Minerals

Minerals are routinely added to dairy cattle diets to satisfy the nutritional needs for these elements. The minerals that are commonly added are shown below and discussed in more detail in this section.

Minerals Supplemented in Dairy Cattle Diets

Major Minerals or Macro Minerals	*Trace Minerals or Micro Minerals*
Calcium	Cobalt
Chlorine	Copper
Magnesium	Iodine
Phosphorus	Iron
Potassium	Manganese
Sodium	Selenium
Sulfer	Zinc

Calcium

- The lowest calcium availability belongs to alfalfa based forages, due to the large concentration of calcium as calcium oxalate, an insoluble compound.
- Dietary calcium levels should be increased (to about 1%) when fat is added to the ration, due to the formation of insoluble complexes between the fat and calcium (calcium soaps).
- Serum calcium levels of 9-11 mg/100 ml are normal. Because serum calcium values vary depending upon the manner in which the samples were handled and analyzed, check with the laboratory for their normal ranges.
- Clinical hypocalcemia (low blood calcium) at calving causes milk fever; related to DCAD balance
- Subclinical hypocalcemia may increase the incidence of retained placenta and depress appetite during early lactation.

Chlorine

- Requirements are typically met when salt is used to supply the animal's requirement for sodium. Feeding high grain diets supplemented with excess sodium bicarbonate could cause a borderline deficiency of chlorine if not supplemented.
- Urine and serum chloride drop sharply with a deficiency.

Cobalt

- An essential component of Vitamin B_{12}, that is synthesized by rumen bacteria.
- Liver level of Vitamin B_{12} is the best diagnostic indicator of cobalt status. Serum levels are poor measures.
- Deficiency results in anemia, rough hair coat, depressed appetite, reduced conception rates and susceptibility to heat stress.

Copper

- Important constituent of several enzymes, immune system and affects iron metabolism and red blood cell maturation.
- At high levels, molybdenum, sulfur, and zinc can decrease copper absorption and affect dietary copper requirements.
- The ideal copper to molybdenum ration is between 6:1 and 10:1 ; 3:1 is borderline; less than 3:1 results in copper deficiency due to the antagonism of molybdenum
- Deficiency symptoms include: faded hair coat, delayed estrus, reduced fertility, retained placenta, incoordination, stiff gait, foot problems, and impaired immune response
- Liver biopsy is the best guide to copper status
- Serum levels are not accurate in determining copper status. Normal serum copper without selenium supplementation is 0.8-1.5 mg/100 ml. With selenium supplementation this is 0.3-1.2 mg/100 ml. Infections or trauma increase blood copper levels
- Copper toxicity (usually >20 ppm supplemental copper) is a practical concern

Iodine

- Iodine is the basic component of the thyroid hormones that regulate energy metabolism in the body
- A deficiency of iodine causes an enlargement of the thyroid gland goiter
- Certain plants are goitrogenic, increasing the iodine requirement
- The diet can be supplemented with either the inorganic forms of iodine such as calcium iodate or the organic form known as EDDI (Ethylenediamine Dihydriodide). Historically EDDI had been used at the rate of 50 mg per head daily for foot rot prevention. In 1986, FDA eliminated the use of EDDI as a “drug” for the control of foot rot. Recently FDA set the maximum consumption level of 49.9 mg of EDDI per head daily for nutritional purpose only

Iron

- Iron is component of hemoglobin and myoglobin for oxygen transport
- The great majority of iron in the body is contained in either hemoglobin or the liver
- Iron deficiency seldom occurs in mature cows
- Milk contains very little iron (thus the possibility of deficiency in calves without supplementation)
- Most plants contain more-than-adequate iron levels

Magnesium

- Functions as bone constituent, involved in neuromuscular transmission and activates many enzymes
- Like calcium, magnesium levels are typically increased when feeding fat (0.35%)
- Higher levels of magnesium are now recommended for lactating cows than NRC requirements (0.30-0.40% of DMI)
- Magnesium oxide is often added in buffer packs in lactating cow diets
- High potassium and nitrogen levels reduce magnesium absorption (typical cause of grass tetany)
- Serum magnesium level is a good indicator of magnesium status (2mg/100 ml is considered normal)
- Classical grass tetany occurs when serum levels drop below 1.1 mg/100 ml
- Excess magnesium causes diarrhea (<.40% of DMI)
- The solubility of magnesium oxide (and likely absorption) is a function of chemical structure, particle size, and kiln temperature at which the ore was processed. Low particle size and medium temperature are optimum

