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MINERAL AN IMPORTANT NUTRIENT FOR EFFICIENT REPRODUCTIVE HEALTH IN DAIRY CATTLE

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Abstract: Apart from energy and protein, mineral constitutes a major role in production and reproduction of animals. Deficiencies of certain mineral elements may cause reproductive disorders as minerals play an important role in health and reproduction of the livestock. Infertility and reproductive disorders has emerged as an important problem in our livestock population. Adequate supplementation of minerals depends on age, stage of pregnancy and lactation. Macro minerals and trace minerals are equally important as they take part in formation of structural component of body and proper functioning of enzymes, hormones, vitamins and cells. Mineral deficiency and toxicity is area specific. Minerals have beneficial or detrimental effects on animal physiological wellbeing, depending on its balance.

Keywords: Mineral, reproduction, infertility, macro, trace.

Introduction

Minerals have a huge impact on animal's reproductive physiology and its imbalance causes various problems leading to reduced reproductive efficiency. Most commonly, dairy animals suffer with nutritional deficiencies because of high production and inefficient feeding, resulted in poor reproductive performance. Minerals are structural components of body and play a vital role in activities of enzymes, hormones, as constituents of body fluids and tissues and as regulators of cell replication and differentiation. Minerals are important for all physiological processes in animals including reproduction (Elrod *et al.,* 1993). However, deficiencies, imbalances and toxicity of certain mineral elements may cause reproductive disorders as minerals play an important role in health and reproduction of the livestock (Sharma *et al*., 2007). Although energy and proteins are the major nutrient, minerals play

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major role in order to optimize production and reproduction in dairy cattle (Bindari, *et al*., 2013).

Minerals are required in reproductive processes because of their role in maintenance, metabolism and growth (Hadiya *et al*., 2010)**.** Requirements for minerals are influenced by several factors that include age, stage of pregnancy and stage of lactation. Apart from energy and protein, the deficiency of these minerals such as, calcium, phosphorus, iron, zinc and copper etc have been reported to be a predisposing factor for the occurrence of retention of placenta (Gupta *et al.,* 2005) and repeat breeding in dairy cows (Sheetal *et al*., 2014; Kumar, 2014) abortion (Mee *et al.,* 2004) and weak calf syndrome (Logan *et al.,*1990). Minerals are classified in to two major categories as for their requirements i.e. macro minerals required in more than 100 ppm in diet and these category includes, calcium, phosphorus, magnesium, potassium, sulfur, sodium and chloride. The another category is trace or micro minerals such as cobalt, copper, iodine, iron, manganese, selenium and zinc; and is required in less than 100 ppm in the diet. In this paper the significant role of minerals and there requirements in relation to reproductive health as well as better productivity of a dairy animals is described thoroughly.

Calcium (Ca)

Calcium had a vital role in structural and physiological functions. It is present more abundantly in the body. Lactating cows must be provided with adequate amounts of Ca to maximize production and minimize health problems. Calcium related disorders (deficiencies) are most commonly occurs during the time of parturition or within few days following parturition. The Ca: P ratio, alteration may affect ovarian function through its blocking action on pituitary gland. This results in prolongation of first estrus and ovulation, increased incidence of dystocia, retention of placenta, prolapse of uterus and delaying of uterine involution process (Satish Kumar, 2003) this is due to impairment of uterine muscle tonicity . Low blood calcium level is also associated with anoestrus where as excess of calcium can affect the reproductive status of animal by impairing absorption of phosphorus, manganese, zinc, copper and other elements from gastro intestinal tract. Ratios (Ca:P) between 1.5:1 and 2.5:1 for lactating cows should not result in problems. The capacitation process results in increased membrane permeability to Ca. This influx of Ca is necessary for the fusion of the plasma membrane and the outer acrosomal membrane and the subsequent initiation of the acrosome reaction (Singh *et al.,*1978; Triana *et al.,*1980). In addition to its role in capacitation and acrosome reactions, calcium is also a common cellular signaling mechanism

that can impact reproduction in a number of ways. Not only is calcium intricately involved in muscle contraction, but it is also important for sperm motility. Sperm motility is correlated with cyclic AMP concentration. Calcium, along with magnesium and manganese, is a potent stimulator of adenylate cyclase, an enzyme that converts
adenosine triphosphate (ATP) to cAMP (Rojas *et al.,* 1992; Tash *et al.,* 1983). Hypocalcemia is responsible for impaired immune function. It has been suggested that 48 h of parathyroid hormone stimulus is required to mobilize Ca from skeleton (Goff *et al*., 1986) and this lag phase play important role in the development of milk fever (DeGaris and Lean, 2008). NRC has recommended that Ca content should be 0.65% of the total ration on DM basis for high producing cows.

