Mineral Supplements for Beef Cattle

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Introduction

Beef cattle for require a number of dietary mineral elements for normal bodily maintenance, growth, and reproduction. Minerals that are required in relatively large amounts are called 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.

Functions of Minerals

Calcium. Calcium is used in the formation and maintenance of bones and teeth. It also functions in transmission of nerve impulses and contraction of muscle tissue. A dynamic system involving calcium, phosphorus, and vitamin D exists to maintain a relatively stable concentration of calcium in the blood. Calcium and phosphorus are stored in bone and mobilized into the circulatory system when dietary intake of the two minerals is adequate. Blood calcium level is not a good indicator of a dietary calcium deficiency because blood calcium is reflective of both calcium intake and calcium mobilization from bone.

Due to its importance in bone structure, deficiency of calcium in young animals leads to skeletal deformities. In older animals, fragile bones can result from extended periods of dietary calcium deficiency. Critical times to ensure that diets contain adequate calcium are during pregnancy (for proper bone growth of the fetus) and during lactation (to prevent excessive calcium mobilization from the bones of the lactating cow). Excessive mobilization of calcium from the skeletal system of the lactating cow can lead to milk fever, also known as parturient paresis or hypocalcemia. Symptoms include muscle stiffness and tremors, extreme weakness, and loss of consciousness. A common method of minimizing the risk of milk fever is to reduce calcium intake by cows for two weeks prior to calving. This ensures that the calcium mobilization system is functioning properly prior to lactation. After calving, dietary calcium is increased to meet the requirement of the lactating cow.

Calcium requirements change depending on animal age and production status. Non-lactating, pregnant cows require calcium at a level of 0.18% of total dry matter intake, while the requirement of lactating cows is 0.27% of total dry matter intake. Growing and finishing cattle require 0.31% calcium for optimal growth. The maximum tolerable level of calcium is not known.

Phosphorus. Phosphorus functions in conjunction with calcium in the formation of bone. In addition, phosphorus is a component of deoxyribonucleic acid (DNA), the molecules which make up chromosomes and control genetic inheritance. Phosphorus is also involved in the chemical reactions of energy metabolism. Phosphorus containing compounds like adenosine triphosphate and creatine monophosphate are the body's major storage depots of readily available energy. Worldwide, phosphorus deficiency is reported to be the most prevalent mineral insufficiency in grazing livestock. Deficiency of phosphorus results in decreased animal performance, including reduced weight gains, poor reproductive efficiency, and low milk production.

Because of their mutual role in bone metabolism, calcium supplementation and phosphorus supplementation are usually considered simultaneously. The recommended calcium to phosphorus ratio in ruminant diets is 2:1 to 1.2:1. Significant deviation from this ratio can result in abnormal bone growth and a condition known as 'water-belly'. Water-belly occurs when calcium-containing concretions known as urinary calculi are formed in the kidneys. These calculi can block normal urine excretion and cause death in steers when left untreated. Heifers are usually not affected by the water-belly disorder.

Magnesium. Magnesium is an activator of many metabolic enzymes. These enzymes control reactions that range from the breakdown of glucose for energy to the replication of DNA, which is necessary for cell division. The most common problem associated with magnesium deficiency is a condition known as grass tetany. Observed most frequently in the early spring, grass tetany results from the consumption of lush forage, which has low levels of magnesium. The apparent depression in magnesium levels results from the high water content of rapidly growing plants. Symptoms include frequent urination, erratic behavior, and convulsions. If left untreated, death can occur within several hours. Grass tetany is a major problem in some areas of Missouri and supplementation with magnesium can alleviate the problem. 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 (up to 0.25 percent of dry matter intake) have been found beneficial to prevent grass tetany.

Magnesium oxide is the most common form of supplemental magnesium used to prevent grass tetany; however, it is characterized by bitter taste. Livestock are often unwilling to consume it at recommended levels making free-choice supplementation of magnesium oxide to grazing cattle problematic. An uncomplicated method of supplementing magnesium oxide to cattle grazing grass tetany-provocative pastures is to mix it with a grain or oil seed supplement. Researchers in Virginia (Frye et al., 1977) found that free-choice magnesium oxide consumption by grazing cattle was adequate when it was mixed in a 1:1:1 ratio with trace mineralized salt and one of the following: corn, alfalfa meal, dry cane molasses, or cottonseed meal.

