



## SIGNIFICANCE OF ANTIOXIDANTS IN MAINTAINING DAIRY AND BEEF ANIMALS' HEALTH

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### ABSTRACT

Oxidation and reduction reactions occurring inside the cell must be maintained in the state of equilibrium so that the integrity of cells can be maintained and production of the animals remains at optimum. If there is imbalance between redox reaction, health of the animals gets affected in terms of onset of various reproductive disorders and diseases like mastitis. A number of antioxidants are produced naturally inside the body but under stressful endogenous and exogenous environment, their production is hampered. Thus, supplementation of animals with antioxidants like vitamin C and Vitamin E in feed or parenteral administration is essential to keep the animal healthy to get maximum possible production.

### 1. INTRODUCTION

Oxygen is a fundamental substrate required for aerobic energy production in all of the higher animals. This energy generation process also produces minute amounts of some substances, known as free radicals that are hazardous to biological structures. These free radicals oxidize lipids and proteins present within lipid bilayer membrane of the cells leading to cellular necrosis [1]. There exist a huge number of molecular species which are capable of producing free radicals and collectively they are referred as Reactive Oxygen Species [ROS]. Main ROS produced within the cell are nitric oxide and superoxide radicals that are transformed to potent oxidizing radicals like alkoxy radicals, hydroxyl radical, peroxy radicals and singlet oxygen through highly complicated transformation reactions. A few ROS are transformed to more dangerous molecular oxidants including peroxynitrite and hydrogen peroxide [2,3].

ROS that are either produced through normal metabolism or the metabolism boosted by xenobiotics are capable of causing impairments in the performance of dairy animals [4]. These ROS cause potential direct and indirect damages to the cell. Lipid peroxidation of cell membrane and other components are amongst the direct injuries caused by ROS. Indirectly, ROS affect the body through alterations in metabolic functions and diversion of glucose from other pathways by induction of monophosphate shunt as a result of consumption of reducing equivalents [5].

Oxidative stress, a state of imbalance between oxidation and reduction reactions within the biological system due to production of ROS, has been found to cause various abnormalities / disease in both human and animals. In humans, oxidative stress leads to development degenerative and chronic diseases like autoimmune impairments, cancer, cataract, rheumatoid arthritis, aging, neurodegenerative and cardiovascular diseases. While in animals, oxidative stress lead to many diseases / conditions including mastitis, poor milk quality, decreased milk quantity, immunosuppression, reproductive disorders and poor meat quality [6].

Antioxidants are the molecules which can easily up an electron and resultantly slow down the oxidation process of other molecules. Within the body, two types of antioxidants are produced naturally viz. enzymatic antioxidants and non-enzymatic antioxidants. Examples of enzymatic antioxidants include catalase, superoxide dismutase, glutathione reductase and glutathione peroxidase [7]. Examples of non-enzymatic antioxidants produced within the body through normal metabolism include glutathione, lipid acid, bilirubin, uric acid, coenzyme Q10, L-arginine and metal-chelating proteins "transferrin" [8,9]. There is another class of non-enzymatic antioxidants that comprises of nutritional antioxidants that can't be manufactured by the cellular machinery and have to be supplied in feed. These nutritional antioxidants include vitamin C, vitamin E, flavonoids, omega-3 fatty acids, carotenoids and trace metals like selenium, zinc and manganese [10]. In this article, a brief overview about oxidative stress and importance of antioxidants in maintaining dairy animal health at optimum level are discussed.

### 2. MASTITIS AND OXIDATION PROCESS

Mastitis is an economically important disease of dairy animals all over the globe. It is caused by variety of etiological agents and factors including oxidative stress. In sheep and goat, mastitis not only decreases production but also lead to high mortality in peracute and acute forms. As a result of production of free radicals, normal microflora of the lactating animal gets disturbed leading to high levels of nitric oxide and decreased level of vitamin C in both milk and blood of the animal. It is mostly evident in subclinical disease [11,12]. Supplementation of antioxidants in feed of the animal significantly reduces incidence, duration and severity of clinical form of mastitis. Vitamin E and selenium supplementation has been found to reduce all of these in addition to reduction in somatic cell count [13].

Milk quality and quantity are affected by mastitis and the extent of changes in quantity and quality are dependent upon the degree of inflammation. Drop in milk constituents like casein, fat and calcium and increase in whey, sodium and chloride in mastitis change technological and organoleptic properties of milk [14,15]. Milk quality is also governed by a low somatic cell count which actually reflects the increase in vascular permeability and escape of leucocytes from blood vessels into the blood. Antioxidant supplementation reduces inflammation and hence migration of leucocytes into the milk [16].

