Immunity and trace mineral **nutrition**

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Producers continue to look for opportunities to improve milk quality while there are more stringent somatic cell count (SCC) limits on the horizon. The area of trace mineral nutrition has been receiving renewed interest by many, as research is well documented regarding the positive impact that trace mineral status has on mammary health and milk quality. When evaluating nutrition solutions to improve milk quality, it is important to understand the relationship between trace mineral nutrition, immune function and mammary health.

The following overview is designed to help build an understanding regarding this relationship, as well as highlight key points related to the role of stress and the impact of udder health on reproductive performance.

Role of key trace minerals

Zinc, copper, manganese and selenium each play critical roles in skin and mammary health, somatic cell count function and disease resistance (immunity). For example, all four minerals help to protect cellular membranes from damage by removing superoxide radicals (free radicals) from the body. Superoxide radicals are normal by-products of cellular protection against infection. However, these radicals disrupt cellular membranes and cause cellular damage leaving the mammary gland more susceptible to infection, scarring and lost milk production.

- Zinc is known to contribute to more than 300 enzyme systems. It helps maintain the health and integrity of skin due to its role in cell replication and repair, which is an important part of the natural defense mechanism of the mammary gland. It also plays a critical role in keratin formation, helping entrap bacteria in the teat canal and prevent bacteria from moving up into the mammary gland. If a cow does develop a case of mastitis, maintaining adequate zinc status will help reduce the severity and duration of mastitis as it is critical for cell replication and differentiation. In response to antigens, B lymphocytes may increase up to 5 000 fold and T lymphocytes may increase up to 50 000 fold.

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- Copper is also considered to have strong effects on the immune system as it is active in neutrophil (somatic cell) production and affects the phagocyte (white blood cell) killing ability. It is also required for antibody development and lymphocyte (white blood cell) replication. In addition, the copper containing enzyme ceruloplasmin has been shown to exhibit anti-inflammatory activity, which may prove beneficial when mastitis occurs. In copper deficient cows, neutrophils are less effective in killing invading bacteria.
- Manganese helps improve immune function through enhanced macrophage (white blood cell) killing ability. Macrophages are one of the types of somatic cells released into the mammary gland in high concentrations to help protect against intramammary infections (IMI).

Therefore, manganese may be beneficial in mastitis management by helping enhance the activity of the immune system.

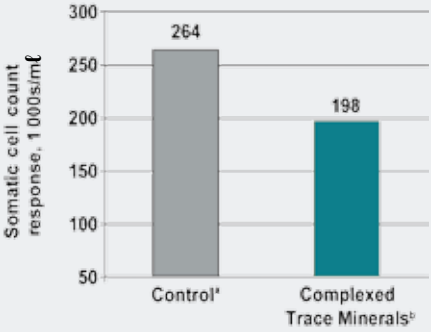
- Selenium plays a vital role in immune response and has an associated role with vitamin E in protecting the mammary gland. Selenium also allows for more rapid neutrophil (somatic cell) influx into milk following an IMI bacterial challenge and increased cellular kill of ingested bacteria by neutrophils.
- Trace minerals are key components in the chain of events responsible for the clearing of foreign materials in the mammary gland leading to mastitis events. Thus, improving trace mineral availability leads to shorter duration of IMI.

In a summary of 14 studies, research shows that feeding a combination of complexed zinc, manganese, copper and cobalt beginning in the dry period and continuing through lactation decreased SCC by 25 percent (*Figure 1*). In comparison, in studies where the same complexed trace minerals were fed only during lactation (not pre-partum), SCC only decreased by 8 percent.

