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Trace mineral requirement for growth performance and immunity of calves

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Abstract

For many years, it has been understood how crucial trace minerals are to the productivity of livestock. The supplementation of essential trace minerals has led to increased growth performance and immunity in claves. There deficiency can lead to impairment of various physiological functions of the animal and can compromise the growth and development of calves. The nine trace minerals that are known to be more essential are Zinc (Zn), Copper (Cu), Manganese (Mn), Chromium (Cr), Cobalt (Co), Iodine (I), Iron (Fe), Molybdenum (Mo) and Selenium (Se). This article will discuss about the major effect of supplementation of these trace minerals in calves.

Introduction

Minerals are very important in the nutrition of calves. They play vital functions in the animal body like structural, physiological, regulatory, immune response, etc. While they are found in minor concentrations as compared with other nutrients such as protein and fat (Singh et al., 2020a; Singh, 2021). So, deficiency in minerals may compromise the growth and development of calves. Yet, not much information is available concerning the mineral requirements for calves raised under Indian conditions. Diet formulation for calves is hence formulated based on mineral requirements described by different councils, where NRC (2001) is the most commonly used publication for formulating the diets for growing calves. In India, ICAR (2013) recommendation is followed.

Minerals are inorganic substances that are nutrients, usually required in small quantities, and play a very important role in the metabolic processes of the body (Singh et al., 2020b; Singh et al., 2020c). Twenty-six mineral elements are essential for the normal growth and development of

animals. Minerals represent a widespread group of Eco physiological importance amongst these sources.

Based on their role in growth and development, minerals are principally divided into the following groups:

1. Macro minerals, with high concentrations and vital functions of the body: Na, K, Ca, Mg, Cl, P, S
2. Trace elements, those are critical to maintaining the proper functions of biomolecules, but are required in relatively low quantities, as their raised concentrations might have a toxic effect on the body metabolism and function: Zn, Cu, Mn, Se, Fe, Co, I, Mo, Cr, etc.
3. Heavy metals, which do not have any detectable biological roles in growth or development. On the contrary, studies have reported heavy metals may cause detrimental effects on body metabolism

Trace minerals

The classification of the essential minerals into major and trace elements depends upon their concentration in the animal or amounts required in the diet. Usually, trace/microelements are present in the animal body in a concentration not greater than 50 mg/kg and are required at less than 100 mg/kg diet. Nine trace minerals are well-thought-out to be essential for cattle, but additional minerals are also required in minute quantities. The nine trace minerals that are known to be more essential are Zinc (Zn), Copper (Cu), Manganese (Mn), Chromium (Cr), Cobalt (Co), Iodine (I), Iron (Fe), Molybdenum (Mo) and Selenium (Se). Requirements and levels of certain trace minerals for maintenance in livestock are given in Table 2.1 & Table 2.2 below.

Dietary requirements of trace minerals

TRACE MINERAL	MAINTENANCE REQUIREMENT (ICAR 2013)	GROWTH REQUIREMENT (NRC 2001)
Zn	40 ppm	32 mg/kg
Cu	10 ppm	10 mg/kg
Mn	15 ppm	22 mg/kg
Co	0.11 ppm	0.11 mg/kg
Fe	50 ppm	43 mg/kg

I	0.25 ppm	0.27 mg/kg
Se	0.25 ppm	0.30 mg/kg

Source: Indian Council of Agricultural Research, 2013. Nutrient requirements of cattle and buffaloes. New Delhi, India: ICAR and NRC 2001.

Trace Minerals and their effect on Growth

It is well-identified that micro minerals (Zn, Cu, Co, Fe, Mo, Mn, I, and Se among others) are required for the normal functioning of most of the biochemical processes in the animal body. To better comprehend the role of trace minerals in animal production it is significant to recognize those trace elements are functional components of many metabolic events. Trace mineral functions can be described by 4 broad categories: physiological, structural, regulatory, and catalytic. Structural function means minerals forming structural components of body tissue and organs, like the contribution of Zn to the stability of molecular and membrane. Physiological function happens when minerals in tissues and body fluids act as electrolytes to maintain the osmotic pressure, membrane permeability, and acid-base balance. The catalytic function may be the largest category for trace minerals as it refers to the catalytic role of metalloenzymes in hormone and enzyme systems. Trace minerals serve as the structural component of different metalloenzymes. Lack of adequate trace mineral levels or upon the removal of the trace element, the enzyme activity is lost. Abundant metalloenzymes are required for a varied range of metabolic activities such as energy production, cell replication, protein digestion, antioxidant activity, wound healing, etc. Regulatory function is exemplified by the role of Zn to influence transcription and iodine as a constituent of thyroxine.

The profitability of animal production units is dependent upon optimum weight gain and efficient feed conversion of poultry and livestock. For example, one among the first indicators of marginal Zn deficiency is a depression in weight gain and feed conversion that is often present before any change in blood and liver levels. Because of the role of micro minerals in growth, Zn, Cu, and Mn all serve as components in different enzyme systems associated with protein and carbohydrate metabolism. Mn is also involved in skeletal development and growth. Cu is required for the synthesis of elastin and collagen fibres that provide elasticity and structure to connective tissue and blood vessels. Zn is essential for cell division and repair, epithelial tissue integrity and uptake transport mechanism, and utilization of Vitamins E and A. Possibly the most outstanding species of environmental concern are cattle, pigs, and poultry and the most important trace

minerals are Zn and Cu. This is because in many animal species (mainly pig and poultry), Zn and Cu are used at high levels as growth promoters commercially.

Mineral requirements are hard to find and establish and most of the estimates are based on the minimum level required to avoid a deficiency symptom but not necessarily to promote the productivity of the animal.

Trace Minerals and their effect on Immune Function

Trace minerals such as Cu, Zn, Mn, and Cr, etc are essential for the functionality of many enzymes, structural proteins, and cellular proteins. These minerals may function as activators of enzymes, cofactors, or stabilizers of secondary molecular structure and they serve other vital functions in the cell metabolism. The immune system is a highly developed mechanism that utilizes a varied cell population to protect its host against the invasion of bacteria, viruses, fungi, and other parasites. Trace minerals have been identified as important for normal immune function and disease resistance. This includes Zn, Fe, Cu, Mn, and Se. A deficiency of one or more of these minerals can compromise the immunocompetence of the animal. The first level of defence is the immune system in the skin. Zn and Mn are key elements for maintaining the integrity of epithelial tissue. Several studies have shown that feeding the amino acid complexes of Cu, Mn, and Zn have improved the performance of cattle by improving the fertility rates and decreasing the incidence of disease. These improvements in the animal's performance seem to be due to the increased availability of micro minerals for metabolism.

Conclusion

For many metabolic processes in livestock, including optimum growth and immunity, trace elements are necessary. Immunity and enzyme function are hampered as the animal's trace mineral status declines from adequate to marginal, and then performance and development are compromised. We must provide the animal with the necessary amounts of trace minerals as supplements in order to prevent the possibility of stunted growth and weakened immunity. Nutritional applications for trace minerals are still a growing area of study.

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