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Popular Article

Importance of Taurine as a critical nutrient for sustainable aqua feeds

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Introduction

Fishmeal, are the primary protein source in the aquafeed industry, has become costly and of limited availability due to dwindling capture fisheries. In the meantime, plant-based protein sources, particularly oil plant sources, have been receiving considerable attention over the past few decades as a partial or total fishmeal replacer in the aquafeed industry. However, most ingredients of plant origin are limited in several nutrients, including taurine, which might be necessary for the optimal performance and metabolism of farmed aquatic animals, particularly carnivorous fish. Therefore, fish fed plant protein-based food may require exogenous taurine to maintain their physiological functions. Nevertheless, taurine may be conditionally indispensable for fish and shrimp, depending on dietary protein source, fish species and size, feeding habits, previous histories, and the rate of metabolism of its precursors, namely cysteine and methionine. Pairing taurine with plant-based proteins enhances feed quality. This allows manufacturers to create high-performance feeds for carnivorous fish using solely plant-based ingredients. Taurine supplementation can improve growth, feed utilization, and antioxidant capacity in aquatic animals.

It's essential to critically examine and analyze the roles that taurine plays in and benefits from farmed fish and shrimp. The present understanding of taurine's functions in fish is summed up in this article. In particular farmed shrimp and fish, with a focus on the physiological processes, taurine biosynthesis and structure, the impact of dietary taurine on fish performance and health, and the enrichment of live food with taurine. This article aims to increase our understanding of taurine's significance in aquaculture.

Structure, Functions, and Dietary Importance in Fish

Taurine, scientifically known as 2-aminoethanesulfonic acid, is a vital component in the biology of many animals, particularly prominent in mammalian tissues where it constitutes a substantial portion of the free amino acid pool. Found abundantly in organs such as the heart, retina, and brain, taurine plays crucial roles in various physiological functions.

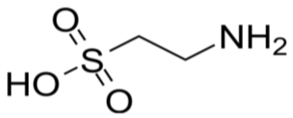

Fig 1: Structure of Taurine

Distribution and Synthesis

Taurine is involved in several essential processes, particularly in the liver and brain, where it's synthesized from cysteine or methionine through enzymatic pathways. This synthesis is facilitated by enzymes like cysteine dioxygenase (CDO) and cysteinsulphinate decarboxylase (CSD), which convert these amino acids into taurine.

Interestingly, different mammalian species have varying abilities to produce taurine internally. Rats, for example, excel at taurine synthesis compared to humans, whereas cats completely rely on dietary taurine due to limited CSD activity. This highlights how genetics and physiology influence taurine metabolism across species.

In the realm of aquatic life, taurine's role takes on a new dimension. Historically, taurine was not considered essential for fish, with many species thought capable of synthesizing it internally. Recent research, however, reveals a different story. Marine fish like Japanese flounder, red sea bream, and yellowtail exhibit limited ability to synthesize taurine due to low CSD activity. This deficiency becomes critical, especially when these fish are fed plant-based diets lacking in taurine. On the other hand, freshwater fish such as rainbow trout and Atlantic salmon possess the enzymatic machinery to synthesize taurine effectively from dietary methionine and cystine.

This distinction in taurine synthesis underscores the importance of dietary considerations in aquaculture. For carnivorous fish species like salmon and trout, which naturally consume other fish or protein-rich diets, taurine synthesis is less of a concern. However, herbivorous species like tilapia face challenges in taurine production unless their diets are carefully supplemented.

Dietary Sources

Diet plays a crucial role in taurine availability for fish. Animal protein sources such as meat, seafood, eggs, and dairy products are rich in taurine, whereas plant-based sources generally lack sufficient levels. Marine algae also contain varying amounts of taurine, contributing to its intake in aquatic ecosystems.

Physiological Functions

Taurine serves diverse physiological functions in fish:

- **Osmoregulation**: Essential for maintaining cellular balance in both marine and freshwater environments, taurine aids in osmoregulation, ensuring stability in varying salinity conditions.

- **Antioxidant Properties**: Taurine acts as an antioxidant, protecting cells from oxidative stress induced by factors like environmental pollutants or alcohol exposure. This property helps maintain cellular integrity and function.

- **Bile Acid Conjugation**: Taurine plays a crucial role in bile acid conjugation, enhancing lipid metabolism and aiding in fat absorption. This process supports digestive efficiency and nutrient uptake in fish.

- **Neurological and Visual Development**: Crucial for retina development and visual acuity, taurine influences neurological functions similar to its effects in mammals, supporting sensory and cognitive processes.

Live food enrichment with taurine

Recent studies have shown that certain essential live food organisms for marine fish, like rotifers Brachionus plicatilis and B. rotundiformis, lack sufficient taurine, a vital amino acid crucial for development. Taurine enrichment of these live foods has emerged as a promising solution to enhance the rearing of marine fish larvae. Researchers have found that supplementing rotifers and artemia with taurine significantly improves not only larval growth and survival rates but also crucial developmental milestones. Studies by Takahashi et al. (2005) demonstrated that taurine levels in enriched rotifers increase steadily with higher taurine concentrations in the medium, stabilizing after about 16 hours. Moreover, enriched rotifers retain a substantial portion of taurine even after several hours, providing a sustained nutritional benefit to growing larvae.

