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Role of Micro-nutrients in Bovine Reproduction

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Abstract

Micro-nutrients have critical roles in the key interrelated systems of immune function, oxidative metabolism, and energy metabolism in ruminants. Micro minerals have a great impact on animal's reproductive physiology and its imbalance causes various problems leading to lowered reproductive efficiency and resultant monetary loss to the dairy industry. Reproductive efficiency is a major factor that affects profitability in ruminants. Trace minerals such as Zinc, Copper, Manganese, and Selenium are essential with classically defined roles as components of key antioxidant enzymes and proteins. Adequate micro minerals supplementation is required as most of the roughages, greens, concentrates and even most of commercial feeds available to Indian market are deficient in trace mineral elements. Often correcting an imbalance in mineral levels can sole a troublesome problem by improving reproductive performance and health with little additional cost. Due to diversity of terrain and agro climatic regions of India, so one therapeutic treatment may not be suitable for other regions. Hence there is a need to map of the various nutrient status in soil, fodder and animal, so that accordingly an area specific mineral may be supplemented.

Keywords: Micronutrients, reproduction, anestrus, repeat breeding, deficiency

The modern dairy cow is a model of remarkable productive efficiency. These levels of production require exquisite control of metabolism and interplay between key physiological systems to support simultaneously high production, health, and reproductive capacity. Excellent nutritional management of dairy cows, particularly during the transition period from late pregnancy to early lactation, is critically important to meeting overall demands for milk yield while maintaining health and reproductive capacity (Roche *et al*. 2013). For optimum reproductive performance in farm animals, twenty two such elements have been identified. The important one includes copper, cobalt, manganese, selenium iodine, zinc, iron, chromium and molybdenum where as others are of less practical value. Micro-minerals are essential for reproduction (Amanlou *et al.* 2012 and Chester-Jones *et al*. 2013). Trace minerals are important for reproductive performance in livestock (Kumar *et al.* 2011) because their supplementation improves reproduction (Grace and Knowles, 2012) and improves conception (Rabiee *et al.* 2010). The ovarian activity of ruminants is influenced by mineral deficiency (Boland *et al*. 2003) They are also involved in synthesis of hormones that are important for reproduction. Their deficiency affects steroid hormone production. (Boland *et al.* 2003) Trace element deficiency may be linked to problems such as retained foetal membranes (Gupta *et al.* 2005), abortion (Mee *et al.* 2004) and weak calf syndrome (Logan *et al.* 1990) Micro minerals are involved in several biological processes, such as component of metallo-enzymes and enzyme co factors. These works both as activator of enzymes involved in intracellular detoxification mechanism of free radicals and in stabilization of secondary molecules. Some of these are component of hormones and thus directly regulates endocrine activities. Due to its involvement in carbohydrate, protein and nucleic acid metabolism, any change in its level may alter the production of reproductive and other hormones (Gupta *et al.* 2005). Its improper level may affect embryonic development, post-partum recovery activities and over all fertility of animal may be impaired. In male animals it may change spermatogenesis and reduce libido.

Copper

Copper status alters functions of neutrophils, monocytes, and T cells (Wintergerst *et al.* 2007) and antibody production. Copper is a vital component in many enzyme systems as cofactors. Cytochrome oxidase is a cupro-enzyme necessary for electron transport in mitocho-ndria for energy metabolism of ATP dependent biosynthetic reactions. The important sign related to reproduction in cattle is decline in fertility. Positive correlation was reported between serum progesterone level and copper-zinc in cows (Yildiz and Akar 2001) Changes in steroidal metabolism may lead to alter reproductive behaviour; such as nymphomania in ewe (Hidiroglou *et al.* 1979). Copper along with Cobalt deficiency delayed onset of puberty, repeat breeding, low conception, early embryonic mortality and increased incidence of retention of placenta (Nix *et al.* 2002). Reproduction is hampered in a manner of depressed oestrus associated with anemia and increased days open due to inactive ovaries. Low fertility associate with delayed or depressed estrus have been reported in cattle graze on copper deficient pastures (Kreplin *et al.* 1992). In males, copper deficiency leads to decreased libido, lower semen quality, and severe damage of testicular tissue may render the bull sterile (Kreplin, 1992, Nix, 2002). The normal body requirement of copper in dairy cattle is 10 ppm but additional supplementation of copper is must for quality semen production (Puls *et al.* 1994). Copper treatment has been found to improve conception rate (Hunter *et al.* 1977).

Requirements for copper in ruminants can vary from approximately 4 ppm to well over 10 ppm in the diet. Copper requirements are increased by high levels of molybdenum, sulfur, and iron in the diet.

