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Mineral Mystery

SDSU professor explains the mystery of minerals and their effect on reproduction.

Story by
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Table 1: Nutrient requirements of beef cows (1,000-lb. mature weight)[a]

	Months since calving											
	1	2	3	4	5	6	7	8	9	10	11	12
10-lb. peak milk production:												
Ca, %	0.24	0.24	0.23	0.22	0.20	0.19	0.15	0.15	0.15	0.24	0.24	0.24
P, %	0.17	0.17	0.16	0.15	0.14	0.14	0.11	0.11	0.11	0.15	0.15	0.15
20-lb. peak milk production:												
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
30-lb. peak milk production:												
Ca, %	0.35	0.38	0.35	0.32	0.28	0.25	0.15	0.15	0.15	0.24	0.24	0.24
P, %	0.22	0.24	0.22	0.21	0.19	0.17	0.11	0.11	0.11	0.15	0.15	0.15

[a]Adapted from *Nutrient Requirements of Beef Cattle* (National Research Council, 2000).

Table 2: Nutrient requirements of beef cows (1,200-lb. mature weight)[a]

	Months since calving											
	1	2	3	4	5	6	7	8	9	10	11	12
10-lb. peak milk production:												
Ca, %	0.24	0.25	0.23	0.21	0.20	0.19	0.15	0.15	0.15	0.26	0.25	0.25
P, %	0.17	0.17	0.16	0.15	0.14	0.14	0.12	0.12	0.12	0.16	0.16	0.16
20-lb. peak milk production:												
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
30-lb. peak milk production:												
Ca, %	0.34	0.36	0.34	0.31	0.27	0.25	0.15	0.15	0.15	0.26	0.25	0.25
P, %	0.22	0.23	0.22	0.20	0.18	0.17	0.12	0.12	0.12	0.16	0.16	0.16

[a]Adapted from *Nutrient Requirements of Beef Cattle* (National Research Council, 2000).

Table 3: Nutrient requirements of beef cows (1,400-lb. mature weight)[a]

	Months since calving											
	1	2	3	4	5	6	7	8	9	10	11	12
10-lb. peak milk production:												
Ca, %	0.23	0.25	0.23	0.21	0.20	0.19	0.16	0.16	0.16	0.27	0.26	0.26
P, %	0.17	0.17	0.16	0.15	0.15	0.14	0.12	0.12	0.12	0.17	0.17	0.17
20-lb. peak milk production:												
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	0.17
30-lb. peak milk production:												
Ca, %	0.33	0.35	0.32	0.30	0.27	0.24	0.16	0.16	0.16	0.27	0.26	0.26
P, %	0.22	0.23	0.21	0.20	0.18	0.17	0.12	0.12	0.12	0.17	0.17	0.17

[a]Adapted from *Nutrient Requirements of Beef Cattle* (National Research Council, 2000).

"Minerals are essential for the proper function of numerous physiological processes. From a production perspective, proper mineral nutrition is critical for metabolic function, health and reproduction. Unfortunately, mineral nutrition is one of the most complicated and least understood components of nutrition," Cody Wright, a South Dakota State University animal science professor, explained to nearly 350 participants of the Applied Reproductive Strategies in Beef Cattle (ARSBC) symposium in Sioux Falls, S.D., Dec. 3-4, 2012.

Wright explained that the biggest challenge of feeding minerals is their concentration and availability in feed. For instance, mineral availability in grazed forages can vary simply by soil type. When he was with extension, he said some of the most-asked questions from producers were about mineral availability in feeds or supplements. Most often, they found that the formulation of minerals was fine, but the cow didn't intake enough of it, eating, for example, 1 ounce (oz.) instead of the formulated 3 oz.

Required macro-minerals for reproduction include calcium, phosphorus (the two largest requirements), magnesium, potassium, sulfur, chlorine and sodium. Trace, or micro-, minerals include cobalt, iodine, manganese, zinc, copper, iron and selenium.

Trace minerals are needed in parts per million (ppm), but can drastically affect animal performance and function. To put parts per million into perspective, Wright noted that 1 ppm is the equivalent of 1 inch within 15.8 miles. However, these small components definitely make a large impact in an animal, he added.

