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MINERAL TOLERANCE OF RUMINANTS

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Introduction

Deficiencies and toxicities can occur through lack of attention to feeding, management or simple lack of availability. These effects can be sub clinical in nature, affecting gain and reproduction. Mineral nutrition is one of the least understood components of the livestock management. Minerals are key component in maintaining health and productivity of live stock. Mineral deficiencies created by depleted soils and other environmental factors is probably the most important responsibility and minerals that are fed in the correct proportions for your particular environment will provide the support your animals need to stay healthy and reproduce abundantly. The key to mineral nutrition is bioavailability but also balance in the ration. Dairy cows probably suffer more from mineral deficiencies than beef animals because of the pressure put on them to produce great volumes of milk. Most dairy cows are in confinement and living in a monoculture type environment. It has been proved that, for the most part, it is a low or slow immune response resulting from inadequate or imbalanced mineral nutrition that causes low pregnancy rates, high levels of mastitis, and high bacteria cell counts in the milk.

Dietary mineral concentration beyond maximum tolerable concentration for livestock is also a very important area. Mineral toxicities resulting from an over supply in feed or water may have observable effects such as decrease in animal performance or a change in animal behavior. Toxicities may also have hidden or indirect effect, such as accumulation in meat or milk, or environmental effects due to increased mineral levels in urine and faces. Mineral supplements that are incorrectly formulated or not correctly matched to animal needs may also result in an over supply of minerals. Toxic minerals may also be present in batteries, paint and contaminated soil. Surface water and possibly deep well or domestic water supplies may contain excessive levels of certain minerals. The objective of this article is to highlight the important of mineral deficiencies and toxicities in cattle, sheep and goat.

Macro and Micro minerals

At least 17 minerals are required by cattle. These minerals are generally divided into Macro and Micro minerals. Macro minerals (expressed in grams or in terms of % ration) required includes

Table.1: Dietary requirement and maximum tolerable concentrations of some minerals for cattle

Mineral	Growing cattle	Lactating cows	Max. Tolerable concentration
Cadmium, ppm	--	-----	10
Calcium,%	0.6	0.3	1.5
Copper, ppm	10	10	40
Fluorine, ppm	--	---	40
Lead, ppm	---	---	100
Mercury, ppm	---	----	2
Molybdenum, ppm	1-2	1-2	5
Phosphorus,%	0.22	0.21	0.7
Potassium,%	0.6	0.7	2
Selenium, ppm	0.1	0.1	5
Sodium chloride, ppm	0.06-0.08	0.1	4.5(growing animal) 3.0(lactating animal)
Sulfur,%	0.15	0.15	0.5
Fluorine, ppm	30-100	40	50
Zinc, ppm	10-30	40	
Iodine ppm	0.05-0.1	0.6	
Manganese ppm	1-10	20	

Calcium, Phosphorus, Potassium, Sodium, Chlorine and Sulfur.

The Micro minerals (expressed in parts per million-ppm-of the ration) 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 diet, but may be toxic if present at high concentration (Table 1).

Reports from National Research Council guide line (2005) identified sodium chloride (salt) and eight individual minerals (Cadmium, Copper, Fluorine, Lead, Mercury, Molybdenum, Selenium and Sulfur) as being of frequent concern for toxicity in cattle. In addition Calcium, Phosphorus and Potassium, three of the most common minerals in beef cattle diet, were identified as being of occasional concern for toxicity.

Toxicity in cattle

An important consideration when balancing rations is the relationship between minerals. Cattle can tolerate mineral levels well beyond their requirement; however, it is important to be aware that any mineral, if consumed in high enough amount, 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 polio encephalomalacia from excess sulfur.

Calcium should always be included in diet at a greater concentration than phosphorus and ratio up to 6 to 1 are generally tolerated by cattle. If ratio falls below 1 to 1, animal performance may be affected even if phosphorus is below the maximum tolerable concentration. 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. However if proper calcium to phosphorus ratio is maintained, cattle can tolerate phosphorus concentrations above the maximum tolerable concentration.

