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# Review: Nutritional Approach to Prevent Mastitis of Dairy Cattle

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**Abstract** Mastitis is the most vulnerable disease from the economic point of any dairy farm world-wide.Mastitis ranked 1st among the diseases in India for dairy industries caused severe production and productivity losses. Mastitis is inflammation of the mammary gland due to invasion of pathogens by any means. Nutrition indirectly effects on mastitis via maintenance of the immune system affecting infection rate. Several nutrients are involved to prevent mastitis and require proper balancing of the nutrients in every day rations.

**Keywords** Cattle, Mastitis, Nutrients balance, Management.

## Introduction

Mastitis is a serious issue in dairy farming worldwide, one of the major causes of low productivity and poor quality of milk, ranked 1st among the diseases that cause huge economic loss to dairy farmers and accounted INR 7165.51 crores losses per annum (NAAS 2013). Mastitis is inflammation of the mammary gland mainly caused by the intramammary invasion of pathogens and it can also occur due to the injury of the cow's udder. Mastitis is one of the most frequent diseases of dairy cattle where the cost of treatment is very expensive. The mastitis are of two types-clinical mastitis and subclinical mastitis ; in clinical mastitis observed secretion of abnormal milk with inflammation of the udder tissues whereas subclinical mastitis affects milk production and its quality and the presence of inflammatory components in the milk (Heringstad et al. 2000). The subclinical mastitis can easily be detected by high somatic cells count (SCC) ; usually, the threshold value of SCC is 200,000 cells/ml between normal and infected milk (Daley 1991). A case report found that the incidence of clinical mastitis was 1–10% with subclinical cases ranges from 10–50% in cows whereas 5–20% in buffaloes (Sharma 2007). In crossbred, the incidence of clinical mastitis range from 14.0 to 38.46% (Sharma 2010, Jingar et al. 2014). It was reported that 70% economic loss due to subclinical mastitis in India (Varshney and Naresh 2004). To know about several factors that cause the mastitis incidence in a dairy farm, help for the better economy.

## Factors contributing to mastitis

Several factors are responsible for mastitis like housing, bedding, health condition, microclimatic condition, genetics and nutrition of animal. The nutritional management stimulates the immune system at the onset of lactation (require a huge amount of protein or energy to maintain body energy balance, production and immunity status).

## The nutritional impact on mastitis

The cow's mammary glands are frequently exposed to potential pathogens, but because of cow's adequate immunity to prevent infection, they do not get masti-

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**Table 1.** Summary of minerals and vitamins present in antioxidant system present of mammalian cells (Modified from Weiss 2005). Vitamin A and β-carotene.

| Components | Location in cell | Nutrients involved | Function |
|---|---|---|---|
| Superoxide dismutase | Cytosol | Copper and zinc | An enzyme that converts superoxide to hydrogen peroxide |
| Superoxide dismutase | Mitochondria | Manganese and zinc | An enzyme that converts superoxide to hydrogen peroxide |
| Ceruloplasmin | Water phase | Copper | An antioxidant protein, may prevent copper and iron from participating in oxidation reactions |
| Glutathione peroxidase | Cytosol | Selenium | An enzyme that converts hydrogen peroxide to water |
| Catalase | Cytosol | Iron | An enzyme (primarily in liver) that converts hydrogen peroxide to water |
| Ascorbic acid | Cytosol | Vitamin C | Reacts with several types of ROM |
| α-tocopherol | Membranes | Vitamin E | Breaks fatty acid peroxidation chain reactions |
| β-carotene | Membranes | β-carotene | Prevents initation of fatty acid peroxidation chain reactions |

tis. The nutrition has many roles to boost the immune system in dairy cattle. Nutrition can affect the immune system of cattle through the 2 main mechanisms. First, certain nutrients are required for specific functions of immune cells, and diets that are the deficit in those nutrients can impair immunity while providing sufficient nutrients for other functions, like for milk production. Secondly, proper nutrition reduces the prevalence of metabolic conditions that inhibit or suppress immunity ; enhance immune function and reduce mastitis risk.

