

Review Article

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Importance of Trace Minerals in the Ration of Breeding Bull - A Review

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ABSTRACT

Proper feeding management of the breeding bulls becomes more important for production of good quality semen. Ration of breeding bull need to supply essential nutrients to sustain life and maximize production of semen. Essential nutrients are classified as energy, protein, water, vitamins and minerals. Minerals are classified as Major and trace mineral. Trace mineral play an important role in male reproduction, as an imbalance in their amounts may lead to defective spermatogenesis, reduced libido and ultimately lead to reduced male fertility. Supplementation of mineral has the ability to increase male reproductive performance that is why mineral in the ration of breeding bull cannot be ignored. This review will provide information to understanding the important role of trace minerals in breeding bull for good semen production.

Keywords

Trace minerals, Ration, and breeding bull.

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Introduction

Reproductive performance of animals is the reflection of many factors, individually and in combination, springing from different aspects viz; genetics, nutrition, management and environment (Kumar, 2003). These different areas are equally significant; however, nutrition is most important aspect as it can be easily manipulated and has profound effect on animal reproductive performance. After energy and protein, minerals are the major nutrients and should be required in order to optimize reproduction in breeding bull. Deficiency of minerals may leads to certain structural, physiological or immunological disorder affecting growth, production and reproductive health of breeding bull. Minerals are important in reproductive processes due to

their direct role in maintenance, metabolism and growth. Trace minerals nutrition is critical, since even minute fluctuation in their levels will have significant impact on reproductive health and performance of animals (Hedao *et al.*, 2008).

Trace minerals are required in small amounts (<100 mg/kg DM) (McDowell, 1992; NRC, 1996) and are present in very minute quantities in animals (<50 mg/kg). Requirements of minerals for reproduction and immunity are generally greater than maintenance requirement of bull which might require supplementation of that mineral. Supplementation of minerals in ration of breeding bulls requires good knowledge of

bioavailability, sources of mineral, requirement of animal and mineral interactions with other nutrients. Trace mineral such as Se (Selenium), Zn (Zinc), Cu (copper), Mn (manganese), Co (Cobalt), Fe (Iron) and I (Iodine) are important in male fertility because of their importance in the functioning of different enzymes and protein. Trace minerals have a great impact on animal's reproductive physiology and its deficiency or excess causes various problems leading to lowered reproductive efficiency and resultant pecuniary loss to the dairy industry.

Adequate micro minerals supplementation is required for bull fertility because most of the roughages, greens, concentrates, unconventional feed and even most of commercial feeds available to Indian market are deficient in trace mineral elements, as in most parts of the India soils are deficient in trace element such as Cu, Zn, Fe and Mn.

Correcting an imbalance in mineral levels can solve this problem by improving reproductive performance and health of bull with little additional cost. Terrain and agroclimatic area of India is quite diverse in respect to mineral status, so one therapeutic treatment may not be suitable for other regions. Hence there is a need to map the mineral status in different soils, fodders and animals, so accordingly an area specific mineral may be formed and then supplemented to bulls.

Trace minerals are present in the animal almost entirely as organic complexes or chelates and not as free inorganic ions. Thus, it has been suggested that dietary organic trace minerals could be more efficiently utilized in body. Studies indicate that organic forms of trace minerals can improve reproductive performance of animal more than their inorganic counterparts, particularly during times of stress.

Zinc

Zn plays an important role in the immune system and certain reproductive hormones formation. Synthesis of testosterone is dependent on adequate dietary Zn. It is a structural part of protein that involved in synthesis and secretion of testosterone. It seems to have regulatory role in the level of dihydrotestosterone by modulating the 5 α -reductase activity, as zinc has been reported to affect the testicular function by activating adenylycyclase system, which stimulates the testosterone synthesis. It is also needed for the normal functioning of the hypothalamus-pituitary-gonadal axis which plays an important role in production and secretion of FSH, LH and prolactin and these in turn, regulate testosterone production (Bedwal and Bahuguna, 1994). A deficiency of Zn in males reduces testicular development, sperm production, poor semen quality and libido. Minerals such as Cu, Cd, Ca and Fe act as antagonist for Zn and reduce Zn absorption and interfere with its metabolism. Requirement of Zn in diet of cattle is 40 ppm (NRC, 2001) and toxic Zn dietary concentration is 500 ppm for all classes of beef cattle, including bulls. The Zn levels in seminal plasma are 10-15 folds higher than those in blood plasma of the bull (Dhami *et al.*, 2001; Roy, 2006). Testicular atrophy is the direct consequence of Zn deficiency. A positive correlation exists between testicular development and semen quality so Zn deficiency leads to poor semen quality. ZnSO₄ and Zn propionate in the diet of crossbred cattle bulls have improved semen quality in terms of quantitative and qualitative characteristics of semen (Kumar *et al.*, 2006). Organic form of Zn (Zn propionate) showed a better response in improving sperm per ejaculate, mass motility and semen fertility test like bovine cervical mucus penetration test (Kumar *et al.*, 2006). It controls the motility of sperms by influencing

