
# EFFECT OF COOKING OIL QUALITY AND STORAGE CONDITIONS ON THE KEEPING QUALITY OF FROZEN FRIED FISH STICKS

During the course of research by the Service's Boston Fishery Technological Laboratory into the many factors affecting the quality and the storage life of frozen fried fish sticks, studies were made on the effects of using old "spent" cooking oil. Two lots of samples were prepared from fish sticks (cod) cooked in relatively fresh corn oil (free fatty acid content, 0.24 percent by weight) and in old "spent" corn oil (free fatty acid content, 2.5 percent) that had been in constant use for 120 hours. In all other respects, insofar as possible, the samples were identical. Each lot of samples was then split into three groups for frozen storage under three different conditions to study the effects of such conditions on quality and storage life.

Table 1 - The Effects of Quality of Cooking Oil and of Storage Conditions on the Storage Life of Frozen Fried Fish Sticks

| Lot No. | Frying Oil | Storage Condition 1/ | Quality Rating Months 0 | 2 | 5 | 8 | 12 | Probable Storage Life |
|---|---|---|---|---|---|---|---|---|
| 1 | Fresh corn oil, free fatty acid content of 0.24 percent by weight | (A) Mild | Very Good | Good | Good | Fair | Fair | Approximately 8 months |
| | | (B) Extremely Severe | Very Good | Good | Good | Fair | Poor | |
| | | (C) Extremely Mild | Very Good | Good | Good | Fair | Fair | |
| 2 | "Spent" corn oil, free fatty acid content of 2.5 percent by weight | (A) Mild | Good | Fair | Poor | Poor | - | Less than 5 months |
| | | (B) Extremely Severe | Good | Good | Fair | Poor | - | |
| | | (C) Extremely Mild | Good | Good | Poor | Poor | - | |

1/ Condition (A) - Packages in sealed master cartons directly exposed to continuous air blast (-3° to +2° F.) of 50 feet per minute.
Condition (B) - Individual packages directly exposed to continuous air blast (-10° to 0° F.) of 900 feet per minute. (Air temperature during the 3-times-daily defrost cycle of 15 minutes' duration reached +15° F.)
Condition (C) - Packages in sealed master cartons inside large draft-free box in a still-air cold room (0° to +5° F.).

The storage conditions were (A) mild, (B) extremely severe, and (C) extremely mild. (See table 1 for description of storage condition.) Three taste tests were performed by an experienced panel on each of the six groups of samples initially and after storage for 2, 5, 8, and 12 months.

Table 1 shows the results of the studies. No consistent reproducible differences in quality of the fish sticks due to differences in storage conditions could be detected by the panel. The quality of the packaging was evidently sufficiently good to protect the samples under the most severe conditions. The three groups of fish sticks fried in fresh corn oil remained in a marketable condition for 8 months. The three groups of fish sticks fried in "spent" oil were considered to be of poor quality and unmarketable after only 2 to 5 months of storage. The very dark, lifeless color and the oily-soggy texture of the coating of the sticks was very displeasing to the panel.

--JOHN A. HOLSTON, CHEMIST,
FISHERY TECHNOLOGICAL LABORATORY,
BRANCH OF COMMERCIAL FISHERIES,
U. S. FISH AND WILDLIFE SERVICE,
EAST BOSTON, MASS.

# FRESHNESS TESTS FOR TUNA

The University of Washington School of Fisheries[1/] is studying the relative value of the following chemical tests as a measure of freshness of various species of fish: volatile acids, volatile-reducing substances, volatile bases, hydrogen sulfide and trimethylamine. The first species of fish to be investigated is tuna, samples of which were stored in ice and at room temperature. At suitable storage intervals and as spoilage progressed, samples of the raw fish were frozen while other samples at the same stages of spoilage were canned.

Analyses for trimethylamine and for volatile acids have been completed on these tuna series. Trimethylamine failed to develop in sufficient quantities to form the basis of a suitable test in these series. Volatile acids did develop as spoilage proceeded and a fairly good correlation (although not completely consistent in all cases) occurred. The analyses for volatile bases, hydrogen sulfide, and volatile-reducing substances on the tuna series are now being made and will be reported later.

1/ This study at the University of Washington under a contract from the U. S. Fish and Wildlife Service is financed from funds made available by Public Law 466, 83rd Congress, approved July 1, 1954, popularly known as the Saltonstall-Kennedy Act.

