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Importance of Minerals in Aquaculture

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Abstract

Minerals play a crucial role in the health, growth, and overall productivity of aquatic organisms in aquaculture. They are essential for various physiological and biochemical functions, including bone formation, osmoregulation, enzyme activation and immune response. Macro-minerals like calcium, phosphorus, potassium and magnesium are vital for skeletal development, muscle contraction and maintaining osmotic balance. Trace minerals such as zinc, selenium and iron are indispensable for enzyme activity, antioxidant defense and haemoglobin synthesis. Inadequate mineral supplementation in aquaculture diets can lead to growth retardation, deformities, and increased susceptibility to diseases, affecting the sustainability and profitability of aquaculture operations. The mineral requirements of aquatic species vary depending on factors like species, life stage and water quality parameters, including salinity and pH. Understanding and optimizing mineral nutrition, through feed formulation and water mineral management, is critical to enhancing production efficiency, environmental sustainability, and the welfare of cultured species (Abrosimova et al. 2020).

Key words: Minerals, Trace minerals, use in aquaculture

Introduction

Maintaining a balanced mineral composition in both their diet and the aquatic environment is important for the health and well-being of aquatic organisms. This essential key mineral plays an important role in various physiological processes such as bone formation, nerve transmission, lacrimation and muscle function. Aquatic organisms adapt their ability to absorb minerals from their surroundings to the aquatic environment. Thus, it is essential to understand and manage mineral levels

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in both natural and artificial aquatic systems to promote optimal growth, reproduction and overall performance of aquatic organisms (Gugulothu et al., 2020; Pillay & Kutty, 2005).

Working of minerals

Common functions of minerals include components of the outer shell, balance of intraocular pressure, structural components of tissues and transmission of nerve impulses and muscle contraction. Minerals occur as essential components for enzymes, vitamins, hormones, pigments and co-factors in metabolism, catalysts and enzyme activators. Shrimp can absorb or excrete minerals directly from the aquatic environment through the respiratory organ gills and body surface. Therefore, the dietary requirement of minerals is largely dependent on the concentration of minerals in the aquatic environment (Chanda et al.2015).

Mineral requirements in food

Aquatic animals have the ability to absorb minerals from the surrounding water in addition to ingested food and because of their variation in salinity regulation or osmotic pressure response, fish and shrimp live in high osmotic pressure environments and may partially meet their mineral needs by drinking salt water. Also, they absorb minerals directly through gills (breathing organ), fins and skin. The situation is reversed in freshwater fish and shrimp. Freshwater fish and shrimp therefore demand an adequate dietary mineral supply more than marine fish and shrimp (Truong et al. 2023).

Types of Minerals:

Minerals are classified into two groups based on the body requirements of aquatic organisms.

1. Macro minerals: These minerals are required in large quantities by the animal body.

2. Trace Minerals: These minerals are required in relatively small amounts.

Macro minerals	Trace Minerals
Calcium	Zinc
Potassium	Iron
Sodium	Arsenic
Magnesium	Copper
Chlorine	Selenium
Phosphorus	Chromium
Sulfur	Cobalt
	Fluorine
	lodine
	Manganese

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	Molybdenum
	Nickel
	Silicon
	Tin
	Vanadium
	Aluminium

Role of microelements:

Calcium and Phosphorus

The mineral element calcium is the most abundant in the living body. Calcium is necessary for the skeleton, teeth, scales and activity of several enzymes. It also controls blood coagulation as well as contractile characteristics of muscles including the system required for transmission of nerve impulses. Calcium and phosphorus primarily occur together within the body due to a suboptimal delivery of either having a restricting quality on both as far as nourishment is concerned. Calcium and Phosphorus Fish scales serve as another prime location for the metabolism and storage of calcium. Fish are also able to mobilize a big portion of their calcium need through water; However, their phosphorus comes preponderantly in the diet with a low delivery rate.

Potassium

Potassium (K) cooperates with magnesium (Mg), sodium (Na) and chlorine (Cl) as electrolytes within the body to control intracellular pressure and acid-base balance. Also necessary for protein, glycogen and glucose metabolism. Fish requirements for potassium are typically fulfilled through food without supplementation.

Manganese

Manganese is a critical element needed by aquatic life. It is also distributed widely in fish and other animal tissues. Manganese is primarily a co-factor for peptidase, arginase, succinic decarboxylase and also an activator of some enzymes like glycosyl transferases and non-specific ones like kinases, transferases, hydrolases and decarboxylases. Manganese also occurs as an integral part of metalloenzymes. Manganese is the basis of normal functioning of the brain and the usual lipid and carbohydrate metabolism. It has also been demonstrated that manganese is a participating factor in the activation of leucine aminopeptidase.

Iron

Iron is actively involved in oxidation reactions and electron transport related to cellular respiration. It occurs in complexes linked with proteins like heme, in enzymes like microsomal

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cytochromes, catalase, etc., and in non-heme complexes like transferrin, ferritin and flavin iron enzymes are present in haemoglobin. Blood is the primary energy carrier.

Sulphur

Sulphur is a critical element of some of the most important amino acids (methionine and cysteine), vitamins (thiamine and biotin), the hormone insulin and the crustacean exoskeleton. As a sulphate, Sulphur is a critical element of heparin, chondroitin, fibrinogen and taurine.

Function of micro elements (trace minerals).

Trace minerals or trace elements, including chromium, cobalt, copper, iodine, iron, manganese, molybdenum, selenium and zinc, are needed only in minute amounts and play a part in numerous biochemical processes. They take part in cellular metabolism, skeletal makeup, regulation of acid-base balance, immune stimulant, stress reducer, resistance to disease and other functions of the body. They form essential parts of hormones and enzymes, and function as cofactors and/or activating factors of a vast array of enzymes (Underwood & Suttle, 1999).

Mineral deficiency symptoms in fish

- **Calcium:** Low growth and food digestibility, high mortality
- **Phosphorus:** Skeletal abnormalities, bone mineralization
- **Magnesium:** Loss of appetite, poor growth, high mortality, skeletal abnormalities
- **Iron:** Hypochromic microcytic anaemia
- **Copper:** Poor growth
- **Manganese:** Poor growth, short and compact body, abnormal tail growth
- **Iodine:** Thyroid hyperplasia.
- **Zinc:** Cataracts, caudal fin and skin erosion
- **Selenium:** Muscular dystrophy, exudative diathesis

Conclusion

Minerals are crucial to the aquatic world and equilibrium, affecting aquatic organisms' physiological processes. Macro-minerals like calcium, phosphorus, potassium and magnesium serve a structural role and control cellular activities, while trace minerals like manganese, iron and sulphur are vital for enzymatic activities and metabolic functions. The knowledge of the individual requirements and roles of these minerals is key to ensuring the health and robustness of aquatic organisms. By maintaining a balanced mineral concentration, we are able to contribute to sustainability within aquatic systems and encourage their growth (Truong et al. 2023).

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