PNW 670

Mineral Supplementation of Beef Cattle in the Pacific Northwest

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Introduction

Mineral supplementation programs are a point of confusion for many ranchers. Sales representatives, university researchers, and cattle buyers bark at ranchers about how important it is to keep their cattle on a mineral program. Ranchers, however, are often at a loss as to how to assess mineral deficiencies, which mineral packages they need to purchase, whether they should have a custom mineral mix prepared, how much to feed, what type to feed, and whether it is even profitable to supplement minerals.

With the flood of information that ranchers receive on the topic, often from sources that are trying to sell a product, it is easy to understand the confusion. This bulletin takes a basic, common-sense approach to assessing mineral needs for beef cattle and beginning the thought process to determine where producers should invest money on mineral programs and where they could save a few dollars without diminishing performance.

Mineral requirements for cattle vary with life stage, phase of production, stress factors, and more. The mineral status of soils and forages can vary greatly over a geographic region as well. Therefore, this bulletin does not address specific mineral requirements, but rather serves as an overview to help producers better understand the importance of mineral supplementation as it relates to optimizing production. Producers should consult with their Extension professional or nutritionist to assess what dietary minerals they need to provide to their cattle given their specific situation.

Bear in mind that it is often hard to measure the effectiveness of a mineral program in terms of dollars made, because the mineral program is only one part of a bigger picture. We do know that when cattle become deficient in minerals, sickness increases and performance declines. Most mineral programs cost $25 to $35 per cow annually (based on 2014 prices) and can be viewed as a relatively inexpensive insurance policy to help protect against disease and financial losses due to poor performance.

Mineral Overview

The minerals in supplements fall into two categories: macro and micro. Macro minerals are the minerals needed in larger quantities in the diet. They are typically represented as a percentage of the diet in a feed or mineral analysis. Macro minerals are not stored well in the body and therefore require a more constant supply. They are typically more available in the cattle's diet than micro minerals, and pass through the milk to nursing calves.

Micro minerals are those needed in trace amounts and generally are in shorter supply within the base diet. Only small amounts of micro minerals pass through milk to nursing calves, making calves reliant on the stores they have in their liver at birth until they begin to ingest forage and supplements as they grow. Calf liver stores at birth largely depend on liver concentrations in the dam. Trace minerals are usually represented in a feed analysis with a ppm (parts per million) unit denotation (table 1). Because micro minerals can be stored in the liver, constant intake is not essential.

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Table 1. Example partial guaranteed feed analysis. This shows the type of nutrition information found on a mineral supplement. Macro minerals are expressed as a percentage of diet, while micro minerals are expressed in parts per million (ppm).

Mineral	Value	Unit
Macro minerals		
Calcium	not less than 12.0	%
Calcium	not more than 14.0	%
Phosphorus	not less than 6.0	%
Salt	not less than 4.75	%
Salt	not more than 5.75	%
Potassium	not less than 1.0	%
Magnesium	not less than 2.8	%
Micro minerals		
Cobalt	not less than 35	ppm
Copper	not less than 3,500	ppm
Iodine	not less than 370	ppm
Manganese	not less than 5,800	ppm
Selenium	not less than 53.0	ppm
Zinc	not less than 7,000	ppm

Determining deficiency

Cattle producers should be aware of two types of mineral deficiency. The first is a clinical deficiency, where a diagnosis can be made by a visual appraisal of an animal showing clear signs related to a specific mineral deficiency. The second and most common is a subclinical deficiency. At this stage of deficiency, signs and symptoms are not well defined or visible/obvious. The animal may not be performing to peak potential but appears to be in good health, making the producer think all is well. For this reason, cattle with subclinical deficiencies often remain untreated.

Deficiencies can be determined through analysis of blood, urine, feces, and liver biopsies, depending on the mineral. While it would be ideal to periodically perform blood tests and liver biopsies of a representative portion of a herd to ensure proper mineral levels, many producers do not have the facilities, time, or resources to perform such tests. Soil analyses can be helpful in determining the diet's mineral status, as minerals in the soil may be (but are not always) indicative of mineral levels in the forage it produces.

The most common way to assess mineral deficiencies at the ranch level is through feed analysis, which offers producers a reasonably priced way to assess what nutrients their animals are ingesting and thus get a reasonable estimate of possible mineral deficiencies and/or interactions. Keep in mind that every haystack and pasture can have different mineral levels. Season and life stage of the forage also affect mineral content, so ideally producers would do a forage analysis for each field, pasture, and season on a ranch. While we don't live in an ideal world, producers should take what measures they can to reasonably assess their mineral situation and move forward from there. A reasonable effort is better than no effort.

