COLD STORAGE OF FROZEN PACIFIC OYSTERS (CRASSOSTREA GIGAS)[1/]

No. 2 - Effect of Antioxidant and Other Treatments on Keeping Quality

INTRODUCTION

The frozen-oyster industry of the Pacific Coast is the result of efforts on the part of producers and packers to broaden the market. In some cases the oysters are the excess from the fresh market and have been held at above freezing temperatures for several days before being frozen. Many packers are troubled by an occasional lack of uniformity and good quality in their product after frozen storage. Through the Pacific Coast Oyster Growers Association, they requested that experimental work be carried out to help improve the quality of frozen Pacific Oysters.

A study of the problems concerned with the frozen storage of Pacific oysters has been in progress at the Seattle Technological Laboratory since October 1954.

The initial paper[2/] reported results of a series of exploratory tests designed to determine what factors contribute to the formation of excessive drip in frozen oysters. Of the factors investigated, only the length of blowing time had materially affected drip. The work was limited to oysters frozen for only short periods of time. Commercial samples of frozen oysters always released considerably more drip than did the experimentally-frozen oysters. These differences in drip may have been caused by the greater length of time the commercial samples had been frozen.

Pacific oysters are usually frozen in 10-ounce eastern oyster cans. This procedure leads to some lack of uniformity in the product since Pacific oysters are often quite large and relatively few will fit into this size can.

Pacific oysters are frozen either raw or after blanching. The latter consists of immersing the oysters in boiling water for about one minute. The purpose is to firm the oyster meats and to overcome the natural slippery feel of the oyster which many homemakers find distasteful.

Certain physical and chemical changes take place in oysters during frozen storage. The body of the oyster darkens gradually and the oysters exposed to the headspace of the can become yellow. The oyster loses some of its firmness and becomes flaccid. The dark pigment from the mantle sloughs off and causes the drip to have a slightly sooty appearance.

While these changes are taking place, a change in flavor also develops. The normal fresh oyster flavor disappears and strong bitter off-flavors develop after extended storage.

1/ THIS WORK WAS CARRIED OUT UNDER A PROJECT FINANCED IN PART BY THE REFRIGERATION RESEARCH FOUNDATION.

2/ THE INITIAL REPORT, "COLD STORAGE OF FROZEN PACIFIC OYSTERS (CRASSOSTREA GIGAS)--NO. 1" WAS PUBLISHED IN THE DECEMBER 1955 (P. 11) ISSUE OF COMMERCIAL FISHERIES REVIEW.

The continuing aim of the present experimental work on frozen Pacific oysters is to slow down or prevent these changes so that (1) the quality of the frozen oysters is improved and (2) the marketing period is extended to a period of a year or longer.

The current phase of the project is concerned with an investigation of the effect of various processing treatments of the oysters before freezing on their storage characteristics. The treatments used include blanching, adding oxygen to the headspace, adding nitrogen to the headspace, and dipping the oysters into various antioxidant solutions.

EXPERIMENTAL

PREPARATION OF SAMPLES: The oysters used in these investigations were obtained from beds in the Willapa Bay area of Washington. They were obtained, freshly shucked and blown, from a commercial plant in South Bend, Wash.; placed in 5-gallon milk containers, packed in ice, and transported by truck to the Service's Seattle Fishery Technological Laboratory. The containers were held overnight in crushed ice, treated, and packed in 10-ounce oyster cans, sealed, and frozen the following day.

Approximately one-half of the oysters were blanched for one minute in boiling water and then drained before being treated and packed. The remaining oysters were treated and packed raw. Treatments consisted of dipping the oysters in solutions of the following antioxidants:

1. Antioxidant mixture[3] dissolved in U.S.P. propylene glycol[4].
   a. Nordihydroguaiaretic acid (NDGA) 0.01 percent by weight of oyster.
   b. Beta hydroxyanisole (BHA)--0.02 percent by weight of oyster.
   c. Ascorbic acid--0.02 percent by weight of oyster.
2. Ascorbic-citric acid mixture in water[4] (0.5 percent ascorbic acid--0.5 percent citric acid).