Selenium

Selenium along with vitamin C is essential for an optimum immune response and influences both innate and acquired immune systems through a key role in redox regulation and anti-oxidant function and contributes to membrane integrity and protection against DNA damage (Wintergerst *et al.* 2007) Selenium deficiency presents a factor favouring the appearance of perinatal metritis and retention of placenta in dairy cattle (Spears, 2008 and Hefnawy, 2010). In addition, selenium deficiency can cause a malfunction of the testosterone and spermatozoon synthesis, which causes infertility in males (Rayman *et al.* 2012). Selenium is known to influence the gross and histological morphology of the testis (Ahsan *et al.* 2014).

Selenium deficiency is often characterized by reduced spermatozoon motility due to the fragility of its intermediate piece (Maiorino *et al.* 1999) Some selenoproteins were localized in the testes as selenophosphate synthase-2 (SPS-2) and the mitochondrial capsule selenoprotein (MCSeP)(Davis *et al.* 2012) Selenium supplementation may reduce the incidence of metritis and ovarian cysts during the postpartum period(Wilde, D. *et al.* 2006). Selenium is important in normal cattle production systems as its apparent direct link to postpartum uterine involution (Arthington *et al.* 2005) Spears and Weiss, reported that selenium supplementation of dairy cows decreased the incidence of retained placenta. Furthermore, it appears from the study of Komisrud *et al.* (2005) reported that selenium supplementation in dairy cows deficient in selenium may improve the success rate to first service. Deficiency of selenium is also responsible for early embryonic deaths aand still birth (Randhawa and Randhawa, 1994).

Manganese

There have been few studies that have specifically assessed the effect of Manganese on immune function and metabolism in dairy cows although Mn is an essential part of a range of enzymes that are involved in: (1) immune and nervous function, (2) antioxidant protection as an integral part of Superoxide dismutase, and (3) carbohydrate and lipid metabolism (Andrieu *et al.* 2008). Moreover reduced reproductive efficiency encountered loss of appetite due to magnesium deficiency (Sathish Kumar *et al.* 2003). It is involved as co factor in cholesterol synthesis which is necessary for the synthesis of steroids like progesterone, estrogen and testosterone (Keen and Zidenburg-Cherr, 1990). Deficiency cause poor fertility problem in both male and female. Wilson *et al.* (1966) suggested that Manganese deficiency was dependent on conditioning factors especially the calcium and phosphorus content of the ration. The principal disorder of Manganese deficiency is infertility, congenital limb deformity and poor growth rate in calves. Deficiency of Manganese may be associated with suppression of estrus, silent estrus, irregular estrous cycle, cystic ovary, poor follicular developments with delayed ovulation, increase in embryonic mortality and reduced conception rate (Kreplin, 1992 and Corrah, 1996).

Even Manganese deficient goats were observed to exhibit no apparent sign of estrous despite normal ovulation (Groppel and Anke, 1971). Manganase supplementation has proven to be effective in shortening the postpartum anoestrus and increasing conception rates in dairy cows (Krolak, 1968). In males the dietary deficiencies of Manganese, leads to absences of libido, decreased motility of spermatozoa and reduced number of sperms in ejaculate (Satish Kumar *et al.* 2003).

The developing fetus is quite susceptible to manganese deficiency. Calves born to cows fed diets deficient in manganese exhibit skeletal abnormalities characterized by stiffness, twisted legs, enlarged joints, and short leg bones (McDowell *et al.* 2003)

Chromium

Although the primary role of Chromium appears to relate to its ability to enhance the action of insulin (Spears and Weiss, 2008), studies have indicated that Chromium supplementation may affect health and immune response in ruminants (Spears, *et al.* 2000). Relative to innate immunity, a study showed that supplemental Chromium did not affect PMN phagocytic function of dairy cows from 6 wk prepartum to 6 wk postpartum (Chang *et al.* 1996). It is present in high concentration in nuclear proteins thus it is necessary for gametogenisis and healthy fetal growth.

Chromium plays an important role in the secretion of pregnancy specific proteins from the uterine endometrium which is helpful in preventing early embryonic death. Chromium exerts a significant influence on follicular maturation and LH release.

Chromium supplementation in a free choice mineral also reduced the interval from calving to first estrus and tended to improve pregnancy rate in young Zebu cows in Brazil (Aragon *et al.* 2001). It can possibly lead to lower sperm count and decreased fertility and influences foetal growth and development (Tuormaa *et al.* 2000).

Magnesium

Magnesium usually does not have direct impact on the reproductive status of animals, since in body it remains in almost antagonistic relation with calcium and any disturbance in Ca-P-Mg homeostasis can impart some influence on reproduction. Moreover reduced reproductive efficiency encountered loss of appetite due to magnesium deficiency (Sathish Kumar *et al.* 2003).