Calcium (Ca)

Calcium is most well-known for being a component of bones,

To calculate mineral needs, Cody Wright advised producers to first figure out the animals' requirements and then determine mineral content of primary sources such as forage, feeds, supplements and water.

as 99% of the body's calcium is found in the skeleton, but it also plays a large part in reproduction. Wright said calcium is closely tied to sperm motility and ability to enter the egg. The physiological changes in the reproduction cycle change the requirements of calcium. It is important to have enough calcium during the breeding season especially.

In most circumstances, he said, very little supplemental calcium is necessary for cattle grazing early in the growing season. As forages mature, though, supplemental calcium may be needed. However, the ratio of calcium to phosphorus should be maintained between 1½:1 and 7:1 to avoid an imbalance.

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Table 4: Requirements and maximum tolerable concentrations of minerals in beef cow diets

Mineral	Unit	Gestation[a]	Early lactation[a]	Maximum tolerable concentration[b]
Calcium	%	Refer to Tables 1-3, page 46		1.5
Chromium	ppm (mg/kg)	---	---	100[c]
Cobalt	ppm (mg/kg)	0.10	0.10	25
Copper	ppm (mg/kg)	10	10	40
Iodine	ppm (mg/kg)	0.50	0.50	50
Iron	ppm (mg/kg)	50	50	500
Magnesium	%	0.12	0.20	0.6
Manganese	ppm (mg/kg)	40	40	2,000[d]
Molybdenum	ppm (mg/kg)	---	---	5-10[e]
Phosphorus	%	Refer to Tables 1-3, page 46		0.7
Potassium	%	0.60	0.70	2
Selenium	ppm (mg/kg)	0.10	0.10	5
Sodium	%	0.06-0.08	0.10	---[f]
Sulfur	%	0.15	0.15	0.3 or 0.5[g]
Zinc	ppm (mg/kg)	30	30	500

[a]Adapted from *Nutrient Requirements of Beef Cattle* (National Research Council, 2000).

[b]Adapted from *Mineral Tolerance of Animals* (National Research Council, 2005).

[c]When chromic oxide (Cr_2O_3) is fed, the maximum tolerable concentration is 3,000 ppm.

[d]If fed adequate concentrations of dietary iron.

[e]For copper-adequate cattle.

[f]Ruminants can consume 0.016 oz. salt (NaCl) per 1 lb. body weight.

[g]To prevent polioencephalomalacia (PEM), the maximum tolerable sulfur concentration is 0.3% for cattle consuming at 85% or more of their diet as concentrate and 0.5% for cattle consuming at least 40% forage in their diet. Dietary sulfur concentrations below the maximum tolerable concentrations may have adverse effects on copper absorption.

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Phosphorus (P)

Phosphorus is the second-most-abundant mineral in the body, with 80% in the bones and teeth.

"It is also an essential component of DNA and RNA, phospholipids, and has a key role in a host of metabolic processes. Given the importance of phosphorus to so many physiological processes, it is not surprising that it can impact reproduction," he said.

Many studies have resulted in conflicting data on the effect of phosphorus in reproduction. One study showed higher pregnancy rates with supplemented phosphorus; another showed no change in pregnancy rates but increased weaning weights of supplemented dams' calves. Another study showed no response to phosphorus supplementation during normal years, but did see response in drought years. Clearly, he observed, there is still much research to be done.

Distillers' grains are a good source of phosphorus, so he recommended working with an extension agent to evaluate whether using distillers' grain could significantly reduce supplementation costs.

Copper (Cu)

Copper is tied to enzyme systems. A copper deficiency can result in delayed or depressed estrus, he explained.

The biggest problem with copper is the negative effects of interactions with sulfur and molybdenum (Mo). The combination of sulfur and molybdenum in the rumen forms thiomolybdates, which then form insoluble complexes with copper, thereby reducing its absorption.

Because of this, Wright shared that recent thoughts in the scientific community actually blame copper deficiency problems on molybdenum. Molybdenum binds copper molecules and makes them unusable and even pulls stored copper from the body.

"Given the relatively high concentrations of molybdenum in feeds and forages and the amount of high-sulfate water and feeds, i.e. distillers' coproducts, copper deficiency is arguably the most common mineral concern in the Upper Great Plains," Wright clarified.

