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FREEZING AND STORING DEEP-SEA LOBSTERS--SOME TESTS ON COOKED WHOLE LOBSTERS

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ABSTRACT

IT WAS FOUND THAT DEEP-SEA LOBSTERS, COOKED ALIVE AND THEN FROZEN IN A BLAST-AIR FREEZER OR IN AN IMMERSION FREEZER (IN A GLUCOSE-SALT SOLUTION), COULD BE KEPT SATISFACTORILY IN FROZEN STORAGE FOR 2 TO 4 WEEKS.

BECAUSE OF THE LIMITED FROZEN SHELF LIFE OF THE DEEP-SEA LOBSTER, IT WOULD NOT BE FEASIBLE TO MARKET FROZEN WHOLE LOBSTERS IN THE NORMAL CHAIN OF DISTRIBUTION. IT WOULD BE POSSIBLE, HOWEVER, TO FREEZE THEM AT SEA AND THEN DISTRIBUTE THEM TO LOBSTER PRODUCERS OR TO RESTAURANTS WHERE A RAPID TURNOVER OCCURS. THE USE OF A BLAST OR IMMERSION FREEZER IS DISCUSSED, AND RECOMMENDATIONS ARE GIVEN FOR SELECTING A FREEZING SYSTEM TO HANDLE LOBSTERS ON A VESSEL.

INTRODUCTION

Because of the problems in keeping deep-sea lobsters alive aboard commercial fishing trawlers, the lobster resource found off the coast of Massachusetts by the U. S. Bureau of Commercial Fisheries research vessel Delaware has not been adequately exploited. Accordingly, information on a satisfactory method of preserving lobsters at sea would contribute to greater utilization of this fishery.

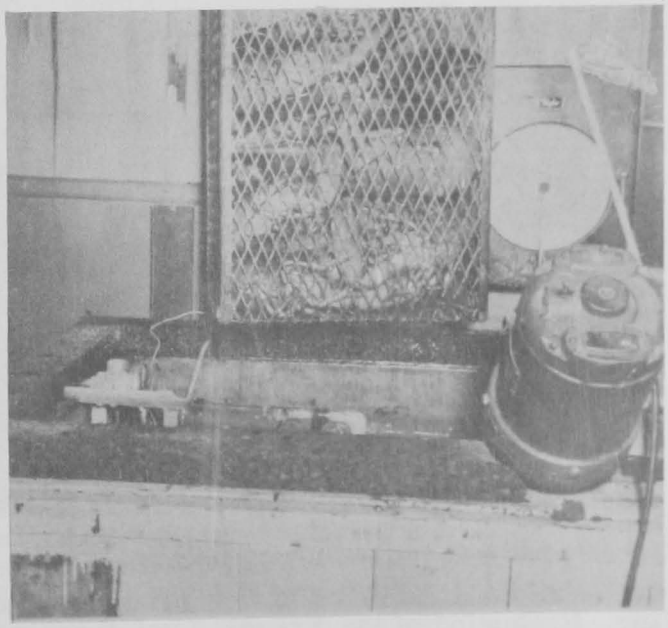

FIG. 1 - LOWERING THE BASKET OF LOBSTERS INTO THE FREEZING SOLUTION.

Keeping deep-sea lobsters alive aboard commercial fishing vessels presents the following problems: (1) the high cost of equipping the vessel with the tanks and pumps necessary to provide the required storage space and sea-water circulation and (2) the high mortality rate of lobsters at certain times of the year in spite of precautions taken to outfit the vessel properly.

Possible solution to these problems would be to freeze the cooked[1/] whole lobsters aboard the vessel in either a blast or immersion freezer, since this equipment is well suited for freezing irregularly shaped products and can easily be installed on a fishing vessel. Information on the storage life of cooked, frozen, whole lobsters is also necessary in order to enable industry to decide if it would be feasible to market these lobsters.

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1/EARLIER TESTS ON FROZEN LOBSTERS (POTTINGER 1950) SHOWED THAT WHEN WHOLE FROZEN UNCOOKED LOBSTERS WERE COOKED, THE MEAT STUCK VERY TIGHTLY TO THE SHELL AND WAS EXTREMELY DIFFICULT TO REMOVE. IN THE PRESENT EXPERIMENT, THE LOBSTERS THEREFORE WERE COOKED PRIOR TO FREEZING.

