World Trend in Surimi Processing with Respect to New Technology and Quality Contol

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Abstract

1. Internationalization and Diversification of Surimi Industry

It is estimated that the world's surimi production in 1994 was 512,000 tonnes. Japan was the biggest surimi producer in the middle of 80's, but the surimi production of Japan decreased to 132,000 tonnes in 1994. The USA started the commercial production of frozen surimi in Alaska in 1985 and became the biggest surimi producer in the world with 209,000 tonnes in 1994.

Thailand started surimi production in 1978 and has increased its production to 65,000 tonnes in 1994. The success of the Thai surimi industry stimulated development of surimi production in other countries in the region.

With an increase in the number of countries producing surimi, the fish species used for frozen surimi has been diversified. Of about 500,000 tonnes of frozen surimi in the world, the share of Alaska pollock surimi was 60% in 1994. The share of surimi from other fish such as whiting, threadfin bream, etc., has been increasing over the years.

2. Intrinsic Quality of Frozen Surimi

Stability of the meat proteins (especially of myofibrillar proteins) against heat and frozen storage is species dependent. Protein stability of cold water species is much poorer than of temperate/tropical water species. The stability or the rate of denaturation of myofibrillar proteins is closely related to the temperature of the water in which the fish lives. Strict temperature control is required for surimi of Alaska pollock and other cold water species.

3. Internationalization of Surimi-Based Products

The world production of surimi-based products in 1993 was estimated at 1,090,000 tonnes. The biggest kamaboko producer is Japan, followed by Korea, USA, Taiwan and Thailand. The production of imitation crab and seafood analogs began in the middle of the 70's and are now manufactured throughout the world.

4. Recent Trend of Kamaboko Products in Japan

Japanese consumers now prefer softer textured foods than previously and pay more attention to healthy foods. Some of the successful soft textured products are made by incorporating isolated soy protein into surimi-based products.

5. New Surimi-Based Product Technology

Vacuum grinding mixers have been introduced more and more into kamaboko processing plants in Japan.

Imitation crab meat, scallop or squid with fine texture and juiciness as compared to conventional products are now produced by twin-screw extrusion cooking. Ohmic cooking, or Joule cooking, with heat generated by flowing electric current through the foods is becoming popular in the kamaboko industry.

Proteinase inhibitors such as blood plasma are used for Pacific whiting surimi infected by Myxosporidian parasites.

Internationalization and Diversification of the Surimi Industry

1. Internationalization of frozen surimi production

It is estimated that in 1995, 506,000 tonnes of frozen surimi was produced in 1995 worldwide. Commercial frozen surimi production was started by a few Hokkaido shore plants in Japan in 1960. Since the frozen surimi production on Japanese factory boats started in the USA waters in 1965, Alaska pollock surimi had made tremendous growth with more than 500,000 tonnes produced in the middle of the 1970's. In those years, Japan was the only surimi producer in the world and most frozen surimi was made from Alaska pollock. The Japanese surimi production, however, has been decreasing over the last 10 years and production in 1994 was 132,000 tonnes.

The USA started commercial production of frozen surimi in Alaska in 1985. Since the shutting out of foreign surimi factory fleets from USA waters in 1990, more than 20 surimi factory boats and about 10 shore plants were producing frozen surimi from Alaska pollock and Pacific whiting. USA became the biggest surimi manufacturer in the world, with production exceeding 200,000 tonnes of surimi in 1994.

Korea started Alaska pollock surimi production in the mid 1970's on factory trawlers. With the American policy of shutting out foreign fishery boats from their 200 miles EEZ, the Japanese and Korean surimi factory fleets had to stop their operations in US waters. They moved to the southern hemisphere waters, first to New Zealand and then to Argentine waters. Korea produced 36,000 tonnes of frozen surimi in 1994.

Both these southern hemisphere countries have produced frozen surimi from *hoki* and southern blue whiting in joint ventures. Argentina is now one of the big surimi producers with production of 26,000 tonnes of frozen surimi in 1994.

The success of the Thai surimi industry stimulated developments of surimi production in the other South East Asian countries such as Hongkong, China, Malaysia, Myanmar, Vietnam, India and Indonesia, etc.

Chile started horse mackerel surimi production in a few shore plants in the early 90's and produced 5,000 tonnes of surimi in 1994.

Besides the countries mentioned above, frozen surimi is produced commercially in Russia, Mexico, Venezuela, France, etc. and many other countries are interested in the frozen surimi industry to use efficiently use their unused or underutilized species as human foods. This is shown in Table 1.

Table 1. Surimi production by country in 1994 (tonnes).