Several trace minerals and antioxidants play important roles in immune function. Vit A and Zn influence epithelial health, the activity of phagocytic cells is influenced by a number of nutrients like Cu, Zn, Se, Vit A and Vit E. Supplement of Vit E has been shown to improve neutrophil function in dairy cattle (Politis et al. 2004).

## Ca : P ratio

In freshly parturient dairy cows, inability to maintain normal Ca levels leads to milk fever and cows spend their maximum time in lying down, makes their teats more prone to infections by pathogens. The risk of periparturient problems such as dystocia, retained placenta (RP), metritis, mastitis increases in sub-optimum Ca homeostasis (Mulligan et al. 2006). Due to hypocalcaemia teat-end sphincter may contract slower and less completely, allowing bacteria to enter the mammary gland (Curtis et al. 1983). For proper functioning of immune cells calcium is required but in hypocalcaemia, these cells don't work properly and the immune system of animal gets suppressed. In milk fever condition cows have higher plasma cortisol levels that suppressed immune function.

Feeding low DCAD during the 3 to 4 wk before calving had beneficial effects on systemic acid-base status, calcium metabolism, prepartum health and also postpartum productive performance (Horst et al. 1994). Dairy cows feeding with negative DCAD (–45 mEq/kg DM DCAD level) during the perparturient period can increase the blood calcium levels and reduces the incidence of postparturient problems (Babir et al. 2017).

## Antioxidants

When the mammary gland becomes infected, an inflammatory response leada to the production of free radicles in substantial amount. Free radicals are kept in check, when adequate antioxidants are present, which increases the lifespan of certain immune cells. In presence of limited antioxidant capacity, the lifespan of those immune cells is reduced and the infection can become established or severity of the infection can increase. Cells and animals have developed sophisticated antioxidants systems which depend on antioxidant nutrients (Table 1) to control oxidative stress. Optimum levels of Cu, Mn, Fe, Se, Zn as well as feed antioxidants (Natural and synthetic)

help to establish the sufficient levels of endogenous antioxidants in the tissues.

For all cellular division and differentiation, Vit A is essential and it has a key role in the inhibition of keratinization. Deficiency of Vitamin A results in hyperkeratinization of the secretory epithelium. Unhealthy epithelium cells increase the chance of infectious organisms to enter through this and finally increasing the susceptibility to diseases. Vitamin A and β-carotene have stimulatory effects on immune cells. In the mammary gland polymorphonuclear neutrophils (PMN) are the major line of defense against bacteria. Supplementation of β-carotene around dry off period exerts a stabilizing effect on PMN and lymphocyte function (Tjoelker et al. 1990). Daniel et al. (1991) concluded that β-carotene enhanced the bactericidal activity of milk and blood PMN, against *S. aureus* but has not affect phagocytosis.

The β-carotene acts as an antioxidant by reducing the superoxide formation within the phagocyte. Dry and lactating cow's diet should contain 110 IU/kg bwt/day and growing dairy animals should be supplemented with 80 IU/kg bwt/day of Vit A (NRC 2001). Plasma concentrations of β-carotene should be > 3 mg/lto optimize udder health in dairy cattle (Jukola et al. 1996).

**Vitamin E and selenium**

Vitamin E (1$^{st}$ line of defense against peroxidation of phospholipids) is a fat-soluble antioxidant and has an important role in the immune response of dairy cows. Vitamin E acts as a chain-breaking antioxidant, prevents oxidation of lipids presents in membranes and neutralizes the free redicals (McDowell 2000). α-tocopherol is principal vitamin E from having antioxidant properties and immune functions. Selenium is the integral part of glutathione peroxidase (Destroys peroxides and hydroperoxides) and presents the 2$^{nd}$ line of defense. Fresh forage is the excellent source of Vit E ; however stored or conserved forages like hay, haylages and silage and concentrate are generally low in Vitamin E (NRC 2001).