OBJECTIVES

The objectives of the present study, which was conducted on a pilot-plant scale, therefore were as follows:

1. To determine the freezing rates and requirements for freezing cooked whole deep-sea lobsters aboard a fishing vessel in (a) an immersion freezer or in (b) a blast freezer.

2. To determine the keeping quality of deep-sea lobsters that are frozen in an immersion freezer or in a blast freezer and that are subsequently stored, unpackaged, at 0° F.[2/]

PROCEDURE

The lobsters used in this test were caught by the Bureau's trawler Delaware on the southeast part of Georges Bank in about 200 fathoms of water. They were kept alive on the vessel in a tank supplied with circulating sea water. After the lobsters were unloaded from the vessel, they were trucked to a local lobster pool, where again a tank of circulating sea water kept them alive.

PREPARING THE LOBSTERS FOR FREEZING: The live lobsters were cooked in boiling sea water, in a large wooden tank, for 30 minutes. They then were removed from the tank and allowed to cool in air before being frozen.

FREEZING OF COOKED DEEP-SEA LOBSTERS: The cooked lobsters were divided into two separate lots of approximately 50 pounds each. One lot was frozen in the laboratory immersion freezer and the other in the laboratory blast freezer.

Immersion Freezing: DESCRIPTION OF FREEZER: The immersion freezer consisted of a rectangular galvanized steel tank with a capacity of 800 pounds of water. The tank was 30 inches long by 30 inches wide by 30 inches deep and, with the exception of a suitable opening on top, was covered with 4 inches of cork insulation on the outside. The insulation was covered with 1-inch-thick tongue-and-groove fir sheathing.

FIG. 2 - BUTCHERING THE THAWED LOBSTERS IN ORDER TO REMOVE THE MEAT FOR TASTE-PANEL TESTS.

The refrigeration equipment consisted of a 1½ horsepower Freon-12 air-cooled condensing unit (capacity 6,800 British Thermal Units (B.T.U.) per hour at -15° F. refrigerant suction temperature) connected to two expansion valves, an evaporator consisting of four banks of copper pipe coils, and the necessary auxiliary units. The total effective cooling surface area was 22 square feet. The evaporator was located within a section of the freezing tank that was separated from the product-freezing area by a wooden baffle. Openings at both ends of the baffle allowed the brine to flow around the cooling coils and the product during freezing. Expansion of the Freon-12 refrigerant through the pipe coils provided the necessary cooling effect. Adequate circulation of the freezing medium was maintained by a ⅓ hp. laboratory-type mixer.

2/ PREVIOUS STUDIES ON LOBSTERS BY THE BOSTON FISHERY TECHNOLOGICAL LABORATORY HAVE BEEN CONCERNED WITH THE FREEZING AND STORING OF LOBSTER MEAT PACKED IN CANS. RESULTS OF THESE STUDIES INDICATED THAT IF PROPER CONTROL OF FROZEN-STORAGE TIME AND TEMPERATURE ARE MAINTAINED, IT WILL BE FEASIBLE TO MARKET THE FROZEN CANNED PRODUCT (PETERS AND SLAVIN 1958).

A basket constructed of ½-inch flattened expanded metal, hot dip galvanized, 24 inches deep by 18 inches long by 12 inches wide, having a hinged opening at the top, was used to hold the lobsters during freezing.

PREPARATION OF THE FREEZING SOLUTION: The solution used as a freezing medium consisted of corn-syrup solids[3] (34 percent by weight) and salt (NaCl--12 percent by weight) dissolved in tap water. In the preparation of the solution, 540 pounds of water were put into the immersion freezing tank. Then 340 pounds of corn-syrup solids and 120 pounds of salt pellets, referred to in the trade as "brine buttons," were added. The mixture was agitated with the laboratory mixer. After the corn-syrup solids and salt had dissolved, which required 5 hours, the refrigeration equipment was started, and the solution was cooled to 3° F.

FREEZING THE LOBSTERS: The basket used to hold the lobsters during freezing had 3 cubic feet of usable space. A ratio of about 17 pounds of lobsters per cubic foot of basket space was used to prevent the lobsters from packing together and restricting the flow of the glucose-salt solution over them during freezing.[4]

Ten lobsters, totaling 50 pounds in weight, were placed in the basket. Copper-constantan thermocouples were inserted into the center of the tail muscle of three of these lobsters, and one thermocouple was put into the glucose-salt solution. The basket containing the lobsters then was lowered into the solution (fig. 1). During freezing, the temperatures of the lobsters were recorded by means of a multipoint recording potentiometer. After the lobsters had been cooled to 6° F., they were removed from the freezer, and the excess solution was allowed to drain off. Finally, the frozen lobsters were transferred to a wooden box and put in a 0° F. commercial-type cold-storage room.