Country	Output (tonnes)	Country	Output (tonnes)
Japan	132,000	Malaysia	3,000
USA	209,000	Indonesia	500
Korea	36,000	India	1,000
Thailand	65,000	Hongkong	5,000
Argentine	26,000	Vietnam	1,000
Russia	17,000	Myanmar	1,000
China	10,000	Chile	4,500
Sub-total	495,000	Sub-toal	16,000
Total	512,000		

2. Diversification of Raw Material Fish

The surimi manufactured from temperate and tropical water species such as threadfin bream and croaker are quite different from that manufactured from fish of high latitude waters such as Alaska pollock and Southern blue whiting. As the fish caught for surimi in the high latitude waters consists of one species of almost the same-sized fish and the manufacturing lot is as big as 100 tonnes, it is common to install large scale, highly mechanized processing lines in frozen surimi plants.

On the contrary, in temperate/tropical waters, the catch consists of fish of a variety of species as well as size. As the catch must be separated by hand according to species, size, and freshness of fish before processing, the manufacturing lots become very small, usually 1 to 5 tonnes. Further, fish of various shapes and sizes and in small quantities make it very difficult to introduce highly mechanized processing systems in the manufacture of surimi.

With an increase in the number of countries producing surimi, the fish species used for frozen surimi has diversified. Alaska pollock, however, is even now the staple raw material for frozen surimi. Of about 500,000 tonnes of frozen surimi in the world, the share of Alaska pollock surimi was 88% and 60% in 1983 and 1994 respectively. Meanwhile, the share of other fish surimi has been increasing during these years. This is shown in Table 2.

Table 2. Surimi production by species in 1994 (tonnes)

Country	Output (tonnes)
Tropical water species	107,000
Southern blue whiting	36,000
Pacific whiting	38,000
Cold water species	31,000
Alaska pollock	300,000
Total	512,000

3. International Trade in Frozen Surimi

Japan supplied the raw material for its own surimi-based products until 1975, but since then, it became an importer of frozen surimi and its imports of frozen surimi has increased dramatically. Thus, Japanese consumption of frozen surimi was 454,000 tonnes and 382,000 tonnes in 1988 and 1993, of which 37% and 67% were imported respectively.

The surimi imported into Japan is diversified in species. The share of Alaska pollock surimi was 60% in 1994 and that of other species has been increasing. As the number of countries manufacturing surimi-based products increases, the international trade of frozen surimi has been carried out among the other countries as well, eg., from the USA to Korea, Taiwan and Europe, from Thailand to Singapore and Korea, etc.

Intrinsic Quality of Frozen Surimi

1. Cold Water Species

Frozen surimi of Alaska pollock and other cold water species were recently introduced into Singapore and other Southeast Asian countries as a result of the growth of international trade. Manufacturers in these tropical countries are unfamiliar with the intrinsic qualities of Alaska pollock surimi and have encountered problems in dealing with this "new" surimi. They should first understand the intrinsic qualities of the surimi and learn how to use it properly.

Stability of the meat proteins, especially the myofibrillar proteins, against heat and frozen storage is species dependent. The protein stability of cold water fish species is much poorer than that of temperate/tropical water species. Myofibrillar proteins of land animals are more stable than that of fish. The stability or the rate of denaturation of myofibrillar proteins is closely related to the body temperature or the temperature of the water in which the fish lives.

For example, Alaska pollock loses the gel-forming ability very rapidly when it is stored in the frozen state; the meat proteins denature completely and cannot be used as raw material for frozen surimi after 3 months storage at -25°C. When the meat temperature of Alaska pollock rises above 15°C during the surimi manufacturing process, its jelly-forming capacity decreases significantly. If the temperature of the meat after grinding with salt rises above 15°C, the texture of the surimi-based products of Alaska pollock becomes fragile and poor, while that of threadfin bream is good even when the meat temperature rises above 15°C. The critical temperature for threadfin bream might be 23 - 25°C. (See Fig. 1)

Suwari, or pre-incubation of the ground surimi paste at low temperature, is widely practised in the commercial production of surimi-based products to enhance their texture. The Alaska pollock meat paste after grinding with salt sets very rapidly when the meat temperature raises above 20°C and then becomes very difficult to shape. Very poor texture might result when the meat paste of Alaska pollock is set at 40°C, the optimum *suwari* temperature for tropical water species surimi. The favourite conditions used in Japan for *suwari* to increase the jelly-strength of surimi-based products of Alaska pollock are 5°C overnight, or 30°C, for 20 - 30 minutes.

In summary, strict temperature control is required for Alaska pollock and other cold water species as follows :

1. Frozen surimi should be stored below -20°C.
2. The meat temperature during grinding with salt should be kept below 15°C.
3. The meat paste should be shaped as soon as possible after grinding with salt.
4. Setting treatment should be carried out at low temperature.

