Minerals and Vitamins for Beef Cows

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Introduction

Many mineral elements and vitamins are essential nutrients with very specific functions. Mineral elements and vitamins are required in small amounts but a deficiency could produce significant reductions in growth and reproduction in otherwise adequately nourished beef cows and calves.

Requirements and Function of Minerals

The requirements and maximum tolerable concentrations for some minerals are shown in *Table I.* At least 17 minerals are required by beef cattle. These requirements are divided into two groups: macrominerals and microminerals. In a nutrient requirement table, macromineral requirements are expressed as percent (%) in a ration on a dry matter (D.M.) basis. In contrast, in a nutrient requirement table, micromineral needs are expressed in parts per million (ppm) or mg/kg (10 ppm of a mineral equal 10 mg/kg of ration dry matter). Requirements are not listed for some minerals because research data are inadequate for them to be determined. Macrominerals required by beef cattle include calcium (Ca), magnesium (Mg), phosphorus (P), potassium (K), sodium (Na), chlorine (Cl), and sulfur (S). The microminerals required are chromium (Cr), cobalt (Co), copper (Cu), iodine (I), iron (Fe), manganese (Mn), selenium (Se), and zinc (Zn). The maximum tolerable concentration for a mineral is defined as "that dietary level that, when fed for a limited period of time, will not impair animal performance and should not produce unsafe residues in human food derived from the animal" (Nutrient Requirements of Beef Cattle, 1996). Supplementing diets at concentrations that exceed requirements not only greatly increases cost, but mineral loss in cattle waste (manure and/or urine) can migrate through the soil and possibly into the groundwater.

The functions of minerals can be divided into four major areas: ***skeletal development and maintenance***, including bone and tooth formation (Ca, P, Mg); ***energy***, including minerals that are components of enzymes or other compounds in the body essential for energy production and utilization or other activities necessary for normal growth and reproduction (P, Cu, Zn, Mn, Se); ***milk production***, (Ca); and ***basis body function***, minerals essential for the normal function of basic systems in the body such as the nervous system (Mg, K, Na, Cl, S, Co, I, Fe).

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Table I. Mineral requirements and maximum tolerable concentrations[a].

		Requirement		
		Cows		
Mineral	*Unit*	*Gestating*	*Early Lactating*	*Maximum Tolerable Concentration*
Calcium[b]	%	0.21	0.30	
Chlorine	%	—	—	—
Chromium	mg/kg	—	—	1,000.00
Cobalt	mg/kg	0.10	0.10	10.00
Copper	mg/kg	10.00	10.00	100.00
Iodine	mg/kg	0.50	0.50	50.00
Iron	mg/kg	50.00	50.00	1,000.00
Magnesium	%	0.12	0.20	0.40
Manganese	mg/kg	40.00	40.00	1,000.00
Molybdenum	mg/kg	—	—	5.00
Nickel	mg/kg	—	—	50.00
Phosphorus[b]	%	0.15	0.19	
Potassium	%	0.60	0.70	3.00
Selenium	mg/kg	0.10	0.10	2.00
Sodium	%	0.06-0.08	0.10	—
Sulfur	%	0.15	0.15	0.40
Zinc	mg/kg	30.00	30.00	500.00

[a]Nutrient Requirements of Beef Cattle, 7th Revised Edition, 1996.
[b]Beef cow 1,200 lb mature weight producing 20 lb milk per day during lactation. Refer to Nutrient Requirements of Beef Cattle, 7th Revised Edition, 1996 for more detail on requirements.

Common Deficiency Problems

The common deficiency problems beef producers should be aware of include:

Signs of Problem	*Mineral Element (s) Commonly Deficient*
Excitability and convulsions (Grass Tetany)	Magnesium
Tender joints and stiff legs with arched back (calves); weak brittle bones (cows)	Calcium and Phosphorus
Reduced fertility and poor weaning weights (when energy and protein are adequate)	Phosphorus
Anemia and de-pigmentation of hair	Copper
Calves born hairless	Iodine
Calves show stiffness in front legs and lameness (White Muscle Disease)	Selenium
Excessive salivation, listlessness, and scaly lesions (Parakeratosis)	Zinc

Sources of Mineral Elements

Base Feed Ingredients

Most feed ingredients contain mineral elements. Forage, the major component of the cow's diet, serves as the most economical nutrient source. Determining the forage's mineral content is important; unfortunately, many factors influence the amount and availability of minerals in forages.

