REDUCTION PROCESS TO CONVERT RAW FISH INTO THIAMINASE-FREE PRESS CAKE

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ABSTRACT

Described is a reduction process designed to increase the use of rough fish in conjunction with relatively small fishing operations. Freshly caught fish are processed into press cake, yielding oil and stickwater as byproducts. In the process, fish are heated with live steam to a relatively high temperature in minimum time. Subsequent pressing of the cooked material yields a cake with several useful characteristics. It is in a form that is easy to handle and requires only one-half the storage space of whole fish. It is a valuable feed supplement, owing to its high protein and mineral content, and is safe to feed because it is not thiaminase-active. Consumer acceptance is increased by its uniform composition. The press cake apparently is readily eaten by mink.

INTRODUCTION

The species composition of fish in the Great Lakes has changed gradually over the years. The food fish of high value have almost disappeared (Brouillard 1960) and have been replaced by less desirable species (alewife, "bloater" chub, and smelt) which have not been used extensively for human food. Because these lower-value species have become highly abundant, or nearly the only fish available, the fishing industry has declined to a point where, to remain vital, it must adopt new or improved products and processes to use its fish profitably.

The pet-food industry uses large amounts of raw fish (Jones 1960), but that market frequently becomes glutted. It could possibly absorb larger quantities, however, if the fish were offered in a uniformly processed, stable form. A significant and large market for fish as mink food has also been established (Jones 1960). Its further development also depends upon products, other than raw fish, that the fur-farming industry can use regularly. Although raw fish is generally regarded as an excellent food supplement for animals, mink ranchers do not always accept it routinely for several reasons. The proximate composition of fish often varies seasonally, which necessitates constant changes in ration formulation. Supplies of fresh fish are not regularly available, owing to the seasonal nature of the fishery. Frozen fish (fresh fish is frozen during glut periods for subsequent use) undergo a gradual lowering of quality during storage. Cooking of the thiaminase-active fish by current methods often lowers the quality of even fresh fish.

Fig. 1 - Experimental equipment used to convert raw fish into thiaminase-free press cake.

Small fisheries, including most of those in the Great Lakes Area, are gravely handicapped because they lack adequate processing methods to convert raw fish into salable processed products. Much of the potential market therefore is closed to them.

This paper describes a reduction process (developed at this laboratory under the process-product development studies on thiaminase-active fish) to convert raw fish into a cooked product that is (1) thiaminase-free, (2) relatively uniform in proximate composition, and (3) apparently suitable as a supplement to rations for mink and other animals. The process, designed to be low-cost and adaptable to any scale of operation, was intended primarily for the production of mink-feed supplements. It is likely, however, that the product can be used to supplement other feeds, like cat and poultry rations. The process, the product, and potential commercial adaptation are described.

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DESCRIPTION OF PROCESS

The process involves heating ground fish with live steam to a relatively high temperature in minimum time. Subsequent pressing of the cooked material at relatively low pressures yields a "cake" with much of the original water and oil removed. The process also yields press liquor, which can be further processed into salable byproducts, thereby defraying part of the cost of operation.

The equipment consists of (1) a grinder; (2) a stuffer, which serves as a means to force the ground material into the cooker; (3) a cooker; (4) a second grinder, which serves as a means of regulating the flow of material through the cooker; and (5) a press (fig. 2). The process is designed for continuous cooking followed by batch pressing.

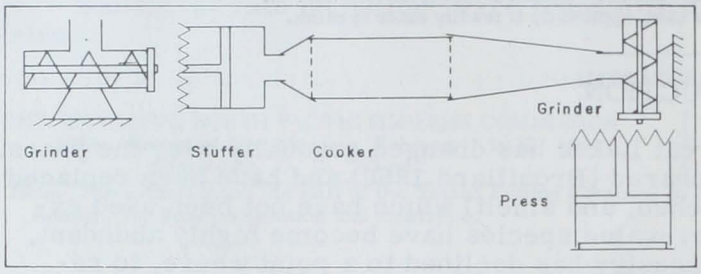

Fig. 2 - Schematic representation of the reduction process.

The raw fish are first ground through a $\frac{1}{4}$-inch plate, and then transferred to a sausage stuffer, which in turn is used to feed the cooker. In the laboratory model, the two operations were done separately, but they could be combined simply by connecting the grinder to the cooker.