Stress and mastitis development

Stress can play a significant role in the development of mastitis as it causes an increase in systemic (whole body) inflammation that may put an unnecessary drain on energy reserves and/or on the immune system. When an animal becomes stressed, cortisol is released into the blood stream as a means of reprogramming the animal's metabolism to fight the stressor. The problem is that cortisol is very immune suppressive, as it changes the animal's metabolism so that the energy needs to fight infection or needed by the immune system (somatic cells) is held in reserve for running away from the stressful event or maintaining organ function to survive the stress challenge. For example, a cow that is stressed due to transition challenges

Figure 1: Somatic cell count response summary from 14 studies evaluating the effects of feeding complexed trace minerals to dairy cows during dry and lactation periods

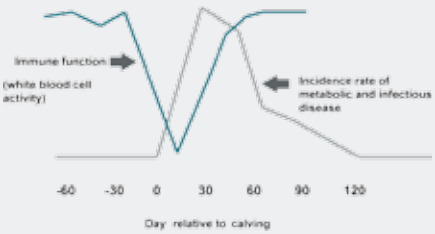


a. All trace minerals provided as inorganic sources with the exception of two trials where zinc methionine complex was included at 360mg per day.

b. Complexed Trace Minerals: zinc methionine complex, manganese methionine complex, copper lysine complex and cobalt glucoheptonate; included in addition to inorganic sources of Zn, Mn, Cu and Co levels in five trials, replaced equal proportions of inorganic sources of Zn, Mn, Cu and Co; in one study, both diets supplied equivalent amounts of Zn, Mn and Cu, but the complexed trace mineral diet supplied an additional 13mg Co/hd/d; in one study, during lactation, both diets provided similar amounts of Zn and Cu, but the complexed trace mineral diet provided 1131mg more Mn (192 mg from manganese methionine complex and 939mg from $MnSO_4$) and 21,4mg more Co from cobalt glucoheptonate.

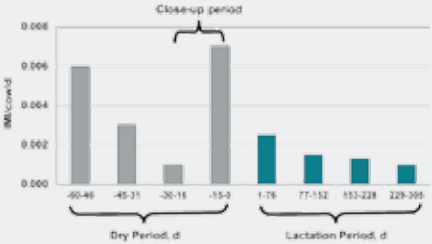
such as parturition, dietary changes, regrouping, on-set of lactation and mild hypocalcaemia (mild milk fever) will have elevated cortisol levels and may be more likely to succumb to an IMI (*Figure 2*). Research at The Ohio State University showed the times of greatest risk for mastitis were at dry-off and again at calving, both times of significant stress (*Figure 3*).

Figure 2: Disease threat and immune suppression are greatest at calving time



Source: Adapted from Nelson; and Kehrli et. al.

Figure 3: Rate of coliform intramammary infections (IMI)



Source: Smith et. al., 1985. J. Dairy Sci. 68:402 & 1531

Stress also changes how an animal absorbs nutrients including trace minerals. While this may be a protective mechanism, it is not always in the best interest of the overall immune function of the animal. Research at Colorado State University demonstrated in cattle that complexed trace minerals were absorbed differently both before and after periods of stress than ordinary inorganic trace minerals. This means that more nutrients will be available to energise the immune cells before and help fight mammary infections after stressful events.

Reproduction

While improving udder health helps improve milk production and quality bonuses, research shows that it also has a positive impact on fertility. Researchers at the University of Tennessee reported that clinical mastitis in the first 150 days in milk increases services per conception, days to conception, and days to first service. University of Florida researchers reported that cows that develop mastitis in the first 45 days of lactation were 2,7 times more likely to abort. More recently, researchers in Israel reported that 30% of cows with mastitis prior to breeding had delayed ovulation by up to 56 hours. It is unclear as to the timing of mastitis and its impact on ovarian function, yet the results are quite definitive. Inflammation and or infection in the mammary gland sets a cascade of events into motion that often lead to changes in normal ovarian function resulting in reproductive failure.

Improving immune competence through improved nutritional adequacy may help alleviate some of the detrimental effects of mastitis on reproductive function. A summary of 14 studies found that feeding a combination of complexed zinc, manganese, copper and cobalt helps impact several key reproductive factors, when compared to feeding inorganic trace minerals, including:

- 15 fewer days open
- 9,2 percentage unit increase in cows pregnant at 150 days postpartum
- 0,3 fewer services per conception
- 5 fewer days to first service

Conclusion

Trace minerals have fundamental roles in eliciting rapid and effective immune responses to pathogens. Minimising the incidence, extent and duration of IMI helps not only keep somatic cell counts low, but can also help maintain greater levels of fertility in dairy cattle.

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