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FREEZING FISH AT SEA--NEW ENGLAND

Part 1 - Preliminary Experiments[1/]

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ABSTRACT

FILLETS FROM ROUND-FROZEN THAWED FISH ARE COMPARED WITH FILLETS FROM ICED FISH AS TO PERCENT DRIP, SALT CONTENT, TRIMETHYLAMINE CONTENT, KEEPING QUALITY, AND YIELD.

INTRODUCTION

Freezing fish at sea as a means of preserving freshness throughout extended trawler voyages necessitated by the apparent scarcity of certain species of fish and the consequent greater effort and time required to bring in a payload has aroused considerable interest in the fishery industries of New England. In view of this interest, experimental freezing studies were initiated by the U. S. Fish and Wildlife Service during the latter months of 1948 aboard the Albatross III in conjunction with survey studies of the major fishing grounds off the New England coast. (The Albatross III was a research vessel of the Service's North Atlantic fishery biological investigations). The development of more successful methods of fish preservation aboard vessels other than icing is of extreme importance in view of the wide variance in quality of fish brought into port and the subsequent losses resulting from the less desirable fish. Freezing fish at sea is not entirely a new procedure and is practiced in some areas with success, particularly on West Coast species such as tuna.

Preserving fish aboard vessels by freezing for later defrosting, processing, and refreezing ashore is contrary to the rather widespread popular belief that once fish is frozen it should never be refrozen. It is believed that the ability of fish flesh to withstand the process of freezing, thawing, and subsequent refreezing is in large measure governed by the condition or freshness of the fish at the time of the initial freezing.

Pottinger et al (1949) in determining the effect of refreezing on quality of sea trout (Cynoscion regalis) fillets concluded that immediate freezing, with subsequent thawing, filleting, and refreezing of the fillets causes no marked adverse effect on quality over fillets prepared from freshly-caught iced fish.

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1/ ORIGINAL PAPER PRESENTED AT THE ELEVENTH ANNUAL MEETING OF THE INSTITUTE OF FOOD TECHNOLOGISTS, NEW YORK, N. Y., JUNE 19, 1951, UNDER THE TITLE "STUDIES ON ROUND FISH FROZEN AT SEA, NEW ENGLAND SPECIES." ALSO APPEARED IN FOOD TECHNOLOGY, VOL. 5, NO. 12 (DECEMBER 1951), PP. 492-5.

EXPERIMENTAL PROCEDURES

The fish used in the studies reported herein were taken in the census trawls of the Albatross III. They included haddock (Melanogrammus aeglefinus), pollock (Pollachius virens), ocean perch (Sebastodes marinus), cod (Gadus morrhua) and hake (Urophycis tenuis). Quantities of fish caught in the census trawls were much smaller than usual commercial catches, consequently each lot of fish studied weighed only 100 to 150 pounds. All samples of fish were prepared for freezing or icing within two hours after being brought on deck.

Samples of fish for freezing were "in the round" (not eviscerated). The fish were washed in circulating sea water prior to freezing. Freezing was accomplished in a multi-coil still-air room capable of maintaining -20° F. (-29° C.) with the temperature rising to no higher than -10° F. (-23° C.) with a full load. The fish were laid flat on galvanized iron pans spread nine inches apart in the lower two-thirds of the freezer room for as effective use as possible of thermal currents. The fish were allowed to freeze solid and were not removed from the pans until after eight hours in the freezer.

After freezing, the fish were stored in boxes at 0° F. (-18° C.) for the remainder of the voyage. Since the trips were of relatively short duration (5 to 10 days), glazing of the fish previous to storage was not considered necessary. For comparison, similar species of fish of the same size and lot were stored in ice. These fish were eviscerated and washed previous to storage in ice. Since relatively small quantities of fish were caught, those fish stored in ice were not subjected to as much pressure in the pens as fish handled under commercial conditions.

