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Formulation Considerations for Mineral and Vitamin Supplements for Beef Cows

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Why Do Minerals and Vitamins Matter?

Minerals and vitamins are essential nutrients with many vital functions, and they are required in small amounts for optimal beef cattle performance. Outright clinical deficiencies rare in beef cow/calf systems; however, subclinical deficiencies that cause impaired performance are much more likely, including reduced calf growth and health or impaired reproductive performance. Therefore, a sound mineral and vitamin program is vital for the success of any cow/calf operation. Those mineral elements that may be deficient in forage-based diets are the macro minerals (calcium, phosphorus, sodium, and magnesium) and the trace minerals (copper, zinc, cobalt, manganese, iodine, and selenium). The other micronutrient that might be deficient in some cow/calf systems is vitamin A. The intent of this guide is to provide guidelines for cow/calf producers in Nebraska and surrounding states when developing a mineral and vitamin supplementation program.

Managing Free-Choice Mineral Intake

Free-choice mineral mixes are commonly used to provide essential minerals to grazing cattle. However, ensuring cattle get adequate mineral intake without over-consuming can be a challenge. Being on either side of the spectrum can be costly, whether in reduced performance because of a mineral deficiency or increased feed cost due to over-consumption. An extra 1 oz. per cow per day can cost $4 to 8 per cow per year. If a mineral mix is designed to meet the cows' needs at 2 or 4 oz. per day, intake above this adds unnecessary cost.

Cattle do not vary their mineral intake based on their mineral needs. Generally, salt is the driver of how much free-choice mineral a cow consumes. Salt is an inexpensive, cost-effective tool to help manage free-choice mineral intake. Other ingredients can be added to the mix, such as molasses or distillers' grains, to improve intake. This is often needed when feeding a high magnesium mineral mix due to the bitterness of magnesium oxide. In most cases, however, salt is a key tool to control intake. Mineral mixes with smaller target intakes usually have more salt compared to mixes with greater target intakes, e.g. 2 vs. 4 oz. intake targets. The salt content needed to reach target intakes will vary throughout the year and from herd to herd, but typically a 4 oz. mineral needs 15 to 25% salt and a 2 oz. needs 30 to 40% salt. As the salt content increases, cattle consume less of the mineral mix, because they reach their salt "fix" with less intake. If cattle are eating more than their targeted intake, adding salt can help reduce intake of the mineral mix and get cattle to consume the mineral closer to the desired intake target. It is recommended to mix the additional salt with the already formulated mineral mix instead of providing a separate salt source. This helps to prevent cows from only consuming salt.

When offering a free-choice mineral mix, it is important to consider the weatherization of the mineral, the number and location of mineral feeders, and the frequency of refilling feeders. If a mineral mix is supposed to withstand weather because the feeder does not protect the mineral from wind and rain, addition of salt can reduce effectiveness of the weatherization feature. An option instead of adding salt is to move the location of feeders; try placing them closer to water or loafing areas to increase intake and further away if needing to reduce mineral intake.

A good rule of thumb is 1 feeder per 30 cows. This helps to assure even timid cows can access the free-choice mineral. If the cows run out of mineral, one can put straight salt out for a day or two before offering more mineral mix. This helps ensure the cows have met their salt cravings, and will help to avoid over-consuming the mix when it is out again. Be sure to remove the straight salt when providing more mineral mix.

Where to Start When Developing or Choosing a Mineral Supplement?

Developing or selecting a free-choice mineral supplement can seem tricky, with so many options available with different mineral sources and other added features. *A good mineral program does not have to be expensive, nor is cost correlated with effectiveness*. It often pays to shop around when purchasing mineral. A significant amount of the cost can be in the packaging and handling. Table 1 shows the relationship between the amount of mineral provided when feeding a 2 or 4 oz intake of free-choice mineral with the various concentrations of minerals in the mix. Providing supplemental mineral will not automatically improve production (weaning weight, weaning rate, etc.). A benefit will only be observed if correcting a deficiency; thus, strategic supplementation based on the feed resources being used is the only way to develop a cost-effective mineral program.

