Small ruminant vitamins and minerals

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Abstract
Nutrition is paramount to small ruminant health and production. All ruminants, though similar, vary in nutrient requirements and predisposition to nutritional toxicities and deficiencies. Therefore, it is important to understand that both ovine and caprine are not to be considered small bovine. The objective of this paper is to serve as a reminder regarding the necessity of adequate nutrition in small ruminant species. It is also intended to provide a brief overview regarding the importance of several minerals and vitamins and their associated toxicities and deficiencies.

Key words: caprine, minerals, ovine, vitamins

Introduction
Nutrition is one of the foundation blocks of small ruminant health. Focus on infectious agents often overshadows nutrition when complications arise in livestock. Adequate supplementation of minerals in small ruminant species is paramount for proper physiological processes. Inadequate or excessive supplementation can lead to detrimental effects reflected by impaired immune system function, reproduction, and growth. Understanding the importance of the function of minerals and vitamins, deficient and toxic associated complications, interactions with other nutrients, and diagnostic sampling is critical in small ruminant practice.

Copper
Copper (Cu) is an essential trace mineral that is critical for the proper functioning of numerous enzymes and biochemical processes in small ruminants. Several enzymes in which Cu is associated with include hephaestin, ceruloplasmin, tyrosinase, cytochrome C oxidase, and super oxide dismutases. Hephæstin is responsible for the oxidation of ferrous iron (Fe2+) within enterocytes to ferric iron (Fe3+) allowing for mobilization and transportation by ceruloplasmin. Melanin, responsible for providing coat pigmentation, is produced through the hydroxylation of tyrosine by the enzyme tyrosinase. Cytochrome c oxidase is important for mitochondrial electron transport chain. Superoxide dismutases are integral in both immune system function and antioxidant properties. It is an essential component of glutathione, glutathione peroxidases and selenoproteins.

Selenium
Selenium (Se) is widely known for its role in immune system function and antioxidant properties. It is an essential component of glutathione, glutathione peroxidases and selenoproteins. Aside from preventing and limiting free radical formation, Se also plays an integral role in thyroid hormone synthesis (T4 to T3) in various tissues through several iodothyronine S-deiodinase enzymes. Dietary sources of Se include grains, legumes, and other forages. The concentration of Se within vegetation is dependent on the region and composition of the soil as the Se content of soil varies greatly by region.

Selenium toxicosis commonly develops through ration misformulations, drenches, consumption of high Se forage, or through incorrect/excessive parenteral supplementation. Regional soil content and vegetation may result in disproportionate concentrations of Se. Numerous plant species accumulate Se. Obligate accumulators include species of the Astragalus, Oonopsis, Stanleya and Xylorrhiza genera. It is not uncommon for plants in these genera to accumulate upward of 1,000 ppm of Se. Lambs that ingest between 2-4 mg/kg sodium selenite
or 4-8 mg/kg selenomethionine developed respiratory distress. Lambs exhibited myocardial necrosis and pulmonary hemorrhage and edema. White muscle disease in ruminants is a common syndrome associated with Se deficiency. The deficiency associated syndrome is usually predominant in young lambs or kids but can also be observed in older juvenile animals. Generalized ill thrift with weakness is the typical presentation of this syndrome. Gross examination of cardiac and skeletal musculature reveals pallor.

**Zinc**

Zinc is a known component of over 3,000 enzymes. As with other trace minerals, zinc plays an integral part in immune system function through maintenance of the epidermal barrier and super oxide dismutase enzymes. Gene expression is largely dependent on zinc. Retinol binding protein, responsible for transport of vitamin A from the liver to other tissues is also dependent on zinc. Supplementation of zinc is predominately through dietary means.

