

THE EFFECTS OF SOME MICROELEMENTS SUPPLEMENTATION – SELENIUM, ZINC AND COPPER INTO DAIRY COWS FEEDS ON THEIR HEALTH AND REPRODUCTIVE PERFORMANCES

Mirjana Joksimović Todorović¹, Vesna Davidović¹, Mirjana Bojanić Rašović²

¹University of Belgrade, Faculty of Agriculture, Nemanjina 6, 11080, Belgrade-Zemun, Republic of Serbia

²University of Montenegro, Biotechnical faculty, Mihaila Lalića 1, Podgorica, Montenegro

Corresponding author: miratodo@agrif.bg.ac.rs

Review paper

Abstract: Microelements such as selenium, zinc and copper are indispensable nutrients for preserving major physiological functions, improving reproductive characteristics and overall health state. By their adequate use different ailments are prevented, while at the same time they have a positive effect on fertility and resistance. Insufficient quantities of these microelements, inadequate absorption and interaction with other microelements may lead to the impairment of the immune response due to metabolic and oxidative stress. In recent years, mainly organic forms of microelements have been administered to animals because they show better biological availability and can be retained longer in the organism. Besides, organic forms improve quality of products for human nutrition. Antioxidants should be added in optimal quantities in food for dairy cows with the aim of maximizing immune function and protection of tissues.

Key words: dairy cows, selenium, copper, zinc, health, reproductive performances

Introduction

Mineral matters play an important role in preserving animal immune function (*Shankar and Prasad, 1998*), fertility (*Rabiee et al., 2010*) and weight gain (*Enjalbert et al., 2006*). During transitional period dairy cows undergo a physiological stress when they prepare for parturition. In addition, significant metabolic changes can occur due to the nutrient needs of mammary gland necessary for the synthesis of milk. Simultaneously there occurs reduced uptake of food, negative energy balance (*Roche et al., 2009*) and oxidative stress (*Sordillo*

and Aitken, 2009). Transitional period is stressful for animals, therefore, decreased retention of mineral matters in the organism can be expected. Parturition and onset of lactation lead to decrease in the concentrations of calcium and zinc (Goff et al., 2002), what is observed also for other mineral matters (copper, selenium, cobalt, iodine) during lactation period. Mineral matters like selenium, zinc, copper, cobalt and iodine play an important role in synthesis of proteins, vitamin metabolism, forming of connective tissue and improvement of immune function. Proper supply of the organism by these minerals has an effect on health, fertility, lactation and immune functions (Griffiths et al., 2007). Moreover, some interactions between mineral matters in digestive tract of ruminants can lead to a significant fall in mineral level. The increase in the level of sulphur from 2 to 4 g/kg in dry matter can reduce the absorption of copper by 54.3 % when the level of molybdenum is 1 mg/kg dry matter. Increase in the concentration of molybdenum from 1 to 10 mg/kg dry matter can decrease absorption of copper by 48.3 % when the concentration of sulphur is 2.5 g/kg dry matter (NRC, 2001).

The role of selenium, zinc and copper in preserving the health status of dairy cows

Selenium is a key food ingredient which provides oxidative protection to the organism. Its biological role is performed through the enzyme glutathione peroxidase (GSH-Px). The activity of this enzyme depends on the level of selenium in food, what can be used as a reliable indicator of biological uptake of selenium. In animal nutrition the organic selenium in the form of selenomethionine and inorganic selenium in the form of Na-selenate or Na-selenite is used. Difference between these two forms is in metabolic pathway and efficiency of action. High levels of inorganic selenium are more toxic than the same levels of organic selenium (Todorović et al., 1999; Joksimović Todorović et al., 2006; Joksimović Todorović and Davidović, 2014). Antioxidative status is one of the factors which impacts the reproduction of dairy cows. Selenium reduces the occurrence of postpartum ailments in dairy cows such as retained placenta, mastitis, metritis, endometritis, ovarian cysts and increases the level of conception. High levels of superoxide (O^{\cdot}) may decrease the function of neutrophils. Inadequate protection against free radicals leads to the reduction of neutrophil granulocytes what may have the incidence of a disease as a consequence. A primary function of selenium is to provide immunological defence and to increase the migration of neutrophil granulocytes into inflammatory region where they will ingest and destroy present bacteria. Selenium deficit leads to a functional disorder of all the cells of the immune system. The activity of T lymphocytes and NK cells (killer cells) is decreased, as well as the synthesis of some antibodies (Sordillo, 2005).