As the parturition approaches, blood levels of vitamin E decreases and remain low for several days postpartum. Vitamin E is directly associated with the neutrophil function in dairy cows by improving the killing ability of blood neutrophils during the periparturient period. Adequate vitamin E levels in the polymorph nuclear neutrophils allow a more active and more prolonged effect of a cow's natural immune system on invading bacteria. During the last 60 days of gestation, dry cows should be provided with 80 IU/kg DMI of Vit E (NRC 2001). Lactating cows should be given with 20 IU/kg DMI of Vit E. Plasma concentrations of greater than 3.5 to 4 mg/ml of α-tocopherol are considered adequate.

Glutathione peroxidase and thioredoxin reductase which function in preventing oxidative stress contains Selenium is an essential component. Se has a protective effect on phagocytic cells from autoxidative damage during the respiratory burst. Selenium can be supplemented at the rate of 0.3 ppm in the diet of cattle.

**Ascorbic acid**

Animals including ruminants can synthesize vitamin C through the glucuronic acid pathway from D-glucose or D-galactose (Basu and Schorah 1982). For mammals, ascorbic acid is the most abundant and important water-soluble antioxidant (Sauberlich 1994). Ascorbic acid represents one of the important antioxidant defences against oxidative damage ; by rapid electron transfer, it scavenges aqueous reactive oxygen species and thus inhibits lipid peroxidation. In the case of bovine mastitis, it acts as oxidative stress biomarkers. Kleczkowski et al. (2005) reported lower ascorbic acid concentration in the serum of cows affected with mastitis.

Administration of Vitamin C subcutaneously in cows may have therapeutic value in mastitis however in the presence of lipid peroxidation its therapeutic effect decreased with some improvement in clinical signs of mastitis (Ranjan et al. 2005). Along with cupric ions, ascorbic acid was successful to prevent and treat the mastitis of dairy cows as teat dip or intramammary infusion (Naresh et al. 2002).

## Copper and Zinc

Copper plays an important role in immunity and it is an integral part of many enzymes. Ceruloplasmin (antioxidant protein, synthesized in the liver) and superoxide dismutase contains copper as a component of the enzyme. Ceruloplasmin prevents copper from participating in oxidation reactions and also helps in iron absorption and transport. Superoxide dismutase converts superoxide to hydrogen peroxide, protects cells from the toxic effects of oxygenmetabolites. In copper deficiency, bacterial capacity of polymorphonuclear cells got reduced (Xin et al. 1991). For copper supplementation copper sulfate and copper proteinates are the recommended sources.

Zinc has a role in cellular repair and replacement thus plays an important role in maintaining health and integrity of the skin. Due to its role in keratin formation, Zn reduces somatic cell count. Being a part of a group of elements that induces the synthesis of metallothionein (binds to free radicals) zinc has an antioxidant role. Superoxide dismutase enzyme contains Zn, it can stabilize cell membrane structures. Zinc oxide, zinc methionine, and zinc sulfate are common sources of zinc. Diets of dairy cattle should contain about 20 ppm of copper (assuming no antagonists) and 50 to 60 ppm of zinc.

## Mammary health maintenance tips

(1) Immediately after milking dairy, cows never allow for late down, (2) Proper maintenance of the dry cow therapy, (3) Feed adequately in late-lactation and dry period to maintain optimum body condition, (4) Prevent hypocalcaemia condition with the nutritional supplement in dry cattle, (5) The trace minerals and vitamins added to feed inadequately, selenium and Vitamin E are most critical.

## Conclusion

Mastitis is the major cause of economic loss in dairy farming. The oxidative stress during per and post-partum period have the severe impact on the health of dairy cows, led to immune suppression. The maintenance of proper nutrition is a key control point to prevent mastitis problem. Several studies showed the importance of vitamins and minerals such as Vit E, Vit A Se, Cu, Zn for maintenance of immunity and health of udder. Improving immunity through nutritional supplement is effective nutritional management against invading several pathogens to control mastitis.

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