Cobalt

Cobalt is an important constituent of vitamin B_{12}. Approximately 4.5% of molecular weight of vitamin B_{12} (cyanocobalamin) is composed of elemental cobalt. The need of cobalt for thymine synthesis, which is required for DNA synthesis, explains the biological role of cobalt for cell division, growth and reproduction.

Infertility is likely to arise as a secondary consequence of debilitating condition such as severe cobalt paucity (Judson *et al.* 1997). Sign of cobalt deficiency include delayed uterine involution, irregular estrous cycle and decreased conception rate (Pulls, 1994, and Satish Kumar *et al.* 2003). Dietary cobalt requirement for lactating cow is 0.1 ppm of the ration dry matter intake.

Iodine

Iodine functions as a component of the thyroid hormones. The thyroid hormones play an important role in energy metabolism, and are required for growth and development in young animals. The iodine requirements of ruminants are fairly low (approximately 0.5 ppm).

However, forages and other feedstuffs produced in some areas are deficient in iodine. Goitrogens present in certain feeds (white clover, raw soybeans, and rapeseed meal) impairs iodine metabolism, and may increase iodine requirements by 2 to 4 fold (NRC, 2000).

Females receiving inadequate iodine during gestation can give birth to offspring with goiter (enlarged thyroid gland). Iodine deficiency can also cause abortion, or result in offspring being born hairless, blind, weak, or dead (McDowell *et al.* 2003). In adult females iodine deficiency is characterized by irregular cycling, low conception rate, and retained placenta. Iodine supplementation of sheep increased the number of lambs born to ewes by 14 to 21% and reduced lamb mortality rate over a 2-year period (Sargison *et al.* 1998).

Zinc

Among these decreased fertility and abnormal reproductive events are of prime importance in females (Sathish Kumar, *et.al.* 2003) where as in male poor semen quality, reduced testicular size and libido are the usual clinical findings (Mass *et al.* 1987). Apart from this zinc has a critical role in repair and maintenance of uterine lining following parturition and early return to normal reproductive function and estrus (Greene *et al.* 1998**)** Zinc deficiencies have been associated with abortion, fetal mummification, lower birth wt and prolonged labour as Zinc plays important role in uterine lining (Nix *et al.* 2002).

The effect on prostaglandin synthesis suggests that Zn deficiency have profound effect on reproductive cycle and pregnancy. Zinc is known to be essential for proper sexual maturity (development of secondary sexual characteristics), reproductive capacity (development of gonadal cells) in males and all reproductive events (estrus, pregnancy and lactation), more specifically with onset of estrus in female. Its deficiency and lower conception rates, failure of implantation and reduction of litter size are also found in association with the zinc deficiency in feed (Kreplin *et al.* 1992). Zinc has a significant role in repair and maintenance of uterine lining following parturition and early return of post partum estrus (Green *et al.* 1998). Zn deficient animals have been shown to have lower concentrations of FSH and LH chiefly in males (Boland *et al.* 2003). Zinc deficiency in male cause atrophy of semeniferous tubule and inefficient testicular development in young ones, leading to reduced testicular size, lack of libido and can adversely affect spermatogenesis (Mass, 1987 and Satish Kumar, 2003).

Iron

It is required for the synthesis of haemoglobin and myoglobin as well as many enzymes and cytochrome enzymes of electron transport chain. Iron functions in transport of oxygen to tissues, maintenance of oxidative enzyme system and is concerned with ferretin formation (Khillare, *et al.* 2007).

Deficiency in adult animals is rare due to its ubiquitous presence in the feed stuffs. The reproductive performance of Iron deficient animals may be badly affected due to anaemia, reduced appetite and lower body condition. A deficient animal becomes repeat breeders and require increased number of inseminations per conception and occasionally may abort.

Molybdenum

Molybdenum is interdependent with Copper with reference to body system of ruminants. Generally lower level of one occurs in presence toxic level of another. Therefore proper balance of Copper and Molybdenum in soil and plant is essential for normal absorption of each other in ruminants (Randhawa and Randhawa, 1994). Molybdenum deficiency decreases libido, reduced spermatogenesis and causes sterility in males and is responsible for delayed puberty, reduced conception rate and anoestrus in females (Satish Kumar, *et al.* 2003).

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Conclusion

Micro nutrients are necessary for health, growth, production and reproduction. They are essential for functioning of a number of components of the immune system. They act as a cofactors for a number of enzymes and proteins which are involved in many physiological and biochemical processes. These physio-biochemical processes are related to growth, production and reproduction. Hence trace elements affect both the health and production performance of animals.

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