

Micro Minerals in Animals: Small Quantity, Big Impact

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OPEN ACCESS

Keywords

Metabolic Functions, Major Micro Minerals, Hormone Regulation, Antioxidant

How to cite this article:

Bhawsar, N. and Nema, E. 2026. Micro Minerals in Animals: Small Quantity, Big Impact. *Vigyan Varta* 7 (04): 116-121.

ABSTRACT

Micro minerals or trace elements, are essential nutrients required in small quantities but play vital roles in maintaining physiological and metabolic functions in animals. This article explores the requirement and functions of micro minerals based on research studies and scientific evidence. It highlights the role of key minerals such as iron, zinc, copper, iodine, selenium, manganese and cobalt in growth, immunity, reproduction and productivity. The issue of micro-mineral deficiencies in the Indian dairy sector and their impact on milk yield, health and economic losses is also discussed. Additionally, factors affecting mineral requirements and the importance of balanced supplementation and scientific feeding practices are emphasized. Ensuring proper mineral nutrition is crucial for improving animal health, productivity and sustainability.

INTRODUCTION

Micro minerals also known as trace minerals are essential inorganic elements that are required in very small quantities in the diet of animals, yet they perform highly significant and diverse biological functions. Despite being needed

only in trace amounts, these minerals are indispensable for maintaining normal physiological balance and ensuring optimal health and productivity in animals. They are actively involved in a wide range of biochemical and cellular processes that sustain

life, At the cellular level, micro minerals play a crucial role in enzyme activation and regulation, where they function as cofactors or integral components of enzyme systems that control metabolic pathways. These pathways are responsible for energy production, nutrient utilization, and synthesis of vital biomolecules. In addition, trace minerals are essential for maintaining proper metabolic functions, ensuring that carbohydrates, proteins, and fats are efficiently digested, absorbed and utilized by the body.

According to the National Research Council (2001) and the Food and Agriculture Organization (1996), micro minerals or trace elements are those mineral nutrients that are required in very small amounts (generally less than 100 mg/kg of diet dry matter) and are present in body tissues in minute quantities, yet they are essential for normal physiological functions, growth, health and metabolic processes in animals.

The major micro minerals include iron (Fe), zinc (Zn), copper (Cu), iodine (I), selenium (Se), manganese (Mn) and cobalt (Co), which are indispensable for processes such as enzyme activity, metabolism, growth, reproduction and immunity. In addition to these, some other trace elements like chromium (Cr), molybdenum (Mo) and fluorine (F) are also required in minute amounts and contribute to various metabolic and regulatory functions in the body. Despite their low requirement, deficiency or imbalance of these micro minerals can lead to serious health disorders and reduced productivity in animals. Micro-mineral deficiencies are a significant nutritional issue in the Indian dairy sector, adversely affecting animal productivity and farm profitability. Essential trace elements such as zinc, copper, manganese and cobalt are often deficient in soils and fodder, resulting in inadequate intake by dairy animals (Dairy Knowledge Portal, 2019). This imbalance can lead to substantial reductions in milk yield

with some studies suggesting that mineral deficiencies alone may cause up to 50% production loss in certain areas (Paul, 2014). Research has also shown that proper mineral supplementation can enhance milk production by around 10–12% (Kumar *et al.*, 2021). In addition, deficiencies of micro minerals contribute to reproductive issues like infertility and delayed maturity, weakening of the immune system, and increased susceptibility to diseases such as mastitis (Suttle, 2010). Poor growth, weak offspring and inefficient feed utilization further add to the economic burden on farmers (McDowell, 2003). Overall, these deficiencies result in considerable economic losses in the dairy industry, highlighting the importance of balanced mineral nutrition (Government of Haryana Report, 2021).

Functions and Importance of Micro Minerals in Animals

Micro minerals or trace elements, perform a wide range of essential functions that are critical for maintaining animal health and productivity. They are primarily involved in enzymatic systems where they act as cofactors or structural components of enzymes that regulate key metabolic pathways including energy production, protein synthesis and nutrient utilization (Underwood & Suttle, 1999). Several micro minerals, such as zinc, copper, and selenium play an important role in strengthening the immune system and protecting cells against oxidative damage through antioxidant mechanisms (Suttle, 2010). Iron is vital for haemoglobin formation and oxygen transport, while iodine is necessary for the synthesis of thyroid hormones that control metabolic rate and growth (McDowell, 2003). In addition, trace minerals are closely linked with reproductive efficiency, as they influence hormone regulation, gamete formation and embryonic development (NRC, 2001). They also contribute to proper growth, skeletal development and maintenance of skin and coat

condition. The importance of micro minerals lies in the fact that even slight deficiencies can disrupt these biological functions, leading to reduced growth, poor fertility, weakened immunity and decreased overall productivity in animals (Suttle, 2010).

