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Effects of Trace Mineral Supplementation and Source, 30 Days Post-weaning and 28 Days Post Receiving, on Performance and Health of Feeder Cattle*

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ABSTRACT : Three hundred and seventy-five steers (approximately 7 mo of age and 239.0±10.4 kg) were utilized to determine the effects of trace mineral (TM) supplementation and source on performance during the on-farm backgrounding and feedlot receiving phases of beef cattle production. At their respective ranches, steers were stratified by body weight into six groups. Groups were then assigned to one of six pens and pens were randomly assigned to treatments. Treatments consisted of: 1) control (no supplemental Cu, Zn, Mn, and Co), 2) inorganic trace mineral ($CuSO_4$, $ZnSO_4$, $MnSO_4$, and $CoCO_3$), and 3) organic trace mineral (iso-amounts of organic Cu, Zn, Mn, and Co). Mineral treatments were fed in alfalfa pellets formulated to supply 360 mg of Zn, 200 mg of Mn, 125 mg of Cu, and 12.5 mg of Co per head per day from either organic or inorganic trace mineral sources. Control steers received alfalfa pellets with no additional Cu, Zn, Mn, or Co. Steers were allowed free access to harvested alfalfa-grass hay throughout the 30-d on-farm backgrounding phase. On day 30 post-weaning, steers were weighed and transported to the feedlot. Steers were blocked by treatment within ranch, stratified by initial body weight, and randomly assigned to one of 36 pens (9-12 head per pen; 12 pens per treatment). Steers remained on the same on-farm backgrounding trace mineral treatments, however, trace mineral treatments were included in the total mixed growing ration. Steers were fed a corn silage-based growing diet throughout the 28 d feedlot receiving period. There was no effect of TM supplementation on performance of steers during the on-farm backgrounding phase. By the end of the 28-d feedlot receiving phase, ADG was similar between control and trace mineral supplemented steers. Steers supplemented with organic TM had greater ($p<0.05$) ADG than steers supplemented with inorganic TM by the end of the 28-d feedlot receiving phase. Morbidity and mortality rates were similar across treatments. (**Key Words :** Cattle, Trace Minerals, Backgrounding, Health, Performance)

INTRODUCTION

Feeder cattle can be exposed to numerous stressors during the production process such as transportation and arrival to a new feedlot environment (Hutcheson and Cole, 1986; Hutcheson, 1989). Stress induced by transportation and a new environment can potentially cause lower dry matter intakes and increased susceptibility to respiratory tract and other infectious diseases in cattle (Hutcheson and Cole, 1986; Hutcheson, 1989).

Zinc (Zn) and copper (Cu), and to some extent manganese (Mn), and cobalt (Co), have been shown to play a role in the immune response of cattle (Underwood, 1971; McDowell, 1992; Galyean et al., 1999; Spears, 2000; Goswami et al., 2005). Therefore, supplementing the appropriate trace minerals in proper amounts prior to transport of newly weaned calves may produce increased stores of essential trace minerals that could potentially be utilized during times of stress and reduced feed intake normally observed in newly received calves (Hutcheson and Cole, 1986). Some attention has been focused on the role of trace mineral nutrition in the immunological adaptation of beef cattle to stress. However, little focus has been placed on mineral supplementation to weaned calves prior to transport to the feedlot. Therefore, the objective of this experiment was to determine the effects of trace mineral

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Table 1. Ingredient composition of control backgrounding and feedlot receiving rations

Ingredient	Backgrounding	Receiving
	------------------- %[a] -----------------	
Corn silage	-	17.80
Alfalfa-grass hay	94.90[b]	17.32
Flaked corn	-	55.96
Protein supplement	5.10	8.92[c]
Diet chemical composition		
DM (%)	91.10	68.82
OM (%)	92.27	94.51
CP (%)	14.28	13.60
NDF (%)	64.18	27.72
Ash (%)	7.73	5.49
Ca (%)	1.23	0.91
P (%)	0.30	0.31
K (%)	1.43	0.78
Mg (%)	0.27	0.21
Na (%)	0.10	0.06
S (%)	0.24	0.21
Fe (ppm)	270.16	188.45
Mn (ppm)	33.08	27.89
Zn (ppm)	45.17	50.68
Cu (ppm)	16.17	15.56
Mo (ppm)	0.11	0.19

[a] Dry matter basis.
[b] Estimated intake percentage.
[c] Provided 33 mg of monensin/kg DM.

supplementation (and source) for 30 days post-weaning on performance and health of newly received feedlot cattle.

MATERIALS AND METHODS

The Colorado State University Animal Care and Use Committee approved care, handling, and sampling of the animals defined in this experiment prior to the initiation of this study.

Three hundred and seventy-five steers (approximately 7 mo of age and 239.0±10.4 kg) were utilized in this experiment. Steers were obtained from three different Colorado State University Research facilities (129 Hereford×Angus steers from the Maxwell Ranch in Livermore, CO; 135 crossbred steers from the San Juan Basin Research Center in Hesperus, CO; and 111 black Angus steers from the Colorado State University Beef Improvement Center in Saratoga, WY).

