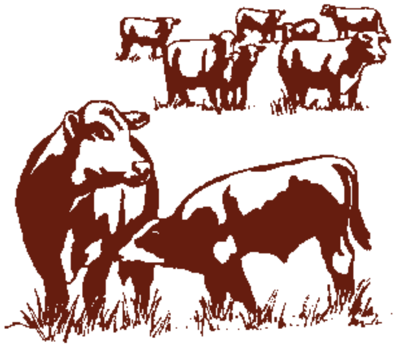

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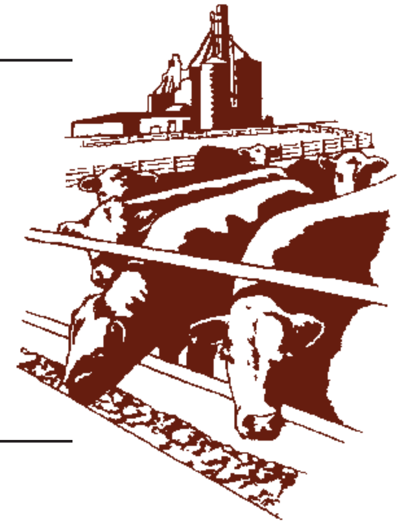

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Considerations In Trace Mineral Supplementation

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There are basically three approaches that can be used in regard to trace mineral supplementation. The first is to assume that the cost of trace mineral mixes do not justify their use. At this point you accept any reduction in animal performance and feed cost savings. The second is to assume that timely supplementation of complete trace minerals is inexpensive insurance and is well worth the cost. The third route would determine if any minerals are inadequate and the extent of the deficiency. This approach would then utilize diagnostic procedures available from university veterinary diagnostic labs and/or commercial laboratories for analysis of animal blood or tissue samples. Each of the three options listed above has advantages and disadvantages (3).

There are 26 elements that are essential for life. However, not all 26 are suspected as problem elements in diets of cattle in the Great Plains or Rocky Mountain region. Generally, the elements—cobalt, copper, iodine, manganese, selenium and zinc—are considered for supplementation.

Cobalt

Function - Ruminants have a requirement for vitamin B_{12} rather than cobalt. However, the microorganisms in the rumen utilize cobalt to synthesize vitamin B_{12} which the animal absorbs and uses. Vitamin B_{12} is a component of a liver enzyme that metabolizes propionate, a volatile fatty acid produced in the rumen.

Deficiency - Symptoms of cobalt deficiency are similar to those seen by other nutritional problems. These include depressed appetite, listlessness, decreased growth or loss of weight, reduced milk production, rough hair coat, anemia resulting in pale skin and membranes. In extreme cases emaciation, muscle incoordination, stumbling gait and death will occur.

Evaluation - Plasma alkaline phosphatase, low blood glucose and plasma vitamin B_{12} are the best indicators of cobalt deficiency (6).

At least .08-.11 ppm cobalt of pasture forage dry matter should provide adequate cobalt for cattle. However, it is important to note that dietary cobalt should he suppled in at least bi-weekly intervals.

Supplementation - Cobalt can be effectively supplied in a supplement. According to the 1984 Beef Cattle Requirements (Table 7), cobalt concentration of .1 parts per million (ppm) should be adequate. A mineral mix with salt should contain .001 percent or .002 percent cobalt to supply 50 or 100 percent of the animal's

Table 1. Changes Due to Cobalt Deficiency (6)

Measurement	Normal	Deficient
Hemoglobin, g/dl [a]	9 - 12	5 - 7
Plasma glucose, mg/dl [b]	70 - 90	38 - 66
Plasma alkaline phosphatase, IU/l [c]	30 - 60	10 - 31
Plasma vitamin B12, pg/ml [d]	400 - 800	53 - 132

[a] *Grams/100 ml.*
[b] *Milligrams/100 ml.*
[c] *International Units/liter.*
[d] *Picograms/milliliter.*

requirements (assuming one oz intake of a salt mineral mix) (Table 6) (7). Vitamin B_{12} can be injected into the animal to alleviate the symptoms of cobalt deficiency.

Copper

Function - Copper is an essential component of a number of enzymes. It is important for prostaglandins and elastin formation. It plays a role in energy transfer in the cell and is also involved in protecting the body from oxidation. It also promotes iron utilization which eventually influences oxygen carrying capacity. In nonruminants a relationship has been established between copper status and suppressed immunity (5).

