Complexed versus amino acid-chelated trace mineral programs in high-risk calves during receiving[1]

S. Richard Goodall[†,2] and Christopher J. Schuetze[‡]

[†]Rick Goodall Consulting, Erie, CO 80516; and [‡]Tracer Minerals, Cimarron, KS 67835

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INTRODUCTION

It is widely recognized that the postweaning and feedlot-receiving periods are high-stress times in the life of a calf. Stress due to commingling, transport, and exposure to new diets and environments can negatively affect calf health and feedlot performance (Duff and Galyean, 2007). During receiving is also when calves become susceptible to bovine respiratory disease (BRD). Even when calves have been vaccinated against viral and bacterial pathogens associated with BRD, they may not be able to mount an adequate immune response against BRD pathogens due in part to a lack of adequate nutrition (Galyean et al., 1999). Trace minerals are essential nutrients for immune system development and for antibody response to pathogens (Chirase et al.,1994). Previous research where inorganic trace minerals were replaced with organic forms have resulted in higher blood infectious bovine rhinotracheitis (IBR) titer levels and reductions in BRD-associated morbidity in feedlot cattle (Chirase and Greene, 2001). However, very little research has been reported where different organic trace mineral sources and/or levels have been directly compared with one another in the same feedlot-receiving experiment. Therefore, we hypothesized that supplementing two different commercial organic trace mineral products (Zinpro Availa-4 or Tracer Micro Maxx) would produce different health and growth performance outcomes in high-risk calves during receiving.

MATERIALS AND METHODS

Animals and Treatments

Approximately 600 head (hd) of light-weight (177 ± 7 kg) beef calves (approximately 500 bulls and 100 steers) were purchased by an order buyer at an auction barn in Seguin, TX, on five separate occasions (approximately 120 hd × 5 purchase dates) over a 10-wk period (November 15, 2014 to January 22, 2015). Calves were transported to the feedlot research center located at OT Feed Yard in Bushland, TX. All calves arrived at the feed yard facilities during the afternoon and were allowed to rest in dirt lot holding pens, with ad libitum access to hay and water, until the following morning, when they were randomly assigned to one of two treatments: a commercial mineral amino acid complex (COMX; Availa-4, Zinpro Corporation, Eden Prairie, MN) or a commercial mineral amino acid chelate (CHTM; Micro Maxx, Tracer Minerals LLC, Cimarron, KS). The randomization process for each of the five calf-arrival groups (120 hd/group) was as follows: from the overnight holding pen, a gate cut of two

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[2]Corresponding author: srichardgoodall@gmail.com

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calves was sent to an alley that accessed either two COMX pens or two CHTM pens (previously assigned at random), and were gate cut again, 1 hd into each pen replicate per treatment. This process was repeated until all four pens (two COMX pens and two CHTM pens) were filled with 30–31 hd/pen on each calf-arrival date. This treatment allocation process was repeated on five separate occasions for a total of 20 pens (2 treatments × 10 pens per treatment) with 30–31 hd/pen.

Pen weights were recorded for each pen after the gate-cut sorting of calves but before processing occurred. Calf-processing procedures were individually applied as follows: each calf received an individual ID ear tag, a three-way bovine viral diarrhea-1 (BVD1), BVD2, IBR vaccine, an intranasal IBR, parainfluenza-3, bovine respiratory syncytial virus vaccine, a clostridial vaccine, a mannheimia haemolytica vaccine, an injectable parasiticide, and a metaphylactic antimicrobial injection. Calves were also branded and bull calves were castrated by elastrator banding.

Feeding and Experimental Diets

In an attempt to insure nutritionally adequate mineral intakes during the first 3 d post-arrival, a liquid form of CHTM was added to in-pen water tanks at a rate of 0.26 ml/l in addition to including dry CHTM to the receiving diet. Both the liquid and dry forms of CHTM contained the same relative proportions of minerals (Zn:Cu:Mn = 1:1:0.4 and Mg:K = 1:1). The dry COMX test article was included in feed only during the first 3 d postarrival, so all pens of COMX calves received clear water from in-pen water tanks during the first 3 d.

