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Minerals for Beef Cattle — Needs

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A number of minerals are essential nutrients in beef cattle rations. Minerals needed in relatively large amounts are major or macro elements. Those needed in small amounts are classified as micro, minor, or trace minerals. These terms, however, have no relationship to the metabolic importance of a mineral in the diet.

A trace mineral can be as essential to the health and performance of an animal as a major mineral. The major minerals include calcium, phosphorus, magnesium, potassium, sodium, chlorine and sulfur. Among those needed in trace amounts are iron, zinc, manganese, copper, iodine, cobalt and selenium.

Mineral needs

Certain factors influence the mineral supplementation of beef cattle rations.

1. Animal requirements differ by age, sex, and production function.
2. The mineral composition of plants varies because of soils, weather, variety, stage of maturity, harvest method, etc.
3. The availability of minerals in feeds can differ.
4. The absorption, excretion and metabolic function of certain minerals are interrelated. These minerals must be kept in proper ratio to one another in the ration.

Mineral requirements of beef cattle are given in amounts per head daily or expressed as a percentage of the ration or in parts per million (ppm). See Tables 1 and 2 for the mineral levels recommended for beef cattle rations by the National Research Council (NRC). Keep in mind, however, the percentage or ppm of a mineral needed in a ration is influenced by the energy density or percentage of TDN in the ration.

Table 1. Calcium and phosphorus requirements of beef cattle[1] (nutrient concentration in ration dry matter).

	Body weight (lbs.)	ADG (lbs.)	TDN (%)	Ca (%)	P (%)
Steer calves and yearlings	400	1.0	56	0.28	0.24
		2.0	77	0.52	0.37

		2.5	83	0.64	0.46
	600	1.0	56	0.26	0.23
		2.0	69	0.31	0.27
		3.0	86	0.46	0.35
	800	2.0	70	0.27	0.24
		3.0	86	0.31	0.27
	1,000	2.0	69	0.20	0.20
		3.0	86	0.25	0.25
Dry pregnant mature cows- all weights			52	0.18	0.18
Cows nursing calves: (first 3 months)					
Average milking ability	800		52	0.29	0.29
	1,200		52	0.27	0.27
Superior milking ability	800		55	0.44	0.39
	1,200		55	0.37	0.35
[1]Adapted from NRC Nutrient Requirements of Beef Cattle, 1976.					

Table 2. Mineral requirements of beef cattle[1] (in percent of ration dry matter or parts per million).

Mineral	Growing and finishing cattle	Dry pregnant cows	Breeding bulls and lactating cows	Possible toxic levels
Sodium, percent	0.06	0.06	0.06	
Calcium, percent[2]	0.18-1.04	0.18	0.18-0.44	
Phosphorus, percent[2]	0.18-0.70	0.18	0.18-0.39	

Magnesium, percent	0.04-0.10	— [3]	0.18	
Potassium, percent	0.60-0.80	— [3]	— [3]	
Sulfur, percent	0.10	— [3]	— [3]	
Iodine, ppm	— [3]	0.05-0.10	0.05-0.10	100
Iron, ppm	10.0	— [3]	— [3]	400
Copper, ppm	4.0	— [3]	— [3]	115
Cobalt, ppm	0.05-0.10	0.05-0.10	0.05-0.10	10-15
Manganese, ppm	1.0-10.0	— [3]	— [3]	150
Zinc, ppm	10.0-30.0	— [3]	— [3]	900
Selenium, ppm	0.05-0.10	0.05-0.10	0.05-0.10	5

[1]NRC Nutrient Requirements of Beef Cattle, 1976.
[2]See MU publication G2067, *Nutrient Requirements for Growing and Finishing Beef Cattle* for more detailed requirements.
[3]Unknown. Use level given for the growing and finishing animal.

Higher-energy rations require a correspondingly higher percentage of minerals and other nutrients. This is because fewer pounds of this feed will be needed to produce a given rate of performance if all brought in balance with energy.

