Minerals and Vitamins

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Important Little Things in Life

Two things that characterize Oregon's agriculture are its abundance of forage on range and pasture lands and its diversity, which makes possible the production of numerous crop and animal products. Diversity is a two-edged sword, however, because it means that different soil and weather conditions affect the composition of forages or other crops, and the effects sometimes are undesirable.

Suboptimal animal performance has been observed when cattle consume forage-based diets, despite an adequate supply of protein and energy. An insufficient supply of micronutrients, including minerals and vitamins, may be involved because cattle must receive all of the essential nutrients in proper quantities to maintain good health, grow, and reproduce at their maximum potential.

Minerals

A good example of the effect of diverse growing conditions is the concentration of mineral elements in forage, particularly the trace minerals, which normally are present in very small ("trace") quantities. Sometimes, these minerals are present at levels that are too low for good animal health, and so-called "deficiency diseases" result. On the other hand, elevated levels of these minerals sometimes cause toxicity.

Table 4.1 identifies the essential minerals as macrominerals or microminerals (trace). Macrominerals are required in relatively large amounts, and the requirements are expressed in percentages. Trace minerals, or microminerals, are required in smaller amounts, and the requirements are expressed in mg/kg (parts per million or ppm) of livestock diets. Many of the essential minerals usually are available in livestock feed in adequate

Table 4.1. Nutritionally essential minerals.

Macrominerals		Microminerals (trace)	
Calcium (Ca)	Potassium (K)	Cobalt (Co)	Manganese (Mn)
Phosphorus (P)	Chlorine (Cl)	Copper (Cu)	Molybdenum (Mo)
Magnesium (Mg)		Chromium (Cr)	Selenium (Se)
Sodium (Na)		Iodine (I)	Zinc (Zn)
Sulfur (S)		Iron (Fe)	Nickel (Ni)

amounts. However, in some cases feeds do not contain sufficient amounts, and supplementation is necessary to optimize animal performance.

Minimum requirements and maximum levels of minerals are shown in Table 4.2.

Macrominerals

Calcium (Ca) and phosphorus (P) are the minerals required in the largest amount by livestock. Calcium is the most abundant cation in an animal's body. Approximately 99 percent of the calcium is found in bones and teeth, with the remaining 1 percent distributed in soft tissues. Phosphorus is a major constituent of bones and teeth and is an essential component of organic compounds involved in almost every aspect of metabolism.

For optimum performance, Ca and P need to be present in the diet at required levels. In addition, the Ca to P (Ca:P) ratio is important. The ideal Ca:P ratio is approximately 1:1 to 2:1. With adequate amounts of P in the diet, a higher Ca:P ratio can be tolerated. In beef cattle, diets with a ratio as high as 7:1 have performed satisfactorily if levels of P are well above

Table 4.2. Mineral requirements and maximum tolerable level of minerals in beef rations.[a]

	Minimum requirement			
Mineral	Growing and finishing cattle	Gestating cows	Early lactation cows	Maximum tolerable level
Calcium (%)[b]	—	—	—	—
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	1,000.00
Magnesium (%)	0.10	0.12	0.20	0.40
Manganese (ppm)	20.00	40.00	40.00	1,000.00
Molybdenum (ppm)	—	—	—	5.00
Nickel (ppm)	—	—	—	50.00
Phosphorus (%)[b]	—	—	—	—
Potassium (%)	0.60	0.60	0.70	3.00
Selenium (ppm)	0.10	0.10	0.10	2.00
Sodium (%)[c]	0.06–0.08	0.06–0.08	0.1	10.00
Sulfur (%)	0.15	0.15	0.15	0.40
Zinc (ppm)	30.00	30.00	30.00	500.00

[a]ppm = parts per million (1 ppm = 0.0001%; 1% = 10,000 ppm; 1 mg/kg = 1 ppm)
[b]Calcium (Ca) and phosphorus (P) requirements vary with age, weight, type of animal, and production level (pounds/day growth, stage of gestation/lactation, etc.). Young animals have high requirements because of bone growth. Also, high rates of gain or milk production and pregnancy increase Ca requirements. See Chapter 1 tables for amounts required.
[c]Percent sodium chloride (NaCl = salt)

Source: National Research Council. 1996. *Nutrient Requirements of Beef Cattle*. National Academies Press, Washington, DC. Web: http://www.nap.edu/

the required level and vitamin D level is high. Depressed performance has been observed with ratios below 1:1. Therefore, the ratio should not exceed 7:1 nor be less than 1:1.

Excess P in relationship to Ca can result in a very detrimental situation, even when Ca is at or above required levels. High levels of P can cause increased calcium resorption from the bone in adult animals. Urinary calculi (urolithiasis) are also caused by excess P. Stones in the kidney or bladder block urine, which can lead to death from uremia.

Calcium also has an interrelationship with other nutrients, and feeding higher levels of Ca for extended periods can have a detrimental effect on performance. Excess calcium can cause a deficiency of other essential elements, i.e., phosphorus, magnesium, iron, iodine, zinc, and manganese.