Mineral content is influenced by both the quantity and availability of the minerals in the soil. Availability is an important consideration; it appears that only a small portion of the soil's total mineral content is available for uptake by the plant. Soil pH influences the mineral uptake by forages from soil. Soil testing is of limited value in predicting mineral content of forages on a farm and ranch. The 1996 National Research Council (NRC) report provides the average mineral concentrations of various forages. Harvested forages and grains can be analyzed for mineral content. When testing forages for mineral content, it is important to take a representative sample of the feed in order to get an accurate estimate. Substantial weathering of harvested forages can cause some mineral leaching. For example, potassium levels will be influenced by weathering because potassium is water soluble. Nebraska data indicate clipped samples of standing forages will provide an accurate estimate of the mineral content.

Mineral Availability in Forages

Data indicate that as the plant matures, mineral availability in the forage decreases. A number of complex interactions in a cow's body influence elemental availability, and it is difficult to determine how much of an individual element is required for each critical physiological function. Just because a particular mineral is measured in a nutrient analysis of a forage or grain sample, it doesn't mean it is 100 percent available (absorbed into the blood stream) to the animal. Generally, 85 to 92 percent of plant or grain P, K, Mn, Fe, and K; 50 to 65 percent of the plant or grain Ca; 40 to 70 percent of the plant and grain Zn; and 50 to 60 percent of the plant or grain Cu is available for animal use. The exception to these higher absorption values is manganese, which may be considerably lower. The wide range in availability of minerals from forages indicates the general lack of data available to predict the biological availability. Mineral requirements established in the 1996 Nutrient Requirements for Beef Cattle (NRC) are based on experiments where dietary mineral content was determined from fed ingredients so the differences between mineral availability are taken into consideration. Therefore, NRC requirements shown in the tables are the amount of a particular mineral needed by the animal.

Mineral Element Supplements

Macrominerals: The major supplemental sources of macrominerals are: Limestone (Ca), dicalcium phosphate and monosodium phosphate (P), white salt (Na and Cl), magnesium oxide (Mg), and potassium chloride (K).

Trace minerals: There are two forms of trace element sources that may be fed to cattle: inorganic and organic. For the inorganic sources, there are differences in the relative availability of the trace elements. As an example, copper in the sulfate form is highly available to the animal, and copper in the oxide form is not very available. Organic complexes of a trace mineral have been shown to be more effectively absorbed by the animal. Organic complexes are created when trace minerals are connected (bound) to a protein or an amino acid. Many studies investigating organic complexes have involved disease situations. In stress situations, the organic complexes may be beneficial compared to inorganic sources, and a pharmaceutical response related to immune function has been noted. Consistent advantages of a mineral linked to a protein or amino acid source compared to inorganic sources in healthy cows with proper protein and energy nutrition have not been shown.

Developing a Mineral Supplementation Program

Mineral supplementation programs range from elaborate, cafeteria-style delivery systems to simple white salt blocks delivered to the cattle periodically by producers. A major reason for this is that it is almost impossible to design and conduct an experiment evaluating minerals because of variablity of the mineral requirments and the variablity in the mineral content of feeds. There is a continual need for information regarding mineral composition and availability from various feedstuffs (i.e., pasture grasses, hays, by-products, etc.) and the possible interactions between minerals in the digestive system.

Mineral supplementation strategies differ among producers. As a general rule, mineral programs should include NaCl (salt). In Nebraska, cow/calf producers or stocker operations should include Mg, especially in areas where grass tetany is a problem. Grass tetany is more prevalent when lactating cows and calves graze cool-season pastures (bromegrass, wet meadows, wheat pasture) in the early spring. Calcium and phosphorus should be the focal point in the mineral program. Phosphorus is the most expensive mineral in a supplement. Consider keeping P in the mineral supplement beginning before calving and through the breeding season. After the end of the breeding season, including P in the mineral program will depend on the forage that cattle are consuming. Distillers grains are high in P, so when distillers grains are fed, P is not needed in the mineral supplement. When feeding distillers grain, supplemental Ca is a focal mineral in the supplement. Other minerals should be considered on a ranch-to-ranch basis. Remember, some minerals interact with one another. Over-supplementation of potassium in areas where grass tetany is a problem will produce tetany because K will make Mg unavailable. In some areas, not all of Nebraska, Zn is deficient so it may need to be included in the supplement. There are not many copper deficient areas in Nebraska. Molybdenum, sulfur, and zinc can interact with copper and make copper unavailable to the animal.

