Metal glycinates improve immune response in lactating dairy cows

Production levels of milk and meat are rapidly increasing. Through breeding, nutrition and management milk production per cow has been on the rise for decades. However, there is also more attention on animal welfare, the use of antibiotics and milk quality.

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In dairy cattle (sub-clinical) mastitis is a big challenge as it influences all of the challenges, the milk production decreases, welfare of the cow is reduced, for clinical cases antibiotics are used for treatment and finally the quality of the milk reduces due to higher somatic cell counts and residues of antibiotics in the milk. To be able to manage and help prevent the effects of mastitis there is a need to understand the cow's immune system and the best way to support this.

For many decades the role of trace minerals in ruminants has been studied. The research however, has been mainly focused on the growth and production of animals. More recent research has provided a growing insight into the influence of some trace minerals on the immune response and therefore the overall health of ruminants.

Micronutrients, for which a positive effect on immunity in general and mastitis in particular has been shown, have a function in the anti-oxidant system: zinc, copper, vitamin E and selenium. Others important to mention are manganese and vitamin A.

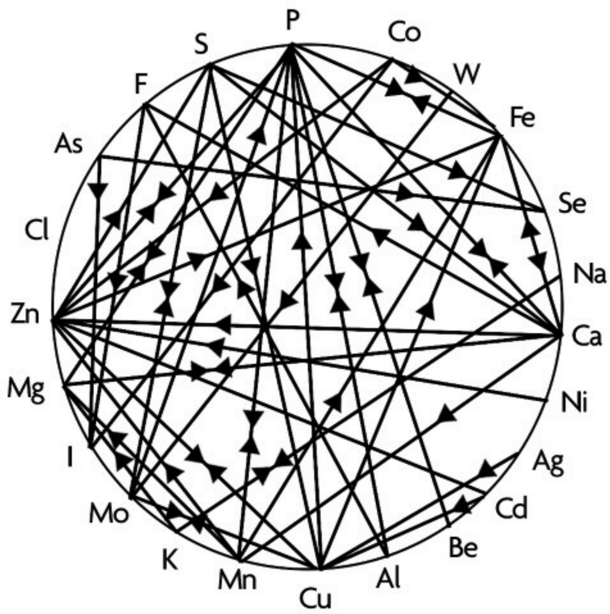


Fig. 1. Mineral wheel showing known antagonistic relationships between minerals (Watts, 1990).

Zinc

The importance of zinc for the human immune system is well-studied and on many different levels. Zinc is known to be essential for multiplying cells and cell metabolism, next to its role in the anti-oxidant function of cells. This is important for the first defence against pathogens: the skin and tissues, but also the non-specific immunity (efficiency of neutrophils to kill pathogens) and the specific immunity (fast production of specific antibodies). In addition, Andrieu (2008) showed the importance of zinc for the structural integrity of tissues, like keratin production to protect infection in mammary glands.

Zinc levels in feedstuffs are generally lower than the minimum requirement which makes supplementation essential and often improving performance or health.

Copper

The role of copper in immunity is less clear, but its antioxidant function helps to protect cells as part of the enzyme copper-zinc superoxide dismutase in the mammalian cytosol.

However, Spears and Weiss (2008) also showed that the ability of neutrophils to kill pathogens is reduced when ruminants are deficient in copper.

An additional limitation for copper is the antagonists often present in ruminant feeds, like molybdenum, sulphur and iron, limiting its bioavailability.

Manganese

Manganese is generally more present in feedstuffs for ruminants, limiting the effect of supplementation (less deficiency), but is essential to protect mammalian cells through manganese-zinc superoxide dismutase in the mitochondria as well as

Fig. 2. Haptoglobin blood levels in beef steers during receiving phase.

