STORAGE TESTS ON FROZEN FRIED FISH STICKS PREPARED FROM PACIFIC COD

INTRODUCTION

West coast producers of fish sticks have needed reliable information on the quality changes and on the maximum storage life of frozen fried fish sticks made from Pacific cod (Gadus macrocephalus). The purpose of the work reported here was therefore (1) to study the quality changes in fried fish sticks prepared from Pacific cod during a 1-year storage period at 0° F. and (2) to determine the maximum period that the fish sticks can be stored at 0° F. in good marketable condition[1]

PROCEDURE

PREPARATION OF FISH BLOCKS: Pacific cod of good quality from Hecate Strait, held in the round 4 to 5 days in ice, were used. The fish were obtained from the top of the load on the fishing vessel, and only firm fish with good skin color and with no softening or bruises were selected. The fish were filleted, skinned, trimmed, deboned, and packed into 9-pound heavily-waxed cartons ($3\frac{3}{4}$ inches x $9\frac{1}{4}$ inches x $11\frac{1}{4}$ inches) and blast-frozen at -25° F. The resulting fish blocks were stored at 0° F. for 6 days prior to being processed into fish sticks.

Examining fish sticks after storage at 0° F.

PREPARATION OF FISH STICKS: The fish sticks were prepared commercially from the fish blocks at a local plant. The blocks were cut into fish sticks with a band saw; the fish sticks were covered with batter and breaded with standard commercial ingredients, and deep-fat fried at 380° F. for 55 seconds in hydrogenated oil[2] that had been used in fish-stick processing for about 20 hours. The fried fish sticks were blast-air cooled, then packaged in 10-ounce waxed cartons, 10 to a carton, with a wax-paper overwrap. These cartons were frozen in a plate freezer for 2 hours and were then left at -20° F. overnight. Lastly, the cartoned frozen fish sticks were cased and stored at 0° F. in the Laboratory cold storage.

1/ The rating "good marketable condition" is defined as being equivalent to not less than grade B (a minimum score of 70 points) in the proposed United States Standards for Grades of Frozen Fried Fish Sticks.

2/ The ratio of tank capacity to hydrogenated-oil consumption per day was about $2\frac{1}{2}$ to 1.

ORGANOLEPTIC EXAMINATION PROCEDURE: The samples were organoleptically judged at approximately monthly intervals. Quality evaluations were made on the frozen fish sticks before and after heating in accordance with the proposed United States Standards for Grades of Frozen Fried Fish Sticks.3/ The frozen fish sticks were heated by spacing them $\frac{1}{4}$-inch apart on a metal tray and then placing the tray in a properly-ventilated oven preheated to 400° F. At the end of 16 minutes, the tray of fish sticks was removed and the fish sticks were examined by a panel of 4 to 7 people experienced in the organoleptic testing of fish.

Table 1 - Scale of Organoleptic Ratings

Description of Flavor and/or Odor of Fish Sticks		Organoleptic Rating
Whole Fish Stick	Component Parts1/	
Normal, characteristic of fresh product; no off-flavor or off-odor.	Normal, characteristic of fresh product; none to trace off-flavor or off-odor; barely noticeable.	Good (Grade A)
Lacking normal flavor or odor of fresh product; none to slight off-flavor or off-odor; barely noticeable.	Lacking normal flavor or odor; slight to moderate off-flavor or off-odor; definitely noticeable but not objectionable.	Reasonably Good (Grade B)
Slight to moderate off-flavor or off-odor; definitely noticeable but not objectionable.	Moderate off-flavor or off-odor; definitely noticeable; objectionable in localized areas only.	Fair (Substandard)
Strong or objectionable off-flavor or off-odor; distasteful but not repugnant.	Strong or objectionable off-flavor or off-odor; diffusing throughout adjacent tissue.	Poor (Out of Grade)

1/ Breading, dark meat (including the layer of skin fat), and light meat. (Each of these parts is judged separately and the rating is on the basis of the worst condition observed.)

