THE DEVELOPMENT OF A PROCESS FOR THE PRODUCTION OF RESTRUCTURED FISH FROM RECOVERED FISH MINCE

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SUMMARY

The edible flesh of fish can be recovered by meat/bone separating machines. These machines recover the flesh by tearing and shearing actions, forcing the flesh through a perforated drum in a form resembling minced meat.

A portion of the protein in fish flesh, as in meat and poultry, is salt soluble. If some of this protein is solubilised in the presence of salt, the protein forms a sol. When this sol is heated, a gel is formed. The gel is used in this development to hold the mince particles together, giving the product its structure. The structural characteristics of the gelled product are shown to be modified by adding varying amounts of salt, water and polyphosphate. These properties are applied to developing a heat gelled or restructured product with textural characteristics similar to cooked fish fillet.

The eating quality of the restructured product depends largely upon the quality of the raw materials used in its production. The quality of samples of fish is tested, and the heating operation used in the restructuring process is shown to reduce the number of bacteria in the product considerably. Quality standards are proposed.

Storage of product prepared from trevally is shown to be difficult due to the development of rancidity in fatty fish. The exclusion of oxygen from the product is found to be the most effective means of prolonging storage life.

A pilot plant is developed for the production of the restructured product. The restructured product is modified to suit the continuous process, whilst retaining the desired textural characteristics. A manufacturing process is proposed, its operation based on the pilot plant.

SECTION I

Introduction

Recovery of edible flesh by meat/bone separators

The production of fish paste products such as Kamaboko (fish paste) and chukawa (fish sausage) is an ancient tradition in Japan, and it is only recently that the industry has developed into a mass production enterprise (Tanikawa 1963). To produce the quantity of boneless, ground fish required for this industry, the Japanese have developed a range of machines by which the material can be processed, and an appropriate technology to ensure quality standards are met. These developments have proved to be very successful, and the principles developed by the Japanese are now being adopted by a number of industries throughout the world.

The success of the meat/bone separation machines is largely due to their versatility, and the high yields of edible fish flesh that can be recovered. Using this process most species of fish will yield 55% of edible material (King and Carver 1970), although flat fish may yield as little as 25% (Tanikawa 1963) and species such as Blue Marlin may yield up to 70% edible fish (King and Carver 1970).

Working with fish caught off the coast of New Zealand, Sorensen (1971b), found that the yield of edible fish flesh recovered depended on the species of fish, and varied seasonally. In every case it was shown that processing the fish by machines yielded more edible fish than traditional processing methods (Table 1:1):

TABLE 1:1 Comparison between yields of machine recovered fish and fish filleted by hand

Species	Machine Recovery (%)	Hand Operation (skilled knifehand)	
		fillet recovery (%)	Skinned & Boned fillet (%)
Snapper	50 - 54%	31 - 37%	25 - 32%
Gurnard	51 - 53%	40 - 44%	-
Trevally	52 - 56%	42 - 46%	19 - 22%
Barracautta	50 - 54%	40 - 44%	-

In addition to the high yields of edible materials recovered from headed and gutted fish, work has also been done to recover edible flesh from fish frames or fish scrap remaining after filleting. Sorensen (1972) reported that an additional 19% could be recovered from snapper by processing the frames after filleting. King and Carver (1970) reported similar results from a variety of fish including ocean perch, pollock and cod.

The high yield of edible flesh recovered from all species of fish, and the ability of the machines to process a wide variety of fish without special fixtures or adjustments has already had an impact on the New Zealand industry. Two companies are currently using meat/bone separators to process species of fish which would otherwise be under utilised. Barracautta, previously difficult and uneconomic to process, largely due to its bone structure, is now used in the production of slabs for use in fish finger processing (Slack 1973). Similarly, recovered trevally fillet is used in products such as fish cakes (Sorensen 1971b).

