AN APPROACH TO THE DEVELOPMENT OF A FORMULATED BREADED PRODUCT FROM MECHANICALLY DEBONED FRESHWATER FISH.

by

D.G. IREDALE
K.J. SHAYKEWICH
R.K. RASTOGI

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An approach to the development of a formulated breaded product from mechanically deboned freshwater fish.

D.G. IREDALE and K.J. SHAYKEWICH
Freshwater Institute
Winnipeg, Canada

and

R.K. RASTOGI
Freshwater Fish Marketing Corporation
Winnipeg, Canada
(Present address: Union Carbide India Ltd.
Vishakapatnam, A.P., India)

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ABSTRACT

Mechanically deboned freshwater fish flesh was used as the basic raw material for a breaded or battered fish shaped portion. The rationale determining a logical approach to the development of various characteristics in the product is discussed, the use of a sensory panel described, and a schematic outline of possible commercial scale production is presented.

RÉSUMÉ

De la chair hachée de poisson d'eau douce a servi de composition de base dans la formulation de portions de poisson enrobées de pâte à frire ou de panure. Dans le présent article on décrit la façon d'obtenir les différentes charactéristiques requises pour ce genre de produit, l'usage d'un jury de dégustation, et finalement un aperçu schématique des lignes de fabrication dans une usine commerciale à venir.

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INTRODUCTION

Mechanized methods of separating the flesh of fish and poultry from skin and bones have been in use for more than 20 years. The Japanese have made extensive use of this technology, especially in the field of fish utilization, but only in recent years has the potential of mechanical flesh separation been recognized by the North American food industry. In poultry processing, these methods allow the recovery of flesh from parts such as necks, backs and carcasses which previously have not been utilized fully. In the fishing industry the application of these techniques permits greater recoveries of edible flesh than obtained by conventional filleting methods.

At the present time, there are two basic types of machines used to separate raw fish flesh from skin and bones. In a review article in Fish Farming Industries (Anonymous 1972) they were described as follows: "The first type uses an 'outside feed' (Fig. 1). Typically, these separators use squeezing and tearing actions to remove flesh from suitable materials. The separated flesh moves through the holes of a perforated drum and leaves the machine from the inside of the drum . . .

"The second type uses an 'inside feed'. Typically these separators use an auger or other means to push the incoming material against a perforated cylinder. The flesh passes through the holes of the cylinder because it can be broken or squeezed. Bones and skin are too large or unbreakable to pass through these holes and leave the machine through a separate opening." All fish for the present study was obtained using an "outside feed" type machine with drum apertures of 5 mm. The resulting recovered flesh had a consistency not unlike hamburger although it was much softer and wetter.

Potential source material for deboning may be obtained from 1) racks from a filleting operation, 2) fish which are considered too difficult to fillet efficiently, 3) fish which are difficult to market in conventional

forms due to their low consumer appeal. The socio-economic benefits to be realized by utilizing such previously scorned freshwater fish species as suckers (Catostomidae), burbot (Lota lota), tullibee (Coregonus artedi), carp (Cyprinus carpio) and sheepshead (Aplodinotus grunniens) are self evident.

There are two basic potential uses for deboned fish flesh. The first is the direct substitution of deboned fish blocks for frozen fish fillet blocks to be made into breaded or battered fish sticks or portions. This could be an outlet for the flesh recovered from the racks of well accepted species such as cod and haddock. The second use is in formulated products such as gefilte fish, fish sausages and frankfurters and various types of fish portions where the basic characteristics of the fish have been modified by the addition of other components. This second use is particularly applicable to those species which have low consumer appeal when processed by conventional methods.

DEVELOPMENT

Sucker was selected as the primary species for the product under discussion since, although it probably has the greatest production potential of any of the underutilized species of freshwater fish, it is difficult to market when processed by conventional methods. The decision to develop a batter- or breading-coated product was based on the advantage that could be taken of the existing market for fish sticks and portions.

Preliminary work with deboned sucker flesh indicated the desirability of modifying various sensory characteristics to improve its acceptability. The texture of the deboned material when cooked becomes rubbery and in addition the flesh develops an unappealing grey color. Also the sucker has a characteristically sweet taste which, although not unpleasant, is unlike the flavor of traditionally acceptable species.