development of flagellar system of spermatozoa tail. Zn localizes in the sperm middle piece in association with lipoprotein fraction and it is involved in catabolism of lipid, which is the principle source of energy required for movement of spermatozoa. High concentration of Zn in the spermatozoa is essential for viability and fertility of bull. Zn has a role in reducing circulating anti-sperm antibodies which prevents asthenozoospermia, which is associated with high level of anti-sperm antibodies (Omu *et al.*, 1988). Zn plays an important role in the preservation of the nuclear chromatin which undergoes decondensation at the stage of male genome transfer during fusion and thus plays a crucial role in fertilization. It helps to increase the functional life of ejaculated sperm. Production of semen demand extensive cell division, which requires a large amount of Zn as it is involved extensively in nucleic acid and protein metabolism. Hence, Zn supplementation is inevitable to bulls producing higher semen volume, sperm concentration, percentage of live sperm and motility. It may be possible that Zn provides protection to the spermatozoa during sperm cryopreservation. Zn inhibits the acrosome reaction before ejaculation of semen. Reactive oxygen species (ROS) production in semen during the time of stress has been associated with loss of sperm motility, decreased capacity of sperm-oocyte fusion and loss of fertility. Zn possesses anti-oxidative properties and it scavenges the reactive oxygen species produced by defective spermatozoa as well as leucocytes, hence increases fertility of bull. It prevents the spermatozoa from premature oxidation. Zn deficiency reduces the activity of enzyme dipeptidyl carboxypeptidase (DC), this enzyme is thought to be required for maturation and development of sperm cells (Reeves, 1990). Some of the most important enzymes of spermatozoa are Zn metalloenzymes like sorbitol dehydrogenase,

lactate dehydrogenase, alkaline phosphatase, etc. These enzymes become dysfunctional when Zn is deficient (Bedwal and Bahuguna, 1994). In cattle, retention of zinc is significantly reduced by 24 % with the exposure to high environmental temperature (32 to 39°C) (Aboul-Naga, 1983) so requirement of Zinc in heat stress increases significantly. Requirement of Zinc for optimal reproduction is greater than the requirement for growth or maintenance. Stressed cattle tend to respond more favorably to supplemental organic Zn compared to inorganic zinc.

Selenium

It is involved in normal spermatogenesis and it is an essential component of a range of selenoproteins, including glutathione peroxidase, thioredoxin reductase and iodothyroninedeiodinase (Noblanc *et al.*, 2011). It also plays a vital role in protecting both the intra- and extra-cellular lipid membranes against oxidative damage. It is involved in sperm formation by protecting spermatozoa from ROS. The dietary requirement of Se for most of the species is about 0.1 ppm. Revised requirement of selenium for better immune response in dairy animals is 0.3 ppm (FDA, 1987) and its dietary toxic level is 5ppm. More recently, the addition of organic Se at 0.3 ppm as selenized yeast was approved in feeds for chickens, swine, turkeys, and cattle (FDA, 2003). Sodium selenite improves semen quality by increasing semen volume per ejaculate, spermatozoa motility and concentration and by decreasing percentage of dead spermatozoa, spermatozoa abnormalities, and acrosome damage (Marai *et al.*, 2009). There are two major sources of Se for animals: Se naturally originating from plants, in the form of seleno-amino acids, including selenomethionine and selenocysteine and inorganic Se in the form of selenate or

selenite. Selenized yeast has been reported as more bioavailable source of Se as compared to selenite (Juniper *et al.*, 2006) thereby it significantly increases the scrotal length, its circumference and testosterone secretion.

