CHROMIUM AS AN ESSENTIAL MINERAL ELEMENT FOR DOMESTIC ANIMALS

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Introduction

Chromium is an essential micromineral with particular importance in the metabolism of carbohydrates and lipids. It serves as an essential component of the glucose tolerance factor which potentiates the activity of insulin. Most of the information on the metabolism of chromium as reviewed by Anderson (1987) has been obtained with humans and laboratory animals. Very limited information is known on the concentration of chromium in foods and feeds or on the form in which it exists. Because definitive methods are not available to evaluate chromium status of humans and animals, dietary requirements have not been stated.

Cattle

Stress

The potential importance of chromium for domestic animals has begun to be explored. The influence of supplemental chromium on the performance and morbidity of stressed feeder calves was examined by Chang and Mowat (1992). Supplemental chromium was provided in the form of high-chromium yeast at a level of 400 ppb of total dry matter intake during the first 28 days and 200 ppb for an additional 70 days. The diet was based on corn silage and, after the initial period, either soybean meal or corn-urea was fed as a supplement. Calves fed supplemental chromium had greater weight gains and more efficient feed utilization during the first 28 days. No effect of chromium was observed on animal performance during the second phase but there was a reduction in serum cortisol and an increase in total serum immunoglobulins for those animals fed soybean meal in combination with chromium.

In further research with market and travel stressed calves (Moonsie-Shageer and Mowat, 1993), chromium (as high-chromium yeast) was added at concentrations of 0, 200, 500 and 1000 ppb to a basal corn-silage diet containing 1600 ppb of chromium. Observations were made for a 30-day period (Table 1). Chromium supplementation decreased morbidity and rectal temperatures during the first week. At day 28, there was a linear decrease in serum cortisol with increasing chromium concentrations. Feed intake and daily gain were greater for calves given supplemental chromium. Thus, additional evidence was provided that supplementation with chromium may improve performance and immune function of stressed calves. The form of chromium present in the high-chromium yeast which was fed in these experiments was not determined.

Crossbred steer calves (236 kg) were fed either a basal diet of 75% alfalfa silage and 25% high moisture corn or the basal supplemented with 750 ppb organic chromium as high-chromium yeast, 750 ppb inorganic chromium as $CrCl_3$, 100 ppm niacin or $CrCl_3$ plus niacin

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for a 28-day stress period followed by a 28-day growing period (Chang et al., 1994). During the first 2 weeks, chromium supplementation was doubled. Treatments had no beneficial effect on overall morbidity. Organic chromium improved rate of gain and feed efficiency by 16 and 19%, respectively, above the control, but these values were not statistically significant. Although inorganic chromium or niacin alone had no effect on performance, the combination increased (P=.09) rate of gain by 39% and feed efficiency (P=.08) by 47%, suggesting that niacin as a component of glucose tolerance factor may improve the absorption or utilization of inorganic chromium. Inorganic chromium and/or niacin had no effect on serum glucose or cortisol concentrations; however, organic chromium reduced cortisol (P=.05) and glucose (P=.06) on day 55 but had no effect on day 27.

Wright et al. (1994) studied the effects of organic chromium supplementation and its interaction with bovine respiratory disease vaccines in newly arrived crossbred feeder calves (250 kg). The four treatment groups in the 49-day trial were control, 140 ppb added organic chromium, vaccination with IBR, PI-3, BVD, BRSV and P. *haemolytica* vaccines, or chromium plus vaccines. Gain tended (P>.05) to increase by 10% with chromium and 16% with vaccination, and increased (P<.05) by 25% in calves administered the combined treatment. Treatments did not reduce morbidity; however, the group treated with chromium had fewer relapses and lower rectal temperatures 10 to 16 days post arrival. Serum haptoglobin, an acute phase protein which increases in response to infection, was reduced in chromium supplemented calves on day 7 when morbidity was greatest. Supplemental chromium (4 mg/day) as chromium-yeast did not affect performance, but reduced incidence of morbidity induced by respiratory disease in newly weaned calves from 34 to 22%, although mediation of stress hormones was not involved (Lindell et al., 1994).

Propionate loading tests were used to study the effect of .5 ppm organic chromium on gluconeogenesis in early lactating cows (Yang and Mowat, 1994). Chromium supplementation increased (P<.01) serum glucose following propionate injection during week 2 and 6 and reduced (P<.02) serum insulin peak during week 2.

Carcass Composition

Chang et al. (1992) obtained carcass composition data on steers fed 0 or 200 ppb supplemented chromium from yeast following a 70-day growing phase and a 68-day finishing period. Continuous supplementation with chromium throughout both periods was without effect on carcass composition. In other research, Wolf et al. (1993) fed a corn-based finishing diet to heifers for 114 days and found carcass traits to be unaffected by a supplement of 400 ppb chromium provided in the form of chromium polynicotinate.

