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# FREEZING AND COLD STORAGE OF PACIFIC NORTHWEST FISH AND SHELLFISH

## Part III - Storage Characteristics of Six Species of Oily Fish

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ABSTRACT

In storage at 6° to 16° F., pilchard (Sardinops caerulea) and eulachon (Thaleichthys pacificus) that were block frozen and ice glazed and albacore tuna sticks (Germo alalunga) that were wrapped in cellophane became slightly rancid in from 0 to 90 days, sablefish steaks (Anoplopoma fimbria) that were wrapped in cellophane became slightly rancid in from 90 to 180 days, and herring (Clupea pallasii) and silver smelt (Hypomesus preticsus) that were block frozen and ice glazed became slightly rancid in from 180 to 270 days.

## INTRODUCTION

Oily fish have the reputation of quickly becoming rancid in frozen storage. Even if properly packaged, some species become rancid in from 60 to 90 days, particularly if stored above 10° F. Their high content of partially unsaturated oils is usually considered as the primary reason for the rapid onset of rancidity.

This paper, the third in a series on the freezing and storage characteristics of Pacific Northwest fish and shellfish, reports on a study made on one marine species that spawns in fresh water and on five strictly marine species, all of which were oily fish.

The following were the species studied: pilchard (Sardinops caerulea), eulachon (Thaleichthys pacificus), albacore tuna (Germo alalunga), 1/ sablefish (Anoplopoma fimbria), herring (Clupea pallasii), and silver smelt (Hypomesus pretiosus).

Fig. 1--Filling the aluminum pans and loading the pan rack.

## SOURCE AND HISTORY OF THE SAMPLES

PILCHARD: The pilchard, purchased from a reduction plant at Bay City, Washington, came from a lot of fish that had been seined from the coastal waters of the Pacific Ocean off Grays Harbor. These fish were caught during cool weather, iced within 12 hours, and maintained in ice until dressed and frozen. Two days elapsed from the time the fish were captured until they were put into the freezer.

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1/Also known as Thunnus germo.

EULACHON: The eulachon were obtained near Kelso, Washington, during their February spawning migration up the Cowlitz River, a tributary of the Columbia River. They were kept at the prevailing out-of-doors temperature without ice while in transit to Seattle and upon arrival there. These fish were about 2 days out of water before being put into the freezer.

ALBACORE TUNA: Three 15-pound albacore tuna were obtained from a Seattle wholesale fish dealer. They had been held in ice for about 4 or 5 days. It is believed that these were troll-caught fish from the coastal waters off the State of Washington. Streaks of color indicative of viscera burn were present in the belly cavity of these fish, but the surrounding flesh was not discolored. These tuna were dressed, quartered, cut in sticks, packaged, and put into the freezer on the day of purchase.

SABLEFISH: The sablefish were taken by otter trawl from the waters west of Vancouver Island. These fish had been dressed heads-off and then iced for 10 days while in transit to Seattle. After being re-iced overnight at Seattle, the fish were definned, washed, steaked, packaged, and put into the freezer.

HERRING: Seine-caught herring were obtained directly from a fishing boat. These fish were taken in Hood Canal and transported un-iced overnight to Seattle. They were about 24 hours out of water before being put into the freezer.

SILVER SMELT: The silver smelt were seined from the waters along the east side of Whidby Island. These fish were iced in transit to Seattle and re-iced upon arrival there. They were about three days out of water before being put into the freezer.

## PREPARATION OF SAMPLES FOR STORAGE

GENERAL PROCEDURE: In the preparation of the samples for storage, the fish were first dressed. If the resulting dressed fish were too large to be conveniently packaged, they were cut into pieces of appropriate size.

Two series of samples were then packaged. The first, a test series, was put up to show how long the fish would keep if prepared, packaged, and stored by ordinary commercial methods in use at the time that the study was made. The second, a control series, was put up under special conditions that were thought would maintain the original quality of the control series for the duration of the test period. The purpose of the control series was to provide a standard against which any loss of quality in the test series could be measured.

The preceding two paragraphs give the general procedure used in the preparation of the samples for storage. The specific details of this procedure are given in the following four subsections.

Dressing and Cutting the Fish for Test Samples: The size and nature of the fish influenced the dressing and cutting procedure. The tuna were dressed by the removal of the heads, fins, tails, and viscera. They were then divided longitudinally into quarters, and the backbones were discarded. Each quarter was cut into sticks 1 to $1\frac{1}{2}$ inches in diameter and about 7 inches in length. The sablefish, which were dressed when purchased, were washed and steaked. The pilchard, eulachon, and herring were dressed with heads off and viscera removed and then washed. The silver smelt were left whole.

Dressing and Cutting the Fish for Controls: Fish for the control samples were dressed and cut exactly as for the test samples, with the exception that the tuna quarters, dressed pilchard, and dressed herring were cut into $1\frac{5}{8}$-inch lengths.

