Use of Vegetable Protein in Processed Seafood Products

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ABSTRACT

In comparison to other muscle foods like red meats, utilization of vegetable protein products in seafood is limited, and can be considered to be in its infancy. The opportunities are not predicated entirely on the future. Opportunities exist today, and vegetable protein products such as soy can and will impact on the seafood market. The opportunities for soy protein products in seafood are and will be realized in terms of nutrition, functionality, and economics. The change in price of frozen fish paste caused by the influence of the 200-mile zones was 2 to 2.5 times in one year. In contrast, the price of soy protein products has not changed during the same period. Obviously, this price difference has an important impact on the demand for soy protein products. As the price of fish in Japan has risen, consumers have tended to avoid buying fish products, and there has been a trend toward buying animal products. Consequently, the use of textured soy proteins in these animal protein foods has also increased. Japan has a long and well developed tradition of eating soybean foods, and at the same time, Japan possesses a high level of scientific technology concerned with new soy protein foods. The whole nation, including the consumers, producers, academic societies and the government, is of the consensus that soybeans are a good food source whose consumption should be encouraged and increased. In spite of such favored conditions, utilization of soy protein foods in Japan has not really taken off even after almost 20 years of development. Reasons for the slow expansion of the market are many. However, the definite factor which decisively affects the increased use seems ultimately to be a balance between the quality and price of the products. In Japan the balance would become favorable to soy protein because of the limited fish resources as well as recent advances in the technology of soy protein foods. Several formulations for fish/soy products are presented.

INTRODUCTION

Fish and other seafoods have been and will be a major food resource for the growing population of the world. In view of the world food situation, many experts agree that something must be done to utilize our fishery resources more efficiently. For example, preference for certain species is said to be limited to about 20% of the total fish available.

Even the 20% preferred species results in considerable waste. In general, a dressed fish averages 73% flesh, 21% bone, and 6% skin. Of this 73% flesh, there is a yield of only 30-35% in fillets from the most common species. The waste from the filleting operation is discarded into fertilizer, canned pet food, or used for animal feed. Obviously, edible fish flesh must be better utilized, and fabricated fish fillets are one viable alternative (1).

This technological development, together with the impact of change in offshore fishing limits on supply, provides an increasing opportunity for the use of vegetable protein products, such as soy and wheat, in processed seafood. These products include concentrates, isolates and textured products (2).

Governmental regulations also have an impact. New U.S. regulations aimed at protecting porpoise have the "net" result of a severe reduction in the tuna catch which can be landed by the U.S. tuna fleet (3).

The decisions by many countries to establish 200-mile economic zones off their shores has made a significant impact on the market, and the food industries concerned have been greatly affected by it.

This report is concerned with an overview of current utilization of vegetable proteins in fabricated seafoods derived from flaked, minced or comminuted flesh. Because of market dominance, major attention will be focused on soy protein products. A brief and selective review of current commercial soy product characteristics and potential uses for soy proteins in fabricated seafood will be given.

In contrast to the Western World, the Orient, particularly Japan, has a major dependence on the sea for its food supply. With current supply restrictions, extension of fish has become an established practice.

One of the characteristics of the Japanese vegetable protein market is that wheat protein products have competed with soy protein products. Almost the same amount of wheat protein as soy protein has been consumed in recent years (4). In 1977, however, demand for soy protein products increased greatly as a result of the 200-mile economic zone. Growth rate of the consumption of soy protein isolates compared with the same period of 1976 is presumed to be about 180%.

Regarding the production and consumption patterns in Japan, the following several points should be emphasized. First, most of the soy protein products have been used as materials by food processors of fish and animal protein products. Second, the consumption of powdered products mainly increased in the form of soy protein isolates. The trend has been stimulated by the establishment of the 200-mile zones. This situation is different from that of the United Sates, where the consumption of soy flour and soy protein concentrates may be far more than that of soy protein isolates. The third point is the Japanese Government's decision in 1975 to promote the utilization of vegetable protein as an effort to increase national self-sufficiency in food production (4). Acting on this decision, the Department of Agriculture and Forestry organized the Study Committee to expand the utilization of vegetable proteins.

In the USA and Europe, economics and functionality of vegetable proteins, especially soy proteins, is used to good advantage in the manufacture of other fabricated foods such as processed meats, cheese, and bakery products. These products now offer similar opportunities to the fish industry as functional aids during processing and to improve finished product acceptability.

