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Importance of Minerals in Dairy Cattle Reproduction

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Introduction

With the ever-growing population of the world, the per-capita demand for animal protein has increased several folds. With milk being the only source of vegetarian protein. The stress of milk production has increased simultaneously. This has led to intensive rearing of cattle to maintain high fertility and production. Minerals play a major role in the animal's reproductive physiology and any imbalance leads to various ailments leading to overall reduced reproductive efficiency.

Dairy animals usually suffer from nutritional deficiencies due to high product demand and inefficient feeding. Minerals are vital components in maintaining physiological health and efficient reproduction. As minerals are the components of the body's structural form and are responsible for activities of enzymes, hormones, regulating cell replication and differentiation their presence in feed is paramount. However, deficiencies, imbalances and toxicity of minerals lead to reproductive disorders of the livestock. Although energy and proteins are the major nutrients, minerals also play an important role to optimize production and reproduction in dairy cattle. Minerals are required for reproductive processes as they have a crucial role in maintenance, metabolism and growth.

Requirements for minerals are influenced by factors such as age, stage of pregnancy and stage of lactation. Apart from energy and protein, the deficiency of minerals (calcium, phosphorus, iron, zinc and copper, etc.) predisposes the animal to the retention of placenta, repeat breeding, abortion and weak calf syndrome.

Minerals are classified into two major categories based on their deity requirements first is the macro minerals required >100 ppm in the diet (calcium, phosphorus, magnesium, potassium,

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sulfur, sodium and chloride). Second is trace or micro minerals (cobalt, copper, iodine, iron, manganese, selenium and zinc) required <100 ppm in the diet.

Calcium (Ca) Calcium is the macromineral that is required at an extensive rate in diet especially in lactating cows. It is a chief component of structural and physiological functions in the body. Adequate amounts of Ca is essential for lactating cows to maintain high production and minimize health problems. Calcium related disorders occur mostly during or within few days of parturition. Variation in the Ca: P ratio, leads to alteration in the ovarian function leading to prolongation of the first estrus and delayed ovulation, increased incidence of dystocia, retention of placenta, prolapse of uterus and delaying of uterine involution process. A low level of Ca is associated with anestrus whereas a high Ca level impairs the absorption of phosphorus, manganese, zinc, copper and other elements from GIT leading to poor reproductive performance. Ideally, (Ca:P) ratios should lie between 1.5:1 and 2.5:1 for lactating cows.

In males, capacitation results in the influx of Ca due to increased membrane permeability leading to the fusion of the plasma membrane and the outer acrosomal membrane and initiating acrosome reaction. It is also important for sperm motility correlating with cyclic AMP concentration. Calcium, along with magnesium and manganese, is a potent stimulator of adenylate cyclase, to the production of cAMP. Hypocalcemia observed during the initial days first (48 hours) of parturition leads to a condition called milk fever. This is chiefly due to high lactational stress on the cow. Ca also is responsible for impaired immune function. NRC recommends Ca be administered @0.65% of the total ration on DM basis for producing cows.

Phosphorus: Phosphorus (P) is the second most abundant mineral in the body after calcium and contributes about 80% to the teeth and bones. It is required for normal lactation, production, growth and the synthesis of microbial protein upon digestion of cellulose by the rumen microorganisms. This mineral one of the major minerals associated with poor reproductive performance in dairy cows. Its deficiency leads to impairment of normal sexual behavior, delayed onset of puberty, delayed sexual maturity, silent or irregular estrus in heifers, failure of estrus, inactive ovaries, and low conception rates, long inter calving period and increased number of service per conception. Sever phosphorus deficiency leads to

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delayed puberty and prolonged postpartum estrus which is due to inactive ovaries. Whereas moderate deficiency leads to repeat breeding conditions and poor conception rate. Hypophosphatemia predisposes dairy cows to periparturient diseases such as post-parturient hemoglobinuria and downer cow syndrome. Phosphorus is also a chief mineral for the demonstration of normal sexual behavior. In heifers, its deficiency leads to delayed onset of puberty and silent or irregular estrus behavior, failure of estrus and long inter calving period and stillborn or weakly expelled calves or even embryonic death which is due to lack of uterine muscle tone. Clinically reduced or delayed conceptions and reduced fertility are the major symptoms of cows suffering from P deficiency. NRC recommends P administration @ 0.3 to 0.4% in dairy cows.

Copper: Copper is present in and essential for the activity of numerous enzymes, cofactors and reactive protein. It also plays an important role in the immune system modulation, production of melanin pigment and interacts with copper and estrogen significantly. Cu and Zn have a strong correlation with reproductive hormones that is progesterone and estradiol as thus affect the reproduction in animals. Copper deficiency leads to delayed or depressed estrus, early embryonic death and resorption of the embryo, increased chances of retained placenta and necrosis of placenta, low fertility associated with delayed or depressed estrus, decreased conception rates and anestrus.

In males, Cu deficiency reduces libido, with the reduction in quality of semen and severe damage of testicular tissue that may render the bull sterile. Thus for quality semen production copper supplementation in breeding bulls is essential. Following mineral ratios must be used to maintain the Cu levels in the blood: Zn: Cu 4:1, Cu: Mo 6:1 and Fe: Cu 40:1. Amino acid chelated with Cu, Mn and Zn significantly reduce services per conception in dairy cows. The physiological requirement of Cu in dairy cattle is @10 ppm (NRC) but additional supplementation of copper is essential for quality semen production in breeding bulls.