In many cases, mineral toxicity can be overcome by simply readjusting rations to provide minerals at non toxic levels. In addition indirect effects of an over supply of minerals may leads to unsafe accumulation of minerals in meat and milk, and may also have impact on the environment. Careful attention should be given to the formulation of mineral supplements, and the specific mineral balance of supplements should account for mineral concentration in feed and water.

Health problems associated with excess Minerals

1.**Calcium:** Excess calcium may reduce fat digestibility and cause metastatic calcium deposition in skeletal and cardiac muscle. It can lead to Osteopetrosis, Vertebral ankylosis and Degenerative osteoarthritis.

Dietary requirement for calcium ranges from 7500 to 8500 milligrams per/day.

2.**Phosphorus**: Excessive dietary phosphorus in relation to calcium results in weak bones, downer cow syndrome and urinary calculi. Maximum tolerated dietary level of phosphorus is approximately 1.0% regardless of calcium level.

The dietary requirement for phosphorus is approximately 4000 milligrams per head/day.

3.**Copper**: Excess copper leads to depression, anorexia, frequent recumbency, abdominal discomfort, jaundice and decreased milk production. Hemolytic crisis leads to hemoglobinuria and hemoglobinaemia. Tolerable copper excess may impart oxidized flavor to milk and reduce sulfur available to rumen flora with consequent reduction in productivity. Copper absorption from diet decreases as animal matures.

Dietary requirements for copper range from 150 to 250 milligrams per day.

4.**Selenium**: Acute signs of selenium toxicity are lassitude, inappetance, dyspnea and death. Blind staggers or Alkali Disease, loss of hair, cracked or deformed hooves and lameness can also result. Current research indicates that blind staggers may not be caused by selenium. Toxicity of the selenium accumulating plants (Astragalus sp.), may not be due to Selenium but other organic toxins in the same plants.

The dietary requirement for selenium for the cow range from 4 to 6 milligrams a day.

5.**Iodine**: Excess iodine causes anorexia, excessive salivation, hyperthermia, coughing, nasal and ocular discharge, bronchopneumonia and abortions. Individual animals show apparent

inability to metabolise and excrete EDDI (ethylenediamine dihydroiodide-an organic form of iodine).

Dietary Iodine requirements range from 25 to 28 milligrams per cow/day.

6.**Zinc**. Young calves are more susceptible to zinc toxicity than adults. It leads to excessive bawling, increased milk replacer consumption, diarrhea and polyuria followed by pica, then reduced appetite, submandibular edema and emaciation. Pneumonia, ocular signs, bloat and cardiac arrhythmias may occur, terminating in tonic-clonic convulsions, nystagmus and lack of sensorium. Increased incidence of arthritis and milk fever may occur in adults.

Toxicity in adult cattle is uncommon. 2.0% zinc in dairy feed has killed mature cows. Zinc at 6-8ppm in drinking water may adversely affect cattle. Pancreatitis occurs with > 1600ppm dietary zinc. 500ppm zinc in milk replacer or 1.5-2.0 grams of zinc per/head/day for 30 days is toxic to preruminant calves. High zinc intake interferes with calcium metabolism. 120 milligrams of zinc (as oxide) per kg of body weight for 3 days can cause hypocalcaemia.

Zinc requirements for cows range from 1200 to 1600 milligrams per day.

7.**Manganese**: Manganese toxicity is indicated by reduced appetite and growth rate, anemia and abdominal discomfort. Abortion and cystic ovaries may be associated with excess manganese. Manganese is excreted in bile at rate of 12.7 umol/kg liver.

Table.2. Dietary requirement and maximum tolerable level of some minerals for sheep and goat.

Mineral	Requirement	Max. Tolerance level
Calcium %	0.20-0.82	----
Phosphorus %	0.16-0.38	-----
Magnesium %	0.12-0.18	------
Potassium %	0.50-0.80	-----
Sulphur %	0.14-0.26	-------
Copper –ppm	7-11	25
Molybdenum -ppm	0.5	10
Manganese-ppm	20-40	1000
Zinc-ppm	20-33	750
Selenium-ppm	0.10-0.20	2
Iron-ppm	30-50	500
Iodine-ppm	0.10-0.80	50

Daily requirements for Manganese range around 1200 milligrams per/cow/day.

