Technical Problems In Surimi And Fish Jelly Products

YUTAKA SHIMIZU

Kobe-gakuin Women's Junior College, Kobe, Japan

Introduction

Fish jelly products are traditional foods of Japan and China. However, its production has increased dramatically in Japan, in spite of the diversification of eating habits after World War II. This development is believed to be primarily due to its inherent consumer appeal and to advances in scientific research and technology related to this food.

In this paper, I will review scientific and technical achievements in this field over the past 40 years and look briefly at some technical problems that remain.

Progress In Fundamental Research

In Japan, scientific research in fish jelly products began half a century ago with the work of Wataru Simidu (1935) and Hiroshi Hirano (1939). However, significant advances were achieved by the generation of young scientists who joined in these studies after World War II. The main areas of advance were as follows:

The Mechanism Of Gel-Formation of Fish Meat

Considered to be an issue that was directly linked to the scientific principle of this food, this topic received attention from the very beginning of the studies. Researchers investigated physico-chemical changes of muscle proteins that occur at each stage of processing, for instance, leaching, salt-grinding or heating. These studies were made in order to construct a theoretical explanation for the changes and to establish criteria for each production process.

Mechanisms of the setting phenomenon of fish meat sol, so-called *suwari*, and the thermal degradation phenomenon of raw gel, so-called *modori*, have also been essentially clarified.

The Mechanism Of The Putrefaction Of Fish Jelly, And Means Of Preventing It

In these studies, researchers have clarified the relationship between composition of meat sol and the spoiling phase, between packaging and heating conditions and the spoiling phase, and between heating temperature and the survival of microflora.

The researchers have also clarified changes in the redox potential of meat sol during heating, and have identified various putrefying bacteria. Fundamental research on putrefaction of this food seems to be almost completed.

Gel-Forming Property Of Fish Meat

Research on this subject lags far behind the other two. Variations in the potential gel-forming ability, the setting property and the *modori*-causing property among and within species were subjects of scientific and industrial interest. However, little information has been obtained about them so far, and only about a limited number of species.

New Technology Development

A variety of devices and new techniques have been introduced to the fish jelly industry of Japan over the past 40 years. Listed below are five considered to be particularly important in terms of originality and usefulness.

Fish Sausage

Fish sausage was introduced as a new type of *kamaboko*, which looks like a sausage and can be kept at room temperature. The prototype was made by Seinan-Kaihatsu Company in 1950 by stuffing horse mackerel meat sol with pork fat and spices into a casing of hydrochloride gum. Aided by the timely invention of nitrofuran, and polyvinylidene chloride casings, this new product developed conspicuously in the 1960s. Peak production was reached in 1972 at 180,491 mt, which was equivalent to 20% of the total annual production of fish jelly products.

The extraordinary shelf life of this product stemmed from two main factors. One was the prevention of secondary bacterial contamination by hermetically sealing with a gas barrier casing. The other was the action of the nitrofuran in eliminating those bacterial spores that survived in the heating process. These factors made it possible to keep fish sausage at room temperature, in spite of being heated under normal pressure. However, in 1974, the use of nitrofuran was prohibited by law, because of its cancer-causing action. Thereafter fish sausage became a retort food.

Double Step Heating

This technique is based on the gel-strength enhancing effect of the setting treatment to meat sol, discovered by W. Simidu in 1944. Before World War II, it was taboo to set the meat sol before the heating process, because the products treated this way were very springy but inferior in mouth-feeling. However, on the recommendation of M. Okada in 1959, the technique was immediately adopted throughout the country.

Frozen Surimi

A technique was discovered which made it possible to endow freeze-stability to washed fish mince or fish meat sol by mixing with sugars. Frozen surimi made of washed mince, so-called *muen surimi*, was developed by K. Nishiya *et al* in 1960. Frozen surimi made from meat sol, so-called *kaen surimi*, was developed by T. Ikeuchi and W. Simidu in 1963. Perfection of this technique has contributed significantly not only to the fish jelly sector, but to the fishing industry as a whole by making it possible to utilize Alaska pollack, a hitherto unexploited North Pacific species, as the raw material for fish jelly products. Truly, frozen surimi qualifies as a "once in a hundred years" technique in the history of fish food technology.