Iron (Fe)- Iron is an essential trace mineral that plays a central role in haemoglobin and myoglobin formation, thereby facilitating oxygen transport and cellular respiration in animals. It is also involved in various oxidative enzymes that support energy metabolism and physiological efficiency. Studies indicate that iron deficiency is one of the most common causes of nutritional anaemia in young livestock, leading to reduced growth rate and lowered productivity (McDowell, 2003). In intensive production systems, especially in piglets, iron supplementation has been shown to significantly improve survival rate and weight gain (NRC, 2001).

Zinc (Zn)- Zinc is a crucial component of more than 300 enzyme systems and is essential for DNA synthesis, protein metabolism and immune function. It plays a significant role in maintaining epithelial integrity and wound healing, thus enhancing disease resistance in animals. Research has demonstrated that zinc supplementation improves immune response and reduces the incidence of infections, particularly in dairy cattle (Suttle, 2010). Zinc deficiency is associated with poor growth, parakeratosis, reduced fertility and compromised immunity, ultimately affecting animal performance (Underwood & Suttle, 1999).

Copper (Cu) -Copper is involved in several enzymatic processes related to iron metabolism, connective tissue formation and antioxidant defense. It is a key component of enzymes such as cytochrome oxidase and superoxide dismutase, which are vital for cellular respiration and protection against

oxidative stress. Studies have shown that copper deficiency can lead to anemia, bone abnormalities and depigmentation of hair or wool, especially in grazing animals (McDowell, 2003). It also adversely affects reproductive efficiency and immune competence in livestock (Suttle, 2010).

Iodine (I)- Iodine is an integral part of thyroid hormones, including thyroxine (T4) and triiodothyronine (T3), which regulate basal metabolic rate, growth and development. It plays a crucial role in energy metabolism and endocrine function. Deficiency of iodine leads to goiter, impaired growth and reproductive disorders and in severe cases, it can cause stillbirths or weak offspring (NRC, 2001). Adequate iodine supplementation has been proven to improve metabolic efficiency and reproductive performance in dairy animals (McDowell, 2003).

Selenium (Se)- Selenium is a vital component of antioxidant enzymes such as glutathione peroxidase, which protect cells from oxidative damage and enhance immune function. It also plays a role in reproductive health and muscle integrity. Research indicates that selenium supplementation reduces the incidence of retained placenta and improves fertility in dairy cattle (Suttle, 2010). Deficiency is commonly associated with white muscle disease, weak immunity and reduced growth in young animals (Underwood & Suttle, 1999).

Manganese (Mn)- Manganese is essential for bone formation, cartilage development and activation of several enzymes involved in carbohydrate and lipid metabolism. It also plays a role in reproductive function and embryonic development. Studies have reported that manganese deficiency leads to skeletal deformities, poor growth and reproductive failure in livestock (McDowell, 2003). Adequate levels are particularly important during the growth phase of young animals (NRC, 2001).

Cobalt (Co)- Cobalt is required for the synthesis of vitamin B12 by rumen microorganisms, which is essential for energy metabolism and red blood cell production in ruminants. It plays a critical role in improving feed utilization and overall metabolic efficiency. Research shows that cobalt deficiency leads to reduced appetite, anemia, poor growth and decreased productivity in ruminant animals (Suttle, 2010). Supplementation of cobalt has been found to significantly enhance weight gain and feed efficiency in grazing livestock (Underwood & Suttle, 1999).

Factors affecting mineral requirements of animals

Mineral intake and requirements in animals are influenced by a combination of environmental, dietary and physiological factors. The quality of soil and type of forage significantly affect mineral consumption, as animals grazing on nutrient-deficient or overgrazed pastures generally require and consume more mineral supplements compared to those on well-managed pastures (McDowell, 2003; Barrows, 1977). Seasonal changes also play an important role, with mineral intake typically increasing during dry or winter periods when forage becomes mature, fibrous and low in mineral availability (Cunha, 1983; McDowell, 1985). The presence of balanced energy and protein supplements in the diet can reduce the need for additional mineral intake, as these feeds often supply part of the required minerals (Weber *et al.*, 1992).

