Minerals and Mastitis in Cows

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Inflammation of the mammary gland (mastitis) is an important disease in dairy cows. Among factors affecting the incidence of mastitis, mineral deficiencies are mentioned, since they strongly influence the immune system. Consequently, these deficiencies result in weakened immunity, which increases the risk of any infectious disease. The minerals (calcium, phosphorus, magnesium, selenium, copper and zinc) interact differently with the immune system; nevertheless, their deficiencies invariably increase the risk of mastitis occurrence in dairy cows.

Keywords: mastitis ; minerals ; immunosuppression ; dairy cows ; dietary deficiencies

1. Introduction

Mastitis is considered one of the most costly diseases in dairy cows, causing severe losses in the dairy industry [1]. Losses do not only refer to economic issues including milk quality and quantity, antibiotic usage or extra labor; they also refer to the disease significantly affecting animal welfare and public health. The etiology of udder inflammation is mainly associated with bacteria, i.e., staphylococci and streptococci, although viruses, fungi and algae can also cause mastitis [2]. Moreover, non-infectious factors such as genotype, environmental conditions, feed composition and dietary supplement addition may also have an impact on mastitis occurrence and its severity [3]. It is well proven that even in the presence of bacteria the immune system can cope with microbial invasion and prevent the development of inflammation. Any nutrition deficiency will result in a weakened immune response and thus be a predisposing factor for udder inflammation. Minerals are a group of nutrients that has been reported to influence udder health status. Basically, they take part in the formation of structural components of the body and proper functioning of enzymes, hormones, vitamins and cells. By the mid- to late 19th century, it was already known that animals need to consume certain minerals to live and be productive, but their specific role and daily requirements were not recognized [4]. Minerals can be divided into two groups based on their concentration in the organism: macrominerals that are present in the animal body in relatively high concentrations, and trace minerals or microelements found in relatively small amounts in the organism. Macrominerals include calcium (Ca), phosphorus (P), sodium (Na), chlorine (Cl), sulfur (S) and magnesium (Mg), while microelements include iron (Fe), copper (Cu), manganese (Mn), zinc (Zn), cobalt (Co), chromium (Cr), iodine (I), molybdenum (Mb) and selenium (Se) [5].

Microelements occur in relatively small amounts in living organisms. Moreover, aluminum (Al), arsenic (As), nickel (Ni), silicon (Si), tin (Sn) and vanadium (V) are also considered trace minerals, but they are present in extremely low concentrations and their specific roles are not yet fully understood. The reference values of selected serum mineral concentrations in dairy cows are presented in **Table 1** . The given values collected from selected publications indicate that the production, health and reproduction performance of studied cows was kept at the optimum level, since both deficiencies and excess of dietary minerals can have a detrimental effect on animals, the environment and dairy farm profitability.

Table 1. Reference values of serum mineral concentrations in dairy cows.

Mineral	Serum Concentration	Reference
Calcium (Ca)	**2.2–2.6 mmol/L**	[6]
Phosphorus (P)	**1.3–2.6 mmol/L**	[6]
Magnesium (Mg)	**0.75–1.0 mmol/L**	[7]
Selenium (Se)	**0.73–1.08 µmol/L**	[8]
Copper (Cu)	**1–18 µmol/L**	[9]
Zinc (Zn)	**8–19 µmol/L**	[10]

In cattle veterinary medicine, mineral deficiencies are mainly associated with characteristic metabolic disorders such as periparturient hypocalcemia (milk fever), hypophosphatemia and hypomagnesemia (grass staggers). However, it has to be remembered that every mineral deficiency leads to immunosuppression [4], which is a well-recognized predisposing factor for the occurrence of infectious diseases including mastitis. Obviously, the key factor determining the concentration of a specific mineral in the body is its supply via feed. Thus, dietary requirements for dairy cows depending of their physiological state are presented in **Table 2** .

Table 2. Daily dietary requirements for selected minerals in dairy cows taking into account their physiological state (lactating/non-lactating) according to the Nutrient Requirements of Dairy Cattle [5].

Mineral	Requirement for Non-Lactating Cows	Concentration in Milk (mg/kg)	Requirement for Lactating Cows
Calcium (Ca)	**0.0154 g/kg BW**	**1220**	**0.106 g/kg BW**
Phosphorus (P)	**1 g/kg DMI**	**900**	**2.5 g/kg DMI**
Magnesium (Mg)	**3 mg/kg BW**	**150**	**10 mg/kg BW**
Copper (Cu)	**152 mg/cow (15.2 mg/kg DMI)**	**0.015**	**313 mg/cow (15.7 mg/kg DMI)**
Selenium (Se)	**0.3 mg/kg DMI**	**0.01–0.025**	**0.3 mg/kg DMI**
Zinc (Zn)	**310 mg/day (31 mg/kg DMI)**	**4**	**1261 mg/day (63 mg/kg DMI)**

Assumptions: 650 kg body weight (BW) Holstein cow, 40 kg of milk per day if lactating, dry matter intake (DMI) in lactating/non-lactating cow equals 20/10 kg per day.