2. Jelly Meat

Some fish species such as Peruvian hake, Australian barracuda and Pacific yellowfin tuna are often infested with micro-parasites, *Myxospordian* spp., which secrete enzymes with very strong proteolytic activity.

Pacific whiting has recently become an important raw material for frozen surimi on the American Pacific coast. Pacific whiting, however, suffers from a serious problem of meat softening by the parasites' enzymes. The washing treatment of minced meat cannot remove all the proteolytic enzymes from the minced meat resulting in its poor gel-forming capability.

Blood plasma having very strong protease-inhibiting activity was found to improve the gel-forming capability of Pacific whiting surimi. By adding this ingredient, frozen surimi of good quality is manufactured successfully from Pacific whiting.

When a new species of fish is explored as raw material for frozen surimi, a careful preliminary study of *Myxosporidian* parasitic infestation is necessary.

3. Small Pelagic Fish

Small pelagic fish such as sardine and horse mackerel are very difficult to use as raw material of frozen surimi. The meat pH of these fish is as low as below 6 and myofibrillar proteins are likely to suffer from acid denaturation. Besides, the meat color is dark and the meat contains a large amount of fat and water soluble components which reduce the gel-forming capability; they also develop strong fish odor.

In the late 80's, technologies for manufacturing frozen surimi from small pelagic fish such as sardine were developed in Japan.

The points the technology studied were:

1. minimization of acid denaturation of myofibrillar proteins,
2. effective removal of fat and water-soluble meat components, and
3. development of hardware such as fish processing machines, meat bleaching facilities, continuous de-watering machines, etc.

After further pulverizing minced meat to the myofibril level, it is bleached with alkaline brine. Lactic acid formed by the post-mortem glycolysis reaction is removed and neutralized efficiently. Water soluble components such as sarcoplasmic protein, myoglobin and extractives are washed out rapidly. Fat is removed by continuous centrifuging. The surimi thus obtained is colored only lightly, has excellent gel-forming ability, contains low level of fat (approx. 1%), and has little fishy odor.

Small pelagic fish in tropical waters generally have higher pH value than fish in Japanese waters. Their meat proteins therefore present us with less problems of acid denaturation. Therefore, the tropical small pelagic fish might be more easily utilized as surimi raw material, though their dark color remains a problem.

Internationalization of Surimi-Based Products

1. World Production of Surimi-Based Products

World production of surimi-based products in 1993 was estimated at 1,090,000 tonnes. The biggest *kamaboko* producer is Japan, followed by Korea, USA, Taiwan and Thailand.

The Japanese production level of one million tonnes of surimi-based products had gradually continued to decline since 1974, and a further sharp depression was noted in 1991/92. *Kamaboko* production was down 4.5% and 7.5%, respectively, as compared to that of 1990. The big decrease was primarily due to the dramatic rise in the surimi price. The price of frozen surimi more than doubled that of the previous year. Though the *kamaboko* producers tried hard to stabilise the market, the decreasing tendency in 1994 continued to the present and the production was 823,000 tonnes.

Table 3. Production of surimi-based products in the world in 1993 (tonnes).

Country	Output (tonnes)
Japan	830,000
Korea	120,000
USA	60,000
Taiwan	60,000
Thailand	20,000
Singapore	6,000
Total	1,096,000

The same type of products as the Japanese traditional *kamaboko* are produced in Korea and Taiwan. Southeast Asian countries produce "fish ball" from minced fish and also recently from frozen surimi for the domestic market.

The production of imitation crab sticks and seafood analogs began in the middle of the 70s and are now manufactured throughout the world. The major producers are Japan, USA, Korea and Taiwan; Thailand and Malaysia are new producers. Besides these countries, imitation crab sticks and seafood analogs are manufactured in Canada, Argentina, Russia, Scotland, France, China, Singapore, Israel, Australia, and other countries.

The Minato News newspaper recently predicted a big growth in the production of surimi-based products in China. The estimated demand for frozen surimi for China in the year 2000 is 100,000 tonnes, while the demand in 1995 was only 1,000 tonnes.

2. International Trade in Surimi-Based Products

Japanese imports of prepared fish products containing more than 20% fish meat, most of which are imitation crab sticks from the USA, have increased recently although the quantities are small. Besides seafood analogs, import of deep fat-fried *kamaboko* from Thailand and China have also increased in these few years.

Export of imitation crab sticks and seafood analogs from Japan to the USA and Europe peaked in 1985 with a record of 39,000 tonnes, but has since declined because both the USA and Europe have their own manufacturers and also because of stiff competition with other new producing countries. Thailand and Malaysia are developing their imitation crab sticks industries and are exporting their products to Europe, USA, Korea and other countries.