Upon arrival at port, fish frozen in the round were thawed in circulating chlorinated (5 p.p.m. residual chlorine) sea water at 50° to 55° F. (10° to 13° C.) for approximately three hours. Thereafter, the round fish and iced fish were handled in accordance with existing commercial practice for filleting and brining.[2/]

The fillets were wrapped individually in cellophane, placed in five-pound waxed cartons and frozen in a multiplate freezer at -30° F. (-34° C.). After freezing, the packaged fillets were placed in master cartons for storage at 0° F. Samples were withdrawn for examination at monthly intervals.

A series of physical, chemical, and organoleptic tests were used to detect differences that might exist between fillets prepared from frozen-round-thawed and iced fish.

DISCUSSION OF PROCEDURES AND RESULTS

Yield of Fillets: During the course of filleting operations, records were kept of the percentage yield of fillets from the frozen-round-thawed fish and iced fish. The thawed round fish were not gutted prior to filleting. In order to place fillet yields on a comparable basis, 15 percent of the total round weight was allowed as the weight of the viscera. This figure is generally used throughout the industry as the average allowance for viscera of the various New England species. Actual weight of viscera from several hundred pounds of fish of different species, in later work, ranged from 11 to 22 percent. The liver portion of the viscera ranged from 1.3 to 3.1 percent of the round-fish weight or 12 to 32 percent of the viscera weight.

2/ GRATEFUL ACKNOWLEDGMENT IS MADE TO THE GENERAL SEAFOODS CORPORATION, BOSTON, MASSACHUSETTS, FOR COOPERATION IN THIS PART OF THE STUDY.

Inasmuch as the experimentally iced-dressed fish, used in this study, were not subjected to the same rigorous conditions of handling as commercially-iced fish, fillet yield data for commercially-iced fish were secured from seven processing plants in New England for further comparison. The yield data on commercially-iced fish are considered authentic since they were furnished by reliable firms normally processing an aggregate total of several million pounds of fillets annually. Fillet-yield data for frozen-round-thawed, experimentally-iced dressed, and commercially-iced dressed fish are shown in table 1.

Table 1 - Yield of Fillets from Round-Frozen-Thawed, Experimentally-Iced, and Commercially-Iced Fish

Species and Market Class	Type of Fillet	Fillet Yield		
		Round-Frozen-Thawed[1]	Experimentally Iced	Commercially Iced[2]
		Percent	Percent	Percent
Pollock, large	skin on	48.1	-	40-44
Pollock	skin on	47.5	47.1	32-42
Pollock, market	skin on, nape on	55.1	53.6	48-51
Ocean perch (rosefish)	skin on	28.3[3]	-	25-28
Cod, whale	skinless	48.5	44.4	35-40
Hake, market	skinless	50.7	48.1	42-43.5

1/ CONVERTED TO ICED-FISH BASIS ALLOWING 15 PERCENT FOR VISCERA.
2/ RANGE OF FILLET YIELDS FROM SEVEN NEW ENGLAND PLANTS.
3/ ALLOWANCE FOR VISCERA NOT MADE SINCE OCEAN PERCH ARE NOT EVISCERATED COMMERCIALLY.

It was observed that fish frozen in the round appeared to retain the physical characteristics of fish in rigor mortis after thawing; also, the experimentally-iced fish appeared somewhat firmer than most commercially-iced fish. It is well known in the industry that the yield of fillets from firm fish (freshly caught) is greater than that from fish iced for seven or eight days.

Trimethylamine (TMA) Content of Round-Frozen-Thawed and Experimentally-Iced Fish: The trimethylamine (TMA) content of fillets from round-frozen-thawed and iced-dressed fish was determined at monthly intervals over a period of seven months of commercial cold storage (0° F.). The method outlined by Dyer (1945) was used. It is recognized that the trimethylamine test is primarily used to estimate the freshness of fish prior to processing into frozen fishery products or for sale as fresh-chilled fishery products. Since the frozen fish fillets prepared in this study were stored in commercial cold storage, it was believed desirable to test for this component throughout the entire cold-storage period as a check on the possibility of the fillets defrosting during storage.