Key Considerations When Formulating a Mineral Supplement

Mineral concentrations in forages vary considerably based upon soil mineral content, soil pH, and forage maturity. Testing your forage is a good first step in developing your mineral program. To get the most useful information from your forage test, minimize dirt contamination, sample the forages that are being selected for by the cattle at the time of sampling, and sample at multiple times of the year. Given the year-to-year variation in forage mineral, it is a good idea to do this over multiple years to get reasonable estimates of typical mineral content. Although this will require initial investments in labor and analysis, it can pay in the long run. This information can be used to find the best fit of commercial mixes available, or allow for development of a custom mix.

Custom mineral supplements can have several benefits, such as reduced cost via localized mixing and handling. The custom supplement can be specially formulated to meet the mineral needs of the herd; however, the supplement may be more prone to losses due to wind and rain than many commercial premixes with weatherization technologies incorporated. The cost vs. the benefits of these technologies depend on several factors, including (1) the amount of rainfall in the region; (2) the type of mineral feeders being used, and the extent of weather protection they provide; and (3) mineral feeding practices, with those providing a week or more worth of mineral at once, potentially having greater benefit than those that fill feeders more frequently.

It is important to note that not all minerals in forage will be absorbed by the animal. The amount of mineral available from forage, and thus supplemental needs, varies because of the interaction with other minerals present in the forage. These factors all influence the required concentrations of minerals in a free-choice mineral supplement. Several key points to consider are outlined in the following section:

The most common trace mineral deficiencies in beef cow systems are copper and zinc. Ensuring that cows have an adequate supply of these minerals is key to ensuring that their calves can mount an immune response when needed. It is especially important that cows have sufficient body stores in late gestation to supply the fetus with these minerals. In late gestation, the cow will prepare the calf to meet its future trace mineral needs by equipping the fetal liver with relatively high concentrations of these trace minerals. Milk is a poor source of trace minerals, and thus the calf will depend on these stores until it starts eating solid feed. Lack of proper mineral supplementation to the cow can have negative effects on the calf, leading to decreased growth and immunity. Once the calf starts eating solid feed, then the mineral supplement provided to the cows will also be a source of mineral for the calf as they will also consume the free-choice mineral.

Remember, mineral supplementation is not magic, and feeding more of a mineral will not necessarily improve performance; responses will only be observed if correcting a deficiency. Thus, the goal is to provide enough of each mineral to meet needs of cattle without feeding more than needed, thereby adding to cost without providing a benefit.

Copper (Cu): The Cu content of forages usually does

Table 1. General guidelines for concentration of mineral for free-choice supplementation of grazing cows[1]

			Amount on tag	
Mineral	Cow requirement	Will supply to total diet[2]	4 oz intake	2 oz intake
Copper, ppm[3]	10	10 to 15	1,300 to 2,500	2,600 to 5,000
Zinc, ppm	30	15 to 22	2,000 to 3,000	4,000 to 6,000
Manganese, ppm	40	0 to 40	0 to 5,200	0 to 10,400
Selenium, ppm	0.1	0.1 to 0.2	13 to 26	26 to 52
Iodine, ppm	0.5	0.5	65	130
Cobalt, ppm	0.15	0.15	20	39
Magnesium, %	0.12 to 0.20	0.03 to 0.10	3 to 13	6 to 26
Calcium, %	0.16 to 0.40	0 to 0.10	0 to 13	0 to 26
Phosphorus, %	0.13 to 0.23	0 to 0.10	0 to 13	0 to 26
Vitamin A, IU[4]/lb.	89,000 to 132,000	0 to 100,000	0 to 400,000	0 to 800,000

[1]See text for guidance based on feed resources and production system

[2]Assumes 1,300 lb. cow consuming 2.5% body weight (BW)