Recent Trends Of *Kamaboko* Products

The Japanese *kamaboko* manufacturers have been trying to maintain or expand their market by developing new products to fit in with consumer trends. Generally speaking, consumers, especially the young ones, prefer softer textured foods than previously and pay more attention to healthy foods.

Some of the successful soft-textured products are made by incorporating isolated soy protein into surimi-based products. Incorporation of isolated soy protein gives many advantages: healthy and natural image, reduction in production cost, improvement in qualities such as soft texture, white color and light flavour, etc..

Addition of up to 50% shredded vegetables to the surimi-based products gives the consumers an impression that the products are healthy and natural. Mashed carrot and pumpkin paste, which contain plenty of b-carotene, are used as colorants to give a healthy and natural image to a variety of surimi-based products. To make products with a healthy image, many *kamaboko* manufacturers are interested in adding dietary fiber rich *konyaku mannan*, calcium-enriched ingredients, DHA and EPA, etc.

In Thailand, dried surimi products are

becoming popular recently. Surimi paste is shaped into a thin belt, cooked on a big drum, dried and puffed and then shredded. Many varieties of the product with various flavours are on the market. A very sophisticated surimi-based product, imitation baby eel, is on the market in Spain.

New Trends of Surimi-Based Product Technology

1. Vacuum/Non-Thawing Grinding

Vacuum grinding mixers have been introduced more and more into *kamaboko* processing plants in Japan. The final products made by the vacuum mixers are of excellent quality with more smooth, flexible and homogeneous texture as compared to those made by the conventional silent cutters. The improvement to the *kamaboko* texture by the vacuum mixer might be due to the "no thawing grinding"; salt and other ingredients are added to the surimi in its frozen state at the beginning of grinding and mixing. The improvement to the texture of *kamaboko* by the "no thawing grinding" method could be expected for any *kamaboko* manufacturer switching from the method using the conventional silent cutter. Some of the other benefits of using a vacuum mixer are savings in both time and labour for grinding and mixing. More water can also be added to the surimi without lowering the quality of the *kamaboko*.

2. Extrusion Cooking

Imitation crab meat, scallop or squid with much more fine texture and juiciness than the conventional products are produced by twin-screw extrusion cooking. High temperature and high pressure during extrusion cooking alters the protein components of the original surimi and results in a new type of texture for seafood analogs.

3. Ohmic Cooking

Ohmic cooking or Joule cooking with heat generated by flowing an electric current through the foods is becoming popular in the *kamaboko* industry. The fish paste can be heat-processed in a short time with excellent energy efficiency. In addition, the fish paste is cooked uniformly regardless of its size. As the *modori* phenomena, the enzymic degradation of the gel network structure at 60-70°C is minimized by quick Joule heating, *kamaboko* with higher gel strength can be obtained as compared to conventional cooking methods from lower grade surimi. Various Ohmic heating facilities are used for the production of traditional surimi-based products such as *kamaboko* and *chikuwa* and also new products such as imitation crab sticks.

4. Blood Plasma

Proteinase inhibitors such as blood plasma are recently used for the production of frozen surimi of Pacific whiting, which is often infected by *Myxosporidian* parasites.

These protease inhibitors are also effective in preventing "modori" due to gel structure degradation during cooking at 60-70°C and improve the texture of the surimi-based products.

5. Transglutaminase

Suwari, a pre-incubation of the ground surimi paste at low temperature, is widely applied in the commercial production of surimi-based products to enhance their texture. It is recently known that *suwari* is in part related to the transglutaminase activity of fish meat. Transglutaminase, TGase, crosslinks a glutamine residue in a polypeptide chain and a lysine residue in another polypeptide of protein. As the cross-linkage reaction strengthens the network structure of fish meat proteins, *suwari* phenomenon proceeds.

As the bacterial-origin TGase preparation is recently available in the market, many *kamaboko* manufacturers are adding the enzyme to their products. The TGase preparation increases both the breaking strength and the breaking strain of the *kamaboko*, though the enhancing effect varies among surimi made from different species. The combined treatment of TGase addition and *suwari* is very effective for improving the quality of *kamaboko*.

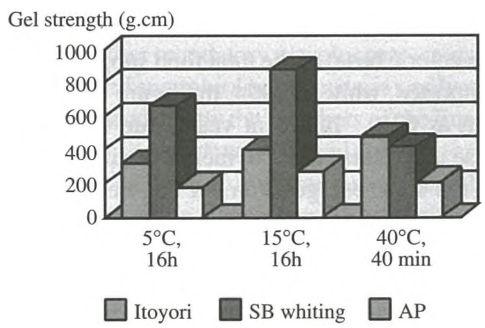

Fig. 1. Effect of *suwari* temperature on gel strength of meat from threadfin bream (*itoyori*), southern blue whiting (SB whiting), and Alaska pollock (AP).