



SOY PROTEIN CONCENTRATE for TECHNICAL BULLETIN

Aquaculture Feeds

How Soy Protein Concentrate is Manufactured
Types of Soy Protein Concentrate
Specifications for Aquaculture Feeds



Welcome. This technical bulletin was produced by the U.S. Soybean Export Council (USSEC) to help inform and educate aquaculture producers around the world about Soy Protein Concentrate (SPC) and its use in aquaculture feeds. This bulletin provides information and specifications to help ensure success in a global arena where cultured aquaculture products are becoming increasingly important as a means to meet human demands for healthy, sustainable seafood and other aquatic products.

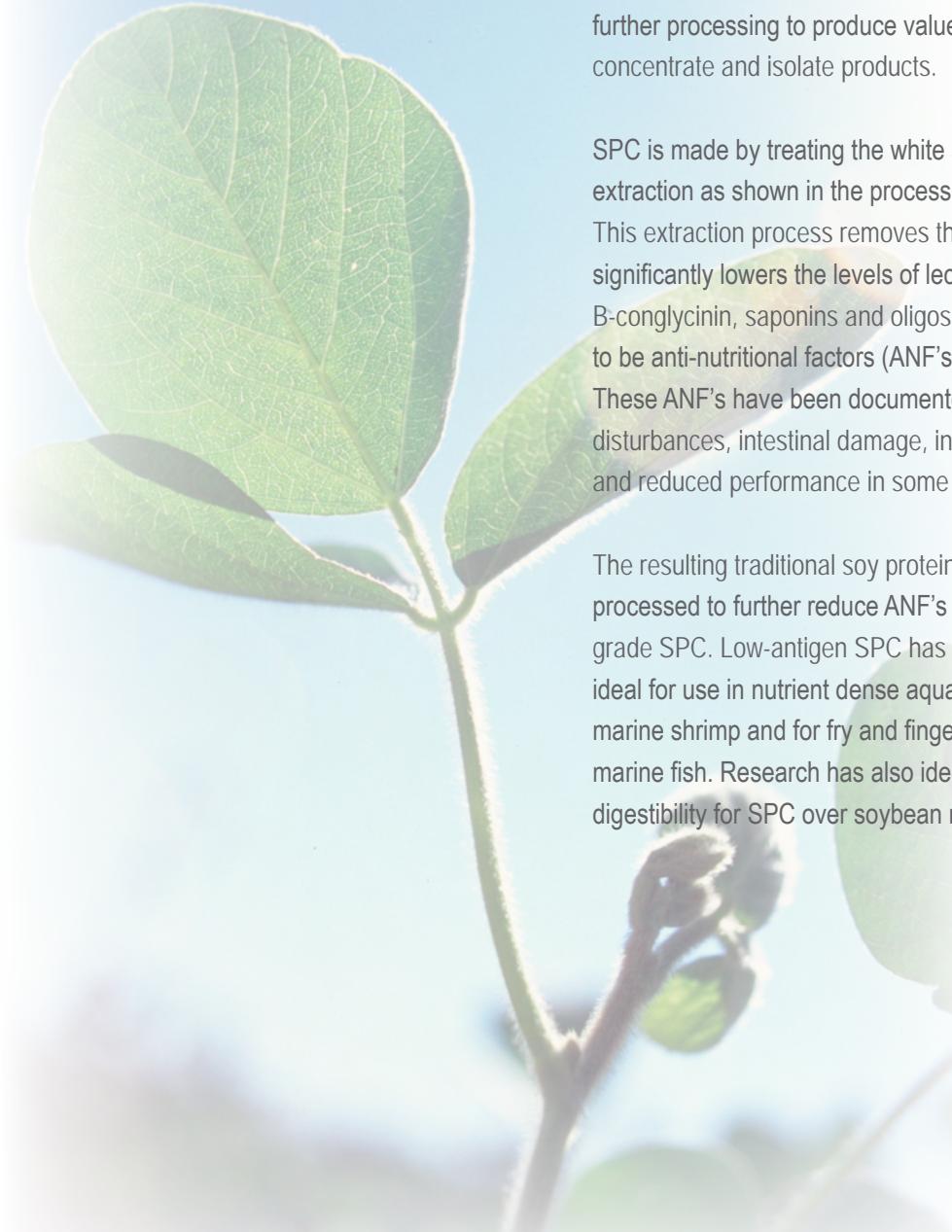
Soy Protein Concentrate (SPC) is 65-67% crude protein