[3]ppm = parts per million

[4]IU = international units

not meet needs, and there are often other minerals that interfere with the absorption of Cu. Molybdenum and sulfur are two minerals that act as antagonists, tying up Cu and making it unavailable to the animal. This means that only looking at Cu content in the forage will not give you an accurate understanding of the amount of available Cu or how much supplemental Cu is needed. One must also look at the sulfur and molybdenum content as well. Given typical sulfur content of forage, the amount of copper needed is increased by 6 to 8 ppm for every additional ppm of molybdenum above 1 ppm. Although variable, vegetative pasture in northwest Nebraska, north-central Nebraska (including the Sandhills), and south-central Nebraska typically contain enough sulfur and molybdenum to make the majority (95%) of Cu in pasture unavailable for absorption. Thus, at a minimum, supplementation of the full requirement (1,300 ppm in a 4 oz. mineral) is often needed to meet needs. In eastern Nebraska, the molybdenum content of pastures appears to be less, resulting in 65 to 90% of the requirement needing to be supplemented (1,000–1,200 ppm in a 4 oz mineral). As mentioned previously, there can be significant variation in mineral content of forages by location and management; thus, testing can be beneficial to refine supplementation. One should also keep in mind that water can also be a source of sulfur, and if the water source is high in sulfate (600 ppm or greater) then additional supplemental Cu will be needed. Due to the higher sulfur content of distillers grains and corn-condensed distillers' solubles (often called syrup), extra Cu may also be needed when feeding diets containing significant amounts of these products. In high sulfur (0.3% S or greater in the diet) and molybdenum situations, a 4 oz. mineral may need to contain up to 2,500 ppm of Cu.

Looking at the concentration of a mineral on the tag of a free-choice mineral will not tell you all you need to know. Different mineral sources have different availability to the animal (bioavailability). In general, inorganic sources are the most cost-effective means of supplying minerals to a beef cow. Several inorganic forms of Cu are available on the market, including copper sulfate and copper oxide. Copper sulfate is preferred over copper oxide as it is considered 100% available to the animal, whereas copper oxide is only 15% bioavailable. Thus, you would need almost 7 times more Cu from copper oxide to have the same amount of Cu available to the animal. Copper chloride is an inorganic source that is bonded in a way that makes it less soluble in the rumen, and thus less likely to be impacted by antagonists. It has been shown to be more available (~20% more) to the animal when high amounts of molybdenum and sulfur are present in the diet, but appears to have similar availability to copper sulfate when moderate or low amounts of these antagonists are present. Organic sources of Cu, such as copper lysine or proteinate, may be beneficial when a rapid change in status is needed. In these situations, it may be useful to provide 50% of the supplemental mineral in question from an organic source. Another option in these situations is to use an injectable trace mineral to increase status before key production periods (pre-breeding and pre-calving). These sources are often greater cost, and thus the cost vs. benefit should be considered. In most cases, a properly designed mineral with inorganic sources can meet the needs of the herd.

Zinc (Zn): Of the grass (both hay and pasture) samples submitted to a commercial lab by producers in Nebraska, 80% had less than the required 30 ppm of Zn, with about 50% of the samples having between 15 and 25 ppm. It is estimated that only about 50% of this is actually available for absorption by the animal. When grazing green pasture, supplementing about 50% of the Zn requirement (which is the lower range in Table 1) will usually be sufficient. The Zn content of forages decreases with plant maturity; thus, when using low-quality forages such as straw, corn residue, or winter range, the upper range of Zn concentration (3,000 ppm for 4 oz. mineral) may be needed. Common inorganic sources of Zn in mineral supplements are zinc sulfate, zinc oxide, zinc carbonate. Organic sources of Zn include zinc methionine, zinc lysine, and zinc proteinate; again, organic sources are typically considered more bioavailable, but are usually higher cost.

Manganese (Mn): Manganese content in hay and pasture can typically provide 50 to 100% of the cow's requirement. Like Zn, greater amounts may need to be supplemented when feeding lower-quality forages. It is common to suggest feeding 50% of the requirement (2,600 ppm for 4 oz. mineral) in these situations. Additionally, it is important to consider dirt contamination when feeding ensiled feeds (silages), as this can increase the iron content of the feed. During the ensiling process, the iron in dirt is converted into an available form that can be absorbed by the cow and will compete with Mn for absorption. The best thing to do is to test silage for iron. Operations that use earthen bunkers or piles with a dirt floor are more likely to encounter this issue. If the iron is 200 ppm or above then feeding higher amounts of Mn is needed (50 to 100% of requirement depending on iron concentrations). Calves born to Mn-deficient cows can be small, and develop enlarged joints and/or have laxity in joints, which makes it hard for them to stand.