The modification of the sensory characteristics of the deboned flesh was accomplished by the incorporation of ingredients such as shortening, spices and binders. The main effects of raising the concentration of the fat and binder components were in increasing the juiciness and firmness of the product respectively. Flavor could be modified by adjusting the seasonings or using fish of different initial freshnesses (Table 1). The addition of artificial color to this type of fish product is prohibited by Canada's health protection branch regulations, but it was found that the addition of small amounts of paprika improved the color of the product substantially.

At the beginning of the study an attempt was made to improve the flavor of the sucker flesh by the addition of appropriate fish seasonings including butter, lemon and seafood flavor based seasonings which were obtained from a number of suppliers to the food industry. These seasonings were evaluated in a modified fish sausage formulation (Table 2) and found to be inferior to the flavoring complex used in the original sausage (Lantz 1966). It was decided at this time that further work to improve flavor should be postponed until texture was studied in greater depth. This was because varying the relatively small amounts of seasoning components would probably have little influence on texture, but varying the components expected to influence texture, such as shortening and ice, which were present at far higher levels than the seasonings, would be likely to also exert an influence on flavor.

A trained panel was considered to be an essential tool to evaluate the effects of various components on the sensory characteristics of the product. The training and use of sensory panels for evaluation of frozen and iced fish has been well documented (Ehrenberg and Shewan 1953; Shewan et al. 1953; Dyer et al. 1956; Baines and Shewan 1965; Varga 1969). However, because of the nature of the product under discussion, which contained shortening, binders and seasonings as well as fish flesh, different training

techniques were required. The main aim of the training sessions in the present study was to have panelists become familiar with differences in a formulated fish product caused by varying concentrations of added components, rather than to illustrate differences in fish quality.

Tasting was carried out in individual booths equipped with red lights to disguise color. Product samples approximately 1½" x 1¼" x 7/16" obtained from a pre-fried, frozen and oven-heated sample measuring approximately 3½" x 3" x 7/16" were presented hot in coded 1 oz fluted paper cups to each panelist. In order to maintain interest and enthusiasm during the study, panelists were informed of their results immediately following tasting sessions. Also, the tests early in the study were easier than those that came later. Ten panelists were trained and from seven to ten were present at each session. Tables from Larmond (1967) were used to determine significant differences between samples for all paired comparison and triangle tests.

The component mainly responsible for texture variation was added fat. The primary function of fat was to increase juiciness of the cooked product. A secondary function was to increase the rigidity of the raw mixture. The original fat used in the product was Crisco[1] shortening. This was a domestically packaged vegetable shortening having a wide range of plasticity which remained soft enough to allow even distribution at the low temperatures encountered during mixing (40°F, 4.4°C). Because this product was not available in commercially packaged quantities, a substitute shortening was sought having similar mixing characteristics. Substitute shortenings tested included Regular Biscot[2], Primex[1], Sweetex[1], Vreamay[3] and Kraft Blue Label[4]. None of these shortening was found to be soft enough to permit even distribution during mixing. To overcome this difficulty the use of both a partially hydrogenated fat and a vegetable oil were tested but found to be less than ideal. Both combined easily with the other ingredients at the required mixing temperature but the resulting mixture was too soft to

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[1] Proctor & Gamble; [2] Canada Packers; [3] Swift's Canadian; [4] Kraft Foods.

be mechanically formed. The problem was eventually overcome by creaming a hydrogenated shortening in a food mixer prior to use. Although this necessitated an additional processing step it proved satisfactory since the fat after creaming was soft enough to be easily combined with the other ingredients while resulting in a sufficiently firm mix.

Other added components influencing texture included wheat crumbs, dried whey and processed wheat flour. The addition of wheat crumbs improved the texture by yielding a product which was more friable and thus helped to minimize the rubbery characteristic of the cooked fish. Dried whey was found to be useful because of its moisture retaining capacity and processed wheat flour improved the cohesive properties of the product. A small amount of water was also added to facilitate the incorporation of the binder and seasoning components and to further tenderize the product.