For example, the National Research Council recommends 0.31 percent calcium and 0.27 percent phosphorus in the dry matter of a finishing ration with 69 percent TDN when fed to a 600-pound yearling steer (Table 1). If the TDN level of this ration is increased to 86 percent on a dry matter basis by adding grain and removing roughage, the mineral and other nutrient percentages should be increased accordingly (calcium 0.46 percent and phosphorus 0.35 percent) to provide a balanced ration.

Calcium and phosphorus. Bones and teeth account for about 99 percent of the calcium and 80 percent of the phosphorus in the body. Milk is also a rich source of these elements. Thus growing, pregnant and lactating animals have higher requirements for calcium and phosphorus. These minerals are essential for many enzyme reactions. Calcium is necessary for blood clotting, nerve function and muscle contraction. Phosphorus is involved in

energy metabolism.

Calcium and phosphorus deficiency signs are similar. Early signs include listlessness, loss of weight and a decrease in milk production. Later, animals often develop depraved appetites and chew on wood or eat soil. Bone breakage, lameness and stiff joints occur. Rickets in the young and osteomalacia in older animals are terms applied to abnormal skeletal development. A deficiency of Vitamin D can cause these same problems since it is involved in the metabolism of calcium and phosphorus. Fertility problems in cows have been related to low phosphorus diets.

Calcium and phosphorus are closely associated. There must be enough of each, but calcium should be equal to or greater than the phosphorus levels in a beef ration. Often 1-1/4 to 1-1/2 times as much calcium as phosphorus is used in formulating beef rations. When phosphorus was adequate, however, calcium-to-phosphorus ratios as wide as 6-to-1 have not been harmful in beef finishing rations. A calcium to-phosphorus ratio of 2-to-1 is often used for rations when urinary calculi are a problem.

Cows or other classes of cattle fed high-roughage rations are more likely to have a phosphorus deficiency than a calcium deficiency. This is because forages tend to be high in calcium but low in phosphorus.

Legumes are especially high in calcium, but cereal straws are low. In contrast, grains are adequate in phosphorus, or nearly so, but deficient in calcium for cattle. Either one or both minerals may be deficient in beef growing or finishing rations, depending upon the ratio of grain and roughage.

Sodium and chlorine (salt). The requirement for sodium and chlorine is commonly expressed as the salt requirement. Sodium is the major mineral in fluids outside the body cells. Chlorine occurs both inside and outside the cell. They both function to maintain the volume, pH and osmolarity of body fluids. Sodium is involved in muscle and nerve function. Chlorine is essential for certain digestive enzymes and for carbon dioxide transport.

The specific requirements for sodium and chlorine are unknown. Including 0.25 percent salt in the ration dry matter of full-fed beef cattle appears to be adequate to meet the requirement for sodium and chlorine. Recent research indicates less may be sufficient. Salt is often fed free-choice. Consumption varies, but cattle usually exceed their requirements when given free access to salt.

More salt will be consumed when fed as loose salt, but the block form is adequate. Cattle often eat 1-1/2 to 2-1/2 pounds of salt a month (3/4 to 1/3 ounce a day) when given free access to loose salt. They will eat more salt with high-roughage than with high-concentrate rations, with silage or pasture than with dry feeds, and with succulent grass than with mature grass. Cattle deficient in salt eat dirt, manure and urine in an attempt to get salt.

Cattle will consume up to 1 pound of salt daily when it is added at 10 to 30 percent levels

in protein or concentrate feeds to control free-choice consumption. If adequate water was available, cattle have consumed as much as 2 pounds of salt daily without harmful effects on rate of gain or digestion of diet. Excessive salt intake can be toxic if water intake is limited. Trace mineral salt should not be used to regulate feed consumption because of the toxicity dangers associated with high levels of certain trace minerals.

Magnesium. Magnesium is closely associated with calcium and phosphorus in its distribution and metabolism in the body. Approximately 70 percent of the body stores of magnesium are in the bone. It is an activator of numerous enzyme systems and affects the nervous system.

A magnesium deficiency rarely occurs in feedlot cattle. Grass or winter tetany, a condition that causes many death losses in Missouri beef cow herds, is associated with low magnesium levels in blood serum. Cattle need about 0.04 to 0.1 percent magnesium in the dry matter of their ration. In areas where grass tetany is prevalent, higher levels of magnesium (0.25 percent of D.M.) have been found beneficial in the ration of cows.

