PAPER 1026

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me Freezing Seafoods

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INTRODUCTION

Freezing, one of the oldest food preservation methods known to man, has long been by far the choice to capture those "just like fresh" characteristics which are so desirable. Drying and salting has its limitations and do not wholly satisfy man's expectations for a preserved product.

Historically, in parts of the world where cold weather made it possible, people have frozen fish on a small scale for later use simply by allowing it to freeze in the cold weather. In those early days, man did not know why freezing prevented spoilage; all he knew was that it did, and that the food tasted pretty good even after months of frozen storage. As he could not depend on the season of the year to preserve his catch year-round, he continued to search for improvements in freezing methods.

Fish were frozen on a commercial scale for the first time in the United States about 1865, primarily to preserve it during transportation. The development of efficient methods for commercially preserving foods by freezing represented a major step forward in the long-time efforts of mankind to discover better ways to preserve foods.

The fish freezing industry has progressed from the covered-pans-with-ice-and-salt method to the complex ammonia and freon refrigeration systems of today. At the end of the 19th century, freezing of fish was an important though rather small industry in New England. New England has had an important history in the development of frozen food methods. Fish made a good low-cost material for the early experiments and was one of the earliest items frozen commercially.

Clarence Birdseye was the pioneer in this regard, conducting a considerable amount of research in Gloucester and Boston. He later organized a company[1] for the commercial production of frozen foods and introduced the consumer-sized container about 1929. Frozen foods can be bought today bearing the name of this man who had an idea and worked hard to bring it to fruition. Springfield, Mass., was the test city for the introduction of frozen fruits and vegetables and much valuable information was obtained there which was put to good use later. This was the start of frozen foods as we know them for consumers.

Birdseye sold his patent and equipment to one of the largest food concerns in the United States. That company began the intensive work of developing additional freezing equipment, working out ways to control enzymes and bacteria, developing cabinets for commercial storage and home use, and all the other things that were necessary before the present day version of the frozen food industry could develop.

Until about 1960 little progress was made relative to the development of more and better food freezing methods. About that time some of the older methods were improved upon (such as brine freezing, which is used extensively in the tuna industry on the west coast). Immersion freezing utilizing propylene glycol or a sugar/salt solution was developed and is being used on a limited scale in the industry today.

The most significant advancements in freezing technology have been made within the past six years. The development of liquid nitrogen, carbon dioxide, and freon freezing systems (Figure 1) have allowed the processor to freeze foods efficiently, economically, and produce a better quality product. These new methods are rapidly sweeping the country, and, in a few years, the old mechanical method of producing refrigeration will be obsolete. It would not be too far out to predict that even these methods will be obsolete in from 10 to 15 years. Technology has made tremendous strides in every field of endeavor since the beginning of the space age.

[1] Use of trade names in this publication does not imply endorsement of commercial products by the National Marine Fisheries Service, NOAA.

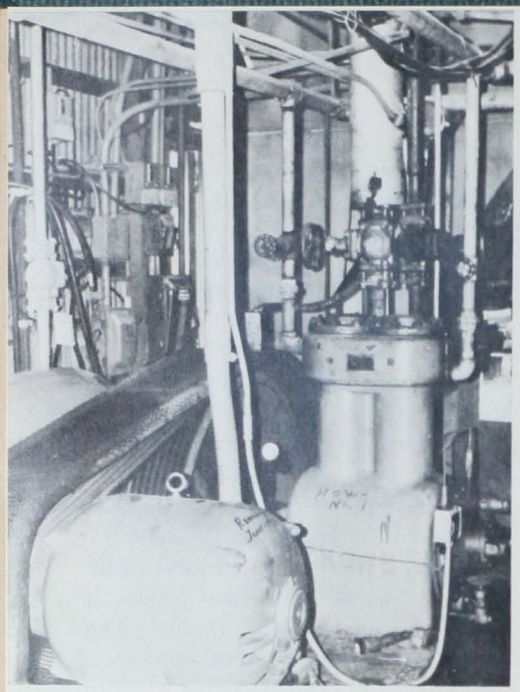


Figure 1.—A new modern industrial liquid freon freezing system.

The term "refrigeration" is hard to define yet is so easy to understand. In simple terms, "refrigeration is produced by the removal of heat." In a more classical definition, "refrigeration is the production and maintenance of the temperature of a substance or space at a lower value than the surrounding atmosphere by the withdrawal of heat." The freezing point of foods is that temperature at which the liquid phase is in equilibrium with the solids. The freezing point of foods is lower than that of pure water and is generally between 32° and 25°F.

SELECTION OF SEAFOOD FOR THE HOME FREEZER

Seafoods are delicious, taste tempting, and provide a delightful addition to any family meal. They also provide excellent nutrition and help stretch the family food dollar. Home freezing is an excellent method for preserving seafoods and will be an added economy since fresh seafoods may be purchased in season when prices are generally lower.

