Taurine: Critical Supplement For Marine Fish Feed

A feeding trial conducted with Florida pompano at Auburn University supported others' findings that taurine may be an essential nutrient for some fish species.

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Summary:
As marine ingredient levels are reduced in aquafeed, supplementation with low levels of taurine may be required to optimize production. Taurine may not only improve growth and performance, but also is required to reduce nutritional diseases such as green liver disease and low hematocrit levels in some fish. Taurine is authorized for fish feed in all species in the European Union and China, but not the United States.

Taurine, 2-aminoethanesulfonic acid, is an organic acid that has a variety of functions as a constituent of bile and in osmoregulation, cell membrane stabilization, antioxidation and early development of visual, muscular and neural systems. Taurine is not an amino acid, since it lacks a carboxyl group and has not been found within any known protein structure, but is often classified as an amino acid.

Taurine exists naturally in animals, including oysters, mussels and fish, but is not found in most plants. Consequently, supplementation of taurine in diets for select species of fish containing high levels of alternative proteins may be necessary. As a chemical reagent for food additives, taurine is added to cat food, chicken feed, energy drinks, infant formula, dietary supplements, cosmetics, inert ingredients in pesticides and pharmaceuticals.

Production

Approximately 5,000 to 6,000 mt of synthetic and natural taurine were produced in 1993, with 50% for pet food manufacturing and 50% used in pharmaceutical applications. In 2008, China's total taurine output reached around 3,000 mt, 90% of which was exported.

Natural taurine can be extracted from ox bile, the large muscles of abalones, oysters and octopuses. According to manufacturers, taurine products are crystalline powders that are more than 98.5% pure to conform to standards of the United States, Japan and Europe. Specifications for pharmaceutical grade, food grade and feed grade taurine are all based on the 98.5% purity.

Regulation

There is little regulation of taurine by governmental agencies. Taurine is sold as a nutritional supplement and included in a number of food and drink products, but is not categorized as "generally recognized as safe" by U.S. codes.

It is, however, permitted as an additive in the feed and drinking water of some animals. Taurine can be used as a nutritional supplement in the feed of growing chickens as long as the total taurine content does not exceed 0.054%.

Dietary Relevance

Taurine has been shown to be an essential dietary requirement for cats. Another large use of taurine is in infant formulas. It is included on the CODEX advisory list of amino acids and other nutrients for use in foods and special formulas intended for infants and young children: Infant formula shall contain 60-70 kcal taurine/100 ml.

A large amount of taurine is used as a supplement in energy drinks, which contain an average of 1,000 mg taurine per serving.

Taurine In Aquaculture

There is also growing interest in using taurine in aquaculture diets. In the European Union and China, taurine is authorized for fish feed in all species. However, in the United States, current regulations would most likely need modification, as they do not list fish.

There is increasing interest in the replacement of fishmeal and other marine ingredients in aquafeeds with alternative proteins. Plant proteins such as soybean meal have received considerable attention, but they contain low or undetectable levels of taurine. In fact, many terrestrial animal meals do not contain adequate levels of taurine, and as a result of processing methods, taurine content varies considerably.

Consequently, the use of such alternative protein sources in aquatic feeds may require supplementation with taurine. In a feeding trial conducted at Auburn University with Florida pompano, *Trachinotus carolinus*, the supplementation of taurine in diets containing plant proteins in combination with about 14% meat and bone meal with blood or 14% poultry by-product meal resulted in enhanced pompano growth and survival.

The response was higher in the former diet, as it contained a lower basal level of taurine. This is only one example of many studies showing that taurine may be an essential nutrient for some fish species.

Table 1. Aquaculture species' responses to taurine.

Species	Size Range (g)	Dietary Taurine (g/100 g)	Response Criteria
Cobia	9.8-150.0	0.40-0.60	Growth, survival
Common dentex	40.0-100.0	0.30-0.40	Growth
Florida pompano	5.0-80.0	0.50-0.75	Growth, survival
Japanese flounder	0.9-15.0 0.2-15.0	1.40 1.60	Growth Growth, feeding behavior
Rainbow trout	18.4-220.0	0.85-1.45	Growth
Red drum	2.5-200.0	1.50-3.00*	Growth
Red sea bream	153.0-560.0 2.5-20.0 580.0-1,049.0	0.26-0.50 0.42-1.60 0.60-2.82	Growth, green liver Growth Growth, green liver
Seabass	0.8-3.0	0.45-5.35	Growth, diet selectivity
Sole	Larvae	0.90	Growth, metamorphosis success
Tilapia	Larvae	0.80*	Growth
Yellowtail	0.5-11.0 ~ 6,100.0 250.0-1,000.0	1.30-2.30 1.20 3.40-7.20	Growth Reproductive performance Growth, survival, green liver, hematocrit

* Supplementation levels.

Fish Requirement

Increasing evidence indicates some marine fish have a conditional requirement for taurine. The taurine content in many of the protein sources and attractants used in marine fish diets may be a primary contributor to the positive responses to these ingredients.

In fish, the ability to synthesize taurine varies among species due to differences in the activity of key enzymes on the pathway of taurine biosynthesis and during ontogenesis. Research has been conducted on several species of larval and juvenile fish, including Japanese flounders, European seabass, red sea bream, yellowtail, cobia, Florida pompano and sole, with results suggesting that taurine may be essential for younger fish. Freshwater species such as rainbow trout and tilapia have positively responded to taurine, whereas common carp and Atlantic salmon do not show a response.

A compilation of the utilization of taurine in diets for several marine and freshwater species is presented in Table 1. The table's comparison among species leads to the conclusions that response to dietary taurine seems to be species-specific and varies among species and growth stages. These results indicate that the dietary supplementation of taurine may be necessary when taurine levels are lower than a minimum requirement.

Supplemental taurine may not only improve growth and performance, but also is required to reduce nutritional diseases such as green liver disease and low hematocrit levels, which seem to be characteristic of a deficiency.

Perspectives

Marine protein sources are rich sources of taurine. As these meals are removed from marine fish feeds, we are finding an increasing number of species which appear to have a conditional requirement for taurine. Poor growth and reduced survival are often the first signs of taurine deficiency, however, in some species the taurine deficiency has also been characterized to cause green liver syndrome and reduced hematocrit readings.