Grass Tetany. Grass Tetany is a common problem for lactating cows on lush pasture. Supplementing with magnesium has long been an effective means to combat grass tetany. However, recent research indicates that other factors may be involved. The occurrence of grass tetany is more frequent in fertilized pastures than unfertilized pastures. In addition, the occurrence of grass tetany will usually be higher after five to 10 days of cold weather. Forages that are prone to causing grass tetany are deficient in magnesium and sodium and have an excess of potassium. Sodium is involved in transporting magnesium into cells, so it is critical to maintain adequate sodium to facilitate proper magnesium utilization. Excess potassium consumption interferes with magnesium absorption from the gut, thus exacerbating the condition of low dietary magnesium. In areas where grass tetany is prevalent, it is critical to consider not only dietary magnesium intake but also dietary levels of sodium and potassium.

Sodium and Chlorine. The requirement for sodium and chlorine is commonly expressed as a salt requirement. Both sodium and cholrine function to maintain the volume, pH, and osmolarity of body fluids. Sodium is involved in muscle and nerve function. Chlorine is essential for hydrochloric acid production in the abomasum and for carbon dioxide transport. The maximum advisable level for dietary sodium in the diet is 0.08% of the dry matter for dry cows and 0.1% for lactating cows. The requirement for chlorine is unknown. To date, deficiencies of chlorine have not been demonstrated in beef cattle.

Salt is often fed to cattle free-choice (i.e., cattle are allowed to select a dietary component of their own volition). Cattle will usually consume more salt than needed when it is fed free-choice. Cattle also consume more salt than needed if it is offered in loose, granular form. Cattle often eat 1-1/2 to 3 pounds of salt per month (3/4 to one and 1/3 ounces per day) when given free-choice access to loose salt. Roughly half that amount is consumed when salt is offered free-choice in block form.

Additionally, cattle 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 often eat dirt, manure, and urine in an attempt to satisfy their appetite for salt. This condition, known as pica, can be easily corrected with salt supplementation.

Potassium. Potassium is ubiquitous in the body of mammals because it is required in large amounts by most organ systems for normal functioning. Thus, a deficiency of potassium results in non-specific symptoms such as poor appetite, followed by thinness, reduced performance, and stiffness, especially in the joints of the front legs. Potassium levels of 0.6 to 0.7% of ration dry matter are necessary to promote optimal performance by growing and finishing cattle. There is no evidence that potassium is needed in feedlot rations that contain sizable amounts of silage or another roughage. Additionally, rations containing molasses and alfalfa meal are not likely to be deficient in potassium. Grain often has less than 0.5 percent potassium; therefore, potassium supplementation may become critical in certain high-concentrate rations.

University of Missouri-Columbia studies have shown that potassium will leach from fescue pasture forage during winter to levels as low as 0.3 percent of the dry matter. Potassium supplementation may be beneficial for cattle grazing these pastures from January through March. In contrast, lush forages like tall fescue pastures in early spring, often have extremely high levels of potassium. High levels of potassium interfere with magnesium utilization. This has the effect of exacerbating the already low magnesium content of the lush forage and increasing the risk of grass tetany.

Sulfur. Sulfur is present in protein, certain vitamins (thiamin and biotin), enzymes, and other compounds. The National Research Council recommends that diets for growing and finishing cattle should be formulated to contain 0.15% sulfur on a dry matter basis (Table 2). Substituting urea and other non-protein nitrogen compounds for natural proteins in the diet 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 necessary to restore dietary sulfur levels to normal. Certain ruminal bacteria use inorganic sulfur to make sulfur-containing amino acids and other organic sulfur compounds. Dietary levels of sulfur that are above 0.4% of the dry matter are considered potentially toxic. Excessive sulfur interferes with the metabolism of selenium, copper, molybdenum, and thiamin. Sulfur deficiency symptoms include decreased feed intake, unthrifty appearance, dullness of the hair coat, and hair loss.

Moderate to high dietary sulfur intake can cause a condition known as polioencephalomalacia in ruminants. Aimless wandering, blindness, muscle tremors, and convulsions characterize Polioencephalomalacia. Young cattle (6-18 months old) are especially vulnerable to this disease. Growing and finishing diets that are high in sulfur (> 0.4% of dry matter intake) and low fiber have been shown to induce polioencephalomalacia. Feeds that are high in sulfur include water, molasses, beet pulp, cruciferous plants, and corn-distilling byproducts like corn gluten feed. Prevention of polioencephalomalacia requires that both feed and water be tested for total sulfur content.

