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What are the Mineral Concentrations of Forages?

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The nutrition of grazing animals is a complicated interaction of soils, plants, and animals. The performance and health of grazing livestock is dependent on the adequacy and availability of essential mineral elements from pastures. Of the nutritional entities provided by the pasture, forage, minerals are the most variable. Mineral requirements are dependent on forage mineral content, animal age, and stage of production. However, simply knowing the animal's requirement is only one component in evaluating an animal's mineral status.

Minerals make up a small portion of an animal's diet; however, they play an important role in health, growth, and reproduction. From the forage and livestock point of view, minerals are classified in two groups: macrominerals and trace minerals. Macrominerals are required in high concentrations in the ration. The macro minerals include calcium (Ca), phosphorus (P), sodium (Na), potassium (K), and magnesium (Mg). Table 1 provides a description of the roles macrominerals play in livestock growth and performance. On the other hand, trace minerals are needed in the ration in low concentrations. Trace minerals include iron (Fe), zinc (Zn), copper (Cu), manganese (Mn), cobalt (Co), molybdenum (Mo), selenium (Se), and iodine (I).

Mineral needs also tend to be area specific and factors like climate, soil type, forage species, agronomic practices, maturity, season, soil mineral concentration, dry matter yield and the amount and type of fertilizer nutrients applied ultimately affect the nutritive value of forages for livestock. Seasonal variability can markedly affect the dietary intake of minerals as a result of changes in composition, stage of growth, availability of pasture, and to changes in the moisture content of the soil. Forage mineral concentration is also affected by maturity. Generally, there is a rapid uptake of mineral during early growth and gradual dilution as the plant matures.

Mineral concentrations in forages vary much more than do protein and energy concentration. Leaves had higher concentrations of minerals than stems, except for potassium. Legumes are generally higher than grasses in calcium, potassium, magnesium, copper, zinc, and cobalt. In contrast, grasses tend to be higher than legumes in manganese and molybdenum. Most common grasses to Mississippi are marginal to deficient in copper and zinc. The mineral content of forages varies and depends primarily on the plant species present in the forage (Table 2).

Table 1. Roles of macrominerals in animal growth and performance.

Mineral	Function
Phosphorus (P)	Animals need P for skeletal growth and for energy metabolism. The P content is similar across different forage types, but is higher in pastures than in hay crops. The P content of pasture usually is adequate for lactating and growing cattle
Potassium (K)	Animals need K for milk production, maintenance of body fluids, nerve impulse transmission, muscle contraction, and the maintenance of enzyme systems
Calcium (Ca)	Animals need Ca for skeletal growth, milk production, nerve impulse transmission, and the maintenance of enzyme systems.
Magnesium (Mg)	Animals need Mg for skeletal growth, milk production, nerve impulse transmission, muscular control, and the maintenance of enzyme systems. The Mg content in forage is higher when there are legumes present.
Sodium (Na)	Animals need Na for glucose and amino acid transport, maintaining body fluids, and acid-base balance.

Grazing livestock requires an understanding of the dynamics of a broad range of forage nutrients. Mineral imbalances (deficiencies or excesses) in soils and forages have been associated with low reproductive rates and animal production among grazing ruminants in tropical regions. Although it is recognized that animal rations usually include a variety of feedstuffs to achieve a better balance of nutrients, it is of interest to compare the mineral contents of the forage. Voluntary intake and mineral concentrations of base feedstuffs determines the level of mineral consumption. This means that adequate intake of forages by grazing animals is essential in meeting mineral requirements. Factors such as low protein and high degree of lignification (reduced digestibility) also reduce total mineral consumption. Livestock producers need to be aware that improper feeding of by-products such as distiller grains and corn glutein can also create mineral imbalances.