In addition to the antioxidants, the following treatments were included for control and comparison:

1. Control--no treatment.
2. Oxygen--air in headspace of can replaced by oxygen.
3. Nitrogen--air in headspace of can replaced by nitrogen.
4. Propylene glycol--for comparison with oysters treated with Tappel's[3] mixture.

The packaged oysters were frozen at -20° F. and stored at 0° F.

EXAMINATION OF SAMPLES: At two-month intervals over a period of 13 months, samples of the frozen oysters were removed from storage and examined.

3/ RECOMMENDED BY A. L. TAPPEL, UNIVERSITY OF CALIFORNIA, FOOD TECHNOLOGY DEPARTMENT, DAVIS, CALIF.
4/ ANTIOXIDANT PICK-UP WAS ASSUMED TO BE PROPORTIONAL TO THE PICK-UP OF THE SOLVENT. THIS WAS MEASURED PRIOR TO DISSOLUTION OF THE ANTIOXIDANTS.

$$\text{WT. \% ANTIOXIDANT DISSOLVED IN SOLVENT} = \frac{(\text{CONCENTRATION OF ANTIOXIDANT})\ (\text{WT. OYSTERS})}{(\text{WT. SOLVENT ABSORBED PER WT. OYSTERS})}$$

A variety of tests were performed in order to follow any changes that might be taking place. The following determinations were made on the thawed oysters: (1) pH, (2) free drip, (3) expressible drip, and (4) organoleptic evaluation (odor, appearance, and flavor).

The pH of the oysters was determined by measuring the pH of a blended sample by means of a glass electrode pH meter.

Free drip and expressible drip measurements were made on samples of the oysters that had been thawed 16 hours at 34° F. Free drip is defined as the weight of liquid lost in terms of percentage of initial product weight, during exactly two minutes of draining on a standard number 4 brass screen. Expressible drip is the percentage weight of liquid lost during exactly two minutes of compression between two layers of plastic sponges. The expressible drip measurements were made after the free drip was released.

Organoleptic evaluations of flavor were made by the investigators and by a taste panel which consisted of students and staff from the fisheries center at the University of Washington. Each panel consisted of from 8 to 16 people.

The oyster samples were presented to the tasters in the form of a standard oyster stew that consisted of chopped oysters, grade A butter, fresh milk, and salt. All samples of stew were prepared simultaneously. Temperatures were maintained by the use of double boilers containing hot water in the lower part during each taste-test period, which varied from 30 to 45 minutes.

For each examination a sample of fresh oysters was obtained and used in a stew as a reference sample. The reference stew was automatically given the highest score possible. All experimental oyster stews were judged in relation to the known and plainly labeled reference.

The score card used was based on a 10-point scale with 7-10 indicating good quality; 5-6, fair quality; and 1-4, poor quality. The tasters were asked to assign appropriate numbers to each sample. The reference sample was always arbitrarily assigned the score of 10.

General observations of the samples were made by the authors at each examination. These included a comparison of the odor, appearance, and the color of the surface of the oyster exposed to the headspace of the can.

RESULTS

There were no significant differences noted between any of the samples at the two- and four-month examinations of the samples. After six months, the oyster surfaces exposed to the headspace in all of the cans had begun to turn yellow in color. No off-odors were noted at this time. There were slight rancid odors detected in all samples after they had been stored for eight months. These odors were especially noticeable in the discolored areas.

After thirteen months of storage at 0° F. all of the samples were found to be of poor acceptability. The surfaces exposed to the headspace of the cans were discolored, the oysters did not have the firmness generally found in fresh oysters, and the body sections of many of the oysters had darkened. The discoloration on the surfaces exposed in the headspace of the can was the most important factor contributing to the poor appearance. Rancid odors were generally detected in product's surface areas. The blanched samples showed a tendency to shrink and to become shriveled. The results of the general observations made after various storage periods are presented in table 1.

