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Avoiding Mineral Toxicity in Cattle

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Minerals are a key component in maintaining health and productivity of cattle. This area of cattle nutrition, however, is often overlooked when determining nutrient needs. Because mineral deficiencies are more likely to occur than toxicities rations are often formulated to easily exceed minimum animal requirements. In these cases it is important to determine if dietary mineral concentrations are beyond maximum tolerable concentrations for cattle. Mineral toxicities resulting from an over-supply in feed or water may have observable effects such as a decrease in animal performance or a change in animal behavior. Toxicities may also have hidden or indirect effects, such as accumulation in meat or milk, or environmental effects due to increased mineral levels in urine and feces. Additionally, an over-supply of minerals in cattle rations is an unnecessary and easily avoidable expense to cattle producers.

Animals may be exposed to toxic levels of minerals from a variety of sources. High concentrations of a mineral in feedstuffs can result from high soil mineral levels due to soil type, use of animal manure, municipal or industrial waste, or industrial pollution. Mineral supplements that are incorrectly formulated or not correctly matched to cattle needs may also result in an over-supply of minerals. Toxic minerals may also be present in batteries, paint, and contaminated soil. Additionally, surface water and possibly deep-well or domestic water supplies may contain excessive levels of certain minerals.

At least 17 minerals are required by beef cattle. These minerals are generally divided into macrominerals and microminerals. Macrominerals required include calcium, magnesium, phosphorus, potassium, sodium, chlorine, and sulfur. The microminerals required are chromium, cobalt, copper, iodine, iron, manganese, molybdenum, nickel, selenium, and zinc. Other minerals, such as aluminum, arsenic, boron, bromine, cadmium, fluorine, lead, mercury, and strontium, are not required in cattle diets, but may be toxic if present at high concentrations.

In 2005, the National Research Council established guidelines for the maximum tolerable levels of several minerals. In this report, sodium chloride (salt) and eight individual minerals were identified as being of frequent concern for toxicity in cattle: cadmium, copper, fluorine, lead, mercury, molybdenum, selenium, and sulfur. In addition, calcium, phosphorus, and potassium, three of the most common minerals in beef cattle diets, were identified as being of occasional concern for toxicity. The recommended level and maximum tolerable level of each of these minerals is listed in Table 1.

Minerals without requirement values are not required by cattle or requirements have not been established. Values derived from National Research Council Nutrient Requirements of Beef Cattle (1996) and Mineral Tolerances of Animals (2005).

An important consideration when balancing rations is the relationship between minerals. For example, calcium and phosphorus are balanced on a calcium to phosphorus ratio. Calcium should always be included in diets at a greater concentration than phosphorus, and ratios of up to 6-to-1 are generally tolerated by cattle. If ratios fall below 1-to-1, animal performance may be affected even if phosphorus is below the maximum tolerable concentration listed in Table 1. This ratio is difficult to maintain without calcium supplementation in most corn-based rations due to the high concentration of phosphorus and low concentration of calcium in corn grain. This can be even more of a challenge with ethanol byproducts such as distiller's grains and corn gluten feed where concen-

Table 1. Dietary requirements and maximum tolerable concentrations of selected minerals for cattle. Expressed as either parts-per-million (ppm) of diet or % of diet dry matter (DM).

Mineral	*Requirement*			Maximum Tolerable Concentration
	Growing and Finishing Cattle	Gestating Cows	Lactating Cows	
Cadmium, ppm	--	--	--	10
Calcium, %	0.6	0.25	0.3	1.5
Copper, ppm	10	10	10	40
Fluorine, ppm	--	--	--	40
Lead, ppm	--	--	--	100
Mercury, ppm	--	--	--	2
Molybdenum, ppm	1-2	1-2	1-2	5
Phosphorus, %	0.22	0.17	0.21	0.7
Potassium, %	0.6	0.6	0.7	2
Selenium, ppm	0.1	0.1	0.1	5
Sodium Chloride, %	0.06-0.08	0.06-0.08	0.1	4.5 (growing animals) 3.0 (lactating cows)
Sulfur, %	0.15	0.15	0.15	0.3 (high concentrate diets) 0.5 (high roughage diets)

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trations of calcium and phosphorus are approximately three times those in corn grain. However, if proper calcium-to-phosphorus ratio is maintained, cattle can tolerate phosphorus concentrations above the maximum tolerable concentration.

Considerable attention has been given to high sulfur levels in ethanol byproducts and the affect this may have on cattle health and performance. Sulfur levels in distiller's grains generally range from 0.4% to 1.0% of dry matter. Although the maximum tolerable concentration for sulfur has been set at 0.3% for high-concentrate diets, research from the University of California indicated that growth performance may be inhibited in feedlot cattle consuming sulfur in excess of 0.2% of the diet dry matter. When feeding distiller's grains to cattle, it is important to account for sulfur levels in water as well, and adjust distiller's inclusion accordingly. Bunk and feed management is also important to ensure that rations are mixed completely and offered evenly to all cattle.

Cattle can tolerate mineral levels well beyond their requirement; however, it is important to be aware that any mineral, if consumed in high enough amounts, can be toxic. Mineral toxicity is generally observed by decreased animal performance, anorexia, weight loss, and diarrhea. Specific disorders caused by mineral toxicity include urinary calculi from excess phosphorus or inadequate calcium to phosphorus ratio, grass tetany from excess potassium leading to reduced absorption of magnesium, and polioencephalomalacia from excess sulfur. In many cases, mineral toxicity can be overcome by simply readjusting rations to provide minerals at non-toxic levels. In extreme cases, however, mineral toxicity can lead to chronic problems and even death. In addition, indirect effects of an over-supply of minerals may lead to unsafe accumulation of minerals in meat and milk, and may also impact the environment. Careful attention should be given to the formulation of mineral supplements, and the specific mineral balance of supplements should account for mineral concentrations in feed and water. For more information on this and other beef cattle topics please visit our Beef Industry Center website at *www.extension.umn.edu/beef*.