Because some fresh seafoods are seasonal, it is important to learn the availability of seafoods during certain times of the year. The local fish dealer can provide this information and indicate which varieties are the most economical. Fresh fish may be purchased by the pound in any of the following forms: whole, drawn, dressed and drawn, steaks, fillets, and chunks.

The selection of seafoods to put in a freezer is one of the most important phases of freezing food for the family. When purchasing seafoods for home freezing, be sure that they have not been previously frozen. Consult the fish dealer to be absolutely certain. When transporting seafoods to the home, they must be kept as cold as possible. A few hours at room temperature or in the trunk of a car on a warm day can completely spoil many types of seafood.

When buying fresh fish, look for the following characteristics:

1. The flesh of whole fish should be firm and not separating from the bones.
2. If the head is attached, the eyes should be bright, clear, and full. As the fish become stale, the eyes become cloudy and often turn pink.
3. The gills should be red and free from slime.
4. The skin should be shiny with an unfaded color.
5. The odor of fillets and steaks should be fresh and mild.
6. Crabs and crab meat should have little fishy odor and no disagreeable ammonia-like taste or odor.
7. Crab shells should not be slippery.
8. Oysters and clams in the shell should be alive and the shells should close when handled.
9. The liquor of shucked oysters should be clear and there should be no sour smell or odor.
10. Fresh shrimp should have no disagreeable odor and their meat or shells should not be slippery.

Whenever in doubt as to the freshness of seafood, do not freeze it. If serious doubt is present, discard the seafood. Poor handling of fish prior to freezing will make it impossible to obtain good results. Freezing can only protect the quality of the fish as it was when frozen; freezing does not improve the quality. Frozen foods can be no better than the material one starts with. Do not purchase more seafood than can be frozen and stored in the available freezer space or more than your family will eat within 3-6 months.

SEAFOOD PREPARATION FOR THE FREEZER

When preparing seafoods for the freezer it is important that all inedible material and debris be eliminated. For example, fish should be scaled and the entrails and heads removed. Shrimp should be deheaded and peeled. This will allow additional space in the freezer and eliminate work prior to serving the dish for a meal. It is important that the seafood be packaged in just that amount which will accommodate or serve the family at one meal.

A technique we would recommend for preserving the quality is to dip raw seafood in a precooked and cooled solution of 5 percent starch. This will help exclude air from individual pieces. This can be done by using about 6 tablespoonsful of corn starch per gallon of water. The starch must, however, be rinsed away after the item is thawed and before cooking.

PACKAGING SEAFOOD FOR THE FREEZER

Choosing the right packaging material is a very important step in the process of freezing in the home. Most of the undesirable flavor and color changes in seafood are caused by oxidation. Loss of water during frozen storage, that is, freezer burn, not only dries and toughens foods but promotes oxidation (Figure 2). Freezer burn and oxidation are always accompanied by an off-flavor, off-odor, and off-color. The housewife should select packaging material that is impermeable to oxygen and water vapor and should exclude as much air as possible during packaging. Cling-type wrapping materials are an excellent barrier to both water vapor and oxygen, cling well to surfaces, and are available in most grocery stores. Metal cans with seal-on lids and glass jars designed for

Figure 2.—Typical case of severe freezer burn (dehydration).

freezing are good oxygen and water vapor barriers and are very useful for most seafoods.

Questions often asked are, "Is it a good practice to freeze fish and shrimp in ice cream cartons and milk cartons?" and, "Is it a good practice to freeze fish in pans of water?" (a common practice in the home freezer). The answers are, "Yes." Freezing fish and shrimp in ice cream or milk cartons is a good practice provided that the seafood is completely covered with an ice glaze and the cartons are tightly sealed to prevent the transfer of moisture and oxygen into and out of the package. These cartons are generally coated with wax or a plastic material and are excellent oxygen and water vapor barriers.

The importance of excluding as much air as possible from the package cannot be overemphasized. Besides preventing oxidation, air will act as an insulator and slow the freezing process. Any pocket of air between the package wall and the contents will promote the formation of ice crystals. When the package is cooled and frozen, moisture will move from the seafood to the inside wall of the package. If the product is warmed slightly during defrosting or each time the freezer door is opened, the moisture may move from the package surface back to the food surface. When the package cools again, the cycle is repeated. This may continue until a large quantity of water is removed from the food and it is severely dehydrated.

A warning is in order about thawing smoked or kippered fish. Never leave smoked or kippered fish in a tightly wrapped package after it has thawed. Some smoking methods do not ensure complete destruction of *Clostridium botulinum* spores, which may be harmful when smoked fish is stored unfrozen over a few weeks in an airtight container.