Cobalt. Cobalt is required for synthesis of vitamin B_{12} by ruminal bacteria. Since vitamin B_{12} synthesis occurs in the rumen, cobalt must be consumed in the diet. Injections of cobalt are not an effective means to correct deficiency. The daily cobalt requirement for beef cattle is 0.1 ppm of the total diet dry matter. Deficiency symptoms for cobalt include loss of appetite in the early stages of deficiency, followed by muscle wasting and anemia, as the deficiency becomes more severe. Vitamin B_{12} levels in the liver are a useful indicator of cobalt status. Levels of at least 0.19 ppm are considered adequate, while lower levels are indicative of cobalt deficiency.

Cobalt supplementation is advisable for beef cows wintered on low-quality roughages of all types. In fact, most tall fescue hay samples collected in Missouri are marginal or deficient in cobalt. Adding 1 ounce of cobalt chloride or cobalt sulfate to each ton of free-choice mineral mixture is recommended for beef cows.

Copper. Copper deficiencies are fairly common among cattle that consume Missouri forages as a major portion of their diet. Deficiency symptoms include unthriftiness, bleaching of the hair coat, and anemia. Copper levels of 10 ppm are considered adequate for beef cattle. In regions where the vegetation supplies less than 5 ppm of copper, adult beef animals occasionally suffer from falling disease, a condition resulting in sudden death due to acute heart failure and anemia. If a copper deficiency is suspected, it may be advisable to have the diet analyzed for sulfur, molybdenum, and iron content in addition to copper. These minerals are known to interfere with copper absorption, thus increasing the copper requirement. High levels of inorganic sulfur 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, but calves raised in a pasture setting rarely exhibit deficiency symptoms.

Copper toxicity in beef cattle has occurred when diets contained as little as 115 ppm copper in the total ration; however, large amounts of copper must accumulate in the liver before toxicity is observed. Just as levels of molybdenum, iron, and sulfur influence the copper requirement, they also influence the level of copper needed to elicit toxicity symptoms. Copper toxicity symptoms include hemolysis (breakdown of red blood cells), hemoglobinurea (hemoglobin in the urine) and jaundice. Death may result after extended periods of toxicity.

Fluoride. A specific requirement for fluoride has not been demonstrated in beef cattle. Rather, toxicity is the major concern with fluoride in beef rations. Rock phosphate that has not been defluorinated often contains 3.5 to 4.0 percent fluoride. If untreated rock phosphate is used as a dietary phosphorus supplement, toxicity can occur when the rock phosphate is fed at 1 % of the diet. Fluoride accumulates in the body and its harmful effects may not be noticed until a metabolic crisis is reached. Toxic levels in the diet cause abnormal bone structure and softening and irregular wear of the teeth. 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. Beef producers in the northern United States, particularly the Great Lakes region, regularly encounter iodine deficiency. Iodine is essential for production of thyroxin, a hormone that regulates metabolic rate. A deficiency in iodine causes a condition called goiter, which is characterized by an enlarged thyroid gland. Other deficiency symptoms include weak or hairless calves, reduced reproductive performance, and retained placentas.

The requirement for iodine is 0.5 ppm of the total diet dry matter. Beef rations that are high in nitrates interfere with the uptake of iodine by the thyroid gland. Supplementation with iodized salt is recommended for cattle consuming high-nitrate feeds and for pregnant cows. Adequate iodine is extremely important in pregnant cow diets to ensure normal development of the calf. Calves born to severely deficient cows may be weak, blind, hairless, or stillborn. Calves born to cows that are even slightly deficient may have goiter. In most instances, iodized salt is an adequate iodine supplement for beef cattle.

Iron. Iron functions in oxidative enzyme systems involved in energy metabolism. It also enables the hemoglobin in red blood cells to carry oxygen to the tissues of the body. The iron requirement for beef cattle is 50 ppm. Milk is low in iron, so young animals are likely to have "nutritional anemia" from a deficiency of iron caused by an exclusive milk diet; however, iron deficiency is rarely seen in calves raised in a pasture setting. Other iron deficiency symptoms include reduced feed intake and pale mucus membranes. A deficiency of iron is not likely to occur with adult cattle in Missouri that have been provided with reasonable parasite control. Under extremely high densities of external parasites, enough blood loss can occur to cause symptoms of anemia.

