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Formulating Mineral Supplements for Beef Cows

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INTRODUCTION

Mineral nutrition of beef cattle is one component of ruminant nutrition that most producers address by simply purchasing a commercial supplement for their herd. However, this practice, while generally effective, can be wasteful.

In many cases, commercial mineral supplements are formulated to provide in excess of 100% of the nutrient requirements for many different minerals. However, at least a portion of the minerals required by beef cows are provided by the feeds the cows are consuming. The formulation of supplements to supply only what the animal needs may provide an opportunity for cost savings.

This paper will describe the process of developing specifications that can be presented to a feed manufacturer to develop a mineral supplement.

DETERMINING REQUIREMENTS

The first step in the process of formulating a mineral supplement for beef cows is to determine what the requirements are. Tables 1 and 2 (pg. 4) have been adapted directly from the Nutrient Requirements of Beef Cattle (NRC, 2000). With these tables, it is possible to determine the *total diet* mineral requirements. It is important to recognize that these requirements are expressed either as a percentage or in mg/kg (ppm) for the total diet.

It is very unlikely that a given set of cows will be exactly the same size and in the same stage of production either with each other or with those listed in the tables. Estimating what the requirement might be, based on the two closest values in the table, will suffice.

Minerals contributed by each of the feed ingredients and supplements will help meet the requirements. Water will contribute some minerals; however, the mineral concentration of water is highly variable and the availability of the minerals has not been well established. Therefore, it is wise to assume that water will not be meaningful contributor of minerals to the diet. However, it is quite possible that high levels of iron or sulfur in water will antagonize copper (iron and sulfur) or selenium (sulfur), thereby increasing the requirements for those two minerals. These antagonisms are complex and difficult to define and will not be discussed in this paper.

If faced with high-sulfate water or the use of feeds containing high concentrations of sulfur (e.g., distillers grains), it is important to work with a nutritionist to best estimate the amount of supplemental copper and/or selenium necessary.

DETERMINING MINERAL SUPPLY

Once the requirements have been identified, the next step in formulating a mineral supplement is calculating how much of each mineral is being provided by each dietary ingredient. To do this, each ingredient needs to be sampled and analyzed for mineral content.

Proper sampling is critical to obtaining an accurate representation of each ingredient. It is important to recognize that the mineral content of harvested forages or grains can vary from year to year, and thus should be sampled and analyzed with each growing season. Outsourced feeds can also vary substantially; ideally, each new delivery should be sampled and analyzed.

Samples of concentrate feeds should be collected from multiple locations in each delivery, then combined prior to analysis. Harvested forages should be sampled using a hay probe; multiple bales that are representative of the crop from a given location should be sampled. Forages from more than one location should be sampled separately to allow for differences in growing conditions.

Determining the mineral content of grazed forages is more difficult. Forage samples can be clipped; however, care should be taken to clip the forages both that the cattle are selecting and from different locations within each pasture. These different clippings can be combined prior to analysis, but they should be combined in relative amounts. Such a combination will represent what the cattle are likely consuming, and this will prevent the inadvertent skewing of results.

An analysis should include each of the minerals listed in Tables 1 and 2 (pg. 4), plus molybdenum and sulfur. These minerals are antagonists to the copper (molybdenum and sulfur) and selenium (sulfur) that can commonly occur in high concentrations in feeds, forages, and water. The use of book values and/or guaranteed analyses reported on feed tags is not recommended. These values are averages calculated based upon samples collected from numerous sources and are generally not accurate enough to allow for supplement formulation.

Once the results of the analyses have been reported, it is possible to *estimate* total mineral intake. This is not an exact science, due to the variation in the dry matter intake of cattle. For beef cows, dry matter intake will vary relative to pregnancy and lactation. Cows that are in mid-gestation (non-lactating, but more than 60 days prior to calving) will generally consume approximately 2% of their body weight *as dry matter*.

For example, a 1300-lb. cow will consume approximately 26 lb. of dry matter. During the last 60 days of gestation, dry matter intake (DMI) will likely increase slightly, to approximately 2.1% of body weight. During the first 90 days after calving, DMI will be approximately 2.5% of body weight; however, this can vary significantly by weight and milk production. Heavier cows will generally consume less as a percentage of body weight, regardless of milk production. Heavy milking cows will generally consume more, regardless of body weight. Therefore, 2.5% is a reasonable estimation. From 90 days after calving to weaning, DMI will decrease as the lactation progresses. It is reasonable to assume that cows will consume 2.2% of body weight during this time.