Preparation of Test Samples for Storage: When the test series were planned, consideration was given to the fact that the storage life of a particular species of fish depends greatly upon the methods of preparation, packaging, and storage used. Fish can be held for a long time with minimum loss of quality if, for example, the individual fish are frozen in a block of ice and stored at a very low temperature. Obviously, such a method is not practical. What is needed is information on how long the fish will keep if prepared, packaged, and stored by ordinary commercial methods. For this reason only practical low-cost commercial methods in common use were employed in handling the test samples.

The test samples of pilchard, eulachon, herring, and silver smelt were prepared by carefully laying the fish side by side, two layers deep into rectangular aluminum pans until each contained about 5 pounds of fish (fig. 1). Once filled, each pan was covered with a tight-fitting lid and subjected to rapidly moving air at -20° F. for about $2\frac{1}{2}$ hours during which time the fish froze into a unit mass or block conforming to the shape of the pan (fig. 2). The pans were then immersed in water at 32° F. As each block thawed slightly, came free from the pan, and was lifted from it, the water adhering to the block froze into a protective glaze covering all of the surface. These glazed blocks were loosely packed into fiberboard cases for storage. At intervals of 90 days the blocks were removed from the cases, reglazed in water, and repacked. At no time did the glaze become so thin as to expose the fish.

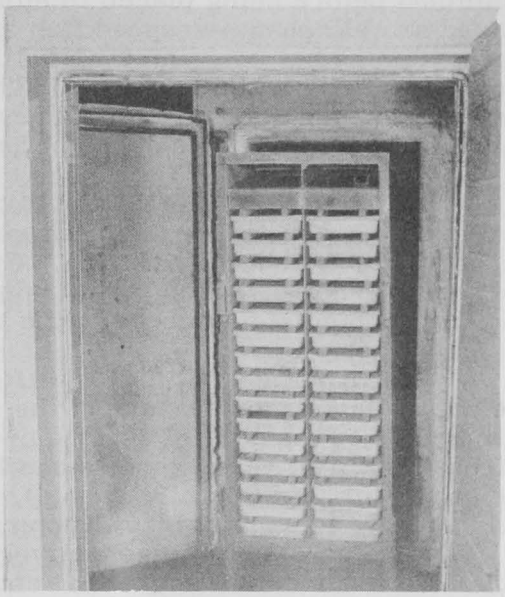

Fig. 2--Loaded pan rack partially removed from the freezer.

Each sample of tuna and sablefish was wrapped tightly in a single sheet of MSAT[2/] cellophane. The wrapped samples were packed into rectangular aluminum pans, each of which had a capacity of 5 pounds. After the pans were covered with tightly fitting aluminum lids, they were held for at least $2\frac{1}{2}$ hours at -20° F. in a stream of rapidly moving air. The samples, which were hard frozen, were then transferred from the pans to five-pound, two-piece, folding waxed cartons.

Preparation of Control Samples for Storage: As fresh fish for use as controls were not consistently available, it was necessary to use packaged controls. In this study the controls were prepared by one of the most effective methods available for preserving frozen fish; that is, they were vacuum packed in hermetically-sealed cans prior to being frozen. Although not always commercially practical, this method has been used by frozen-food laboratories to prolong the time over which experimental samples will retain their original fresh qualities.

The control samples were packed in $\frac{1}{2}$-pound flat cans in one of three ways as follows: (1) the $1\frac{5}{8}$-inch lengths of herring, pilchard, and tuna were packed tightly on end; (2) the sablefish steaks were packed flat, two deep; and (3) the eulachon and silver smelt were packed curled into circles. The cans were then sealed under 15 inches of vacuum, held for $2\frac{1}{2}$ hours in rapidly moving air at -20° F. to hard freeze their contents, and finally transferred to open wooden boxes, which were placed in frozen storage.

## STORAGE CONDITIONS

Since frozen storage facilities were not available at the laboratory, commercial facilities were used. The temperature of storage ranged from 6° to 16° F.

2/"MSAT" means moisture-vapor proof, heat sealing, anchored coating, transparent.

## ORGANOLEPTIC EXAMINATION

Objective chemical and physical tests have not proven entirely successful in the determination of frozen-fish quality; instead, the organoleptic factors of palatability and appearance are usually considered the best criteria. All of the samples were therefore examined organoleptically for changes in odor, flavor, texture, and color by a test panel. In each test this panel was made up of at least eight people experienced in making organoleptic determination.

GENERAL PREPARATION OF FISH FOR ORGANOLEPTIC EXAMINATION: The samples were prepared for organoleptic examination by the test panel after 0, 90, 180, and 270 days of storage. (The number 0 indicates that the sample was examined before being placed in storage). About 5 pounds (one block) of the ice-glazed or cellophane-wrapped fish and 8 to 10 cans of the vacuum-packed controls were examined at each interval. All samples were thawed at room temperature in moving air from an electric fan. The only fish that required dressing after being thawed were the silver smelt. They were headed and eviscerated at this time because storage in the round was believed to result in a product having better quality.