Consuming forage low in magnesium (Mg) leads to low blood levels of Mg (hypomagnesemia), which can cause grass tetany. Cattle in a state of severe magnesium deficiency become hypersensitive to tactile or sound stimuli and experience tremors. Convulsions and death usually follow.

Calcium and potassium (K) also can affect Mg blood levels by influencing Mg absorption. Thus, Mg concentration, as well as Ca and K levels, is important. By calculating a tetany ratio, K ÷ (Ca + Mg), you can estimate the risk of grass tetany.[1] A tetany ratio of greater than 2.2 represents a tetany-prone diet.

Microminerals (trace)

The levels of microminerals in forages or other feed crops may make the difference between profit and loss in an animal operation. For example, a deficiency of selenium may cause animals to suffer white muscle disease, which can interfere with growth and reproduction and may cause death.

An excess of molybdenum results in toxic molybdenosis and, because molybdenum ties up copper in the diet, may cause copper deficiency. Molybdenum levels of 5 to 6 ppm produce signs of molybdenosis. Some areas in Baker County have high levels of molybdenum in the soil, and animals show symptoms of copper deficiency, even though the forage contains normal levels of copper.

Deficiency symptoms often are similar for several microminerals, making diagnosis difficult. One specific symptom is goiter (a neck swelling), which indicates iodine deficiency.

The importance of trace minerals has been known for years. The need for copper and cobalt was discovered in the 1930s; for selenium in the 1950s. Yet, many livestock operators fail to ensure adequate quantities in rations for their animals. A 1996 audit of cow/calf feeds in 18 states showed deficiencies of various trace elements ranging from about 5 percent to nearly 50 percent of the 352 forage samples studied (Corah and Dargatz, 1996).

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[1]The tetany ratio is calculated on an equivalent weight basis (i.e., it does not use the percentage or ppm of the mineral as shown in the forage analysis report, but rather uses the amount of each element corrected for molecular weight.) Thus, the formula actually is:

(K concentration ÷ 39) ÷ [(Ca concentration ÷ 20) + (Mg concentration ÷ 12.1)]

The concentration of the elements must be on the same basis—percentage, ppm, or mg/kg.

To overcome a deficiency is fairly easy and generally not costly. One simply locates a source of the deficient mineral, usually a salt-mineral supplement, and adds it to the diet at a level to meet the animals' needs.

Preventing toxicity is more difficult, but it can be accomplished by eliminating the toxic feed from the diet (changing grazing sites, for example) or by adding a mineral that counteracts the effect of the toxic element, such as copper in cases of molybdenum toxicity.

Supplements seldom contain an element as such, but rather a salt of the needed element, such as sodium selenite in the case of selenium. Recently, interest has been shown in chelated minerals, which are thought to be more available to animals. A chelate is a combination of a mineral element and an organic substance, such as a protein or an amino acid. Chelated forms are more expensive, so consider using a blend of chelated and simple salt forms.

When supplementing feeds with essential trace elements, you'll need to calculate the amount of supplement to provide, based on the percentage of the needed element in the salt (see Worksheet 4.1).

Vitamins

Cattle require most of the vitamins needed by other mammals. However, ruminants are unique because rumen microorganisms can synthesize some essential vitamins. Synthesis by rumen microorganisms, supplies in natural feedstuffs, and synthesis in tissues meet most of the requirements.

Calves from adequately fed mothers have minimal stores of vitamins at birth. Colostrum is rich in vitamins, providing an immediate source of vitamins to the newborn calf. The ability to synthesize B vitamins and vitamin K in the rumen develops rapidly when solid feed is introduced into the diet. High-quality forages contain large amounts of vitamin A precursors and vitamin E. Vitamin D is synthesized by animal exposure to sunlight and is found in large amounts in sun-cured forages.

In ruminants, five classes of vitamins are important. Vitamin A likely is the most important. Vitamins D, E, K, and some of the B vitamins also are known to be essential. Supplemental vitamins can be added to the trace mineral salt mixture. Information on requirements, metabolic role, and signs of deficiency and toxicity is available in the references listed at the end of this chapter.

Vitamin A

When feed sources are likely to be low in vitamin A, supplementation is recommended to prevent potential problems with productive efficiency of cattle. Supplementing brood cows with vitamin A before (16,000 IU/day) and after (40,000 IU/day) the calving season can increase conception rates by 10 percent and decrease calf morbidity by as much as 50 percent as compared to a deficient state.

It is not uncommon for liver stores of vitamin A to be reduced when cattle consume a diet of low-quality, mature forage. Typically, 2 to 4 months of protection can be expected from stored vitamin A. Increasing dietary vitamin A by 5,000 IU per day can double the amount of vitamin A stored in the liver. Supplemental vitamin A may not always be necessary when cattle are grazing dormant rangelands, or if the cattle are fed properly cured and stored hay.

Vitamin E

Supplementation is recommended for brood cows consuming poor-quality forage during late pregnancy through early lactation. During the late stages of pregnancy, vitamin E concentration in the blood tends to decrease below marginal levels. Feeding supplemental vitamin E is an effective method of maintaining proper levels during this period.