Animal-specific factors such as age, breed, growth rate and physiological status, including pregnancy and lactation, further determine mineral requirements, with highly productive animals having greater needs (McDowell, 2003). The level of salt in drinking water and the palatability of mineral mixtures also influence voluntary intake, as excessive salt in water may suppress consumption, while

inclusion of salt in supplements enhances acceptability (Becker *et al.*, 1944; McDowell, 2003). Modern intensive systems, particularly confinement rearing, limit access to natural mineral sources and therefore increase dependence on dietary supplementation (Cunha, 1987; McDowell, 2000).

In addition, stress, disease conditions and unfavorable environmental factors can elevate mineral requirements by affecting metabolism and immune efficiency (McDowell, 2003). Disorders that impair intestinal function, such as diarrhea or vomiting, reduce mineral absorption and increase dietary needs. The interactions among different minerals and nutrients are also critical, as imbalances can interfere with their proper utilization and alter overall requirements. Moreover, body reserves of certain minerals, including calcium, phosphorus, copper, selenium and iodine, can temporarily support physiological functions during periods of low intake. However, to achieve optimal productivity and fully express genetic potential, animals often require adequate or slightly higher-than-recommended mineral allowances to compensate for these influencing factors (McDowell, 2003; NRC, 2001).

Fulfill the mineral requirements

To ensure adequate mineral nutrition in animals, livestock owners must adopt a comprehensive, balanced and evidence-based feeding strategy that is tailored to the specific nutritional requirements of their animals. These requirements vary depending on species, breed, age, body weight and physiological status such as growth, pregnancy, lactation and production level. A key component of this strategy is the regular provision of a well-formulated mineral mixture or mineral blocks containing both macro and micro minerals in appropriate proportions. The use of area-specific mineral mixtures (ASMM) is particularly important, as

mineral deficiencies are often region-dependent due to variations in soil composition, cropping patterns and forage mineral content.

In addition to supplementation, farmers should emphasize the use of high-quality, nutritionally balanced feed and fodder, including green forages, legumes and crop residues enriched with mineral supplements. Diversification of the diet helps in improving the natural intake and bioavailability of minerals. Proper feed processing techniques, such as chopping, silage making and total mixed ration (TMR) can further enhance nutrient utilization and reduce selective feeding. Ensuring access to clean, fresh, and uncontaminated drinking water is equally essential, as excess salts, heavy metals, or other impurities can interfere with mineral absorption and overall metabolism. Regular nutritional assessment and health monitoring including blood profiling, feed analysis and veterinary consultation are critical for the early detection and correction of mineral imbalances. Strategic supplementation should be practiced during critical physiological stages, such as early growth, late gestation and peak lactation, when mineral demands are significantly higher. Moreover, adopting good management practices such as maintaining proper housing, reducing stress, controlling diseases and ensuring adequate hygiene can improve mineral utilization and overall animal performance.

Furthermore, awareness and training of farmers regarding the importance of mineral nutrition, correct dosage and method of supplementation play a vital role in successful implementation. Overall, an integrated approach combining balanced feeding, targeted supplementation, scientific management and continuous monitoring is essential to meet mineral requirements, enhance productivity, improve reproductive

efficiency and ensure the long-term health and sustainability of livestock systems.

CONCLUSION

Micro minerals, though required in small quantities have a profound impact on animal health, productivity and reproductive efficiency. Their involvement in vital biological processes such as enzyme activation, metabolism, immune response and hormone regulation makes them indispensable in livestock nutrition. Deficiencies of these elements particularly in the Indian dairy sector result in significant production losses, poor growth, reduced fertility and increased disease susceptibility. Therefore, understanding the factors affecting mineral requirements and adopting appropriate feeding and management strategies are crucial. The use of balanced and area-specific mineral supplementation along with proper nutrition, health monitoring, and farmer awareness, can effectively address these deficiencies. Ensuring optimal mineral nutrition not only enhances animal performance but also contributes to economic sustainability and improved livelihoods of dairy farmers.

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