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Popular Article

Nutrients for Mastitis Prevention and Control in Dairy Animals

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Abstract

Mastitis is the major reason for economic loss in dairy farming. The oxidative stress that occurs during the pre-partum as well as post-partum period adversely affect health of dairy cows and lead to immune suppression. Therefore, maintenance of proper nutrition is an important management practice to prevent mastitis in herd. The importance of vitamins and minerals such as Vitamin E, Vitamin A, Vitamin C, Selenium, Copper and Zinc for maintenance of immunity and health of udder is to be considered while developing a mastitis control programme. Nutritional deficiency leads to metabolic diseases which in turn suppresses immune mechanisms.

Keywords: Bovine, Mastitis, Nutrient, Prevention

Introduction

Mastitis is one of the economically devastating diseases affecting dairy animals. It exerts a negative impact on production potential of dairy animals. It deteriorates milk quality and decreases milk yield. There will be significant reduction in economic benefits to farmer. The fields of animal breeding, animal nutrition and husbandry practices that had undergone a paramount advancement play a significant role in increasing production potential of dairy animals over the last decades (Shook, 2006) that aid in meeting the immense demand for milk and milk products. Despite continuous efforts in understanding the host responses to intramammary infections and in developing treatment regimen for preventing and controlling mastitis, the problem of mastitis continues to create the greatest menace to dairy industry worldwide (Atalla *et al*., 2010). There exist a large number of predisposing factors that contribute to emergence of mastitis in dairy animals. Those predisposing factors can be physiological, genetic and pathological or environ- mental (Sordillo, 2005). The mammary glands are getting exposed to potential pathogens frequently. The adequate immunity of animal prevents the mammary gland from getting infected and keeps them away from mastitis. The nutrition has numerous roles to uplift the immune response of dairy animals. Nutrition affects immune system through two major mechanisms:

- Certain nutrients are crucial for specific functions of immune cells and diet that lacks those nutrients can impair immune mechanisms. Vitamin A and Zinc have impact on epithelial health. The phagocytic cells are influenced by micronutrients like Copper, Zinc, Selenium, Vitamin E and Vitamin A.
- Proper nutrition decreases the prevalence of metabolic diseases that can inhibit or suppress immunity. Proper nutrition thereby enhances the immune function and lowers mastitis risk.

Vitamin E and Selenium

Vitamin E is essential for integrity and optimum function of reproductive, muscular, circulatory nervous and immune system in animals and human (Sheffy and Schultz, 1979). Reactive oxygen species generated by aerobic metabolism (superoxide, hydroxyl radicals, hydrogen peroxide etc.) damage cellular proteins, nucleic acids and membrane lipids. There are multiple defense mechanisms that work synergistically against oxidative damage which includes antioxidant enzymes, Vitamin E and Vitamin C (Sies *et al.,* 1992). Vitamin E serves several interrelated functions as it is the primary lipid soluble antioxidant in cell membranes. It is an intracellular defense against adverse effects of reactive oxygen species (Sies *et al.,* 1992), Vitamin E traps lipid peroxyl free radicals produced from unsaturated fatty acids under oxidative stress. Vitamin E and Selenium intensity the immune response against several types of pathogenic organisms. Enhancement of both antibody titer and phagocytosis of pathogens is observed with increasing dietary Vitamin E supplementation in calves, lambs and dairy cows (Weiss et al., 1998). Intracellular destruction of *Staphylococcus aureus* and *Escherichia coli* by neutrophils was amplified by dietary supplementation of Vitamin E (Hogan *et al.,* 1992). Minimum requirement of Vitamin E for dairy cattle (NRC, 2001) has been estimated to range from 10-60 IU per kg of diet dry matter. The dairy NRC (2001) Vitamin E requirement for pregnant heifers and dry pregnant cows ranges from 80-120 IU per kg and for lactating cows it is 16-27 IU per kg. Politis *et al.* (2004) proved that feeding 3,000 IU per day of supplemental Vitamin E in diets containing 0.3 ppm Selenium, for 28 days prior to calving and continuing for 56 days after calving significantly improved neutrophil and macrophage function and reduced somatic cell count in dairy cows.