There were variations in the drip values between the individual samples of as much as 30 percent. This variation was caused mostly by the differences in the amount of excess liquid in the cans at the time of packing; however, variation in the size of the oysters and the number of oysters in the cans also contributed to the

Table 1 - Results of General Observations of Frozen Pacific Oysters Stored at 0° F.

Oyster Treatment	Observations								
	After 4 Months of Storage			After 8 Months of Storage			After 13 Months of Storage		
	Acceptability[1]	Odor	Surface Color[2]	Acceptability[1]	Odor	Surface Color[2]	Acceptability[1]	Odor	Surface Color[2]
Raw									
Control	Good	Normal	Normal	Fair	Very slightly rancid	Yellow	Fair	Slightly rancid	Yellow
Oxygen in headspace of can.	Good	Normal	Normal	Poor	Very slightly rancid	Yellow-green	Unacceptable	Rancid	Yellow
Nitrogen in headspace of can	Good	Normal	Normal	Poor	Very slightly rancid	Dark yellow	Poor	Very slightly rancid	Yellow
Dipped 30 seconds in U.S.P. propylene glycol	Good	Normal	Normal	Poor	Very slightly rancid	Yellow-green	Poor	Slightly rancid	Yellow
Dipped 30 seconds in anti-oxidant mixture	Good	Normal	Normal	Fair	Normal	Red-brown	Fair	Slightly rancid	Yellow-brown
Dipped 30 seconds in ascorbic acid–citric acid mixture	Fair[3]	Normal	Normal	Poor[3]	Very slightly rancid	Yellow-green	Poor[3]	Slightly rancid	Yellow-brown
Blanched									
Control	Fair	Normal	Slightly yellow	Poor	Slightly rancid	Yellow-green	Unacceptable	Rancid	Yellow-green
Oxygen in headspace of can.	Good	Normal	Normal	Poor	Slightly rancid	Gray	Unacceptable	Rancid	Yellow
Nitrogen in headspace of can	Good	Normal	Normal	Poor	Very slightly rancid	Yellow-green	Poor	Slightly rancid	Yellow
Dipped 30 seconds in anti-oxidant mixture	Good	Normal	Normal	Fair	Slightly rancid	Yellow	Fair	Slightly rancid	Yellow-brown
Dipped 30 seconds in ascorbic acid--citric acid mixture	Fair[3]	Normal	Normal	Poor[3]	Slightly rancid	Yellow-green	Poor[3]	Very slightly grassy	Yellow

1/ ACCEPTABILITY NOT BASED ON FLAVOR OF ANY OF THE SAMPLES.
2/ SURFACE COLOR--THE COLOR OF THE OYSTER SURFACE EXPOSED TO THE HEADSPACE OF THE CAN.
3/ RATING DOWN-GRADED BECAUSE OF WHITE APPEARANCE OF FREE LIQUID.

drip variation. The expressible drip values were more consistent than the free drip values because the excess liquid was removed before expressible drip was measured. There were no significant differences either between the individual drip values of the raw samples or between the individual drip values of the blanched samples. However, the average values of both groups increased with storage time. The average drip values are presented in table 2.

Table 2 - Results of Drip Measurements on Raw and Blanched Pacific Oysters

Item	Product	Storage Period, Months at 0° F.						
		0	2	4	6	8	10	13
Percent free drip[1]	Raw[3]	4.9	7.1	8.0	8.7	9.8	11.9	9.0
	Blanched[4]	14.1	13.9	15.6	16.1	15.4	13.3	13.5
Percent expressible drip[2]	Raw[3]	5.8	7.5	8.9	9.9	9.4	11.5	11.3
	Blanched[4]	8.3	8.0	11.6	11.6	11.1	15.7	15.1

1/ PERCENTAGE OF FREE DRIP--PERCENTAGE WEIGHT OF LIQUID LOST DURING EXACTLY TWO MINUTES OF DRAINING ON A STANDARD NO. 4 BRASS SCREEN.
2/ PERCENTAGE OF EXPRESSIBLE DRIP--PERCENTAGE WEIGHT OF LIQUID LOST DURING EXACTLY TWO MINUTES OF COMPRESSION BETWEEN TWO LAYERS OF PLASTIC SPONGES UNDER A FORCE OF 2,560 GRAMS. DETERMINED AFTER FREE DRIP HAD BEEN REMOVED.
3/ AVERAGE OF 6 VALUES.
4/ AVERAGE OF 5 VALUES.

