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Comparison of methionine hydroxy analogue chelated versus sulfate forms of copper, zinc, and manganese on growth performance and pregnancy rates in yearling beef replacement heifers

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ABSTRACT

Our objectives were to compare growth performance and pregnancy rates of heifers supplemented with Cu, Zn, and Mn as either methionine hydroxy analog chelate (provided as MINTREX) or in the SO_4 form. The experiment used 3 ranches, each having 2 replicate pens per treatment. Performance data were analyzed by ANOVA as a randomized complete block design using pen as the experimental unit. Pregnancy diagnosis data were analyzed using Chi-squared analysis. Heifers ($n = 2{,}480$) were fed diets for 181 d (ranch A), 149 d (ranch B), and 151 d (ranch C) before breeding. Heifers were weighed (shrunk) at trial initiation, end of feeding, breeding, and at pregnancy diagnosis. Ranch A heifers were bred by AI followed by natural service (45-d breeding), ranch B heifers were bred by natural service (50-d breeding), and ranch C heifers were bred by AI once at estrus detection only. No ranch × treatment interactions were detected for any measurements, and no differences were detected between treatments for gain, ADG, and G:F. Ranch effects were significant for gain, ADG, G:F, and overall pregnancy rate but not for conception in the first 21 d of breeding. Pregnancies conceived during the first 21 d of breeding did not differ between treatments. Overall pregnancy rate was increased by 2% for heifers supplemented with methionine hydroxy analog chelate versus SO_4 form. Under the conditions of this experiment, methionine hydroxy analog chelate contributed to increased pregnancy rates compared with a readily available inorganic form of trace mineral.

Key words: chelated mineral, fertility, mineral nutrition, methionine hydroxy analog chelate

INTRODUCTION

Heifers must calve by 24 mo to achieve maximum lifetime productivity (Patterson et al., 1992). One suggested cause of pregnancy failure in heifers is mineral deficiency of Cu, Zn, and Mn (NRC, 1996; Paterson and Engle, 2005). Supplementation of both Cu and Zn together increased liver storage of each mineral more than when only one mineral was supplemented (Wellington et al., 1998), and supplementation of both Zn and Mn increased immunity compared

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with supplementation with Zn alone (Chirase et al., 1994). Sulfate, Mo, and Fe are antagonists to Cu absorption (Suttle, 1974, 1991). Bioavailability of organic minerals in beef cattle has been questioned (NRC, 1996), and research has produced inconsistent results (Suttle, 2010). Nockels et al. (1993) reported that copper lysine (CuLys) and zinc methionine (ZnMet) were more bioavailable than $CuSO_4$ and $ZnSO_4$. Kegley and Spears (1994) reported that CuLys and $CuSO_4$ had similar bioavailability. Other research has suggested that feeding elevated levels of methionine hydroxy analog chelate (**CTM**) as MINTREX (Novus International, St. Charles, MO) resulted in reduced mortality and morbidity in the feedlot when a high level of SO_4 was present in water (Vazquez-Anon et al., 2007). Kincaid et al. (1986) and Rabiansky et al. (1999) reported that CuLys was more available than $CuSO_4$ when S and Mo were present. Organic mineral supplementation has resulted in greater pregnancy rates in cows but with inconsistency across age groups, breeding methods, and time (Stanton et al., 2000; Ahola et al., 2004; Arthington and Swenson, 2004). Research has explored CuLys, ZnMet, and manganese methionine (MnMet), but limited research has compared supplementation with the CTM form of Cu, Zn, and Mn to the SO_4 form to satisfy requirements for rate and efficiency of gain or attainment of pregnancy in heifers. The objectives of this study were to compare rate of gain, efficiency of gain, and pregnancy rates in heifers supplemented with either a CTM form or a SO_4 form of Cu, Zn, and Mn. The null hypothesis tested was that no differences would exist in drylot performance or in pregnancy rates between forms of supplemental trace minerals.

MATERIALS AND METHODS

Three ranches were used for this experiment. One ranch was near Dillon, Montana, and held 498 Angus heifers. Dillon, Montana, (45.21N, 112.64W) lies at an elevation of 1,555 m, receives annual precipitation of 25 cm and annual snowfall of 92 cm, and has a mean minimum temperature of −1°C and mean maximum temperature of 13°C. A second ranch was near Terry, Montana, and held 240 fixed composite (50% Red Angus, 25% Charolais, and 25% Terrantaise) heifers. Terry, Montana, (46.79N, 105.31W) lies at an elevation of 686 m, receives annual precipitation of 30 cm and annual snowfall of 36 cm, and has a mean minimum temperature of −1°C and mean maximum temperature of 14°C. The third ranch was near Dayton, Wyoming, and held 1,742 heifers of primarily Angus genetics but were also influenced by Hereford and Charolais. Dayton, Wyoming, (44.87N, 107.26W) lies at an elevation of 1,195 m, receives annual precipitation of 44 cm and annual snowfall of 154 cm, and has a mean minimum temperature of −1°C and a mean maximum temperature of 15°C. All animals were cared for and handled using acceptable practices (FASS, 2010) that followed ranch protocol and BQA (Beef Quality Assurance) standards.