When making decisions about mineral supplementation strategies, first know the animal's mineral needs. The mineral requirements of cattle are reported by the 1996 NRC. These requirements, given in *Table I,* are expressed as a percent or mg/kg (ppm) of the diet. Producers can use these values to calculate an animal's required daily mineral intake. The second step is to estimate the animal's mineral consumption from all sources other than the mineral supplement. To accomplish this, an understanding of total feed or forage dry matter intake, mineral composition of the feed or forage, and mineral digestibility is important. Finally, provide for mineral deficiencies with an economical mineral supplementation strategy.

The ability of cattle to store minerals allows them to accumulate minerals at times of the year when the feedstuffs being consumed exceed the requirements and then subsequently draw from those reserves when deficiencies in feedstuffs, or increases in nutrient demands such as milk production, occur. There may be certain periods during the year when available feedstuffs for the cow are "deficient" of certain minerals. Often, as long as this "deficiency" period does not occur for an extended period of time, the cow can utilize stored reserves of minerals and then replenish them when minerals become more available in feedstuffs again. An example of when this **might not** occur is in the case of grass tetany. Cows can store magnesium in times when consumption is greater than demand. However, when grass tetany manifests itself, cows cannot mobilize stored magnesium fast enough to fend off the grass tetany symptoms.

Forage Intake

When estimating the mineral supplementation needs of a cow herd, estimate the animal's dry matter intake of the feed or forage the cattle are consuming. Forage intake will decrease as forages mature. When forage quality is high (vegetative growth), dry matter intake will be between 2.5 and 3 percent of live body weight on a dry matter basis. When forage quality is low, dry matter intake of forages is closer to 1.8 percent of body weight. Therefore, even if mineral concentration in the forage remained constant during the grazing season, intake differences alone would affect mineral intake.

Providing Proper Protein Nutrition

The relationship of a cow's protein and energy status is a key component in proper mineral utilization. Protein aids in absorption, transport, and metabolism and is critical in maintaining the absorption function of trace elements in the intestinal tissues. Carrier proteins are essential for effective transport of trace elements. Copper and zinc transport involve very specific proteins. The protein requirements for beef cattle are listed in the 1996 NRC.

Estimating Mineral Intake

Cow/calf producers should be able to estimate trace element intake from the forage and the mineral supplement, when used. The ingredient content of trace elements is expressed in concentration terms. Remember: concentrations are intake dependent and the requirement is not a concentration requirement (i.e., 8 ppm) but an absolute amount, such as 80 mg/day.

The following examples indicate how to calculate trace element consumption and intake influence.

Calculating Element Intake

Example 1

Copper content of forage and trace mineral.

	Cu content	Intake
Forage	4 ppm	20 pounds
Supplement	500 ppm	5 ounces

1. Convert intakes to appropriate metric units.
    a. 1 lb = 0.454 kilograms (kg)
    b. 1 oz = 28.35 grams (gr)
        i. Forage intake in (kg): 20 lb x 0.454 kg/lb = 9.08 kg - - rounded to 9.1 kg
        ii. Mineral supplement in kg: 5 ounces x 28.35 g/oz = 141.75 gr - - rounded to 142 gr
            1. There are 1,000 grams in 1 kg
                a. 142 g ÷ 1,000 g/kg = 0.142 kg

2. Convert ppm to mg/kg.
    a. 1 ppm = 1 mg/kg
        i. 4 ppm = 4 mg/kg
        ii. 500 ppm = 500 mg/kg

3. Calculate intake of copper in mg.
   Forage: 9.1 kg x 4 mg/kg = 36.4 mg
   Mineral supplement: 0.142 kg x 500 mg/kg = 71.0 mg

Total intake of copper per day = 36.4 mg + 71.0 mg = 107.4 mg per day

Total intake of feed and supplement = 9.1 kg (forage) + 0.142 kg (supplement) = 9.242 kg per day
Requirement is 10 mg/kg of intake
Amount consumed per kg of feed consumed = 107.4 mg of Cu consumed ÷ 9.242 kg (total feed and supplement) = 11.62 mg/kg
Requirement is 10 mg/kg; the animal is eating 11.62 mg/kg
This calculation did not include the copper that may be in the water.