The pH values of all of the samples varied from 6.0 to 6.4 except for the samples treated with a mixture of ascorbic and citric acids. The pH values of these samples varied from 5.8 to 5.9. No reproducible change in pH occurred during storage.

There were some differences in the flavors of the stews noted by the investigators. The stews made with antioxidant-treated samples did not have the rancid flavor noted in some of the stews made with the control and the oxygen-treated samples. Propylene glycol, the solvent used in the application of Tappel's mixture, gave the stew a bitter unpleasant off-flavor. This flavor was not detected when the oysters were rinsed with water before the stew was prepared.

The taste panel members were found to be somewhat erratic in their judgment of the various samples. The average scores received by the treated samples were not very different from the scores received by the control sample through the 11-

month examination. At the 13-month examination, samples treated with ascorbic-citric acids, Tappel's mixture, nitrogen, and nitrogen-blanched received average flavor scores (8.2-8.3) that were considerably higher than those given the control samples (average 6.8). Because no consistent or significant differences between the control samples and the experimental samples had been noted in previous examinations, the findings at the 13-month examination can be considered as an indication only.

CONCLUSIONS

The storage life of freshly shucked Pacific oysters, frozen in hermetically-sealed containers and stored at 0° F., appears to be approximately 8 months. The antioxidants tested appear to have at least a limited effect in retarding oxidative changes in Pacific oysters frozen in sealed cans. Replacing the air in the headspace of the can with nitrogen or with oxygen had very little effect on the rate at which the samples deteriorated. Nitrogen slowed the rate slightly, whereas oxygen increased it slightly.

There are several important factors which should be considered before antioxidants are used. First, antioxidants are of little or no value if the quality of the oyster is poor at the time of freezing. Second, proper care and handling are more important in obtaining a good frozen oyster than antioxidant treatment. Third, the carrier used in applying the antioxidant must be carefully chosen. It must not have a flavor which would be detectable in the oyster product and it must be acceptable to the Food and Drug Administration.

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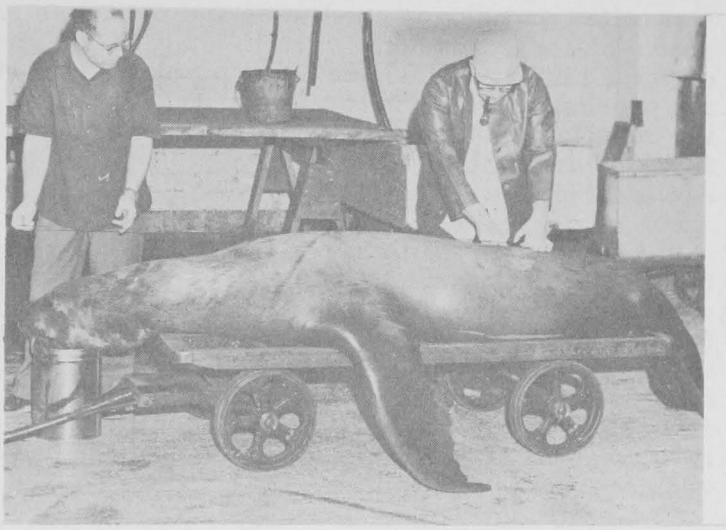
CHEMICAL COMPOSITION VARIES FOR DIFFERENT PARTS OF FISH

Information about the complex composition of fish is needed for such fields as nutrition, processing, and use of waste materials. This knowledge has been sought for many years, but a great deal remains to be learned as to the composition of over 200 edible species of fish and shellfish marketed in the United States. The technological laboratories of the United States Fish and Wildlife Service have under way a continuing project to analyze chemically salt-water and fresh-water fish as samples become available. Recently, at the Seattle laboratory, determinations have been made to compare the composition of different parts of fish meat. Twelve species of fish, caught commercially along the Pacific Coast, were carefully cleaned and the following portions were separated: light meat, dark meat, belly flap, dorsal (strip along back of fish), and waste. A number of interesting results were obtained from these analyses. Oil distribution in the meat, in order of decreasing amounts, was in the dorsal, dark meat, belly flap, and light meat. Dorsal meat from several species contained 11 times more oil than light meat from the same species. Light meat, however, had the highest protein content and dorsal meat the lowest, even lower than the waste material.