The experimental design was a randomized block (3 ranches) with each ranch having 2 pens per treatment. Treatments were supplemental trace minerals provided in either sulfate form of Cu, Zn, and Mn or a methionine hydroxy analog chelate form of Cu, Zn, and Mn. Treatments were provided as part of a total mixed ration while in the feedlot or in mineral feeders when cattle were on pasture (ranch C). Pen was the experimental unit for drylot performance measures with approximately 125 heifers per pen at ranch A, approximately 60 heifers per pen at ranch B, and 333 to 537 heifers per pen at ranch C. Diets were formulated using NRC (1996) recommendations for CP and NE_g so that heifers would achieve 65% of mature BW by the time of breeding. Diets, water, and supplements were analyzed at a commercial laboratory (Midwest Laboratories, Omaha, NE) for CP, ADF, NDF, and mineral content. Midwest Laboratories performed a 2-step DM determination of wet samples using forced-air drying ovens (Undersander et al., 1993), analyzed CP via animal feed combustion method (AOAC International, 2009), analyzed NDF and ADF via filter bag technique following Ankom (Macedon, NY) procedures using Ankom fiber analyzers, and analyzed minerals via inductively coupled argon plasma (AOAC International, 2009). Net energy and TDN values were calculated based on the results of the wet chemistry analysis. Heifers were fed silage-based diets that contained approximately 13.5% CP and 64% TDN (DM basis) and had minimal concentrations of SO_4, Mo, or Fe in either feed or water. Diets contained an average of 24 mg/kg Cu, 70 mg/kg Zn, and 64 mg/kg Mn (Table 1), consistent with common industry practice in the area. Diets were fed as a TMR once daily during the feedlot phase of the trial and then fed in free-choice mineral feeders when cattle were on pasture in the days between the end of the feeding period and breeding. Prior to breeding, heifers received the treatment supplements for 181, 149, and 151 d at ranch A, B, and C, respectively.

Initial shrunk BW (shrunk BW = BW, kg × 0.95) of heifers was collected on December 11, 2010, at ranch A (BW 257 kg ± 2.0), on December 15, 2010, at ranch B (BW 269 kg ± 2.8), and February 8 to 11 and 14, 2011, at ranch C (BW 295 kg ± 1.5). Body weight (shrunk) was recorded upon completion of the drylot phase of the experiment after 181 d at ranch A (BW 341 kg ± 2.6), after 149 d at ranch B (BW 390 kg ± 3.9), and 77 to 81 d at ranch C (BW 348 kg ± 1.6). Ranch A heifers were bred via AI by a trained technician June 3 to 5, 2011, with bulls introduced on June 15, 2011, for 45 d. Ranch B heifers were bred via natural service for 50 d starting on May 20, 2011, with a bull-to-heifer ratio of 1:20. Ranch C heifers were placed on pasture immediately after drylot phase conclusion but remained segregated by treatment and continued to receive the assigned treatment until breeding commenced, at which time they were

Table 1. Dry-matter analysis and content of diets fed daily to heifers by ranch

Item	Ranch A	Ranch B	Ranch C
CP, %	12.67	13.28	15.20
ADF, %	37.83	25.22	34.78
TDN, %	59.42	67.55	63.95
NE_m, Mcal/kg	1.28	1.50	1.41
NE_g, Mcal/kg	0.77	0.90	0.79
S, %	0.23	0.23	0.21
P, %	0.30	0.39	0.32
K, %	1.89	1.43	1.50
Mg, %	0.31	0.26	0.31
Ca, %	1.55	0.92	1.53
Na, %	0.18	0.20	0.20
Fe, mg/kg	309	416	184
Mn, mg/kg	70	59	64
Cu, mg/kg	20	23	28
Zn, mg/kg	62	69	80
Cooked potatoes, %	33		
Corn silage, %		63	64
Cracked corn, %		10	
Dried distiller grain, %		5	
Chopped alfalfa/grass hay, %	35	20	34
Chopped barley or oat hay, %	30		
Supplement, %	≤2	≤2	≤2

