Trace minerals play role in cattle immunity

The interactions between trace minerals and disease resistance are extremely complex, and many factors can affect an animal’s response to trace mineral supplementation. These factors include the duration and concentration of trace mineral supplementation, physiological status of an animal, absence or presence of dietary antagonists, environmental factors and stress.

Mineral functions

Minerals can be broken down into four functional categories:
1. Trace metallic minerals play a role as components of enzymes.
2. Trace metallic minerals are components of defensive barriers.
3. Catalytic activity of enzymes includes utilization of trace metallic minerals.
4. Trace metallic minerals are involved in cell replication processes.

Minerals can be further divided into two branches: humoral and cell-mediated immunity. The humoral branch of the immune system involves antigen-specific B cells that proliferate, differentiate and secrete antibodies upon interaction with their specific extracellular antigen. These antibodies are the effector molecules of the humoral response as they bind to extracellular structures and initiate the process of antigen elimination.

Trace minerals and immunity

Zinc. Numerous experiments with humans and laboratory animals have indicated that zinc deficiency reduces immunity and disease resistance (Chesters, 1997). However, there is limited research in ruminants examining the influence of zinc deficiency on immune function and disease resistance (Spear, 2000).

Lamb's fed a semi-purified diet severely deficient in zinc showed a reduced in vitro T cell growth response to a mitogen (a substance that stimulates proliferation) but an increased B cell growth in response to a mitogen that relies on T cells (Broke and Spear, 1993). Zinc-deficient lambs also had a lower percentage of lymphocytes and a higher percentage of neutrophils (phagocytic cells). The inflammatory response by T cells was similar in zinc-deficient and zinc-deficient lambs.

Furthermore, zinc-deficient cattle showed similar cell-mediated and humoral immune responses to zinc-deficient cattle (Spears and Kegley, unpublished data).

Hord et al. (1997) reported a greater skin swelling response to a subdermal antigen injection in zinc-deficient calves compared to marginally zinc-deficient calves.

Zinc supplementation has been associated with an increased antibody response and a decrease in respiratory disease in feedlot steers (George et al., 1997). This may be due to the function of the copper-zinc superoxide dismutase enzyme or to an increase in a variety of other immune processes that involve zinc as well (Hambridge et al., 1986).

Copper. Copper is an essential element that is required for an array of metabolic functions, including iron metabolism, cellular respiration (energy production), cross-linking of connective tissue, central nervous system formation, reproduction and immunity, as well as several other functions (McDowell, 1992).

Severe copper deficiency induced by feeding a semi-purified diet low in copper did not affect in vitro mitogen-induced B and T cell proliferation in cattle (Stabel et al., 1993; Ward et al., 1993).

Furthermore, the addition of 5 mg/kg of molybdenum to the semi-purified diet produced a more severe copper deficiency did not reduce B and T cell proliferation to mitogens (Ward et al., 1997). However, Wright et al. (2000) indicated that a low copper status in steers was associated with a reduced response of T cells to mitogens following weaning and an infectious bovine rhinotracheitis virus (IBRV) challenge.

Selenium. Since its discovery by Rotruck et al. (1975), selenium has been shown to affect specific components of the immune system. Earlier research by Reffett et al. (1988) reported lower serum immunoglobulin M — an antibody produced by B cells — concentrations and anti-IBRV levels in selenium-deficient calves challenged with IBRV than in selenium-adequate calves.

Neutrophil function was reduced in goats (Aziz et al., 1984) and cattle fed selenium-deficient diets compared with controls receiving selenium-adequate diets.

Some studies have shown increased T cell proliferation following in vitro stimulation with mitogens, while others have not (Spear, 2000).

The Bottom Line

The interactions among trace minerals, immunology and disease resistance are extremely complex. From the more basic molecular immune research, it is clear that trace minerals play an important role in the immune response.

Despite the apparent involvement of certain trace minerals in the immune system, trace mineral deficiencies have not always increased the susceptibility of domesticated livestock species to natural or experimentally induced infections (Spear, 2000).

Many factors could affect an animal’s response to trace mineral supplementation — such as the duration and concentration of trace mineral supplementation, the physiological status of an animal, the absence or presence of dietary antagonists, environmental factors and the influence of stress on trace mineral metabolism — and may depend on the class of immune cell being studied (Dorton et al., 2003). Portions of this article were published previously in other publications.

References