Antagonists

Some minerals are referred to as antagonists. These minerals bind other minerals, making them unavailable to the body. If an antagonist is binding an essential mineral, it can create a deficiency for the cow. When antagonists are present, producers must feed more of the bound mineral to compensate for the antagonistic interaction, as it is generally unrealistic and impractical to remove the antagonist from the diet.

Water sources are often the origin of antagonists, particularly iron and sulfates. Water quality tests can be critical in determining the level of antagonism present in a diet. Soils and forages can also harbor antagonists, so forage quality should be analyzed as well. Examples and strategies for compensating for antagonists will be discussed later in this bulletin.

Mineral interactions

When developing mineral supplementation programs for cattle, it is not always possible to identify one mineral that is deficient and supplement for that mineral alone. Minerals interact with each other, such as the antagonist interactions just described. They can also have synergistic reactions that complement each other or have indirect interactions.

Figure 1 illustrates the comprehensive approach needed to analyze or develop a mineral supplementation program. Even a cursory look at this interaction wheel reveals that mineral nutrition is a complex subject.

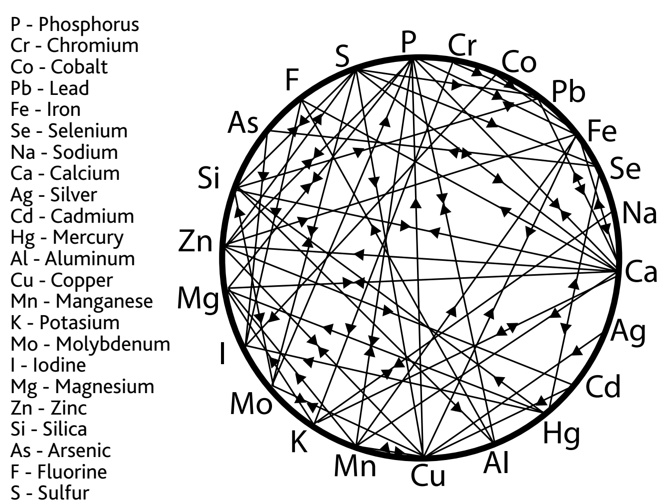

Figure 1. Mineral interactions. Lines on the "wheel" indicate an interaction between minerals. Adapted from Underwood, E. J. 1971.

Macro Minerals and Symptoms of Deficiency or Toxicity

Calcium

Calcium is a macro mineral needed in the diet for bone structure, milk production, and a host of other biological functions. Calcium is prevalent in good-quality forage and a deficiency is generally not a major concern in beef cattle herds. Most mineral packages have adequate calcium to ensure that deficiency is not a problem. Toxicity is rarely a concern because cattle can excrete excess calcium.

Calcium reacts with phosphorus and the two minerals are best utilized when they are present in a Ca:P ratio between 1:1 and 3:1. Urinary calculi can lead to "water belly" in cattle when the Ca:P ratio falls below 1:5; however, this is more prevalent in concentrate diets typically used in a feedlot setting. While Ca:P ratios of up to 7:1 have occurred for short periods of time with no ill effects, allowing a ratio greater than 7:1 for an extended period can bind up phosphorus and make it unavailable to the animal.

Phosphorus

Phosphorus deficiencies are common and generally result in less-than-desired performance in the areas of reproduction, milk production, and growth of calves. Not surprisingly, two signs that producers observe when phosphorus is deficient are decreased appetite and loss of cycling activity in breeding females. Phosphorus is rarely present in levels that could be toxic, and phosphorus requirements rise with an increase in production demands. As noted above, the calcium-to-phosphorus ratio should stay between 1:1 and 3:1.

Magnesium

Magnesium is a macro mineral for which deficiency is most notably associated with the disease grass tetany. Signs of tetany include staggering, drooling, and belligerent behavior. Affected cattle often appear to be healthy one day and are dead the next. A cow can die in as little as 48 hours from the onset of tetany. Grass tetany typically remains in a subclinical status for most of that time. The visual signs of tetany occur only 4 to 8 hours prior to death, making it hard to detect until the final stages. When tetany deaths are found, it is common to see signs that the cow struggled to get up. Note in figure 2 how the ground around the cow has been kicked clean of forage, leaving only bare dirt. This results from the cow struggling in the final stages of tetany.