Under the proposed United States Standards for Grades of Frozen Fried Fish Sticks, a grade A product must have good flavor and odor and score not less than 85 points on other factors. A grade B product must have reasonably good flavor and odor and score not less than 70 points on other factors. A substandard product is one that fails to meet the requirement for grade B. Under these fish-stick standards, the quality rating (grade) is determined, in part, by physical factors not especially subject to change during cold storage, such as uniformity of size and shape, color, continuity of the coating, degree of oiliness or crumbliness, and presence of defects (broken and damaged sticks, bones, and blemishes). The quality rating is also determined, in part, by organoleptic factors of texture, flavor, and odor--which are subject to change. The organoleptic rating of the present samples of fish sticks was based on the flavor and odor of the whole fish stick (breading plus fish, as a unit) and on the separate evaluation of the breading, the light meat, and the dark meat (including the layer of skin fat).

In order that these generalized fish-stick standards could be implemented, detailed examination procedures and the scale of organoleptic ratings shown in table 1 were developed. In the development of this scale, consideration was given to the fact that an off-odor or flavor--for example, rancidity--tend to localize in critical areas, such as in the layer of skin fat. Evaluation of these critical areas is important, since if only the whole stick is tested, an off-flavor in a critical area may not be noticed and the test will be less sensitive. Flavor and odor were therefore judged separately on the whole stick and on the breading, dark meat (including layer of skin fat), and light meat.

The termination of the maximum period of storage for fish sticks in good marketable condition was taken to be that time at which rancidity and any off-odors and/or

3/ These standards were published in the Federal Register on April 26, 1956, by the Agricultural Marketing Service, U. S. Department of Agriculture, Washington 25, D. C.

flavors were definitely noticeable (moderate in intensity) in any component part of the fish stick but were not objectionable.

RESULTS AND DISCUSSION

The data on the organoleptic observations are given in table 2. As indicated in the table, the maximum period that these fish sticks could be stored at 0° F. in good marketable condition was 8 months.

Despite the initial appearance of trace rancidity in the skin-fat layer at the end of 3 months of storage, and the advance of rancidity to slight at the end of 5 months of storage, no noticeable increase in rancidity was observed during the next 2 months. However, after 8 months of storage, rancidity was definitely noticeable (moderate in intensity) in the skin-fat layer and it was detectable in the adjacent light meat but was not otherwise detectable in the light meat. At this stage, the fish sticks were considered to be reasonably good in flavor and odor and in Grade B. After 9 months and after 11½ months of storage, they were considered to be fair in flavor and odor and in the substandard grade.

Table 2 - Organoleptic Ratings of Pacific Cod Fish Sticks[1] Stored at 0° F.

Storage Time	Observations	Rating	Grade
Months			
0	Good, sound product.	Good	A
1	No decrease in quality.	Good	A
2	Slight toughening in texture of meat.	Good	A
3	A trace of rancidity detectable in skin-fat layer but definitely not detectable in white-meat portion.	Good	A
5	Slight rancidity detectable in skin-fat layer but not detectable in white-meat portion. Some tasters detected trace of off-flavor in breading.	Reasonably Good	B
6	No further noticeable change in rancidity.	Reasonably Good	B
7	No further noticeable change in rancidity.	Reasonably Good	B
8	Slight off-flavor due to rancidity detectable in whole stick. Rancidity definitely noticeable (moderate in intensity) in skin-fat layer and in dark meat, and detectable in adjacent light meat but not otherwise detectable in light meat. Light meat, when slightly warm, moderately tough and characterized by slight dryness and slight woodiness of texture but, when hot, not noticeably tough, dry, or woody.	Reasonably Good	B
9	Slight further decrease in quality.	Fair	Substandard
11½	Slight further decrease in quality. Rancidity advanced but other off-odors or flavors not apparent. Fish sticks considered barely marketable, owing to rancidity.	Fair	Substandard

1/ Prepared from good-quality cod by deep-fat frying at 380° F. for 55 seconds in hydrogenated oil that had been used in fish-stick processing for about 20 hours.

