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Minerals Matter for Beef Cattle

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Minerals are an essential nutrient for beef cattle. If minerals are not consumed in the diet, deficiencies can occur. At the same time, overconsumption of certain minerals can result in toxicity. Providing the proper balance of each mineral without overconsumption is necessary for optimal performance, as minerals are essential for supporting growth, reproduction, lactation, and health.

The eighth revised edition of Nutrient Requirements for Beef Cattle, published in 2016 by the National Academies of Sciences, Engineering, and Medicine, identified 17 minerals as essential for beef cattle. Minerals are further classified into two categories based on how much is needed by the animal. Macrominerals are needed in a higher quantity (parts per hundred or percent) compared to microminerals or trace minerals (parts per million [ppm] or milligrams per kilogram [mg/kg]; Table 1).

Table 1. Essential minerals for beef cattle.

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

Mineral Function

Minerals have a variety of functions in the body, but in general, they help support all tissues and major metabolic processes required to maintain beef cattle performance. Minerals play essential roles in the immune system, connective tissue and muscle, digestion, metabolism of feed, and both male and female reproduction. Further details regarding the functions of specific minerals are shown in Table 2.

As with other nutrients, such as protein and energy, performance can decrease when mineral intake is low. However, certain processes are affected more quickly than others. For example, immunity is affected before growth or fertility. As mineral intake decreases, initial losses in performance are difficult to measure and can often go unnoticed. In cases of severe mineral deficiency, symptoms develop quickly, and decreases in immunity, fertility, and growth may be noticed throughout the herd in a relatively short period of time. Grass tetany, a disorder caused by hypomagnesemia (abnormally low magnesium concentration in the blood), is an example of how quickly a deficiency can lead to a noticeable impact.

Table 2. Functions of selected macro- and microminerals.

Mineral	Functions
Calcium	Skeletal and tooth formation, muscle function, and hormone secretion
Phosphorous	Skeletal and tooth formation, nutrient metabolism, component of DNA, and muscle growth
Magnesium	Required for growth, nutrient metabolism, and nerve and muscle function
Potassium	Nerve and muscle function, nutrient digestion and metabolism, embryonic development, and hormone secretion
Sulfur	Energy metabolism, component of certain amino acids, and rumen microbial protein synthesis
Copper	Formation of connective tissue, normal function of red blood cells, and nutrient metabolism
Zinc	Immune function, growth, reproduction, and hoof health
Manganese	Reproductive performance, growth, and immune function
Selenium	Immune function, reproduction, and growth

Cattle Mineral Requirements

The latest beef cattle mineral requirements are published by NASEM in the 2016 edition of Nutrient Requirements for Beef Cattle. Mineral requirements are based on peer-reviewed scientific literature and updated periodically. They are defined as the minimum concentrations of each mineral that must be consumed to prevent deficiencies. Current mineral requirements for selected classes of cattle are shown in Table 3.

Most mineral requirements are similar across classes of cattle. For example, a growing steer, mature bull, and lactating cow all have a zinc requirement of 30 ppm. Exceptions to this include calcium, phosphorus, and manganese, which have varying requirements across classes of cattle. Stressed cattle have increased mineral requirements compared to other classes, partly due to

Table 3. Mineral requirements of different classes of beef cattle and maximum tolerable concentrations[1].

Mineral	Growing/finishing cattle	Gestating cows	Early-lactation cows	Stressed cattle	Maximum tolerable concentration
Macrominerals, %					
Calcium	0.4–0.6	0.17–0.3	0.2–0.3	0.6–0.8	-
Magnesium	0.1	0.12	0.2		0.4
Phosphorous	0.2–0.3	0.14–0.2	0.16–0.2	0.4–0.5	-
Potassium	0.6	0.6	0.7	1.2–1.4	2
Sodium	0.06–0.08	0.06–0.08	0.1	0.2–0.3	
Sulfur	0.15	0.15	0.15		0.3–0.5
Microminerals, ppm					
Cobalt	0.15	0.15	0.15	0.1–0.2	25
Copper	10	10	10	10–15	40
Iodine	0.5	0.5	0.5	0.3–0.6	50
Iron	50	50	50	100–200	500
Manganese	20	40	40	40–70	1000
Selenium	0.1	0.1	0.1	0.1–0.2	5
Zinc	30	30	30	75–100	500

[1]Adapted from NASEM Nutrient Requirements of Beef Cattle, 8th revised edition, 2016.