Blast Freezer: DESCRIPTION OF THE FREEZER: The freezer used was similar to many low-temperature blast freezers found in commercial freezing plants. The refrigeration equipment consisted of a 25-hp., two-stage, Freon 22, water-cooled condensing unit (capacity 36,000 B.T.U. per hour at -40° F. refrigerant suction temperature), a finned-pipe coil evaporator, and the necessary auxiliary units. A flow of air at high velocity was provided by a 2 hp. centrifugal fan having a capacity of 6,000 cubic feet per minute.

The evaporator and fan were within the insulated freezing room. This equipment was located above the product-freezing chamber and separated from it by a horizontal baffle. Suitable openings in the baffle allowed for circulation of cold air, at a high velocity, through the product-freezing space.

FREEZING THE LOBSTERS: Eleven cooked whole lobsters, weighing about 50 pounds, were placed in a single layer on an expanded metal shelf of the freezer truck. The shelf was arranged so that cold air at a high velocity could circulate over and under the layer of lobsters. Copper-constantan thermocouples were placed in the center of the tail muscle of three of the lobsters, and one thermocouple was placed so as to be in the stream of cold air. The truck containing the lobsters then was wheeled into the blast-freezer room, which had been precooled to -11° F. The temperatures of the lobsters and of the air circulating over the lobsters were recorded on a multipoint recording potentiometer during freezing. After the lobsters had been cooled to 3° F., they were removed from the blast freezer, transferred to a wooden box, and put in storage at 0° F., with the immersion-frozen lobsters.

PREPARATION OF THE LOBSTERS FOR TASTE-PANEL EVALUATION: Prior to each taste test, two blast-frozen and two immersion-frozen lobsters were re-

3/ THE CORN SYRUP SOLIDS IS A COMMERCIAL ACID HYDROLYSATE OF CORN STARCH. FORTY-TWO PERCENT OF THE SOLIDS IS EQUIVALENT TO DEXTROSE (GLUCOSE), AND THE REMAINDER CONSISTS OF 2- TO 6-MOLECULE DEXTROSE POLYMERS.

4/ SLAVIN (1956) REPORTED THAT IN THE IMMERSION FREEZING OF FISH MORE THAN 20 POUNDS OF FISH PER CUBIC FOOT OF SPACE RESULTS IN PACKING. PRELIMINARY TESTS SHOWED THAT THE RATIO OF PRODUCT TO SPACE FOR FREEZING LOBSTERS WAS SIMILAR TO THAT FOR FISH.

moved from the 0° F. storage room and allowed to thaw for 18 hours in a 35° F. chill room. The meat then was removed from the tails and claws and was cut into pieces for serving to the taste-panel (fig. 2). The control sample used in the taste tests was obtained from a local lobster dealer and consisted of meat picked from inshore lobsters that had been cooked alive on the day of the examination.

The taste-panel, consisting of 6 to 8 members of the laboratory staff, graded the thawed lobster meat for appearance, odor, flavor, and mixture.

RESULTS AND DISCUSSION

FREEZING OF DEEP-SEA LOBSTERS: The freezing rates of deep-sea lobsters (average weight 5 pounds) in an immersion freezer and in a blast freezer are shown in figure 3. These curves show that lobsters immersion-frozen in a 4° F. glucose-salt solution were cooled from 74° F. to 6° F. in 120 minutes and that blast-frozen lobsters were cooled from 80° F. to 6° F. in 128 minutes, indicating that very little difference existed in the time required to cool the two lots of lobsters to 6° F. The immersion-frozen lobsters were cooled to 10° F. at a much faster rate, however, than were the blast-frozen lobsters. The slower cooling of the immersion-frozen lobsters, from 10° F. to 6° F. (the temperature at which they were removed from the feezer) was due to the small temperature difference between the lobsters and the glucose-salt solution. If all of the lobsters were frozen to 10° F. instead of 6° F., which might well occur in commercial operation, only 90 minutes would be required to immersion-freeze lobsters, whereas 126 minutes would be required to blast-freeze lobsters of the same size.