Regardless of water treatment, all calves were transitioned from water tanks to automated drinking fountains on day 4 and received mineral test articles solely via their receiving diets for the duration of the trial.

Feed was delivered to all 20 pens of trial cattle twice daily (a.m. and p.m.). Feed bunks were read twice daily and managed to provide ad libitum access to feed and minimize feed refusals. Bunk reader and feed delivery truck drivers were blinded of treatment assignments.

The basal diet was formulated so as to meet or exceed the nutrient requirements of receiving stressed calves, except for trace minerals (NRC, 2006). The composition of the basal receiving diet is provided in Table 1.

Commercial trace mineral test articles comprised of either COMX or CHTM were added to the receiving diet in a blinded fashion via a micromachine as per each manufacturer's label recommendation. Receiving diet final trace mineral levels resulting from the addition of the two test articles to the basal diet are reported in Table 2. Feed (total mixed ration) samples were taken from the bunks weekly throughout the experiment and submitted to a commercial laboratory for proximate and mineral analyses.

Table 1. Basal diet composition (without mineral treatment test articles) fed to steer calves from day 1 to 42

Ingredient (% DM basis)	
Flaked corn	31.50
Cottonseed hulls	20.00
Corn silage	20.00
Corn gluten feed	13.50
Molasses-fat blend	10.00
Supplement	5.00
Nutrient composition (DM basis)	
DM, %	69.80
Crude protein, %	14.00
NPN, %	3.49
Fat, %	3.35
NE main, MCal/kg	1.73
NE gain, MCal/kg	1.09
Crude fiber, %	18.59
Ca, %	0.85
P, %	0.41
K, %	1.10
Mg, %	0.27
Cu, ppm	4.88
Mn, ppm	23.12
Zn, ppm	31.07
Se, ppm	0.30
Co, ppm	0.10

Diets were formulated to include a total of 30,000, 3,000, and 50 IU/hd/d of vitamins A, D, and E, respectively

NE = net energy; NPN = non-protein nitrogen

Health Observations and Treatments

Calves were evaluated twice daily for clinical symptoms of respiratory disease (nasal or ocular discharge, lethargy, anorexia, or depression), digestive upsets, or any other ailment. Pen riders and animal health crews were also blinded to the dietary treatments. Sick cattle were removed from the pen, treated according to the feedlot's designated veterinary protocols, then returned to their home pens. Morbid calves were not allowed to be treated more than three times for respiratory disease but were not removed from the experiment until after the day-42 weight. If a calf was treated three times for

Table 2. Calculated final trace mineral composition of receiving diets resulting from addition of complexed (COMX) and chelated (CHTM) organic mineral test articles.

Item	COMX	CHTM
Copper (Cu), ppm	31.8	40.7
Manganese (Mn), ppm	65.3	38.0
Zinc (Zn), ppm	106.7	67.2
Cobalt (Co), ppm	2.9	0.1

respiratory disease, recovered, and relapsed after 14 d, it was treated as an initial episode and treated as previously described.

Morbidity and mortality rates and the rate of retreatments as a percentage of initial treatment rates were determined from day 0 to 14, 15 to 42, and 0 to 42. Morbidity rate was calculated as the percentage of steers in a pen that required at least one treatment for BRD.

Mortality percentage was calculated as the number of steers that succumbed to death during the experimental period as a percentage of the original received head count for that pen.

Retreatments were calculated as the number of steers that received at least one treatment for BRD and required at least one additional treatment for respiratory disease.

Body Weight and Feed Measurements

Average daily gain (ADG), dry matter intake (DMI), efficiency of gain (G:F), and cost of gain (COG) were calculated on a per pen basis. Each variable was calculated for the first 14 d, the following 28 d, and the entire 42-d period. Pen weights were used to calculate ADG for each period. Feed delivery on an "as fed" basis was converted to DM basis using laboratory results for proximate analysis. G:F utilized the ADG and DMI values calculated as previously described. The COG was calculated as all costs (feed, water treatment, processing, and all other veterinary costs), including the theoretical cost for the donated commercial test article products during receiving.