Deficiency - Calves generally have higher copper levels at birth even when their dams are depleted; consequently, except in extreme deficiency, the calf is protected in utero and for up to two months of age. In older animals normal bone development may be inhibited due to the role copper plays in collagen formation. A copper deficiency may result in fragile, easily broken bones which may include enlargement of long bones, beading of ribs and osteomalacia (6). Other symptoms may include severe diarrhea, depigmentation of hair, cardiac failure and reduction in fertility (due to embryonic or fetal death (2).

Evaluation - In general copper is poorly absorbed by the digestive tract. Copper deficiency may be categorized into four groups: l) high concentration of molybdenum (greater than 20 ppm); 2) low copper but significant amounts of molybdenum (ratio greater than 2:1); 3) deficient copper (less than 5 ppm); and 4) adequate copper and low molybdenum with high concentration of rapidly degradable protein (high protein concentration is associated with high concentration of sulfur).

Copper is stored in the liver and transported to other tissues. Blood levels may remain constant as liver copper is being depleted which makes liver concentration a more sensitive indicator of copper status. To assess copper status, liver samples from at least 6-14 head, either by liver biopsy or at slaughter, should be sampled. Hair samples should only be used to determine chronic deficiency in conjunction with another analysis.

Forage containing less than 3 ppm of copper in the dry matter is considered deficient, while 3 - 6 ppm is considered marginal. Feeds containing 6 ppm or more are considered adequate. Grains are generally lower in copper than forages, and most forages contain three to four times the copper requirement. A copper to molybdenum ratio no less than four to one should ensure adequate copper availability.

Supplementation - Copper can be effectively supplied in a supplement. A self-fed mineral mix with salt should contain .1 percent and .2 percent copper to supply 50 or 100 percent of the animal's requirement (assuming one oz per head per day intake of salt mineral mix) (Table 6) (7). Subcutaneous or intramuscular injection of safe and slowly absorbed copper solution are effective means of treating animals. A second injection would be required in three months. Copper glycinate and copper-calcium EDTA are currently available injectable sources. Deaths of young cattle have been reported with copper-calcium EDTA with improper injection technique (1).

Table 2. Changes Due to Copper Deficiency (5)

Measurement	Normal	Deficient
Liver, ppm [a]	30 - 120	1 - 30
Ceruloplasmin, mg/l [b]	—	< 154
Blood plasma, ppm [a]	.9 - 1.2	< 0.7
Hair, ppm [a]	8 - 15	< 7

[a] *Parts per million.*
[b] *Milligrams/liter.*

Iodin

Function - The primary role of iodine is the synthesis of hormones by the thyroid gland. Thyroid gland hormones actively regulate energy metabolism, thermoregulation, reproduction, growth and development, circulation and muscle function.

Deficiency - Iodine deficiency exists in the United States, especially in the northern tier of states. The principal clinical sign is goiter. In calves it may also be manifested by general weakness, animals born blind, hairless or dead. A lack of hair is indicative of a more severe deficiency than goiter. Iodine deficiency may be exhibited by severely reduced productivity in breeding animals (suppression of estrus in the female and lack of libido in males).

Evaluation - Cattle requirements for iodine have not been extensively studied due to the obvious deficiency symptoms (goiter) and immediate response to iodine supplementation. Iodine absorption may be diminished by these interfering compounds: 1) thiocyanates, perchlorate and rubidium salts; 2) arsenic, fluorine or calcium; 3) deficient or high dietary cobalt; and 4) low

Table 3. Concentration of Iodine in Serum and Milk of Cows Fed Increasing Levels of Iodine (6)

Intake, mg/d [a]	Serum, ng/ml [b]	Milk, ng/ml [b]
12	109	216
28	157	449
40	167	450
80	247	893
160	398	1,559
400	1,351	2,036

[a] *Milligrams/day.*
[b] *Nanogram/milliliter*

manganese intake. Although serum iodine is not routinely used to diagnose a deficiency, Table 3 is presented as a reference (6).

Supplementation - The estimated requirement for a 1100 lb beef cow is 1 mg per day or .05-.1 ppm. The most convenient and widely used method of supplementing the diet is through the use of iodized salt. Problems of iodine deficiency should not occur, but problems can be encountered when iodine leaches or evaporates from salt blocks. A mineral mix with salt should contain .008 or .016 percent iodine to supply 50 or 100 percent of the animal requirements (assuming one oz intake of a salt mineral mix) (Table 6) (3).

Manganese

Function - Manganese is involved in a number of enzyme systems in the body which participate in carbohydrate, fat and protein utilization. It is also involved with proper bone development and maintenance. Manganese contributes to proper functioning of the reproductive process in both males and females. The body has only a limited storage of manganese reserves that can be mobilized. The absorption of manganese in all domestic livestock is poor.