Unlike most other minerals that are absorbed through the small intestine and stored in the liver, magnesium is not stored well in the body because it is absorbed

Figure 2. Bare dirt kicked clean of forage is a sign of struggle in the final stage of tetany, a deadly condition caused by magnesium deficiency. Photo courtesy of B. Regas.

from the rumen and large intestine directly into the bloodstream. Mature cattle are at higher risk of tetany because they cannot mobilize magnesium from their bones to overcome a short-term deficiency like immature cattle can; lactating cattle have a large magnesium loss in milk as well. The cause of grass tetany is not necessarily a magnesium deficiency in the diet, but at the metabolic level. High potassium and nitrogen levels in the diet can bind magnesium, making it unavailable to the animal. While not normally a driver of tetany, calcium plays in the tetany equation as well, and an imbalance between calcium, nitrogen, or potassium can result in tetany.

Tetany instances are most prevalent in the spring, but can occur at any time. For example, tetany can strike shortly after an overcast and cooler weather pattern rapidly changes to sunny and hot conditions. The stress of the rapid weather change forces forage to pull excess potassium out of the soil. This excess potassium can in turn bind the magnesium in the diet and incite a tetany situation. Cattle have been lost to tetany in the mid- to late-summer grazing period where this weather pattern has occurred. Cattle fed cereal grain hay such as barley or oat hay can exhibit tetany even during winter. If the hay was cut in the heat of summer shortly after irrigation was turned off, it may store high levels of potassium and thus incite a tetany situation. At these critical times of the year, producers need to ensure that cattle have access to a mineral supplement with adequate amounts of magnesium to overcome the binding effect of high potassium.

If you've had a feed analysis performed, you can use a mathematical equation to determine whether your cattle are at risk for tetany. The tetany risk ratio is:

$$\frac{\%K \times 255.74}{(\%Ca \times 499) + (\%Mg \times 822.64)}$$

If the result of this equation is 2.23 or higher, then there is a tetany risk that must be mitigated by increasing the amount of magnesium and calcium in the diet. Here is an example of how to use the tetany risk ratio:

- From the abbreviated forage analysis shown in table 2, we can determine the percentage on a dry-weight basis of the magnesium (Mg), potassium (K), and calcium (Ca) in the forage.
- Insert the amount of K, Ca, and Mg from the feed analysis into the equation:

$$\frac{1.41 \times 255.74}{(1.05 \times 499) + (0.22 \times 822.64)}$$

$$= \frac{360.5934}{523.95 + 180.981}$$

$$= \frac{360.5934}{704.931}$$

The result is 0.5115. This feed would not be expected to place cattle at risk for tetany. This assumes that the forage source was sampled correctly and provides an accurate estimate of the overall mineral concentration.

Table 2. Abbreviated example forage analysis results. Producers can use data from a feed analysis to calculate the amount of each nutrient in the diet.

Component	As sent (%)	Dry weight (%)
Crude Protein	7.63	15.8
ADF	13.6	28.2
TDN	31.1	64.5
Sulfur (S)	0.11	0.23
Phosphorus (P)	0.17	0.35
Potassium (K)	0.68	1.41
Magnesium (Mg)	0.11	0.22
Calcium (Ca)	0.51	1.05

Potassium

There is generally more concern of potassium being too prevalent in the diet at certain times of the year (as discussed previously) than being deficient. Most base diets and commercially available mineral pre-mixes have adequate levels of potassium. For this reason, potassium is of little concern in most mineral supplementation programs.

Sodium

Sodium is rarely deficient in cattle diets because it is the only known mineral for which cattle have nutritional wisdom. Recent research indicates that cattle seek out palatable supplements for taste rather than for regulating nutritional needs—with the exception of the mineral sodium. Cattle have the wisdom to know they need sodium and will actively seek it out. Sodium is best supplemented as salt. This makes sodium an excellent tool to increase intake of other minerals as part of a mineral mix when they may be deficient or, at greater sodium concentrations, to decrease mineral intake to avoid overconsumption. Cattle consume more salt (sodium) when it is fed in loose form instead of a compressed block. By providing a loose mineral mixed with loose white salt, producers can experiment to find the right mixture of salt and mineral to obtain the desired level of consumption.