Statistical Analysis

Data were analyzed as a completely randomized design with pen as the experimental unit using the MIXED procedure of SAS (SAS Institute Inc., Carey, NC). Calf initial weights were used as covariates in the analysis. Results are presented in tables as the following: treatment least squares means (LSM) as either percentages or kg (pen basis), with SEM, and *P*-values. Significance is declared at $P < 0.05$ and trends declared at $P < 0.10$.

Table 3. Morbidity, mortality, and retreatment rates per pen receiving either complexed (COMX) or chelated (CHTM) minerals from day 0 to 42

Item	COMX[a]	CHTM[b]	SEM[c]	*P*-value[d]
Morbidity, % pulls/pen				
days 0 to 14	10.5	9.10	1.81	0.61
days 15 to 42	13.8	9.44	3.10	0.33
days 0 to 42	24.3	18.6	3.99	0.32
Mortality, % dead/pen				
days 0 to 14	0	0	—	—
days 15 to 42	1.98	0.97	0.80	0.38
days 0 to 42	1.98	0.97	0.80	0.38
Retreatments, % of initial pulls/treatment:				
days 0 to 14	38.8	12.5	9.86	0.08
days 15 to 42	16.0	1.7	4.68	0.04
days 0 to 42	25.7	7.7	5.22	0.03

[a]COMX delivered at a rate of 7.0 g/hd/d.
[b]CHTM delivered at a rate of 5.7 g/hd/d.
[c]Standard error of the means.
[d]Probability of significance.

RESULTS

Calf morbidity, mortality, and retreatment rate results expressed as LSM percentages and SEM are presented in Table 3. While morbidity and mortality rates did not differ, calves fed CHTM had numerically lower rates of morbidity and mortality throughout the 42-d trial. In addition, the percentage of CHTM calves requiring retreatment for BRD was less during days 0–14 ($P < 0.08$), days 15–42 ($P < 0.04$), and days 0–42 ($P < 0.03$). The percentage of CHTM calves requiring more than one BRD treatment was 89% less from d 15 to 42 and 70% less overall than that of COMX calves.

Calf ADG, DMI, and ADG/DMI on a "deads out" basis are presented as LSM with SEM in Table 4. There were no differences in ADG, DMI, or ADG/DMI for the entire receiving study (days 0–42). With initial weight as a covariate, a significant difference was obtained in days 0–14 ADG/DMI ($P < 0.05$) and a trend in ADG ($P = 0.10$), which translated to a 10.7% improvement in feed efficiency and a 12.7% improvement in weight gain for the CHTM vs. COMX treatments, respectively. In contrast, from day 15 to 42, COMX calves exhibited trends of a similar magnitude for higher ADG ($P < 0.06$) and ADG/DMI ($P < 0.07$) than CHTM calves.

Overall receiving performance data (days 0–42) was similar across treatments. No treatment

Table 4. Growth performance of calves that received complexed (COMX) or chelated (CHTM) minerals from day 0 to 42

Item	COMX[a]	CHTM[b]	SEM[c]	*P*-value[d]
Initial no. hd/pen	30.5	30.7	0.16	0.39
Initial no. bulls/pen	24.0	26.0	0.69	0.05
Initial body wt., kg/hd	178.8	175.5	2.35	0.34
Final body wt., kg/hd	230.5	224.3	3.05	0.17
ADG, kg/d				
days 0 to 14	1.40	1.55	0.10	0.10
days 15 to 42	1.11	0.96	0.05	0.06
days 0 to 42	1.23	1.16	0.05	0.39
DMI, kg/d				
days 0 to 14	2.69	2.65	0.14	0.70
days 15 to 42	5.14	5.05	0.13	0.64
days 0 to 42	4.25	4.24	0.13	0.74
G:F, ADG/DMI				
days 0 to 14	0.522	0.586	0.029	0.03
days 15 to 42	0.216	0.192	0.009	0.07
days 0 to 42	0.289	0.276	0.011	0.41