Zinc is an indispensable microelement for maintaining major physiological functions preserving in that way the health of individuals. By adequate zinc supplementation in feeds for dairy cows the incidence of either zinc surplus or deficit in the organism is being prevented (*Davidović et al., 2014, 2015*). Insufficient intake or disturbance in the zinc absorption can weaken the immune system due to metabolic and oxidative stress and development of mastitis (*Anton et al., 2013*). Zinc deficiency can cause the loss of appetite and metabolism disorder since this microelement is included in the synthesis of proteins, metabolism of carbohydrates and nucleic acids. Zinc plays a significant role in the synthesis of DNA and RNA by increasing the cellular replication and cellular proliferation (*Spears and Weiss, 2008*). It affects reproductive functions, secretion of gonadotropine, androgens, prostoglandin and prolactin, and also that of antioxidants (*Arthur, 2001*). *Kellogg et al. (2004)* report that zinc-methionine can significantly increase lactation performance and improve health of mammary gland since it reduces the number of somatic cells.

Copper is an important microelement for preserving health, reproductive status, immune functions and lactation performances in dairy cows. It is an integral part of a great number of metalloenzymes involved in numerous physiological processes such as: cellular respiration, lipids and carbohydrates metabolism, development of connective tissue, processes of myelinization, keratinization and pigmentation (*McDowell, 2003*). The adequate levels of copper in food are indispensable for optimization of immune system, since copper reduces the occurrence of development of metabolic and oxidative stress in dairy cows (*Cortinhas et al., 2010*).

Over a considerable time period these microelements were added into the animal feeds in the form of inorganic salts (sulphate and carbonates). In a last decade, organic sources of microelements (chelate, proteinates) which reduce the interaction of minerals with other matters in rumen preventing the accumulation of undissolving complexes and making in that way their intestinal absorption easier (*Spears, 2003*) were most used. Dairy cows fed rations that contain insufficient quantities of copper are often exposed to the risk of developing mastitis, metritis and disorder in locomotive system (*Enjalbert et al., 2006*). Copper overdose, in quantities higher than 40 mg/kg DM can cause toxicoses if this state is prolonged during lactation (*Engle et al., 2001*). The studies of *Kinal et al. (2007)* and *Joksimović Todorović et al. (2015)* indicate that there are statistically significant differences in the concentration of copper in blood plasma in the individuals fed copper inorganic sources in comparison with the individuals fed copper organic sources. However, *Cortinhas et al. (2012)* did not determine significant differences in the concentrations of copper in blood plasma in the individuals fed inorganic and individuals fed organic copper sources. *Anton et al. (2013)* discuss these results in following direction: the concentration of copper in blood plasma, besides its

adequate supplementation, can be affected by numerous various factors such as infection, inflammation and stress.

The use of microelements with the aim both of preventing postpartum ailments and improving reproductive characteristics

Placenta retention is a disease with a multifactorial etiology while a cause thereof is often unknown. During a transitory period in cows there occur metabolic, hormonal and biochemical changes. A prepartum function of neutrophils decreases what can provoke the occurrence of postpartum diseases. The state in which placenta is retained for more than 12h is considered as having a disease. Numerous factors, including mechanical, nutritive and infective causative agents can impact the incidence of this disease. Incidence of placenta retention is often (about 50% animals) associated with zoonoses, such as brucellosis, salmonellosis, leptospirosis and listeriosis (*Gunay et al., 2011*). One of the studies indicated that placenta retention is one of the major causes of endometritis in cows (*Han and Kim, 2005*). This disease can either reduce fertility and therefore the percentage of conception, complicate conception or prolong a calving interval (*Bella and Roberts, 2007*). Selenium improves the function of neutrophils, influences their migration and chemotactic activity. An increased concentration of cortisol represents a response to stress and inflammation of pregnant uterus. Cortisol can diminish the function of neutrophils or completely prevent their activity and provoke this disease. The increased content of cytotoxic aldehyde (malondialdehyde) in erythrocytes and increased concentration of cortisol are considered as major causes of the onset of this disease. Many studies indicate that adequate levels of selenium, copper, zinc and certain vitamins, which play a role of antioxidants, can decrease the percent of individuals with retained placenta disease. (*Tillard et al., 2008; Sharma et al., 2011; Joksimović Todorović and Davidović, 2007a, 2013*).