Aquaculture is the world's fastest-growing animal agricultural industry. Aquaculture producers are seeking more efficient and sustainable ways to cultivate healthy species to satisfy growing market needs in a world whose population and food requirements are growing rapidly. The availability of quality protein ingredients for aquafeeds is a critical concern of aquaculture producers and feed manufacturers. Static supply of fishmeal, long the staple protein ingredient for high quality aquaculture feeds, is insufficient to meet the growing feed protein needs of the global aquaculture industry. Additional renewable and sustainable protein alternatives are needed. SPC can accommodate the many nutritional needs of aquaculture worldwide as a protein substitute in aquafeeds. SPC is a renewable plant protein product that can help reduce pressure on natural fisheries stocks and help provide sustainability to the growing demand for aquatic products.

This bulletin provides current information about how SPC is manufactured, outlines types of SPC available and provides information on the types of SPC most suitable for aquaculture.

Information in this technical bulletin was provided by The Solae Company, St. Louis, Missouri, USA. The U.S. Soybean Export Council sincerely thanks The Solae Company for its cooperation and assistance in producing this technical bulletin. For more information about The Solae Company, please see the web site www.solae.com.

SOY PROTEIN CONCENTRATE MANUFACTURING PROCESS



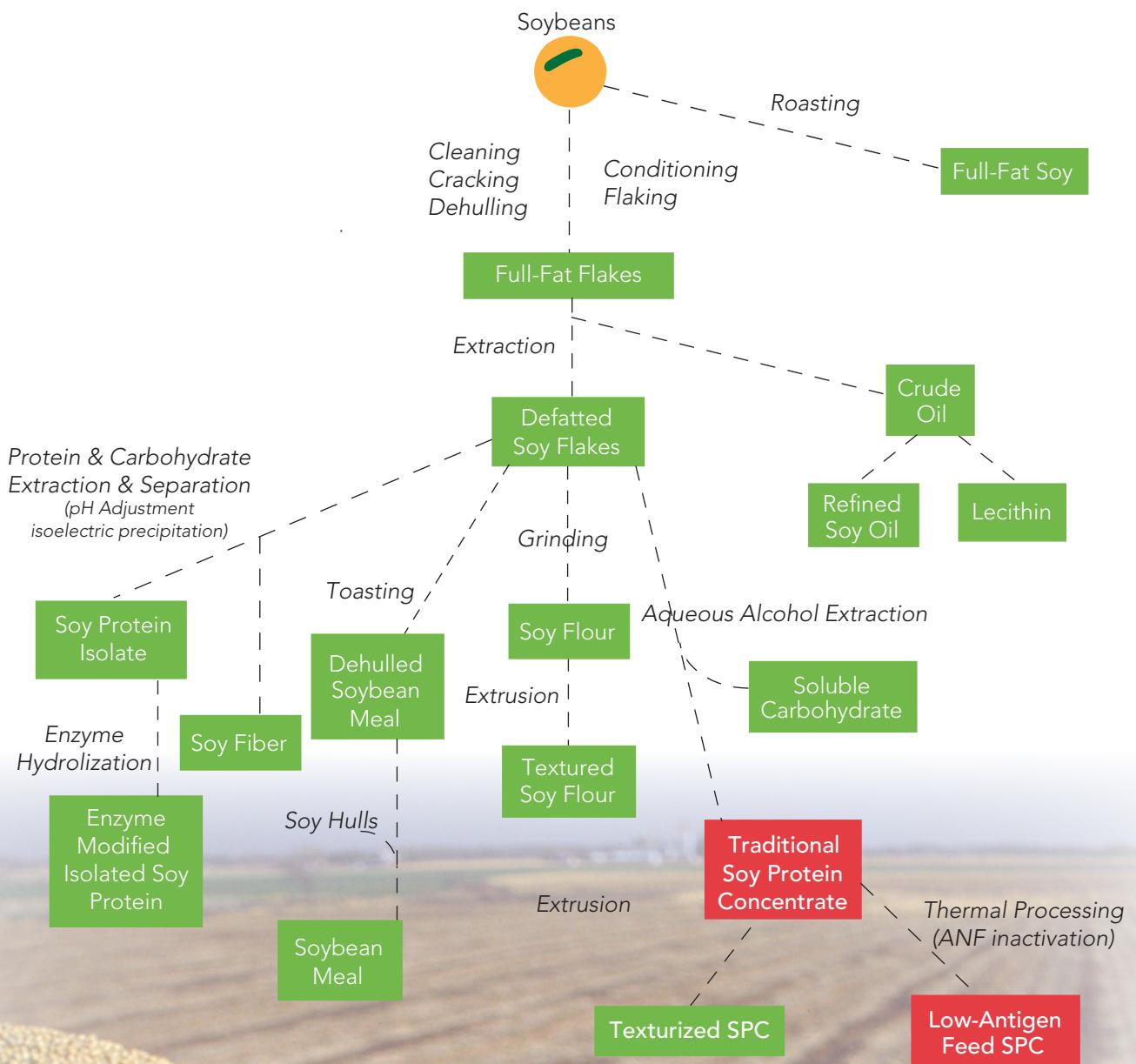