COMMERCIAL USE OF ALASKA SEA LIONS STUDIED

Studies of a possible commercial use for the Alaska sea lion, under way at the United States Fish and Wildlife Service Technological Laboratory at Ketchikan, Alaska, have shown that the sea lion may be processed into meal without alteration of the reduction equipment. This large marine animal (weighing up to 2,200 pounds), which is classed as a predator by most commercial fishermen, has potential value as animal food and as raw material for reduction to meal and oil. The present phase of the Laboratory's investigation is concerned with the most likely commercial application, that is, to reduce the animal to meal and oil in existing Alaska reduction plants.



TAKING MEASUREMENTS OF 800-POUND MALE SEA LION.

Laboratory experiments were recently completed whereby a whole sea lion, without viscera, was reduced to meal and oil. These experiments indicated that the only necessary additional piece of equipment would be a suitable grinder to prepare the carcass for reduction in existing equipment. The laboratory-produced meal will be assayed for its value as a protein source by chick-feeding tests.

In past investigations, parts of sea lion such as the liver, viscera, meat, and bone were reduced to separate meals. Protein evaluation of these meals by chick-feeding tests indicated that the liver meal was exceptionally good, meat meal and viscera meal were fair, and bone meal was poor. Proximate analyses have indicated that the hide is a good protein source. It is believed that the carcass meal, recently produced, should be of considerable value for chick feeding.

NOTE: SEE COMMERCIAL FISHERIES REVIEW, JANUARY 1957, P. 5.

STUDY OF DRY SOLIDS, SALT, AND FREE LIQUOR RELATIONSHIPS IN OYSTERS

Collection of samples for studies on the relationships between free liquor, salt, and dry solids of oysters, being conducted by the Service's Fishery Technological Laboratory, College Park, Md., was half completed when the Chesapeake season closed during the last week in March. The collection of samples was started in February. The work has been suspended until the new season begins in September. The three factors mentioned are used to test the degree of loss of liquid from the oyster after processing.

Liquor loss appears to differ in oysters taken from different beds, from one week to the next and from one season to another. Other factors apparently affecting liquor loss from oysters appear to be sex, climatic conditions, degree of cultivation of the oyster, and possibly many others. The data thus far obtained for 44 samples of oysters have shown markedly that the problem of determining the ultimate cause or causes of liquor loss is extremely complex.

TECHNICAL NOTE NO. 38 - A PORTABLE FISH-MEAL BLENDER FOR PILOT-PLANT USE

A portable fish-meal blender was constructed recently by the Seattle Technological Laboratory in order to simplify the mixing and sampling of experimentally-produced meals in quantities up to 200 pounds. The experimental meals, prepared under rigidly controlled processing conditions and from fish of known history, are being used to study the effects of prior history of the raw material as well as of the processing conditions on the nutritive values of the resultant meals. The research is supported by funds made available by the Saltonstall-Kennedy Act of 1954.

FIG. 1 - THE PORTABLE FISH-MEAL BLENDER, SHOWING THE SLIDE AT THE BASE FOR REMOVAL OF THE MEAL AFTER MIXING.

As shown in the illustrations (figs. 1, 2, and 3), the vertical worm-type blender, used in some commercial units on a larger scale, was adapted for laboratory purposes. The unique features of the modified blender design are the use of a light, strong, funnel-shaped hopper mounted on a wheeled base for portability and a gearhead motor drive located at the base of the unit for safety and convenience of access to the hopper.