Manganese

- Affects enzyme systems, brain functions, collagen formation, bone growth, protein digestion and fatty acid synthesis.
- A deficiency is associated with reproductive parameters including silent heats and reduced conception

Phosphorus

- Major constituent of bone and teeth, impacts energy metabolism and is part of DNA and RNA
- The costliest mineral supplemented
- Phytate phosphorus is utilized quite well by ruminants in contrast to poultry and swine
- Adequate serum inorganic phosphorus is 4.5-6 mg/100 ml., but is affected by the following:
    1. First lactation cows have higher values than older cows
    2. Values increase as milk yields decrease
    3. Values increase for 2 hours after feeding, and then decrease; related to the time of feeding
    4. Calcium deficiency causes values to increase
- Deficiency symptoms include reduced feed intake and milk yield, unthriftness, lethargy, impaired reproduction (silent heat, low fertility), and milk fever like symptoms in late lactation
- Cows deficient in phosphorus may exhibit a depraved appetite (chew on wood, metal, etc)
- Phosphorus source should contain less than 1 part fluorine per each 100 parts of phosphorus to prevent fluoride toxicity (fluoride accumulates in the bone)
- Symptoms of fluoride toxicity include: mottled or chalky teeth, lameness, stiffness, delayed estrus, anemia, and calcification of soft tissues. Since fluoride is cumulative, older animals are most susceptible to fluorosis

Potassium

- Maintain electrolyte balance, activates enzymes and is involved in muscle and nerve function
- Most alfalfa based diets contain potassium in excess of requirements. Monitor corn silage diets, or diets containing high levels of brewers grains
- Requirement increases during heat stress
- Deficiency causes a rapid decline in feed intake, milk production, and low blood and milk potassium levels
- High levels reduce magnesium absorption, increase the incidence of udder edema due to its effect on osmotic balance, and increase the incidence of milk fever due to its effect on cation-anion balance
- Potassium carbonate is sometimes used during periods of heat stress.

Selenium

- Maximum legal level of 0.3 ppm in the total diet (about 6 mg per head for a lactating cow) appears necessary for optimum performance of immune and reproductive systems
- Normal levels for whole blood are 0.1 ppm. The corresponding values for serum are 0.05-0.07 ppm
- Severe deficiency symptoms include white muscle disease in calves, muscle stiffness, and sudden death due to cardiac failure. Marginal deficiency symptoms include retained placentas, weak calves unable to stand or suckle, reduced reproductive performance, mastitis, and impaired immune response
- For quick response, injectable selenium may sometimes be necessary. The two most commonly used products are MuSe® (5 mg Se + 50 mg vitamin E per ml) and BoSe® (1 mg Se + 50 mg vitamins E per ml). Recommended dose age is 2.5-3 mg of selenium per 100 lb body weight. One injection should be adequate for about 60 days

Sodium

- Sodium functions in maintaining body fluid balance, osmotic pressure and acid-base balance
- Deficiency symptoms include craving for salt, reduced appetite and milk production and weight loss. Excess sodium is excreted by the kidneys. Therefore, toxicity is not likely unless water intake is restricted
- Requirements should be increased during heat stress
- Possible factor in udder edema
- Increased dietary potassium increases sodium requirements

Sulfur

- Sulfur is a component of the sulfur containing amino acids such as methionine and the B-vitamins thiamine and biotin. These are products of microbial synthesis in the rumen
- Sulfur is low in corn silage diets and low protein feedstuffs. It is highest in high protein feedstuffs
- The nitrogen to sulfur ratio in the total diet should be approximately 12:1
- Deficiency symptoms include reduced growth, milk production and feed conversion
- Additional sulfur may be added to dry cow diets to reduce the anion-cation difference. Limit the sulfur to 0.4% in making these adjustments

Zinc

- Zinc is a key trace element involved in a number of metabolic pathways such as carbohydrate and energy metabolism and protein synthesis
- Zinc is essential for normal wound healing and Vitamin A utilization
- Deficiency signs include weak hoof horn, (increasing the susceptibility to foot problems), reduced conception rate, and impaired immune response

Chelated Trace Minerals

The mineral allowances for lactating and dry cows that are suggested by Vita Plus are outlined for each class in (Table 2). Trace minerals in blood and other tissues, as well as feedstuffs exist largely bound to organic complexes or chelates). In contrast, trace minerals are usually supplemented in diets as inorganic salts.