As previously discussed, further study on the flavor of the product was postponed until texture had been studied in some depth. During the study of texture the basic seasonings used included salt, pepperoyal[1], onion powder and paprika. At this time optimum levels of each of these seasonings were determined individually. As indicated earlier, the natural flavor of sucker flesh is not characteristically fishy so it was not surprising that the addition of a small amount of flavoring extractive improved the acceptability of the product. Of all the flavoring extractives evaluated, including Griffith's Seafood Flavoring F.W.I.[1], PFW imitation shrimp FLAV-O-LOK 600079U[2], PFW imitation shrimp FLAV-O-LOK 600037[2], PFW imitation tuna FLAV-O-LOK 610499U[2], and Firmenich imitation shrimp[3], Griffith's Seafood Flavoring F.W.I.[1] was found to be the most appropriate.

The product when evaluated by a group of consumers consisting of 100 adults and 100 children[4] appeared to be too highly seasoned, although the type of seasoning was thought to be appropriate. Therefore the level was

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[1] Griffith Laboratories Limited, Scarborough, Ontario; [2] Polak's Frutal Works, Inc., Middletown, New York; [3] Firmenich, Toronto, Ontario.

[4] Evaluation conducted by Marketing Insights, Polo Park, Winnipeg, Manitoba, April 1972.

readjusted and the product retested with more positive results. This final formulation may be seen in Table 3.

Before the development of the product began, it was recognized that it might be necessary to dilute the primary species (Catostomidae) with other species as a contingency measure if the supply of sucker became limited. Triangle tests were used to determine a "no difference" level for the dilution of sucker in the product with other species of freshwater fish. The flesh of these other species including northern pike (Esox lucius), whitefish (Coregonus clupeaformis), burbot (Lota lota) and tullibee (Coregonus artedi) was introduced into the product, diluting the sucker, the species used alone until this time, in varying degrees. The blended samples were then compared with the product made from sucker alone. The results of these tests may be seen in Table 4.

Of the many coatings available for deep fried products, the use of three types was evaluated. One was a batter[1] containing leavening agents. The fish portions were coated with the batter, deep fried at 375°F (190.5°C) for 45 seconds and frozen. These required oven heating for serving. Additionally two types of crumb coating were used. The first of these crumb coatings[2] was designed for an institutional product. The fish portions were dipped in a starch based slurry, then coated with crumbs and frozen. Since this type of coating was intended for a product requiring cooking from the frozen raw state it was designed to brown slowly. The product with this coating was designed to be deep fried at 375°F (190.5°C) for 4 minutes for serving. The other crumb coating was more applicable to a retail marketed product requiring only oven heating for serving. This coating[3] containing toasted crumbs was applied in a similar manner to the institutional breading. However, the crumbs were designed to color more rapidly so that an attractive finish could be obtained during a brief pre-cooking period in hot oil. Following the application of this coating, the fish portion was deep fried at 390°F (198.8°C) for 30 seconds (which

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1 BA 4070, Griffith Laboratories Limited, Scarborough, Ontario.

2 BR 1549, Ibid.

3 BR 7017 DGI, Ibid.

permitted surface browning without cooking the interior) and frozen. These were fully cooked during oven heating prior to serving. This final coating was used during product development.

PRODUCTION

All fish flesh used in this study was obtained using an outside feed flesh separating machine. Special emphasis was placed upon obtaining separated flesh with a minimum bacterial load and as free as possible of extraneous material. This was accomplished by completely removing the kidney and thoroughly washing the fish prior to separating the flesh. The deboned flesh was frozen into 16½ lb blocks measuring 9" x 19" x 2½", wrapped in polyethylene film, packed in waxed cardboard cartons and stored at -20°F (-29°C) until required. Throughout the development period, the required amount of frozen material was thawed and other components were added and combined in a small institutional mixer. The resulting mix was very sticky and too soft to hold its shape without support. For this reason it was packed into molds of the required depth, frozen and bandsawed into rectangular portions before breading.