Copper

Cu is necessary for many enzymes like the Cu-Zn superoxide dismutase which is involved in sperm cell protection against free radicals. Cu prevents lipid peroxidation in spermatozoa membrane via the activity of superoxide dismutase. SOD catalyzes both extracellular and intracellular super oxide anion to H₂O₂ and molecular oxygen. It may also be involved in the stimulation of pituitary cells which control the release the LH hormone (Slivkova *et al.*, 2009). It prevents premature hyper activation and capacitation induced by super oxide radicals before ejaculation of semen (Agarwal and Prabakaran, 2005). Deficiency of Cu leads to decreased libido, lower semen quality and induces severe damage to testicular tissue which may render the bull sterile. The normal body requirement of copper in dairy cattle is 10 ppm (NRC, 1996) but additional supplementation of copper is required for good quality semen production (Puls, 1994). However, copper requirements may vary by breed and some breeds maintain greater plasma concentrations of copper compared with other breeds (Mullis *et al.*, 2003; Ward *et al.*, 1995). Toxic Cu dietary concentration is 100 mg/kg of DM for all classes of cattle, including bulls. Cu deficiency in cattle is generally due to the presence of dietary antagonists, such as S, Mo and Fe that reduce bioavailability of Cu. The following mineral ratios may be helpful in maintaining Cu levels in blood: Zn: Cu 4:1, Cu: Mo 6:1 and Fe: Cu 40:1 (Hutjens, 2000). Proper supplementation of copper along with healthy ratio with other minerals is required for production of good quality semen. During hot and humid seasons

retention of copper decreases so additional amount of Cu is require for optimum production.

Manganese

Mn appears to have an important role in reproduction of breeding bull. There is large variation in Mn levels in common available feedstuffs. Fodders are generally adequate in Mn but concentrates may be deficient (Bhanderi *et al.*, 2014). Generally, legume and grass hays have more Mn than corn or corn silage and interestingly Mn is reported to be more available in hay than silage (Puls, 1994). It is necessary for cholesterol synthesis (Kappel and Zidenberg, 1999), which ultimately is required for synthesis of the steroids, estrogen, progesterone and testosterone. Insufficient steroid production results in decreased circulating concentrations of these reproductive hormones resulting in abnormal sperm production in males. Recommended dietary concentration for bulls is 40 mg/kg of DMI (NRC, 1996) and toxic Mn dietary concentration is 1000 ppm for all classes of cattle, including bulls. Antioxidant capacity of Mn²⁺ is related to effective quenching of peroxyradicals and superoxide anion (Coassin *et al.*, 1992). It increases serum levels of puberty-related hormones. It protects the bull sperm against (lipid peroxidation) LPO/oxidative stress and facilitates the occurrence of capacitation and acrosome reaction after ejaculation of semen which is important in fertilization of sperm with oocyte.

Iodine

Iodine deficiency leads to delay in puberty, failure of fertilization, decrease in libido and deterioration of semen quality in males (Sathish Kumar, 2003). It is required in the synthesis of thyroxin hormone which regulate energy metabolism. Dietary requirement of

iodine is 0.25 ppm (NRC, 2001). Its maximum toxicity level is 50 ppm.

Cobalt

Cobalt is important component of vitamin B₁₂ enzyme. Cobalt is needed for synthesis of thymine which is required for DNA synthesis. So it plays role in cell division, and has a profound impact on growth and reproduction of animal. Dietary concentration for bulls is 0.1 mg/kg of DM (NRC, 2001) and its toxic dietary concentration is 10 mg/kg of DM for all classes of cattle, including bulls.

Iron

Iron is trace elements that present in cells and tissues in the male reproductive system. Within the male reproductive system, Sertoli and Leydig cells are important reservoirs of ferritin. The molecule acts as a readily available source of Fe for the developing spermatozoa, while providing an extra layer of protection to the testicular tissue (Wise *et al.*, 2003). Iron is important components of catalase which is main antioxidant enzyme preventing fluctuations in ROS production and protecting the cellular structure and function against oxidative damage. CAT breaks H₂O₂ into O₂ and water (H₂O). Fe plays an important role in the synthesis of nucleic acids and proteins, electron transport, cellular respiration, proliferation and differentiation (Lieu *et al.*, 2001), which are ultimately lead to spermatogenesis and spermatozoa metabolism (Wise *et al.*, 2003). It is component of cytochrome enzyme which is important in electron transport chain and plays role in spermatozoa motility. Dietary requirement of iron is 50 ppm in animal (NRC, 2001) and its dietary toxic concentration is 1000ppm. However, their accumulation in large amounts may lead to metabolic disruptions which in turn could compromise male fertility.

Male reproductive efficiency can be improved through maintenance of proper trace mineral balances in animals. Supplementation of trace minerals during active reproductive phase of the animal will improve their reproductive performance, however care should be taken about the interaction with other minerals and over-supplementation. Organic Trace mineral supplementation produce better results due to its greater absorption and least interaction with other minerals. The feeding of antioxidants (Zn, Se, Cu, Mn) during stress can improve health and fertility of the bull.

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