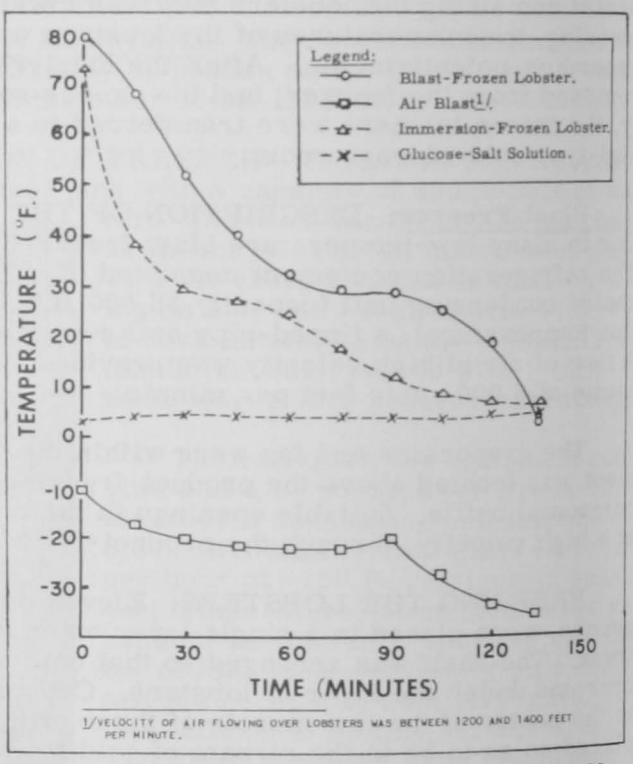

FIG. 3 - FREEZING RATE OF COOKED WHOLE LOBSTERS.

The curves in figure 3 also show that during freezing, the glucose-salt solution was at an average temperature of about 4° F., whereas the cold air circulating over the lobsters in the blast freezer ranged from -10° F. to -34° F. (These temperatures are representative of those used commercially for blast freezing fish.) The refrigerant evaporative temperatures for both the blast and the immersion freezers were 15° F. lower than were the temperatures of the respective cooling media. Slavin (1956) reported that as the refrigerant evaporative temperature decreases, the efficiency of the refrigeration compressor also decreases. The lower evaporative temperature at which the blast-freezer compressor operated therefore also resulted in decreased operating efficiency. The lower operating efficiency of the blast-freezer compressor, the additional compressor capacity required because of the heat given off by the blast-air fan, and the electrical energy necessary to operate the blast-air fan indicate that it would be more costly to freeze a given quantity of lobsters in a blast freezer than in an immersion freezer. Accordingly, the use of an immersion freezer should be seriously considered for freezing deep-sea lobsters aboard the vessel.

STORAGE OF FROZEN LOBSTERS: Table 1 shows the results of the examinations of the lobster meat obtained from the blast-frozen and immersion-frozen lob-

sters. After 2 weeks of storage at 0° F., the meat was of fair-to-good quality, and no signs of deterioration could be detected. After 4 weeks, however, the tips of the claws had developed a yellow color and had a slightly rancid odor. The rancidity had not affected the claw meat as a whole, but the rancid sections would have to be trimmed off before the meat could be marketed. By the end of 8 weeks of storage, the rancidity had increased to such a stage that the lobsters were considered unmarketable.

Since yellowing and rancidity appear during the third and fourth week of storage at 0° F., we therefore recommend that frozen cooked whole lobsters should not be stored at 0° F. longer than 2 weeks, if possible, and certainly no longer than 4 weeks.

Table 1 - Results of Examinations of Blast-Frozen and of Immersion-Frozen Whole Cooked Deep-Sea Lobsters

Sample	Storage Time at 0° F.	Quality of Thawed Lobster Meat Removed from: 1/							
		Claws				Tail Section			
		Appearance	Odor	Flavor	Texture	Appearance	Odor	Flavor	Texture
Blast-frozen lobsters	Weeks 0	Good	Very good	Fair	Fair	Very good	Very good	Fair	Good
	2	Good	Very good	Very good	Good	Good	Very good	Very good	Good
	4	Tips yellow Body good	Tips slightly rancid Body fair	2/ 4/ Borderline	Borderline	Good	Fair	Borderline	Borderline
	8	Tips yellow Body good	Tips moderately rancid Body fair	2/ Borderline	Borderline	Good	Good	Good	Good
Immersion-frozen lobsters	0	Good	Very good	Fair	Fair	Good	Very good	Fair	Fair
	2	Good	Good	Fair	Fair	Good	Good	Fair	Fair
	4	Tips yellow Body good	Tips slightly rancid Body good	2/ Fair	Fair	Good	Fair	Fair	Fair
	8	Tips yellow Body good	Tips moderately rancid Body fair	2/ Borderline	Borderline	Borderline	Borderline	Borderline	Fair
Fresh control	0 3/	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent

