PACKAGING FROZEN FISH IN TIN RESULTS IN SUPERIOR STORAGE LIFE

SUMMARY

Laboratory tests on 19 species of fish have shown that fish frozen and stored in evacuated tin cans keep far better than in any conventional packaging material. The original flavor is retained, and adverse alteration in color and flavor is almost eliminated. Certain health hazards based on the possibility of the user storing the product at room temperature have in the past prevented adoption of such a method. With the consumer becoming accustomed to purchasing frozen fruit juices, certain fruits, and frozen soups in tin containers, this difficulty may no longer exist. Certain production problems will have to be worked out before such a method can be adopted for commercial use.

BACKGROUND

Many of the adverse changes which develop during prolonged cold storage of frozen fish can be completely eliminated or greatly retarded by packaging the frozen product in evacuated hermetically-sealed tin cans. Much of the deterioration of frozen fish in cold storage is brought about by the action of oxygen. This oxygen may be present when the fish is packaged or may seep through the packaging material during cold storage. Packaging materials made of paper or fiberboard cannot withstand a vacuum; hence, considerable air and oxygen must be left in contact with the product within the package. Most all such materials, while resisting any large transfer of oxygen, permit slow seepage over a period of months such that as fast as the oxygen reacts with the fish more enters from the outside, providing a relatively constant atmosphere to continue the deleterious reactions taking place. Tin cans can be evacuated to remove most all of the air, and no more can ever enter the can after the lid is fastened in place.

EFFECT OF OXYGEN ON COLOR AND FLAVOR OF FISH

Oxygen combines with the fish in several ways to produce undesirable changes. The first such change generally noticed is the disappearance of the natural flavor of the fish resulting in a tasteless product. The natural flavor constituents become oxidized giving rise to a loss of flavor. This change occurs early in the storage of fish so that a very great part of the frozen fish reaching the consumer has already lost a part or nearly all of its natural flavor and may be relatively tasteless although still entirely edible. This loss of flavor occurs so gradually that the deterioration often goes unnoted. Indeed, many persons to whom fresh fish is unavailable are unfamiliar with the flavorful taste of really fresh fish and are under the impression that a flat tasteless product is the natural original condition of most species.

Long after disappearance of most of the natural flavor constituents of fish held in cold storage, certain off-flavors and odors, which are described as rancid, make their appearance. These are caused by oxidation of the fish oils. When rancidity has proceeded only a short way, the fish become of borderline acceptability and shortly thereafter are completely unmarketable.

Simultaneously with changes in flavor occur alterations in the appearance of fish. These changes, caused by oxidation of the pigments, take place in a variety of ways, depending upon the species of fish involved. With some species (e.g. salmon) the natural color may fade. With other species a darkening or discoloration may occur. Changes in color, while perhaps not quite so serious as changes in flavor, detract from the general appearance and, in extreme cases, may render the product unsalable.

EFFECT OF VACUUM ON TEXTURE OF FROZEN FISH

Another type of change occurring during the holding of fish in cold storage is the development of a tough or rubbery texture. Toughening is especially noticeable in certain species of shellfish. Heerdt (1947) demonstrated (table 1) that vacuum

Table 1 - Tenderometer Values of Crab Meat as Affected by Container and Storage Time 1/

Container	Seal	Tenderometer Readings After Storage of Crab Meat at 5° F. For:								
		3 Months			6 Months			9 Months		
		Leg	Body	Avg.	Leg	Body	Avg.	Leg	Body	Avg.
MSAT cellophane 2/	-	28	22	25	31	32	31	44	32	38
Can	First operation roll 3/	27	21	23	23	28	25	37	34	35
Can	Vacuum	13	8	10	12	9	10	17	14	15

1/ Freshly-picked crab meat will yield tenderometer values varying from 10 to 16, depending upon cooking time and other conditions. Freezing and thawing may lower these readings to values varying from 7 to 13. Frozen storage causes a toughening that results in increasingly higher values.
2/MSAT = moistureproof-vaporproof, sealable by heat, anchored coating, transparent.
3/First operation roll securely attaches the lid to the can but does not give a hermetic seal.

packing in tin was very effective in delaying toughening in frozen dungeness crab meat. The development of toughness apparently is greatly retarded by storage of the product in the absence of air. Reasons for this effect are unknown.