Potassium. Potassium is required for many body functions. Thus, a deficiency results in non-specific symptoms such as poor appetite, followed by thinness, reduced performance and stiffness, especially in the joints of the front legs.

The potassium requirement of beef cattle has not been critically measured, but potassium levels of 0.6 to 0.8 percent of ration dry matter are considered to give optimum performance for growing and finishing cattle (Table 2). There is no evidence that potassium is needed in feedlot rations that contain sizable amounts of silage or other roughage. Rations containing molasses and alfalfa meal are not likely to be deficient in potassium. Grain often has less than 0.5 percent potassium; therefore, levels may become critical in certain high-concentrate rations.

University of Missouri-Columbia studies have shown potassium will leach from the forage in fescue pasture during winter to levels as low as 0.3 percent of the dry matter. Potassium additions could be beneficial for cattle grazing these pastures from January through March.

Sulfur. Sulfur is present in protein, the sulfur-containing vitamins (thiamine and biotin), and other compounds of the body. The National Research Council recommends 0.1 percent sulfur in the dry matter of rations for growing and finishing cattle (Table 2). Substituting urea and other non-protein nitrogen compounds for natural protein lowers the sulfur content of a ration. Adding one part inorganic sulfur for each 15 parts of non-protein nitrogen used in the ration is often recommended. Rumen bacteria can use inorganic sulfur to make sulfur-amino acids and other organic sulfur compounds. Thus both elemental and sulfate sulfur are effective dietary supplements for ruminants.

Excessive levels of sulfur were not toxic to beef cattle in USDA feedlot studies. Conversely, high levels of sulfur have seemed to interfere with the metabolism of selenium, copper and molybdenum in experiments with sheep. Deficiency signs for sulfur include decreased feed intake, unthrifty appearance and dullness and loss of hair.

Trace minerals

Trace minerals most likely to be deficient in beef cattle rations are cobalt, copper, iodine, iron, manganese, zinc, and selenium. Table 2 lists the level of trace minerals recommended for beef cattle rations. The interrelationship between minerals results in the exact requirement for a trace mineral depending on the level of other minerals in the ration.

Feeds grown in certain regions or on certain types of soils are recognized to be deficient in specific trace minerals for beef cattle. Trace-mineralized salt or mineral premixes are either added to the ration or fed separately as free-choice mixtures to protect cattle against trace mineral deficiencies. A common practice is to add trace minerals to rations at a level that meets most or all of the animal's requirement and to ignore the trace mineral content of natural feeds. Overfeeding of trace minerals by including them in the ration and in free-choice supplements, too, should be avoided to guard against reaching toxic levels with some minerals.

Beef cattle rations that have good-quality alfalfa hay are not apt to benefit from trace mineral additions. Trace minerals improved performance one of two years at University of Missouri-Columbia when they were added to a shelled corn finishing ration with 25 percent orchardgrass hay. Work at Kansas and New Mexico, among other experiment stations, has shown no increase in performance when trace minerals were added to conventional milo beef cattle finishing rations containing alfalfa hay.

Cobalt. Cobalt is required for synthesis of vitamin B_{12} by rumen bacteria. Thus, the requirement for cobalt in beef cattle rations is actually a B_{12} requirement. There is evidence that cattle should receive their cobalt requirement every day. The deficiency symptoms for cobalt are generally non-specific.

A positive response to supplemental cobalt has been reported when certain high-concentrate finishing rations were fed. Forty-six fescue hay samples collected throughout Missouri were mostly marginal or deficient in cobalt for beef cattle. The cobalt content was less than 0.04 ppm (dry matter) in 1/4 of the samples and between 0.04 and 0.07 ppm in 1/4.

Cobalt supplementation is advisable for beef cows wintered on low-quality grass, hay, straw, or similar roughage. Adding 1 ounce of cobalt chloride or sulfate to each ton of free-choice mineral mixture is recommended for cows if the mixture is made with plain salt.