# COMMERCIAL-SCALE FREEZING-FISH-AT-SEA TRIP MADE BY DELAWARE

The experimental freezer trawler Delaware returned October 9 from a 13-day cruise (No. 10) in the Georges Bank area with about 100,000 pounds of high-quality brine-frozen groundfish. The frozen catch consisted of 42,000 pounds of large haddock, 25,000 pounds of scrod haddock, 25,000 pounds of pollock, 4,000 pounds of flounder, and 4,000 pounds of cod. In addition, about 3,000 pounds of fresh iced fish were aboard.

During the 13-day trip, fishing operations were conducted for 24 hours a day, according to the commercial practice of the Boston trawler fleet. A total of 100 sets were made, averaging 1,000 pounds of market fish per set. However, $2\frac{1}{2}$ days of fishing time were lost in taking two sick crew members ashore.

OPERATION OF REFRIGERATION SYSTEM: The experimental brine-freezing system operated very satisfactorily during the trip, freezing at a rate of approximately 850 pounds of haddock per hour. All automatic controls on the absorption refrigeration plant functioned properly and the only attention required was to check the temperature and pressure gauges once an hour. The low-temperature brine thermostat and solenoid valves shut down the brine cooler when the brine temperature reached $0^{\circ}$ F. The pressure switch on the brine-pump discharge prevented the brine cooler from freezing in case of brine-flow stoppage.

All freezing was done between brine temperatures of $5^{\circ}$ and $10^{\circ}$ F. Loads consisting of 2,000 pounds of scrod haddock, when put into the freezer, caused only a $3^{\circ}$ rise in brine temperature, after which the brine returned to its original temperture within 2 hours and 20 minutes. The largest daily catch consisted of over 18,000 pounds of scrod haddock, of which fish from individual sets were placed into the brine freezer immediately or within 2 hours after being caught.

When freezing large fish, such as pollock and large cod, the freezing rate dropped to about 550 pounds per hour. The brine-freezing system aboard the Delaware is subject to certain definite refrigeration losses. When freezing the larger fish, these losses increase per pound of fish frozen, thereby giving a decreased freezing rate. This is a function of the fish thickness and would be the same for any refrigeration system.

It was possible to obtain data on the cost of operating the freezer during the trip. A fuel-oil meter was used to measure the fuel used in the steam boiler on the vessel. The absorption system, freezing at full capacity and maintaining two fish-holds at 8° F., used a maximum of 101 gallons of oil per day. The motor driving the freezer baskets, brine pump, antifreeze pump, circulating pump, and aqua pump used 7.74 kilowatts. In order to produce 7.74 kilowatts, the diesel generating set on the vessel used about 17 gallons of fuel oil per day (calculated figures). Therefore, the total fuel oil used was 118 gallons per day. At a price of 10 cents per gallon, the cost of operating the system at maximum capacity was $11.80 a day.

In order to preserve 100,000 pounds of fresh (unfrozen) fish on a similar-size trawler, about 40 tons of ice are required at a cost of $6.00 per ton. Therefore, assuming a 12-day trip, about $240 would be spent for ice. In a 12-day trip on the Delaware the maximum refrigeration cost would be $11.80 a day. (The actual cost would be somewhat less because the system would not be operating at full capacity all the time.) This would give a total refrigeration operating cost of not more than $142 for the trip. Therefore, the cost of freezing and storing 100,000 pounds of fish during a 12-day trip would be $98 cheaper than the cost of ice necessary to preserve 100,000 pounds of fresh fish during the same period of time. This saving partially offsets the cost of maintaining and purchasing the freezing equipment.

HANDLING ABOARD THE VESSEL: The fish, after being caught, were put into bushel baskets which were dumped into the cylindrical freezer baskets. A board on which were mounted 11 dummy clocks and 1 real clock was used to record the freezing time of the various loads. The procedure was as follows: The freezer consists of 11 cylindrical metal-mesh baskets which have a number stamped on their sides. As each basket was loaded, the dummy clock for that basket was advanced to the time when the fish should be unloaded from the basket. Then when the time shown by the real clock and the dummy clock coincided, the fish were unloaded and conveyed by metal chutes into either the after or forward refrigerated hold. In many cases the baskets were unloaded and loaded at the same time. It was possible to unload 2,000 pounds of frozen fish from the freezer into the fish hold and load an additional 2,000 pounds of fish from the checkers into the freezer within 30 minutes.

An observer from Northeastern University was aboard during the trip to obtain pertinent data for the economic study of freezing-fish-at-sea being conducted by that University under a contract with the Fish and Wildlife Service.