Soy Protein Concentrate is one of many products obtained during the processing of mature soybeans. High quality soybeans are selected and cleaned as the first step in soy product processing. The clean soybeans are dehulled, then the oil is extracted for cooking, biodiesel and other uses. The residue, consisting of defatted white flakes, can then be ground to make soy flour, toasted and ground to make soybean meal, or subjected to further processing to produce value-added soy fiber and protein concentrate and isolate products.

SPC is made by treating the white soy flakes to aqueous alcohol extraction as shown in the processing flow chart in Figure 1. This extraction process removes the soluble carbohydrate and significantly lowers the levels of lectins, trypsin inhibitors, glycinin, B-conglycinin, saponins and oligosaccharides that are considered to be anti-nutritional factors (ANF's) in regular soybean meal. These ANF's have been documented to cause gastrointestinal disturbances, intestinal damage, increased disease susceptibility and reduced performance in some aquatic species.

The resulting traditional soy protein concentrate is then thermally processed to further reduce ANF's and produce low-antigen, feed-grade SPC. Low-antigen SPC has nutritional qualities that make it ideal for use in nutrient dense aquafeeds for marine fish species, marine shrimp and for fry and fingerling feeds of both freshwater and marine fish. Research has also identified higher energy and nitrogen digestibility for SPC over soybean meal included in feed for fish.

SPC MANUFACTURING PROCESS

Figure 1. Soybean processing flow chart showing the techniques used to produce various soy products for human and animal use. Low-antigen feed Soy Protein Concentrate (bottom right) is the preferred product for aquafeeds.