Example 2

	Cu content	Intake
Forage	10 ppm	20 pounds
Mineral supplement	.01%	1/2 pound

1. Convert intakes to appropriate metric units.
    a. 1 lb = 0.454 kilograms (kg)
        i. Forage intake in (kg): 20 lb x 0.454 kg/lb = 9.08 kg - - rounded to 9.1 kg

ii. Mineral supplement (kg): 0.5 lb x 0.454 kg/lb = 0.227 kg

2. To convert ppm to mg/kg:
   a. 1 ppm = 1 mg/kg
      i. 10 ppm = 10 mg/kg

3. To convert a percent to mg/kg:
   a. Move the decimal 4 places to the right.
      i. 0.01% = 100 mg/kg

4. Calculate intake of copper in mg.
   a. 9.1 kg x 10 mg/kg = 91 mg
   b. 0.227 kg x 100 mg/kg = 22.7 mg

Total intake of copper per day = 91.0 mg + 22.7 mg = 113.7 mg per head per day

Total intake of feed and supplement = 9.1 kg (forage) + 0.227 kg (supplement) = 9.327 kg per day
Requirement is 10 mg/kg of intake
Amount consumed per kg of feeds consumed = 113.7 mg of Cu consumed ÷ 9.242 kg (total feed and supplement = 12.30 mg/kg)
Requirement is 10 mg/kg; the animal is eating 12.30 mg/kg
This calculation did not include the copper that may be in the water.

Example 3

Mineral purchased at the feed store is usually sold in 50 lb bags. As an example, on the feed tag, copper is listed at 250 ppm. In this example, instead of ppm = mg/kg, the concentration of copper is mg/lb. The amount of copper consumed from the mineral supplement can still be determined.

	Cu content	**Intake**
Supplement	250 ppm	5 ounces

1. Convert ppm/lb to mg/kg.
   a. 1 lb = 0.454 kg
      i. 250 mg/lb divided by 0.454 lb/kg = 550.7mg/kg - - - rounded to 551 mg/kg

2. Convert intake of supplement to metric units
   a. 1 oz = 28.38 grams
      i. 5 ounces x 28.38 grams/oz = 141.75 gr - - - rounded to 142 gr
         1. There are 1,000 gr in 1 kg
            a. 142 gr ÷ 1,000 g/kg = 0.142 kg

3. Calculate intake of copper consumed from the supplement.
   a. Copper intake from the mineral supplement: 0.142 kg x 551 mg/kg = 78.24 mg

Mineral Mixes

There are several different commercial mineral supplements available to producers. In some instances, a simple mixture of salt and a phosphorus source can be an inexpensive alternative. A mix of two parts salt to one part of the phosphorus mineral source would work for most areas and times of the year. Where phosphorus is deficient; however, a mixture of equal parts salt and phosphorus source would be needed. Several mineral mixes suitable for beef cows are listed in *Table II.*
Note: Neither calcium carbonate (limestone) nor trace mineralized salt contain phosphorus. Because high phosphorus minerals are costly, calculate cost per pound of phosphorus to determine the best buy.

Table II. Composition of several *mineral supplements.*

	Mineral	*Composition*	*Percent P in mixture containing*	
	Ca	*P*	*1/3 salt*	*2/3 salt*
Defluorinated rock phosphate	32	18	12.0	6.0
Dicalcium phosphate	24	18	12.0	6.0
Monocalcium phosphate	18	21	14.0	7.0
Monosodium phosphate	0	25	16.6	8.3
Calcium carbonate	38	0	0	0
Trace mineralize salt	0	0	0	0

Diagnosis of Mineral Deficiencies

Assessing the consequences of mineral deficiencies in cow, calf, or stocker cattle is difficult. Slightly lowered weight gains in calves, reduced milk production and/or decreased reproduction rates in cows may occur without visible signs of a mineral deficiency. At the same time, excess mineral consumption may cause reduced cow and/or calf performance without obvious signs of low-level toxicity. Producers need sufficient information to establish a "least cost" method of correcting mineral deficiencies.

To predict the mineral status of cattle, the major storage site of the trace element must be sampled. In most cases blood is not the major storage site. For example, a major storage site of copper is the liver. When the diet is deficient in copper, copper in the liver will be released into the blood. Although the liver may be gradually depleted of copper, the amount of copper in the blood will remain constant. Only in very severe deficiencies does the blood become a good indicator of the trace element status.

The most effective method to prevent urinary calculi is to maintain a total dietary calcium to phosphorus ratio between 1.5:1 and 3:1. Cattle can tolerate calcium to phosphorus ratios of up to about 7:1 but this is not recommended. However, excessive calcium has been shown to reduce absorption of phosphorus and many of the essential trace minerals. A second method to minimize the risk of this disease is to make certain the cattle have access to salt or the total diet contains 0.5 percent up to 4 percent salt. Salt increases water intake, which increases mineral solubility and dilutes the urine. Again, distiller grains are high in phosphorus and usually need some calcium supplementation.