Vitamin A and β-Carotene

Vitamin A is a crucial micronutrient that plays an inevitable role for maintaining vision, promoting growth and development protecting epithelium and mucus integrity in body. Green and Mellandy (1928) found that Vitamin A could amplify the anti- inflammatory response of organisms and called Vitamin A the 'anti-inflammation vitamin'. Vitamin A performs a critical role in development of immune system. Vitamin A also has regulatory roles in cellular immune responses and humoral immune processes. Keratinization of epithelial tissues due to Vitamin A deficiency results in loss of protective functions in alimentary, genital, reproductive, respiratory and urinary tracts, increasing the susceptibility to infection. Neutrophil function is reduced by Vitamin A deficiency (Twining *et al.*, 1997). Increasing concentrations of Vitamin, A has a positive impact on neutrophils and alveolar macrophages in vitro (Eicher *et al.*, 1994). βeta carotene, a precursor of Vitamin A functions as an antioxidant. It reduces superoxide formation within phagocyte. It can directly enhance immunity exerting this effect on reproductive system and mammary glands. Lactating cows require 3,900 IU per kg feed. Lactating and gestating ewes require between 2,667 or 3,305 IU per kg of feed, respectively. The Vitamin A requirements for small ruminants are 45.5 retinol equivalent per kg body weight for late gestation and 53.5 RE per kg body weight for lactation.

Vitamin C

Vitamin C is a water-soluble antioxidant in cells, tissues and gastrointestinal tract. It is involved in synthesis of adrenal steroids and catecholamines, synthesis of carnitine (hydroxylation of tri methyl lysine) and synthesis of bioactive amines in brain and nervous system. It is inevitable for detoxification of toxins, natural compounds and other xenobiotics by liver microsomes. It is essential for normal functioning and stability of leukocytes and erythrocytes. It has antihistamine and anti- inflammatory properties. It is an anti-endotoxin. When bovine mastitis is considered, Vitamin C acts as oxidative stress biomarkers. Administration of Vitamin C subcutaneously in cows may have therapeutic value in mastitis but it has reduced therapeutic effect due to lipid peroxidation (Ranjan *et al.*, 2005), Ascorbic acid was successful to prevent and treat the mastitis of dairy cows as teat dip or intramammary infusion along with cupric ions (Naresh *et al.*, 2002). Kleczkowski *et al.* (2005) observed lower ascorbic acid concentration in serum of cows affected with mastitis.

Zinc

Zinc is an essential nutrient for animals, functioning largely or entirely in enzyme systems and being involved in protein synthesis, carbohydrate metabolism and many other biochemical reactions. Zinc is known to play a pivotal role in immune system. It is clear that zinc affects multiple aspects of immune system, from the barrier of skin to gene regulation within lymphocytes. Zinc is crucial for normal development and function of cells mediating non- specific immunity such as neutrophils and natural killer cells. Zinc deficiency also affects development of acquired immunity by preventing both the outgrowth and certain functions of T lymphocytes such as activation. Th1 cytokine production and B lymphocyte help. Zinc also functions as an antioxidant and can stabilize membranes. Zinc is required for keratin formation. Spain et at (2005) proved that cows supplemented with zinc methionine had significantly higher teat canal keratin. Studies conducted to analyses the effect of supplemental zinc methionine on somatic cell count found that in most cases supplementation statistically or numerically reduced SCC. In some studies, SCC reduction was about 22% (Kincaid et al., 1984). Organic forms of Zinc appear to be better absorbed and retained by animal. Popovic (2004) by replacing 33% of supplemental Inorganic zinc sulphate with organic zinc (zinc proteinate) from 45 days pre- calving until 100 days post calving found that cows receiving the organic zinc had significantly lower SCC (62,670 vs 116,440 cells/ml at day 100 respectively). Replacement of 50% supplemental inorganic Zinc with organic zinc (zinc proteinate) in cows had led to significantly fewer new intra- mammary infections (Spain *et al.*, 1993).