SPOILAGE HAZARDS

Storage of frozen fish in completely hermetically-sealed containers (such as tin cans)--while reducing the alterations in flavor, appearance, and texture--presents certain disadvantages. The public has long associated fish packed in tin cans with a steam processed product which will keep indefinitely at room temperature. If fish frozen in tin containers were to be placed on the pantry shelf, spoilage would occur in a very short time, and with spoilage of certain types, gases might form within the can which might build up sufficient pressure to cause the can to explode. If botulinum organisms happened to be present under such conditions, toxins might form resulting in an exceedingly dangerous condition. On the other hand, the housewife is becoming accustomed to seeing frozen fruit juices, strawberries, peaches, etc., packaged in tin containers. Even some fishery products such as oysters and crab meat have been frozen and marketed in tin cans. Under these circumstances, it seems likely that if the fishery product were plainly marked "perishable--do not thaw until ready for use," the product would be handled properly.

LABORATORY RESULTS

For a period of more than 10 years the Seattle Laboratory of the U. S. Fish and Wildlife Service has been experimentally storing fish in evacuated hermetically-sealed tin cans. In the beginning these tests were not set up with the object of recommending that the fishing industry might consider packing fish commercially in this way. At the time these studies were initiated no other frozen foods were packed extensively in tin, and it was believed that such a proceeding would be impractical. Rather, the tests were set up as control samples for comparison with others packaged in cellophane or in other ways. These control samples in tin were found not to change or to change very little during the experiment. Hence they served to remind the experimenter as to the exact original condition of the samples.

Such tests, in which fish were packaged in evacuated tin cans, have been carried out with albacore tuna, silver smelt, Columbia River smelt, English sole, surf perch, Dolly Varden trout, steelhead trout, true cod, herring, pilchard, orange rockfish, sablefish, pink salmon, chum salmon, silver salmon, Pacific oysters, dungeness crab, king crab, and tanner crab. In each experiment the fishery product kept in cold storage in much better condition with respect to flavor, appearance, and, in some cases, texture than did a fishery product packaged or treated in any other way. Generally, there was no detectable change in appearance or flavor in the fishery product after nine months storage at 0° F. In these experiments the products were packed in half-pound C-enamel tins with 22 inches of vacuum applied at the seamer. Most cans, when tested after storage intervals of up to nine months, had at least 15 inches of vacuum.

In some instances the differences in keeping quality between the fish vacuum-packed in the cans and those packed in cellophane were most outstanding. One such example is that of pink salmon, a species which deteriorates in cold storage at such an exceedingly rapid rate that it has never been possible to market it in the frozen state.

Bucher (1944) found that pink salmon when steaked, wrapped in cellophane, frozen, and placed in storage became faded and very slightly rancid after only 7 weeks at 0° F. (table 2) and was discolored and decidedly rancid after 3 months at 0° F.

Table 2 - Effect of Method of Packing and of Time in Frozen Storage on Pink Salmon Steaks

Method of Packing	Condition of Pink Salmon Steaks After Storage at 0° F. For:			
	7 Weeks	3 Months	5 Months	9 Months
Cellophane-wrapped steaks packed in 5-pound fillet boxes.	Color fading--becoming yellow; very slightly rancid.	Definitely discolored; odor rancid; flavor rancid.	Appearance very bad; rancid.	Darkened; blood spots very brown; large amount of rusting; very rancid.
Steaks packed in vacuumized tin cans.	Perfect condition.	Appearance normal; flavor normal.	Appearance normal; flavor normal; texture normal.	No deterioration.

Similar steaks when packed in evacuated tin cans were still in good condition after 9 months at 0° F.

ADVANTAGES TO PACKING FROZEN FISH IN TIN CANS

Frozen fish stored in tin cans would be of immeasurable higher quality than those packaged in the ordinary way. If care were taken to see that only first class fresh fish were frozen, for the first time it would be possible for all consumers, no matter how far removed from the fish-producing centers, to purchase fish which retained its original sea-fresh flavor. It would no longer be necessary to offer for sale frozen fish having altered flavor or appearance.

Species hitherto not handled in the frozen state could be made available in the packaged frozen form. As an example of the possibilities along this line, pink salmon can be cited. This species before canning is a light red color but, upon canning, fades to a faint pink color. If frozen in tin cans, it would reach the consumer with a bright red color equal or very nearly equal in appearance to the canned more expensive varieties such as coho (medium red).