Research by Salze et al. (2011, 2012) highlighted that taurine-enriched diets positively impact the morphology and organ development of cobia larvae, enhancing their lateral line system, olfactory organs, and gills. This supplementation also boosts enzyme activities critical for digestion, such as amylase and trypsin, ensuring that larvae efficiently metabolize their food. Similar findings have been observed across various marine fish species, including red sea bream, Japanese flounder, Pacific cod, and California yellowtail. Taurine-enriched diets consistently lead to improved growth rates, survival, and overall health compared to diets lacking this essential amino acid. These studies underline the importance of taurine not just as a growth promoter but as a key element in larval development. However, not all marine species respond equally to taurine supplementation. For instance, gilthead sea bream larvae (*Sparus aurata*) showed no significant improvement in growth or survival when fed taurine-enriched liposomes or supplemented diets, suggesting their ability to synthesize taurine internally.

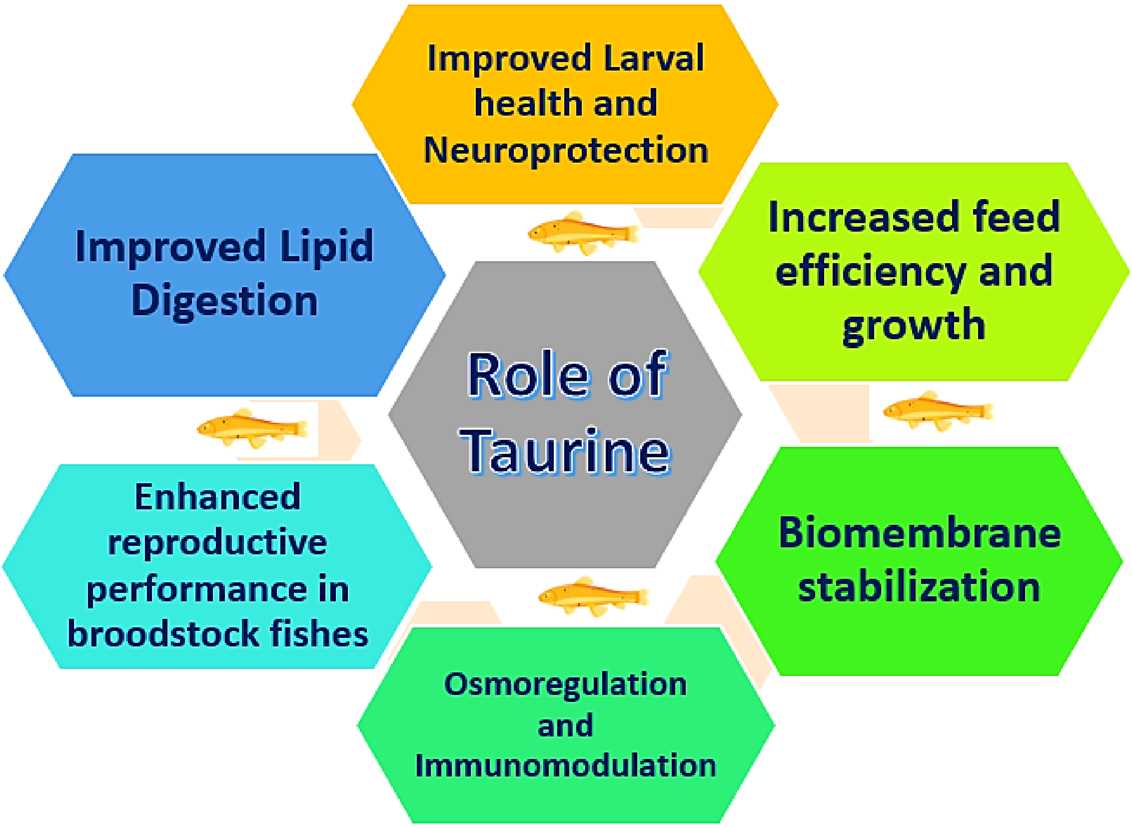

Fig 2: Role of Taurine in aquatic animals

Research and Applications

Studies have highlighted taurine's impact on fish behavior and feeding habits. Taurine-enriched diets have been shown to enhance feed consumption and stimulate appetite in various species, indicating its role beyond basic metabolic functions.

Conclusion

In conclusion, taurine stands as a multifunctional amino acid crucial for the health and vitality of fish. From osmoregulation to antioxidant defense and metabolic regulation, its diverse roles underscore its significance in aquatic ecosystems. Understanding taurine's metabolism and dietary requirements contributes to optimizing nutrition in aquaculture and enhancing the welfare of fish populations worldwide.

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