Once dry-matter intake has been estimated, the next step is to calculate the diet composition on a percentage basis. For example, if a group of 1300-lb., non-lactating, mid-gestation cows are receiving 3 lb. of DDGS (90% dry matter) while grazing winter range, the diet composition is calculated as follows:

1) 1300 lb x .02 (2% as a decimal) = 26 lb total DMI
2) 3 lb DDGS x .90 (90% as a decimal) = 2.7 lb DMI from DDGS
3) 26 lb total DMI – 2.7 lb DMI from DDGS = 23.3 lb DMI from dormant winter range
4) 2.7 / 26 = 0.104 (DDGS is 10.4% of the diet DM)
5) 23.3 / 26 = 0.896 (dormant winter range is 89.6% of the diet DM)

These percentages can then be used to calculate the amount of each mineral provided from each of the feeds. To do this, simply multiply the percent (as a decimal) of the diet DM by the % (not as a decimal) or mg/kg (ppm) of each of mineral contained in the feed. Next, the amounts of a given mineral from each of the feeds can be added together to find out the concentration of that mineral in the total diet.

Below are example calculations using the percentages from the calculations above and assuming that 1) the DDGS has 0.70% phosphorus and 6 mg/kg copper and 2) the dormant winter range has 0.15% P and 3 mg/kg copper:

Phosphorus
DDGS: 0.104 x 0.70 = 0.073
Range: 0.896 x 0.15 = 0.134
Total: 0.207 (the total diet contains 0.207% phosphorus)

Copper
DDGS: 0.104 x 6 = 0.62
Range: 0.896 x 3 = 2.69
Total: 3.31 (the total diet contains 3.31 mg/kg copper)

FORMULATING A SUPPLEMENT

Once the amount of each mineral required and supplied has been determined, it is possible to formulate a supplement. First, simply subtract the amount of each mineral supplied from the amount required. Using the 1300-lb. cow and the feeds described above, the following example will illustrate the calculations for phosphorus and copper.

Phosphorus
Requirement: 0.12
Supplied: 0.207
Difference: -0.087 (no supplementation is needed)

Copper
Requirement: 10
Supplied: 3.31
Difference: 6.69 (the supplement needs to provide 6.69 mg/kg copper to the total diet)

To correct a deficiency in a mineral measured in mg/kg (copper in this example), the total amount of that mineral needed needs to be calculated. This is done by first converting the DMI from pounds to kilograms. For this conversion, simply divide the pounds by 2.2. Once the DMI in kilograms has been determined, multiply the mg/kg of the mineral by the DMI in kilograms:

Copper
1) Convert from lb to kg: 26 lb ÷ 2.2 = 11.8 kg
2) 11.8 kg x 6.69 mg/kg = 78.9 mg
3) The supplement needs to provide 78.9 mg copper

Once the amount of the mineral needed has been determined, the next step is to decide how much supplement will be provided per day. This is a relatively arbitrary decision. Most mineral supplements are formulated based on 2–4 oz. per head per day intake. Therefore, making a formulation based on 3 oz. per head/per day is reasonable. To determine the necessary concentration of the mineral in the supplement, first convert ounces to kilograms. This is done by multiplying the ounces by 0.0284. Once the kilograms of supplement provided per day has been determined, the concentration of the mineral needed in the supplement is calculated by dividing the number of milligrams needed by the number of kilograms supplied per day:

Copper
1) Convert from oz to kg: 3 oz x .0284 = 0.0852 kg
2) 78.9 mg ÷ 0.0852 kg = 926 mg/kg
3) The supplement needs to contain 926 mg/kg copper

In the example, supplemental phosphorus was not necessary. However, when a mineral measured in percentage (calcium, magnesium, phosphorus, potassium, or sodium) is deficient, the amount needed in the supplement can be calculated by first multiplying the percentage of the mineral needed (as a decimal; 0.1% = 0.001) by the DMI in pounds. The result is the pounds of the mineral needed per day. This number can be multiplied by 16 to get the ounces of mineral needed per day. The ounces of mineral per day is then divided by the ounces of supplement provided to the animal (3 oz. in this example) and multiplied by 100 to get the percentage of the mineral needed in the supplement. For example, assume the diet for the cow described above was 0.1% deficient in calcium. The calculations would be as follows:

Calcium
1) Calculate lb of calcium needed: 0.001 (0.1% deficient) x 26 = .026 lb of calcium needed
2) Convert from lb to oz: 0.026 lb x 16 oz/lb = 0.416 oz of calcium needed
3) 0.416 oz of calcium needed ÷ 3 oz of supplement provided x 100 = 13.9%
4) The supplement needs to contain 13.9% calcium to correct the deficiency.

Once the mg/kg or percentage of each mineral needed in the supplement to correct any deficiencies has been determined, it is possible to put together a spec sheet for the complete mineral. This will be used by a feed manufacturer to determine how much of each mineral ingredient must be included in a batch of supplement.

Because of variations in animal requirements, genetic differences, nutrient concentrations of feed ingredients, sampling error, antagonists, and supplement intake, the development of supplement formulations to precisely correct deficiencies is extremely difficult. Nonetheless, it is possible to formulate supplements to complement the diet of the "average" animal in a given group.