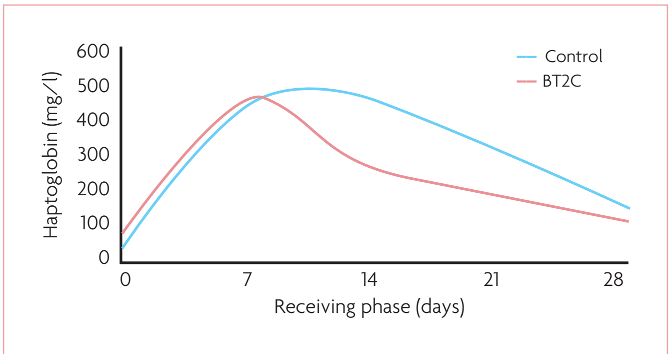
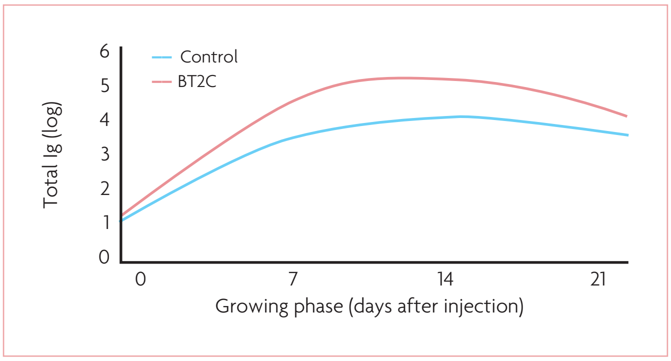


Fig. 3. Immunoglobulin (Ig) levels in the blood of beef steers after injection with pig red blood cells.



part of enzymes with function in the immune response.

Fulfilling ruminant's mineral requirements

Normally it is no problem to supply enough minerals, but supplying enough minerals that are bioavailable for a dairy cow is much more challenging.

Ruminant diets, even of high performing lactating dairy cows, have high fibre levels. Fibre is needed to sustain rumen microflora to support performance and is digested very efficiently in comparison to non-ruminants.

However, non-digested fibre can bind minerals and this may influence bioavailability of the minerals. Many complexes are formed with fibrous fractions and part of them are not again soluble (digestible) afterwards, also at low pH in the abomasum.

There are many interactions known between minerals for absorption and metabolism (both synergies and antagonisms) and still new interactions are being found.

Only the antagonistic relationships between minerals are displayed in Fig. 1, and it is already very complex. It shows the complexity of supplementing enough but also not too much of most minerals, to have limited antagonistic effects.

The negative effects of interaction with feed components and competition for absorption on bioavailability can be reduced by combining the mineral with an organic ligand.

Inorganic mineral forms (sulphates) are very weakly bound and are therefore free to interact, while organically bound minerals are not reactive.

The stability of the organic bond is essential to prevent interactions and competition, demonstrating the added value of an organic mineral source. Variable chemical structures and stability between sources may explain the variable effects in ruminants.

In different trials, the high stability of a specific metal glycinate (minerals bound to the amino acid glycine), B-TRAXIM 2C, has been shown and more uniquely also the chemical structure.

Spears et al. (2004) already showed for zinc the improved bioavailability of this specific glycinate in Angus beef steers, compared to non-supplemented animals, or supplementation with inorganic or other organic sources.

Hansen et al. (2008) showed for copper that this specific glycinate could improve the mineral status in beef steers fed high dietary sulphur and molybdenum, compared to copper sulphate.

The improvement of mineral status was even greater when molybdenum levels were increased, showing the benefits of this source when known antagonists are present in the diet.

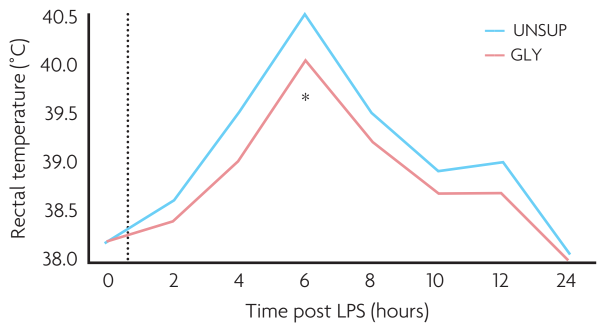


Fig. 4. Rectal temperature of dairy cows after lipopolysaccharide (LPS) challenge.