returned to the feedlot and commingled to facilitate breeding. The total prebreeding supplementation period for the ranch C heifers when both the feedlot and prebreeding grazing period were combined was 151 d. During the prebreeding grazing period for the ranch C heifers, the mineral was delivered in free-choice mineral feeders, but feeders were only refilled as often as required to maintain the same average daily consumption of minerals (based on disappearance) as they were provided in the feedlot. Ranch C heifers (BW 400 kg ± 0.0) were bred by AI from July 17 thru August 1, 2011, and were bred only once. At each ranch, heifers were commingled at breeding and remained so until the date of pregnancy diagnosis. Body weight and date of conception was recorded at the time of pregnancy diagnosis, which was August 22, 2011, at ranch A, August 10, 2011, at ranch B, and September 12 to 16, 2011, at ranch C. Because of management practices some heifers that were included in the feedlot trial were removed from the reproductive phase of the experiment. Heifers were not removed from treatments in equal numbers. Heifers remaining in the experiment for the reproductive phase numbered 474 at ranch A, 236 at ranch B, and 1,621 at ranch C.

Analysis of variance was performed utilizing the GLM of Statistix 9 (Analytical Software, Tallahassee, FL) for the effects of ranch, treatment, and potential treatment × ranch interactions for gain, ADG, and G:F using pen as the experimental unit and ranch as a blocking variable. Pregnancy rate differences between treatments were analyzed utilizing the Chi-squared analysis of SAS (SAS Institute Inc., Cary, NC), and the treatment × ranch interaction was tested with Statistix 9 (Analytical Software).

RESULTS AND DISCUSSION

Rate and efficiency-of-gain data include data from heifers present for the feedlot phase of the experiment that were removed from the reproductive phase of the experiment. There were no ranch × treatment interactions ($P \geq 0.76$) for total gain, ADG, or G:F (Table 2). There were no differences ($P \geq 0.57$) due to form of mineral for total gain, ADG, or G:F at any individual ranch or across ranches. Gain, ADG, and G:F differed ($P < 0.001$) among ranches. No treatment differences in rate or efficiency of gain were expected based on prior research. Spears (1989), Ward et al. (1993), and Wellington et al. (1998) all noted no differences in gains or ADG in growing steers and heifers when organic and inorganic forms of Cu and Zn were tested against each other in the presence or absence of antagonists. The feedlot performance results are similar to these other studies as should be expected; there were no significant levels of antagonists in the diet, and the heifers were not being challenged to meet maximum daily gain but were only targeted for 0.45 to 0.68 kg of daily gain. In previous experiments where chelated minerals have aided in achieving superior feedlot performance, some form of stress such as a pathogen presence (Chirase et al., 1991, 1994) or antagonist (Vazquez-Anon et al., 2007) were present that inorganic mineral forms were less able to overcome. None of the heifers in this trial were exposed to any such additional stress, therefore, not truly challenging the chelated mineral's proven abilities to overcome such stresses.

When all data were combined there was no ranch × treatment interaction ($P \geq 0.47$) for pregnancy rates attributed to the first 21 d of breeding or for overall pregnancy (Table 3). No difference was detected ($P = 0.12$) between form of mineral fed on percent pregnant resulting from the first 21 d of breeding (Table 3). Overall pregnancy rate was greater ($P = 0.05$) in the CTM-fed heifers (Table 3). Ranch was not a significant factor ($P = 0.10$) for pregnancies achieved during the first 21 d of breeding but was significant ($P \leq 0.001$) in overall pregnancy and reflects the decreased breeding season at ranch C where heifers had only one opportunity to conceive. Heifer pregnancy rates attributed to

Table 2. Summary of differences in feedlot performance of heifers fed CTM[1] or SO_4 form of Cu, Zn, and Mn

Item	Ranch A		Ranch B		Ranch C			All ranches		*P*-value		
	SO_4	CTM	SO_4	CTM	SO_4	CTM	SE	SO_4	CTM	Trt[2]	Ranch (R)	R × Trt
No. of heifers	251	246	120	119	870	872		1,241	1,237			
DoT[3]	181	181	149	149	77	77						
IBW,[4] kg	249	251	268	270	288	294	2.82	268	272			
EBW,[5] kg	341	340	389	391	347	349	4.11	359	360			
Gain, kg	92	89	121	121	59	55	2.77	91	88	0.60	<0.001	0.88
ADG, kg	0.50	0.49	0.81	0.81	0.76	0.70	0.03	0.69	0.67	0.57	<0.001	0.76
G:F, kg	0.16	0.16	0.26	0.26	0.23	0.25	0.04	0.18	0.22	0.91	<0.001	0.85

[1]CTM = Cu, Zn, and Mn as metal methionine hydroxy analog chelated trace mineral provided as MINTREX (Novus International, St. Charles, MO).