Although the hydrogenated cooking oil employed in this experiment had been used in fish-stick processing for about 20 hours, the age of the oil was apparently not a factor in the storage life. Rather, the limiting factor was considered to be the oxidative changes in the dark-meat skin-fat layer. The use of poorer-quality fish, older fish blocks, or higher storage temperatures and otherwise poorer storage conditions would undoubtedly have reduced the storage life of the fish sticks.

CONCLUSIONS

(1) The quality changes most critically affecting the storage life of frozen fried fish sticks made from good-quality Pacific cod (Gadus macrocephalus) prepared under commercial conditions (deep-fat fried at 380° F. for 55 seconds in hydrogenated oil that had been used in fish-stick processing for about 20 hours) and stored at 0° F. were the oxidative changes in the layer of skin fat in the dark meat.

(2) The maximum period that fried fish sticks, produced from good-quality Pacific cod under the conditions of this experiment, can be stored at 0° F. in good marketable condition[4] was organoleptically determined to be 8 months.

4/ For explanation of footnote see footnote 1/ on page 15.

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EFFECT OF RAW MATERIAL ON TUNA-MEAL QUALITY

BACKGROUND

Fish meals show considerable variation in their nutritive value--even when manufactured from the same species of fish and by the same process. An important phase in the determination of the causes of this variation is a study of the protein quality of the meals. Work on such protein-evaluation studies was started several years ago by Dr. C. R. Grau in the Poultry Husbandry Department of the University of California. At that time Dr. Grau found considerable variation in the nutritive value of fish meals, but he was not able to continue the studies long enough to determine the causes for this variation.

In studies that have been undertaken by the U. S. Fish and Wildlife Service on the quality of fish meal, a large number of samples have been collected from reduction plants located in the important fishing centers of the United States. These samples are being tested at several laboratories for different variables. In collaborative studies at the Poultry Husbandry Department of the University of California, chicks have been used to test the meals for protein quality. In addition, a systematic search has been undertaken to determine the causes for the differences in the protein quality of tuna meals. This phase report will describe the work that has been done to the present on the effect of raw material on the nutritive value of the meal.

SAMPLE COLLECTION AND PREPARATION

The samples used for these studies were collected at San Pedro, Calif., in May 1955. The following portions from skipjack tuna (Katsuwonus pelamis) were collected: raw skin, raw caecae, raw livers, raw loins, cooked loins, and cooked heads. Hearts from skipjack were not available, but hearts from yellowfin (Neothunnus macropterus) were obtained and used instead. The tuna from which the samples were taken were of marginal quality.

Each of the selected portions was ground and blended in an electric food chopper and then was packed in six 1-gallon press-top cans (but only one-half of a can in the case of the skin). The one-half can of skin and two cans of each of the other portions were placed in frozen storage. The four cans remaining of each of the portions were allowed to stand at the open-air temperature for 2 days (48 hours), at the end of which time two cans of each of the raw portions were placed in the freezer. The next day (72 hours), two cans of both cooked and raw portions were put into the freezer. After 7 days (168 hours), the remaining two cans each of the cooked loins and the cooked heads were put in the freezer. During the period that the material was allowed to stand in the open, the temperature ranged from 56° to 66° F. The cans, when placed in the freezer, were fresh-frozen at -20° and then held at 0° F. After all the samples had been assembled and frozen, they were sent to the Poultry Husbandry Laboratory of the University of California, where they were lyophilized (freeze-dried) prior to being incorporated into test diets. The **treatments given the various samples are summarized in table 1.**

Table 1 - Treatment of Samples

Sample	Frozen Immediately1/	Held at 56°-66° F. for 48 Hours and Then Frozen1/	Held at 56°-66° F. for 72 Hours and Then Frozen1/	Held at 56°-66° F. for 168 Hours and Then Frozen1/
	(Number of Cans)			
Raw skin	½	-	-	-
Raw caecae	2	2	2	-
Raw livers	2	2	2	-
Raw hearts	2	2	2	-
Raw loins	2	2	2	-
Cooked loins	2	-	2	2
Cooked heads	2	-	2	2

1/ Frozen at -20° F., stored at 0° F., and then lyophilized for incorporation into test diets.