Chromium supplementation as $CrCl_3$, chromium picolinate or chromium-nicotinic acid complex at 400 or 800 ppb to steers fed a high concentrate diet for 84 days did not affect performance (Claeys et al., 1994). Carcass quality grade was improved (P<.05) in steers given both concentrations of the chromium-nicotinic acid complex compared with steers given $CrCl_3$. Chromium nicotinic acid complex altered glucose metabolism and increased body weight gains in calves whereas chromium chloride ($CrCl_3$) was without effect (Kegley and Spears, 1994).

Swine

Carcass Composition

Page et al. (1993) conducted studies to test the effect of chromium picolinate on growth performance, serum metabolites, and carcass traits of growing-finishing swine. In an initial study, supplemental concentrations of 0, 25, 50, 100 or 200 ppb of chromium in the form of chromium tripicolinate were added to a corn-soybean meal basal diet containing 735 ppb of the element for both growing and finishing phases. Secondly, a similar study was conducted in which 0, 100, 200, 400 and 800 ppb of chromium were added to the basal diet. Daily gain was increased and serum cholesterol was decreased with additional chromium in the first experiment. Carcass characteristics were not influenced by treatment. In the second experiment in which greater concentrations of chromium were fed, quadratic effects of treatment were evident and the results indicated that 100 or 200 ppb of chromium were effective in increasing longissimus muscle area and percentage of muscling and in decreasing fat covering over the ribs. In other studies, Mooney and Cromwell (1993) supplemented 0 or 200 ppb chromium as chromium picolinate to corn-soybean meal diets for growing-finishing pigs and observed increased percentage of muscle and decreased percentage of fat when chromium was fed.

Form of chromium was demonstrated to be important by Page et al. (1993) in their work with growing-finishing pigs. Inorganic chromium ($CrCl_3 \cdot 6H_2O$) when fed at concentrations of 100 or 200 ppb chromium was without effect on carcass composition. Average backfat thickness was lower ($P<.05$) in pigs supplemented with 200 ppb chromium as chromium nicotinate during growing (34 - 57 kg) and finishing (57 - 102 kg) phases, but performance was not affected (Smith et al., 1994).

Evoke-Clover and Steele (1994) examined the interaction between 300 ppb chromium as chromium picolinate as a dietary supplement and daily intramuscular injection of 100 µg of recombinant porcine somatotropin (rPST) on growth and carcass composition of growing-finishing swine. In this experiment, there was no effect of chromium alone or an interaction with rPST on growth or nutrient partitioning during the grower or finisher phase. Mooney and Cromwell (1994) fed either 0, 200, or 400 ppb chromium as chromium picolinate or 5 or 25 ppm chromium as $CrCl_3 \cdot 6H_2O$ to pigs (20 kg) for 35 days, dissected the right ham for composition and found no alteration of nutrient partitioning. Boleman et al. (1994) reported an effect of chromium on carcass composition of swine only during the finishing phase. They fed 200 ppb chromium as chromium tripicolinate during growing and finishing or only during finishing and reported that percentage of fat ($P<.10$), and intermuscular and total fat ($P<.07$) decreased and percentage of muscle increased ($P<.07$) in pigs fed chromium only during the finishing phase.

Summary

Research with supplemental dietary organic chromium has shown beneficial effects by improving performance and immunocompetence of stressed calves. Feed intake and weight gain of the animals were greater and morbidity was reduced with added chromium. In addition, research with swine has indicated in some of the studies an increased percentage of muscling and a decrease in backfat thickness when chromium picolinate was provided. These recent observations are important for livestock production. Further exploration with regard to the role of chromium in nutrition and the animal's well-being in regard to its requirement, effective forms and metabolic function should increase the value of the element to the animal industry.

At the time this article was prepared (October, 1994), the use of supplemental dietary chromium was not approved by the Food and Drug Administration.

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Table 1. Performance and morbidity of feeder calves during the first 30 days after arrival

	Supplemental Cr, ppb			
Item	0	200	500	1000
No. of calves	21	21	21	21
Live wt, kg				
Initial	232	241	234	240
Daily gain, kg	.66[b]	.84[a]	.70[ab]	.84[a]
DMI, kg/d				
0-10 d	2.02	2.80	2.08	2.57
11-21 d	4.85	5.64	4.68	5.49
22-30 d	5.12	5.51	5.02	5.68
Overall	3.99[b]	4.66[a]	3.91[b]	4.57[a]
Gain/DMI	.16	.18	.18	.18
Morbidity, %				
0-30 d	52.4[b]	14.3[a]	33.3[b]	47.6[b]
2-30 d	42.9[b]	0[a]	23.8[ab]	23.8[ab]
Rectal temperature, °C				
2 d	39.70[b]	39.14[a]	39.16[a]	39.16[a]
5 d	39.65[b]	39.22[a]	39.50[ab]	39.14[a]
7 d	39.77	39.58	39.76	39.46

[a,b] Values in same row with different superscripts differ ($P<.05$).
Moonsie-Shageer and Mowat. 1993.