Steers were backgrounded at their respective ranch locations. Post-weaning steers were weighed on two consecutive days and stratified by body weight into six groups. Groups were then randomly assigned to one of six group pens equipped with bunk feeders and automatic waterers. Pens were then randomly assigned to treatments. Treatments consisted of: 1) control (no supplemental Cu, Zn, Mn, and Co), 2) inorganic trace mineral ($CuSO_4$, $ZnSO_4$, $MnSO_4$, and $CoCO_3$), and 3) organic trace mineral (iso-amounts of organic Cu, Zn, Mn, and Co; Zinpro Corp., Eden Prairie, MN). Mineral treatments were fed in alfalfa pellets formulated to supply 360 of mg Zn, 200 mg of Mn, 125 mg of Cu, and 12.5 mg of Co per head per day from either organic or inorganic sources. Control steers received alfalfa pellets with no additional Cu, Zn, Mn, or Co. Steers were allowed free access to harvested alfalfa-grass hay throughout the 30 d backgrounding phase. On day 30 post-weaning, steers were weighed and transported to the Agricultural Research, Development, and Education Center (ARDEC) feedlot facility in Fort Collins, CO. Transport time varied between ranches. Steers from the Maxwell Ranch traveled approximately 48 km. Steers from the San Juan Basin Research Center in Hesperus, CO, traveled approximately 656 km, and steers from the Colorado State University Beef Improvement Center traveled approximately 230 km.

Receiving phase

Upon arrival, all steers were weighed (on two consecutive days), vaccinated with Ultrabac®7/Somubac and Bovishield™ 4+L5, and dewormed with Decomax (Pfizer Animal Health, Exton, PA). Steers were blocked by backgrounding treatment within ranch, stratified by initial entry body weight into the feedlot, and sorted into one of 36 pens (9-12 head per pen; 12 pens per treatment) equipped with automatic waterers. Steers remained on the same trace mineral treatments that they received during the on-farm backgrounding phase. Treatments consisted of: 1) control (no supplemental Cu, Zn, Mn, and Co), 2) inorganic trace minerals ($CuSO_4$, $ZnSO_4$, $MnSO_4$, and $CoCO_3$), and 3) organic trace minerals (iso amounts of organic Cu, Zn, Mn, and Co). Trace mineral treatments were included in the total mixed growing ration to supply the same concentrations of Zn, Mn, Cu, and Co as supplemented during the on-farm backgrounding phase. Steers were fed a corn silage-based growing diet (Table 1) throughout the 28-d receiving phase. Diets fed during the receiving phase were formulated to meet or exceed NRC (1996) recommendations for all nutrients except Cu, Zn, Mn, and Co. Diets were fed once daily in the morning in amounts adequate to allow *ad libitum* access to feed throughout the day. Steers were weighed 28-d post-arrival to the feedlot. Morbidity and mortality were monitored throughout the receiving phase.

Statistics

Statistical analysis of data was performed using Proc Mixed procedure of SAS (2001). The experiment was a completely randomized design. Continuous response variables included ADG during both post-weaning and receiving periods, final weight, and number of times treated for respiratory disease. The model included fixed effects of treatment, ranch of origin, and the treatment×ranch of origin

Table 2. Effects of trace mineral supplementation and source on backgrounding and receiving performance of newly weaned steers.

Item	Dietary treatments			SEM
	Control	Inorganic	Organic	
No. of animals/treatment	125	126	124	-
Backgrounding phase 0-30 d				
Initial body weight (kg)	238.8	239.2	238.9	10.4
ADG (kg/d)	0.57	0.57	0.61	0.03
Receiving phase (0-28 d)				
Body weights (kg)				
Initial	249.0	249.9	250.9	11.0
Final	290.7	290.2	296.5	4.2
ADG (kg/d[a])	1.49	1.44	1.63	0.05

[a] Inorganic vs. organic trace mineral treatments ($p<0.05$).

interaction. Pen means were used as the experimental unit for performance data during the on-farm backgrounding and feedlot receiving phases. When the overall effect of treatment was significant ($p<0.05$), differences among means were determined using pre-planned single degree of freedom orthogonal contrasts. The contrasts were: 1) control vs. supplemented and 2) inorganic trace mineral vs. organic trace mineral. Morbidity data were analyzed using the chi-squared analysis of SAS (2001).

RESULTS AND DISCUSSION

The majority of trace mineral experiments in feedlot cattle have focused primarily on the supplementation of an individual trace mineral in order to determine the effect of that specific trace mineral on measured response variables at either the receiving and/or finishing phases of beef production. The current experiment evaluated the combined effects of Cu, Zn, Mn, and Co supplementation and source during the post-weaning (on-farm backgrounding) and feedlot receiving phases of production. Therefore, it is not possible to determine the individual effects of Cu, Zn, Mn, or Co for any of the response variables measured.