EXPERIMENTAL PROCEDURE

The bioassay utilized 10-day-old male chicks for the protein-evaluation studies. Enough fish protein to provide 20 percent crude protein in the final diet was added to a basic mixture of essential dietary components. The basal mixture and the procedure used for the chick-feeding tests were those described by Grau and Williams (1955). Modifications were made, however, on housing and on replication procedure. Special cages adapted from rat cages made it possible to conduct nine treatments simultaneously, with high accuracy. Each fish meal was fed to four groups (one treatment) with four chicks per group. These modifications were made to obtain the greatest amount of information from the smallest sample size. The protein was evaluated by the rate of growth of the 16 chicks during an 8-day test period.

RESULTS OF FEEDING TESTS

In the tests using the unspoiled material, the raw skin and the cooked heads produced poor growth, but all of the other materials produced good growth.

For the tests using the spoiled material, the same growth was obtained as with the unspoiled material, except with the cooked loins. Whereas the spoiled raw loins produced good growth, the spoiled cooked loins produced an actual weight loss in the chicks. The growth rate of the chicks was not improved when the spoiled cooked loins were autoclaved for 15 minutes at 15 pounds pressure, indicating that the negative growth was not caused by heat-labile toxin. Similarly, the growth rate was not improved by the addition of chlortetracycline (aureomycin) at 10 micrograms per kilogram, indicating, in addition, that the negative growth was not caused by pathogenic bacteria.

DISCUSSION

The negative growth response obtained with the spoiled cooked loins indicates that the condition of the raw material may be an important factor in the nutritional value of the tuna meal. The results offer a number of possibilities for future studies. Since the indications are that the negative growth was caused neither by heat-labile toxin nor by pathogenic bacteria, the probable cause was damage to the protein. These feeding tests were repeated, and the results verified. Further spoilage studies are being conducted under more rigidly-controlled conditions with several species.

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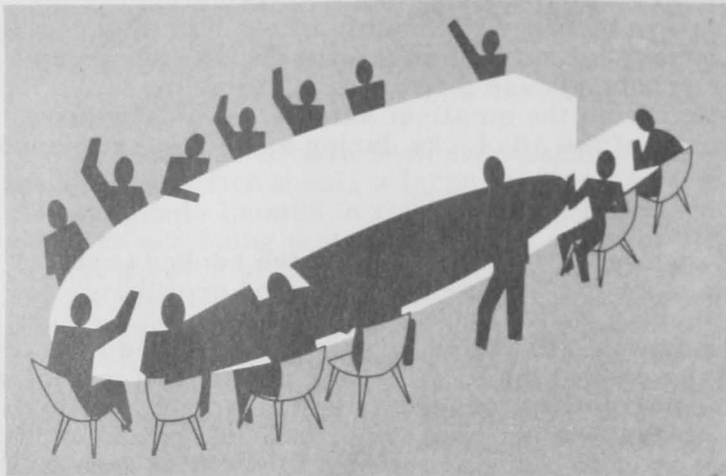
RESEARCH PROGRAMS DISCUSSED AT PACIFIC FISHERIES TECHNOLOGISTS CONFERENCE

At the Seventh Annual Conference of the Pacific Fisheries Technologists, held at Gearhart, Ore., March 18-21, the current status of some of the Fish and Wildlife Service's contract research with Saltonstall-Kennedy Act funds was discussed. Maurice Stansby of the Seattle Fishery Technological Laboratory presided at this session of the meeting and outlined some of the programs under way in the new Fish and Wildlife Service research program on fish oils and fish meals. Details of several of the programs were discussed by those project leaders who were in attendance at the meeting.



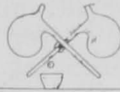
Dr. Walter O. Lundberg of Hormel Institute, University of Minnesota, Austin, Minn., described the three programs under way in his laboratories on (1) composition and analysis of fish oil fatty acids, (2) separation of fish oil fatty acids by employment of inclusion-type compounds, and (3) the chemistry of compounds responsible for odor in fish oils.