If frozen fish were to be packaged, before freezing, in tin cans, considerable labor in preparation and packaging would be saved, since high speed can-handling equipment could be used. It might even be possible to adapt existing fish-canning lines for the frozen product, merely by eliminating the salting stage and substituting the freezer for the retort. Such a product could be put up at a very low cost but would be quite different from what the public expects when a frozen fishery product is purchased. For example, salmon might be handled as for canning and then frozen instead of being retorted. Such a process, however, would result in a chunk of frozen fish containing the skin and backbone. This product might not be acceptable to the consumer although frozen salmon steaks containing skin and bones are marketed in consumer packages. In canned salmon the retorting or cooking process softens the bones so that they may be eaten along with the balance of the can contents.

DISADVANTAGES

In addition to the spoilage hazards from improper storage mentioned in a preceding section, certain production problems would occur. If the fish were packaged in round cans, such cans would be difficult to freeze in high-speed freezers of the plate type. Also frozen-food merchandisers sometimes object to handling round containers because they do not pack well in frozen-food cabinets with the usual square frozen-food cartons. The recent advent of frozen soups in round tin cans may be a step toward overcoming this objection.

If the fish were to be cut as fillets or steaks, a production problem in filling the cans would be created, since the usual mechanical fish can fillers could not be used.

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--M. E. Stansby, Chief,
Pacific Coast and Alaska Technological Research,
Fishery Technological Laboratory,
Branch of Commercial Fisheries,
U. S. Fish & Wildlife Service, Seattle, Wash.

STUDY OF PHARMACEUTICAL AND OTHER INDUSTRIAL PRODUCTS FROM SALMON EGGS

To further study the possible utilization of salmon cannery waste for industrial purposes, investigations are in progress on the enzymatic digestion of salmon eggs. Work to date has indicated that enzyme digestion is effective but that the digested mass putrefies under optimum conditions for action of the enzyme. This putrefaction may be prevented by the addition of aureomycin. The optimum level for addition has not been determined, however. When the digested egg mass is extracted with a solvent, an almost oil-free salmon-egg meal is produced. It is hoped that the oil-free egg meal may have possibilities as a fish-hatchery feed.

SULFIDE DISCOLORATION IN CANNED TUNA

Occasional lots of canned tuna may develop a dark discoloration caused by reaction in the can of hydrogen sulfide with iron to form black iron sulfide. A joint collaborative program between the Continental Can Company and the U. S. Fish and Wildlife Service is under way to find the reason why this occurs in some cases and not in others and to develop a method of minimizing its occurrence. In these studies at the Service's Seattle Fishery Technological Laboratory it has been noted that the black iron sulfide does not form until after the cans of fish have been removed from the cannery retort. It has been found that if the cans of tuna are retorted on trays and the cans are inverted between 5 and 20 minutes of their coming out of the retort, no discoloration takes place. This solution to the problem will work in the relatively few canneries which are equipped to retort on trays and can not be applied to the majority of canneries where jumbled lots of cans in cars are retorted except by rather drastic modification in facilities.

TECHNICAL NOTE NO. 32 - FREEZING RATES AND ENERGY REQUIREMENTS FOR FREEZING PACKAGED FISH FILLETS AND FISH STICKS IN A MULTIPLATE-COMPRESSION FREEZER

INTRODUCTION

The multiplate compression-type freezer is used quite extensively for the freezing of packaged fish fillets and fish sticks. Some advantages of this type of freezer are that (1) it is a compact unit requiring but a small amount of floor space; (2) it is easily loaded and unloaded; (3) it has a fast freezing rate; and (4) it yields uniformly-shaped packages.

Although the multiplate-type freezer has been used for a number of years, information pertaining to its freezing rates and efficiency for freezing various sized packages of fish fillets and fish sticks has not been readily available to fish processors and freezer operators. As a result packages of fish are often left in the freezer much longer than is necessary for complete freezing. This practice is not only uneconomical from the standpoint of power consumed, but it limits the daily capacity of the equipment. In other cases, the packages of fish are removed from the freezer before the meat has passed through the critical freezing temperature range of approximately 29° to 20° F., and the quality of the fish is accordingly decreased.

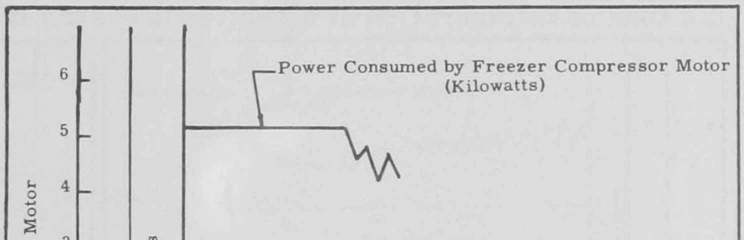

Fig. 1 - Freezing 187 pounds of 1-inch packaged pollock fillets in a multiplate compression freezer.