TABLE I

Approximate Analysis of Soy Protein Products

	Soy flour			Soy protein concentrate	Soy protein isolate
	A	B	C		
Moisture, %	6.5	6.5	6.6	5.3	4.8
Protein, N x 6.25 (as is basis), %	53.0	53.0	40.5	67.8	91.0
Water soluble protein (as % of total protein)	15-25	60-70	---	variable	variable
Fat, %	1.0	1.0	20.5	0.3	---
Crude fiber, %	3.0	3.0	2.3	3.6	0.25
Ash, %	6.0	6.0	4.5	4.8	4.5

TABLE II

Approximate Analysis of Textured Soy Protein Products

	Textured soy flour	Textured soy concentrate	Textured soy isolate
Moisture, %	4-8	10 Max.	63
Protein (MFB), %	50 Min.	70 Min.	93
Fat, %	1.5 Max.	1 Max.	0.1
Fiber, %	4.0 Max.	6.0 Max.	---
Ash, %	6.0 Max.	7.0 Max.	0.9

Changes within the food industry have had a significant impact upon the increased interest in, and actual utilization of, soy proteins. Some of these changes are (2) increasing production and acceptance of fabricated foods; generation of new types of convenience foods; and increasing cost of traditional protein ingredients of animal and seafood origin. Illustrative seafood applications for vegetable protein use are traditional Japanese food, including those made from fish paste, as well as novel fabricated items such as fish sausages, fish burgers, marine patties, fish and shrimp sticks, seafood salads and the like. Certain opportunities for new utilization concepts, e.g., increasing the yield of fish blocks and whole muscle tissue by injecting soy protein, are now being investigated.

SOY PROTEIN PRODUCTS – DESCRIPTION AND MANUFACTURE

Three basic soy protein products are derived from soybeans. These are soy flour and grits, soy protein concentrates, and soy protein isolates. Soy flours and grits are obtained by removing none or all of the fat from soybean flakes. The degree of fat removal, and the heat treatment used in processing, differentiate the commercially available products (5). Soy protein concentrates are obtained by removing oligosaccharide material from defatted flakes or flour. Several different commercial processes are used. All arrive at a 70% protein product on a moisture-free basis as required by definition (5,6). Soy protein isolates are obtained by extracting defatted flakes with water or mild alkaline solutions. Various treatments during processing, such as thermal, chemical, enzymatic, or pH control, yield isolates with different physical and/or chemical properties. These treatments can affect the flavor and/or functional properties of the isolates. Soy protein isolates contain 90% protein on a moisture-free basis as required by definition (5,6).

A comparison of the chemical composition of flour, concentrate and isolate is shown in Table I.

Textured soy protein has become a generic term for a number of different types of protein products. Textured materials may be produced by spinning technology (7,8), thermoplastic extrusion (9), thermal lamination (10), and steam texturization (11). Thermoplastic extrusion and steam texturization of soy flour, and/or soy protein concentrate are the most widely used commercial techniques. Textured soy protein materials can be colored, flavored and fortified. The physical properties of textured materials can be modified by manipulation of processing conditions and chemical processing aids; and through the use of different cutting and sizing equipment (2) (Table II).

SOY PROTEIN PRODUCTS – FUNCTIONALITY

A detailed discussion of the function of soy protein in all current applications is beyond the scope of this presentation. Protein functionality is dependent upon the primary, secondary, tertiary and quaternary structure of the molecule.

As an example, the presence of both lipophilic and hydrophilic groups in the same polymer chain facilitates association of the protein with both fat or lipophilic compounds and water. This results in the formation of stable oil in water emulsions when a protein solution is mixed with oil (12).

The multiplicity of groups attached to the polymer chain of the protein, such as lipophilic, polar, nonpolar, negatively charged, and positively charged groups, enables soy protein to associate with many different types of compounds. Thus, it may adhere to solid particles and act as a binder or, when in solution, as a dispersing and suspending agent (12). Protein films may adhere to surfaces and, in addition, solids may be distributed and cemented together within the protein film. The principal requirement is for the surface or solid particles to contain accessible sites or groups with characteristics similar to those reactive groups within the protein molecule.

The properties discussed above require a protein product with relatively high degree of water solubility. In a relatively insoluble soy protein, these properties can be expected only to a very limited degree. Although such a product remains highly valuable nutritionally, it may contribute only slightly to viscosity, gel formation, emulsification, binding and adhesion, etc., or to the stabilization of emulsions and suspensions (12).

An insolubilized protein essentially contains the same functional groups as the native protein, the only difference being a change in the accessibility of these reactive groups. Through unfolding, rearranging, and cross-linking of the polymer chains, interactions and associations with food ingredients, such as water and oil, are still possible. Presumably, the accessibility of hydrophilic sites has been reduced and, although the protein still is able to hydrate, the degree of hydration is sufficient only to get the product into a swollen state, but not into solution. Therefore, instead of forming an aqueous solution, a relatively insoluble soy protein *absorbs* water and, when the maximum amount is absorbed, forms a suspension in the excess water. For similar reasons, such a product is also capable of absorbing oil or fat, although the maximum amount of absorbed oil is lower than that of water (12).