Copper. Copper deficiencies are likely to occur when cattle consume forages grown in Missouri. Deficiency symptoms include unthriftiness, bleaching of hair and anemia. In regions where the vegetation supplies less than 5 ppm of copper, adult beef animals frequently suffer from falling disease. High levels of inorganic sulfate and molybdenum in the diet can increase the copper requirement by two- or threefold. Calves fed exclusive

milk diets for long periods may develop copper deficiencies.

Copper toxicity levels may be as little as 115 ppm of the total ration for cattle. Sheep, however, are more susceptible to copper poisoning than cattle.

Fluoride. A specific requirement for fluoride has not been shown in beef cattle. Toxic levels are the main concern with fluoride in beef rations. Rock phosphate that has not been defluorinated often contains 3.5 to 4.0 percent fluoride, which is a toxic level when the rock phosphate is 1 percent of the diet. Fluoride is an accumulative poison and its harmful effect may not be noticed for some time. Toxic levels in the diet affect teeth and bone structure and the use of other nutrients.

Safe levels of fluoride in the diet dry matter for finishing cattle are no more than 100 ppm (0.01 percent) and not more than 40 ppm (0.004 percent) for animals to be kept in the breeding herd.

Iodine. The entire Great Lakes area and most of the northern section of the United States are subject to an iodine deficiency. Iodine is essential for production of thyroxine, a hormone that regulates metabolic rate. A deficiency causes enlargement of the thyroid gland, a condition called goiter.

High nitrates in the rations are thought to interfere with the uptake of iodine by the thyroid gland. Iodized salt is recommended with high-nitrate feeds and for pregnant cows. Trace mineralized salt should be an adequate source of iodine except with high-nitrate rations.

Iron. Iron functions in certain enzyme systems and as a part of the hemoglobin in red blood cells. Milk is low in iron and copper, so young animals are most likely to have "nutritional anemia" from a deficiency of these two elements. A deficiency of iron is not likely to occur with adult cattle, under reasonable parasite control, in most areas of the United States.

Manganese. A deficiency of manganese in beef cattle under natural conditions has been reported in only a few areas. This deficiency is found in Washington and other northwestern areas. Deficiency symptoms are reduced fertility in cows and newborn calves with weak legs and pasterns.

Zinc. Deficiency symptoms of zinc include general unthriftiness, scabby skin on legs, loss of hair and dermatitis over the entire body. A deficiency of zinc is not apt to occur under practical feeding conditions. Purdue University and other researchers have reported beneficial effects from zinc in high-grain rations fed to beef cattle, but a consistent improvement has not been shown.

Selenium. Illinois and other states east and northeast of Missouri are in an area that produces feeds considered to be deficient in selenium for ruminants (less than 0.1 ppm selenium). Feeds grown on sandy or acid soils in other areas may be deficient in selenium. Some Missouri soils produce feeds deficient in selenium for beef cattle.

Selenium additions to the ration of steer calves grazing fescue pasture increased average daily gains in University of Missouri trials. One of the most familiar symptoms of selenium deficiency is white muscle disease (WMD), a muscular degeneration in young lambs and calves. A few cases of this condition have been diagnosed in beef calves in Missouri.

In contrast, selenium toxicity in cattle and sheep grazing on alkali soils in the West is called "blind staggers," alkali disease, or forage poisoning. Selenium and Vitamin E spare each other so the selenium requirement of beef cattle depends upon the amount of Vitamin E in the diet. However, both selenium and Vitamin E are irreplaceable on a total basis. Note in Table 2, the selenium requirement of beef cattle is about 0.1 ppm of the diet dry matter, while the toxic level is about 50 times this (5 ppm).

Selenium has been approved for use in complete feeds for beef cattle at a level not to exceed 0.1 ppm of the dry matter. In a supplement for limit feeding, selenium may be used at a level not to exceed an intake of 1 milligram (mg) per head per day. Up to 20 ppm may be used in a salt-mineral mixture for free-choice feeding to cattle, but the daily intake of selenium shall not exceed 1 milligram per head per day. Selenium additions to chick's rations and to rations of certain classes of swine and sheep had been approved earlier.

Meeting mineral needs

Information on supplements to meet the major and trace mineral needs of beef cattle fed various rations is given in MU publication G2081, *Minerals for Beef Cattle — Supplements.*