Soy-in-Aquaculture Partnership Studies Soybean Meal Use in Fish Feeds

Summary:

The Soy-in-Aquaculture Managed Research Program is working to determine the chemicals in soybean meal that can limit the greater use of soy meal in feeds for varied aquaculture species. Initial work with the salmonid industry found problems related to soy lectins and trypsin inhibitors, but determined benefits from saponins and isoflavones.

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Soybean meal has received considerable attention as a partial replacement for fishmeal in diets for fish and crustaceans. It has a relatively high concentration (about 48% for dehulled soybean meal) of protein in comparison to other processed plant protein feedstuffs. The cost of soybean meal is typically 25-50% of the price of fishmeal, so it also offers an economic advantage.

Soybean meal is the primary protein source in many diets fed to channel catfish, tilapia, and other omnivorous species. Although soybean meal is deficient in several essential amino acids, the deficiencies can be addressed relatively inexpensively with the increased availability of feed-grade amino acid supplements.

Problems to Answer

While the potential benefits of soybean meal are undeniable, certain problems still need to be overcome before it can be fully utilized in aquaculture industries. In trout and salmon diets, diminished growth responses have been reported when soybean meal is incorporated at 15-25% of the diet, even when the diets are formulated to meet essential amino acid requirements.

Several compounds in soybeans can potentially inhibit a higher incorporation of soy in diets. Many of these compounds have been labeled antinutritional factors because they negatively impact nutrient digestion and absorption in the gastrointestinal tract. The lectins, oligosaccharides, saponins, and trypsin inhibitors in soybeans have been associated with negative effects in fish.

Soy isoflavones, also called phytoestrogens, are also considered a potential problem because they can interfere with reproduction. However, isoflavones can have a beneficial effect as antioxidants. Asian communities that consume higher amounts of soy have lower rates of heart disease than communities that consume less soy. It has been theorized that the antioxidant power of soy isoflavones contributes to this rate.

SIA Research

In 2002, the United Soybean Board and U.S. state soybean boards of Illinois, Indiana, and Ohio collaborated with seven American universities led by Purdue University to conduct the domestic portion of the Soy-in-Aquaculture (SIA) Managed Research Program. An international component focused on increased use of soybeans by fish farmers in Southeast Asia.

The goal was quite simple: to specifically determine the chemicals in soybean meal that cause limitations in aquaculture species. The initial targets were those species that appeared sensitive to soy inclusion, with the salmonid industry an obvious choice.

Antinutritional, Estrogenic Testing

The first two-year SIA program systematically evaluated the antinutritional and estrogenic effects of soy to determine which limited the use of soy in salmonid diets. Researchers at each of the universities agreed to evaluate specific potentially limiting components of soy.

Purdue University evaluated the effects of lectins, Ohio State University studied saponins, and Michigan State University and the University of Idaho evaluated trypsin inhibitors. Additionally, the University of Wisconsin and University of Maine evaluated the effects of genistein, a soy isoflavone. Finally, Kentucky State University conducted an economic evaluation of the use of soy in salmonid diets.

Lectins, Trypsin Inhibitors

The effects of lectins and trypsin inhibitors on rainbow trout and Atlantic salmon were potential areas of concern. Fish were fed purified diets containing levels of soybean lectins that corresponded to the amount found in 35- to 40%-soybean meal diets.

These fish experienced slight reductions in growth and insulin production at every level of lectin inclusion. Atlantic salmon fed similar diets containing trypsin inhibitors experienced increased mortality, decreased trypsin production, and decreased protein digestion at higher levels of trypsin inhibitor inclusion.

Researchers at the University of Idaho used extruder techniques to test if additional processing would limit the effects of certain antinutritional factors. They found that using higher processing temperatures and much shorter retention times in the extruder barrel resulted in diets that produced higher weight gain and lower feed conversion in rainbow trout.

Saponins

Soybean saponins were not detrimental to salmonids, and in fact may provide a potential benefit by increasing disease resistance. Atlantic salmon fed purified soy saponins grew as well as fish fed a fishmeal control diet. Further, soy saponins acted as an immune stimulator when salmon faced a bacterial challenge from *Aeromonas salmonicida.*

Isoflavones

Soy isoflavones were identified as having a potential benefit to salmonid aquaculture. The growth of rainbow trout and Atlantic salmon fed purified soy genistein was not negatively affected. The isoflavone did not produce a negative estrogenic impact on rainbow trout, but inhibited smoltification in Atlantic salmon.

Fillets from fish grown to food size at the University of Wisconsin were sent to researchers at the University of Maine, who detected soy genistein accumulation in the fillets. They determined that fillets from fish fed soy genistein had a potentially longer shelf life. Lipid oxidation was reduced in fillets from fish that received higher levels of soy genistein. These results were replicated in fish fed high levels of soybean meal.

Sensory Tests

Additionally, sensory tests were conducted to determine if soybean meal impacted the quality of the fillets. Untrained panelists were asked to detect differences in the color and taste of fillets from fish fed diets with high soybean meal content and a fishmeal control. The panelists detected that fish fed soybean meal had whiter fillets, but did not find differences in flavor.

Current, Future Research

The first two years of SIA were only the beginning. This year, the effects of oligosaccharides are being evaluated, as well as the potential interactions between oligosaccharides and the antinutritional lectins and trypsin inhibitors found problematic for salmonids.

Additionally, demonstration projects will be conducted at the University of Idaho and North Carolina State University to evaluate high inclusion rates of soybean meal on a commercial scale.

A marine shrimp project will also begin in 2005. These trials will be far more extensive than the previous SIA salmonid work in incorporating high levels of soybean meal into feeds and measuring the resulting effects on production.

Future projects for the cooperative SIA partnership will continue to evaluate the effects of high-soy diets on crustaceans and fish, with marine fish the next major targeted group of animals. Additional work may be conducted on eliminating antinutritional factors from soybeans through traditional breeding, transgenic modifications, and optimized processing and extrusion techniques.

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