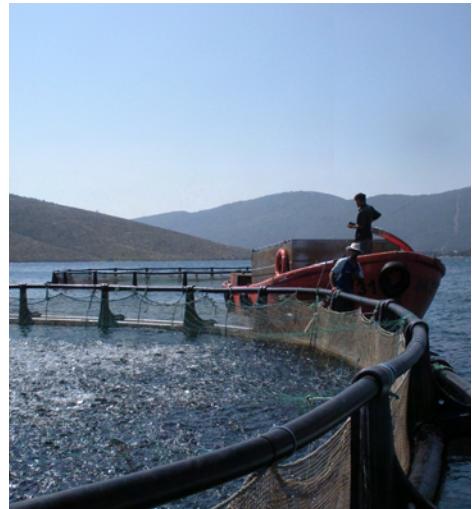
TYPES OF SPC

Hundreds of Soy Protein Concentrate products are made for specific human and animal food and feed products. The majority of these SPC products are not suitable for aquaculture. Three types of SPC are of interest for aquaculture. These are *traditional*, *texturized* and *low-antigen* SPC products (Figure 1).

Traditional SPC is made by aqueous alcohol extraction of defatted soy flakes.

Texturized SPC is produced using extrusion technology on traditional SPC. Extrusion is conducted under pressure, under moist conditions (20-30%) and under high temperature (250-350°F). Extruders also "work" the protein to develop a thermoplastic state. These processing conditions result in a modified functional protein structure. Extruded, texturized SPC is a suitable product for aquaculture feeds.

Low-antigen SPC is produced by modifying the aqueous alcohol mixture, the temperature and time of processing, further reducing the ANF composition of the Soy Protein Concentrate. Low-antigen SPC is the preferred product for aquafeeds, due to the significant reduction in the level of most ANF's.



LOW-ANTIGEN SPC IS THE PREFERRED PRODUCT FOR AQUAFEEDS

BENEFITS OF SPC



Soy Protein Concentrate is increasingly important for aquaculture industries as a protein alternative to fishmeal. Many aquaculture species require high levels of protein and fat in their diets. Most marine fish species in particular require nutrient dense diets with 40-55% crude protein and up to 30% fat. A growing body of research indicates that SPC is a high quality protein product for use in aquafeeds for many marine fish species, as well as for marine shrimp feeds and as a replacement for fishmeal in fingerling diets of freshwater fish. Many fish feed manufacturers are now utilizing SPC because of its inherent productive advantages.

There are many benefits to using SPC for aquaculture feeds. These include:

- **The crude protein level of SPC (65-67%) is similar to fishmeal**
- The high protein level of SPC makes it suitable for nutrient dense aquafeeds for marine fish, marine shrimp and for fry and fingerling feeds of both freshwater and marine fish
- SPC has protein and energy digestibility similar to fishmeal and much higher than soybean meal (protein digestibility of 96-97% has been measured in trout and sea bass)
- SPC has amino acid levels equal to or greater than fishmeal with the exception of methionine and lysine (Figure 2)
- SPC has much lower levels of ANF's than soybean meal (Table 1)
- The soy antigens glycinin and β -conglycinin are denatured during the manufacturing of SPC
- Indigestible and harmful carbohydrates (oligosaccharides - sucrose, raffinose, stachyose) are extracted during SPC processing
- Nitrogen-Free Extract (NFE) + cellulose is significantly less in SPC compared with soybean meal
- Content of amino acid nitrogen as a percentage of total nitrogen is approximately 90% in SPC compared to about 78% in fishmeal
- Neutral in taste due to removal of oligosaccharides
- Lower ash content than fish meal
- Uniform high quality compared to variable quality fish meal
- Stable for storage
- In extruded fish feed, produces a firm pellet which slowly dissolves in water
- The addition of SPC in salmon feed was found to increase surface fat absorption during feed processing

BENEFITS OF SPC

Figure 2. The amino acid composition of Soy Protein Concentrate is equal to or greater than menhaden fishmeal in all but the sulfur amino acids methionine and lysine. (Courtesy of The Solae Company)