Producers should note the amount of salt already in their trace mineral package and factor that into the total supplement package they provide. While sodium toxicity can occur in areas with a high salt concentration in the forage, soil, or water, the risk of "salt poisoning" is generally low if water availability is good. Cattle have been known to consume in excess of 3 pounds of salt daily with no ill effects, provided adequate water is available.

Sulfur

Sulfur is generally present in adequate amounts in most diets and is not typically a concern for deficiency. However, a nitrogen:sulfur ratio of at least 10:1 is recommended to maximize ruminal fermentation and bacterial growth, especially with forage-based diets. Nevertheless, sulfur can be present in overabundance and cause toxicity or antagonism. Sulfur acts as an antagonist to copper and selenium, particularly when molybdenum is also present, thus making copper and selenium less available to the cow.

Sulfur toxicity is usually caused by excess sulfates (a sulfur compound) in the diet, often from the water, and can cause polioencephalomalacia in cattle. Cattle that suffer from sulfur toxicity are often called "stargazers" or "brainers" because they appear disoriented, wander in circles, and literally appear to be daydreaming or looking upward with no apparent awareness of their surroundings (figure 3).

Figure 3. Cattle suffering from sulfur toxicity may gaze upward and appear to be daydreaming; hence, such cattle are often called "stargazers." Photo courtesy of Dr. Trey Patterson.

Micro Minerals and Symptoms of Deficiency or Toxicity

Iron

Iron is an essential mineral needed to prevent anemia. Iron is generally abundant in cattle diets, but has an antagonistic relationship with some trace minerals, particularly copper. Telltale signs of excess iron in an area include red soils, red rock, and red residue left from water. This does not preclude areas that do not have red soil, rock, etc. from being high in iron. Surface water is generally less likely than well water to contain excess iron.

Selenium

Selenium is a trace mineral that can be highly toxic if present in overabundance. It is therefore highly regulated by the U.S. Food and Drug Administration. While some areas have high selenium content, most areas throughout the Pacific Northwest tend to be selenium neutral to deficient. Clinical signs of selenium deficiency include retained placentas after calving, weak calves, and white muscle disease. Selenium works in tandem with vitamin E and both are critical for reducing the risk of retained placenta and white muscle disease.

If white muscle disease is found in calves, it often shows up 2 to 3 weeks after calving. Calves will appear to be completely healthy, yet unable to stand on their own. While a diagnosis should come from a veterinarian, a layman's method of determining whether a calf has white muscle disease is to pick the calf up and see if its legs go out straight and stiff, like a carpenter's sawhorse. Note in figure 4 the calf's resemblance to a sawhorse, with straight, stiff legs pointing at angles from the body instead of straight down. The calf appears unsteady on its feet. If caught early, the condition is generally easily treated, though not necessarily cured, with an injection of bovine selenium (common trade names include BoSe® or MuSe®).

Figure 4. A calf shows stiff legs and a wide stance indicative of white muscle disease, caused by selenium deficiency. Photo courtesy of Billy Whitehurst.

Iodine

Iodine is not a major concern for toxicity, but can be lacking in the diet if producers supplement non-iodized salt. Iodine deficiencies can result in goiter, decreased reproduction, and foot rot. Iodine supplementation is recommended on a year-round basis as a precautionary measure. It is inexpensive and mixes easily in salt or a mineral package. Most commercial pre-mixed mineral packages include available sources of iodine.

Cobalt

Cobalt is one of the trace minerals that is often disregarded. However, recent research has indicated that it is needed for proper immunological response. Cobalt is an element used to form vitamin B12, which in turn is needed to form propionic acid, one of the critical volatile fatty acids produced in the rumen and used by the cow for energy. Cobalt deficiency or toxicity is rare and most commercially available or custom mineral packages include trace amounts of cobalt to ensure the minimum requirement is satisfied.

Molybdenum

Molybdenum is rarely deficient, but more often is in too great of a supply. Molybdenum is one of the most notorious antagonists to copper, especially when in the presence of sulfates, and is known to be present in very high levels in some areas of Idaho. Molybdenum and sulfates together will tie up copper in the rumen so that it cannot be absorbed. Molybdenum can tie up copper even once it has entered the bloodstream, making it necessary to greatly increase the amount of copper in the diet.