Selenium: Selenium is one of the most important trace elements and its deficiency is associated with poor growth, health and fertility in dairy animals. With a narrow safety margin in supplemented herds, Se deficiency is relatively rare in farm animals than its toxicity. Se deficiency leads to reproductive disorders in cattle such as weak, silent, or

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irregular estrus, early embryonic death, stillbirth or weak offspring, abortions and retained fetal membranes, cystic ovaries, metritis and mastitis. In pregnant animals, Se toxicity will cause abortions, stillbirth, weak and lethargic calves as selenium accumulates in the fetus. Vitamin E and Se are supplemented in the diet as it has a protective effect against acute infections mammary gland. The recommends dietary Se for most species @ 0.1 ppm. The dairy animals 0.3 ppm have an immune modulative function. Prepartum injections of Se (50 mg) and vitamin E (680 IU) for three weeks reduce the incidence of retained placenta. In males, testis has a high concentration of Se that is vital for efficient testicular function. Both deficiency and excess of Se lead to impaired normal spermatogenesis and sperm quality by reducing motility. This can be prevented by dietary Se administration @ 1.0 ppm on dry matter bases to bulls.

Zinc: Zn has a major role in the immune system and reproductive physiology. It has a significant role in the repair and maintenance of the uterine lining following parturition (uterine involution), speeding return to normal reproductive function and early return of postpartum estrus (ovarian rebound). Zn deficiency is associated with abortion, fetal mummification, lower birth weight, prolonged labor, delayed puberty and lower conception rates, failure of implantation and reduction in litter size. Animals with Zn deficiency have lower concentrations of FSH and LH. In males, Zn deficiency causes inefficient testicular development, leading to reduced testicular size, lack of libido and can adversely affect spermatogenesis. The recommended dietary Zn for dairy cattle is @ 18-73 ppm based on the stage of lifecycle and dry matter intake. Cu, Cd, Ca and Fe reduce Zn absorption and interfere with its metabolism. The requirement of Zn in the diet of dairy cows is @ 40ppm (NRC). Bulls supplemented with Zn demonstrate better sperm ejaculate volume, sperm concentration, percent live and individual motility, mass motility and semen fertility (bovine cervical mucus penetration).

Manganese: Manganese is a vital component of many enzyme systems and has a significant role in reproduction. It directly correlated to the function of the corpus luteum as an enzyme cofactor, involved in the synthesis of cholesterol and sex hormones. The deficiency of Mn causes poor fertility in both females and males. In the female it leads to silent estrus and anoestrus or irregular estrus, cystic ovary, poor follicular development with delayed

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ovulation, increase in embryonic mortality and reduced conception rate, the birth of deformed claves and abortions. In males, the dietary deficiency of Mn, leads to impairment of testicular growth, libido, decreased spermatozoa motility and reduced number of spermatozoa per ejaculate. The maintenance requirement is @ 0.002 mg/kg of body weight, growth requirement is @ 0.7 mg/kg of growth, pregnancy requirement is @ 0.3 mg/d, and lactation requirement is @ 0.03 mg/kg of milk (NRC, 2001). During gestation, the cattle may need up to 50 mg of Mn/Kg of DM to help in skeletal cartilage growth and fetal bone formation.

Cobalt: Cobalt is vital in the synthesis of vitamin B_{12}. Co deficiency causes reduced fertility, poor body condition of the offspring, increased early calf mortality, delayed uterine involution, irregular estrous cycle and decreased conception rate. Cobalt deficiency ultimately resulted in vitamin B_{12} deficiency. Manganese, Zinc, iodine and monensin may reduce cobalt deficiency. The dietary requirement for a lactating cow is @ 0.11ppm of the ration of dry matter intake NRC.

Iodine: Iodine is a vital element in cattle reproduction as it is essential for the development of the fetus and maintenance of general basal metabolic rate. Iodine deficiency resulted in the delay in puberty, irregular estrus, failure of fertilization, early embryonic death, stillbirth with weak calves, abortion, and increased frequency of retained placenta in females, decrease in libido and deterioration of semen quality in male. Reproduction is influenced directly through iodine via its action on the thyroid gland. Impaired thyroid function reduces ovarian activity and conception rate. Iodine supplementation @15-20 mg of iodine in dairy cows each day is optimum. Excessive iodine intakes lead to abortion and decreased resistance to infection and disease. Signs of iodine deficiency in breeding females include suppressed estrus, abortions, still births increased frequency of retained placentas and extended gestation periods. lugol's iodine is efficient in the treatment of silent estrus, repeat breeding and conception rate due to iodine deficiency.

Conclusion: To maintain the production potential of dairy cows and bulls to the optimum level, balanced nutrient and mineral concentration in the feed is paramount. With the high production demand and limited feeding, there is a profound impact on the fertility of both female and male animals. Mineral deficiency or toxicity has a profound effect on the normal physiological. Thus to maintain fertility and productivity of high-yielding dairy cattle

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administration of mineral mixes containing various macro and micro minerals in a balanced form recommended for the nutritional management of animals. Farmers that observe the reduced reproductive potential of cattle must contact a veterinarian for efficient diagnosis and treatment of the animal.