Selenium (Se): Selenium is generally quite variable in forages. In Nebraska, Se supplementation is recommended if the amount of Se in the forage is unknown. It is a good idea to have your forage tested to determine the amount of supplemental Se needed. Sufficient Se in a mineral mix can cover some of the roles of vitamin E, thus reducing the need for supplemental vitamin E. Supplements often include Se in the form of sodium selenite or Se yeast. Both of these are good sources, although the yeast is often considered twice as available as the selenite, meaning that it takes half as much Se from yeast as selenite to result in the same amount being absorbed. The margin of difference between Se adequacy and Se toxicity is exceptionally narrow. It is imperative to understand the amount of supplemental Se being provided. Most commercial supplements are formulated to provide more than the requirement. Thus, using multiple fortified supplements can cause an issue. Toxicity has occurred when using injectable minerals and multiple fortified supplements at the same time.

Iodine (I): Forages are generally deficient in I, and the mineral supplement should be formulated to meet the I requirement stated in Table 1. Iodine inclusion usually adds very little cost and, thus, is always recommended. The most common sources of I are calcium iodate or ethylenediamine dihydroiodide (EDDI); both forms are highly available to the animal. Many commercial mixes will have I included, but one must read the ingredients to be sure.

Cobalt (Co): Forages are likely to be deficient in Co, especially in sandy soils. The mineral supplement should be formulated to meet the Co requirement stated in Table 1. Typical forms of Co include cobalt sulfate and cobalt carbonate; both are relatively inexpensive to include in the mineral supplement.

Iron (Fe): Iron content of forages usually meets or exceeds the requirement of cattle; thus, supplementation is unnecessary. When in excess, Fe interferes with Zn, Cu, and Mn absorption. Two common situations that can cause high available Fe in the diet are high Fe water or soil contamination of silage. Testing water and silage samples for Fe content can be useful to determine if additional supplemental Cu, Zn, and Mn are needed to overcome high available Fe. Due to its negative effects upon the absorption of other essential minerals, it is suggested that Fe not be added to a mineral supplement for beef cattle. Many multi-species commercial mixes will include ferrous sulfate or carbonate; while Fe supplementation essential for swine, this can have negative effects on Zn, Cu, and Mn absorption in cattle. Thus, these multi-species mixes are not recommended for beef cattle. Ferric oxide is also sometimes used as a coloring agent, but is not available to the animal and does not interfere with absorption of other minerals as much as the other Fe sources mentioned above.

Magnesium (Mg): A secondary Mg deficiency known as grass tetany becomes a concern during periods of grazing lush, cool-season grasses as they contain a high concentration of nitrogen and potassium that interact with Mg by impairing absorption in the rumen. When tested, these cool season forages appear to have adequate Mg concentrations; however, the interaction of potassium and nitrogen with Mg leads to less Mg being absorbed. This is a particular concern with lactating cows, as they have a higher requirement due to milk production. The Mg requirement for the pregnant cow is 0.12% of the diet on a dry matter basis and jumps to 0.20% with lactation. The Mg in

colostrum is 3 times what is in milk during the rest of the lactation. Thus, Mg demand is greatest around calving.

Thus, in the early spring when cattle are grazing lush, young, cool-season grasses (such as bromegrass, bluegrass, or small cereals) or in the fall when they are moving back from the range and grazing lush meadow regrowth, it is suggested to supplement 12 to 15% Mg in a 4 oz. mineral. Mineral supplements with greater Mg concentrations (*magnesium oxide or magnesium sulfate*) should be offered several weeks prior to grazing to allow cattle to adjust to the new mineral, and let producers gauge mineral intake and adjust the mineral if needed. The most common Mg source is magnesium oxide, which can be very bitter. Many commercial high-Mg mineral mixes will add ingredients to increase palatability, such as corn by-products or molasses. If using a custom mineral mix, consider adding 1 lb of dried distillers grains or corn per 50 lbs of mineral mix to help increase intake. Sodium deficiency can increase the risk of Mg deficiency, so if using a mineral-fortified supplement that is provided daily, such as a cake (and not a free-choice mineral), make sure that free-choice salt is provided. If using a free-choice mineral mix, do not provide salt separately as this will reduce the likelihood that the cows consume the mix.