Concentrates, and textured protein products, for example, which have a low degree of protein solubility

TABLE III

Shrimp Puff

Formula	
Ingredients	%
Shrimp, frozen uncooked	43.00
Textured soy protein concentrate	14.00
Water	28.00
Binder	15.00
Batter	As desired
Breading	As desired

Processing procedure

1. Hydrate textured soy protein concentrate in water (120 F) and liquid from thawed shrimp for 20 min.
2. Coarse grind thawed shrimp using a 3/8" plate.
3. Combine hydrated textured soy protein concentrate, shrimp and binder. Mix thoroughly.
4. Form into desired shape and pass through a 4% calcium chloride solution.
5. Batter and bread.
6. Fry at 350 F for 15 sec, then freeze.
7. Reconstitute by frying at 350 F for 2 min.

TABLE IV

Tuna Salad

Formula	
Ingredients	%
Canned tuna, light	41.00
Steam textured soy flour	3.00
Water	6.00
Celery, fresh chopped	10.20
Onions, fresh chopped	7.67
Sweet pickles, chopped	4.70
Salt	0.40
White pepper, ground	0.03
Salad dressing	27.00
	100.00

Processing procedure

1. Hydrate textured soy flour in juice from canned tuna and cold water for ten min.
2. Flake tuna, add all the other ingredients and mix until well blended. Do not over mix to the point where the flake-like integrity of the tuna is destroyed.
3. Chill to 40 F.

absorb and hold about 2.5 to 3 times their weight of water and about 1 to 1.5 times their weight of oil. This indicates that even a relatively insoluble soy protein may have valuable functional properties. Also, some functionality can arise from insoluble matter through surface phenomena (12).

A singular property of all soy protein products is their ability to absorb one to four times their weight in moisture or food juices. The rehydrated soy protein material can be a functional and economic alternative to a number of seafood ingredients. Processors can select from a number of commercial textured materials which could satisfy a need for a desired texture, color, flavor or cost factor (2).

Thus far, only individual properties of soy protein have been described, but no relation of these properties to the function of the soy protein in the various applications has been established. In some cases, the property which is the principal contributor to the function of the soy protein in the processed food is obvious. There are many other cases, however, particularly when combinations of several properties are involved, where it is more difficult – and sometimes impossible – to establish such a relationship. An additional complication in practical food formulas is the presence of a number of additives and ingredients which may interact with the protein to bring about unexpected property changes that may or may not be beneficial to the overall function (12).

SOY PROTEIN PRODUCTS – NUTRITION

Economics and functionality are major factors in the utilization of these protein products, yet, in addition, they provide good nutritional value. Fish protein is a nutritionally balanced protein. However, fish is neither a cheap nor readily available source of protein except in coastal areas, and if the supply of fish could be extended and preserved by combining filleting waste and/or "under-utilized" species of fish with relatively low cost soybean curd, it could bring the benefits of fish to more people (13).

Over the years, meat protein has been a primary source of food value in many areas of the world. Any substitute must fulfill the nutritional value of meat. Thus, any product that fills this market need should be nutritionally comparable to meat. Several studies (14,15) have shown that soy protein does not significantly degrade meat protein nutritionally when used at the recommended level, and a slight supplementation of methionine will improve the overall protein quality significantly (16). Wilding (16) published data on the nutritional qualities of textured proteins, in meat-soy mixture showing that textured soy protein when blended with meat protein at a 30% level, exceeded the nutritional value of casein. Other studies (17) have shown that a one percent addition of methionine to a beef-soy mixture enhances PER to 2.82 when ground beef has PER of 2.37. Hamdy (18) presented similar findings based on very elaborate studies of the biological value of textured proteins. He also reported that changes in soy protein digestibility and PER during and after thermoplastic extrusion are minor. Defatted soy flour averaged 89% in digestibility in comparison with 80% for textured soy proteins.

Unfortunately, extensive nutrition studies are not available yet on fish-soy products because of the more recent developments in the utilization of soy products in this area. By analogy, however, the conclusions obtained with red meat should be also applicable to fish. The low fat and cholesterol content of fish-soy combinations are claimed by many as a definite advantage for these products.

FISH-SOY PRODUCTS – U.S.A. AND EUROPE

Flaked, Minced or Comminuted Flesh

Recently, textured soy protein products have become increasingly advocated as seafood extenders. Pink or off-white products are finding widest use. These materials are used in one of two ways. In the first use, generally the textured material is hydrated, then mixed with ground or minced flesh and a matrix-forming material. The matrix usually contains cereal flours, gums and spices or flavorings. The mix is extruded or molded into various shapes. The shapes are generally in the form of sticks or characteristic shrimp or fish shapes. Depending on the matrix composition, the shaped products may pass through a chemical solution to "set" the product. The shapes are then battered, breaded, fried and frozen. A second use of textured soy protein in seafood products is directed more towards the end users of canned seafood items such as tuna or salmon. Hydrated textured soy protein or analog type products may be used in preparing items such as tuna salad and salmon patties.