Phosphorus: Phosphorus (P) is the second most abundant mineral in the body and approximately 80% is found in the teeth and bones (Suttle, 2010). It is required for normal milk production, growth and efficient use of feed and by the rumen microorganisms in the digestion of cellulose and synthesis of microbial protein. This mineral has been most commonly associated with decreased reproductive performance in dairy cows. Impairment of normal sexual behavior, delayed onset of puberty, delayed sexual maturity, silent or irregular estrus in heifers, failure of estrus, inactive ovaries , low conception rates(Reddy *et al.,*2004), long inter calving period have been reported when phosphorus intakes are low. Marrow (1969) reported that the number of service required per conception can be reduced from 3.7 to 1.3 with the proper supplementation in dairy heifers suffering from phosphorus deficiency. Sever phosphorus deficiency may leads to delayed puberty and post partum estrus. This may be due to many post parturient complication like inactive ovaries and vaginal prolepses. Whereas moderate deficiency may lead to repeat breeding condition and poor conception rate (Sathish Kumar *et al*., 2003). Hypophosphatemia have been a predisposing factor for typical periparturient diseases of dairy animals such as the postparturient hemoglobinuria and downer cow syndrome (Gahlawat *et al*., 2007; Kacchwaha and Tanwar, 2010). Phosphorus is declared to be one of significant element for normal sexual behaviour (Sathish Kumar, 2003). In Phosphorus deficient areas the heifers exhibit delayed onset of puberty and silent or irregular estrus behaviour. Moreover the cows had failure of estrus and long inter calving period in and still born or weakly expelled calves or even embryonic death due to lack of uterine muscle tone are reported to be some of important clinical manifestation (Chaudhary and Singh, 2004). Reduced or delayed conceptions and reduced fertility are the most important signs of phosphorus deficiency and this can be overcome with proper

supplementation of phosphorus. NRC (2001) has recommended for dairy cattle the level range from 0.3 to 0.4%. Increasing the concentration of dietary phosphorus above requirement (more than 0.38-0.40%) does not improve reproductive performance (Amaral-Philips, 2015). A recent study reported that lowering dietary P from 0.57 to 0.37% did not negatively affect milk production, but did significantly reduce P excretion into environment (Wang *et al*., 2014).

Copper: Copper is present in and essential for the activity of numerous enzymes, cofactors and reactive protein (Suttle *et al.,* 2010). Cu also plays an important role in the immune system. Cu is necessary for production of melanin pigment and interaction of copper and estrogen are also observed (Hidiroglou *et al*.1979). Cu and Zn have a correlation with reproductive hormones especially progesterone and estradiol (Prasad *et al.,* 1989) as for as reproduction is concern copper is one of the important mineral. Copper deficiency has been associated with delayed or depressed estrus (Phillippo *et al.,*1982), early embryonic death and resorption of the embryo (Miller *et al.,* 1988), increased chances of retained placenta and necrosis of placenta (Nix *et al.,* 2002), low fertility associated with delayed or depressed estrus (Hawell and Hall, 1970) decreased conception rates and anestrus (Mudgal *et al.,* 2014). In males, Cu deficiency leads to reduction in libido, there is reduction in quality of semen and severe damage of testicular tissue may render the bull sterile (Kreplin et al., 1992, Nix *et al.,* 2002). In addition to this, proper copper supplementation is must for quality semen production (Puls, 1994). Copper treatment is reported to improve conception rate as the copper treated cow require 1 service and the untreated cow require 1.15 services per conception (Hunter, 1977). 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). Amino acid chelates of Cu, Mn and Zn have been reported to reduce services per conception significantly in dairy cows (Bosseboeuf *et al*., 2006). The normal body requirement of Cu in dairy cattle is 10 ppm but additional supplementation of copper is essential for quality semen production (Puls *et al.,* 1994).

Selenium: Selenium is an important trace element and its deficiency is associated with poor growth, health and fertility in dairy animals (Weiss *et al*., 1990). The safety margin for selenium is so narrow that its deficiency is relatively rare in farm animals than its toxicity. However commonly recorded Se responsive reproductive disorders in cattle are weak, silent or irregular estrus, , early embryonic death, still birth or weak offspring, early embryonic mortality ,abortions and retained fetal membranes in females, cystic ovaries, metritis and

mastritis this can be reduced by supplementation of Se (Randhawa and Randhawa, 1994). In pregnant animals, selenium toxicity will produce abortions, stillbirth, weak and lethargic calves as selenium accumulate in the fetus at the expense of the cow (Patterson *et al*., 2003). Vitamin E and Se supplements in diets have a protective effect against acute infections mammary gland (Ata and Zaki, 2014). The dietary requirement of Se for most of the species is about 0.1 ppm. The dairy animals receive at the level of 0.3 ppm had better immune response (Weiss, 2002). Supplementation of Se leads to improvement in conception rate at first service (McClure *et al.,* 1986). Prepartum injections of Se (50 mg) and vitamin E (680 IU) for three weeks which leads to reduce the incidence of retained placenta are observed in Se-deficient animals. However either Vitamin E or Se was effective alone. The testis contains high concentration of Se that is essential for testicular function. Both deficiency and excess of Se in male animals cause for impaired normal spermatogenesis and sperm quality (Wiltbank *et al*., 2007). Se supplementation in bull has been found beneficial in maintaining sperm motility. The percentage of sperm motility increased significantly as dietary Se level increased from 0 to 1.0 ppm.