Manganese. Manganese functions as a part of numerous enzyme systems. Growing cattle require 20 ppm in the diet while breeding cattle require 40 ppm. High levels of dietary calcium and phosphorus may interfere with manganese metabolism, causing the dietary requirement for manganese to increase. A deficiency of manganese in beef cattle under natural conditions has been reported in only a few areas of the northwestern United States (Ensminger et al. 1990). Deficiency symptoms include reduced fertility in cows and crooked calf syndrome in young calves. Crooked calf syndrome is typified by weak legs and swollen joints in newborn calves.

Selenium. States east and northeast of Missouri (i.e., Illinois, Michigan, Ohio, and Indiana) produce feed grains and forages that are deficient in selenium (less than 0.1-ppm selenium). Generally, cattle feeds grown on sandy or acidic soils in other areas may also be deficient in selenium. Some Missouri soils fall into these categories. Occasional soil tests are necessary to determine if selenium deficiency may be a problem on a particular farm.

One of the most familiar symptoms of selenium deficiency is white muscle disease, a muscular degeneration in young calves. A few cases of this condition have been diagnosed in Missouri. A deficiency of selenium in gestating cows may cause retained placentas Selenium toxicity, which occurs primarily in cattle and sheep grazing on alkali soils in the West, is called "blind staggers," alkali disease, or forage poisoning.
Selenium and Vitamin E have similar metabolic activities. As a result, they tend to spare one another so that the selenium requirement of beef cattle depends upon the amount of Vitamin E in the diet. The selenium requirement of beef cattle is about 0.1 ppm of the diet dry matter, while the toxic level is about 50 times higher (5 ppm). High levels of fat in the diet may increase the requirement for selenium.

Selenium has been approved for use in total mixed rations for beef cattle at a level not to exceed 0.1 ppm of the dry matter. In a limit-fed supplement, FDA regulations allow selenium to be used at a level not to exceed an intake of 1-milligram (mg) per head per day. Up to 20 ppm selenium may be used in a salt-mineral mixture for free-choice feeding to cattle, but care must be taken to ensure that the total daily intake of selenium does not exceed allowed levels.

Zinc. Enzymes for protein and carbohydrate metabolism require zinc. The immune system also requires zinc to function properly. The maintenance requirement for zinc is generally thought to be 30 ppm, but the requirements for lactation and reproduction are not known. Deficiency symptoms of zinc include general unthriftiness, excessive salivation, scabby skin on the legs, slow wound healing, loss of hair, and dermatitis over the entire body. A deficiency of zinc is not likely to occur under normal feeding conditions; however, high calcium in the diet has been shown to interfere with zinc absorption in the gut. Zinc supplementation of beef cattle diets has not been proven to have a consistently beneficial effect.

Animal Requirements

Cattle will require different levels of minerals based on age, size, sex, physiological state, and level of performance. Some examples of nutrient requirements for cattle at different stages of maturity and production are provided in table 1. The maximum level of each mineral that can be safely tolerated by beef cattle is also included for reference purposes.

A compilation of supplements that may be used to meet animal requirements for specific mineral nutrients is provided in table 2. Both the amount of mineral in the supplement and the bioavailability (i.e., the amount of mineral in the supplement that is able to be absorbed and subsequently used by the animal) are important factors in determining which mineral supplement is most cost effective. The first supplement under each mineral heading is the standard to which all of the other supplements were compared to determine the relative bioavailability value (RV). For instance, calcium carbonate is the standard by which all calcium supplements are compared. It is assigned an RV of 100%. Calcium from bone meal is 10% more bioavailable than calcium carbonate, resulting in an RV of 110%.Some commonly used supplements contain more than one mineral (Table 3). If diets are deficient in more than one mineral, it may be cheaper to use a supplement that supplies more than one required mineral versus purchasing a separate supplement for each mineral.

Many common feedstuffs included in the diet of beef cattle can contribute a significant portion of the animal’s mineral requirements. The mineral composition of feeds that are commonly used in Missouri is show in table 4.