Soy protein isolate may also be a useful ingredient for seafood applications. Some isolates have excellent binding and gelling properties. The integrity of fish cakes, patties or other shapes may be improved by incorporating isolate. Another application for soy protein isolate is in batter systems. A combination of soy protein isolate and sweet dairy whey may be used successfully to replace 100% of the nonfat dry milk in batters at a significant cost savings.

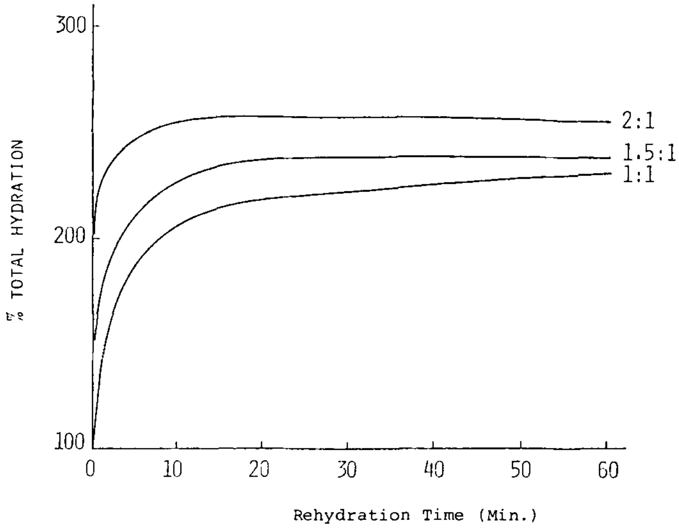

FIG. 1. Total hydration at 10 C of textured soy protein concentrate prehydrated to 100, 150, and 200%.

TABLE V

Fish Block Formulations

	%
Fish flesh	69.00
Textured soy flour	10.00
Water	20.00
Fish block flavor enhancer	1.00
	100.00
Fish flesh	79.00
Soy protein concentrate	5.00
Water	15.00
Fish block flavor enhancer	1.00
	100.00

As mentioned before, a processor can select from a number of commercial textured materials which could satisfy his need for a desired texture, color, flavor or cost parameter. Table III presents a fairly high use of textured soy protein concentrate as an alternative to shrimp in an extruded batter and breaded frozen product.

Table IV presents the use of a steam-textured soy flour as an alternative to canned tuna flesh in a food service tuna salad or sandwich spread. Steam-texturized soy flour can be colored to match pink shrimp as well.

There is an active interest by U.S. tuna canners for an alternative to tuna flesh. They have done considerable work with textured soy protein, particularly textured soy protein concentrates. Textured soy protein concentrate will retain much of its texture after retorting, and it can also be colored to match the visual requirements of a canned tuna alternative. Textured soy protein concentrate can also be used as an alternative for clams in such items as canned, minced clams; or clam chowder.

In many applications a processor will find it desirable to fully hydrate a textured soy protein in order to take full advantage of the economics. Textured soy protein concentrate, as well as other textured soy proteins, can be partially hydrated, such as 1:1 or 1:2. The partially hydrated soy protein will then again start to hydrate to its normal capacity when placed in the presence of moisture or food juices.

It is suggested that partially hydrated textured soy protein concentrate could be used to absorb fish moisture or juice normally lost during processing. The textured soy protein concentrate could be mixed with minced fish, fish fines or even fish fillets. Figure 1 shows the moisture absorption curves when a textured soy protein concentrate was prehydrated to levels of 100, 150 and 200%. The prehydrated textured soy protein concentrate was then subjected to rehydration with 10 C water on a 1:1 basis. It can be seen that the textured soy protein concentrate quickly absorbed moisture, generally doubling its weight.

These properties can be utilized in a number of different ways in the seafood industry. The water absorption and retention properties can be used to bind moisture in fish blocks, bind fish pieces in minced fish blocks and to pick up some of the fish moisture lost during processing.

Frozen minced fish blocks are currently becoming quite popular with primary processors, as this commodity facilitates the incorporation of deboned fish flesh to improve yields over normal fillet blocks. The minced block format is suitable for addition of extenders such as textured soy protein and soy protein concentrate (19).

Fresh filleted fish V-cuts, deboned fish, or equivalent fish flesh source is combined with soy protein concentrate or textured soy protein, water and flavor enhancer, mixed

TABLE VI

Frozen Fish Cakes

Formula	
Ingredients	%
Fish, frozen raw	16.00
Potatoes, cooked	54.77
Textured soy protein concentrates	5.65
Water	11.30
Soy protein isolate	0.95
Onions, dehydrated sliced	3.91
Vegetable oil	1.14
Parsley, chopped	0.14
Garlic, minced	0.33
Eggs, frozen whole	5.22
Salt	0.49
White pepper	0.10
Fish flavor	As desired

Processing procedure

1. Thaw frozen raw fish, reserving juices, and shred or break into small pieces.
2. Hydrate textured soy protein concentrate in juices from fish and water (120 F) for ca. 20 min.
3. Saute onions in vegetable oil until light brown. Add parsley and garlic.
4. Combine all ingredients and mix thoroughly.
5. Form into patties, freeze.
6. To serve, fry cakes at 350 F until golden brown.