8.**Magnesium**: Excess dietary magnesium reduces feed intake, retards growth rate and produces diarrhea and emaciation. BUN and serum creatinine levels become greatly elevated, and serum calcium is reduced.

Magnesium dietary requirements for cows range from 5,000 to 10,000 milligrams per head/day.

Toxicity in Sheep and Goat

The quantity of minerals required will vary depending on age, weight, health, species and type, and level of production of the animal. Sheep and goat require the major minerals sodium, chlorine, calcium, phosphorus, magnesium, sulfur, potassium and trace minerals like cobalt, copper, iodine, iron, manganese, molybdenum, zinc and selenium. Young animals absorb minerals such as calcium more efficiently than older animals, but they have higher requirements. High rates of gain or milk production and poor health or parasitic burden will increase mineral requirements. Sheep have different requirements than beef cattle, with copper being the prime example. For sheep, levels above 25mg/kg of copper are considered toxic; while cattle do not reach toxicity levels until 400mg/kg is present. As copper toxicity in sheep is swift and deadly, it is crucial that only minerals designated for sheep be used. Copper supplied in feed usually is adequate and supplementation is unnecessary and dangerous. Trace mineralized salt provides an economical method of preventing deficiencies of sodium, chlorine, iodine, manganese, cobalt, copper, iron and zinc. Dietary requirement and maximum tolerable level is given in Table 2. Deficiency and toxic effects of minerals is given in Table 3.

Conclusion

Mineral requirement and their toxicity will first be observed in the areas of animal health and reproduction. The impact will not be immediate. Many mineral deficiencies are noticed only after a prolonged period of underfeeding has occurred. Although it may take time for clinical symptoms of a mineral deficiency to appear, sub clinical deficiencies may have been impairing optimum performance for quite some time. The primary exception to this rule is in the case of a mineral toxicity. At high levels, many minerals can be toxic. To minimize the problems, nutritionists should try

Table.3: Deficiency and Toxic Effect of Minerals.

Mineral	Deficiency	Toxicity
Phosphorus	Impaired reproduction, bone abnormalities, lethargy	Weak bones and urinary calculi
Zinc	Poor reproduction, rough skin, and poor immune function	Uncommon. Reduced bone formation and weight gain.
Sulphur	Reduced general performance and rumen fermentation	Dehydration, acidosis, heart, liver and lung damage.
Sodium	Depressed appetite	Salivation, abdominal pain, convulsion and muscular spasms.
Potassium	Rapid decline in feed and water intake, loss of vigor and pica.	Cardiac problem and edema.
Molybdenum	----------	Posterior weakness, bone malformation, delayed puberty and reproductive disruption.
Manganese	Impaired reproduction, skeletal abnormalities, abortion and reduced growth.	Disruption of rumen flora reduced appetite and growth.
Lead	----------	Blindness, abortion, abdominal pain and anemia.
Iron	anemia	Decreased intake and gain
Fluoride	----------	Mottling of teeth, dry skin and hair poor reproduction
Copper	Poor or faded hair, reduced growth and lameness	Hemolytic crisis, abdominal pain, jaundice and anorexia.
Iodine	Goiter, reproductive failure and abortion.	Rough hair, nasal or ocular discharge, respiratory problem and weepy eye.
Cobalt	Rough hair, impaired conception and anemia	Low growth, muscular in coordination and increased PCV and hemoglobin.

to observe the percent of minerals provided by typical feedstuffs. However, it is important to remember that mineral content in feedstuffs is quite variable. Frequent forage testing is beneficial for economical mineral feeding.

Minerals are an integral part of any successful herd management program. Often, correcting an imbalance in mineral levels can solve a nagging problem by improving reproductive performance or animal health, with very little additional cost. The above mentioned basic information regarding the minerals will help us to go from overwhelming sickness in our herds to the virtual elimination of several diseases by recognizing the signs caused by mineral imbalances especially mineral deficiencies and toxicities.

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