Special considerations

Forage Analysis and Mineral Supplements. The mineral values listed in the table 4 are intended to serve as guidelines only. In general, forages are good sources of calcium, while grains and animal products are fair to good sources of phosphorus. When planning a mineral supplementation program for forage-fed cattle, it is important to realize that bioavailability of minerals from forage may be low. As a rule of thumb, mineral values in forages should be discounted by 50% to account for potentially low bioavailability. A forage-testing program is necessary for reasonably accurate evaluation of the mineral composition of forage-based cattle diets. Mineral content in forage often mirrors the concentration of minerals in the soil. Pasture fertilization schemes and stage of maturity of the forage affect mineral content and mineral bioavailability.

Usually, a commercial mineral supplement can be purchased that will meet the needs of most classes of cattle. Commercially available mineral supplements contain predetermined amounts of each mineral. They are produced in mass quantities to ensure a consistent and relatively inexpensive. The many commercially available products give beef producers a wide range of supplements from which to choose. Suitability of these products to an individual operation will be determined by forage mineral profiles, concentrates feeds that are typically offered, and soil type. The amount of each mineral provided by commercially produced mineral supplements must, by law, be printed on the label, which provides beef producers with the criteria they need to select a supplement that best suits a particular situation.

In some instances, a commercial supplement may not supply an appropriate amount of certain specific minerals. Custom-mixes can be used to tailor a mineral supplement to a specific farming or ranching enterprise. In this circumstance, the supplier of the supplement will work with the producer to provide the proper level of minerals based on analysis of the animal's diet. Using a custom mix ensures that all nutrients are fed at levels needed to promote optimum performance, while none are fed in excessive amounts. Custom mineral mixes can be more expensive than commercial mixes, but this is not always the case.

Supplementation Strategies. Several methods are commonly used to supplement rations for beef cattle with minerals:

- **Mix minerals into complete ration.** The best way to ensure that each animal gets the proper level of minerals in its diet is to mix a good source of the missing or deficient minerals into a complete ration. Some nutritionists recommend that minerals be offered free-choice to cattle even though the ration includes minerals. If this is done, trace-mineralized salt should be fed separately from a mixture of equal parts iodized salt and dicalcium phosphate. This will allow animals a choice of salt alone or a salt-mineral mixture with the correct ratio of calcium to phosphorus -- 1.2:1.0.

- **Add minerals to a supplemental feed.** In this scenario, minerals should be added to a feed grain supplement at levels that are sufficient meet requirements for all mineral elements. This approach ignores minerals supplied by the forage. Knowing the level of intake of the supplement is critical to the success of this method.
- **Use free-choice mixtures.** Self-feeding minerals free-choice is a satisfactory method of mineral supplementation under most conditions; however, cattle will not have their mineral needs perfectly met with this system. Some animals will over-consume a self-fed mineral supplement while others will eat less than they need. In this system, salt or highly palatable concentrates are used to encourage supplement intake. The target intake is about two ounces per animal per day for most commercially available self-fed mineral supplements.

Mineral Interactions. Proper balance between minerals is critical. Perhaps the best illustration of this principle is the relationship between calcium and phosphorus. Calcium to phosphorus ratios of 2:1 to 1.2:1 are recommended for beef cattle diets. Variation from the recommended ratios, especially providing more phosphorus than calcium in the diet, can lead to urinary calculi, or “waterbelly”, in steer calves. While striving to maintain the proper balance between dietary calcium and phosphorus, care must be taken not to get the absolute levels of these minerals too high in the diet. High levels of these calcium and phosphorus increase the magnesium, manganese, iron, iodine, sulfur, and zinc requirements. Beef producers should also be aware that high levels of magnesium, iron, or aluminum might interfere with the uptake of calcium and phosphorus from the small intestine.

Another important example of maintaining adequate balance between minerals is the relationship between copper, molybdenum, iron, and sulfur. These minerals form complexes with one another in the body, reducing the amount of copper absorbed by the animal. Addition of molybdenum, iron, or sulfur to diets that are already deficient in copper is of particular concern because these minerals will further exacerbate copper deficiency. It is recommended that the level of copper be at least twice as high as the molybdenum content. Furthermore, in areas with high soil molybenum, copper levels five times higher than normal may be required to overcome copper deficiency symptoms (Ensminger et al, 1990). In contrast, toxic levels of sulfur and molybdenum in the diet can be counteracted by the addition of copper.