Some molybdenum will naturally be in the diet, so producers need to ensure that copper is available in great enough amounts to overcome the molybdenum. Generally for every ppm of molybdenum, there should be 6 to 8 ppm of copper, depending also on iron and sulfates in the diet. Figure 5 illustrates how much faster a cow's copper stores can be depleted in the presence of molybdenum (and sulfur). In this experiment, cattle were supplemented to bring their liver copper to approximately 85 ppm. They were then deprived of copper for 98 days. Some of the cattle were fed excess molybdenum and sulfur, while the rest ate a diet free of the antagonists. After 98 days, the excess molybdenum and sulfur lowered copper stores in the liver by twice that of a diet free of antagonists.

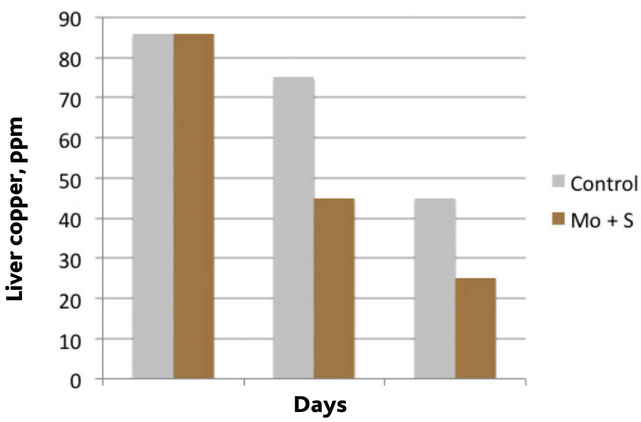

Figure 5. Effect of copper antagonists. Researchers tested the level of copper depletion in cattle in the presence of molybdenum and sulfur over 98 days. Adapted from Arthington et al. 1996.

Copper

Copper is a critical element needed for many biological functions ranging from metabolism of iron, which prevents the animal becoming anemic, to assisting with immune functions and reproduction. Cattle in the Pacific Northwest are often copper deficient, especially in the presence of antagonists such as molybdenum, sulfates, and iron, as previously discussed. Often, cattle are subclinically deficient in copper, leaving producers unaware of the problem.

Clinical signs of copper deficiency are often accompanied by a "rusty" appearance on black-hided cattle or an obvious lack of shedding of the winter coat (figure 6). Red-hided cattle that are copper deficient will often shed hair that looks more yellow than red. Note that the steer in figure 3 that was exhibiting sulfur toxicity also shows clinical signs of copper deficiency. It should be noted that hair discoloration or lack of shedding is not a guarantee that cattle are copper deficient, but rather raises suspicion of the possibility. Some "blonding" may occur during the summer months, especially in red cattle, that should not be construed as a sign of copper deficiency. Other signs of copper deficiency include diarrhea and scouring of calves and cows, especially during the late summer and early fall.

Figure 6. A rusty-colored hide on black cattle and failure to shed the winter coat can be signs of copper deficiency. Photo courtesy of Billy Whitehurst.

Copper is one of the most difficult minerals to maintain at an adequate level because of the low concentration of copper in most diets and the frequent presence of high levels of antagonists. It should be noted that breed can affect copper requirements, as well. Clinical trials have indicated that Simmental and Charolais cattle need more copper than Angus cattle because those breeds metabolize the mineral differently.

Zinc

Zinc is a vital element for immune response, growth, and reproduction. Clinical signs of zinc deficiency include reduced feed intake, thin/unthrifty cattle, and increased prevalence of skin lesions (figure 7). Stressed cattle that are zinc deficient typically demonstrate higher levels of sickness, lower response to treatment, and longer recovery times than cattle with adequate levels of zinc in their system.

Zinc has an interdependent relationship with copper in that increasing the supplementation of both minerals together will result in a greater increase in zinc levels than will supplementing for zinc alone (figure 8). Note in figure 8 that two forms of the zinc-and-copper combination were supplemented—a chelated (or organic) compound and a sulfate (or inorganic) compound. The difference between chelated and sulfate minerals will be discussed later in this bulletin. Regardless of the mineral form, increasing supplementation of both copper and zinc resulted in higher levels of zinc than supplementing one mineral alone. While zinc tends to work in tandem with copper, there are cases where extreme levels of zinc can tie up copper. However, this scenario is generally of little concern for cattle in the Pacific Northwest.

Figure 7. Signs of zinc deficiency can include thinness and an unusual number of skin lesions. Photo courtesy of Billy Whitehurst.