The cooker (fig. 3) has a distance of $\frac{1}{2}$-inch between the two metal steam plates. The holes in the plates ($\frac{1}{32}$-inch diameter) are positioned so that jets of steam can be delivered uniformly to both sides of the ground material as it passes through the cooker. Under this arrangement, the ground material, through direct contact with live steam, can be heated quickly to a relatively high temperature. Injection of steam in this manner actually serves three purposes: it cooks the material rapidly; it facilitates the movement of the material through the cooker; it aides in the extraction of oil from the cooked fish.

Once the raw ground fish enters the cooker, the steam pressure moves the material through the rest of the system. As a result of this increased pressure, over that provided by the stuffer, the rate of passage of the cooked fish through the cooker tends to be variable. Some mechanism is needed to regulate the flow. In the present arrangement, a small grinder equipped with a plate having holes $\frac{1}{2}$-inch in diameter is affixed to the exit end of the cooker. This addition makes it possible to govern the rate of flow (and in turn the rate of cooking). The grinder serves also to disintegrate the coagulated material emerging from the cooker and thus makes a homogeneous mass.

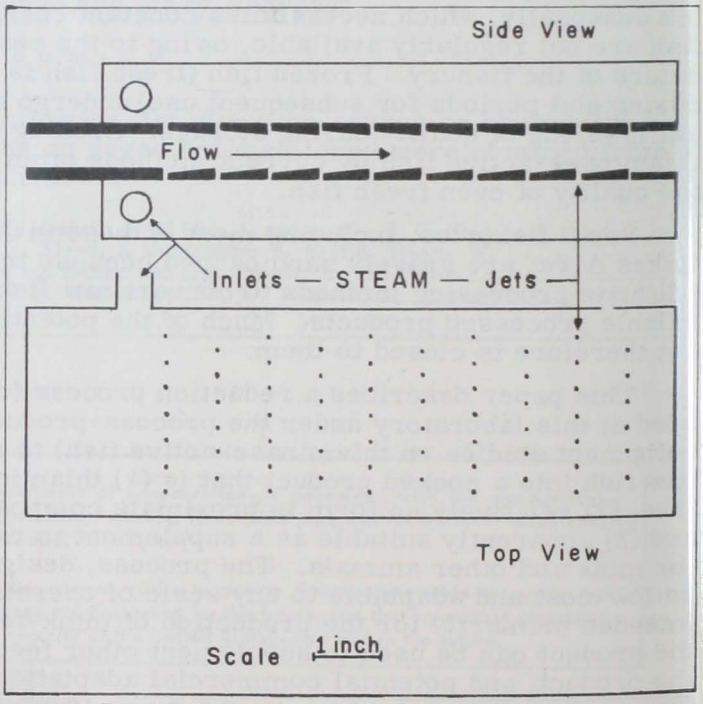

Fig. 3 - Side and top views of the steam cooker.

The cooked ground fish emerging from the grinder falls directly into a press cage and is pressed for 5 minutes at a pressure of 10 to 15 pounds per square inch. The cage, constructed of $\frac{1}{16}$-inch brass, is insulated to minimize loss of heat during filling and pressing. The pressed material, which is in the form of a cake, is packed in plastic bags and is allowed to cool at room temperature for about 1 hour before being plate-frozen. Immediate packaging of the hot material minimizes contamination of the product during subsequent handling. In the present

study, the temperature of the cake was measured immediately after pressing. Depending upon the quality of the raw fish, the yield of press cake was about 50 to 60 percent of the quantity of raw fish used.

DESCRIPTION OF PRODUCT

To determine the suitability of this process as a potentially useful reduction method, the press-cake products from different species of fish were evaluated from the standpoint of uniformity, residual thiaminase activity, and acceptability by animals.

The table gives the proximate composition of various lots of fresh fish and of their respective cooked products. The results show that raw fish of widely different proximate composition can be rendered into a relatively uniform product. As would be expected, the water and oil contents were decreased while the ash and protein contents were increased. For all species tested, the concentration of water in the raw fish ranged from 61 to 82 percent; whereas, that of the cooked products ranged from 61 to 71 percent. The concentration of oil varied from 2.3 to 22.3 percent in the raw fish; whereas, in the cooked material, the range was 4.1 to 10.1 percent. Thus, the water and oil ranges were reduced considerably in the cooked products. The amounts of oil and water removed during the cooking and pressing processes were directly proportional to the amounts initially present in the raw fish. For example, only a very small amount of oil was removed from smelt; in fact, the cooked material contained more (on a percentage basis) than did the raw fish. In contrast, a very high proportion of the initial amount of oil in carp was removed during processing. In all cases, the concentration of protein and ash increased in the press cake. This increase resulted, of course, from the removal of water and oil, but the data also indicate that no excessive amounts of protein and