Table 4. Average mineral concentrations of common feedstuffs, with deficient minerals shown in red[1].

Mineral	Calcium	Phospho-rous	Cobalt	Copper	Iron	Manganese	Selenium	Zinc
Common Feedstuffs								
Cool-season forage	0.56	0.44	0.60	10	275	75	0.19	36
Cool-season hay	0.58	0.23	0.45	9	156	72	0.06	31
DDGS[2]	0.22	0.83	0.34	8	178	27	0.39	65
Corn gluten feed	0.07	1.00	0.17	6	196	23	0.19	75
Cracked corn	0.04	0.30	3	3	54	11	0.07	27
Soyhulls	0.63	0.17	0.12	10	604	26	0.21	35

[1]Adapted from NASEM Nutrient Requirements for Beef Cattle, 8th revised edition, 2016 and Dairy One – Feed Composition Library.
[2]Dried distillers' grains with solubles (DDGS).

their lower feed intake and circulating corticosteroids, or stress hormones, which can impact mineral usage and recycling in the body. Thus, feeding a more concentrated mineral product during stressful periods can compensate for decreased intake from the feed. Elevated diet concentrations are not needed for long periods of time (five to seven days). Research indicates that once intake returns to pre-stress levels, no benefit is noted for higher diet concentrations.

Although research has shown some differences in mineral utilization across different breeds or breed types (for example, *Bos taurus* versus *Bos indicus*), these differences have not been shown to change the minimum requirement to prevent deficiencies. Thus, minerals currently are not formulated to be breed or breed-type specific.

The Mineral Content of Feedstuffs

All feedstuffs contain minerals; however, most feedstuffs are not balanced and are deficient in one or more essential minerals (Table 4). Mineral content can also vary significantly within a given feedstuff. Additionally, little is known about the potential availability of minerals contained in feedstuffs to the animal. Therefore, it is often recommended to feed beef cattle a complete mineral supplement that contains 100 percent of the animal's requirement of certain minerals to overcome any potential deficiencies in concentration or availability. Exceptions to this practice include minerals such as potassium or iron that are routinely supplied at two to three times the animal's requirement in forages.

Forms of Mineral Supplementation

Several options exist for supplying supplemental minerals to cattle, including blocks, tubs, free-choice loose supplements, injectable products, and complete feeds. While multiple forms of supplementation are available, it is crucial to recognize that not all forms are equal in terms of the concentration and source of minerals supplied.

Figure 1. Examples of two designs of covered free-choice mineral feeders.

Table 5. Number of days a 50-pound bag of mineral should last, based on herd size and formulated target intake.

Herd size	Targeted intake		
	2 oz	3 oz	4 oz
10	40	27	20
25	16	11	8
50	8	5	4
75	5	4	3
100	4	3	2
150	3	2	1
200	2	1	<1

Free-Choice or Loose Mineral Supplementation

Free-choice or loose mineral supplementation is a commonly used method to provide supplemental minerals to cattle on pastures. This method provides a complete mineral supplement that is available to cattle at all times, including both macro- and micro-minerals and necessary vitamins such as vitamins A and E. For more information on vitamins, see the UK Cooperative Extension Service publication *Vitamin Supplementation for Beef Cattle* (ASC-248). Free-choice minerals are usually granular products designed to be fed in covered mineral feeders (Figure 1). It is important to carefully read the mineral tag on a free-choice mineral product to understand the quantity and quality of minerals being provided in the product. For more information on how to read a mineral tag, refer to the UK Cooperative Extension Service publication *Reading the Fine Print: Understanding Mineral Tags* (ASC-249). Free-choice minerals are typically formulated for a target intake of three to four ounces per head per day and contain 15 to 25 percent salt. The salt is included to meet cattle's desire to consume salt and meet sodium requirements, but it also helps to limit intake of the mineral product.

