Mineral nutrition and immune response in mastitis

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Mastitis, defined as inflammation of the mammary gland, is one of the most prevalent diseases with the highest economic losses in dairy herds in developed countries.

In addition to the economic losses, mastitis is a cause for concern for public health due to the antibiotics needed for the treatment and the resistance developed by the microorganism to those antibiotics.

In most cases inflammation is caused by bacterial invasion. Pathogenicity of the bacteria together with environmental factors and the individual condition of the cow will determine the clinical picture of the disease.

Infection by Gram positive bacteria such as Staphylococcus aureus could produce a long term mastitis; Gram-negative bacteria such as Escherichia coli are usually isolated from mastitis with an acute response.

The immune system of the cow plays a main role in the response to the inflammation. Some nutrients as trace minerals are quite important for the immune response against the pathogenic bacteria.

Knowledge of the trace minerals and their action mechanism is very important to improve the status of the immune system, to prevent infections and to reduce the effects produced by mastitis. Antibiotic treatment can also be reduced with preventive actions.

Trace minerals

Trace minerals like zinc, iron or copper are present at a very low level but they are involved in essential functions such as catalysis of different chemical reactions and physiological processes.

Trace minerals are an essential part of different proteins with different functions in the immune system. Zinc in the organism is bound to the methallotionein that acts in the activation, adherence and invasive capacity of the macrophages. Iron is a component of the lactoferrin, transferrin and desferoxamine.

Lactoferrin is a very important glycoprotein with a high presence in milk and another epithelial secretions with high activity bactericide and bacteriostatic capacity; moreover it has an inmunomodulator effect.

Different papers have shown higher lactoferrin concentrations in milk obtained from infected teats than from milk obtained from healthy teats. Epithelium secretes lactoferrin as an unspecific response against pathogenic agents. Chaneton et al show the efficacy of the lactoferrin in the inhibition of the growth of many bacteria responsible for mastitis like E. coli and S. aureus. However, another bacterium like Streptococcus uberis does not reduce their development under high concentration of lactoferrin.

Copper works in the immune response as a component of the ceruloplasmin that is involved in the inflammatory process, moreover it has antioxidant properties and plays a key role in the homeostasis of iron.

Mastitis and mineral levels

The effect of minerals in the reduction of somatic cell count and mastitis is very well known. The inclusion of organically chelated zinc has been reported to reduce somatic cell count (SCC) in high producing dairy cows, particularly when the initial SCC was high. For example, Corbellini et al. in 1995 showed a reduction of somatic cell count when zinc was supplemented in an organic form (zinc methionine, Biomet ZN), where an increase in the zinc concentration in milk was also found. Podal injuries were reduced and reproduction parameters were also improved.

Erskine and Barlett in 1993 tried to understand the mechanism involved in the immune response against mastitis and infected cows intracisternally with E. coli as a way to produce acute mastitis. Results showed that the levels of zinc in serum decreased to 72% from levels previous to infection. At the same time iron levels and copper were reduced to 62 and 48% respectively. After E. coli infection a different inflammatory process is triggered and the final consequence is the drop in the plasmatic mineral concentration.

One hypothesis suggested by the authors to explain the drop in mineral levels is the chelation of the minerals by the proteins to reduce the availability of the mineral for the bacteria that needed the minerals for growth. Another hypothesis is the reduction of the free radicals responsible for the cellular damages in the tissues during the inflammatory process.

The drop in the levels of copper, zinc and iron has also been observed when the animals have been infected intracisternally with strains of S. aureus, but the drop was lower when compared with E. coli infection (11, 17 and 19% less than previous infection levels).

Both cases produced a reduction of the mineral concentration, but the lower drop of the mineral plasmatic levels could be explained due to a less acute response against the infection from S. aureus than E. coli.

The role of trace minerals is much more important as a non-specific immune response in acute infections than in chronic infections, but in both cases a relationship exists between level of minerals and the factor acting in the inflammatory response, like metallothionein, lactoferrin and ceruloplasmine.

Mineral requirements

From a practical point of view, it is very interesting to determine the increase of the requirements in trace minerals when a cow is infected by different pathogens causing mastitis and has to respond to the infection.

Scalleti et al studied this point trying to improve the resistance of the cows when a mastitis with E. coli was induced.

They prepared two groups, a control group with 6.5mg/kg of copper in the basal diet and a treatment group supplemented with copper sulphate 20g/kg from day 60 before calving to 42 days of lactation. At day 34 of lactation both groups were infected with E. coli. During the next few days the number of colonies excreted of E. coli, somatic cell count and temperature were collected. A clinical score of the mastitis was also done. No differences were found in milk production, body weight and dry matter intake but the copper supplemented group resulted in a lower number of E. coli colonies excreted in milk, lower SCC, and lower clinical symptoms of mastitis than the control group and a lower temperature peak was observed. Animals supplemented with copper suffered a milder infection, the response to the infection was better and the clinical symptoms were lower than in the control group animals.

Copper requirements could be higher when mastitis infection occurs in order to improve the immune response. Similar to copper; iron and zinc could help modulate the immune response for a better response against mastitis.

Conclusions

Trace minerals have an important role to play in the immune response. They participate in the immune response and in the inflammatory process through different proteins. The immune response is different depending on the causal agent that produces mastitis and the chronic or acute process.

Zinc reduces the somatic cell count and mastitis. Mastitis produces a drop in the plasmatic level of trace minerals. This drop is much higher when mastitis courses with acute response like E. coli infections.

Requirements of trace minerals could increase when animals are infected, mainly when clinical mastitis occurs. More knowledge is needed for a better determination of the requirements for the best immune response against infectious mastitis.

This could reduce antibiotic treatments and reduce clinical and economic effects produced by mastitis. ■