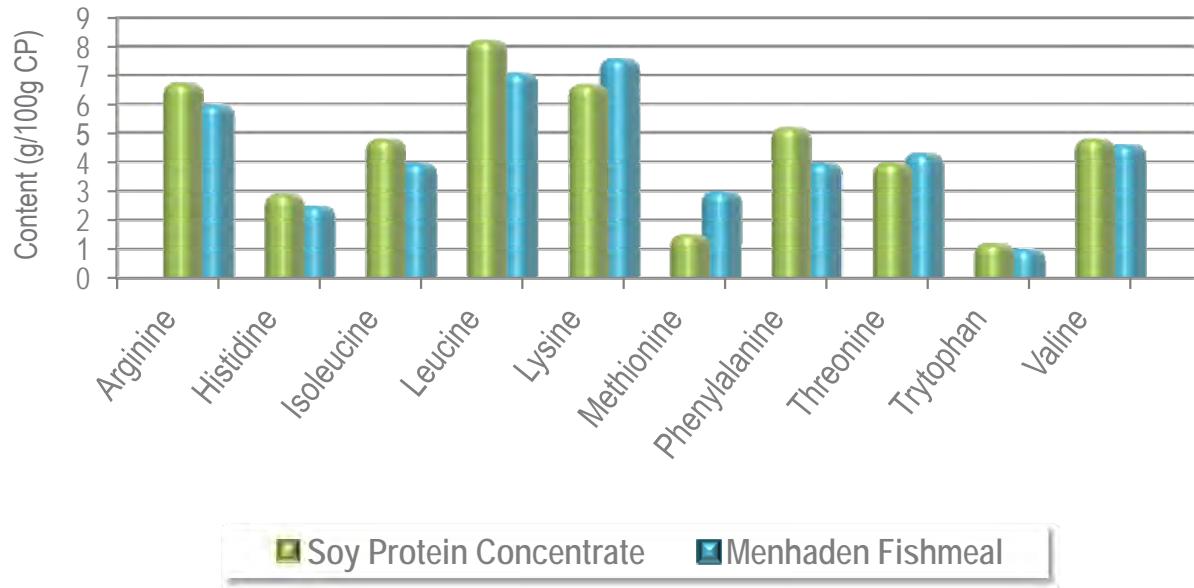


Table 1. Comparison of the anti-nutritional factor levels in various soy products. Extruded SPC and low-antigen SPC have significantly lower ANF levels than soybeans, soybean meal and soy flour and are the preferred products for use in aquafeeds for species sensitive to soy ANF's. (Courtesy of The Solae Company)

	Raw Soybeans	Toasted Soybean Meal	Toasted Soy Flour	Traditional Soy Protein Concentrate	Extruded Soy Protein Concentrate	Low Antigen Soy Protein Concentrate
Urease Activity, pH rise	2.0	0.05-0.5	0.05-0.2	.02-.03	.01-.02	.02-.03
Trypsin Inhibitor, mg TI/gm	45-50	5.0-8.0	5.0-8.0	<4.0	<1.25	<2.0
Glycinin Antigen, ppm	>15 184,000	13-15 66,000 +/-	13-15 66,000 +/-	<2 <30	<1 <5	<1 <1
β -conglycinin Antigen, ppm	>15 >69,000	13-15 16,000 +/-	13-15 16,000 +/-	<1 <10	<1 <1	<1 <1
Lectins, mcg/g	3600	10-200	10-200	<0.1	<0.1	<0.1
Saponins, %	0.5	0.6	0.6	0	0	0
Oligosaccharides, %	14	15	15	3	3	3

SOY PRODUCTS IN AQUAFEEDS

Aquatic species vary in their sensitivity to soy products. Most omnivorous freshwater fish species have a high tolerance to soybean meal and are not affected by soy anti-nutritional factors, particularly when high soy inclusion aquafeeds are manufactured using extrusion technology. Many marine fish species also appear to have a high tolerance for soybean meal, including Japanese sea bass, red drum, cobia, cod, yellow croaker, pompano and gilthead sea bream. Other marine fish species have a low tolerance for soybean meal, such as salmon, yellowtail and amberjack, many sea bass species, groupers and others. These species require the use of low-antigen Soy Protein Concentrate to negate the effects of ANF's found in soybean meal. However, even in species with a high tolerance for soybean meal, the maximum inclusion level of soybean meal in feeds is generally restricted to about 35% due to the high nutrient density of the feeds. There is not sufficient space in the feed to include higher levels of protein ingredients like soybean meal and still meet the nutritional requirements of the aquatic species being cultured. Low-antigen SPC can be used to complement soybean meal in these diets to produce plant protein feeds with significantly lower reliance on fishmeal.