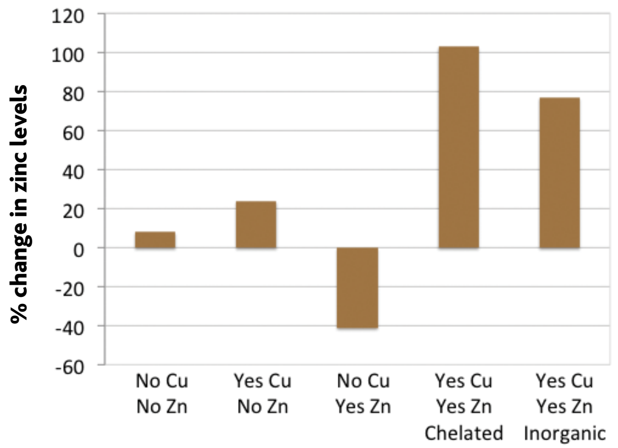

Figure 8. Copper-zinc interdependency. Effect on zinc levels in cattle when copper was supplemented along with the zinc. Both chelated (or organic) and sulfate (inorganic) mineral combinations were tested. Adapted from Wellington et al. 1998.

Manganese

Manganese deficiencies are generally difficult to diagnose without clinical tests. Manganese is critical for proper gonad (testes and ovaries) function and development. Manganese deficiencies generally result in reduced fertility, but because there are no true clinical signs of a deficiency, they usually go unremedied. Most mineral packages contain enough manganese to maintain needed levels.

Organic vs. Inorganic Minerals

Organic minerals are called by several different names, including complexed minerals and, more commonly, chelated minerals. Chelated minerals are affixed to an amino acid, usually either lysine or methionine. Inorganic minerals are affixed to a sulfate, chloride, or oxide compound. The inorganic compound is the standard industry form of most minerals. Inorganic minerals are more widely used mainly because they are less expensive and in most cases provide adequate nutrition to cattle.

Many assertions have been made that chelated minerals are more advantageous to cattle, but research supporting these assertions is inconsistent when making broad comparisons. When more specific circumstances are considered, the majority of research indicates that chelates have greater bio-availability, especially when antagonists such as molybdenum, sulfates, and iron are present or when animals are under stress. The most common minerals to feed in a chelated form are copper, zinc, manganese, and cobalt.

Table 3 illustrates a compilation of research to compare the bio-availability of the most common types of mineral packages currently available to producers. For the purpose of comparing this data, the sulfate form of copper, zinc, and manganese was considered to be the benchmark for bio-availability. The table is not meant to imply that the sulfate form of the mineral is 100 percent available to the animal, but rather uses 100 percent merely to set the comparison benchmark. As the comparison shows, the chelated forms of minerals are generally more bio-available.

Table 3. Comparison of bio-availability of mineral packages. Data are based on a compilation of research on mineral bio-availability. The availability of the sulfate form is set at 100 percent to serve as the benchmark for comparison purposes. Adapted from Greene 2000.

Mineral	Sulfate form	Oxide form	Carbonate	Chloride form	Chelated form (complexed, organic, etc.)
Copper	100	0	-	105	130
Manganese	100	58	28	-	176
Zinc	100	-	60	40	159-206

Common reasons to use chelated minerals

In some cases, using chelates can offer some benefits. Here are some examples for the most commonly used chelates.

Copper, zinc, and manganese:

- Chelated copper, zinc, and manganese can boost short-term growth and immune response when cattle are under stress from weaning and feedlot receiving, disease challenges, hauling, artificial insemination (AI), nutritional stress (lack of feed or poor feed), and so on. Chelated minerals may also be used to "prime" the immune system prior to these known times of stress as a preventive measure to help cattle cope with the stress. Long-term studies comparing the two forms of minerals show similar results, but the chelated minerals have shown more rapid short-term recoveries from mineral deficiencies. If a deficiency exists, producers may benefit from supplementing with chelated minerals for a specified period of time, then re-evaluating the mineral program once recovery is complete (Spears 1989 and Chirase et al. 1994).
- Producers may also find that chelated minerals are beneficial when dietary antagonists such as molybdenum, iron, and sulfates are present, because chelated minerals are more likely to pass through the rumen and get absorbed from the small intestine rather than getting bound up in the rumen and rendered unavailable.
- Research has shown that chelated minerals can help achieve greater pregnancy rates to AI breeding, especially among cattle that may have endured

some nutritional stress before the breeding season (Stanton et al. 2000, Ahola et al. 2004, and Whitehurst et al. 2014).