[a]COMX delivered at a rate of 7.0 g/hd/d
[b]CHTM delivered at a rate of 5.7 g/hd/d
[c]Standard error of the means
[d]Probability of significance

Table 5. Veterinary costs for BRD and gain costs of calves receiving complexed (COMX) or chelated (CHTM) minerals from d 0 to 42

Item	COMX[a]	CHTM[b]	SEM[c]	P-value[d]
Vet cost, $/hd				
days 0 to 14	3.85	3.06	0.649	0.40
days 15 to 42	7.29	4.37	1.55	0.21
days 0 to 42	11.14	7.43	1.81	0.17
Feed cost, $/hd				
days 0 to 14	10.65	10.51	0.550	0.86
days 15 to 42	40.70	39.96	0.930	0.58
days 0 to 42	51.52	50.60	1.350	0.64
Total gain cost, $/kg				
days 0 to 14:	1.92	1.66	0.119	0.14
days 15 to 42:	2.27	1.98	0.330	0.55
days 0 to 42:	2.04	1.81	0.191	0.40

[a]COMX delivered at a rate of 7.0 g/hd/d.
[b]CHTM delivered at a rate of 5.7 g/hd/d.
[c]Standard error of the means.
[d]Probability of significance.

differences were detected for ADG, DMI, or for ADG/DMI. In addition, it is worth noting that the number of castrated bull calves was greater ($P < 0.05$) in the CHTM group than in the COMX group (Table 4).

Estimated BRD veterinary treatment costs on a per hd basis, feed cost on a per hd basis, and total cost per kg of gain are presented in Table 5. Although there were numeric differences in costs for these economic parameters, no difference in treatment costs were detected between treatments. All costs (veterinary cost, feed cost, and cost per kg of gain) were numerically less in the CHTM treatment.

DISCUSSION

To our knowledge, no other studies have been published that directly compare the effects of complexed and amino acid-chelated minerals sources on the health and performance of newly received, high-risk feedlot calves. In an unpublished report (Larson, 2002), weaned beef calves were fed either polysaccharide or complexed trace minerals (Zn, Mn, Cu, Co) at the same levels during receiving. Results indicated there were no significant performance or health differences in newly weaned calves for 45 days in a receiving feed yard.

Our results suggest there are differences in the magnitude of health-related responses to the COMX vs. CHTM mineral product programs in high-risk calves during receiving (based upon percentage of calves requiring BRD retreatments). There was also a trend for improved rate and efficiency of gain during the first 14 days of the feedlot-receiving period for the CHTM feed and water treatment program. This difference may have in part been due to calves consuming CHTM in water and feed, while the COMX calves only consumed COMX in their feed. The COMX calves appeared to compensate during the subsequent period (days 15–42), and this may have been related to a greater DMI than during the previous period.

There are reviews in the scientific literature summarizing several inorganic and organic trace mineral studies with feedlot calves or yearlings (Duff and Galyean, 2007). These authors concluded that although there is some evidence that organically complexed mineral sources might occasionally have different effects on feedlot performance and immune function, the effects seem too variable to recommend feeding particular sources.

Feeding proteinated trace minerals to high-risk calves under conditions similar to the current study resulted in reduced morbidity and mortality due to BRD as compared with feeding inorganic trace minerals (Holder et al., 2016). Results of the current experiment suggest that an amino acid-chelated minerals program could be more efficacious than a complexed mineral program for improving health and immunity in high-risk feedlot calves.

IMPLICATIONS

This study, conducted under commercial conditions, may be the only published direct comparison between two organic trace mineral products in receiving feedlot cattle. Supplying minerals in an amino acid-chelated form reduced the number of BRD treatments required for morbid calves to recover. This is important because of the high costs associated with BRD treatment. These results suggest that either the mineral form (complex or chelate) or the level of one or more of the minerals supplemented could have differing effects on calf health and immunity.

Conflict of interest statement. The authors has no conflict of interest.

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