Alkaline Saline Leaching

Alkaline saline leaching, first devised by Y. Shimizu in 1963, is a technique in which low gel-forming capability of dark-fleshed fish meat is improved. The effectiveness of this leaching technique is due to the neutralization of muscle pH and the promotion of solubility of sarcoplasmic proteins by the soaking of fish mince in dilute alkaline saline solution (0.25% NaCl + 0.2% $NaHCO_3$).

Crab Leg Analogue

The history of crab leg analogue development began in 1975 when the Sugiyo Company introduced a new type of *kamaboko*, similar in appearance and flavour to crab leg. The first crab analogue was produced by the "cutting" method. In this procedure, cut fibers of *kamaboko* were mixed with a small quantity of fish meat sol and the mixture was tied up into a crab-leg-shaped rod. In 1985 the "continuous folding" method was devised by Osaki Suisan Company, and it replaced the "cutting" method. The introduction of crab leg analogue marked the start of a new era in the history of *kamaboko* by winning, for the first time, acceptance for the product among western consumers.

Progress Of Manufacturing Machines

Over the past 40 years, there have also been remarkable developments in the technology side and specifically in the capabilities of fish jelly manufacturing equipment. Various large, automatic and high-speed machines have been

combined into a continuous manufacturing system. Compared with grinding systems of 30 years ago, today's high speed vacuum cutters are ten times as efficient in terms of treatment volume, and four times as efficient in terms of speed.

Technical Problems Requiring Immediate Attention

Before World War II, the effectiveness of technical control of production depended on the personal skill and experience of the workers engaged in the operation. However, because of technological advances over the past 40 years, control is now much more of a textbook operation and is achieved through the use of automatic machines. Today, if frozen surimi is given, anyone can make products anywhere in Japan. However, the market place is also flooded with springy but unpalatable and generally inferior products.

Southeast Asian countries must not become another Japan. In this sense, I would like to recommend three areas for specific attention in this region.

A Second Look At Traditional Processes

Traditional foods are always the product of the climatic conditions of the regions in which they are developed. Not surprisingly then, the making process of a traditional food is seen at its best in its native setting. This is demonstrated by the example of Japanese *kamaboko* and Chinese fish balls.

The common secret of fish processing is how to remove, eliminate or mask the smell of fish. Leaching process in case of Japanese *kamaboko* is done for the purpose, while in case of Chinese fish balls "soaking" process is carried out in place of leaching. Which is better? Of course, "soaking" process is. In the climate of Southeast Asia, it will never be possible to make high quality products by the Japanese process. This is because during the leaching process the gel-forming capability of myofibrillar proteins is reduced, and so is its tastiness. By contrast, the "soaking' treatment in the making of Chinese fish balls has important advantages. Specifically it allows the washing out of the fish smell without sacrificing either the gel-forming characteristics or the taste of fish meat. The "traditional" process merits more careful evaluation.

Development Of New Local Products

The chief advantage of fish jelly products over other fish products is flexibility in terms of seasoning, shaping the product form, and combining the products with other materials. We should make use of this advantage to develop distinctive new products matched to the eating habits and tastes of different populations. These could include spices, vegetables, cereals, fruits, dairy products, meat products and various aquatic products other than fish.

Use Of Under-Utilized Fish

In various parts of Southeast Asia, large amounts of freshly landed fish go to waste because there is no present market for them. However, I think it is entirely possible that they could be processed into fish jelly products. Such a development would contribute greatly not only to the fish jelly sector but also to the fishing industry as a whole. A good model for this kind of development is *jako-tempura*, a fried *kamaboko* made of miscellaneous small fish in the island of Shikoku, Japan.

Predictable Technical Developments

There are three technical problems currently in focus, and some for which we can expect solutions in the near future.

Standardization Of Methods For Evaluating The Physical Property Of Fish Gel

Since frozen surimi achieved the status of an international product, pressure has grown for the establishment of standands to certify its quality, and FAO has begun preliminary work in this direction.