The infections of mammary gland and uterus are frequent in dairy cows during peripartum period. Other health disorders which may happen in that period are milk fever and ketosis. Although the etiologies of the infections and metabolic disorders of these two diseases are different there is a significant connection between the incidence of these two ailments. In cows with milk fever clinical mastitis occurs five times more frequently compared to the cows which have no such health problems (*Curtis et al., 1985*). Dairy cows are exposed to numerous genetic, physiological and external factors which can endanger the immunity and increase the frequency of the incidence of mastitis (*Sordillo, 2011*). Selection directed to maximizing milk production increases metabolic stress caused by increased synthesis and secretion of milk and reduces resistance to mastitis.

The application of antioxidants in dairy cows reduces the duration and intensity of disease. Precise mechanisms into the improvement of health of mammary gland are not completely known but they are associated with their antioxidative functions (*Joksimović Todorović and Davidović, 2007b; Joksimović Todorović et al., 2012*). Antioxidants in dairy cows increase the resistance to mastitis, provide phagocytic capacity of neutrophils increasing the chemotaxis at the spot of the infection (*Spears and Weiss, 2008*). *Bicalho et al. (2007)* and *Formigoni et al. (2011)* established that supplementing the mineral matters to dairy cows can lead to decrease in the number of stillborn calves and the incidence of endometritis what is important for preserving proper reproductive performances. The study by *Machado et al. (2012)* showed that systemic addition of microelements to dairy cows` feeds can significantly reduce the number of cows with intrauterine contamination by *Fusobacterium spp.* and *Trueperella spp.* These bacteria are associated with the disease of uterus, particularly the onset of metritis and clinical endometritis. *Manspeaker et al. (1987)* suggest that dairy cows fed chelate minerals during late gestation and lactation have higher fertility due to increased ovarian activity, better involutions, regeneration of endometrial tissue, less periglandular fibrosis and lower mortality of embryos.

The results of the research into the effects of microelements supplementation on reproductive performances are controversial. Some authors reported that mineral matters supplementation can have either a negative (*Vanegas et al., 2004*), positive (*Sales et al., 2011*) or neutral effect (*Vanegas et al., 2004*) on reproductive performances. *Vanegas et al. (2004)* used copper, zinc and manganese in very low concentrations. These authors have determined that once administered mineral matters supplementation postpartum has no effect while two supplementations (the first prepartum and the second postpartum) can reduce reproductive performances. On the other hand, *Sales et al. (2011)* determined an increased levels of conception and embryonal survival in heifers that received subcutaneous injection of the same microelements 17 days before embryotransfer.

Conclusion

The application of organic form of mineral matters in the nutrition of dairy cows during pregnancy and lactation period has a positive effect on immune system and therefore on overall health status. Moreover, their application reduces the percentage of animals with postpartum diseases (placenta retention, mastitis, metritis, endometritis) improving, in that way, their reproductive performances.

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Efekti dodavanja pojedinih mikroelemenata – selena, cinka i bakra u hranu za mlečne krave na zdravlje i reproduktivne performanse

Mirjana Joksimović Todorović, Vesna Davidović, Mirjana Bojanić Rašović

Rezime

Mikroelementi selen, cink i bakar su neophodni nutrijenti za očuvanje osnovnih fizioloških funkcija, zdravlja i poboljšanje reproduktivnih karakteristika. Njihovom adekvatnom primenom preveniraju se različita oboljenja, a istovremeno pozitivno utiče na fertilitet i otpornost. Nedovoljna količina ovih mikroelemenata u obroku, neadekvatna apsorpcija i interakcija sa drugim mikroelementima, mogu dovesti do slabljenja imunskog odgovora usled metaboličkog i oksidativnog stresa. Poslednjih godina, uglavnom se daju organske forme mikroelemenata, jer imaju bolju biološku raspoloživost i duže se zadržavaju u organizmu. Pored toga, organske forme poboljšavaju kvalitet proizvoda namenjenih za ishranu ljudi. Antioksidanse treba dodavati u optimalnim količinama u hranu za mlečne krave u cilju maksimiziranja imunske funkcije i zaštite tkiva.

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