- Research has also shown that chelated minerals increase liver stores more rapidly. Producers should consider chelated minerals if they know that their cattle will face a mineral shortage in the future or if minerals have not been provided for an extended period (Spears 1989, Eckert et al. 1999, and Rabiansky et al. 1999).

Cobalt:

- Chelated cobalt, when compared to other forms of cobalt, has been shown to boost immune response when cattle are exposed to a disease challenge or vaccinations (Sager 2013).
- Commercially available chelated cobalt has been shown to help maintain body condition. As discussed previously, cobalt is required to synthesize vitamin B12, as well as propionic acid. Of the volatile fatty acids produced in the rumen and used by the cow for energy, propionic acid results in the greatest energy content. The idea and industry claim is that chelated cobalt, when properly used, will have the equivalent energy value of adding a pound of corn to the daily diet. Some research exists to support this industry assertion, but results are inconsistent (Anderson et al. 2008). As with any mineral, assess your particular situation before you commit to a mineral package.

Cost considerations

Mineral packages with chelates cost more per ton than typical inorganic mineral packages. For this reason, each producer must analyze the benefits and cost for his or her particular situation. Some may be able to meet their herd's mineral needs simply by feeding a larger amount of the less expensive inorganic minerals. On the other hand, it may be more financially beneficial to feed a chelated mineral at a lower level.

The cost/benefit outlook for mineral supplementation changes throughout the year. Many cost-minded producers incorporate chelated minerals at certain times in their production cycle while relying on the inorganics at other times.

Life stage considerations

The vast majority of research in chelated minerals (copper, zinc, manganese) has focused on two areas: growth and feedlot performance, and reproduction. Cattle in feedlots generally have not reached full maturity and are still expending energy on growth. Experiments evaluating reproduction have been performed with cattle over a wide range of ages. The cattle that seem to benefit the most from chelated minerals have been less than 4 years of age (those still growing). Replacement heifers have demonstrated improved pregnancy rates to AI when supplemented with chelated copper, zinc, and manganese. Responses in the form of improved body condition have been shown across multiple age classes in the research conducted with chelated cobalt (Arthington and Swenson 2004, Stanton et al. 2000, Ahola et al. 2004, Whitehurst et al. 2014, and Anderson et al. 2008).

Injectable trace minerals

Injectable minerals, like chelated mineral supplements, have been shown to be highly available to cattle and have resulted in benefits similar to chelated minerals in regard to immune response, response to vaccines, etc. Given the high bio-availability of injectable minerals, they can be a great addition/supplement to a producer's mineral program. They do, however, provide only a short-term response and should not be the sole source of mineral supplementation provided to a herd. It is neither feasible nor practical to think that producers can "inject" their way to a balanced mineral program. When administering injectable minerals, producers should carefully follow labels and Beef Quality Assurance guidelines to reduce the incidence of shot lesions and damage to the end product (beef).

Supplementation Frequency, Final Advice

There is no foolproof method for supplementing minerals, but producers should always follow label recommendations. Feedlots have the luxury of mixing the mineral package with the feed and distributing it daily as part of the ration. Cattle operations in a range setting do not have that luxury and may not be able to distribute mineral supplements more than once every week or two. Fortunately, with the exception of magnesium, cattle can store most minerals in their liver for several weeks. For this reason, it is possible to place a week's ration out on the range with little fear of something going awry if the cattle go without a supplement for a day or two.

If you know your cattle will go without mineral supplements for a time, you may need to feed them higher levels of minerals (and perhaps incorporate chelates, as well) to build up their liver stores in preparation for the upcoming nutritional stress. Take the time to work with a nutritionist to determine the best practice for your operation.

Lastly, consider these final recommendations before buying and using any supplement:

- Take measures to assess your herd's mineral status (e.g., diet nutrient analysis, pregnancy rate, calving distribution, calf health, and blood and liver tissue analysis).

- Test your feeds to determine the mineral content and relate this to the expected intake and the animals' requirements.
- Work with your local Extension office, nutritionist, or industry feed representative to develop a mineral program that is right for your herd and your management plan. No two operations are the same. What works for you may not work for your neighbor.
- Always follow the label guidelines for mineral supplements and monitor consumption.
- Don't risk the financial consequences of an inadequate mineral program.

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