To help account for some of the aforementioned variation, many nutritionists advocate formulating to provide 110–125% of the animal's requirements in the total diet. However, caution should be exercised when formulating supplements that will provide more than the required amount of minerals: oversupplementing a given mineral may lead to toxicities or create antagonisms with other minerals.

WHITE SALT

Because cattle know they need sodium and self-regulate their intake of it, supplements are generally not formulated to meet sodium requirements. Most mineral supplements will contain 10–30% white salt. This is acceptable, but cattle should have free access to additional white salt. White salt can be blended with the mineral supplement in various ratios to insure that the mineral supplement is being consumed at an appropriate rate.

MINERAL SOURCES

Because different manufacturers utilize different sources of mineral, this paper will not discuss how to determine the amount of a given ingredient (e.g., copper sulfate) needs to be included in a batch of feed. However, Table 3 (pg. 5) is a list of suggested sources that producers can request to be used in their supplement.

There has been a great deal of media coverage and interest regarding organic mineral sources (e.g., chelates). The research investigating the use of organic mineral sources has produced inconsistent results. However, organic mineral sources *may* have a place in some production systems.

In situations where antagonists are present in high concentrations (high sulfur, molybdenum, and iron are potent copper antagonists), organic minerals may overcome the negative interactions. However, it may also be possible to supplement at concentrations 2–3 times the requirement with inorganic mineral sources and accomplish the same result with less cost. This will vary on a case-by-case basis.

Organic mineral sources *may* also be beneficial during times of high stress (i.e., calving and weaning time) on the cow or calf. However, it is *highly* unlikely that any production response will result from the supplementation of organic or inorganic mineral sources when a non-stressed animal is in an adequate state.

CONCLUSION

Balancing mineral supplements to correct the deficiencies of specific cattle under specific conditions can potentially offer an operation substantial cost savings. However, formulating mineral supplements is more art than science. Nonetheless, with the accurate estimation of animal requirements and the determination of the mineral supplied from the diet, it is possible to formulate a mineral supplement to augment the diet of a specific group of animals under specific conditions.

REFERENCES

NRC. 2000. *Nutrient Requirements of Beef Cattle.* 7th revised ed. Nat. Acad. Press, Washington, DC.

Table 1. Total diet calcium and phosphorus requirements of beef cows relative to calving

	Months since calving											
	1	2	3	4	5	6	7	8	9	10	11	12
1000-lb cow												
Ca, %	0.30	0.32	0.30	0.27	0.24	0.22	0.15	0.15	0.15	0.24	0.24	0.24
P, %	0.20	0.21	0.19	0.18	0.17	0.15	0.11	0.11	0.11	0.15	0.15	0.15
1200-lb cow												
Ca, %	0.29	0.31	0.29	0.26	0.24	0.22	0.15	0.15	0.15	0.26	0.25	0.25
P, %	0.19	0.21	0.19	0.18	0.17	0.15	0.12	0.12	0.12	0.16	0.16	0.16
1400-lb cow												
Ca, %	0.28	0.30	0.28	0.26	0.24	0.22	0.16	0.16	0.16	0.27	0.26	0.26
P, %	0.19	0.20	0.19	0.18	0.17	0.16	0.12	0.12	0.12	0.17	0.17	0.16

Table 2. Total diet mineral requirements of beef cows

Mineral	Unit	Gestating cows	Early lactation cows
Magnesium	%	0.12	0.20
Potassium	%	0.60	0.70
Cobalt	mg/kg[a]	0.10	0.10
Copper	mg/kg	10	10
Iodine	mg/kg	0.50	0.50
Iron	mg/kg	50	50
Manganese	mg/kg	40	40
Selenium	mg/kg	0.10	0.10
Zinc	mg/kg	30	30

[a]Same as parts per million (ppm).

Table 3. Recommended mineral sources for beef cattle

Mineral	Inorganic	Organic
Calcium	Calcium carbonate Limestone	---
Cobalt	Cobalt carbonate Cobalt sulfate	Cobalt glucoheptonate
Copper	Copper sulfate Tri-basic copper chloride	Copper amino-acid complex Copper polysaccharide Copper proteinate
Iodine	Potassium iodate	EDDI
Iron	Ferrous sulfate heptahydrate	Iron amino-acid complex Iron polysaccharide
Magnesium	Magnesium sulfate Magnesium oxide	Magnesium polysaccharide
Manganese	Manganese sulfate	Manganese amino-acid complex Manganese methionine Manganese polysaccharide Manganese proteinate
Phosphorus	Dicalcium phosphate Monocalcium phosphate	---
Potassium	Potassium chloride Potassium bicarbonate	---
Selenium	Sodium selenite	Selenomethionine High-selenium yeast
Zinc	Zinc sulfate Zinc oxide	Zinc amino-acid complex Zinc methionine Zinc polysaccharide Zinc proteinate

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