Copper

Copper plays an important role in immune mechanisms. Copper is a component of the enzyme ceruloplasmin, synthesized in liver, which helps in iron absorption and transport. Besides this copper is an important part of superoxide dismutase, an enzyme that protects cells from toxic effects of oxygen metabolites released during phagocytosis. Either of these functions is important in reducing the incidence of mastitis during the peri-parturient period. Copper supplementation in heifers from 60 days pre-calving and up to 30 days post-partum decreases the severity of Escherichia coli induced mastitis (Scalleti *et al.*, 2003). Apart from this cow supplemented with copper had fewer infected quarters and fewer intramammary infections caused by major mastitis pathogens but no difference in prevalence of coagulase-negative Staphylococcal mastitis at calving (Scalleti *et al.*, 2003). NRC (2001) recommends 11 mg/kg copper supplementation for lactating cows.

Calcium

Milk fever cows are more susceptible in developing mastitis, Calcium is essential for proper contraction of muscle. Severe hypocalcemia lead to reduced muscle contraction to the point that clinical syndrome known as milk fever occurs. Muscle contraction is reduced by any decrease in blood calcium. The contraction rate and strength of muscle of intestinal tract is directly proportional to blood calcium concentration. The teat sphincter consists of smooth muscle which must contract if closure of teat end is to occur. If low blood calcium reduces teat sphincter contraction the teat canal may remain open inviting environmental pathogens to enter the mammary gland. Hypocalcemic cows tend to spend more time lying down than do normocalcaemic animals. Again this could increase teat end exposure to environmental opportunists. Calcium is required for proper functioning of immune cells. The immune cells got suppressed hypocalcemia persists. In hypocalcaemic animals the plasma cortisol level will be higher that leads to suppression of immune system. The amount of calcium/kg milk produced varies slightly with amount of protein in milk which in turn varies with breed. The absorbed calcium required/kg milk produced is 1.22

grams for Holstein cows, 1.45 grams for Jersey cows, and 1.37 grams for other breeds. Cows require about 2.1 grams absorbed calcium/kg of colostrum produced.

Energy

Ketosis, a metabolic disorder that occurs in cattle when energy demand exceeds energy intake and result in negative energy balance. Ketotic cows often show reduced blood glucose concentration. When large amounts of body fat are utilized as an energy source to support production, fat is sometimes mobilized faster than liver can properly metabolize it. If this situation occurs, ketone production exceeds ketone utilization by cow, and ketosis results. In dairy cow, the mismatch between input and output usually occurs in first few weeks of lactation, because cow is not able to eat enough to match the energy lost in milk. Clinical ketosis as well as sub-clinical ketosis has a negative impact on immune system of affected animals. There is an increased incidence of mastitis and metritis in those affected animals which significantly reduces the retention times of these animals in farm from the economic point of view (Uyarlar *et al.*, 2018)

Conclusion

Nutrition enhances the animal's resistance to mastitis, though it has no influence on exposure of teat ends to pathogens. Mastitis control strategy includes annual milking machine test, post-milking teat disinfection, dry cow therapy on all cows, correct treatment of clinical cases and record keeping, culling chronically infected cows and provide clean dry environment for cows. The adequate amount of energy, minerals and vitamins for optimal milk production is essential for maintenance of udder health and immune status. It should be taken into consideration that potential influence of energy balance, mineral or vitamin status has no capability to surpass the effect of poor control measures, A holistic approach to mastitis control should be taken and nutritional management is last one component of control programme.

References

Atalla, H. Wilkie, B., Gyles, C., Leslie, K., Mutharia, Land Mallard, B. (2010). Antibody and cell-mediated immune responses to Staphylococcus aureus small colony variants and their parental strains associated with bovine mastitis. Dev Comp Immunol., 34: 1283-90.

Eicher, S.D., Morrill, J.L. and Blecha, F. (1994). Vitamin concentration and function of leukocytes from dairy calves supplemented with Vitamin A, Vitamin E and beta-carotene in vitro. J. Dairy Sci. 77: 560-65,

Hogan, J.S., Smith, K.L, Weiss, W., Todhunter, DA, and Schockey, W. L (1990). Relationships among vitamin E. Selenium, and bovine blood neutrophils. J. Dairy Sci.73: 2372.

