Soybean Use – Aquaculture

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UNITED SOYBEAN BOARD™

Soybean Meal in Aquaculture

There are lots of fish in the sea, as the saying goes. In fact, we know of more than 30,000 species.

But it will take more than the naturally occurring fish in the sea and commercial harvest alone to meet the future demand for fish as a foodstuff. In the late 1980s, commercial harvest was declared at maximum sustainable yield, prompting increased attention to "fish farming."

Since 1990, most of the increases in aquaculture production have been with fish, mollusks and crustaceans in the southern hemisphere, primarily Asia and developing countries, with production nearly equally divided between freshwater and saltwater species.

Demand for new food aquaculture production during the next 30 to 40 years is expected to be between 60 and 120 million metric tons (MMT), rivaling the global poultry and swine industries. What will be the source of nutrition for these cultured fish?

Currently, 358 species of fish are cultured, of which 54 have been fed soybeans — the focus of nutritional research for new cultured species. But additional research is needed to confirm soy's role in supplying protein to this new and growing market.

SPECIES OF AQUATIC ANIMAL
in Which Soybean Meal has Been Evaluated

SPECIES	NUMBER OF TECHNICAL REPORTS IN LITERATURE	SPECIES	NUMBER OF TECHNICAL REPORTS IN LITERATURE
Atlantic Salmon	13	Greenback flounder	1
Rainbow Trout	41	African sole	1
Coho Salmon	4	Florida pompano	1
Chinook Salmon	1	Channel catfish	13
Tilapia	14	African catfish	10
Ayu	1	Blue catfish	1
Pacu	1	Chinese longsnout catfish	1
Siberian sturgeon	1	Yellow mystus — tropical	1
Largemouth bass	1	Indian carp — Labeo	5
Hybrid striped bass	9	Indian carp — Catla	3
Striped bass	2	Indian carp — Mrigal	2
Turbot	1	Black carp	1
Red drum	5	Grass carp	2
Tin foil barb	1	Common carp	16
Giant gouramy	1	Chinese hairy crab	1
Yellowtail	7	Chinese mitten-handed crab	1
Korean rockfish	2	Pacific white shrimp	4
Seabass	6	Grass shrimp	1
Seabream	10	Banana shrimp	1
Japanese sea bass	1	Indian white shrimp	2
Milkfish	1	Australian crayfish	4
Bluntnose black bream	1	Red swamp crayfish	4
Australian snapper	2	Spiny lobster	1
Plaice	1	American lobster	1
Winter flounder	1	Green sea urchin	1
Japanese flounder	3	Abalone	2

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Replacing Fish Meal and Fish Oil

Initial diets for aquaculture species typically contain high levels of fish meal and fish oil, which are flavorful ingredients for aquatic animals. Fish meal is a high protein ingredient with a good balance of quality essential amino acids (EAA), and fish oil contains n-3 fatty acids, required by many aquatic animals. Most aquatic animals grow well when fed relatively high levels of crude protein and lipid, and essential amino acid and fatty acid concentrations are priority considerations when formulating fish diets.

However, supplies of fish meal and oil are insufficient to realize needed growth in aquaculture production during the next 40 years. Global fish meal supplies are approximately 6.8 MMT annually, of which approximately 1.7 MMT, or 25 percent, is used in diets for aquatic animals. If we assume aquaculture grows the least amount predicted (60 million metric tons), and we can restrict fish meal usage to 10 percent of the diet, then aquaculture will demand 6 MMT of fish meal in the next 40 years. Keep in mind, the current global supply is only 6.8 MMT, and this will most likely not increase.

Fish meal contains higher crude protein concentrations than solvent-extracted soybean meal, but soybean meal prices are more stable than fish meal prices due to the more consistent supply of soy. Availability will likely be the primary deterrent to the use of fish meal in the future. Supplies and price are affected by such natural occurrences as El Nino, which will likely continue to bring uncertainty to future supplies of fish meal, as it did during the most recent cycle.

Aquaculture currently demands 0.4 MMT, or approximately 36 percent, of the annual global fish oil supply. As with fish meal, this is a finite resource, and increases in demand will strip supply if growth projections for aquaculture are realized. Replacing fish oil in aquatic diets will most likely be a more difficult challenge than replacing fish meal.

Dietary development for aquaculture has, in general, followed a consistent pattern. The first evaluations of new species, often unpublished, use those diets that are available.