Organic Vs. Inorganic Mineral Sources. The source of minerals in the diet can effect the performance of the animals and the cost-effectiveness of the supplementation program. The relative bioavailability of the mineral and the amount of the mineral in the supplement are important factors to consider when purchasing a mineral supplement. Organic mineral sources are characterized by the presence of an amino acid or a carbohydrate carrier for the trace mineral that is to be fed to cattle. In a process informally termed chelation or proteination, the organic carrier molecule is chemically bound to the trace mineral of interest. Inorganic sources of minerals are much more commonly encountered in the North American feed industry. They are mined or chemically synthesized from natural mineral sources and are not bonded to a carrier molecule. They are fed as the naturally occurring inorganic mineral complex. Organic mineral sources reportedly have higher bioavailabilities than do inorganic sources of minerals; however, chelated minerals are usually more expensive than inorganic sources. Careful evaluation of expected benefits to animal performance in relation to added costs is warranted before exercising the option to feed organic mineral sources to beef cattle. Consult an extension professional for assistance in evaluating which mineral supplement would fit best into any particular scenario.

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Table 1. Mineral requirements and maximum tolerable levels for beef cattle

Mineral	Units	Growing and Finishing Cattle	Gestating and Dry Cows	Lactating Cows	Maximum Tolerable Level
Calcium	%	0.31	0.18	0.27	-
Chlorine	%	-	-	-	-
Chromium	ppm	-	-	-	1000.00
Cobalt	ppm	0.10	0.10	0.10	10.00
Copper	ppm	10.00	10.00	10.00	100.00
Iodine	ppm	0.50	0.50	0.50	50.00
Iron	ppm	50.00	50.00	50.00	1000.00
Magnesium	ppm	0.10	0.12	0.20	0.40
Manganese	%	20.00	40.00	40.00	1000.00
Molybdenum	ppm	-	-	-	5.00
Nickel	ppm	-	-	-	50.00
Phosphorus	%	0.27	0.18	0.27	-
Potassium	%	0.60	0.60	0.70	3.00
Selenium	ppm	0.10	0.10	0.10	2.00
Sodium	%	0.07	0.07	0.10	-
Sulfur	%	0.15	0.15	0.15	0.40
Zinc	ppm	30.00	30.00	30.00	500.00

Adapted from NRC, 1996

Table 2. Sources, empirical formulas, mineral concentrations, and relative bioavailabilities of common mineral sources