Kincaid, R.L., Hodgson, A.S. and Riley, R.E. (1984), Supplementation of diets for lactating with zinc oxide and zno methionine, J. Dairy Sci Suppl. 1:103.

Kleczkowski, M., Klucinski, W., Shaktur, A. and Sikora, J. (2005). Concentration of ascorbic acid in the blood of cows with subclinical mastitis. Polish J. Vet. Sci. 8: 121-25.

Mellanby, E and Green, H.N. (1928). Vitamin A as an anti-infective agent. Br. Med. J. 2: 691-96:

Naresh, R., Dwivedi, S.K., Swarup, D. and Patra, R.C. (2002). Evaluation of ascorbic acid treatment in clinical and sub-clinical mastitis of Indian dairy cows. J. Anim. Sci. 5.905-11.

National Research Council (2001). Nutrients Requirements of Dairy Cattle 7 Revised Edn. National Academy Press, Washington DC.

Politis, I. Bizelis, I., Tsiaras, A. and Baldi, A. (2004). Effect of Vitamin E supplementation on neutrophil function, milk composition and plasmin activity in dairy cows in a commercial herd. J. Dairy Res. 71: 273-78,

Popovic, Z. (2004). Performance and udder health status of dairy cows influenced by organically bound zinc and chromium, Ph.D. Thesis, University of Belgrade, Putman ME. Comben N (1987) Vitamin E. Vet. Rec. 121: 541.

Ranjan, R., Swarup, D., Naresh, R. and Patra, R.C. (2005) Enhanced erythrocytic lipid petroxides and reduced plasma ascorbic acid and alteration in blood trace elements level In dairy cows with mastitis. Vet. Res. Comm. 29: 27-34.

Scaletti, R.W., Trammell, D.S., Smith, B.A. and Harmon, R. J. (2003), Role of dietary copper in enhancing resistance to Escherichia coll mastitis. J. Dairy Sci. 86. 1240-49.

Sheffy, BE and Schultz, R.D. (1979), Influence of vitamin E and selenium on immune response mechanisms. Fed Proc. 38: 2139-43.

Shook, G.E. (2006) Major Advances in Determining Appropriate Selection Goals. J. Dairy Sci. 89: 1349-61.

Sies, H., Stahl, W. and Sundquist, A. R. (1992) Antioxidant functions of vitamins. Vitamins E and C, beta-carotene and other carotenoids. Ann NY Acad Sci. 669: 7-20.

Sordillo, L.M. (2005), Factors affecting mammary gland immunity and mastitis susceptibility. Livestock Prod. Sci. 98: 89-99.

Spain, J.N., Jones, C.A. and Rapp. C. (2005). The effect of complexed zinc on keratin synthesis in the teat canal and the establishment and severity of experimentally induced E coll mastitis in dairy cows. In: Mastitis in dairy production: Current knowledge and future solutions. Hogeveen H (ed). 948.

Spain, J.N., Stevens, B.J. and Hardin, D.K. (1993). Effects of Bioplex zinc or zinc oxide on mastitis incidence in lactating dairy cows. J. Dairy Sci. 76: 265

Twining, S., Schulte D.P., Wilson, P.M., Fish B.L and Moulder, JE (1997). Vitamin A Deficiency Alters Rat Neutrophil Function. J. Nutr. 127: 558-65.

Uyarlar, C., Cetingül, I.S., Gültepe, EE, Sial, AR and Bayram, I. (2018). Effects of Sub-clinical and Clinical Ketosis on the Incidence of Mastitis, Metritis, Culling Rate and Some Hematological Parameters in Dairy Cows. Kocatepe Vet J. 11: 186-93.

Weiss, A., Herzig, A., Jacobs, H. and Lehner, C.F. (1998). Continuous Cyclin E expression inhibits progression through endoreduplication cycles in Drosophila. Curr. Biol 8: 239-42.