The basic steps required to produce a breaded product on a commercial scale from deboned fish are shown in Fig. 2. Pathways A and B require the incorporation of additional components immediately following the deboning operation. This was considered impractical because the seasonal characteristics of the sucker fishery can result in almost unmanageable quantities of fish being received at certain times of the year, requiring rapid processing to preserve quality. Pathways C and D are used when a product is to be prepared from frozen blocks of deboned fish. Pathway C is chosen when a fish stick or other relatively simple shaped portion containing only fish and no additional components is desired. For the product under discussion it was not possible to use this pathway, since apart from requiring the addition of other components a decision had been made to produce a fish-shaped product. Therefore pathway D was chosen as the most useful system.

In this case, following thawing and the incorporation of the other components, it was necessary to chill the mix to 29°F (-2°C) to have it retain its shape after being formed. Forming the chilled mix offered several advantages over sawing a frozen pre-mixed block:

1. less shape limitation;
2. no dust produced, therefore eliminating waste;
3. less danger of microbiological contamination since handling is reduced;
4. better portion weight control;
5. less space required;
6. automatically deposits and arranges portions on belt.

There are two types of commonly used machines for shaping a product. One type is based on a mold plate and punch; the second type is based on extruding the mix through an orifice. The choice of a unit is made on the basis of the shape required. A mold plate and punch type of forming machine[1] was selected because of its ability to produce a flat fish shape. This forming machine consists of a self-feeding hopper which is loaded with the chilled mix. Rotating tumblers force the mix into fish-shaped openings in a mold plate. This plate moves out over a moving belt and the portions are punched out. The number of strokes per minute and the belt speed were chosen to allow at least ½" space between successive rows of product. The space between these rows is increased in the coating unit by running its belt at a speed greater than that of the forming machine.

Following coating, with or without subsequent frying, the rows of product were brought closer together to allow more efficient loading of the freezer belt. The product was then frozen in a nitrogen freezing system, packaged and held in cold storage.

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[1] Bridge Machine Company, Palmyra, New Jersey.

CONCLUSIONS

This systematic approach to the development of a new product provided several advantages. The examination of the effects of each component separately led to a well-developed understanding of the product, so that when it was found desirable to modify its characteristics, it could be accomplished without undue difficulty. Although panel training took place over a relatively long period of time, by considering the capabilities and limitations of the panelists, it was possible to obtain valuable information for the development of the product early in the study.

Several modifications in the processing of the product were found necessary to facilitate commercial production. For example, in the laboratory it was relatively simple to incorporate solid shortening into the mix because the action in the laboratory mixer was sufficiently rapid and the batches were always small. For commercial production incorporation of solid fat presented serious difficulties, as a result of the limiting range of plasticity of the fat, the large batch sizes, and a slower mixing action. To overcome this problem, pre-mixing the fat alone was found necessary to soften its texture sufficiently before incorporation into the product. If portions were to be bandsawed from frozen blocks of the mix, oil rather than solid shortening could be used, but since the product was to be formed this became impracticable, as the oil-containing mix would not become firm until a very low temperature was reached.

Although this work has been concerned only with the use of underutilized species of freshwater fish, it could be applied to other freshwater or marine species, especially as the use of mechanized deboning methods becomes more common.

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Table 1. The effects of changing various components on product characteristics.

Component variation	Effect on product
Increased fat concentration	Increased juiciness
Increased binder concentration	Increased firmness
Increased seasoning concentration	Stronger flavor
Older fish used	Increased off-flavor

Table 2. Modified fish sausage formulation.

Component	Percent
Deboned sucker flesh	72.54
Vegetable shortening	14.48
Onion - frozen chopped	5.43
Whey powder	.96
Salt	1.53
Sugar	.22
Pepperoyal	.12
Powdered ginger	.12
Garlic powder	.03
Monosodium glutamate	.03
Crushed ice	4.54

Table 3. Composition of mix.

Component	Percent	Function in product
Deboned sucker flesh	85.30	Product base
Vegetable shortening	9.00	Texture - increased juiciness and tenderness and decreased rubberiness
Water	3.00	Texture - increased tenderness
Salt	.873	Flavor
Breadcrumbs #888[1)]	.794	Texture - decreased rubberiness
Seafood flavoring F.W.I.[1)]	.238	Flavor
"Banner" onion powder[1)]	.199	Flavor
Pepperoyal[1)]	.159	Flavor
Special soup flour[1)]	.159	Texture - increased cohesiveness
Modified whey LP10[2)]	.159	Texture - increased moisture retention
Paprika	.119	Color improvement

1) Griffith Laboratories Limited, Scarborough, Ontario.