Data Relating to Proximate Composition of Certain Fish Before and After Being Processed

Species 1/	Data on Capture		Proximate Composition of:							
			Raw Fish				Press Cake			
	Date	Location	Moisture	Protein	Oil	Ash	Moisture	Protein	Oil	Ash
			(Percentage)							
Alewife	7/6/64	Lake Michigan	72.16	12.04	12.64	2.57	64.30	19.52	7.80	4.71
	9/9/64		74.31	12.75	12.35	2.75	67.30	17.64	8.02	4.17
	9/30/64		74.90	11.99	8.60	2.73	66.96	18.10	7.14	4.70
	10/22/64		72.16	12.11	10.71	2.73	68.29	17.14	7.36	4.03
Carp	3/25/64	Lake Erie	64.4	-	16.2	-	63.1	-	7.1	-
	5/20/64		61.05	-	20.51	2.94	61.43	-	9.83	5.99
"Bloater" chub	7/-/64	Lake Michigan	69.13	12.76	14.56	2.17	65.29	20.45	7.65	3.68
Gulf fish	7/19/64	Gulf of Mexico	73.87	14.56	4.50	4.26	63.73	21.80	4.22	6.14
Gizzard shad	1/-/64	Arkansas	72.44	13.74	11.90	2.70	62.47	21.64	8.52	5.84
Gizzard shad:										
(5.8 fish/lb.)	10/28/64	Lake Erie	62.67	12.09	22.25	2.19	62.98	18.67	10.11	3.53
(36.5 fish/lb.)			70.58	12.01	14.16	2.24	-	-	-	-
American smelt	6/29/64	Lake Superior	81.57	11.85	2.34	1.99	70.90	18.04	4.13	3.13
	10/28/64	Lake Erie	75.54	12.71	7.60	2.01	68.87	18.79	6.35	2.70

1/Alewife, Pomolobus pseudoharengus; carp, Cyrinus carpio; "bloater" chub, Coregonus hoyi; gizzard shad, Dorosoma cepedianum; American smelt, Osmerus mordax; Gulf of Mexico fish, mixture of king whiting (Menticirrhus americanus), cutlassfish (Trichiurus lepturus), spot (Leiostomus nothus), croaker (Micropogon undulatus), sea robin (Pronotus sp.).

minerals are lost in the process. The composition of a typical sample of stickwater was as follows: 95.2 percent water, 0.3 percent oil, 0.8 percent protein, and 3.4 percent ash. In general, the variation in protein and in ash of the raw and cooked products was about the same, but their concentrations (on a percentage basis) were much higher in the press cake, approximately 50 percent and 70 percent, respectively.

The press-cake products were analyzed for residual thiaminase activity by the chemical method of Gnaedinger (1964). Cakes that had a temperature of 180° F. or above after being pressed were not thiaminase-active. Cakes that did not reach that temperature after pressing were usually thiaminase-active.

The most critical evaluation of the product lies in its acceptance by the animals for which it is intended. Consequently, a sample of alewife press cake was tested for palatability by mink at the U. S. Department of Agriculture Fur Animal Experiment Station at Cornell University. Twenty male mink were divided into two equal groups; each group was fed for 3 days

on either a test- or a control-diet at a rate of 225 grams of feed per day. After 3 days, and after each succeeding 3 day-period for a total period of 12 days, the diets were reversed. The test diet was formulated by replacing the fish of the control diet with alewife press cake. The control diet was that normally used at the Cornell Station for maintenance, and it contained 30 percent by weight of fish. At the end of the 12-day feeding period, the animals had refused 622 grams of the control diet and 448 grams of the test diet. Thus, acceptability appeared to favor the press cake in this test with alewife.

These promising results led to a study of the effects of the press cake on growth and reproduction, which started in June 1964 in cooperation with the Cornell Station. Twenty male and 20 female weaned mink kits were put on an experimental diet containing 30 percent by weight of alewife press cake. A statistical analysis will be made to determine the effects of the experimental diet on growth, fur quality, and reproduction. The results of this study as well as the results of a chemical evaluation of the press cake will be reported later.