Grass tetany is most common in lactating cows grazing lush, cool season, spring pastures. The reduction in standing forage magnesium concentration can be substantial during the winter months. Cloudy weather can increase the incidence of grass tetany for cattle grazing lush, immature forages in the spring. Magnesium oxide and magnesium sulfate (Epsom salts) are good sources of supplemental magnesium. Including 15 to 20 percent magnesium oxide in the mineral mix should reduce the problem. Adding 6 to 10 percent molasses or soybean meal will assure intake. In high-risk situations, cows should consume around 1 ounce of magnesium oxide per day. This is difficult because magnesium oxide is very unpalatable to cattle. It is best to provide the high magnesium supplements at least one month ahead of the period of tetany danger. Feed commercial grass tetany mineral mixes at levels stated on the feed tag. If you manage cows in an area where grass tetany is prevalent, begin feeding the mineral supplement 30 days before grass turnout and continue until growing conditions are not interrupted by cool, cloudy days that interfere with grass growth.

Vitamins

Vitamins are unique among dietary nutrients fed to ruminants, as they are both singularly vital and required in adequate amounts to enable animals to efficiently use other nutrients. Many metabolic processes are initiated and controlled by specific vitamins. Vitamin needs are specific to age and production status. Vitamins A, D, E, and K are fat soluble vitamins. Vitamin A is essential for normal growth, reproduction, maintenance of epithelial tissues, and bone development. Vitamin A does not occur, as such, in plant material; however, its precursors, carotenes or carotenoids, are present in plants. Vitamin A is stored in the liver. The beef cattle requirements for vitamin A are 1,000 IU/lb dry feed for beef feedlot cattle; 1,273 IU/lb dry feed for pregnant beef heifers and cows; and 1,773 IU/lb dry feed for lactating cows and breeding bulls. Vitamin A can be provided in unweathered, harvested forages through a supplement or a vitamin A injection. The vitamin D requirement of beef cattle is 125 IU/lb dry diet. Ruminants do not maintain body stores of vitamin D because the vitamin is synthesized by beef cattle when they are exposed either to sunlight or fed sun-cured forages. They rarely require vitamin D supplementation. Vitamin E occurs naturally in feedstuffs as α-tocopherol. Vitamin K is required for the synthesis of plasma clotting factors. Two major natural sources of vitamin K are the phylloquinones (vitamin K found in plants) and the menaquinones (vitamin K produced by bacterial rumen microflora). Because vitamin K is synthesized in large quantities by ruminal bacteria and is abundant both in pasture and green roughages, supplementation is not needed. The only sign of deficiency to be reported in cattle is the "sweet clover disease" syndrome. This results from the metabolic antagonistic action of dicoumarol, which occurs when an animal consumes moldy or improperly cured sweet clover hay. Consumption of dicoumarol interferes with blood clotting and may cause death from uncontrolled hemorrhages. Because dicoumarol passes through the placenta, the fetus of pregnant animals may be affected.

The water-soluble are B vitamins and include thiamin, niacin, and choline. Rumen microorganisms have the ability to synthesize water-soluble vitamins. Supplementation of water-soluble vitamins is generally not necessary in ruminants. B-vitamins are abundant in milk and other feeds. B-vitamins are synthesized by rumen microorganisms beginning soon after a young animal begins feeding. As a result, B-vitamin deficiency is limited to situations where an antagonist is present or the rumen lacks the precursors to make the vitamin. Niacin is supplied to the ruminant by three primary sources: dietary niacin, conversion of tryptophan to niacin and ruminal synthesis. Although adequate quantities of niacin are normally synthesized in the rumen, several factors can influence ruminant niacin requirements, including protein (amino acid) balance, dietary energy supply, dietary rancidity, and niacin availability in feeds. Choline is essential for building and maintaining cell structure and for the formation of acetylcholine, the compound responsible for transmission of nerve impulses. While all naturally occurring fats contain choline, little information is available on the biological availability of choline in feeds. Choline can be synthesized by most animal species; however, it is recommended that milk-fed calves receive supplementation of 0.26 percent choline in milk replacers.

A proper level and balance of minerals and vitamins are essential to the health, growth, and reproduction of beef cows and calves. By knowing a cow's nutrient requirements as well as the amount and availability of minerals and vitamins in the feedstuffs being consumed by the cow, producers can understand when supplementation may be beneficial. Cost effectively meeting these requirements through available feedstuffs and strategic supplementation can improve profitability to the cow-calf business.

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