Supplement	Empirical Formula	Mineral Concentration (%)	Relative Bioavailability (RV)	Mineral Availability (% of content)
Calcium				
Calcium carbonate	$CaCO_3$	38	100.00	38.00
Bone Meal	variable	24	110.00	26.40
Calcium chloride (dihydrate)	$CaCl_2(H_2O)$	31	125.00	38.75
Dicalcium phosphate	$Ca_2(PO_4)$	20	110.00	22.00
Limestone		36	90.00	32.40
Monocalcium phosphate	$Ca(PO_4)$	17	130.00	22.10
Cobalt				
Cobaltous Sulfate	$CoSO_4(H_2O)_7$	21	100.00	21.00
Cobaltic Oxide	Co_3O_4	73	20.00	14.60
Cobaltous Carbonate	$CoCO_3$	47	110.00	51.70
Cobaltous Oxide	CoO	70	55.00	38.50
Copper				
Cupric sulfate	$CuSO_4(H_2O)_5$	25	100.00	25.00
Copper EDTA	variable	variable	95.00	variable
Copper Lysine	variable	variable	100.00	variable
Cupric chloride (tribasic)	$Cu_2(OH)_3Cl$	58	115.00	66.70
Cupric oxide	CuO	75	15.00	11.25
Cupric sulfide	CuS	66	25.00	16.50
Cuprous acetate	$CuC_2O_2H_3$	51	100.00	51.00
Iodine				
Potassium iodide	KI	69	100.00	69.00
Sodium iodide	NaI	84	100.00	84.00
Calcium iodate	$Ca(IO)_3$	64	95.00	60.80
Diiodosalicyclic acid	$C_7H_4I_2O_3$	65	15.00	9.75
Ethylenediamine dihydriodine	$C_2H_8N_2(HI)_2$	80	105.00	84.00
Pentacalcium orthoperiodate	$Ca_5(IO_6)_2$	39	100.00	39.00
Iron				
Ferrous sulfate heptahydrate	$FeSO_4(H2O)_7$	20	100.00	20.00
Ferric citrate	variable	variable	110.00	variable
Ferric EDTA	variable	variable	95.00	variable
Ferric phytate	variable	variable	45.00	variable
Ferrous carbonate	$FeCO_3$	38	10.00	3.80
Magnesium				
Magnesium sulfate	$MgSO_4$	20	100.00	20.00
Magnesium acetate	$MgC_2O_2H_4$	29	110.00	31.90
Magnesium basic carbonate	$MgCO_3$	31	100.00	31.00
Magnesium Oxide	MgO	55	100.00	55.00
Manganese				
Manganese sulfate	$MnSO_4(H_2O)$	30	100.00	30.00
Manganese carbonate	$MnCO_3$	46	30.00	13.80
Manganese dioxide	MnO_2	63	35.00	22.05
Manganese methionine	variable	variable	125.00	variable
Manganese monoxide	MnO	60	60.00	36.00
Phosphorus				
Sodium phosphate	$NaPO_4$	variable		
Bone meal	variable	21	100.00	21.00
Deflourinated phosphate	variable	12	80.00	9.60
Dicalcium phosphate	$CaHPO_4$	18	85.00	15.30
		18.5	100.00	18.50
Selenium				
Sodium selenite	Na_2SeO_3	45	100.00	45.00
Cobalt selenite	variable	variable	105.00	0.00
Selenomethionine	variable	variable	245.00	0.00
Selenoyeast	variable	variable	290.00	0.00
Sodium				
Sodium chloride	$NaCl$	40	100.00	40.00
Sodium bicarbonate	$Na(CO_3)_2$	27	95.00	25.65
Zinc				
Zinc sulfate	$ZnSO_4(H_2O)$	36	100.00	36.00
Zinc carbonate	$ZnCO_3$	56	60.00	33.60
Zinc oxide	ZnO	72	100.00	72.00

Adapted from Ammerman et al., 1995 and NRC, 1998

Table 3. Composition of mineral supplements

Supplement	Calcium %	Phosphorus %	Sodium %	Potassium %	Magnesium %	Manganese ppm	Iron ppm	Copper ppm	Zinc ppm	Selenium ppm
Bone meal	24.00	12.00	0.46	--	0.64	30.40	840.00	16.30	424.00	--
Calcium carbonate	38.00	--	0.06	0.06	0.50	279.00	336.00	24.00	--	0.07
Curacao phosphate	36.00	14.00	--	--	--	--	--	--	--	--
Diamonium phosphate	0.50	20.00	0.04	--	0.45	500.00	15000.00	80.00	300.00	--
Defluorinated phosphate	33.00	18.00	4.50	0.09	--	220.00	9200.00	22.00	44.00	0.60
Dicalcium phosphate	20.00	18.50	0.08	0.07	0.60	300.00	10000.00	80.00	220.00	0.60
Mono-dicalcium phosphate	16.00	21.00	0.05	0.06	0.50	220.00	7000.00	70.00	210.00	0.60
Mono-ammonium phosphate	0.50	24.00	0.06	--	0.45	500.00	12000.00	80.00	300.00	--
Sodium phosphate	--	21.80	32.30	--	--	--	--	--	--	--
Sodium tripolyphosphate	--	25.00	31.00	--	--	--	42.00	--	--	--
Phosphoric acid (75%)	--	23.80	--	--	--	--	5.00	--	--	--

Adapted from NRC, 1996

Table 4. Mineral composition of feedstuffs common to Missouri

Feedstuff	Calcium %	Phosphorus %	Sodium %	Potassium %	Magnesium %	Manganese ppm	Iron ppm	Copper ppm	Zinc ppm	Selenium ppm
Fescue hay	0.41	0.30	0.02	1.96	0.16	97.00	132.00	22.00	35.00	--
Alfalfa hay	1.40	0.28	0.05	2.43	0.28	30.30	198.00	7.30	18.80	0.41
Corn silage	0.25	0.22	0.01	1.14	0.18	23.50	131.00	4.18	17.70	0.53
Soybean meal	0.25	0.60	0.04	1.97	0.27	27.50	120.00	28.00	60.00	0.1
Corn gluten feed	0.07	0.95	0.26	1.40	0.40	22.10	226.00	6.98	73.30	1.8
Soybean Hulls	0.53	0.18	0.03	129.00	0.22	10.00	409.00	17.80	48.00	0.14
Corn	0.30	0.32	0.01	0.44	0.12	7.89	54.50	2.51	24.20	0.6
Barley	0.05	0.35	0.01	0.57	0.12	18.30	59.50	5.30	13.00	1.16