The vessel was unloaded at the Fish and Wildlife Service laboratory at East Boston. Large amounts of the scrod and haddock will be used for a consumer-acceptance test of the brine-frozen fish which will be conducted by Northeastern University. The remainder of the fish will be used in other research projects being conducted by the laboratory.

--J. W. SLAVIN, REFRIGERATION ENGINEER,
FISHERY TECHNOLOGICAL LABORATORY,
BRANCH OF COMMERCIAL FISHERIES,
U. S. FISH AND WILDLIFE SERVICE,
EAST BOSTON, MASS.

## FEEDING STUDIES WITH MENHADEN PRESS CAKE

In the manufacture of menhaden fish meal, the raw fish are first cooked with direct steam to break down the tissues so that the oil and stickwater can be removed. The cooked fish are then pressed in continuous screw-type presses to remove as much oil and stickwater as possible. The partially-dried material at this stage contains 45-50 percent moisture and is called press cake.

The proximate composition varies depending on the size of fish, quality of the raw material, and the efficiency of the cooking and pressing operations. An average composition would be about 55 percent dry matter--35 percent protein, 5 percent fat, 3 percent nitrogen-free extract, and 12 percent minerals. The raw menhaden contains an appreciable amount of thiaminase, which means that this fish has to be cooked before feeding to animals. The press cake has already been cooked so the bioassay shows very little thiaminase present. The press cake contains considerable fish bones which have not been broken down, and which may decrease consumption by some species of animals.

In order to obtain information on the nutritive value of this product, six weanling rats were allotted to the experiment on September 15, 1953. At first they were fed press cake alone as much as they would eat. It was soon evident that the diet was not complete enough to permit growth. The rats did not gain in weight during the first two weeks, so the diet was then changed. In addition to the press cake, they received free-choice fresh cabbage and a high-calorie diet made up of starch, vegetable shortening, and cod-liver oil in the proportion of 80, 16, and 4 parts by weight, respectively. The rats then started to grow normally. The press cake which was stored frozen was eaten with relish. The bones were cleaned of meat and left in the feeding dishes.

A number of litters were born, the first on January 15, 1954, but quite a few of the young died soon after birth. This seemed to be more a question of maternal care than due to diet and is a common experience with the breeding rats of the stock colony in this laboratory. The litters that were raised grew satisfactorily without abnormal mortality.

At the present time there are three fourth-generation litters. These were born on August 17, August 29, and September 22 of this year and there are five to eight siblings in a litter.

The data indicate that no young or adult rat has died from mechanical obstruction by bones. All of the animals now living are sleek and healthy looking. In two instances, males belonging to third-generation litters showed nervous symptoms that might be described as a "fit." The males were given a solution of thiamine and the seizures stopped. After the treatments were suspended the seizures returned.

One of the males seemed to lose muscular coordination and died after about three weeks. No gross unusual conditions were found during necropsy. The seizures of the other male continued for a few weeks after which he returned to normal. It is not known whether the diet did not supply some nutrient needed to alleviate a physiological stress or whether the deficiency was of genetic origin in these highly-inbred rats. As mentioned previously, the fourth-generation rats appear very healthy at the present time, namely, at the age of one or two months.

In summary, menhaden press cake, a high-calorie diet, and fresh cabbage have been fed free-choice to rats, for a period of about two years. At the present time these include fourth-generation litters. No difficulty has been experienced due to the numerous bones in the press cake. The rats have been generally very healthy. Two male rats of the third generation have had seizures apparently of nervous origin. It is not known whether these were due to a deficiency of the diet or were of genetic origin. The press cake seems to be a satisfactory source of protein and possibly of some vitamins for normal growth and reproduction. The experiments are being continued.

--HUGO W. NILSON, CHEMIST, AND
DONALD G. SNYDER, BIOCHEMIST,
FISHERY TECHNOLOGICAL LABORATORY,
BRANCH OF COMMERCIAL FISHERIES,
U.S. FISH AND WILDLIFE SERVICE,
COLLEGE PARK, MD.

# PILOT REDUCTION PLANT

A pilot reduction plant supplied and maintained by a contractor at Reedville, Va., has been operated in September and October 1955 by staff members from the Service's Fishery Technological Laboratory, College Park, Md. This project is financed by Saltonstall-Kennedy Act funds.

The pilot plant (consisting of a direct steam cooker, continuous screw-type press, and a hot-air dryer) was designed to permit the study of some processing variables that may affect the nutritive quality of the fish meal which is produced.