POTENTIAL COMMERCIAL ADAPTATION

The equipment used in the present pilot study was relatively small. Because of this physical limitation, it was difficult to determine precisely the optimum conditions for a larger-scale operation. The steam for cooking was generated by an electric autoclave, but that device did not have the capacity to maintain a desired head of pressure (5 to 10 p.s.i.). As a result, the maximum possible rate of flow was limited to about 1.5 to 2 pounds of fish per minute. The cooker, even though small, could have handled larger amounts if adequate steam pressure could have been maintained.

The greatest difficulty was in the design and construction of the cooker, which was intended originally to function under continuous pressure. It proved difficult, however, to cook under pressure and at the same time to maintain a uniform and constant flow of material. The small grinder attached to the terminal end of the cooker partially solved the problem, which made it possible to vary the speed of the auger and to obtain the desired pressure and rate of flow. But, even this final arrangement did not entirely eliminate the variable flow of the cooked material, so the steam pressure tended to vary correspondingly.

Batch pressing was preferred for several reasons in addition to its low cost and lower capacity. The cooked material could be pressed and molded into a form convenient for subsequent handling, freezing, and storing. The inactivation of the enzyme thiaminase is a function of time as well as temperature; thus, pressing the cooked material into a cake maintains its maximum temperature over a longer period of time which aids in the destruction of the enzyme. This time-temperature relation applies to the destruction of other enzymes and of bacteria as well.

Several general observations were made regarding the conditions that influenced the cooking process and the effect of certain variables on the composition of the press cake. The temperature attained in the cooked material is important because the compressibility, and in turn the amount of water and oil expressible, is directly proportional to the temperature attained. In general, a minimum product temperature of 180° F. is required to effect satisfactory pressing and to destroy thiaminase. Further, fish that are partially decomposed and those that are frozen and then thawed appear to cook more rapidly than fresh fish. (Fresh fish, however, give the highest yields and the highest quality products). Highly viscous preparations appear to cook faster and are more easily handled than slurries. The pressure applied during pressing affects the composition of the press cake; that is, higher pressures simply remove more water and oil. If the starting temperature of the fish is low, the rate of cooking has to be decreased correspondingly. Other variables, such as particle size, thickness of the fish layer, number of steam jets, and steam pressure, all influence the rate of cooking. Those variables were not investigated in the present study. The reduction unit is currently being scaled up to pilot-production size so that a more thorough evaluation of the entire process can be made.

CONCLUSIONS

Fish can be cooked very rapidly with live steam by extruding the ground material into a thin layer and forcing it between a series of steam jets. The cooked material can then be pressed relatively uniform in proximate composition under low pressure; the loss of protein and mineral matter is small. A temperature of at least 180° F. is required to effect satisfactory pressing and to inactivate the enzyme thiaminase. The resulting "press-cake" product, which was made from alewife in this study, is readily consumed by mink.

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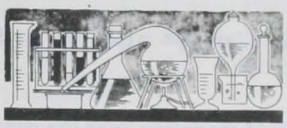

HISTORY OF SPICED AND PICKLED FISHERY PRODUCTS

Pickling with vinegar and spices is a very ancient form of food preservation, going back to prehistoric times. Stevenson (1899) believes that it probably antedates even pickling with salt. It is mentioned frequently in the writings of the Greeks and Romans, as witnessed by the citations of Smidth (1873) and Radcliffe (1921) in their accounts of the fisheries of the ancients. Certain fishery products prepared with vinegar and spices were considered great delicacies, selling at such high prices that they were reserved for the banquet tables of the rich. One dish popular in Spain and in the Latin American republics of Central and South America today is "escabeche." It is prepared by frying fish in oil with bay leaves and spices, then marinating in vinegar and oil. This dish can be traced directly to the Romans, who in turn had it from the Greeks.

Pickling with vinegar was used extensively down through the Middle Ages, especially for fish that were fat and did not cure well by the very crude salting methods of the times. While the product did not keep so long, it was more appetizing than the dried and salted products of the period. Vinegar-pickled fish played a very important part in the food economy of the north European people down through the seventeenth century.

Brine-salted fish is often called "pickled," but this is a misnomer, if the name as applied to other food products is considered. Pickled foods are fermented in the process of manufacture with the formation of organic acids. If the amount of organic acids formed is not sufficient, more acid may be added in the form of vinegar; or vinegar may be used in the original cure instead of depending on the natural formation of acid. Therefore, only fish preserved with vinegar or vinegar and spices should be considered pickled.

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