TABLE VII

Breaded Salmon Patties

Formula	
Ingredients	%
Salmon, canned drained	45.27
Cracker crumbs	9.35
Steam textured soy flour	7.00
Soy protein isolate	1.00
Water	14.61
Whole eggs	22.12
Salt	0.63
Pepper, ground	0.02
Batter/breading	As desired

Processing procedure

1. Drain liquid from canned salmon and flake fish.
2. Hydrate steam-texured soy flour in liquid from salmon and cold water (about 5 C) for 10 min.
3. Combine salmon, hydrated steam textured soy flour and all other ingredients.
4. Grind the mixture through a ¼" plate.
5. Form the mix into patties and freeze.
6. Patties may be served after they are fried in a small amount of oil at 175 C for 5 min on each side.

TABLE VIII

Fish Sausage

Formula	
Ingredients	%
Fish, boneless	60.20
Water	30.20
Soy protein isolate	7.24
Salt	1.81
Spice*	0.55
*Spice blend:	%
Pepper, white	13.82
Mace, ground	27.74
Coriander	27.74
Paprika, ground	22.32
Garlic, ground	5.53
Sodium Nitrite	2.85

Processing procedure

1. Chop boneless fish in silent cutter with water, salt and spices for 2-3 min.
2. Add soy protein isolate, and chop for an additional 2-3 min.
3. Stuff and cook using normal processing techniques.

TABLE IX

Binder Matrix for Minced Cod Formulations

Binder matrix:	A[a] %	B[b] %
Water	10	10
Minced cod	9	9
Variable	3	0.5
Salt	1	1
Formula:		
Binder matrix	23	20.5
Minced cod	72	74.5
Soy oil (winterized)	5	5.0

[a]Included soy protein concentrate, bread crumbs, calcium-reduced skim milk solids as variables.
[b]Included alginate, egg albumin, STPP as variables.

for a minimum of 1-2 min in a Hobart type mixer, formed into standard blocks and deep frozen for storage or further processing (Table V).

Further processing of fish blocks would be identical to that of conventional blocks. This may include sale in block form, cutting into fish sticks, portions, wedges of formulation into fish cakes, extruded snacks, etc.

The adhesion and cohesion, viscosity generation and water absorption and retention properties can be used to "cement together" fish cakes, salmon patties and the like. Another example presents a typical formula for a fish cake using soy protein isolate as a binder and textured soy protein concentrate as a fish alternative (Table VI).

Table VII shows a similar product using salmon and steam-textured soy flour as the salmon alternative, with soy protein isolate being used as a binder.

The emulsion formation and stabilization properties of soy protein isolate can be used to formulate a fish sausage. Fish sausages are quite popular today in the Orient, especially in Japan. Flavor of the system can be varied depending upon the source of the minced fish and spices used (2) (Table VIII).

VanDenover (1) used the following commercial additives in the binder matrix for minced cod: soy protein concentrate, calcium-reduced skim milk solids, egg albumin, sodium alginate, bread crumbs and sodium tripolyphosphate. The binder matrix and formulae are detailed in Table IX.

The "binder" matrix utilized fish protein binding ability by extracting myosin through mixing fish in the presence of salt and water. Minced fish was used in this test, as it provided a better test of the additive due to its poor water-holding capacity. The cooking time and method were designed to create additional stress. Cooking losses, i.e., drained juices, were measured immediately after cooking with six observations per variable. Pressed losses were measured on drained product which had been allowed to equilibrate to 22 at 25 C for 16 hr. Water-holding capacity was indicated by the total sum of % cook loss and % pressed loss (Table X).

TABLE X

Water-holding Capacity with Various Binder Matrixes[a]

Binder	Water-holding capacity (%)[b]
None (control)	43.0 ± 2.0 a
Sodium tri poly phosphate (STPP)	32.4 ± 1.4 b
Egg albumin	32.6 ± 1.1 b
Calcium-reduced skim milk solids (-Ca SMS)	28.9 ± 1.0 c
Soy protein concentrate	21.8 ± 0.5 d
Bread crumbs	21.0 ± 0.5 d
Alginate	19.2 ± 2.1 d

[a]Water-holding capacity is expressed as the total juice loss upon cooking and pressing. The data are means of six observations per vairable.
[b]Those means bearing the same letter did not differ significantly (P = 0.05).