Menhaden are the only fish which are processed in the Reedville area. The variables studied were limited mainly to the effect of size and quality of fish on the resultant meal. A few studies were done on the degree of cooking of the fish and the temperature in the dryer.

All samples of meal will be fed to poultry to determine the nutritive quality of the meal. Until these tests are completed, it will not be possible to draw any conclusions on the effect of processing variables on nutritive quality of meals made in these tests.

# CONFERENCE OF CONTRACTORS DOING RESEARCH ON SOUTHERN OYSTERS

A conference was held on October 17 to discuss the research work on Southern oysters financed by Saltonstall-Kennedy Act funds. Staff members from the Florida State University, Louisiana State University, and Tulane University, and a representative of the U. S. Fish and Wildlife Service were present at the conference in Tallahassee, Fla. The previous conference was held in May in New Orleans.

The staff at the University of Florida reported on frozen storage tests with cooked oyster dishes, and sterilization of raw oysters using radioactive cobalt. Those from the Louisiana State University reported on frozen storage tests with raw oysters treated in various ways. The men from Tulane University described tests designed to explain the physiology of the body-fluid losses of oysters. The Southern oysters lose substantially more weight through this process than do oysters of the same species from other sections of the East Coast. The Service representative outlined the chemical studies that had been done to determine the proximate composition of samples collected at monthly intervals from the important producing areas in the Gulf and South Atlantic.

Detailed data cannot be given on any of the work at present since no research reports have been published. It is expected that several reports from each unit will be submitted before the end of the contract year which will be in January and February 1956.

# COLD-STORAGE LIFE OF FRESH-WATER FISH--NO. 2 [1/]

(Yellow Perch, Crappie, White Bass, Utah Chub, and Sqawfish)

Although fresh-water fish form a substantial segment of the domestic fish supply, only limited data are available on their cold-storage life. These data are of value to the producer in adopting proper packing preocedures and in evaluating marketing problems, and to the sport fisherman in preserving a portion of his catch.

1/ This work was carried out under a project financed in part by the Refrigeration Research Foundation.

Furthermore, studies on the freezing and cold-storage keeping characteristics of species not now being extensively used may ultimately lead to their wider utilization. For these reasons, a project to develop this type of information was started at the Seattle Technological Laboratory about four years ago. The first report of the findings was published in the September 1954 Commercial Fisheries Review. In the present report, the results of the cold-storage tests on additional samples and with new species are presented.

The fish used in this study were collected in Wisconsin, Minnesota, Montana, and Washington. Samples of each species of fish were stored in the round. Some were also stored as dressed fish.

The fish, which were in five lots, were shipped from the collection points to the Seattle laboratory. Three of the lots were shipped iced; two, frozen.

Table 1 - Cold-Storage Life of Certain Fresh-Water Fish Stored at 0° F.

| Description of Samples | | | | | | Condition of Samples Stored at 0° F. for: | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Common Name | Scientific Name | Source | Date Caught | Method of Shipping | Packaging Used for Storage | 0 Months | 3 Months | 6 Months | 9 Months | 12 Months |
| Yellow perch | Perca flavescens | Lake Winnebago, Wisconsin | July 1953 | Iced | In the round, packed in polyethylene bags | Mild flavor; tender; slightly dry after cooking (good) | Texture very firm and slightly tough; slightly bitter flavor noted in parts of belly flaps but flavor otherwise good | Quality unchanged (good) | Quality unchanged (good) | Quality unchanged (good) |
| Crappie | Pomoxis annularis | Two Rivers Lake, Benton County, Minnesota | October 1953 | Iced | In the round, ice-glazed, packed in polyethylene bags | Meat white; tender, firm, and flaky; flavor bland but pleasant (excellent) | No change noted | Some off-flavor in belly flaps; otherwise good | No further change (good) | Discontinued |
| White bass | Lepibema chrysops | Lake Winnebago, Wisconsin | July 1953 | Iced | In the round, packed in polyethylene bags | Appearance good; texture firm, tender, and moist. Flavor mild and sweet (excellent) | Good | Some off-flavor in belly flaps; otherwise good | Some discoloration and off-flavor in belly flaps; otherwise good | Same as at 9 months |
| | | | | | In the round, packed in quart jars, flooded with tap water | Same as above | Good | Same as above | Same as above | Same as above |
| | | | | | Dressed fish, packed in quart jars, flooded with tap water | Same as above | Good | Same as above | Same as above | Same as above |
| Utah chub | Gila atraria | Hebgen Lake, Montana | July 1953 | Frozen | In the round, ice-glazed, packed in polyethylene bags | White meat extremely soft with many small bones; good flavor (acceptable) | Texture soft; white meat flat flavor; dark meat strong flavor | White meat flat; dark meat extremely strong flavor | No further change | No further change |
| | | | | | Dressed fish, glazed, packed in polyethylene | Same as above | Belly cavity discolored; texture soft; white meat flat flavor; dark meat strong flavor | Same as above | Discontinued | |
| Squawfish | Ptychocheilus grandis | Drano Lake, Washington | February and June 1953 | Frozen | In the round, glazed, wrapped in cellophane | White, flaky, tender meat; many small bones; mild flavor | White meat flat flavor; dark meat and belly flaps off-flavor | White meat flat; dark meat extremely strong flavor; belly flaps off-flavor | Same as at 6 months | Discontinued |