To provide data which would be of value to those engaged in the freezing of fishery products, representative tests on a multiplate-compression freezer were conducted by the U. S. Fish and Wildlife Service Fishery Technological Laboratory at East Boston, Mass.

OBJECTIVES

The objectives of the tests were as follows:

1. To determine (a) the freezing rates and (b) the electrical energy requirements for freezing full-freezer loads of pollock (Pollachius virens) fillets in packages of various thicknesses and of fish sticks in $1\frac{1}{2}$-inch-thick 10-ounce packages.

2. To determine the thickness of packaged pollock fillets which can be frozen the most economically.

3. To calculate from the results of the freezing determinations the total number of kilowatt-hours required to freeze 1,000 pounds of pollock fillets in packages of various thicknesses and of fish sticks in $1\frac{1}{2}$-inch-thick 10-ounce packages.

EXPERIMENTAL

DESCRIPTION OF FREEZER: A 6-station junior-model multiplate compression-type freezer designed to freeze about 200 pounds of 1-inch-thick packaged fish fillets within a period of 60 minutes was used in the various tests (fig. 5 and fig. 6). The refrigeration machinery consisted of a $7\frac{1}{2}$-hp. induction motor connected by means of 4 V-belts to a 4-cylinder freon-12 reciprocating compressor capable of producing 2.4 tons of refrigeration at a suction pressure of 0 pounds per square-inch gauge.

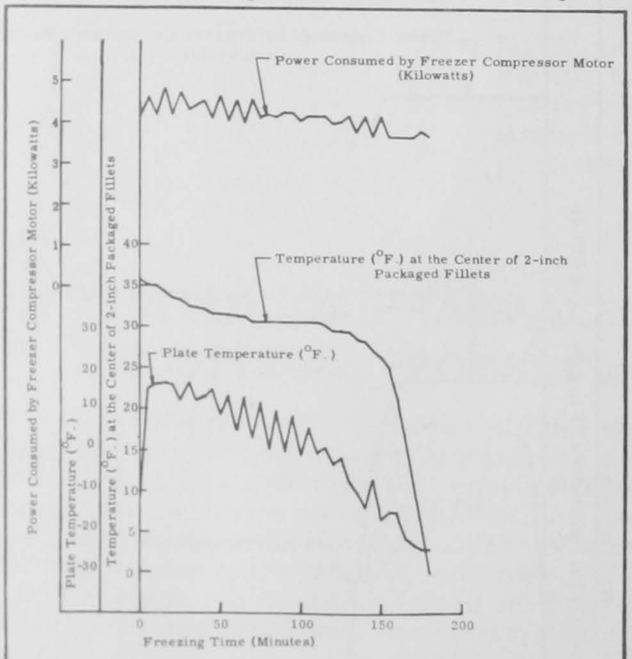

Fig. 2 - Freezing 360 pounds of 2-inch packaged pollock fillet in a multiplate compression freezer.

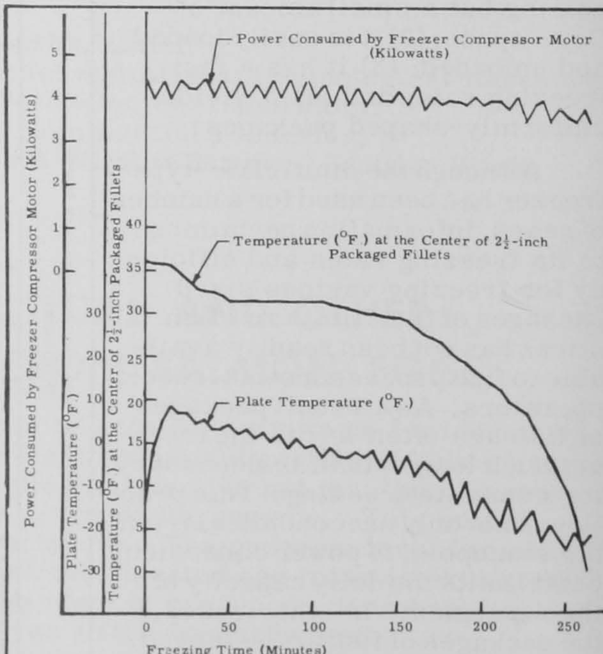

Fig. 3 - Freezing 420 pounds of $2\frac{1}{2}$-inch packaged pollock fillets in a multiplate compression freezer.