It is not known how much fish has been dumped overboard

from New Zealand fishing vessels, although it was reported in 1966 (Anon., 1966) that as much as 200 tons of trevally, kahawai and red cod were dumped overboard each month. In addition to the dumping of commercially recognised fish is the dumping of fish caught incidental to the main catch. A survey by a Japanese research vessel off the east coast of New Zealand showed that a number of fish not used commercially at present were suitable for Surumi (ground fish) production.

Uses for Ground Fish Flesh

Although a market does exist for Surumi in Japan, current prices are not attractive, and the quality demanded by Japanese importers would require the Surumi to be processed only from premium quality fish. Thus uses must be found for the product either in New Zealand or Australia.

Ground fish flesh has been used in fish cakes, canned fish products (King and Carver 1970), fish luncheon sausages, savoury fish bites and fish burgers (Sorensen 1971b). The material has also been used to produce the fish sausage described by Thomas (1966) and in Surumi-type fish fingers (Achjolberg 1971, Slack 1973). In addition it has been used as a binder in fish loaf or jellied roll type products (Learson et al 1969, King and Carver 1970) and has been used in the preparation of simulated shell fish products (Learson et al 1971).

Sandwich, or hors d'oeuvres type of spreads have also been proposed, and King and Carver (1970) cite a case for institutional or commercial mass feeding, where the aim is to produce a nutritive menu at a low cost. These workers claim that preliminary tests suggest that it is possible to include freshly prepared machine separated fish flesh with ground beef in recipes

such as hamburgers, sloppy joes, meat loaf and spaghetti with meat sauce. A beefless frankfurter was also proposed.

Marketing of Processed Seafood Products

Market surveys in New Zealand (Nielsen 1971) and Australia (van Dijk 1971) on frozen fish products indicate a strong demand for fish fingers (fish sticks) and fish portions. In view of the U.S. fish stick production increase of 16.9% in 1972 (Q.F.F.1973) it would appear that this trend is likely to continue.

Compounded products such as fish cakes on the other hand, appear to have more limited appeal. This can be seen in Table 1:2, listing local retail sales of fish fingers, frozen fish fillets and fish cakes for the twelve months ending July 1971. (Other figures for New Zealand are not available, and the local sales trend is not known).

TABLE 1:2 Sales of frozen uncanned fish products in New Zealand; for 12 months ending July 1971

Product	Sales Volume (lbs.000)	Retail value ($.000)	% Of Grocery Turnover
Fish fingers	1404.7	1093.3	0.45
Fish fillets	427.3	335.8	0.14
Fish cakes	85.6	56.0	0.02

(Condensed from Nielsen Report, 1971)

Having established the importance of the fish finger and the frozen fish fillet market, it is necessary to understand why consumers prefer these products. A survey carried out by Heylen Research Centre (1972) showed that people have an image of what a fish finger should be, and have expectations associated

with this image. It appears that a fish finger should contain "white flesh", and have a "real fish flavour", and a "moist" and "fine" texture. Similar criteria can be expected for all products traditionally processed from natural fish fillet. Fish fingers can be processed directly from frozen slabs of ground fish (Sorensen 1971b, Schjolberg 1970, and Slack 1973), and such products are currently sold on the New Zealand Market (Slack 1973).

Consumer reaction to fish fingers processed from ground fish was evaluated from a survey conducted by the Heylen Research Centre (1972) on behalf of JBL Seafoods Limited.

Three fish fingers were evaluated on a comparative basis:

(1) Smoked fish fingers prepared from ground fish; fish content 72%

(2) White fish finger prepared from ground fish; fish content 72%

(3) White fish finger prepared from fish fillet; fish content 50%

Results from this survey suggest that the smoked fish finger did not have the characteristics expected of fish fingers. This product was commonly associated with fish cakes. A comparison between the two white fish fingers revealed the overriding importance of textural characteristics in fish products. Although the fish fingers prepared from ground fish were preferred for their flavour, the overall preference was with the product prepared from natural fish. The appeal for this product was largely due to its texture, which was described

as "real fish" with a "light", "fine" texture. In addition the texture was noted to be "moist", "juicy" and "succulent". The products prepared from ground fish on the other hand, were described as "tough", "chewy", "heavy" and "dry". Some people disliked the product being "minced", and others considered the product to be "like sausages".

