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Sulfur amino acid utilization in aquaculture

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Important element of fish nutrition varies by species

Methionine supplementation can improve the ability of aquafeeds to meet the total sulfur amino acid requirements of fish.

Various plant feedstuffs are increasingly being considered for use in fish diets to reduce the dependence on fishmeal and other animal protein feedstuffs, and thereby reduce feed costs in aquaculture. Many of these plant feedstuffs are limiting in the sulfur amino acids methionine and cystine relative to fishmeal and other animal proteins.

Therefore, the sulfur amino acid nutrition of fish is an increasingly important aspect of fish nutrition. Various studies have been conducted to more fully understand and satisfy the total sulfur amino acid (TSAA) requirements of fish.

Biochemical functions

Methionine is involved in three main biochemical functions. It takes part in protein synthesis as a constituent amino acid, serves as a methyl donor, and is a sulfur donor in intermediary metabolism. As a methyl donor, methionine undergoes conversion to S-adenosylmethionine, a principal donor in carbon metabolism. Methionine in combination with adenosine triphosphate catalyzed by the enzyme S-adenosylmethionine synthase and magnesium plays key roles during S-adenosylmethionine synthesis.

The methyl groups of important biochemicals such as creatine, choline, and carnitine may be derived from methionine. The sulfur provided by methionine through cysteine is used as a constituent of glutathione, taurine, and mucopolysaccharides such as chondroitin sulfate.

The hydroxy analog of methionine was better utilized by red drum (top) than hybrid striped bass in meeting TSAA requirements.

Fish diet supplementation

Along with lysine, methionine is a limiting amino acid in many plant ingredients used to replace fishmeal in aquafeeds. Soybean meal, which has been used most extensively in replacing fishmeal in diets for fish and shrimp, is typically deficient in methionine and cysteine.

Various forms of methionine and other compounds have been evaluated as to their efficacy in meeting the total sulfur amino acid requirements of commercially important fish. In most studies, the naturally occurring form L-methionine was used as the source of supplemental methionine. However, a synthetic DL-methionine form is also available.

When DL-methionine is supplied in fish diets, it has to be converted to L-methionine before its utilization in the body for protein synthesis. DL-methionine is converted by oxidation into a keto analogue and then into L-methionine through transamination. The efficiency and degree of conversion varies with different animals, and in most fish studied to date, the utilization of dietary DL-methionine has been rather efficient.

Methionine hydroxyl analogue (MHA) is a synthetic, sulfur-containing compound that also can be converted to methionine via a two-step process of oxidation and amination of the alpha carbon. MHA has been extensively used in poultry and swine feeds, and recently in experimental diets for hybrid striped bass and other fish species. It was reported that MHA was only 26 percent as efficient as L-methionine for channel catfish, but 75-100 percent efficiency has been reported in hybrid striped bass and red drum.

Interrelationships with other sulfur amino acids

Cysteine is a dispensable amino acid that can be synthesized from methionine. If a cysteine-free diet is offered to fish, part of the dietary methionine is used for protein synthesis and part is utilized for the production of cysteine, which is incorporated into synthesized protein as cystine.

Methionine is believed to be converted into cysteine via homocysteine and serine. The presence of cysteine in a diet can limit the amount of methionine that must be converted into cysteine, thereby reducing the overall amount of methionine required to meet the TSAA requirement. This is commonly referred to as the sparing action of cysteine on methionine. Therefore, both the methionine and cysteine contents of diets must be considered together in meeting the sulfur amino acid requirements of fish.

Cysteine can spare and replace up to 50 percent of the TSAA requirements of Indian major carp and several other fish species. The biochemical interconversions of methionine and cysteine are depicted in Fig. 1.

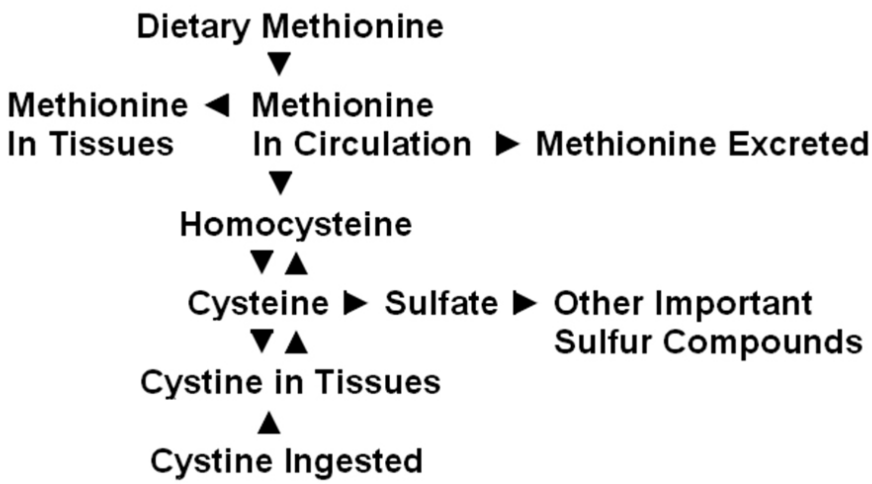

Fig. 1: Biochemical interconversions of methionine and cysteine.

Quantitative dietary TSAA requirements have been estimated for several commercially important fish species, including salmonids (0.70-0.92 percent of diet), channel catfish (0.56 percent), hybrid striped bass (1.00 percent), and Indian major carp (1.42 percent of diet). Species-specific differences in the TSAA needs of fish have been well documented.

Methionine manipulation in fish

Several studies have been carried out in recent years at the second author's laboratory at Texas A&M University in Texas, USA, to quantify TSAA requirements and evaluate various supplements in red drum and hybrid striped bass. These studies demonstrated that adequate levels of methionine are required to support optimal growth, survival, feed efficiency, and nutrient utilization. Cysteine could replace methionine up to 50 percent in both red drum and hybrid striped bass.

Recent studies also indicated that the hydroxy analog of methionine was well utilized by red drum in meeting the TSAA requirement, but had slightly lower utilization by hybrid striped bass. Research continues in an effort to optimize the production of least-cost, yet nutritionally balanced diet formulations for commercial aquaculture.

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