Free-choice minerals should be offered in a covered feeder to protect the mineral from precipitation, as many mineral sources are in a salt form that may dissolve in water. These feeders should not be higher than 24 inches from the ground to allow calves adequate access to the mineral. It is a common misconception that calves do not require mineral supplementation; however, research shows that cow's milk is deficient in one or more minerals. There should be one mineral feeder for every 25 to 35 head. Mineral feeders should be placed in high-traffic areas where the herd is likely to visit routinely. A common suggestion is to locate mineral feeders near the water source or shade.

It is essential to monitor the intake of free-choice minerals. Table 5 shows how long a 50-pound bag of minerals should last, based on herd size and formulated target intake. It is important to note that mineral intake can vary based on several factors, including the weather, location, and number of mineral feeders. If mineral intake is lower than expected, consider adding a feeder, moving the feeder closer to a high-traffic area or closer to water, or trying a different product that may be more palatable. If mineral intake is too high, consider offering a salt block for 24 hours or adding five pounds of loose salt per 50 pounds of free-choice product for a short period of time. This can allow the herd to satisfy its craving for salt without overconsuming minerals, which can be expensive.

Salt-Based Blocks

Another common method of mineral supplementation is the use of salt-based blocks. However, this method does not provide adequate concentrations of required macro- and microminerals and does not provide vitamins. These products are typically 95 to 99 percent salt. Even when a block product contains trace minerals, the low daily intake combined with the mineral concentrations included in the block place cattle at risk of developing mineral deficiencies. For these reasons, it is not typically recommended to utilize salt-based blocks for mineral supplementation. Another common mistake is providing a salt block along with a free-choice mineral supplement. When a salt block is provided, cattle may meet their desire to consume salt from the block and fail to visit

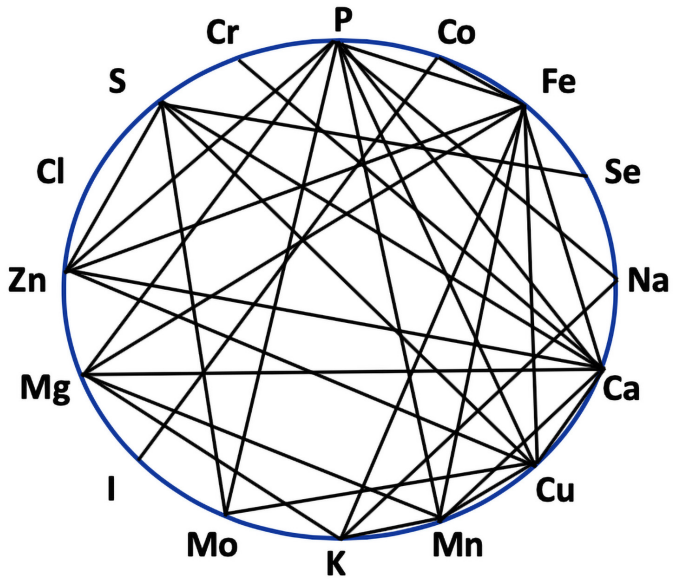

Figure 2. Common antagonisms between minerals, indicated by a solid line. These antagonisms can occur when animals are fed imbalanced diets or when high levels of certain minerals exist in the environment, including the soil and water.

or adequately consume minerals from a mineral feeder. This can also put cattle at risk of developing mineral deficiencies. An exception to this recommendation would be when providing salt to limit overconsumption of a free-choice mineral product, as mentioned previously.

