for Se- dependent antioxidant glutathione peroxidase, where lesser activity was recorded on d 14 ( $P = 0.07$ ). The decrease of these antioxidants could indicate a greater antioxidant utilization at this time in response to greater temperatures.

### Conclusions

In conclusion, greater concentrations of S and Mo greatly decreased Cu status in beef cattle, and had negative effects on Se, Mn, and Zn status. The use of an injectable trace mineral most rapidly improved TM status of steers from a deficient to mildly deficient, or adequate state. These data suggest any of the TM supplementation strategies utilized would be sufficient depending on the urgency of TM repletion, with ITM having the most rapid improvement in Cu and Se status. There were very few DEP  $\times$  REP interactions during the trial, indicating TM repletion is similar within REP strategy, regardless of presence of the antagonists S and Mo.

### Acknowledgements

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**Table 1.** Effect of depletion diet on liver mineral concentrations, plasma mineral concentrations, and red blood cell lysate glutathione peroxidase activity of feedlot steers at the end of the depletion period.

	Depletion Diet		SEM	P - value
	CON <sup>1</sup>	ANT <sup>2</sup>		
Liver mineral, mg/kg DM				
Cu <sup>3</sup>	251	23	-	0.0001
Mn	9.8	8.5	0.24	0.01
Se	2.00	1.22	0.052	0.0001
Zn	123	118	2.6	0.42
Plasma				
Cu, mg/L	0.81	0.71	0.092	0.01
Fe, mg/L	2.09	1.86	0.066	0.02
Mo, ug/L	12.8	21.1	0.47	0.0001
Se, µg/L	135	129	1.7	0.01
Zn, mg/L	1.26	1.17	0.019	0.03
Red blood cell lysate				
GSH-px, U × 10 <sup>3</sup> /g Hb <sup>4</sup>	145.3	143.5	2.52	0.62
Mn-SOD, U × 10 <sup>3</sup> /g Hb <sup>5</sup>	2.91	2.57	0.142	0.09

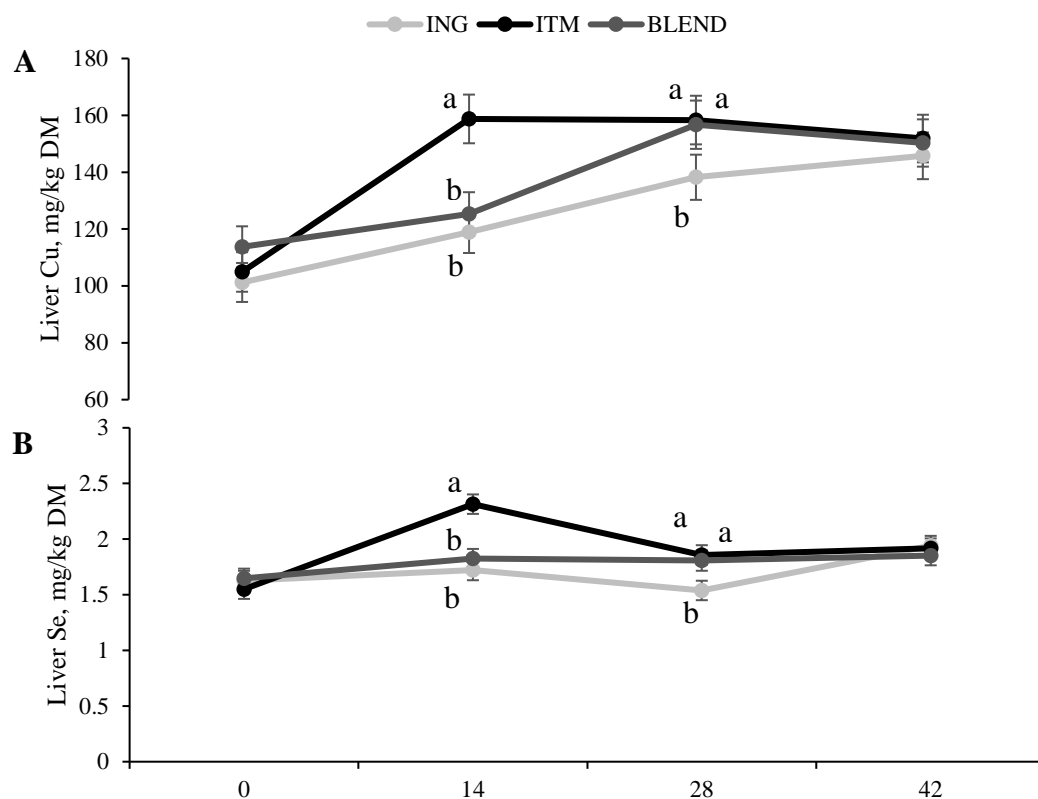
<sup>1</sup>Control diet provided supplemental trace minerals per kg diet DM: 10 mg of Cu (copper sulfate), 30 mg of Zn (zinc sulfate), 20 mg of Mn (manganese sulfate), 0.5 mg of I (ethylenediamine dihydriodide), 0.1 mg of Se (sodium selenite), and 0.1 mg of Co (cobalt carbonate).

<sup>2</sup>Antagonist diet provided supplemental trace minerals per kg diet DM: 0.5 mg of I (ethylenediamine dihydriodide), 0.1 mg of Co (cobalt carbonate), and 2 mg Mo/kg DM, as well as 0.3% S (as CaSO<sub>4</sub>).

<sup>3</sup>CON liver Cu SEM is 8.1 mg/kg DM and ANT liver Cu SEM is 2.5 mg/kg DM.

<sup>4</sup>Glutathione peroxidase activity unit is defined as the amount of enzyme necessary for the oxidation of 1.0 nmol of reduced NADPH to NADP<sup>+</sup> per minute at 25°C.

<sup>5</sup>Manganese superoxide dismutase activity is defined as the amount of enzyme required to exhibit 50% dismutation of the superoxide radical.



**Figure 1.** Effect of trace mineral replenishment strategy × day of replenishment period on liver Cu (**Panel A**,  $P < 0.0001$ ) and liver Se (**Panel B**,  $P < 0.0001$ ) concentrations. ITM is Multimin90 injection containing Cu, Mn, Se, and Zn and 100% NASEM (2016) supplemental dietary Cu, Mn, Se, and Zn from inorganic sources; BLEND is 150% of NASEM (2016) dietary Cu, Mn, Se, and Zn supplementation from 25% organic and 75% inorganic sources; ING is 150% of NASEM (2016) dietary Cu, Mn, Se, and Zn supplementation from entirely inorganic sources. Within a panel, within a day, superscripts that differ are different ( $P \leq 0.06$ ).