Effects of Trace Mineral Source on Growth and Mineral Balance in Yearling Horses

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Story in Brief

Sixteen yearling Quarter Horses were used in a split-plot experimental design to evaluate the response of different trace mineral sources on growth and mineral balance. Horses were blocked by sex and weight, and randomly assigned to one of two dietary treatments (inorganic vs organic). Experimental diets were formulated to contain supplemental levels of copper, zinc, and manganese at four times NRC requirements. The concentrate consisted of wheat, corn, soybean meal, and cottonseed hulls, fed in a 50:30:20 ratio with ryegrass hay and alfalfa cubes, respectively. Diets were fed at 2% of body weight daily, which was divided into two equal feedings. The 60-d trial consisted of three 72-h collection periods at d 0 (Period I), 30 (Period II), and 60 (Period III), during which total fecal and urine collections were taken. The lack of significant differences in balance and digestibility data indicate that the feeding of organic trace minerals does not improve mineral retention.

Key Words: Horses, Copper, Zinc, Manganese, Mineral Metabolism

Introduction

Trace minerals are often supplemented in livestock diets due to the relatively low level and availability of many minerals in feedstuffs, particularly those derived from plants. The requirement for trace minerals in young, growing animals are often higher than those of mature animals at maintenance, due to the increased need for skeletal growth and development. Many supplemental sources of trace minerals exist, including inorganic sulfates, oxides, and carbonates, as well as organic chelates, polysaccharide complexes, and proteinates. Little work exploring organic mineral sources, specifically chelates, has been conducted in horses. It was reported by Ott and Johnson (2001) that growth, development, and bone mineral deposition were not altered by trace mineral source, although chelated minerals may be more effective in meeting the needs of the rapidly growing hoof. In contrast, Siciliano et al. (2001a, 2001b) demonstrated that trace mineral source did not affect hoof wall growth rates, hardness, strength, or trace mineral content. Miller et al. (2003) reported that retention of copper and zinc were improved when organic sources of these minerals were fed to yearling horses. Therefore, the objective of this study was to evaluate the effects of trace mineral source on the growth and mineral balance of yearling horses fed supplemental levels of copper, zinc, and manganese.

Materials and Methods

Sixteen Quarter Horse yearlings were used in a split-plot design to determine the effect of trace mineral source on mineral balance. Horses were blocked by sex and weight, and then randomly assigned to one of two dietary treatments. Dietary treatments were a basal ration supplemented with either: 1) inorganic copper, zinc, and manganese as sulfates, or 2) organic copper, zinc, and manganese as metal amino acid chelates (Table 1). Horses were housed in 12’x12’ box stalls and allowed 4 to 6 h of free exercise daily in an outdoor pen. The basal ration was fed for 45 d prior to feeding of the dietary treatments. Diets were fed for 60 d, at 2% of the estimated final body weight for each horse per day, in two feedings. Orts were weighed daily and recorded prior to each feeding to determine daily feed intake for each horse. Total fecal and urine collections were conducted at d 0, 30, and 60 for 72-h, during which composite samples were made for subsequent mineral analysis. A 7-d adaptation period preceded the collection at d 0.

Data were analyzed using the Mixed procedure of SAS (SAS Inst. Inc., Cary, NC) with horse, treatment, and period as main effects. Least squares means were calculated for each treatment within a given period. The Least Significant Difference procedure was used to test for differences between treatment means.

Table 1. Composition of treatment diets, as fed basis

	Treatments	
Ingredients (%)	Inorganic	Organic
Ground wheat	17.00	17.00
Ground corn	17.75	17.75
Cottonseed hulls	4.92	4.72
Soybean meal	9.00	9.00
Calcium carbonate	.50	.50
Monosodium phosphate	.75	.75
Copper sulfate	.01	____
Zinc sulfate	.0335	____
Manganese sulfate	.0370	____
Cobalt sulfate	.0000394	____
Cuplex 100	____	.0255
Zinpro 100	____	.1190
Manpro 80	____	.1330
Copro 25	____	.00052
Marshall ryegrass hay	30.00	30.00
Alfalfa cubes	20.00	20.00
Nutrient		
DE, Mcal/lb	1.28	1.29
Calcium, %	.79	.82
Phosphorus, %	.49	.50
Zinc, ppm	178.92	161.66
Copper, ppm	35.21	42.47
Manganese, ppm	173.13	147.92
Cobalt, ppm	.41	.55

Results and Discussion

Copper. The effect of trace mineral source on copper excretion, retention, and digestibility is shown in Table 2. Horses consuming the organic diet had a higher ($P<.05$) fecal copper excretion than those fed the inorganic diet in Periods I and III, but were not different ($P>.05$) in Period II. Urinary copper excretion was significantly higher in horses fed the organic diet in Period I, while excretion was similar ($P>.05$) in Periods II and III. Copper balance was higher ($P<.05$) for horses consuming the inorganic diet in Period I. During Period II, however, copper balance was significantly higher for the organic vs the inorganic treatment. There was no significant difference in balance between diets in Period III. Copper digestibility was significantly higher (P<.05) in horses consuming the inorganic diet in Period I and the organic diet in Period II, with no significant difference (P>.05) found in Period III. These results are inconsistent with those of Miller et al. (2003), who found that retention increased with the feeding of supplemental copper proteinate to yearling horses.