Toxicity of zinc in small ruminants is not often reported but has been reported in suckling lambs provided excess. Concentrations of Zn high enough to cause toxic effects would likely originate from ration misformulations. Goats or sheep located near facilities that galvanize steel may be exposed to zinc dust or exhaust that covers the forage. Deficiency is due in part to inadequate supplementation or decreased bioavailability. Calcium and phosphorous as well as Cu impair zinc absorption within the GI tract. Signs of deficiency include reduced feed intake and immune system function. Reproduction may be negatively impacted by Zn deficiency. Severely deficient individuals may develop hyperkeratotic parakeratosis, a crusty scaling of the skin. Animals may also present with anorexia, abnormal hoof growth and foot soreness.

**Manganese**

Manganese plays a significant role in immune system function and in structural development. As with Cu and Zn, Mn is a component of super oxide dismutase enzymes. It is also integral in glycosyl transferase enzymes that allow for proper cartilage and bone development. Forage and grasses tend to possess greater concentrations of Mn than silage. Manganese is further supplemented by either dietary or parenteral means. Manganese is tightly regulated within the body, and toxicities are rare. Inadequate supplementation of Mn in the dam during gestation can lead to skeletal anomalies in offspring. Extremities exhibit enlarged joints with shortened long bones. This has been observed in calves. Microscopic examination reveals chondrodysplasia within the metaphyseal region of the bone. Deficiency can also be brought on by excessive Fe consumption.

**Vitamin E**

Alpha tocopherol is the active form of vitamin E within the body. Although it holds many functions, one of the primary roles of vitamin E is acting as an antioxidant to prevent tissue damage from free radicals while also supplementing the action of glutathione peroxidase enzymes. Vitamin E is provided through both dietary and parenteral means. Adequate supplementation of vitamin E along with Se is necessary to prevent nutritional myopathy or white muscle disease. Sodium selenite has the potential to reduce liver vitamin E.

**Antagonists**

Sulfur, molybdenum and iron are three of the most important antagonistic minerals in ruminant nutrition. The mechanism of antagonism includes binding to the mineral making it unavailable for absorption, competition for transporters or storage space, or through down regulation of shared transporters. Primary sources of S associated antagonism include high dietary sulfur or elevated sulfate within water. Vegetation growing in Mo rich soil can possess high levels of Mo. All three minerals impair absorption of Cu. Both Mo and S alone are able to inhibit Cu absorption by 0.5% and 3.1% respectively. However, when combined in the rumen, thiomolybdate formation can result in an approximately X% inhibition of Cu absorption. Sulfur and Se share similar transporters, so excessive S can result in impaired Se absorption. Both Fe, Cu, and Mn share the divalent metal transporter 1 (DMT1) within the GI tract. Excessive Fe from feedstuffs not only compete for the transport use but also decreased DMT1 activity following Fe saturation within enterocytes. Zinc and Cu both compete with each other for metallothionine and ultimately storage within the liver.

**Diagnostics**

When evaluating mineral and vitamin status in small ruminants, proper sample selection and submission is imperative for optimal analysis and interpretation. Fresh liver should be submitted for trace mineral analysis as it is the main storage organ of trace minerals. Antemortem liver of approximately 0.005-0.006 g DM are sufficient for diagnostic interpretation. Although simple to collect, serum is not the optimal sample for Cu analysis. Serum Cu concentrations do not necessarily correlate with hepatic concentrations. Submission of suspect feed and water samples is encouraged to evaluate for excess or deficiencies. Due to accumulation of minerals over time, the submitted sample may not be representative of what was consumed by the individual that lead to the accumulation. Since milk and colostrum serve as major sources of vitamin E, evaluation of vitamin E in stillborn lambs or kids is of little diagnostic help.

**Conclusion**

Although ruminants, sheep and goats should not be considered small bovine. There is variation between species in regards to necessities and tolerances to different nutrients. The nutrients presented are all essential for life and must be provided adequately. Presentation of clinical signs and lesions associated with deficiencies and toxicities also vary between species. The manner in which small ruminants are supplemented not only depends on their age and use but also by geographic region. Methods of supplementation must also be taken into consideration.
References