### 3. REPRODUCTIVE ISSUES

Deficit of antioxidants has also been found to have relevance with occurrence of reproductive failures. For example, transport of semen in the oviduct and muscular tone of uterus is dependent upon antioxidants. If there is deficiency of antioxidants, retained fetal membrane (RFM) followed by parturition can occur. It has been found that the level of Vitamin C level in both the placental tissue and dam are 50% lower in cows when they have RFM than when they do not have. Moreover, supplementation with vitamin E and selenium (0.3 mg/kg diet) in pre-partum period can decrease the chances of RFM [17].

### 4. IMMUNE SYSTEM

The immune system is responsible for protection against infection by destroying the pathogens such as bacteria, viruses, and protozoan parasites. Antioxidants play a vital role in boosting up the immune functions of the body and reducing the chances of incidence of bacterial, viral and protozoan diseases. Depletion of antioxidants in body adversely affects phagocytic activity body's defense cells. Decreased phagocytic activity may lead to increased incidence of mastitis and variety of infectious diseases before, during and after parturition [18]. Vitamin E quenches free-radicals and increases the efficiency of neutrophils as it protects the cell membrane of neutrophils from lipid peroxidation followed by engulfing and killing of bacteria. Vitamin E has also been found to decrease the levels of glucocorticoids which are immunosuppressive in their actions [19]. Apart from phagocytosis, Vitamin A is essential for normal development and optimal functioning of T and B lymphocytes. Low vitamin A level in

body results in poor antibody response followed by vaccination and reduction of cell-mediated immunity [20].

## 5. PERIPARTURIENT PERIOD

The periparturient period is a testing time for dairy animals and they have to cope with endocrine, metabolic and physiological changes in addition to managerial and environmental stressors [21]. This transition period is characterized by many folds increased risk of infectious and metabolic diseases. It is mainly due to impaired immune system during peripartum phases. This transition period is of high significance for health and performance of dairy animals. Levels of Vitamin A, Vitamin E and P-Carotene decrease in pregnant animals gradually and reach to a minimum value during parturition and then start to rise in the post-partum period. The fall in levels is due to utilization of these vitamins for colostrum and milk synthesis. It has been found that somatic cell count in milk during lactation is less in cows that were supplemented with P-Carotene and vitamins A [22]. Levels of these antioxidants can be much higher during stress periods like parturition as compared to stress-free phases of life. Concentration of vitamin E in plasma is lowest during periparturient period when the phagocytic activity of neutrophils is depressed. So, there is need of supplementing Vitamin E every day until the transition period is over [23].

## 6. MEAT QUALITY

Lipid peroxidation is a free radical mediated reaction that can appear in different cells including myocytes adversely affecting meat quality. This oxidation stress lead to malodor and imparts off-flavors to meat paving the way for lower palatability. Moreover, nutritional quality is also affected as there is reduction in fat soluble vitamins, pigments and polyunsaturated fatty acids. In addition, there is production of aldehydes and peroxides that can be toxic for the consumers of such quality compromised meat [24,25].

## 7. RECOMMENDATIONS

With the aim of preventing oxidation process, a few recommendations are given. Administration of selenium at dose rate 0.1mg/kg body weight intra-muscularly can save the animal from oxidative stress. Selenium has also been found to reduce duration of stress induced clinical mastitis in ruminants. Selenium supplementation at the dose rate 0.3mg/kg body weight should be done 15 days pre-partum as it also reduces the incidence of retention of fetal membranes. Oral supplementation of vitamin E at dose rate of 740IU per day is highly beneficial in order to reduce both the incidence and duration of mastitis due to oxidative stress.

## 8. CONCLUSION

Cells contain potent antioxidant enzymes and molecules which may not be capable enough to normalize the redox status during oxidative stress. Under such scenarios, supplementation with exogenous antioxidants is required. Vitamin A is present in high amounts in many of the animal feed stuffs and vitamin C is produced naturally in the tissues of farm animals. However, supplementation of both of these vitamins can further secure the health of the animal. Vitamin-E is a lipid soluble antioxidant that protects against free radical-initiated lipid peroxidation. Thus, supplementation of antioxidants in feed of the animal or parenteral administration is much important to prevent free radical formation, infections and other disorders such as mastitis in animals.

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