Understanding How Beef Cow Trace Mineral Requirements Relate to Production Parameters

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Introduction

Approximately 16 different minerals are required to support normal biological functions in beef cattle. Under grazing situations nearly all of these are adequately provided by forage and water. Minerals which are not met by dietary sources need to be supplemented. These minerals are grouped into two categories, macrominerals and microminerals. The macrominerals which are commonly supplemented to grazing animal diets include; sodium (as NaCI), potassium, calcium, phosphorus, magnesium, and sulfur. Only the microminerals which form a group called the essential trace minerals (ETMs) will be discussed in this report. Although false, a commonly held theory of trace mineral utilization is one which suggests that animals will consume trace minerals as they are needed. In reality, sodium as sodium chloride is the only mineral which animals have the innate ability to consume as needed. Therefore proper trace mineral intake is crucial when addressing potential deficiency situations.

Seven trace minerals are considered essential to support normal physiological functions in beef cattle. These include: cobalt, copper, iodine, iron, manganese, selenium, and zinc. The level at which these ETM's are supplemented varies in accordance with the amount and availability with the diet being consumed.

Trace Mineral Availability

Analyzing a feedstuff for levels of trace minerals generally gives us limited useful information on the true ETM value because of the many factors that can potentially impede the absorption of these minerals once consumed. Form of the element, distribution within the plant, and interactions with other minerals all play a role in the availability of an ETM. Table 1 includes data obtained from ruminal release studies of minerals from both a legume and grass specie.

Table 1. Mineral Release From Grass and Legume Plants (%)

Mineral	Alfalfa	Bermudagrass
Copper	92.9	75.8
Zinc	79.4	62.1

Emanuele and Staples (1990); 72 hour incubation

Upon review of several insitu studies of mineral availability, it has been shown that minerals exist in plants in three separate fractions: 1) a soluble fraction, 2) a fraction released slowly as plant cell walls and protein is degraded, and 3) a fraction which is unavailable.

After minerals from feedstuffs are transferred to the ruminal pool there is opportunity for mineral interaction. This may lead to the formation of other insoluble complexes, independent of the plant. Although these complications, associated with mineral availability, are often unescapable, they are an important consideration. This is especially true when deficiency symptoms are present even under dietary situations which appear adequate. In many cases corrections can be made either by increasing trace mineral supplementation or by changing the form of mineral being supplemented. The following contains an overview of each of the seven ETM's.

Cobalt

The ruminal synthesis of vitamin B_{12} is dependent upon cobalt. Cobalt stores are located primarily in muscle and bone, and are not readily mobilized under situations of dietary deficiency. Therefore a continuous oral intake of cobalt is essential to maintain adequate levels of vitamin B_{12}. Vitamin B_{12} acts as a cofactor for the metabolism of propionate to glucose. Cobalt requirements may increase in dietary situations which promote an increase in propionate production.

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Although liver is considered to be a better indicator than serum, neither are good indicators of cobalt status. Instead, vitamin B_{12} levels can be used to assess cobalt status. Cattle with serum levels of 0.40 to 0.90 ng/ml and liver levels of 0.25 to 2.50 ppm of vitamin B_{12} are considered to be cobalt adequate.

Signs of cobalt deficiency
- ---- Reductions in vitamin B_{12} levels
- ---- Increases in pyruvate levels
- ---- Ocular discharge
- ---- Loss of appetite
- ---- Reduced conception rate

Copper

Next to phosphorus, copper is the most limiting mineral in grazing cattle diets. Copper is involved in numerous physiological functions such as hemoglobin formation, iron absorption and mobilization, and connective tissue metabolism. It is estimated that copper plays a role in over thirty enzyme systems. In fact, one of the major effects of copper deficiency in beef cattle may well be its influence on enzyme systems which are involved in reproduction and immune function.

Copper is essential for the function of Cu,Zn-superoxide dismutase (Cu,Zn-SOD) which is the body's primary scavenger of toxic oxygen radicals. Under instances of copper deficiency, an attenuation of Cu,Zn-SOD activity has been shown. A subsequent build up of these oxygen radicals can promote oxidative damage leading to tissue deterioration.