[2]Trt = treatment.

[3]DoT = days on test.

[4]IBW = initial BW.

[5]EBW = BW at end of feeding in the drylot.

the first 21 d of breeding and overall pregnancy rate did not differ ($P \geq 0.46$) between treatments at ranches A and B. Ranch C heifers had 7% greater conception rate following one AI breeding when supplemented with CTM ($P = 0.03$). Among ranch C heifers, no differences ($P \geq 0.77$) in BW between mineral treatments existed at time of breeding or pregnancy diagnosis. Similar results to the current experiment have been noted by Stanton et al. (2000), who used 300 Angus cows supplemented with 3 mineral treatments in the presence of antagonists; a low level inorganic mineral supplement containing Cu, Zn, Mn, and Co; a high level of inorganic supplement containing Cu, Zn, Mn, and Co; and a high level of complexed organic Cu, Zn, Mn, and Co. Cows supplemented with the high level of organic minerals had significantly greater conception rates to AI breeding than cows supplemented with the other 2 treatment minerals; however, overall reproductive performance did not differ. Similarly, Ahola et al. (2004) conducted a study in which 178 crossbred multiparous cows were fed 2 treatment supplements: 100% inorganic mineral containing Cu, Zn, and Mn compared with a 50% complexed:50% inorganic mineral supplement containing Cu, Zn, and Mn. In yr 1 overall reproductive performance did not differ between treatments, but the trend ($P = 0.08$) was for those cows supplemented with the high level of complexed minerals to have a greater rate of pregnancy to AI breeding. In yr 2 of the trial, cows fed the complexed mineral treatment had 10% greater conception to AI breeding than those fed the inorganic mineral treatment. Arthington and Swenson (2004) conducted an experiment using 160 Braford cows over a 3-yr period where sulfur antagonism was present. Cows were assigned to 1 of 4 treatments, which included a treatment using complexed organic forms of Cu, Zn, and Mn supplement and an inorganic form of Cu, Zn, and Mn. Over the course of the trial it was determined that mineral source had no effect on cow BW, cow BCS,

Table 3. Summary of differences in pregnancy rates of heifers fed CTM[1] or SO_4 form of Cu, Zn, and Mn

	Ranch A		Ranch B		Ranch C			All ranches		*P*-value		
Item	SO_4	CTM	SO_4	CTM	SO_4	CTM	SE	SO_4	CTM	Trt[2]	Ranch (R)	R × Trt
% Pregnant	85	86	92	91	59	66	0.02	79	81	0.05	<0.001	0.47
% Pregnant 1st 21 d	58	57	54	51	59	66	0.02	57	58	0.12	0.10	0.54

[1]CTM = Cu, Zn, and Mn as metal methionine hydroxy analog chelated trace mineral provided as MINTREX (Novus International, St. Charles, MO).

[2]Trt = treatment.

or calf weaning weight. However, pregnancy rates were greater in yr 2 ($P < 0.05$) and calving intervals were shorter in yr 1 and 3 for young cows that were fed the organic forms of Cu, Zn, and Mn, but older cows did not differ regardless of mineral type or source. When comparing similarities between the present experiment and prior research, it appears that chelated, organic forms of Cu, Zn, and Mn can contribute to greater pregnancy rates to AI in some instances. The current experiment supplemented heifers with CTM for a period of 149 to 181 d. Ahola et al. (2004) and Arthington and Swenson (2004) both supplemented cattle with complexed, organic forms of Cu, Zn, and Mn over a period of 2 to 3 yr. In both experiments, overall pregnancy rates were not different due to differences in mineral form in all years, indicating that organic forms of minerals did not always achieve greater pregnancy rates when fed over extended periods of time. Although CTM supplementation was a factor in achieving greater pregnancy rates to AI breeding at ranch C as well as to the overall pregnancy rate differences when ranches were combined, the high level of significance that ranch exhibited in the analysis indicates that location or management also plays a key factor in the ability of the CTM to have an effect on animal reproductive performance.

IMPLICATIONS

This experiment suggests that rate and efficiency of gain, when diets contained adequate levels of dietary protein and energy, were not affected by form of mineral supplementation. However, yearling heifers exhibited greater conception to AI breeding when supplemented with CTM (provided as MINTREX) compared with those supplemented with SO_4 form of Cu, Zn, and Mn, indicating that chelated trace mineral supplementation has benefits in reproductive capacity of replacement heifers even when limited antagonists are present in the basal diet.

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