The freezer consisted of seven horizontal movable aluminum plates stacked vertically within an insulated cabinet. (See fig. 5 and fig. 6.) Expansion of the refrigerant through the plates furnished the low plate temperatures necessary for freezing.

MEASUREMENT OF TEMPERATURE AND ELECTRICAL POWER AND ENERGY: A multiple-station potentiometer with calibrated copper constantan thermocouples was used to measure the temperature of the plates and of the packaged fillets and fish sticks during the freezing process. An electric analyzer was used to measure the electrical power and energy requirements of the motor driving the compressor.

TEST SERIES: Four test series were carried out using full freezer loads of 1-, 2-, and $2\frac{1}{2}$-inch-thick packages of pollock fillets and of $1\frac{1}{2}$-inch-thick packages of fish sticks.

The 1-inch-thick package consisted of unwrapped fillets packed in a 1-pound commercial waxed chipboard box with no overwrap. The 2-inch-thick package and the $2\frac{1}{2}$-inch-thick package consisted of fillets individually wrapped in moisture-vaporproof cellophane and packed in 5-pound commercial waxed chipboard boxes with no overwrap. The $1\frac{1}{2}$-inch-thick fish-stick package consisted of breaded pre-cooked fish sticks, 2 layers deep, packed in a 10-ounce commercial waxed chip-board box with a microcrystalline wax overwrap.

Owing to the differences in the size of the packages, full freezer loads of the product being frozen varied in weight as follows:

a. 1-inch-thick pkgs. of fillets - 187 lbs.
b. 2-inch-thick pkgs. of fillets - 360 lbs.
c. $2\frac{1}{2}$-inch-thick pkgs. of fillets - 420 lbs.
d. $1\frac{1}{2}$-inch-thick pkgs. of fish sticks - 165 lbs.

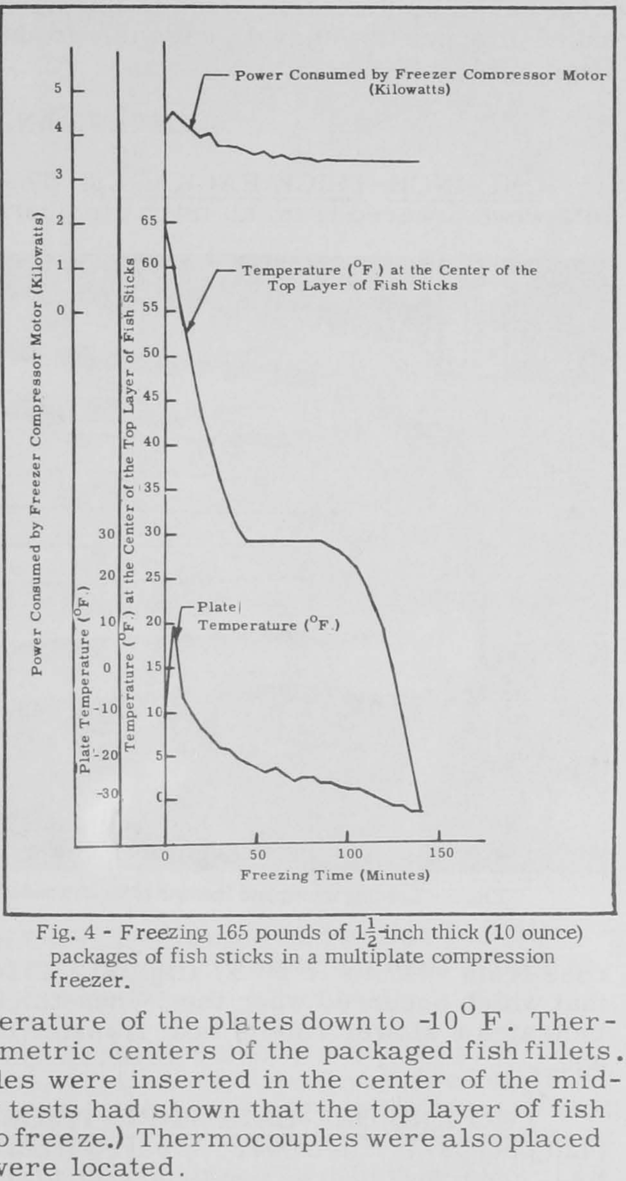

Fig. 4 - Freezing 165 pounds of $1\frac{1}{2}$-inch thick (10 ounce) packages of fish sticks in a multiplate compression freezer.