Lactating cows fed a diet of distillers grains (20% or more of diet DM) and low-quality forage can also be prone to low blood Mg. The higher levels of potassium, nitrogen and sulfur in the distillers grains can negatively impact absorption of Mg from the rumen. Again, the solution to this problem is feed more Mg. When feeding these types of diets to lactating cows, having at least 10% Mg in a 4 oz mineral mix is recommended.

Calcium (Ca): Calcium requirements are often met with forages. However, it is imperative to maintain a Ca-to-phosphorus ratio in the diet of at least 1:1. Forages have more Ca than P, so ensuring that the mineral mix itself has a 1:1 ratio is typically sufficient. However, additional supplementation may be needed when feeding grain or a grain by-product in the diet. When feeding cows in confinement, a minimum of 12% Ca in a 4 oz. mineral is needed if feeding 20% distillers grains, and 26% Ca when feeding 50% distillers grains. Mineral supplements typically include Ca as calcium carbonate, limestone, or dicalcium phosphate.

Phosphorus (P): Phosphorus is the most expensive mineral to supplement. The concentration and digestibility of P in forages declines with increased maturity and weathering. When feeding mature forages (low-quality grass hay or dormant range) to dry cows, P supplementation may be needed. Grain and grain by-products, such as distillers' grains, are a good source of P, and should be accounted for in the animal's mineral intake; this may reduce or eliminate the need to add supplemental P in your mineral mix, even when using low-quality forages. If the base forage (dormant range or mature hay) contains 0.10% P, then 2 lbs of dry distillers' grains or 6 lbs of alfalfa hay should supply enough P to meet the needs of a dry cow. Early growth of forages has greater P concentrations, and supplementation may not be needed even during early lactation when needs are greatest.

Vitamin A: The most common symptom of vitamin A deficiency in a cowherd is increased young calf illness and diarrhea. Fresh green forages are an excellent source of vitamin A, and supplemental vitamin A is not needed when cattle are grazing these forages. Brown grass, stored forages, and concentrates are typically low in vitamin A, and insufficient to meet the animal's needs; thus, supplementation may be needed when offering these feeds. Cattle grazing on green grass can meet their vitamin A needs and store the excess vitamin A present in their liver to be used when the diet is not sufficient. Thus, the amount of supplemental vitamin A needed when not grazing fresh green forage depends on time spent grazing green forages. Typically for cows grazing green pasture for four-plus months of the year, it is recommended that when they are being fed stored forage or grazing brown forages they be supplemented with 42,000 IU/day for a dry cow or if lactating, 59,000 IU/d, which would be 168,000 IU/lb or 234,000 IU/lb in a 4 oz mineral. Particular attention should be given to cows that do not get access to fresh green forage for a significant amount of the year. Those fed in confinement long term and those fed in confinement in the summer and then turned out onto corn residue will not have significant vitamin A stores to pull from, and additional supplementation will be needed. In these cases, it would be suggested to supplement at least 100,000 IU/d or 400,000 IU/lb in a 4 oz. mineral.

Summary

The supplemental mineral and vitamin needs for cow herds will differ based on feed resources used and location.

- The most common trace mineral deficiencies in beef cow systems are copper and zinc. Supplementation of these minerals is needed. Increased amounts of both will be needed when feeding low quality forages. Copper needs will vary based on molybdenum and sulfur intake.
- Supplemental manganese may be needed if silage is fed; especially if the silage is contaminated with soil.

- Supplemental magnesium is needed for lactating cows: when grazing lush cool season grass, when high-quality alfalfa is a main part of the diet, and when low quality forage and distillers grains are the primary feeds in the diet.
- If feeding high amounts of corn co-products (such as distillers grains) then additional calcium may be needed.
- Phosphorus is the most expensive mineral to supplement. Producers should consider the contribution of the forage and any concentrates (grains/co-products) fed to determine how much, if any, supplemental phosphorus is needed.
- The less time cows spend grazing green forage, the greater their supplemental vitamin A needs.

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