Adapted from NRC, 1996

Cow Herd Mineral Supplementation

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The primary mineral needs for most cow-herd are for salt and phosphorus. There are many commercial mineral supplements available that will meet the needs of cows, but these supplements are usually more expensive than what you can mix yourself.

Calcium content of grass stays pretty much the same all year, but phosphorus is leached out, so that by mid-winter, levels are very low. The phosphorus in feedstuffs (both grain and forages) is often not highly available (the exception is alfalfa) therefore, although feedstuffs commonly supply more than half of the phosphorus in the diet, they supply less than half of the phosphorus that is available to the animal. Also, it is important to realize that both the calcium and phosphorus requirements increase greatly during lactation.

A simple mixture of salt and a phosphorus source will meet the needs of most cows on most forages. Dicalcium phosphate is the phosphorus source used most commonly. You can also use steamed bone meal (usually more expensive) or monocalcium phosphate as phosphorus sources. Limestone (calcium carbonate) is a good source of calcium, but has no phosphorus.

Composition of several common mineral sources.

Mineral Source	Ca%	P%	Ca:P Ratio
Bone Meal	30	14	2.14 : 1
Dicalcium phosphate	24	18	1.33 : 1
Monocalcium phosphate	18	21	0.85 : 1
Calcium carbonate (limestone)	38	0	
Trace mineralized salt	0	0	

Cows should eat 2-4 oz. salt/phosphorus mix per day (.125-.25 lbs). Offering in a hand-fed supplement is preferred, but often not practical. Loose free-choice mineral sources should be kept dry and refilled at least weekly.

A standard mixture is 1 to 2 parts trace mineralized salt and 1 part dicalcium phosphate. If the cows are not eating enough of the mixture add 5% grain, molasses, wheat mids or soybean meal to improve the flavor. If the cows are eating too much mineral (a $ problem, usually not a health problem) increase the amount of salt in the mixture. If phosphorus deficient forage is being consumed, change the ratio to 1 part trace mineralized salt and 1 part dicalcium phosphate.

During periods when hypomagnesemia (grass tetany) is a danger, the following mixture is recommended: 30% trace mineralized salt, 30% bone meal or dical, 30% magnesium oxide, and 10% dried molasses (due to low palatability of MgO). This mixture will supply about 18% Mg.

Appropriate Ca:P ratios for different cattle

Diet Type	Min Ca%	Min P%	Ca:P Ratio
Gestation	.35	.3	1.16 : 1
Lactation	.4	.3	1.33 : 1
Grower	.6	.4	1.50 : 1
Finisher	.6	.35	1.71 : 1

There are some questions as to whether you need to use trace-mineralized salt or regular salt. Most herds will do equally well on regular salt in the mixture if their forages contain adequate levels of trace minerals. Higher producing cows have higher requirements for trace minerals.

Pricing Mineral Sources Based on Phosphorus Content

Mineral Source	% Phos.	Lbs. Phos per Ton	Price/Ton	Cost/Lb. Phosphorus
Dicalcium Phosphate	19	380	$280	$0.74
Monosodium Phosphate	22	440	$760	$1.73
Steamed Bonemeal	14	280	$470	$1.68
Brand "X"	10	200	$300	$1.50
Brand "Y"	12	240	$330	$1.38

Bioavailability of Phosphorus From Various Sources for Cattle

Phosphorus Source	Relative Value
Dicalcium Phosphate	100
Monosodium Phosphate	107
Steamed Bonemeal	92
Defluorinated Phosphate	71-95
Soft Rock Phosphate	17-88
Calcium Phytate	66
Phytate Phosphorus (plant)	60

* Miller, Michigan State University 1980 Review
** Relative biological value compared to dicalcium phosphate ($CaHPO_4$ $2H_2O$) as the standard = 100