Cafeteria-Style Mineral Supplementation

Although sometimes referred to as free-choice minerals, this style of mineral intake relies on placing individual minerals, or mixes containing two or three minerals, in their own containers or compartments within a feeder, versus putting a formulated mixed-mineral product into a single feeder. This style of mineral supplementation has been made popular through popular press articles and social media. No research has shown that this supplementation method is advantageous compared to feeding a formulated mix. This style of mineral supplementation is not recommended for several reasons. Cattle lack nutritional wisdom, which means they do not make nutritional decisions based on what is healthy for them or what their diet is lacking, but rather feed intake is driven solely by palatability. When cafeteria-style minerals are offered, those deemed more palatable will be the first to be consumed, and the herd will avoid consuming less palatable minerals that may be needed, such as magnesium oxide. Additionally, many minerals have complex interactions with one another, often referred to as antagonisms. When too much of one mineral is consumed, a deficiency of a second or third mineral can be induced, even if intake of that mineral is adequate. Figure 2 shows the complexity of these mineral antagonisms. A cafeteria-style program for providing minerals is not recommended due to the risk of developing mineral deficiencies because of poor mineral intake or mineral antagonisms.

Supplemental Feeds and Protein Blocks

Many supplemental feeds or protein blocks may also contain supplemental minerals mixed directly into the product. This can be a good source of mineral supplementation, but the feed tag should be read carefully to ensure that the product meets all mineral and vitamin requirements and no additional supplemental forms of minerals or vitamins are required to meet the animal's needs. As an example, some products may not contain salt and recommend providing free-choice salt.

Injectable Trace Minerals

Injectable forms of trace minerals are also available via a prescription from a licensed veterinarian. These products are not intended to be a complete mineral program but can provide a quick dose of select trace minerals, including copper, zinc, manganese, and selenium. These products can quickly elevate circulating levels, as they enter the blood within hours and the liver (the primary storage site for trace minerals in the body) within 48 hours. However, research regarding benefits to reproductive and immune function shows mixed results. These products might benefit high-risk calves that may have trace mineral deficiencies due to previous low mineral intake. It is important to note that injectable trace minerals are designed not to replace a conventional mineral supplementation program but to work alongside free-choice supplementation. As with any product, care should be taken to read the label instructions and dosage information carefully.

Supplemental Mineral Sources

Most minerals can be supplied from one or more sources. However, it is important to note that not all mineral sources are considered equal, due to differences in bioavailability. Bioavailability refers to the amount of the mineral that is consumed and absorbed from the gastrointestinal tract for use by the animal. Thus, a source with greater bioavailability can provide more of the desired mineral to the animal. This is especially important for trace minerals such as selenium. Selenium concentrations in animal feed are regulated by the FDA and are not to exceed three milligrams per head per day. Forages can be deficient in selenium, and selenium deficiency is common throughout the region. Since the concentration of selenium cannot be increased in mineral supplements, it is important to provide a selenium source with increased bioavailability to prevent selenium deficiency.

There are three main types of mineral sources: inorganic, organic, and hydroxy. Inorganic minerals are mined from the earth. These sources are available in the form of sulfates, oxides, and carbonates. They are termed inorganic because they lack a carbon-hydrogen structure. Organic or chelated minerals include a mineral that is bound to a carbon-containing molecule, typically an amino acid or sugar. Common organic or chelated sources include amino acid complexes, proteinates, and minerals bound to lysine, methionine, and glycinate. Hydroxy minerals, which include a mineral bound to a hydroxy group, encompass sources like zinc hydroxychloride or basic copper chloride. In general, organic, or chelated, and hydroxy sources have greater bioavailability than inorganic sources of minerals. For cattle in Kentucky, it is especially important to pay attention to sources of copper and selenium in supplemental mineral products, as these are the most common deficiencies observed in the region. Information about the sources

of supplemental minerals included in a product can be found in the ingredient section of the product mineral tag. For a more in-depth discussion of interpreting information from a mineral tag, refer to the UK Cooperative Extension Services publication *Reading the Fine Print: Understanding Mineral Tags* (ASC-249).