Deficiency - Symptoms in the cow are characterized by reproductive disorders. These include delayed estrus, reduced fertility, abortions, deformed calves born with weak and shortened bones, deformed legs with enlarged joints, stiffness, twisted legs and "over knuckling" (sometimes referred to as a crooked calf). The occurrence of this disease has been reported in nine western states. The content of manganese to reproductive tissue may suggest a relationship between manganese and reproduction. For males, manganese deficiency is demonstrated by impaired spermatogenesis, testicular and epididymal degeneration, sex hormone inadequacy, and eventually sterility.

Evaluation - There is no single, simple test that will permit early detection of manganese deficiency in beef cattle (7). Liver concentration can serve as an indicator, but not definitive, of a deficiency. Possibly values of 10-6 ppm liver manganese indicates a deficiency along with diet samples showing less than 20-40 ppm. Normal plasma manganese is suggested to be 25 ng per ml. The only sure way of detecting a mild manganese deficiency is by measuring responses in reproduction to manganese supplementation.

Supplementation - Requirements for manganese are increased by elevated dietary concentration of calcium and phosphorus. Mature females have a higher requirement than feedlot cattle because of the increased need for reproduction and fetal development. Cows would require 40 ppm, and feedlot cattle 20 ppm.

Selenium

Function - The exact physiological function of selenium is not clear. The functions that are attributed to it are: nonspecific antioxidant which protects tissues and membranes, participates in enzyme biosynthesis, and influences absorption of vitamin E and fat (triglycerides).

Deficiency - Selenium deficiency symptoms may include reduced growth, muscular dystrophy and poor reproductive performance. The incidence of muscular dystrophy can be sporadic—very severe one year but of little consequence the next. Skeletal muscles most affected include those involved with movements of the legs and neck. Animals tend to carry their rear feet farther forward and the front feet farther back than normal. However, in calves the most sensitive muscles are cardiac. Sometimes muscles show increased mineralization (elevated levels of calcium, phosphorus, sodium and magnesium). Reports vary as to the effects on reproduction. However, impaired fertility is associated with increased embryonic death. This effect is observed as increased number of services are required to settle a cow. A reduction in retained placentas may occur when cattle are treated with injectable selenium and Vitamin E. Other studies have also shown a reduction in the incidence of cystic ovaries when treated with selenium.

Evaluation - McDowell (7) states that muscular dystrophy is easily diagnosed by tissue selenium concentration and elevation of serum glutamicoxalacetic transaminase (SGOT). The liver and kidney are sensitive indicators of selenium status, along with blood selenium and glutathione peroxidase.

The similarities between selenium and sulfur have suggested competition between the two elements. Reduced concentrations of selenium in harvested feeds are sometimes the result of yield increases seen with sulfur fertilization (5).

Supplementation - The dietary requirement for selenium has been set at .1 ppm. The maximum tolerable level is 2 ppm. Anything above this level is considered toxic. The effectiveness of selenium supplementation is generally enhanced when vitamin E is supplied concurrently. Both sodium selenate and sodium selenite are effective supplemental sources. McDowell suggests that self-fed supplements contain .001 or .002 percent selenium to supply 50 or 100 percent of the selenium requirement (assuming the animal consumes 1 oz of a self-fed salt mineral mix) (Table 6, (7). Injectable selenium plus vitamin E are available. If this product is to be used prior to calving, it should be administered at least 60 days before calving to get the full benefit.

Table 4. Critical Concentration of Selenium in Animal Tissue (7)

Tissue	Critical Level
Liver, ppm[a]	.25
Serum, ug/ml[b]	.03
Hair, ppm[a]	.25

[a] *Parts per million.*
[b] *Micrograms per milliliter.*

Zinc

Functions - Zinc is a component of metal containing enzymes which participate in nucleic acid and carbohydrate metabolism, along with protein metabolism. It has been associated with appetite growth, male sexual development and wound healing. There are no significant stores of body zinc, so the animal must rely on a daily supply to meet requirements (5).

Deficiency - Clinical signs of zinc deficiency include excessive salivation, deterioration and loss of hair, itching and stiff joints. Cracks may appear around the fetlock and pastern, skin around nostrils, neck and scrotum. Teats can become thickened, scaly, dry and crack easily (5). A severe deficiency of zinc will resemble mange. A mild zinc deficiency in finishing cattle will result in decreased gains with no visible symptoms. The cell mediated immune system may be adversely affected because of zinc's role in protein and nucleic acid metabolism. A mild zinc deficiency would be difficult to diagnose clinically. The first signs would be decreased feed intake, growth, feed efficiency, milk production, resistance to infection and stress, and lower reproductive efficiency (6).