An indication of the value placed on the texture of the product was found by a "propensity to purchase" test carried out during the survey. It was shown that most housewives considered fish fingers prepared from fish fillet to be a better buy at 69c per 10 oz pack, than fish fingers prepared from ground fish selling at 58c for a 10 oz pack.

Products prepared from skinned and boned fish fillet pose a number of problems to the producer. Skinning and boning fish is a slow and laborious process, and during the peak of the season, factories do not have the time or the staff to handle large quantities of fish in this way. Furthermore, the low yields and high labour content result in high costs, and despite the premium paid for products prepared from skinned and boned fillets, the proposition is not financially attractive.

Restructured Flesh Products

The foregoing discussion outlines the problem faced by the fishing industry, and it is noted that the use of the meat/bone separation process to recover high yields of edible flesh can be of great benefit to the industry. On the other hand, it is also appreciated that products prepared from fish fillets are most desirable from a marketing point of view. To satisfy both of these requirements, it would be necessary to reprocess the recovered flesh to simulate a form that resembles

and has the textural qualities associated with fish fillet. For the purpose of this thesis, such a process will be referred to as "restructuring".

The principle of restructuring flesh materials depends upon the binding together of individual particles to form a continuous mass. The binding is achieved by dissolving a portion of the myofibrillar proteins by the action of salt (sodium chloride), and forming a "sol", which is very adhesive (Tanikawa 1970). When this adhesive mixture is heated, the sol converts to a gel, forming a ternary network protein structure enclosing particles of ground fish.

Using this principle, a number of different concepts have been proposed in the literature on restructuring flesh products. Unilever (1971) in a patent application for restructuring ground fish, meat and poultry, describe a system whereby fibrous material is laid parallel and intimately bound together by the addition of comminuted meat components. The textured component contains separate meat muscle fibre bundles (length 2 - 50 mm), fat (1 - 40%), salt, water and additives such as herbs, farinaceous or other vegetable material and vegetable protein. The alignment of the textural components is achieved by extrusion with orientation of fibre bundles and is consolidated by freezing or heat coagulation.

Work has also been done on the binding together of cubes of meat. Schnell et al (1970) found that cubes of chicken could be bound together by the action of heat to form chicken loaves. These workers found that the amount of fluid expressed during cooking was inversely related to the amount of binding

achieved. Sodium chloride and food grade phosphate compositions were reported to reduce the fluid expressed, and thereby assisted the binding properties of the meat cubes. A process of tumbling meat cubes has also been described (Anon. 1971). Tumbling the meat is said to produce optimum protein activation, resulting in excellent binding and reduce cooking losses. Sommer (1969) describes a process in which pieces of moist meat are worked for 20 - 25 minutes, to release protein substances to the surface of the meat where binding is effected. This process has also been used by Sorensen (1972) in the preparation of fish finger slabs. Torr (1970), Gilbert (1971) and Wilcox and Hafstead (1969) all describe variations of the process whereby salt is used to extract myofibrillar protein from pieces of animal or poultry meat, causing them to become tacky, and then forming the pieces into a coherent mass and coating with an external binder.

Fenters and Ziemba (1971) describe a process in which boneless meat is cut into flakes instead of being ground, the flakes being knitted together subsequently during blending. The blended meat is frozen, tempered, then machine pressed into loaves ready to be sliced or cubed. The authors claim that the restructured meat can be used in various forms, including stews and casseroles, and that it will not disintegrate on cooking.

Processes have also been described where introduced binders are used to hold together the pieces of meat. Binders proposed include fish protein (Learson 1971), plant protein, caseinate, skim milk powder and egg albumin (Torr 1970).