1/ THE GRADES OF QUALITY ARE BASED ON THE AVERAGE SCORES RECEIVED FROM A TASTE PANEL OF 6 TO 8 MEMBERS.
2/ TIPS OF CLAWS WERE REMOVED BEFORE THE CLAWS WERE SERVED TO THE PASTE PANEL.
3/ LOBSTER MEAT OBTAINED FROM INSHORE LOBSTERS COOKED ALIVE ON THE DAY OF THE TASTE-PANEL EXAMINATION.
4/ THE TERM "BORDERLINE" INDICATES THAT THE QUALITY IS BETWEEN SLIGHTLY POOR AND FAIR AND IS OF MINIMUM ACCEPTABILITY.

INDUSTRY APPLICATION

Our study on freezing and storing whole cooked lobsters shows (1) that deep-sea lobsters can be frozen on board a fishing vessel in either an immersion freezer, using a glucose-salt solution, or in a blast freezer and (2) that they can be satisfactorily stored, unpackaged, at 0° F. for 2 to 4 weeks.

This information indicates that it would be feasible to freeze lobsters at sea if they can be marketed within 2 to 4 weeks after being frozen. Because of the very limited keeping quality of the frozen lobsters, it would not be feasible to market them in chain stores. It might be possible, however, to distribute frozen whole lobsters to a large producer of lobster food products or to restaurants, where a rapid turnover is possible.

An immersion freezer would be preferred over a blast freezer for use on the vessel because of the low space requirements, rapid freezing, and efficiency of operation. Commercial equipment is available for freezing lobsters at sea. The capacity of equipment employed would depend on the size of the vessel and on the anticipated catch.

SUMMARY

A pilot-plant study was conducted to simulate conditions that would occur aboard a commercial fishing vessel equipped to freeze lobsters at sea. The investigations concerned the freezing of whole cooked lobsters in an immersion freezer (glucose-

salt solution) and in a blast freezer. Information on the freezing rates and keeping quality of immersion and blast-frozen lobsters, stored at 0° F. was obtained. Results of the study show that cooked whole lobsters frozen in a glucose-salt solution at an average temperature of 4° F. were cooled to 10° F. faster than were lobsters that were frozen in a blast freezer having an air temperature of -10° F. to -34° F. Lobsters, immersion- or blast-frozen, were stored satisfactorily at 0° F. for 2 to 4 weeks.

Information presented in the report indicates that an immersion freezer would be more satisfactory for freezing lobsters aboard a fishing vessel than would a blast freezer and that it would not be possible to market whole frozen lobsters in chain stores because of the limited storage life. It might be possible, however, to distribute frozen lobsters to large producers of lobster food products or to restaurants that have a rapid turnover.

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NOTE: IF YOU ARE INTERESTED IN FREEZING LOBSTERS AT SEA, CONTACT THE BUREAU OF COMMERCIAL FISHERIES TECHNOLOGICAL LABORATORY AT EAST BOSTON, MASS., FOR PARTICULARS REGARDING SELECTION OF EQUIPMENT, COSTS OF CONVERTING YOUR VESSEL, AND CATCHES OF LOBSTERS THAT YOU CAN EXPECT.

LARGEST FISH

The three largest fish-like animals in the sea are all sharks. The largest is the whale shark which attains a length of 50 feet or more and a weight of several tons. It is an offshore species which feeds primarily on small organisms and is consequently harmless to man. The basking shark and the white shark are next in size. Both grow to be 40 feet or more and attain a weight of several tons. The basking shark, like the whale shark, is considered harmless. The white shark, however, is extremely dangerous. Fortunately, this shark is an offshore species, but its visits to inshore waters may be accompanied by shark attacks on man. Its occurrence in inshore waters is very sporadic, except along the coasts of Australia and Venezuela and, to a lesser degree, California.

In the Caspian Sea the large beluga or sturgeon attains a length of 30 feet and a weight of more than 4,000 pounds. Among the bony fishes, both the black and blue marlin approach 2,000 pounds in commercial catches, well above rod-and-reel records.

--"Sea Secrets," January 1958, The International Oceanographic Foundation, Miami, Fla.