The three lots of iced fish were shipped express and maintained in a chilled condition until their arrival at the laboratory. The time elapsing between catching and delivery at the laboratory was not more than 5 days. At the laboratory, the fish were washed, prepared for freezing, and frozen in a blower-type freezing unit at a temperature of -20° F. After being frozen, they were placed in storage at 0° F. The methods of packaging the individual samples are shown in table 1.

The two lots of frozen fish had been frozen in commercial freezers, packed in suitable containers with dry ice, shipped to Seattle by express or by air freight, and received in good condition. Part of the lot of frozen Utah chub (and iced white bass) was dressed when received. The frozen dressed Utah chub were thawed in cold running water only until soft enough to handle and were then packaged for the cold-storage tests.

Table 1 gives data on the cold-storage life of all five lots of fish.

## CONCLUSIONS

The yellow perch, which were frozen in the round, were of good quality throughout the 12-months' storage test. These results were the same as those obtained with another lot of yellow perch in a previous test.

The crappie, which were frozen in the round, were of good quality for more than 9 months. Samples were not available to carry the tests beyond this period.

White bass, packed in the round in polyethylene bags or in glass jars or as dressed fish in glass jars, were of good quality throughout the 12-months' storage period.

Utah chub, packaged in polyethylene bags either in the round or as dressed fish, were of fair quality up to 4 months. At 6 months, the dark meat had an objectionable off-flavor, and the white meat was flat; no further changes were noted during the test period of 12 months.

The squawfish, frozen in the round, were off-flavored in the dark meat and belly flaps at 3 months. At 6 months, the dark meat had a strong objectionable off-flavor.

Additional studies on such variables as seasonal changes, methods of handling, and methods of packaging and storing are necessary before general conclusions can be drawn on the cold-storage life of these species of fresh-water fish.

## SPECIES CURRENTLY UNDERGOING STORAGE TESTS

In addition to the fish listed in table 1, the following species are currently undergoing storage tests, which will be completed by February 1956:

(1) Sheepshead (Aplodinatus grunniens) taken from Lake Winnebago, Wis., in January 1954.

(2) Chub (Leucichthys sp.) taken from Lake Michigan in August 1954.

(3) Whitefish (Coregonus clupeaformis) taken from Red Lake, Minn., in August 1954.

(4) Northern pike (Esox lucius) from Litchfield, Minn., February 1955.

--KATHRYN L. OSTERHAUG AND DAVID T. MIYAUCHI, FISHERY PRODUCTS TECHNOLOGISTS,
FISHERY TECHNOLOGICAL LABORATORY,
BRANCH OF COMMERCIAL FISHERIES,
U. S. FISH AND WILDLIFE SERVICE, SEATTLE, WASH.

## CONTINENTAL SHELF

The continental shelf is a submarine plain of varying width, forming a border to the continents. The water above it is comparatively shallow, somewhere between 300 and 450 feet. The shelf varies greatly in its width and slope. In some cases, as off mountainous coasts, the shelf may be almost absent, whereas off glaciated coasts and off the mouths of large rivers and areas of broad lowlands, the shelf may be very wide. For the world as a whole, the width of the shelf is approximately 30 miles, varying from zero to 800 miles. This extremely wide shelf is in the North Polar Sea along the coast of Siberia. The rapid descent of the continental shelf to the ocean depths is the continental slope.

--Sea Secrets, January 18, 1955,
The Marine Laboratory, University of Miami,
Coral Gables, Fla.