He did say that copper supplementation can solve the problem.

Iodine (I)

Iodine plays a vital part in thyroid hormones. Iodine deficiency impairs thyroid function and can result in goiter and suppressed estrus. Iodine deficiency can also lead to infertility, sterility and poor conception rates in females, and decreased libido and semen quality in males.

Wright explained that cover crops like turnips and radishes have become popular feed for ruminants, but these cover crops can also contain compounds called goitrogens, which interfere with thyroid hormone production. He recommended making sure that iodine is in the diet to counteract these goitrogens, which can be solved with iodized salt.

Manganese (Mn)

Manganese is among the least well-researched trace minerals. It is linked to the function of the corpus luteum and the synthesis of cholesterol and sex hormones. He said that a deficiency in manganese can result in reduced or irregular estrus, reduced conception rates, and abortions and stillbirths. Manganese deprivation has also been shown to restrict testicular growth in rams.

Not much research has been done on supplemental requirements, but he said supplementing to meet the 40-ppm requirement is generally the best management practice.

Selenium (Se)

Selenium is a component of several enzyme systems and serves as an antioxidant. Selenium deficiency can cause reduced immune function, reduced semen viability, retained placenta, cystic ovaries, endometritis, and white muscle disease.

This mineral can be challenging in that certain areas have an abundance of selenium to the point of toxicity, but other areas are deficient.

"Selenium supplementation should be based on the amount of selenium in the basal dietary ingredients. In some areas, supplementation will result in beneficial responses; in others it may be the straw that breaks the camel's back relative to toxicity. Given the narrow window between the requirement and toxicity, feed analysis and careful formulation is as essential for selenium nutrition as for any other mineral," he warned.

Zinc (Zn)

Zinc is the most pervasive of the trace minerals; it is an integral component of more than 300 enzymes and is associated with many biological processes. Gene expression is an important process in which zinc is required, so zinc should not be underestimated, Wright noted.

Deficiencies can reduce growth, fertility and disease resistance. More specifically in males, reduced testicular development, semen quality and libido are side effects of zinc deficiencies. He added that zinc supplementation has been shown to increase ejaculate volume, sperm concentration, percent live sperm and percent motility in bulls. While zinc supplementation is important, especially for a bull battery, he warned against wasting money by supplementing beyond the requirements.

Inorganic vs. organic

The source of each mineral can have a dramatic impact on supplement effectiveness. In general, he said, inorganic sources are the most cost-effective means of supplying minerals to beef cattle. However, not all inorganic sources are created equal. Research suggests that sulfate and chloride forms of various minerals are the most bioavailable, followed by carbonates and oxides as the least. Copper oxide is the exception, though. He reported that copper oxide needles, administered as a bolus, are effective in delivering copper to cattle on forage-based diets.

Organic mineral sources are another option. He said positive responses to organic supplementation are most likely during stressful periods in the production cycle or when mineral antagonists (sulfur, molybdenum, iron or aluminum) are present in large amounts. Organic sources are more costly, and thus should be warranted by increased animal performance.

Supplementation

To begin supplementing minerals, Wright recommended figuring out the animals' requirements (which differ by production stage) and determining mineral content in primary sources such as forage, feeds, supplements and even water. Wright advised producers not to rely on book values for feedstuffs as there is too much variability across a region to rely on them.

"It's a really worthwhile investment to do some testing to understand what those animals' [unmet] requirements really are," he asserted.

Knowing which supplements are needed most and which are available is integral, because too many minerals can produce toxicity and some minerals can interact adversely (such as copper and molybdenum), he warned. To avoid these issues, he recommended consulting professionals to help with mineral supplementation and analysis.

"Developing the most cost-effective mineral program is certainly not a formula that can be applied to every farm and ranch around the country. Producers should carefully evaluate their production system, its resources, level of production and production constraints to develop the most cost-effective program for their operation. Keep in mind that more expensive mineral supplements do not always correlate with increased production or performance," he concluded.

Wright spoke during Tuesday's session focused on herd fertility and nutrition. Visit *www.appliedreprostrategies.com/2012/SiouxFalls/newsroom.html* to listen to his presentation and view the accompanying PowerPoint and proceedings paper.