The TMA content of packaged fillets, prepared from various species of round-frozen-thawed, experimentally iced-dressed, and commercially iced-dressed fish after commercial cold storage for periods up to seven months is shown in table 2.

The TMA values of round-frozen-thawed fillets of all species of fish studied were lower than those of fillets prepared from experimentally-iced or commercially-iced fish. In the case of haddock, all values were low and the differences not too significant. Low values for the experimentally-iced haddock may possibly be accounted for by the difference in age of the fish (6 days) over iced fish of the other species (10 days).

TMA values of fillets prepared from experimentally-iced fish were from two to five times greater than the values of fillets from round-frozen-thawed fish, depend-

ing on species. The "fishy" odor was particularly noticeable in the fillets of hake, pollock, and ocean perch prepared from iced fish. Fillets from round-frozen-thawed fish retained their fresh fish odor throughout the storage period. Fillets prepared from round-frozen-thawed hake had TMA values somewhat higher than others; however, the odor was that of good fresh fish.

Table 2 - Trimethylamine (TMA) Content of Frozen Fillets Prepared from Various Species of Round-Frozen-Thawed, Experimentally-Iced, and Commercially-Iced Fish

Species	Treatment Prior to Filleting	Trimethylamine in mg. per 100 g. of Fillet: Months in Commercial Cold Storage (0° F.) 1	2	3	4	5	6	7	Mean TMA Value for 7 Months Storage Period
Haddock	Round-frozen-thawed	0.5	0.5	0.5	0.3	0.4	0.2	0.2	0.4
	Bled, round-frozen-thawed	0.5	0.5	0.5	0.3	0.4	0.2	0.3	0.4
	Experimentally iced for 6 days	0.8	0.9	0.9	0.4	0.8	0.4	0.6	0.7
Cod	Round-frozen-thawed	0.5	0.4	0.8	1.4	1.4	1.3	0.8	0.9
	Experimentally iced for 10 days	5.9	4.3	2.2	4.4	4.6	4.9	4.9	4.5
Pollock	Round-frozen-thawed	1.1	2.8	1.3	1.3	1.1	1.1	-	1.5
	Experimentally iced for 10 days	11.7	5.9	7.0	9.6	5.6	6.6	-	7.7
Hake	Round-frozen-thawed	2.6	6.6	4.3	2.4	2.2	2.8	3.0	3.4
	Experimentally iced for 10 days	10.0	8.7	17.2	8.8	11.2	6.9	5.6	9.8
Ocean Perch (rosefish)	Round-frozen-thawed	0.3	0.3	0.2	0.0	0.1	-	-	0.2
	Commercially iced for 10 days	6.8	7.0	6.9	3.5	2.2	-	-	5.3

Free Drip: Drip measurements were made at monthly intervals on thawed samples of frozen fillets from round-frozen-thawed, experimentally-iced, and commercially-iced fish of the various species under test. Fillets were thawed for a period of three hours at room temperature on a $\frac{1}{2}$-inch mesh wire screen enclosed in an air-tight rectangular metal container. A tightly covered container was used in order to reduce drying by the warm room air. Differences in weight between the frozen and thawed samples were noted and calculated as the free-moisture loss or drip.

As will be seen from table 3, there is a tendency for the drip of fillets prepared from experimentally-iced and commercially-iced fish to be slightly higher over a 7-month storage period than the drip of fillets prepared from fish frozen in the round. In later experiments it is planned to determine the amount of expressible or press drip present in addition to the free drip for further information on this point.

It was noted after 5 to 6 months of cold storage that some of the fillet samples showed signs of desiccation. This may account in part for the variance in drip values for some of the fillets under study.

Organoleptic Tests: Throughout the storage period fillets prepared from the various species of fish under study were judged at monthly intervals for differences in appearance and taste by a qualified taste panel composed of members from the laboratory and selected experts from the industry. The appearance of the thawed and cooked fillets was considered in terms of color, firmness, and "wetness," and taste was evaluated by the flavor and texture characteristics of the samples.