Along the way it will be necessary to standardize the method of measuring gel-strength – this must be done in order to estimate the gel-forming capability of raw meat or frozen surimi. Various methods have been used for the measurement of gel-strength. They include tensile, puncture, torsion and teeth-cutting tests. Each of these method has its advantages and its drawbacks. We will need to standardize measuring conditions for each test, not only for the evaluation of the surimi quality but in order to conduct scientific research on fish gel.

Establishment Of *Modori*-Preventing Technique

Gel degradation phenomenon occurring during the heating process, so-called *modori* is the most serious obstacle to the use of fish meat for fish jelly products. Recently, our group at Kyoto University has found four types of *modori*-inducing proteinases (MIP), revealed their enzymatic properties, and investigated their distribution among fish species. Since inhibitors which are effective against one type of MIP has also been found in spinach and red pepper, it is reasonable to expect the development of a *modori*-preventing technique in the near future.

Establishment Of The Technique Of Recovering Proteins From Waste Water Produced In The Leaching Process

A lot of water soluble muscle proteins are washed out during the leaching process. Recovering the proteins from the washings is very important in terms of efficient utilization of food resources and prevention of water pollution. Though these proteins have been collected by the use of chemical coagulants such as polyacrylate, the protein recoverd by such a coagulant is of no use either as food or feed.

However, there is a unique method, called the "pH shifting" method, which was devised by Nishioka and Shimizu (1983) eight years ago. In this method, washings are only acidified by HCl or alkalified by NaOH beyond the critical pH zone between 5 and 11 respectively, and then neutralized. By this 95% of proteins are made to precipitate from the washings of Pacific mackerel. E. Okazaki of the Central Fisheries Research Institute, Japan, is now investigating the conditions to put this method to practical use. In the near future we can expect to recover the waste proteins in an edible state.

In conclusion, I hope that fish jelly making technique will promote better utilization of low market value fish in the countries of Southeast Asia, and it will also contribute towards improving the diet of each country in her own way.

Hirano, H. 1939. On the gelation of fish. Bull. Jap. Soc. Sci. Fish., 8:29-40.

Ikeuchi, T. and W. Simidu. 1963a. Study on cold storage of brayed fish meat for the material of *kamaboko*-I. Effect of setting phenomenon on the jelly-forming ability of frozen brayed fish meat. Bull. Jap. Soc. Sci. Fish., 29: 151-156.

Ikeuchi, T. and W.Simidu, 1963b. Study on cold storage of brayed fish meat for the material of *kamaboko*-II. Effects of saccharides and others on setting of brayed fish meat. Bull. Jap. Soc. Sci. Fish. 29: 157-160.

Kinoshita, M., H. Toyohara and Y.Shimizu. 1990. Proteolytic degradation of fish gel (*modori*-phenomenon) during heating process. *In* Chilling and Freezing of New Fish Products - Proceedings of the IIR Meeting, Aberdeen, 18-20 Sep.: 61-67.

Nishioka, F. and Y.Shimizu. 1983. Recovery of protein from washings of minced fish meat by pH-shifting method. Bull. Jap. Soc. Sci. Fish. 49: 795-800.

Nishiya, K. 1960. A preventing method of denaturation of muscle proteins in watery species of fish. Jap.Patent, Sho-37-9257.

Okada, M. 1959. Profitable use of setting as a gel-strength enhancing method of *kamaboko*. Rep. Tokai Reg. Fish. Res. Lab., No.24: 67-72.

Shimizu, Y. 1963. A method of manufacturing leached fish meat. Jap. Patent, Sho-40-21224.

Simidu, W. and Y. Takebayashi. 1935. Studies on *kamaboko* and its similar products-I. *Ashi*(texture) of *kamaboko*. *Suisan Seizo Kaishi*, 3: 63-80.

Simidu, W. 1944. Studies on the muscles of aquatic animals IV. On phenomena of so-called *suwari* and *modori*. Bull. Jap. Soc. Sci. Fish., 12: 165-172.

Discussion

In the discussion, Dr Shimizu informed the meeting that in the recovery of proteins at various pH-shifting conditions, monitoring had been conducted using the Kjeldahl method.