A photograph showing a large, dark, pyramid-shaped fishing net or trap set in the ocean. A white fishing boat is positioned next to the net, with several people visible on board. The water is slightly choppy, and the sky is clear.

**LOW-ANTIGEN SPC CAN BE USED TO
COMPLEMENT SOYBEAN MEAL IN
AQUACULTURE DIETS TO PRODUCE PLANT
PROTEIN FEEDS WITH SIGNIFICANTLY
LOWER RELIANCE ON FISHMEAL**

Low-antigen feed grade SPC and texturized (extruded) SPC with a minimum protein content of 65% are recommended for use in the manufacture of quality aquafeeds. While traditional SPC can be used, the lower levels of anti-nutritional factors in low-antigen and extruded SPC make them preferred products for a wide range of aquaculture applications. It is recommended that feed manufacturers purchase SPC from reliable suppliers and test purchased SPC products for compliance with the manufacturer's published nutrient profile.

Research on SPC use in the diets for a variety of marine fish species, marine shrimp and freshwater fish fingerlings is currently underway through funding support from the U.S. soybean check-off program. The U.S. soybean industry is committed to a sustainable global aquaculture industry that promotes food safety, environmental protection, the use of renewable plant proteins and sustainable production technologies and conservation and wise use of all aquatic resources.

Information on the results of SPC use with specific aquaculture species can be found in the literature and at the U.S. soy industry's aquaculture web site www.soyaqua.org.

SPECIFYING SPC FOR AQUAFEEDS



**MORE INFORMATION ON AQUACULTURE
RESEARCH CAN BE FOUND AT
WWW.SOYAQUA.ORG**



Opposite page: ASA-IM ocean cage trial cooperators in China feeding pompano with a soy-based feed in an offshore ocean cage. The feed was formulated with a combination of soybean meal and soy protein concentrate to reduce fishmeal inclusion to 10%. Pompano exhibited comparable growth on this soy-based feed (50% soy products) to a fishmeal-based diet.

Key Points:

- SPC can accommodate the many nutritional needs of aquaculture worldwide as a protein substitute in aquafeeds.
- SPC is a renewable plant protein product that can help reduce pressure on natural fisheries stocks and help provide sustainability to the growing demand for aquatic products.
- Low-antigen SPC is the preferred SPC product for aquafeeds.
- The high protein level of SPC (65-67%) makes it suitable for nutrient dense aqua feeds for marine fish, marine shrimp and for fry and fingerling feeds of both freshwater and marine fish.
- SPC, when supplemented with methionine, can significantly reduce dependence on fishmeal in aquaculture diets.

Activities of the U.S. Soybean Export Council to expand international markets for U.S. soybeans and soy products are made possible by producer checkoff dollars invested by the United Soybean Board and various State Soybean Boards; support from cooperating industries; and through the American Soybean Association's investment of cost-share funding provided by USDA's Foreign Agricultural Service. The U.S. Soybean Export Council is recognized internationally as American Soybean Association International Marketing, or ASA-IM.

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The U.S. Soybean Export Council connects soybean producers with opportunities to improve human nutrition, livestock production and aquaculture. We accomplish our mission with a science-based technical foundation and a global network of partnerships including soybean growers, exporters, agribusiness and agricultural organizations, researchers and government agencies. The U.S. Soybean Export Council also operates nine international offices worldwide, and works with aquaculture programs in different nations to help ensure success and profitability for industry producers.



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