The ability of forage minerals to meet grazing livestock mineral requirements depends upon quantity (the concentration of minerals in the plant) and the bioavailability of those minerals (amount livestock can absorb from the digestive tract). Although mineral concentrations in the forage might be adequate, the percent that is available to the livestock might be much lower. Mineral bioavailability depends upon various digestive tract interactions, mineral solubility and digestive tract pH. Table 3 provides a rough estimate of nutrient availability in forages. Many types of forage contain antagonists that reduce the availability of minerals. There are many mineral-mineral interactions that increase requirements such as high Mo-S diets increase the requirement for Cu and as dietary K increases Mg requirement increases. In addition to mineral-mineral interactions, there are significant interactions between minerals and organic constituents found in plants. Many organic acids may be present that have been shown to reduce the bioavailabilty of forage minerals. Studies in Arkansas have indicated that forages grown on poultry-litter amended soils had too little magnesium or copper, which would put the cows in danger of developing grass tetany or to suffer from copper deficiency. The combination of all of these factors makes it extremely difficult for livestock producers to determine the actual mineral status of their herd and the degree of supplementation that may be needed to meet production goals.

Table 2. Calcium (Ca), phosphorus (P), magnesium (Mg), potassium (K), and sulfur (S) concentration of pastures used for cattle.

Feed Type	P	K	Ca	Mg	S
Pasture					
Grass	0.38 ± 08	3.38 ± .71	0.43 ± .22	0.22 ± .05	0.32 ± .07
Mixed mostly grass	0.38 ± .08	2.76 ± .71	0.75 ± .22	0.26 ± .05	0.33 ± .07
Mixed mostly legume	0.35 ± .08	2.65 ± .71	1.99 ± .22	0.29 ±0.05	0.30 ± .07
Legume	0.33 ± .08	3.07 ± .71	1.21 ± .22	0.30 ± .05	0.26 ± .07
Hay					
Grass	0.22 ± .06	1.84 ± .57	0.55 ± .21	0.21 ± .06	0.19 ± .09
Mixed mostly grass	0.23 ± .06	1.93 ± .53	0.75 ± .29	0.23 ± .05	0.15 ± .06
Mixed mostly legume	0.25 ± .05	2.26 ± .47	1.14 ± .29	0.26 ± .05	0.18 ± .06
Legume	0.25 ± .05	2.58 ± .51	1.46 ± .29	0.29 ± .06	0.26 ± .07
Silage					
Grass	0.23 ± .08	2.35 ± .86	0.67 ± .26	0.22 ±0.06	0.22 ± .08
Mixed mostly grass	0.28 ± .06	2.29 ± .67	0.87 ± .27	0.23 ± .05	0.20 ± .06
Mixed mostly legume	0.29 ± .05	2.54 ± .59	1.14 ± .25	0.25 ± .05	0.22 ± .06
Legume	0.30 ± .06	2.64 ± .55	1.26 ± .23	0.25 ± .05	0.23 ± .06

Note: Sodium: <0.05 in all forages, Chloride (Legume/Grass forages): 0.5 to 1.0%.
Adapted from Rayburn, 1995.

Summary

While free-choice mineral supplementation is common for beef cattle on pasture, pasture forage is still the main source of nutritionally essential minerals. When considering diet formulations for a specific type of livestock, it is important to consider the amount, the availability and the interactions between minerals. For example, high K levels can affect the uptake of Mg or high levels of S can limit Cu availability. Of the nutrients provided to grazing cattle by forages, trace mineral content is the most variable. Trace mineral levels in forages are influenced by numerous variables. Although total concentration of a mineral in forage is important, the biological availability of the mineral is equally important. Biological availability (absorption and utilization) of minerals varies substantially among animal species and breeds within a species, as well as among forages. Feeding resources and feeding systems for livestock vary from one place to another. The creation of a custom mineral supplement for a specific farm would require an extensive investment of time and sampling of both soil and plant tissues throughout the growing season.

Table 3. General bioavailability of nutrients in forages.

Nutrient	Bioavailability (%)
Phosphorus	60 – 65
Potassium	85 – 90
Calcium	30 – 35
Magnesium	15 – 20
Sulfur	85 – 90
Sodium	<0.05
Chloride	85 – 90

Source: Linn, Univ. of Minnesota.