TABLE XI

Subjective Organoleptic Evaluation With Various Binder Matrixes[a]

Variable	Degree off-flavor	Juiciness	Texture
Alginate	6.0 a	8.8 a	good
Bread crumbs	4.9 a	6.6 a	mushy
Sodium tri poly phosphate	5.1 a	6.3 b	good
Egg albumin	5.0 a	6.3 b	good
Calcium-reduced skim milk solids	5.1 a	5.3 b	good
Soy protein concentrate	5.0 a	5.0 b	good

[a]Those means bearing the same letter did not differ significantly (P = 0.05). Rank on a scale of 1-10; higher number indicative of better product.

Use of soy protein concentrate increased total water-holding capacity by ca. 50% above that of the control. The good water-holding capacity of soy protein concentrate was equivalent to that of bread crumbs and alginate; calcium-reduced skim milk was fair; egg albumin and STPP, comparatively poor.

The subjective evaluation with various binder matrixes is given in Table XI. The alginate matrix was perceived as significantly juicier than the other samples. Some comments were made that it had an excessively juicy and atypical creamy mouthfeel. The significance of these comments cannot be measured, as preference was not a parameter. The soft, mushy texture of the fish with bread crumbs was a distinct and unacceptable difference from the other fish products. None of the various binder matrixes had significant off-flavors.

Moledina et al. (13) published a method for producing a dehydrated, salted fish-soy product. The best results were obtained when mechanically deboned flounder meat from headed and gutted fish frames ("racks") was thoroughly mixed with salt (30% of the meat weight), soybean curd (20% of the meat weight), and the mixture was subjected to a pressure of 75 psi to remove juices and form cohesive cakes. The cakes were dried at 50 C for 8 hr to give a final product of 59.8% protein, 14.4% moisture, 21.1% salt and 5.3% fat. The salt was effectively removed from the product in preparation for consumption by bringing the fish-soy cake to a boil in three changes of water. Such a

TABLE XII

Protein-based Foods and Amount of Fish Protein Used (4)

	Amount of protein-based foods (mt/yr)	Fish protein used (mt/yr)
Kamaboko and derivatives	ca. 1,000,000	ca. 600,000
Fish ham and fish sausage	ca. 140,000	ca. 50,000
Fish hamburger	ca. 95,000	
Ordinary ham and sausage	ca. 300,000	ca. 50,000
Total	ca. 1,535,000	ca. 700,000

TABLE XIII

Boiled Fish Paste (Kamaboko)

Formula		
Ingredients		%
Fish, frozen paste		64.7
Emulsion curd*		11.4
Salt		2.1
Starch		3.8
Sugar		1.9
MSG		0.9
Egg white, frozen		3.8
Water (ice)		11.4
Flavoring		as desired
*Emulsion curd ingredients	Blend	Ratio
Soy protein isolate	1	1
Soybean oil	1	2
Water	3-4	6

Mix all ingredients in silent cutter at high speed until emulsified (10-20 min).

Processing procedure

1. Thaw frozen fish paste and chop them in silent cutter for ca. 15 min.
2. Add emulsion curd and chop for 5-10 min.
3. Add salt and chop for 20 min.
4. Combine all other ingredients and chop thoroughly.
5. Form into Kamaboko shape.
6. Steam for 15-30 min, cool and pack.

TABLE XIV

Boiled Fish Paste (Retainer Kamaboko)

Formula	
Ingredients	%
Fish, frozen paste	55.7
Soy protein concentrate	2.5
Water (1)	7.4
Salt	2.0
Starch	5.3
Sugar	1.2
MSG	1.0
Egg white, frozen	5.3
Water (ice)	19.6
Flavoring	as desired

Processing procedure

1. Thaw frozen fish paste and chop in silent cutter for ca. 15 min.
2. Add soy protein concentrate in a form of paste prepared by mixing it with water (1) and chop for 5-10 min.
3. Add salt and chop for 20 min.
4. Combine all other ingredients and chop thoroughly.
5. Form into Kamaboko shape and pack.
6. Age them by keeping at the constant temperature (e.g., 15 C/5 hr, 40 C/2 hr, etc.).
7. Steam for 15-30 min and cool.

product can be made economically with the use of simple equipment and therefore could serve as an inexpensive protein for the developing countries. Further development work and appropriate acceptance trials with a given target population seem desirable.

Fish Muscle Augmentation Systems

Witte (20) has reported a method whereby fish muscle can be enlarged by injecting the muscle with a soy protein isolate slurry. The forms of fish tested have been whole eviscerated fish, fresh fillets, and frozen/tempered fillets. The level of pump has ranged from 10 to 25%. The brine ingredients tested are in the following ranges:

Ingredient	%
Water	88-84
Soy protein isolate	9-10
Salt	2.5-5
Phosphate	0.5-1

The brine can be prepared with high shear mixing equipment. The procedure to make the brine involves hydrating the protein with the formula water before adding the salt or phosphate. Additional flavorings, such as smoke or lemon flavoring, may be added to the brine.