2) Purity Products, Mayville, Wisconsin.

Table 4. Maximum concentration of other species which may be substituted for sucker without significantly affecting the product.

Species	% substituted[1)]
Tullibee	25
Whitefish	25
Burbot	20
Northern pike	< 15

1) Calculated as percent of sucker in the mix.

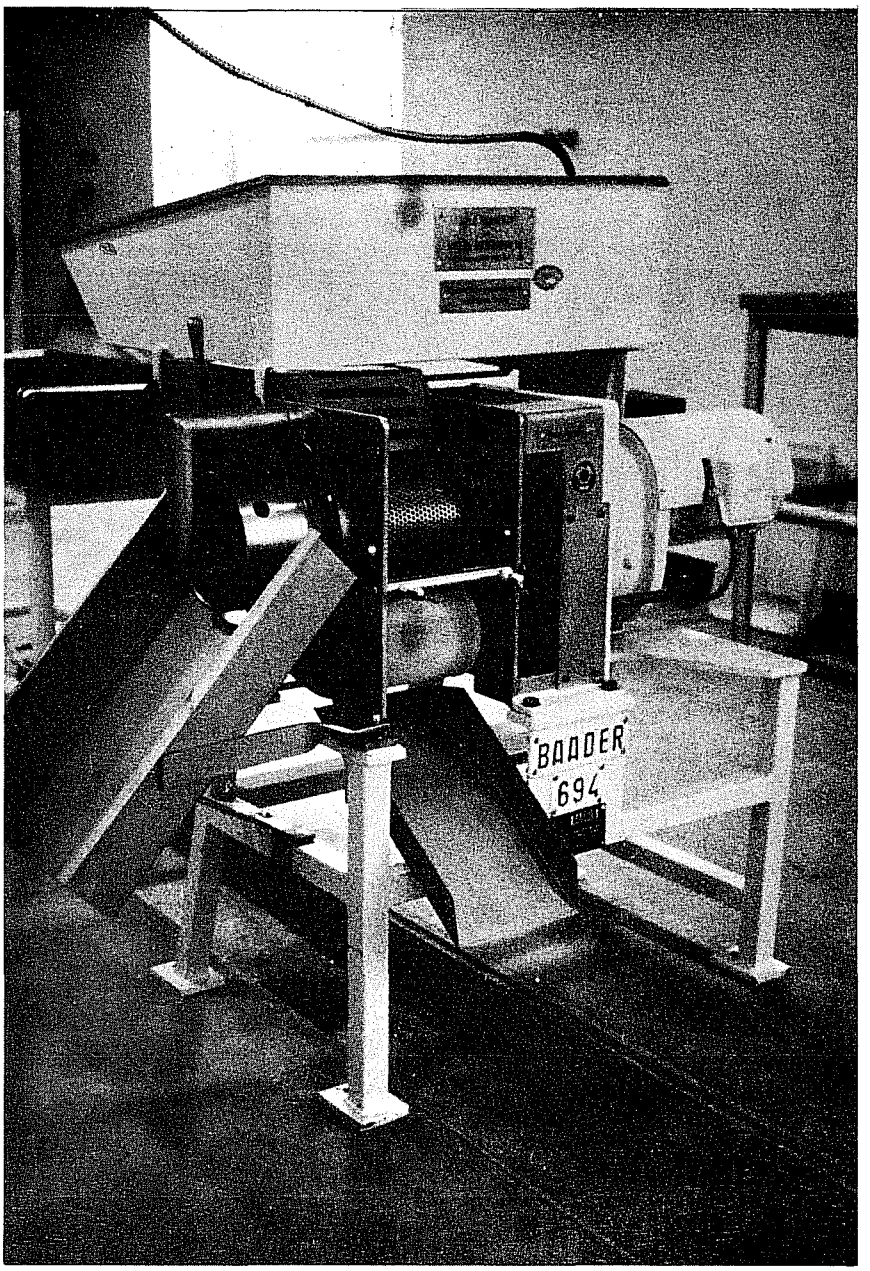

Fig. 1. Outside feed flesh separator.