Most initial diet choices have been high fish-meal diets formulated for trout or salmon diets that are palatable by most species of fish. As studies progress, diets are gradually modified to more closely meet the nutritional requirements of target species.

Initial studies with a new species include evaluation of optimal dietary crude protein concentration, optimal protein to non-protein energy ratio, optimal ratio of carbohydrate to lipid and, finally, evaluation of commercial feedstuffs.

Is Soy the Answer?

In earlier nutrition work, as dietary development for ruminants and other animals progressed, essential amino acid requirements were recognized as being important.

However, of those aquatic species currently cultured, researchers have estimates of all 10 identified EAA requirements for only nine species. Lysine and methionine requirements, the two most limiting essential amino acids in feed formulations for most species, are known for another eight to 10 species. Despite this lack of specific knowledge, various forms of soybean meal have been evaluated in a variety of aquatic animals.

The table on the previous page shows species in which any form of soybean meal has been used as a source of crude protein and EAA in a diet. Many of these published reports are not formal evaluations of soy for target species, but rather studies of an initial diet that contains soy, or digestibility values using a form of soybean as a test feedstuff. The full-fat soybean meal designation includes raw, heated and roasted soybeans.

Slowly but surely, progress is being made. An article published in 2000 identified 17 species in which formal evaluations of soybeans had been conducted. That number has now grown to 54 species. However, despite the number of evaluations, the specificity in the research is generally lacking. For example, there have been few definitive studies on trypsin inhibitors from soybeans and their effects on fish.

The article summarized the available data on the use of soy in fish, and argued that virtually all fish could handle a minimum of 10 percent to 15 percent soybean meal in their diets, but that several of the more carnivorous species could not handle more than 20 percent. The salmonids (trout, salmon and char) are one of the most sensitive species to soy, handling no more than 25 percent to 30 percent, with some species handling no more than 15 percent soy. It is unclear why this limitation occurs.

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With some of the newer aquaculture species, soybean incorporation into the diet can be relatively high. For example, once the critical EAA were established for the hybrid striped bass, researchers were able to incorporate up to 40 percent solvent-extracted soybean meal into commercial diets. A subsequent series of experiments identified mineral supplementation as limiting higher soybean use in hybrid striped bass. Once that was evaluated, soybean use could be increased to 45 percent to 50 percent of the diet.

Most of the evaluations with fish and crustaceans have not involved quantified EAA requirements of the targeted species. Experimental formulations are most often on a crude protein basis, a method that may be yielding suspicious results. The striped bass, a hybrid, is a strict carnivore. Thus, following the model created by evaluations with salmonids, one might assume that hybrids would not handle high levels of soybean meal.

This has not been the case. The evaluations with hybrids were one of the few in which soybean meal was substituted as a source of EAA, rather than crude protein. Thus, the crux of the problem seems to be a basic lack of understanding of the EAA requirements of the target species, and scientists who substitute soy products simply on a crude protein basis.

Additionally, the lack of specificity in experiments with soy led to numerous speculations on the cause of soy's limited use in diets. Most focused on trypsin inhibitor activity; others on saponins and, more recently, allergenic proteins. However, the number of detailed studies examining any of these anti-nutritional factors is limited, which is somewhat surprising, considering there have been more than 200 evaluations of soy in fish and crustacean diets.

In general, the most common method used to date for evaluating soybeans in aquatic diets is to include them at increasing levels, and sometimes maintain isonitrogenous diets. Other times, soy is simply included at some level, and then the cause of any problems is speculated.

The research needed to expand the use of soy products in aquaculture requires detailed studies examining various soy components that are considered anti-nutritional factors. These data will guide researchers to appropriate processing methods to remove those components that are causing legitimate problems, or to biotechnological solutions that will result in a modified soybean for the aquaculture market.

Should soybean meal become widely used in aquatic diets, it will offer more than just a nutritional benefit. Diminishing use of fish meal and increasing use of soybean meal appears to improve the effluent characteristics of aquaculture operations. This will be an increasingly important consideration in aquaculture, as it is in other animal production industries.

The last major food item we still hunt and gather from the wild are those animals that live underwater. However, we cannot harvest more from the seas. If man wants to consume fish and shellfish in the future, the percentage grown in commercial operations must increase. Additional research is required in order to participate in this new global industry.

The above is a synopsis of the aquaculture paper published by Paul B. Brown. The paper in its entirety, together with a list of references, can be found at www.soymeal.org.

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Summary Comments

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