In recent years, various trace mineral chelates or complexes have been introduced into the marketplace. The most common are complexes with zinc, copper, manganese, or iron. These organic trace mineral complexes may stimulate specific biological processes, or the mineral may enter different pools within the body than the inorganic form. Also, the conversion of inorganic minerals to organic forms for absorption may limit certain physiological processes. Under certain conditions, animal performance, reproductive performance, and immune responsiveness have been increased by the use of organic trace minerals.

Table 2. MINERAL GUIDELINES FOR DAIRY CATTLE DIETS

NUTRIENT	<21 Days Post-Fresh	22-100 Days Early	101-240 Days Mid	>240 Days Late	DRY	Pre-Fresh
Calcium	.90-1.1	.85-1.1	.80-1.0	.80-.95	.60-.80	.60-.802
Phosphorus	.35-.40	.35-.40	.33-.38	.25-.32	.25-.32	.30-.40
Magnesium[1]	.36-.40	.35-.40	.28-.35	.25-.30	.20-.22	.35-.40
Potassium[2]	1.2-1.4	1.2-1.4	1.0-1.4	1.0-1.4	.70-.80	.70-.80
Sodium[2]	.20-.40	.20-.35	.18-.25	.18-.25	.10	.05-.10
Chlorine[1]	.40-.55	.40-.55	.35-.45	.30-.40	.10-.25	.20
Salt[1]	.25-.50	.25-.50	.25-.40	.25-.40	.10-.25	.10-.25
Sulfur[1]	.20-.24	.20-.24	.20-.24	.20-.22	.16-.20	.16-.20
N:S[3]	11-13:1	11-13:1	11-13:1	10-12:1	10-13:1	5-12:1
----------PPM IN RATION DRY MATTER----------						
Cobalt	.5(.4)	.5(.4)	.4(.3)	.3(.2)	.3(.2)	.4(.3)
Copper	17-(15)	17-25(15)	15-20(10)	17-50(15)	12(8)	17-25(15)
Iodine	.8(.8)	.8(.8)	.8(.8)	.8(.8)	.5(.5)	.5(.5)
Iron	100(0)	100(0)	100(0)	100(0)	100(0)	100(0)
Manganese	60(45)	60(45)	50(40)	50(40)	60(45)	60(45)
Selenium	.3(.3)	.3(.3)	.3(.3)	.3(.3)	.3(.3)	.3(.3)
Zinc	80(50)	80(55)	70(50)	60(45)	70(50)	80(55)

[1]Prefresh cows fed anionic salts should receive a minimum of 1.0% calcium, delete salt from the ration, and may have chlorine, sulfur, and magnesium levels up to 1.0%, 0.4%, and 0.4% respectively. Avoid feeding buffers to all dry cows.

Prefresh rations should be balanced as close to potassium requirements as possible. High dietary potassium levels (<1.5%) can be counteracted by reducing DCAD with anionic sources. DO NOT trust mineral values determined by NIR analysis.

[2]Increase potassium to 1.3-1.5% and sodium to .30-.50% under heat-stress conditions.

[3]N:S ratios will vary depending on protein and sulfur levels fed. Feeding anionic salts may reduce the ratio to 5-7:1, and should not be a concern. Rations high in bypass protein (UIP) may require a ratio no higher than 11-12:1.

Assessing Mineral Status

The best means of checking the mineral status of a herd is to calculate the daily intake of each mineral based on forage and feed analyses. However, when no obvious things are found, or no relief is obtained from ration changes, other methods can be used to supplement your ration information. Blood, liver, urine or milk mineral analyses can all add pieces of information. However, before interpreting results, you should understand the sensitivity of each test to the nutrient in question. For example, blood is a good measure of the selenium, iron and magnesium status. If you are interested in copper, manganese or zinc however, the liver biopsy is the most accurate. Urine can be used to accurately measure sodium. Milk is a good measure of the iodine status. To properly assess the mineral status with any of these diagnostic tests, make sure that at least a half dozen cows are analyzed to properly interpret the results. Another system that is occasionally promoted is the use of hair analysis. Hair analysis has been used to determine severe deficiencies of some required minerals or exposure to heavy metals. The variations due to season, breed, hair color, sire, age, and body location make interpretation of hair analysis extremely difficult and very limited for most practical situations. Typically, hair analysis is not recommended as a method of determining the mineral status of an animal.