Improving immunity with specific metal glycinates

Fry et al. (2009) compared the effects of supplementation with two sources of zinc (specific metal-glycinates (BT2C), or zinc sulphate (CTRL)) in a trial with 102 beef steers. The sources were supplemented at 30ppm on top of a receiving and a growing diet containing respectively 22 and 25ppm of zinc.

During the receiving phase (28 days) more than 75% of the animals needed treatment related to respiratory diseases.

Haptoglobin is an acute phase protein, known to increase in case of infection and therefore used as an indicator for infection levels.

Haptoglobin levels were measured at day 0, 7, 14 and 28 in the receiving phase. Starting from day 14, the haptoglobin levels were reduced for the BT2C animals, compared to the CTRL animals (Fig. 2).

This indicates a decrease of infection level for the BT2C group. The observation was also confirmed by a reduced number of animals treated in the BT2C group during this trial.

In the growing phase, steers from each treatment were injected with pig red blood cells to induce an immune reaction. Their immunoglobulin (Ig) level was measured at days 7, 14 and 21 post-injection.

The Ig level indicates the intensity and quality of the immune response.

Animals with higher Ig levels will therefore have a better protection against this infection. BT2C steers showed higher levels of total Ig following the injection than CTRL steers (Fig. 3), this indicates a better immune response for the BT2C group.

It was therefore concluded that supplementation with 30ppm of zinc from a specific metal glycinate reduces infection levels and improves immune response of beef cattle, compared to zinc sulphate.

Improved immune response in lactating dairy cows with metal glycinates

After the findings in beef, Wall et al. (2016) looked at the effects of supplementation with specific metal glycinates on the immune response of lactating dairy cows.

For this, 12 mid-lactation dairy cows were either fed an unsupplemented diet (UNSUP), or the same diet with 30, 30 and 8ppm of zinc, manganese and copper, respectively, added as metal glycinates from B-TRAXIM 2C (GLY).

After 30 days, the copper levels in the serum of the GLY cows were increased significantly, as an indicator for mineral bioavailability.

The neutrophils showed a lower phagocytic index (number of bacteria ingested per phagocyte), but with a trend for a higher intracellular kill, indicating a change in neutrophil function.

On day 30, all dairy cows were challenged by an injection of lipopolysaccharides (LPS) from Escherichia coli into the teat canal, simulating a mastitis infection. All cows showed a marked increase in clinical scores (going up to 4 out of 5 quickly, results not shown), without any effect of treatment.

All cows showed a marked increase in body temperature in the first 24 hours post challenge (Fig. 4), but the GLY cows had a significantly lower body temperature.

Before, during and after the LPS challenge a trend for decreased somatic cell count (SCC) was observed in the GLY cows, with p-values <0.15 (Table 1).

Table 1. Somatic cell count (SCC) in milk before and after lipopolysaccharide challenge.

SCC in log_{10}	UNSUP	GLY	p-value
72-0 hours, pre LPS challenge	5.28	4.66	0.07
0-12 hours, post LPS challenge	7.00	6.75	0.14
24 hours to 7 days, post LPS challenge	6.40	6.20	0.09

After earlier results in beef cattle, it has now been shown that supplementation with mineral glycinates influences the immune response also in lactating dairy cows.

The decreased body temperature after an LPS challenge, combined with the lower SCC in dairy cows supplemented with mineral glycinates, indicates that mineral-glycinate supplementation may improve their ability to fight off infection.

This has implications for mammary health in general and mastitis problems in particular.

Summary and conclusion

Selecting the best source for effective mineral supplementation in ruminants is essential to support optimal performance in high demanding production systems: maintaining high health status and welfare, while increasing the production of high quality milk, with increasing scrutiny on the use of antibiotics.

Using a specific source of metal glycinates has shown to improve bioavailable minerals at the same supplementation levels, with increasing benefits when known antagonists are present.

Both in beef and dairy cattle improved immune responses have been shown in challenged animals, with less veterinary treatments and higher total Ig levels in challenged beef and lower SCC and body temperature in challenged dairy.

This indicates that supplementation with the right mineral source can support the immune system in ruminants and more specifically reduce the impact of (clinical) mastitis on the performance of dairy cows. ■

References are available from the author on request