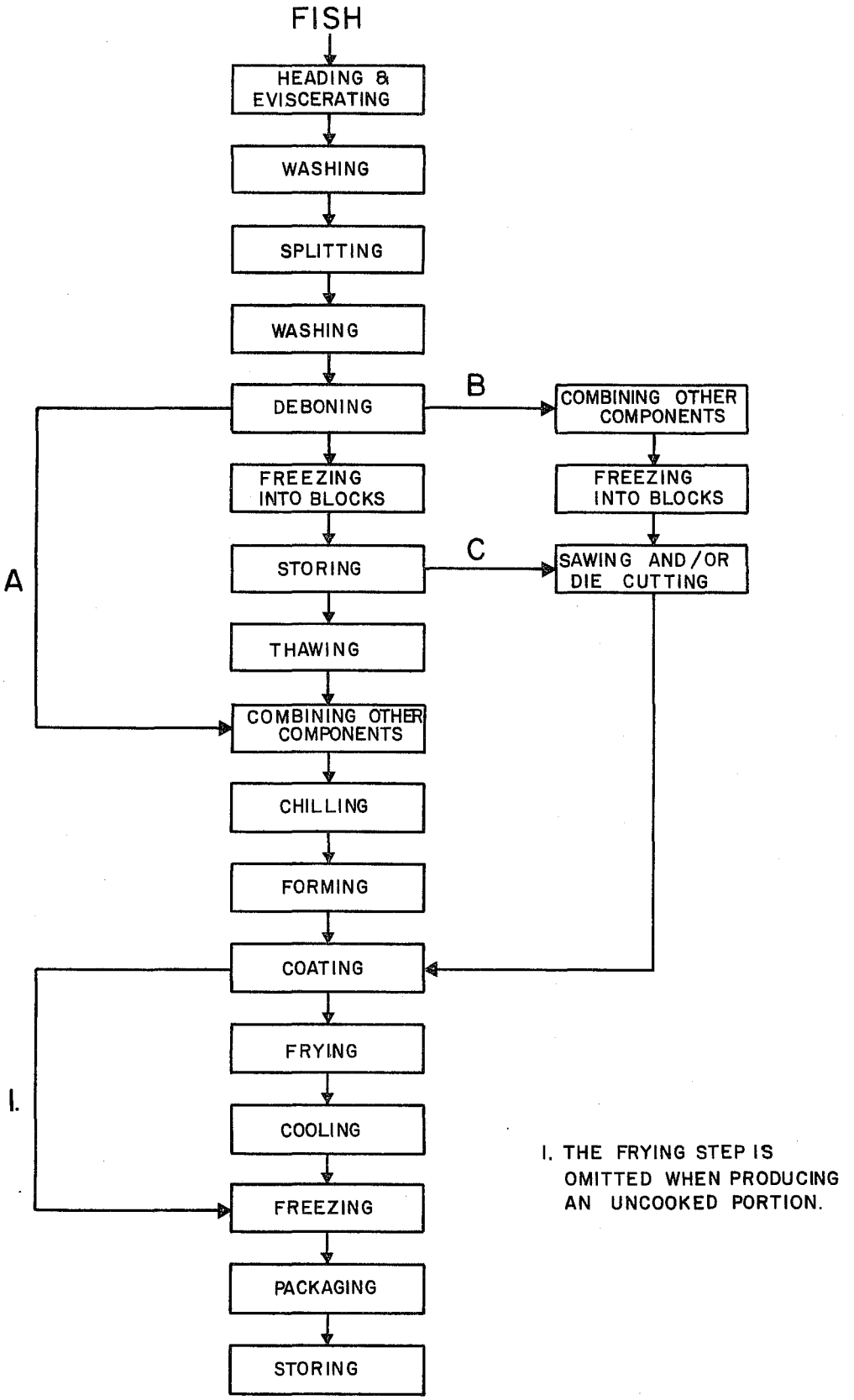

Fig. 2. Suggested processing sequences for a formulated fish product.