PROCEDURE: At the beginning of each test, prior to the loading of the unit, the freezer-compressor was operated for a period of time sufficient to bring the temperature of the plates down to -10° F. Thermocouples were then inserted into the geometric centers of the packaged fish fillets. In the case of fish sticks, the thermocouples were inserted in the center of the middle sticks of the top layers. (Preliminary tests had shown that the top layer of fish sticks was the last portion of the product to freeze.) Thermocouples were also placed on the plates where the various products were located.

The machine was loaded to its full capacity with the particular sample under test. Proper spacers were then inserted, and the plates were forced down in order

Table 1 - Data on Freezing Packaged Pollock[1/] Fillets and Fish Sticks in a Multiplate Compression-Type Freezer

Description of Samples: Packaged Product	Thickness of Package	Weight of Package		Weight of Product Frozen[2/]	T_1, Temp. of Product Before Freezing	T_2, Final Temp. of Frozen Product	Time Required to Lower Temp. of Product from T_1 to T_2	Energy Consumed by Freezer Compressor Motor in Cooling Product from T_1 to T_2	Product-Freezing Capacity of Unit in a 24-hr. Period (Calculated)[3/]		Energy Required to Lower the Temp. of 1,000 Lbs. of Product From T_1 to T_2[3/] (Calculated)	
	Inches	Lbs.	Ozs.	Lbs.	°F.	°F.	Minutes	Kw.-hr.	Lbs.	Ratio	Kw.-hr.	Ratio
Fillets[4/]	1	1	-	187	36	0	57	4.66	4,730	1.00	24.9	1.00
Fillets[5/]	2	5	-	360	36	0	180	12.33	2,880	0.61	34.3	1.38
Fillets[5/]	$2\frac{1}{2}$	5	-	420	36	0	262	17.35	2,310	0.49	41.4	1.66
Fish Sticks[6/]	$1\frac{1}{2}$	-	10	165	65	0	137	8.34	1,730	0.37	50.6	2.03

1/ Preliminary tests indicated that the results obtained with pollock fillets would apply also to haddock fillets.
2/ Full-load capacity of the freezer.
3/ Calculated values (assuming no lost time in loading and unloading freezer).
4/ Unwrapped fillets packaged in a 1-pound commercial waxed chipboard box with no overwrap.
5/ Fillets individually wrapped in moisture-vaporproof cellophane and packaged in a 5-pound commercial waxed chipboard box with no overwrap.
6/ Breaded precooked fish sticks (2 layers) packaged in a 10-ounce commercial waxed chipboard box with a microcrystalline wax overwrap.

to provide good contact between the plates and the product. The zero-time readings for temperature of the fish, temperature of the plates, and electrical power required were taken immediately prior to lowering the plates. Subsequent readings were taken at specific intervals until the products reached an internal temperature of 0° F. (figs. 1-4).

RESULTS AND DISCUSSION

ONE-INCH-THICK PACKAGES: The 1-inch-thick packages (187 pounds) of fillets were lowered from an initial temperature of 36° F. to a final temperature of 0° F. within 57 minutes (fig. 1). A total of 4.66 kilowatt-hours of electrical energy was required (table 1). The plate temperature rose from -10° to 22° F. because of the fast rate of heat transfer due to the relatively thin packages of fish (fig. 1). If the refrigeration capacity of the machine had been larger, the initial plate-temperature rise would not have been as high, and a faster freezing rate would have resulted.