During the backgrounding phase, average daily gain (ADG) was similar across treatments (Table 2). By the end of the 28-d feedlot receiving phase, ADG was similar between control and trace mineral supplemented steers. However, steers that were supplemented with organic TM had greater ($p<0.05$) ADG than steers supplemented with inorganic TM by the end of the 28-d feedlot receiving phase. In agreement with the present data, Chirase and Green (2001) reported that calves supplemented with Zn methionine plus Mn methionine or Zn oxide plus Mn oxide post weaning had similar body weights. However, by day 28 post-arrival to the feedlot, body weights and ADG were greater ($p<0.05$) in steers supplemented with organic TM compared to steers supplemented with inorganic TM (Chirase and Green, 2001). George et al. (1997) utilized weaned heifers in a 42-d growing experiment to determine the combined effects of Cu, Zn, Mn, and Co supplementation and source on performance. Copper, Zn, Mn, and Co were supplemented in inorganic form at NRC (1984) concentrations or at NRC (1984) or three times NRC (1984) concentrations in organic form for the first 14-d and then at NRC (1984) recommended concentrations for the remainder of the growing phase. Dry matter intakes, ADG, and gain:feed ratio (G:F) were not affected by supplementation or source of trace mineral (George et al., 1997). However, heifers receiving the organic form at three times the NRC (1984) had greater ADG and G:F compared to those receiving either inorganic or organic minerals at NRC (1984) recommended concentrations.

Although not directly comparable to the present experiment, the effects of either Cu or Zn supplementation and/or source on receiving/growing phase performance have been evaluated extensively. The effects of Zn supplementation and source on growing phase performance have been variable. Kegley et al. (2001) reported higher ADG in cattle supplemented with organic Zn compared to inorganic Zn from day 15 to 28 of a 28-d receiving experiment. However, overall (day 0-28) ADG for cattle that were supplemented with organic or inorganic Zn were similar (Kegley et al., 2001). Furthermore, in a 28-d cattle receiving experiment, Spears et al. (1991) reported similar ADG responses to organic vs inorganic Zn supplementation. Higher ADG in steers (Spears and Kegley, 2002), higher G:F and ADG in lambs and heifers (Spears, 1989), higher body weights, G:F, and ADG in heifers (Engle et al., 1997b), and higher ADG and DMI in steers (Rust and Schlegel, 1993) receiving supplemental Zn have been reported. However, no effect of Zn source on overall growing phase performance (Spears, 1989; Spears et al., 1991; Engle et al., 1997a; Spears and Kegley, 2002) has also been reported.

Performance responses to Cu supplementation also have been highly variable. Performance has been reported to not be affected by Cu supplementation (Ward et al., 1993; Engle and Spears, 2000; Engle et al., 2000; Engle and Spears, 2001; Lee et al., 2002) or source (Engle and Spears, 2000; Lee et al., 2002); or enhanced by Cu supplementation during the first 21 d of a 98-d growing phase (Ward et al., 1993).

The reason for the discrepancy between results is not clear. There are many factors that could potentially affect an animal’s response to trace mineral supplementation, such as the duration and concentration of the trace mineral being supplemented, the absence or presence of dietary antagonists, differences in basal ration trace mineral concentrations between experiments, environmental and health factors, and breed differences in trace mineral metabolism. Shipping distances may also affect an animal’s

Table 3. Effects of trace mineral supplementation and source on morbidity of receiving steers

	Dietary treatments			P-value	
	Control	Inorganic TM	Organic TM	TM	TM
Item					Source
Steers, no.	125	126	124	-	-
Morbidity (%)	13/125 (10.4 %)	17/126 (13.5 %)	9/124 (7.3 %)	0.99	0.25
Treated/morbid animal	1.15	1.06	1.00	0.59	0.60

response to trace mineral supplementation. Although the distances the steers in this study traveled in order to reach the feedlot were relatively short in comparison to longer hauls of 1,500 to 2,000 km, any length of transport may cause an animal to become stressed. Stress could potentially have an affect on how steers metabolize trace minerals.

There was no effect of TM supplementation on morbidity or the number of treatments per morbid animal throughout the receiving phase (Table 3). In agreement with the present findings, Chirase and Green (2001) reported that calves supplemented with inorganic or organic Zn and Mn had similar morbidity rates. Similar results were reported in steer calves (Kegley et al., 2001) and heifers (George et al., 1997). In contrast to these experiments as well as the present experiment, Johnson et al. (1988) reported a lower incidence of morbidity in calves supplemented with Zn methionine. A lower incidence of morbidity was also reported in newly weaned steers supplemented with 35 or 70 mg Zn/kg DM from Zn methionine or 70 mg Zn/kg DM from $ZnSO_4$ (Galyean et al., 1999).

CONCLUSION

Although trace mineral supplementation is an important nutritional component for beef cattle, other factors such as overall animal management, environment, reduced feed intake during receiving, breed type, antagonistic compounds to trace mineral absorption/ metabolism present in the diet and water, and disease status may impact an animals overall performance. Therefore, further research is needed to determine the effects of TM supplementation post weaning and prior to transport to the feedlot on performance and health of calves.

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