Dr. W. Duane Brown described the collaborative program under way at the Food Technology Department, University of California, at Davis, on oxidative deterioration in fish and fishery products. Results of experiments were discussed on

the mechanism of oxidation of oil in fish tissue, on application of antioxidants to retarding of such oxidation, on the reaction between fish oil and protein in such fishery products as fish meal, and on alterations in pigments such as those resulting in green tuna.

Dr. J. E. Oldfield of the Animal Husbandry Department, Oregon State College, Corvallis, Ore., discussed his program on incorporation of fish oil in the diet of swine and its effect on growth and on quality of the resulting meat. Dr. C. R. Grau of the Poultry Husbandry Department, University of California, at Davis, discussed the collaborative program on nutritive value of protein in fish meals. Dr. E. Geiger of the Pharmacology Department, University of Southern California, described experiments under way on unidentified growth factor assays.

John Dassow of the Seattle Fishery Technological Laboratory discussed at another session of the conference the Service's program of development of voluntary grade standards for fishery products.



PROGRESS IN RESEARCH ON SOUTHERN OYSTERS

The three university groups conducting research related to technological improvements for the Southern oyster industry are well started on their second year. They reported recently that satisfactory progress is being made in every phase of the work. One report of the work conducted at Tulane University is already published under the title, "Osmotic Behavior and Bleeding in the Oysters (Cyassostrea virginica)," by M. Fingerman and L. D. Fairbanks, in Tulane Studies in Zoology, vol. 3, no. 9, April 12, 1956. Three reports are now in editorial hands; and three or four additional reports on the work done in the first year are expected to be received within 45 to 60 days.

Placing oysters in equipment for sterilization by gamma radiation.

The work during the second year has been expanded at Louisiana State University, with four lots of oysters being prepared for frozen storage tests in contrast with one in the first season. Florida State University reports unexpectedly encouraging results in the latest experiments on sterilization of oysters by irradiation with Cobalt 60. The thiobarbituric acid tests have also been developed to give a quite satisfactory method of following oxidative rancidity affecting quality of stored oysters. They expect to develop many more cooked oyster products and dishes for frozen storage studies this season. At Tulane University recent work has related to study of liquor losses of imported "Northern" oysters under identical conditions used in their work with the local product. Major emphasis of work during the coming year will be on more intensive study of the internal mechanism of the live oyster which is responsible for regulating the amount and composition of body fluid losses.

Note: See also Commercial Fisheries Review, April 1956, p. 9.

NEW TECHNIQUES FOR FREEZING AND STORING NORTH ATLANTIC LOBSTERS

In order to make possible the utilization of the large quantities of deep-sea lobsters discovered by the Service's exploratory fishing vessel Delaware in the Georges Bank fishing area off the coast of Massachusetts, experiments have been conducted by the Fish and Wildlife Service Technological Laboratory at East Boston, Mass., to determine (1) the feasibility of freezing lobsters aboard a fishing vessel, and (2) means of increasing the storage life of frozen lobster meat. The following report concerns the results so far obtained regarding these experiments:

FEASIBILITY OF FREEZING LOBSTERS ABOARD A FISHING VESSEL: A sodium-chloride brine (22 percent salt by weight), used successfully for freezing New England groundfish aboard the Delaware, was tried as a freezing medium for whole or butchered cooked[1] lobsters. Lobsters landed on the vessel were immediately cooked in a barrel containing sea water heated by steam from the vessel's boiler. After cooking, these lobsters either whole or butchered (by removing the tails and claws) were put into polyethylene bags, frozen to 0° F. in the vessel's brine-immersion freezer, and stored at 0° F. in the refrigerated hold. Examination of these lobsters when landed showed that 50 percent of the bags used had been torn or punctured by the sharp spines on the claws of the lobsters. This caused intimate contact between the lobsters and brine during freezing, resulting in excessive salt penetration into the meat. As a result of this salt penetration, lobsters contained in polyethylene bags that were punctured were inedible when examined one week after being frozen. Lobsters in polyethylene bags that were not punctured lost their characteristically pleasing flavor and were tough and dry three weeks after being frozen and stored at 0° F. Such a method of freezing therefore was not suitable.