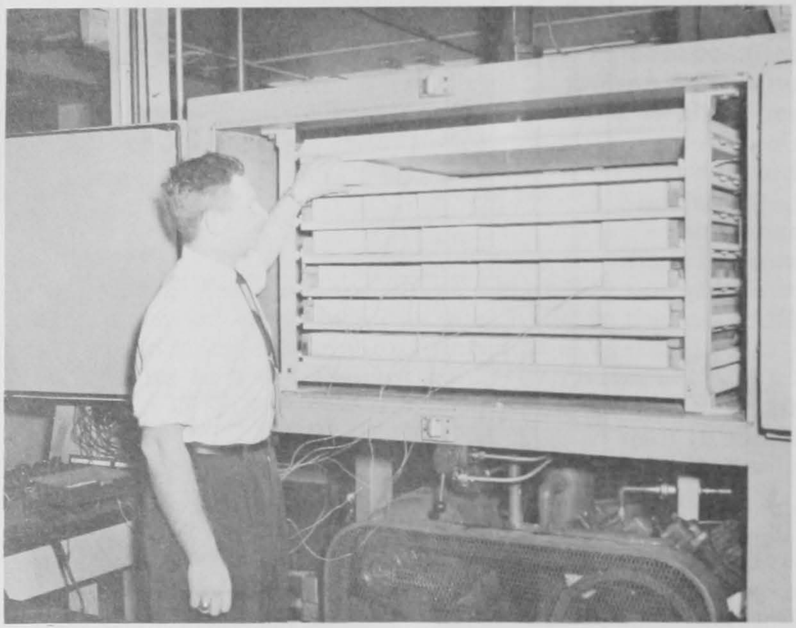

Fig. 5 - Loading multiplate freezer prior to conducting tests.

TWO-INCH-THICK PACKAGES: The 2-inch-thick packages (360 pounds) of fillets were lowered from 36° to 0° F. in 180 minutes (fig. 2). The total electrical energy required was 12.33 kilowatt-hours (table 1). The plate temperature rose from -11° to 16.5° F. (fig. 2). This plate-temperature rise was less than that which occurred when the 1-inch-thick packages of fillets were frozen. This indicates a slower rate of heat transfer due to the increased thickness of the package.

TWO AND ONE-HALF-INCH-THICK PACKAGES: The $2\frac{1}{2}$-inch-thick packages (420 pounds) of fillets were lowered from 36° to 0° F. in 262 minutes (fig. 3). The total electrical energy required was 17.35 kilowatt-hours (table 1). The initial rise of the plate temperature was from -13° to 8° F. (fig. 3). The plate temperature then began to drop. The immediate drop of the plate temperature and the maintenance of the plates at a low temperature indicates that the heat from the fillets was given off at a very slow rate. This was due to the relatively thick packages of fillets.

EFFECT OF THICKNESS OF FILLET PACKAGES: A comparison of the "Time required to lower temperature of product from T_1-T_2" and the "Product freezing capacity of unit in a 24-hour period" (table 1) indicates that as the thickness of the packaged fillets increases the rate of heat transfer decreases, resulting in a slower freezing rate and a lower freezing output capacity. It is also noted that the amount of electrical energy required to freeze 1,000 pounds of fillets (table 1) increases as the thickness of the package increases. Therefore, fillets can be frozen faster and more economically in the thinner packages than in the thicker ones.

FISH STICKS: The $1\frac{1}{2}$-inch-thick packages (165 pounds) of fish sticks were lowered from a temperature of 65° to 0° F. within a period of 137 minutes (fig. 4). The total electrical energy required was 8.34 kilowatt-hours. The plate temperature rose from -11° to 9.5° F. (fig. 4). It then dropped very rapidly and remained at a low temperature, indicating a slow rate of heat transfer between the plates and the product. The relatively slow rate of freezing was caused by (1) the thickness of the package ($1\frac{1}{2}$-inch), (2) the relatively large air space between the top layer of fish sticks and the package wall, and (3) the insulation effect of the overwrapped package.

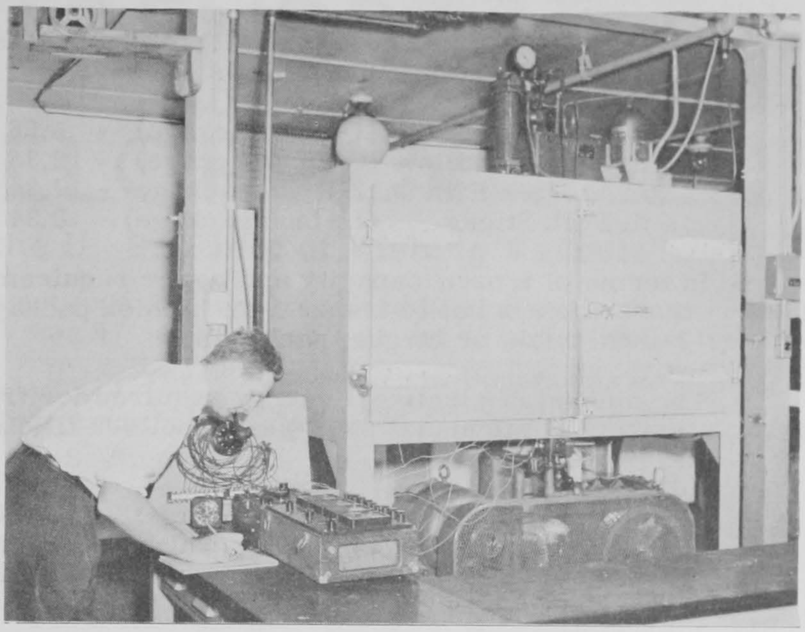

Fig. 6 - Recording data during tests.