SALTING AND BAKING: Both the thawed test samples and the thawed control samples were immersed in a six-percent salt solution for five minutes to bring out the natural flavor of the fish. Upon being removed from the solution, the samples were drained, baked for 20 minutes on cooky sheets in an oven set at 350° F., and then immediately served to the test panel.

ORGANOLEPTIC TEST: After observing color changes, if any, and noting the odor, flavor, and texture of the sample, each panel member assigned to the test sample and to the control sample one of the following ratings: VG for very good (highest quality), G for good (some loss of original quality but no indication of rancidity), F for fair (slightly rancid), P for poor (rancid and barely edible), and U for unacceptable (very rancid). Numerical values of 4, 3, 2, 1, and 0 were assigned to VG, G, F, P, and U, respectively. The average of the resulting scores gave a single final numerical score that could be changed back to the equivalent alphabetical rating.

## RESULTS AND DISCUSSION

The results of the organoleptic examinations appear in table 1.

Table 1--Effect of Time in Frozen Storage on the Quality of Six Species of Commercially-Packaged Oil Fish Taken in the Coastal Marine Waters of the Pacific Northwest

| Time in frozen storage at 6° to 16° F. | Quality Rating[1/] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pilchard | | Eulachon | | Albacore tuna | | Sablefish | | Herring | | Silver smelt | |
| | Ice-glazed block | Control in tin | Ice-glazed block | Control in tin | Cellophane wrapped | Control in tin | Cellophane wrapped | Control in tin | Ice-glazed block | Control in tin | Ice-glazed block | Control in tin |
| Days | | | | | | | | | | | | |
| 0 | G | G | VG | VG | VG | VG | VG | VG | VG | VG | VG | VG |
| 90 | P | F | F | F | F | VG | G | VG | G | VG | G | VG |
| 180 | P | F | F | F | F | VG | F | G | G | G | G | VG |
| 270 | P | F | P | P | F | VG | F | G | F | G | F | F |

1/VG = Very good (highest quality)
G = Good (some loss in original quality but no indication of rancidity)
F = Fair (slightly rancid)
P = Poor (rancid and barely edible)
U = Unacceptable (very rancid)

TEST SAMPLES: Each species appeared to have its own storage characteristics, as follows:

Pilchard: Pilchard that had been block frozen apparently were not suitable for storage, for they became poor (rancid and barely edible) in from 0 to 90 days. The cut surfaces, in particular, darkened and became rancid in this initial storage period. The rancidity did not markedly increase thereafter.

Eulachon: These eulachon had an oily flavor that was objectionable to some of the tasters and that was difficult to distinguish from rancid flavors. They became

definitely rancid after 180 days of storage. (Even though frozen eulachon apparently tend to become slightly rancid in from 0 to 90 days, it is interesting to note that they are acceptable to the retail market if sold and consumed promptly after being frozen.)

Albacore Tuna: Of the six oily fish studied, albacore tuna had the most unique storage characteristics. The test samples wrapped in cellophane became slightly rancid between 0 and 90 days of storage; yet for unknown reasons they did not become progressively more rancid between 90 and 270 days of storage. By the end of 180 days, however, the light meat had become somewhat gray at the surface and the dark meat had become brown. The control samples remained unchanged throughout the entire 270 days of storage.

Sablefish: Sablefish steaks, cellophane wrapped, became darkened and discolored (yellow) in appearance and fair (slightly rancid) in quality in from 90 to 180 days of storage. These steaks had average storage qualities.

Herring: Herring, block frozen and ice glazed, remained good in quality until between 180 and 270 days of storage, but the cut surfaces darkened gradually during this period. A few rust spots could be seen on the skin of the herring after 270 days of storage. These herring appeared to have above-average storage qualities.

Silver Smelt: Silver smelt, block frozen and ice glazed, remained good in quality until between 180 and 270 days of storage, although yellow discoloration became evident in the belly cavities between 90 and 180 days of storage. The silver smelt appeared to have above-average storage qualities.

CONTROL SAMPLES: Of the six species of fish packed as controls, only the albacore tuna remained unchanged for the entire 270 days. The silver smelt declined from very good to fair between 180 and 270 days; the sablefish and herring declined from very good to good between 90 and 180 days; and the eulachon and pilchard declined from very good and good to fair during 0 to 90 days of storage.

## CONCLUSIONS

(1) Dressed eulachon and dressed pilchard--block frozen, ice glazed, and stored at 6° to 16° F.--had poor storage characteristics. They became slightly rancid and rancid, respectively, in from 0 to 90 days, and both were rancid and barely edible after 270 days.

(2) Albacore tuna sticks wrapped in cellophane and stored at 6° to 16° F. showed good inherent storage characteristics. Although they became slightly rancid in from 0 to 90 days, they were still only slightly rancid after 270 days.

(3) Sablefish steaks wrapped in cellophane and silver smelt and dressed herring--block frozen, ice glazed, and stored at 6° to 16° F.--also showed good storage characteristics. Although the sablefish steaks became slightly rancid in from 90 to 180 days and the herring and silver smelt in from 180 to 270 days, all three were still only slightly rancid after 270 days.

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