Large, deep-water, left-handed lobster captured on the southeastern edge of Georges Banks. The utilization of this newly-discovered resource has been delayed pending development of methods of preservation on board the vessel.

In view of these findings, it was thought that the use of a freezing solution which provides a protective glaze on the frozen lobster and which does not cause excessive salt penetration into the lobster meat might be successful. A glucose (34 percent)-salt (12 percent) solution used in small-scale tests in the laboratory's project on freezing fish at sea seemed to have the desired properties. To determine the possibility of freezing cooked whole lobsters in a glucose-salt solution aboard the fishing vessel, landing the lobsters in a frozen condition, thawing ashore, vacuum packing the meat in cans, refreezing, and storing the frozen meat, the following pilot-plant experiment was performed:

Cooked whole lobsters were precooled to a temperature of 45° F. in running fresh water prior to freezing. Some of these lobsters were then butchered and others were left whole. Both lots were cooled to 0° F. by immersion in the glucose-salt freezing solution. Once frozen, some were left without packaging and some were packed in polyethylene bags. These lots were then stored for two weeks (to simulate the length of time they might be kept at sea aboard the fishing vessel) at 0° F. and -20° F. They were then thawed, the meat picked out and packed in C-enamel lined cans under a vacuum of 27 inches of mercury, frozen, and stored at 0° and -20° F.

1/ Earlier tests on frozen lobsters showed that when whole frozen uncooked lobsters were cooked, the meat stuck very tightly to the shell and was extremely difficult to remove. Therefore, in this experiment the lobsters were cooked prior to freezing.

After 8 weeks from time of freezing the whole lobsters, no deterioration in the quality of the meat had occurred. The lobsters butchered before freezing in the glucose-salt solution were slightly, but not objectionably salty, due to small amounts of salt penetration into the meat. However, no salt penetration was noted in the lobsters frozen whole.

The glucose-salt freezing solution used seemed to provide a protective glaze which contributes greatly to the storage life of frozen whole lobsters. These results indicate that freezing of deep-sea lobsters aboard a fishing vessel is a definite possibility. Tests on a larger scale will be conducted.

STORAGE LIFE OF FROZEN LOBSTER MEAT: A number of deep-sea lobsters brought in alive by the Delaware were cooked, and the meat vacuum-packed in C-enamel cans under a vacuum of 27 inches of mercury, frozen, and stored at temperatures of 0° and -20° F. The following results were obtained in these tests:

Cooked lobster meat thus packed in cans, frozen, and stored at 0° F. showed loss of texture and flavor in 6 to 8 weeks. Storage at -20° F. increased this storage life to 10-12 weeks. By adding a 2.5 percent salt solution to the canned meat and storing it at 0° F. a storage life of 12 to 14 weeks was obtained. Tests are presently being conducted on the storage life of cooked lobster meat packed with a 2.5-percent salt solution under a vacuum of 27 inches of mercury and stored at -20° F., and on the effect of different levels of vacuum on the storage life of frozen lobster meat.

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SHARKS ARE EDIBLE

Sand sharks, and almost all other kinds of small sharks, are edible. Very large sharks and hammerhead sharks should not be eaten. A prejudice exists against the consumption of shark meat, but this is largely unfounded. Perhaps it is partly due to the fact that shark meat spoils more quickly than that of other fish. This is particularly true of the dark portion. Actually shark is eaten in many parts of the world, although sometimes it is given names which conceal its identity.

To prepare shark meat for food, cut fillets of the light meat about 9 by ½ inches thick and wash them thoroughly in salt water. Place the fillets in ice or in a refrigerator for about 24 hours, or soak them in a clean cold brine for about 6 hours. If they are kept on ice or in the refrigerator, a brine soak of about 2 hours will be sufficient. The fillets should be used immediately or else frozen. They can be boiled or fried.

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