Results given in table 1 show the freezer to be capable of lowering the temperature of 1,730 pounds of packaged fish sticks from 65° to 0° F. in a 24-hour period. A total of 50.6 kilowatt-hours would be required to lower the temperature of 1,000 pounds of fish sticks from 65° to 0° F. A comparison of the results (table 1) indicates that the multiplate-compression freezer in terms of capacity and energy requirements is not as suitable for the freezing of packaged fish sticks as it is for the freezing of packaged fish fillets.

APPLICATION OF DATA TO OTHER MULTIPLATE-COMPRESSION FREEZERS:

1. Freezing Rates: The freezing rates (figs. 1-4) would be similar for all multiplate-compression freezers that are designed to freeze a full capacity load of 1-inch-thick packaged fillets in 60 minutes.

2. Energy Requirements: The energy requirements (table 1) would vary for other multiplate-compression freezers depending on (1) capacity of freezer, (2) type of refrigerant used, and (3) the type and number of compressors used to supply the necessary refrigeration. The ratios between the kilowatt-hours required to freeze 1,000 pounds of the various products (table 1) would to a large extent be applicable for the majority of multiplate-compression freezers in commercial use today.

SUMMARY

A 6-station junior-model multiplate-compression-type freezer was used in tests in which the following observations were made.

1. The time intervals required to freeze full freezer loads of pollock fillets and of fish sticks were found to be as follows:

    a. Pollock Fillets (1-inch package) - 57 minutes
    b. Pollock Fillets (2-inch package) - 180 minutes

c. Pollock Fillets ($2\frac{1}{2}$-inch package) - 262 minutes
d. Fish Sticks ($1\frac{1}{2}$-inch package) - 137 minutes

2. The energy required to freeze full freezer loads of pollock fillets and of fish sticks was found to be as follows:

a. Pollock Fillets (1-inch package) - 4.66 kilowatt-hours
b. Pollock Fillets (2-inch package) - 12.33 kilowatt-hours
c. Pollock Fillets ($2\frac{1}{2}$-inch package) - 17.35 kilowatt-hours
d. Fish Sticks ($1\frac{1}{2}$-inch package) - 8.34 kilowatt-hours

3. In terms of frozen capacity and power requirements, it is more efficient and more economical to freeze 1-inch-thick packages of fillets than to freeze 2-inch-thick, or larger, packages.

4. The amount of electrical energy required for freezing 1,000 pounds of the various commercial packages of pollock fillets and of fish sticks was found to be as follows:

a. Pollock Fillets (1-inch package) - 24.9 kilowatt-hours
b. Pollock Fillets (2-inch package) - 34.3 kilowatt-hours
c. Pollock Fillets ($2\frac{1}{2}$-inch package) - 41.4 kilowatt-hours
d. Fish Sticks ($1\frac{1}{2}$-inch package) - 50.6 kilowatt-hours

ACKNOWLEDGMENT

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-- J. W. Slavin, Refrigeration Engineer,
Fishery Technological Laboratory,
Branch of Commercial Fisheries,
U. S. Fish and Wildlife Service, East Boston, Mass.

CUTTLEFISH MEAL

A new feeding meal made from cuttlefish is stated to give a better growth response and increased egg yield than herring meal when added at a 10-percent level to a chicken ration which includes maize, wheat, and rice. The cuttlefish feeding meal is made by autolysing 100 parts of the viscera with 10 parts of water at 50° to 52° C. (122°-126° F.) and at pH 5.0 to 5.2 for 4 hours. The autolysate is heated to 80° to 85° C. (176° to 185° F.) and centrifuged to remove the oil. It is adjusted to a pH of below 4.5 to preserve it, absorbed in wheat bran, and dried. The protein content is stated to be about 31 percent and vitamin B_{12} about 0.4 ug./g.

--Bulletin of the Japanese Society of Scientific Fisheries, Vol. 18, No. 10, 1953.