Zinc: Zn plays a major role in the immune system and certain reproductive hormones (Capuco *et al*., 1990). This mineral has a significant role in the repair and maintenance of the uterine lining following parturition, speeding return to normal reproductive function and early return of postpartum estrus (Green et al., 1998). Zn deficiency has been associated with abortion, fetal mummification, lower birth weight and prolonged labour as Zn plays important role in uterine lining (Nix *et al.,* 2002). Zn deficiency associated with delayed puberty and lower conception rates, failure of implantation reduction in litter size. Animal deficient with Zn have lower concentrations of FSH and LH chiefly in males (Boland *et al.,* 2003). Zn deficiency in male causes inefficient testicular development in young ones (Spears, 1994), leading to reduced testicular size, lack of libido and can adversely affect spermatogenesis (Mass, 1987; Satish Kumar, 2003). The recommended dietary content of Zn for dairy cattle is typically between 18 and 73 ppm depending upon the stage of lifecycle and dry matter intake. Cu, Cd, Ca and Fe reduce Zn absorption and interfere with its metabolism (Patterson *et al*., 2003). Requirement of Zn in diet of dairy cows is 40ppm (NRC, 2001). Crossbred bulls improved semen supplemented with Zn showed a better response in improving sperm per ejaculate, mass motility and semen fertility test like bovine cervical mucus penetration (Kumar *et al*., 2006). Zinc supplementation has also increased ejaculate

volume, sperm concentration, percent live and percent motility in bull (Arithington *et al.,* 2002; Kumar *et al.,* 2009).

Manganese: Manganese is an integral component of many enzyme systems and has a significant role in reproduction. It has been linked to the function of the corpus luteum and because of its role as an enzyme cofactor, they involved in the synthesis of cholesterol and sex hormones (Suttle, 2010). Deficiency causes poor fertility problem both in female and male (Wilson, 1966).

In the female animal, it deficiency causes silent estrus and anoestrus (Corrah, 1996) or irregular estrus (Brown and Casillas, 1986), cystic ovary (Patterson *et al.,*2003), poor follicular development with delayed ovulation, increase in embryonic mortality and reduced conception rate (Kreplin, 1992; Corrah, 1996). It is responsible for silent and decrease conception rate, birth of deformed claves and abortions in females. Supplementation of Mn in dairy cow leads to reduction in post partum anestrus (Krolak 1968) so thus the number of service required per conception increased (Rojas, 1965). In males the dietary deficiency of Mn, leads to absence of impairment testicular growth (Masters *et al.,*1988), libido, decreased spermatozoa motility and reduced number of spermatozoa in ejaculate (Satish Kumar, 2003). The maintenance requirement for absorbed Mn was set at 0.002 mg/kg of body weight, for growth the requirement was set at 0.7 mg/kg of growth, pregnancy requirement was set at 0.3 mg/d, and for lactation requirement was at the level of 0.03 mg/kg of milk (NRC, 2001). During gestation the cattle may need up to 50 mg of Mn/Kg of DM because it helps in skeletal cartilage growth and fetal bone formation (Schefers, 2011).

Cobalt: Cobalt is essential for proper vitamin B_{12} synthesis. Maintaining adequate vitamin B_{12} status benefits both the dam and offspring. Reduced fertility and sub-optimal conditioning of the offspring are noted in a cobalt deficiency. Insufficient level of cobalt in the diet has been correlated with increased early calf mortality. Cobalt deficiency leads to delayed uterine involution, irregular estrous cycle and decreased conception rate (Pulls, 1994; Satish Kumar, 2003). A cobalt deficiency ultimately resulted in vitamin B_{12} deficiency. Manganese, Zinc, iodine and monensin may reduce cobalt deficiency. Dietary requirement for a lactating cow is 0.11ppm of the ration of dry matter intake.

Iodine: Iodine is a vital element for dairy animals. It is essential for the development of fetus and maintenance of general basal metabolic rate. Iodine deficiency resulted in delay in puberty, irregular estrus (Puls, 1994), failure of fertilization, early embryonic death, still birth with weak calves, abortion, increased frequency of retained placenta in females and

decrease in libido and deterioration of semen quality in males (Sathish Kumar, 2003). Reproduction is influenced through iodine's action on the thyroid gland. Impaired thyroid function reduces ovarian activity and conception rate. Iodine supplementation recommended for cows consume 15-20 mg of iodine each day. Excessive iodine intakes have been associated with various health problems including abortion and decreased resistance to infection and disease. Signs of subclinical iodine deficiency in breeding females include suppressed estrus, abortions, still births, increased frequency of retained placentas and extended gestation periods (Hess *et al*., 2008). A number of studies have reported beneficial effect of lugol's iodine in treatment of silent estrus, repeat breeding and conception rate (Pandey *et al*., 2011; Ahmad and Elsheikh, 2014).

Conclusion: Mineral nutrition can have a profound impact on the fertility of both female and male animals. Either deficient amount or in higher amount have been shown to be capable of altering reproduction. Mineral mixes containing calcium, phosphorus, selenium and other trace minerals are recommended in the nutritional management of animals.

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