Table 2. Effect of trace mineral source on copper retention and digestibility in yearling horses[a]

Period I	Inorganic	Organic	SEM[d]
Intake, mg/kg BW	.814	.809	
Fecal output, mg/kg BW	.513[b]	.619[c]	.0448
Urinary output, mg/kg BW	.002[b]	.005[c]	.0012
Balance, mg/kg BW	.295[b]	.185[c]	.0445
Digestibility, %	36.53[b]	23.67[c]	6.24
Period II			
Intake, mg/kg BW	.623	.861	
Fecal output, mg/kg BW	.577	.632	.0432
Urinary output, mg/kg BW	.002	.003	.0012
Balance, mg/kg BW	.045[b]	.226[c]	.0430
Digestibility, %	7.51[b]	26.58[c]	6.03
Period III			
Intake, mg/kg BW	.595	.744	
Fecal output, mg/kg BW	.506[b]	.667[c]	.0432
Urinary output, mg/kg BW	.002	.003	.0012
Balance, mg/kg BW	.087	.074	.0430
Digestibility, %	14.57	10.49	6.03

[a]Values are least squares means

[b,c]Means within a row with unlike superscripts differ (P<.05)

[d]Values are average standard errors

Zinc. The effect of trace mineral source on zinc excretion, retention, and digestibility is shown in Table 3. Zinc excretion in feces and urine was similar (P>.05) between treatments during all periods. Zinc balance was higher (P<.05) for horses consuming the inorganic diet in Periods I and III, while there was no difference (P>.05) in zinc balance during Period II. Digestibility of zinc was significantly higher for the inorganic diet in Periods I and III, however, did not differ (P>.05) in Period II. These results contradict those of Miller et al. (2003), who demonstrated that retention of zinc was increased in yearling horses fed a zinc proteinate. The differences in zinc balance in the present study may reflect the numerical differences in zinc intake. Excretion of endogenous zinc may have increased to compensate for the high level of dietary zinc intake, resulting in negative digestibility values. Zinc is not stored in large amounts within the body, and endogenous zinc may be excreted in order to maintain homeostasis when requirements are exceeded (Wedekind and Baker, 1990).

Table 3. Effect of trace mineral source on zinc retention and digestibility in yearling horses[a]

Period I	Inorganic	Organic	SEM[d]

Intake, mg/kg BW	4.34	3.08	
Fecal output, mg/kg BW	3.14	3.22	.2197
Urinary output, mg/kg BW	.015	.013	.0023
Balance, mg/kg BW	1.17[b]	-.161[c]	.218
Digestibility, %	27.32[b]	-4.56[c]	7.01
Period II			
Intake, mg/kg BW	2.97	3.32	
Fecal output, mg/kg BW	3.28	3.33	.2117
Urinary output, mg/kg BW	.012	.013	.0023
Balance, mg/kg BW	-.322	-.018	.2100
Digestibility, %	-10.42	-.16	6.77
Period III			
Intake, mg/kg BW	3.04	2.80	
Fecal output, mg/kg BW	3.18	3.45	.2117
Urinary output, mg/kg BW	.010	.009	.0024
Balance, mg/kg BW	-.151[b]	-.671[c]	.2178
Digestibility, %	-4.56[b]	-23.58[c]	6.77

[a]Values are least squares means

[b,c]Means within a row with unlike superscripts differ (P<.05)

[d]Values are average standard errors

Manganese. The effect of trace mineral source on manganese excretion, retention, and digestibility is shown in Table 4. Fecal manganese excretion was significantly higher (P<.05) for the inorganic diet in Period II, while excretion did not differ significantly between treatments in Periods I and III. No significant differences between treatments were observed for manganese urinary excretion, balance, or digestibility during Periods I, II, and III. Manganese balance and digestibility were numerically lower for the organic diet during all periods, which may be the result of the lower intake of manganese by horses consuming the organic diet. These results demonstrate that intake may affect balance, and the excretion of endogenous manganese may increase when the horse's requirements are exceeded by the dietary supply.

Table 4. Effect of trace mineral source on manganese retention and digestibility in yearling horses[a]

Period I	Inorganic	Organic	SEM[d]
Intake, mg/kg BW	3.22	2.78	
Fecal output, mg/kg BW	2.96	2.64	.2044
Urinary output, mg/kg BW	.001	.001	.0004
Balance, mg/kg BW	.242	.137	.2009
Digestibility, %	7.78	5.09	6.65
Period II			
Intake, mg/kg BW	3.61	2.93	
Fecal output, mg/kg BW	3.36[b]	2.83[c]	.1988
Urinary output, mg/kg BW	.001	.001	.0004
Balance, mg/kg BW	.252	.093	.1957
Digestibility, %	7.01	3.19	6.47
Period III			

Intake, mg/kg BW	3.13	2.69	
Fecal output, mg/kg BW	3.15	2.83	.1988
Urinary output, mg/kg BW	.001	.001	.0004
Balance, mg/kg BW	-.020	-.139	.1957
Digestibility, %	-.550	-5.38	6.47

[a]Values are least squares means

[b,c]Means within a row with unlike superscripts differ ($P<.05$)

[d]Values are average standard errors

Implications

The present study indicates that the feeding of organic trace minerals does not improve mineral digestibility and retention. Increased intake of minerals may potentially result in increased mineral retention, but supplying dietary sources of minerals in excess of the horse's requirements could result in the increased excretion of endogenous mineral in order to maintain mineral homeostasis.

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