Neonatal calves must receive dietary vitamin E because its placental transfer is very limited. However, it may not be necessary to supply supplemental vitamin E directly to the calf. Feeding an additional 1,000 IU of a-tocopherol (vitamin E) to cattle during the last trimester of pregnancy can increase antibody production and sequestration in the colostrum and increase vitamin E concentration in the colostrum by up to 30 percent. You can maintain plasma concentrations of vitamin E in the calf above the minimal level by continuing maternal supplementation into the early stages of lactation.

Vitamin D

Sunlight typically stimulates sufficient production of vitamin D in grazing cattle. Vitamin D status is improved more effectively by increasing the animal's exposure to sunlight than by dietary supplementation.

Vitamin K

Ruminal microorganisms generally synthesize and supply vitamin K in amounts sufficient to meet the ruminant animal's requirements. Supplemental vitamin K usually is justified only when cattle are suspected to have been exposed to vitamin K antagonists.

Consumption of a natural vitamin K antagonist (dicumarol) can be a problem if cattle ingest moldy sweetclover forage. Because dicumarol antagonizes vitamin K, an essential component of the blood clotting process, feeding moldy sweetclover hay to cattle may cause hemorrhage and uncontrollable bleeding.

Response to vitamin K therapy depends somewhat on differences in the dicumarol source and dosage. Therefore, prevention (avoid feeding moldy sweetclover hay) is a better alternative to supplemental treatments.

B vitamins

Microbial synthesis of the B vitamins in the rumen is thought to satisfy the ruminant's requirements. Supplementation with B vitamins should not be necessary under normal production situations, especially if cattle consume high-quality forage or are fed supplemental protein and/or energy that improves ruminal digestibility and subsequent microbial synthesis. Injections of B vitamins seem to be beneficial only to combat overt stress and disease.

Conclusions

Minerals and vitamins, whether essential or nonessential, can adversely affect an animal if included in the diet at excessively high levels. Feeding excessive amounts is costly in terms of dollars and animal performance. Having your forage sampled and analyzed for mineral content is the most practical way to assure that you are feeding an adequate, but not excessive, level.

Because of the availability of low-cost sources of vitamins A and E, consider regular supplementation of these vitamins to cattle fed low-quality forage. Supplementing other vitamins is not recommended, except under special circumstances.

It is in keeping with good husbandry and nutritional practice to maintain the intake of these important dietary constituents at required levels, but below the maximum tolerable levels. The benefits of such programs are seen in increased production efficiency. Aside from direct effects on reproduction, producers should benefit from cattle in better health.

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Worksheet 4.1
Practice Questions for Mineral Supplementation

1. A herd of cattle shows signs of copper (Cu) deficiency (scouring, light coat color), but when the forage they are grazing is analyzed, it shows 10 ppm Cu, which should be adequate. What do you suppose is causing the problem?

2. You wish to supplement a diet with copper, using copper sulfate as the source. Copper sulfate contains 39.81 percent Cu. How much copper sulfate must you add to supply 7 ppm Cu to a ton of feed?
1 ton = 908,000 grams (see example below)

3. Young calves are born with large swellings in the upper throat area. Can you relate this symptom to a micromineral deficiency? What is the common name for this deficiency disease?

Example for calculating amount of mineral compound to add to a desired mineral mix (and why you should consider a salt-mineral supplement that is formulated and mixed by a reputable dealer)\
You are losing some calves to white muscle disease and decide to supplement their diet with 0.1 part per million (ppm) of selenium (Se). You obtain some sodium selenite. How much should you add to the feed to get 0.1 ppm of selenium? Sodium selenite contains 45.65 percent Se.

When calculating small quantities, such as parts per million, it is easier to use small units (grams), rather than pounds. There are 454 grams in a pound, and 908,000 grams in a ton (2,000 pounds in a ton x 454 grams in a pound = 908,000 grams in a ton). A paper clip weighs about 1 gram.

1. You want 0.1 ppm Se in the 1 ton of feed (0.1 ÷ 1,000,000) x 908,000 grams per ton = 0.0908 gram Se per ton of feed.

2. Sodium selenite is 45.65 percent Se, so you need 2.19 grams of sodium selenite to get 1 gram of Se (100 ÷ 45.65 = 2.19).

3. You need 0.1989 (approximately 0.2) gram of sodium selenite to get 0.0908 gram of selenium per ton (2.19 x 0.0908 = 0.1989).

This is a very small amount to disperse evenly in a ton of feed, so it's best to make a premix. Add 0.2 gram of sodium selenite to 100 pounds of feed, mix thoroughly, and then add the other 1,900 pounds and continuing mixing. It may be best to have a feed dealer do the mixing since dealers are familiar with premixes and have efficient mixing equipment.

Resources
You can find information for calculating supplement values from the following resources.

- *The Merck Veterinary Manual* provides brief descriptions and percentage composition of all mineral supplements.
- *The Mineral Nutrition of Livestock* is a good source of information on animal symptoms of various deficiencies and supplementary levels of minerals needed to correct them.
- *Nutrient Requirements of Beef Cattle*