Evaluation - Serum or plasma zinc may drop from normal levels of .8-1.2 mg per l to concentrations of .15-.20 mg per l. Total zinc content of bovine tissues and organs appears to be well regulated and is reduced slightly when a zinc deficient diet is consumed (Table 5) (5). Zinc liver contents will be reduced 30-60 percent when deficiency symptoms appear (which occurs faster in the liver than any other organ). Other diagnostic measurements may include reduction in blood hemoglobin and activity of alkaline phosphatase.

Supplementation - Zinc can be provided either by injection of zinc salts or by feeding in mineral salt mixtures. The requirement is thought to be between 20 and 40 ppm. Most hays and silages contain less than 60 ppm, while cereal grains contain 10-30 ppm. A mineral mix with salt should contain .5-1.0 percent zinc to supply 50 or 100 percent of the animal's requirements (assuming one oz intake of a salt mineral mix) (Table 6, (7).

Table 5. Zinc Concentration of Various Tissues (6)

Dietary Zinc	Liver, mg/kg[a]	Serum, mg/l[b]
2, ppm[c]	84	
17, ppm[c]	109	
40, ppm[c]	114	
223, ppm[c]	213	
normal		.8 to 1.2
deficient		.15 to .20

[a] *Milligram per kilogram.*
[b] *Milligram per liter.*
[c] *Parts per million.*

Evaluation of Mineral Programs

The most reliable methods of supplying trace minerals is through a range cake (or some type of mixed feed) or by using injectable minerals. Both of these methods may not "fit" into current management. The self-fed salt mineral mix is often the most convenient way of supplying minerals. Cattle have a craving for salt, and we can exploit this desire by packaging minerals along with it. However, not all cattle will consume the mix, and those that do may have quite different daily intakes. Generally, cattle do not have as great a desire for other minerals on a consistent basis. If self-fed salt mineral mixes are to be used, this should be the only source of salt available. Appetizers may be used to improve consumption such as yeast culture, feed flavors, molasses, etc. Place mineral feeders in areas where they frequent, such as near water, loafing areas, back rubbers, etc. Keep mineral in the feeders at all times to encourage steady consumption. Watch for caking, mold, manure and other contamination of mineral mixtures. Consumption will vary with the season. Cattle may consume more mineral when grazing dry forage than rapidly growing forage. Mineral content of water (esp. alkali) may reduce mineral intake.

Biological availability (Table 6) of minerals should be taken into consideration when evaluating a mineral mix. Chelates are a form of trace minerals that significantly improve absorption of minerals (4). The cost of these sources needs to be weighed against the benefits. Remember only small quantities of these minerals need to be absorbed. If chelates are considered and cost is a concern, their use may be restricted to those periods when mineral nutrition is most critical. As the awareness of the essentiality of trace mineral nutrition expands, we run the danger of over feeding. Too much of any of these minerals is as detrimental as not enough. Table 7 lists the maximum tolerable level of each mineral.

Summary

Overall, the number one criteria for using a particular mineral supplement is to profitably satisfy a mineral deficiency. If a deficiency is met, there should be a marked improvement in animal performance (growth, reproduction and resistance to stress). If a marginal deficiency exists, there are two methods that may be used to document that deficiency. The first is through the use of diagnostic tests that indicate deficiency symptoms. The second is by supplying the mineral in question and, through the use of records, determine if an improvement in animal performance occurred.

Table 6. **Sources of Trace Minerals, Concentration and Availability (7)**

Mineral	Source	% Mineral in Source	Availability
Cobalt	Carbonate	46 to 55	Not known, but effective
	Sulfate	21	
	Chloride	25	
Copper	Sulfate	25	High
	Carbonate	53	Intermediate
	Chloride	57	High
	Oxide	80	Low
	Nitrate	34	Intermediate
Iodine	Calcium iodate	63.5	——
	EDDI	80	Unstable
	Potassium, iodide (stabilized)	69	High
Manganese	Sulfate	27	High
	Oxide	52 to 62	High
Selenium	Sodium selenate	40	High
	Sodium selenite	46	High
Zinc	Carbonate	52	High
	Chloride	48	Intermediate
	Sulfate	22 to 36	High
	Oxide	46 to 73	High

Table 7. **Mineral Requirement and Maximum Tolerance Level for Beef Cattle**

Mineral	Requirement		Maximum Tolerance Level
	Suggested Value	Range	
Cobalt, ppm	0.1	07. to .11	5
Copper, ppm	8.0	4 to 10	115
Iodine, ppm	0.5	.2 to 2.0	50
Manganese, ppm	40.0	20 to 50	1,000
Selenium, ppm	0.2	.05 to .3	2
Zinc, ppm	30.0	20 to 40	500

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