Meal, when placed into the hopper for blending, is conveyed from the bottom of the hopper upward to the surface of the meal where the rotating worm throws it tangentially against the sloping sides of the hopper. A cavity is created, at the bottom of the hopper in the neighborhood of the screw, which is continuously refilled by the movement of the meal downward along the sloping sides of the hopper. The blended material is removed through a sliding door at the base of the hopper. Laboratory tests in which a dye tracer was added to a 100-pound batch of meal showed that thorough mixing of all components in the meal required approximately 10 minutes.

FIG. 2 - A DOWNWARD VIEW OF THE MEAL BLENDER, SHOWING THE 6-INCH DIAMETER HELICAL WORM.

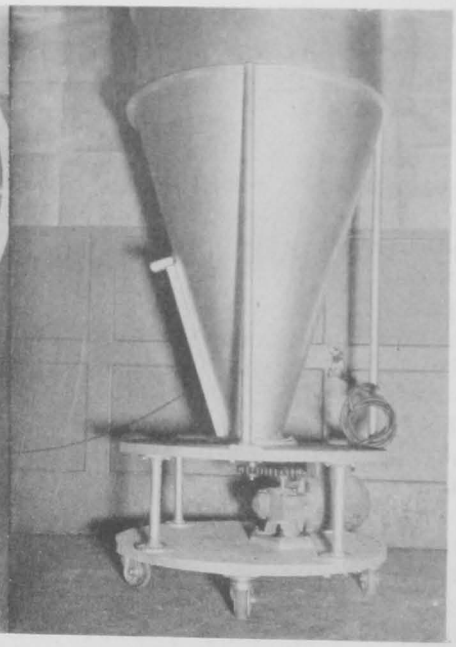
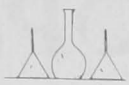


FIG. 3 - THE LOWER PART OF THE MEAL BLENDER, SHOWING THE $\frac{1}{2}$-HORSEPOWER GEARHEAD MOTOR DRIVE.

The blender consists of five main elements: (1) a funnel-shaped hopper 48 inches high with a 26-inch diameter at the top and tapering to a 6-inch diameter at the base; (2) a vertical helical worm 48 inches long and 6 inches in diameter; (3) two

shaft bearings consisting of a top radial bearing and a tapered roller bearing at the base; (4) a ½-horsepower gearhead motor drive; and (5) a double-decked caster-mounted dolly of 1-inch thick plywood to carry the assembly. The 12-inch space between decks on the dolly provide space for the gearhead motor which drives the vertical worm at 250 r.p.m. The unit is constructed to allow the use of a tight cover when desirable during the mixing period.



BOILED SALMON WITH EGG SAUCE

Salmon are caught in both the North Atlantic and North Pacific Oceans, and in certain fresh water streams entering these oceans.

The meat is fine in texture, yet firm and moist. It varies in color from almost white to bright red. The protein content is substantial. Salmon also contain the important minerals and vitamins necessary for proper nutrition of the body.

Regardless of where you reside, the home economists of the United States Fish and Wildlife Service suggest that this summer you try this traditional New England menu which contains "Boiled Salmon with Egg Sauce," new potatoes, and peas.

BOILED SALMON WITH EGG SAUCE

2 POUNDS SALMON STEAKS OF FILLETS
2 QUARTS BOILING WATER
3 TABLESPOONS SALT
EGG SAUCE

Cut steaks into serving-size portions and place in a wire basket or on a plate. If a plate is used it should be tied in a piece of cheesecloth. (This will prevent the fish from breaking up and facilitates removal when cooked.) Lower the fish into the salted boiling water and simmer about 10 minutes or until it flakes easily when tested with a fork. Remove fish carefully to a hot platter. Cover with egg sauce. Serves 6.

EGG SAUCE

2 TABLESPOONS BUTTER OR MARGARINE
2 TABLESPOONS FLOUR
½ TEASPOON SALT
DASH PEPPER
1 CUP MILK
3 HARD-COOKED, EGGS, CHOPPED

Melt butter; blend in flour seasonings. Add milk gradually and cook until thick and smooth, stirring constantly. Add eggs; heat. Serves 6.