A boneless model or bacon model stitch injector is recommended for injecting the slurry. Care should be taken to select machines that will not tear or break up the fish muscle. Pressure and belt advances should be adjusted to achieve the desired level of pump in one pass through the stitch pump.

The pump fish can be packaged and frozen or further processed. Whole, eviscerated pumped fish can be smoked and packaged or frozen without smoking. The pumped fillets can be frozen individually or formed into a block and frozen. The frozen blocks are suitable for sawing into fish sticks or larger fish portions. The eating quality of the species tested (cod, pollock, salmon) has remained high. The finished product tends to be more tender and juicier.

FISH-SOY PRODUCTS – JAPAN

Aoki (4) recently described the soy protein food market in Japan. Table XII shows some major protein-based foods and the amount of fish protein used for these foods. Soy proteins are incorporated extensively in fish pastes including Kamaboko, fish sausage, and so on.

The greater part of the protein-based foods in Japan is not animal protein but fish protein products. The production total of fish protein products, including Kamaboko, fish ham, and fish sausage is around 1,250,000 tons. This number is four times the amount of animal foods produced. Fish protein is also widely used in Japan as a minor ingredient in animal protein foods. A certain amount of fish protein is allowed in ham sausage by the JAS (Japan Agricultural Standards). Thus, the total amount of fish protein used as an ingredient by food processors is over 700,000 tons, and 80% of that supplied as frozen fish paste (4).

Along with this increasing demand, a new type of semiprocessed food consisting of soy protein combined with various kinds of meats has been developed. For example, several products combining structured soy protein with chicken, mutton, pork or fish paste are on the market for industrial and institutional uses (4).

TABLE XV

Fried Fish Paste

Formula	
Ingredients	%
Fish, frozen paste	46.4
Chopped shrimp, boiled	14.0
Textured soy protein concentrate seasoned and flavored*	14.0
Salt	1.4
Sugar	0.9
Starch	3.7
MSG	0.4
Fish extract	0.5
Eggs, frozen whole	4.7
Water	14.0
Spices	as desired

*Ingredients	Weight units
Textured soy protein concentrate	100
Shrimp extract	20
Salt	10
MSG	10
Natural red color	1
Water	500

Mix all ingredients and heat for 10 min at 205 F, and then drain off excess water.

Processing procedure

1. Thaw frozen fish paste and chop them for 15 min.
2. Add salt, sugar, starch, MSG, fish extract, eggs, water and spices, and chop.
3. Mix chopped shrimp and hydrated textured soy protein concentrate.
4. Form into desired shape.
5. Batter and bread, then freeze.
6. To serve, fry them at 175 C until golden brown.

TABLE XVI

Fish Sausages

Formula	
Ingredients	%
Fish, frozen paste	71.1
Soy protein isolate	2.5
Water (ice)	10.0
Salt	2.5
Starch	6.0
Sugar	1.7
MSG	0.3
Pork fat, minced	5.9
Flavoring, color	as desired

Processing procedure

1. Thaw frozen fish paste and chop them for 10 min.
2. Add water (ice) and color, then chop.
3. Add salt and chop.
4. Combine all other ingredients and chop thoroughly.
5. Stuff them into casing and heat for 60 min at 90 C, and cool.

TABLE XVII

Frozen Scallop Cream Croquette

Formula	
Ingredients	%
Chopped scallop, boiled	15.5
Textured soy protein concentrate seasoned and flavored*	15.5
Onions	21.8
Salt	0.5
White pepper	as desired
White sauce	46.7

*Ingredients	Weight units
Textured soy protein concentrate	100
Sugar	15
MSG	2
Scallop extract	10
Scallop flavor	5
Water	400

Mix all ingredients and heat for 10 min at 205 F, and then drain off excess water.

Processing procedure

1. Saute onions in vegetable oil until light brown.
2. Combine all ingredients and mix thoroughly.
3. Form into croquette.
4. Batter and bread, then freeze.
5. To serve, fry them at 175 C until golden brown.

TABLE XVIII

Tuna Burger

Formula	
Ingredients	%
Tuna, frozen raw	39.2
Tuna, flaked	16.3
Textured soy flour	3.3
Water	6.5
Salt	2.0
Sugar	0.7
Lard	6.5
Bread crumbs	5.2
Onion	16.3
MSG	0.7
Shortening oil	3.3
Spices	as desired

Processing procedure

1. Thaw frozen tuna, mince the meat.
2. Thaw frozen tuna, steaming the meat, and shred or break into small pieces.
3. Chop the minced tuna for 5 min, add salt, then chop for 5 min.
4. Add all other ingredients without tuna flake, chop for 5 min, and then mix tuna flake.
5. Stuff them into casing and heat for 60 min at 100 C and cool.