2. Mineral Supplementation as an Auxiliary Tool in Mastitis Treatment—Field Trials

From a clinical point of view, it is well-known that some mastitis cases require supportive therapy including fluids with calcium, since cows with udder inflammation are often hypocalcaemic [11]. Besides, the injectable supplementation of trace minerals, such as zinc, manganese, selenium and copper, can also be considered as an auxiliary tool in therapy of mastitis in dairy cows. For example, Hoque et al. [12] claimed that antimicrobial therapy is the most effective in mastitis treatment; however, in the same experiment cows injected only with selenium preparations were less prone to udder inflammation compared to the untreated control group. Ganda et al. [13] demonstrated that injection of trace minerals (including zinc, manganese, selenium and copper) reduces the number of chronic mastitis cases, but has no impact on the incidence of clinical cases requiring treatment. Machado et al. [14] showed that injection of a multimineral preparation (including selenium, copper, zinc and manganese) had a positive impact on udder health, decreasing linear somatic cell count (SCC) scores and the incidence of subclinical and clinical mastitis. Moreover, the same researchers reported that administration of this multimineral preparation increases serum superoxide dismutase (SOD) activity, but does not subsequently affect leukocyte function [15]. However, Ferreira and Petzer [16] observed no evident correlation between SCC and the milk or serum selenium values in cows supplemented with Se in different forms, while in a study performed by Bourne et al. [17], supplementation of vitamin E with Se reduced the risk of culling and mastitis rate by 10 %. Recently, Smulski et al. [18] confirmed that administration of an antibiotic combined with antioxidant including selenium slightly improves the effectiveness of clinical mastitis treatment.

To recap, a brief summary of the pathomechanisms related to mineral deficiencies and mastitis incidence is given in **Figure 1**.

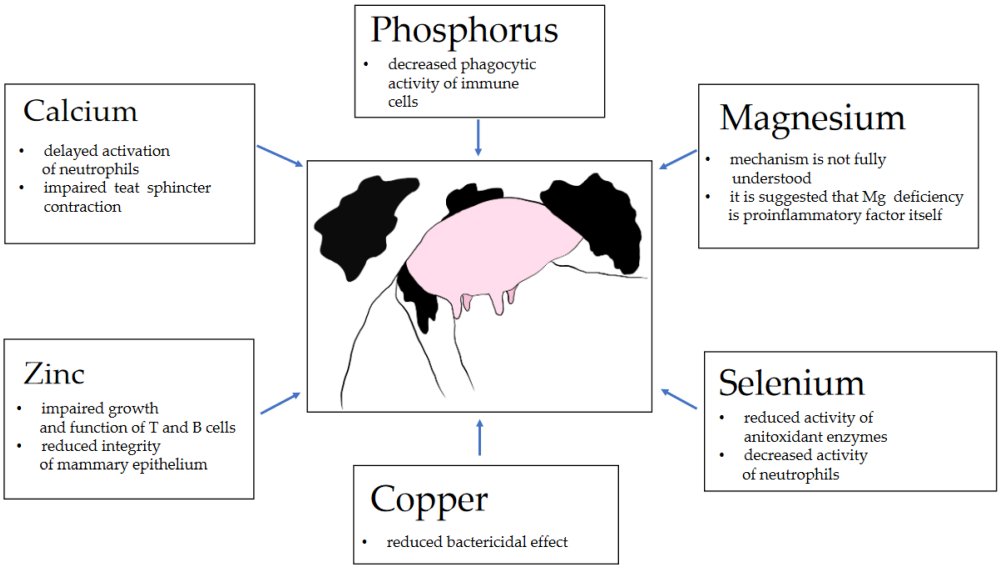

Figure 1. Brief summary of pathomechanisms related to mineral deficiencies and mastitis incidence.

3. Conclusions

When managing nutrition on a dairy farm, special attention should be paid to minerals because they are involved in various biological processes in cows and hence influence key traits in dairy production. Moreover, minerals are essential for the proper function of immune cells, so any mineral deficiency may lead to suppression of immunity, which predisposes cows to infection. Mastitis is an ongoing problem even on well-managed farms, and mineral supplementation might be a way to enhance the innate immunity of the mammary gland and thus contribute to a decreased risk of udder inflammation.

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