Copper is also involved in numerous other physiological functions. Currently, the manifestation of copper deficiency has been shown to effect two key areas of beef cattle production, immune function and reproduction.

Common Antagonists of Copper Utilization

The availability of copper in beef diets is a unique consideration when compared to monogastric species. The absorption of copper in the ruminant's digesta is commonly impeded through the formation of insoluble complexes. Primarily, these complexes result from the consumption of diets which contain high levels of molybdenum and/or iron. The involvement of these elements in dietary copper absorption results in the need for defining two types of copper deficiency.

1. *Primary Deficiency:* copper deficiency resulting simply from diets which do not contain adequate levels of copper.
2. *Secondary Deficiency:* Copper deficiency resulting from diets containing adequate copper levels, but which are unavailable due to high levels of copper antagonists.

A study by Phillippo *et al.* (1987) characterized the impact of dietary molybdenum and iron on copper utilization. The results of this study are shown in *Table 2:*

Table 2. The Effect of Dietary Iron and Molybdenum on Liver Copper in Growing Heifers

Week	Control[a]	Iron (500 ppm)	Molybdenum (5 ppm)
0	128.7	134	127.4
8	48.9	16.3	19.5
16	31.3	5.6	4.8

[a] Control animals were fed the basal diet only (Cu = 4 ppm)

In this example it appears that dietary iron and molybdenum, at these levels, are equally effective in their ability to induce copper deficiency. In addition, it is interesting to note that control animals also experienced declines in liver copper stores. Although less dramatic verses those animals supplemented with molybdenum and iron, this decline in liver copper suggests that dietary copper at 4 ppm is inadequate in growing heifers.

In our experience, the most common culprit of acquired copper deficiency is the consumption of forages which contain excessive levels of molybdenum with adequate sulfur. These two elements, when joined in the rumen, form a complex called a thiomolybdate. Thiomolybdates have a high affinity for elemental copper, and upon binding, form an insoluble copper-thiomolybdate complex. Therefore when attempting to diagnose a copper deficiency it is important to also look at dietary levels of molybdenum and sulfur. **The copper to molybdenum ratio should be equal to or greater than (4.5:1) with sulfur levels less than .25%.**

Liver copper levels are the best indicator of animal status. Serum ceruloplasmin levels are a more reliable indicator than serum copper levels. Serum ceruloplasmin levels less than 10mg/100ml are indicative of copper deficiency. Ceruloplasmin is classified as an acute phase protein and serum levels will increase during periods of physiological stress. Thus, high ceruloplasmin levels should not always be considered as indicating adequate copper levels in the animal. Information on the use of cupric enzymes as a means of diagnosing copper deficiency are further described in the second part of this review.

Signs of copper deficiency
- ---- Rough, faded hair coat
- ---- Greying of hair around the nose and ears
- ---- Scouring which does respond to treatment
- ---- Abomasal ulcers
- ---- Heel cracks, sole abscesses, and foot rot

Iodine

Reproductive failure is the most common manifestation of iodine deficiency, resulting as a secondary response to thyroid disfunction. Iodine is required for the biosynthesis of thyroid hormones (T3 and T4) which regulate energy metabolism. This proposes a functional role for iodine in numerous physiological systems including thermoregulation, reproduction, growth, and muscle function. Iodine is essential to fetal thyroid function and in iodine deficient cows abortions are common. Iodine deficiency which continues for prolonged periods of time often results in goiter, a condition which involves enlargement of the thyroid gland.

Ethylenediamine (EDDI) is commonly added to mineral supplements as both an antimicrobial agent for foot rot prevention, as well as a source of supplemental iodine. Still, the most widely used method of iodine supplementation occurs through the use of iodized salt as the base of a trace mineral supplement.

Signs of iodine deficiency

---- Goiter
---- Growth retardation
---- Reduced conception
---- Increased abortion

Iron

Due to its relative large requirements in grazing beef cattle (50 ppm) it has often been questioned whether or not iron should be considered an essential trace mineral. Generally iron content in forages is high, also, phosphorus is often contaminated with iron sources. Therefore, under most grazing situations, where phosphorus is supplemented, additional iron is not needed.