In all instances throughout the period of the test, the raw fillets from round-frozen-thawed fish were judged to be more acceptable from the standpoint of being

Table 3 - Free Drip of Frozen Fillets Prepared from Round-Frozen-Thawed, Experimentally-Iced, and Commercially-Iced Fish

Species	Treatment on Vessel	Percent Drip: Months in Commercial Storage at 0° F. 1	2	3	4	5	6	7	Mean Value for 7 Months Storage Period
Haddock	Round-frozen	0.2	1.1	0.8	1.8	2.2	1.6	1.1	1.3
	Bled, round-frozen	0.2	1.1	0.9	0.6	1.3	1.0	1.1	0.9
	Experimentally gutted, iced for 6 days	0.6	1.2	1.3	1.4	1.8	1.7	1.3	1.3
Ocean Perch (rosefish)	Round-frozen	0.3	0.7	0.6	1.8	1.8	-	-	1.0
	Commercially iced for 10 days	0.9	1.3	1.1	2.0	3.7	-	-	1.8
Cod	Round-frozen	0.4	0.6	1.2	2.4	2.1	1.0	2.0	1.4
	Experimentally gutted, iced for 10 days	1.1	1.1	1.5	1.5	2.2	1.9	3.1	1.8
Hake	Round-frozen	1.3	0.9	3.5	1.7	1.1	0.8	1.6	1.5
	Experimentally gutted, headed, and iced for 10 days	2.1	1.8	3.4	2.2	1.8	1.4	4.0	2.4
Pollock	Round-frozen	0.6	1.2	1.8	2.7	1.1	1.9	-	1.5
	Experimentally gutted, gilled, and iced for 10 days	1.0	1.1	1.4	1.6	1.5	2.1	-	1.5

fresh; also, the cooked fillets had a "sea-salt" flavor without the undesirable fishy aftertaste associated with fillets from iced fish.

The firm texture of the raw fillets from fish frozen at sea in contrast to the sometimes mushy texture of fillets prepared from iced fish was also considered a significant difference. The color of the fillets from fish frozen in the round remained "bright and life-like" whereas fillets prepared from experimentally and commercially iced fish were dull and bleached out. Additional work on differences in color, taste, and texture under carefully controlled conditions is planned in order to further develop the findings of this preliminary study.

Bleeding Fish Prior to Freezing: Blood in the round fish frozen at sea had been considered as a possible factor in discoloring fillets after thawing. Accordingly, a sample lot of scrod haddock was bled prior to freezing. Fillets prepared from this sample appeared no different than the fillets prepared from unbled haddock frozen in the round. Although this observation indicates that blood may not be a factor of importance in the coloration of fish fillets prepared from unbled round frozen fish, additional experiments are planned on the relationship of bleeding to storage life and palatability of fish fillets. It is probable that fish which have been iced have lost color because of the pressure and bleaching action of the ice when in storage aboard the vessels.

Salt Content of Fillets: In view of the "sea-salt" flavor noted in fillets prepared from round-frozen-thawed fish, a series of salt determinations (table 4) according to A.O.A.C. methods for fish were carried out on the fillets under study. The salt content (chloride expressed as NaCl) of fillets prepared from fish frozen in the round was greater than that of fillets from experimentally-iced and commercially-iced fish. Since all samples of fillets were brined in identical solutions for the same period of time when being prepared, it is conceivable that the lower salt content of iced fish is due in part to the leaching out of the salt in the

flesh by melting ice. There is also the possibility that the flesh of fish frozen in the round absorbed more brine than the flesh of fish iced. The higher salt content was not considered objectionable from the flavor standpoint.