High-Magnesium (High-Mag) Mineral

High-magnesium (high-mag) mineral supplements contain a greater inclusion of magnesium than typical beef-cattle minerals. These products aid in the prevention of grass tetany. Grass tetany is typically observed in lactating cows during spring months when forages are rapidly growing or when lactating animals are grazing cereal grains such as wheat, rye, oats, or triticale. These forages are high in potassium and low in magnesium. When consumed, this excess potassium interacts with magnesium in the rumen, resulting in reduced magnesium absorption. Therefore, supplementing additional magnesium can help prevent grass tetany. It is generally recommended that high-mag minerals be fed to cattle susceptible to developing grass tetany, especially cows in early lactation, when environmental conditions for grass tetany exist. These conditions include grazing of ryegrass, small grains, and cool-season grasses in late winter to early spring, when pastures are lush and high in potassium. High-mag minerals should be fed to cattle at least 30 days before calving and continued through late spring, when grasses are more mature and daily temperatures reach at or above 60°F. High-mag mineral products should contain 10 to 15 percent magnesium from magnesium oxide for a free-choice mineral formulated with a target intake of four ounces. For more information on grass tetany, check the UK Cooperative Extension Service publication *Forage-Related Cattle Disorders: Hypomagnesemic Tetany or "Grass Tetany"* (ID-226).

Co-product Balancing Mineral

Beef-cattle requirements for calcium are twice that of phosphorus, based on the skeletal mass having a calcium to phosphorus (Ca to P) ratio of 2:1. Thus, the Ca to P ratio of beef-cattle diets should be close to 2:1. Common co-product and grain feedstuffs fed to cattle, including corn, distillers by-products, and corn gluten feed, are often low in calcium and high in phosphorus. When these ingredients are used in beef-cattle diets, often this results in a diet with a low Ca to P ratio (less than 1:1). When this occurs, cattle are at risk of developing urinary calculi or stones, which result in the condition known as water belly. Unfortunately, this condition is often fatal, but it can be prevented by ensuring an adequate Ca to P ratio in the diet. Additional calcium can be added to the diet either as feed-grade limestone or by selecting a co-product balancing mineral high in calcium (typically 20 percent or greater) and low in phosphorus (typically less than two percent). Aside from changes to the calcium and phosphorus content, these minerals are typically formulated to provide both macro- and microminerals and vitamins. However, most co-product balancing minerals are designed to be mixed directly into the feed, rather than being fed free choice through a mineral feeder.

Medicated Minerals

A mineral supplement can be a convenient method to deliver medication or other feed additives to cattle through the feed. For example, commonly available medicated minerals can contain chlortetracycline to control anaplasmosis, ionophores for the prevention of coccidiosis, or products for fly control. These products can be purchased through your local feed dealer, except for those that contain antibiotics such as chlortetracycline, which require a prescription from a licensed veterinarian. As with any supplement, the efficacy of medications delivered through minerals is largely dictated by mineral intake. It is important to pay attention to mineral intake to ensure adequate intake of the included medication.

Conclusion

Minerals are essential nutrients that are required in the diets of beef cattle and support many economically important traits, such as reproduction, growth, lactation, and health. Mineral supplements should be provided to cattle throughout the year. However, certain times of the year may warrant changing the formulation, such as delivering high-mag mineral in the spring to lactating cows or medicated minerals for control and treatment of anaplasmosis. The use of certain feedstuffs may also influence the mineral supplement needs of the herd. It is important to supplement with a complete mineral that provides macro- and microminerals and necessary vitamins to the herd. Take care to evaluate mineral products, as there can be variation across products in both concentration and mineral source. The most expensive product may not be the best product available. Once a mineral has been purchased, manage the mineral's delivery to ensure the products' efficacy and minimize risks of mineral deficiencies. Monitor intakes and compare them to the listed targeted intake on the product tag. For further guidance on selecting a suitable mineral for your herd, please contact your local county Extension office.

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