The soy protein products used in fish products are mainly soy protein isolates and soy protein concentrates. These products are usually utilized in the following three ways: as a powder; as a paste prepared by mixing the soy products with water; and as an emulsified paste prepared by mixing soy products with water and fat or oil. The common weak points of these substitutional materials are the color, flavor and texture. Textures of the final products become softer, atypical flavors are noted, and the color becomes somewhat grayish or opaque white, depending upon the amount of soy protein added and the method of addition. Because of these weak points, the use level of soy protein is usually below 30% based on fish paste. Soy protein products are not generally used in high grade Kamaboko.

Japanese consumers are highly susceptible to the qualities of Kamaboko and its derivatives. Thus, the possibility of utilization of soy protein products in this field seems to depend upon the price difference between the fish paste and the soy protein products. If a fairly large price difference between the two continues for a long enough period, the consumers may become accustomed to the new type of Kamaboko and its derivatives containing soy proteins.

As mentioned earlier, frozen fish paste is widely used as an ingredient in many processed foods, e.g., ham and sausage, prepared frozen foods, prepared dried foods, retorted foods, and other ready-to-eat foods.

Recently, soy protein products have gradually been increasing in use as substitutes for fish paste in these foods. In these foods, it is not necessary for consumers to stick to fish protein flavor and texture themselves, as in the case of Kamaboko. Thus, whether soy protein products may become an ingredient in them or not will depend upon their functionalities and price. It is likely that the soy protein products will become accepted ingredients in this area sooner than in Kamaboko production (4).

Yasumatsu et al. (21) attempted to define the properties of soybean products desirable for producing processed fish products. Kamaboko made with soybean products was evaluated by both sensory testing and instrumental measurements. It was found that the "hardness" of the Kamaboko made with soybean products correlated highly with the degree of denaturation of soy protein and with the amount of protein nondispersible in 3% sodium chloride aqueous solution.

It was also concluded that the textural properties of Kamaboko made with soy protein could not be correlated with the textural properties of heat-coagulated gels of the corresponding soybean products.

Tables XIII through XVIII are illustrative of Japanese formulations using soy protein products in fish and seafoods.

REFERENCES

1. VanDenover, R., Food Eng., March 1978.
2. Endres, J.G., "Potential Soy Proteins for Fish Products," Presented at Atlantic Fisheries Technological Conference, Halifax, Canada, 1977.
3. PFW/Hercules Food Technology Center, Middleton, NY. Food Eng., June 1977.
4. Aoki, H., "New Soy Protein Food Market and Products in Japan," Proceedings of the Soybean Conference, Singapore, 1978.
5. Circle, S.J., and A.K. Smith, in "Soybeans: Chemistry and Technology, Vol. 1, Proteins," AVI Publishing Co., Westport, CT, 1972.
6. Meyer, E.W., in "Protein as Human Food," Edited by R.A. Laurie, Buttersworth, London, England, 1970.
7. Noyes, R., "Protein Food Supplements," Noyes Data Corp., Park Ridge, NJ, 1969, pp. 302-376.
8. Gutcho, M., "Textured Foods and Allied Products," Noyes Data Corp., Park Ridge, NJ, 1973.
9. Smith, O.B., in "World Soybean Research," Edited by L.D. Hill, The Interstate Printers and Pub. Inc., Danville, IL, 1976.
10. Anon, Food Process. (1974).
11. Valentas, et al., U.S. Patent 3,803,329, April 9, 1974.
12. Cook, C.F., E.W. Meyer, N. Catsimpoolas, E.F. Sipos, "Physical-Chemical Properties and Consumer Attributes of Meat-Soy Food Systems," Proceedings of the 15th European Meeting of Meat Research Workers, Helsinki, Finland, 1969.
13. Moledina, K.H., J.M. Regenstein, R.C. Baker, and K.H. Steinkraus, "A Process for the Preparation of Dehydrated Salted Fish-Soy Cakes," J. Food Sci., 42:3. (1977).
14. Meyer, E.W., in "Proceedings of the International Conference on Soybean Protein Food," Peoria, IL, pp. 142-155, October 1966.
15. Rakosky, J., Jr., J. Agric. Food Chem. 18:1005 (1970).
16. Wilding, M., JAOCS 51:5 (1974).
17. Kies, C., H.M. Fox, Jr., J. Food Sci., 36:841 (1971).
18. Hamdy, M.M., JAOCS 51:5 (1974).
19. Information Bulletin No. 7528. Griffith Laboratories, (UK) Ltd., Cotes Park Farm, Somercotes, Derby.
20. Witte, P.A., "Seafood Augmentation Systems," Presented at Atlantic Fisheries Technological Conference, Halifax, Canada, 1977.
21. Yasumatsu, Katsuharu, M. Misaki, T. Tawada, K. Sawada, J. Toda, and K. Ishii, Agric. Biol. Chem. 36:737 (1972).