Table 4 - Salt Content of Fillets Prepared from Round-Frozen-Thawed Experimentally-Iced, and Commercially-Iced Fish

Species of Fish	Treatment of fish on vessel	Chlorides, as sodium chloride in percent (Fish stored for 4 mos. in commercial storage—0° F.)
Haddock	Round-frozen	0.84
	Bled, round-frozen	1.09
	Experimentally gutted, and iced for 6 days.	0.78
Ocean Perch (Rosefish)	Round-frozen	0.71
	Commercially iced-round and iced for 10 days.	0.54
Cod	Round-frozen	0.61
	Experimentally gutted and iced for 10 days.	0.57
Hake	Round-frozen	0.74
	Experimentally gutted, headed and iced for 10 days.	0.50
Pollock	Round-frozen	0.78
	Experimentally gutted, gilled and iced for 10 days.	0.44

Effect of Prolonged Commercial Storage of Round Frozen Fish Prior to Thawing, Filleting, and Refreezing: It is well known that fish held in commercial cold storage 0° F. (-18° C.) for prolonged periods undergo certain physical changes that result in toughening of the flesh and increased moisture losses (drip) on thawing. In view of this it was felt that consideration be given to the length of time fish frozen in the round could be safely held at commercial storage temperatures, prior to defrosting and filleting, before adverse physical changes occurred in the refrozen fillet on further storage. Accordingly, samples of haddock and ocean perch were frozen in the round at sea, glazed, and stored at 0° F. for 10 weeks before thawing, filleting, and refreezing. Fillets from these round-frozen-thawed fish were packaged as described earlier and were compared with fillets prepared from haddock and ocean perch iced for 10 days after intervals of 1, 4, and 5 months in commercial cold storage.

The TMA content and free drip of the samples under test appear in table 5. It will be noted that the TMA values for haddock fillets prepared from round-frozen fish stored for 10 days and 10 weeks are extremely low and vary but little. This is also true for fillets prepared from experimentally-iced haddock kept in ice for six days. Likewise the TMA content of ocean perch fillets was low for fish stored for similar periods prior to thawing, filleting, and refreezing. It was noted that the flavor characteristics of the fillets under test were not altered.

The free drip of fillets prepared from ten-weeks old round-frozen-thawed fish increased significantly over that from fillets prepared from ten-day old frozen fish. For this reason, at least, fish frozen in the round should not be held for excessive periods in cold storage prior to thawing and filleting.

The limited data indicate that prolonged storage of round-frozen fish has an effect on the physical characteristics of the refrozen fillets, and commercial cold storage of the round fish should, therefore, be limited to a period not exceeding ten weeks prior to thawing and filleting.

CONCLUSION

These studies in general indicate that frozen fillets prepared from round-frozen-thawed fish are as good as or better in quality than fillets prepared from experimentally-iced and, in the case of ocean perch, commercially-iced fish. Larger-scale experiments to test commercial application of freezing round fish at sea are planned.

Table 5 - Trimethylamine Content and Free Drip of Stored Frozen Fillets Prepared From Round-Frozen-Thawed Fish after Ten Days and Ten Weeks Commercial Cold Storage as Compared to Fillets from Iced Fish

Species	Treatment	TMA, mg./100 g. Months in Storage at 0° F.			Drip (Percent) Months in Storage at 0° F.		
		1	4	5	1	4	5
Haddock	Round-frozen, stored 10 days, defrosted, filleted.....	0.5	0.3	0.4	0.2	1.8	2.2
	Round-frozen, stored 10 weeks, defrosted, filleted.....	0.3	0.2	0.1	2.3	5.2	4.1
	Experimentally iced, 6 days, filleted.....	0.8	0.4	0.8	0.6	1.4	1.8
Ocean Perch (Rosefish)	Round-frozen, stored 10 days, defrosted, filleted.....	0.3	0.0	0.1	0.3	1.8	1.8
	Round-frozen, stored 10 weeks, defrosted, filleted.....	0.1	0.1	0.2	2.3	3.6	3.3
	Commercially iced, 10 days, filleted.....	6.8	3.5	2.2	0.9	2.0	3.7

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