Reproduction is one area where iron may play a associative role with other EMT's Some studies have shown a positive correlation between higher serum levels of iron, along with, manganese, copper and zinc with regular breeders.

Estimation of iron through feedstuff analysis is the least informative of all the EMT's. This is due to the high degree of variability in iron bioavailability among supplemental iron sources used, Feedstuffs contaminated with dirt will report artificially high levels of iron which is virtually unavailable to the animal. In addition, iron oxide is often added to mineral supplements for its red color. This is of aesthetic quality only because iron from it's oxide form is highly unavailable to the animal.

Manganese

Considerable attention in the livestock industry is focused on trace element deficiencies associated with copper, selenium, and zinc. One of the hidden trace elements that may have considerably more influence than we realize is manganese.

Adequate manganese intakes are required for proper bone development and reproduction. Manganese is another example of an ETM that is required for the biological function of many enzyme systems. Manganese status is difficult to measure in the animal. It is estimated that as much as 50% of the body's manganese pool is ingested daily. Therefore, an adequate daily intake of manganese is essential.

Also, manganese is considered an ETM which is poorly absorbed. Evidence suggests that only 14-18 percent of ingested manganese is actually absorbed. Therefore, using a source of manganese which offers the highest availability should be considered. Availability of manganese is best with the sulfate form followed by oxide and carbonate forms. In addition, manganese is one of the least toxic at high concentrations of all the ETM's.

Signs of manganese deficiency

---- Silent heat
---- Reduced conception
---- Abnormal calf development

Selenium

When considering selenium supplementation one must be equally concerned with toxicity as well as deficiency. The range at which selenium is considered optimum is much smaller than other ETM's.

Both selenium and vitamin E are considered antioxidants and they appear to be closely interrelated in their physiological roles in the animal. Although they both have specific functions, they also have a sparing affect toward each other. Much like Cu,Zn-SOD, described earlier, selenium and vitamin E protect the body's biological systems from oxidative damage.

White muscle disease is a commonly reported symptom of selenium deficiency. In addition, selenium deficiency has also been associated with reductions in fertility. This is most evident with increases in the incidence of retained placentas and early embryonic death. Also, there appears to be some connection between selenium deficiency and impaired immune function. Whole blood selenium levels are considered to be of limited value. Liver selenium is the best indicator of animal status.

Signs of selenium deficiency

---- Retained placentas
---- Weak, lethargic calves
---- Reductions in immune function

Zinc

Zinc also exerts its influence as being an integral component in many enzymatic systems. These enzymes play important roles in many physiological processes including immune function, nucleic acid metabolism, carbohydrate metabolism and protein synthesis.

Zinc is essential for proper testicular development and spermatogenesis. Zinc is also important for the mobilization and tissue utilization of vitamin A. Recently, zinc supplementation, above that recommended by NRC, has been shown to have a positive effect on carcass quality in feedlot steers.

Tissue stores of zinc are not readily mobilized under times of dietary deficiency. Zinc absorption, however, is readily accomplished through the small intestine and under most supplementation programs zinc deficiency rarely occurs.

Signs of zinc deficiency

---- Increased susceptibility to foot rot
---- Impaired spermatozoan maturation
---- Decreased conception rate
---- Reduced feed intake and growth
---- Reduced immune response

Problems Associated With Trace Element Supplementation

There are four key problems associated with trace element supplementation. Unfortunately, these are difficult barriers to control and they often make the optimum supplementation of trace minerals an arduous task to achieve.

1. Trace element requirements in animals are poorly defined and seldom in cow diets are these requirements altered to fit the productivity stage of the cow.
2. There is considerable variability in the level and availability of trace elements found in forages. Also, the factors that influence this variability is poorly documented.
3. There is tremendous variability in the trace element content of mineral mixes sold commercially. In fact, it is often difficult to obtain this information at least through local sales personnel.
4. The mode of action of how trace elements may impact reproductive function and immune systems are poorly defined, and additional research is certainly needed.

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