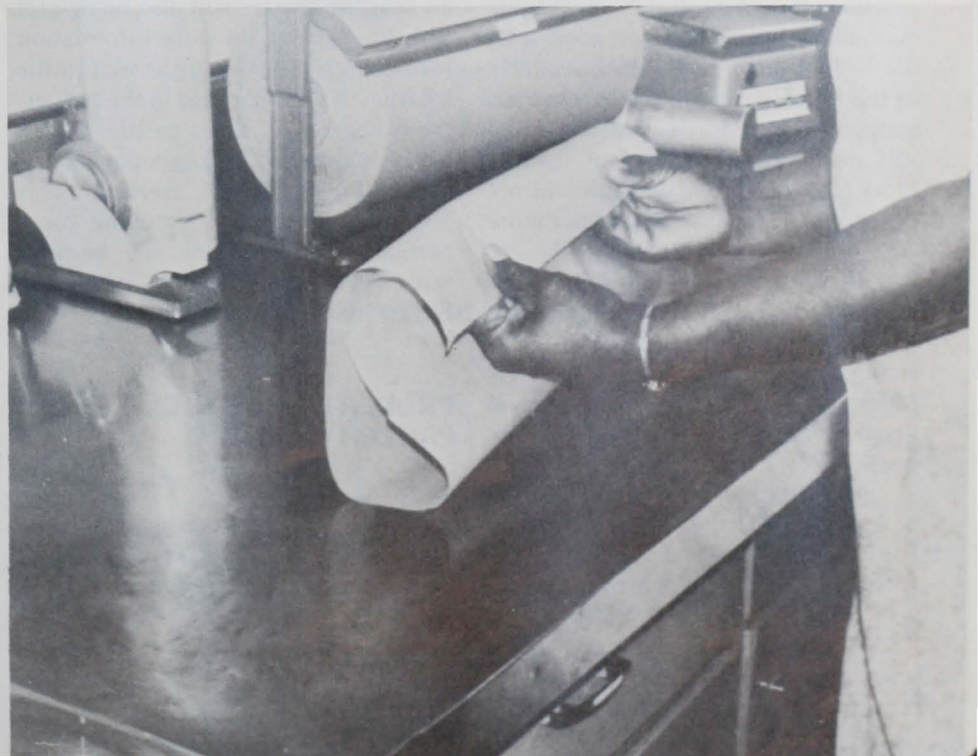
While it is advisable to package seafoods under vacuum, most housewives do not have access to this equipment. The next best thing is to wrap the seafood to exclude as much oxygen as possible. The drug store wrap is suggested (Figure 3). This is done by placing the item on the sheet of wrapping paper and bringing the ends together at the top and "roll the fold" until it is snug against the food. The ends should be folded in a similar manner while pressing out as much air as possible. The wrapping material should be secured with tape to prevent unfolding.

FREEZING AND STORING SEAFOODS IN THE FREEZER

The homemaker can save time, avoid losses, and make freezing seafood a pleasure by planning ahead. Check the freezer to see that it is functioning properly. To maintain the quality, adjust the thermostat to the coldest setting about 2 hours prior to anticipated use. Do not guess; check the temperature with a thermometer. Consider the size of the freezer. Generally, about 2 or 3 pounds of seafood for each cubic foot of freezer space will freeze in from 10 to 12 hours.

It is very important that packages

Figure 3.—The "drug store wrap" recommended for packaging seafoods for home freezers.



be placed in the freezer as soon as they are ready. Usually, the faster the food is frozen, the better the quality and the longer the storage life. This is partly due to less cell destruction by freezing. Slow freezing may actually allow bacterial and enzymatic spoilage to take place while the food is still in a semi-frozen state. To obtain the fastest freeze, place the packages in direct contact with the freezer floor or walls or coils until they are frozen. If the packages take more than 5 or 6 hours to freeze, they are probably too large. Packages should be stored at 0°F or colder where the temperature does not fluctuate. Generally, the farther away from the freezer door, the more stable the temperature.

Temperature fluctuation can be harmful to frozen seafood. Arrange packages in the freezer so that there is adequate space between them to allow good air circulation (Figure 4). Unfrozen packages surrounded by several other packages may not freeze for 3 or 4 days. If this happens, freshness will be lost and spoilage may occur. Never place unfrozen packages near frozen food. It may cause the frozen food to thaw. Leave the thermostat at the coldest setting until all of the packages have been frozen. Then maintain the temperature at 0°F or colder.

Although commercial packaging may allow over a year of good shelf life, freezing methods available in the home generally will not permit seafood to be stored that long and still maintain its flavor and texture. Most home-frozen seafood should not be stored over 6 months and not more than 3 months for salmon, crab, and shrimp. A good rule for a continuous supply of high quality frozen food is "first in, first out." Two to 3 months storage for all seafood is ideal. Seafood is very delicate in flavor and deserves to be eaten at the peak of quality.

Trying to guess the age and contents of a frozen package of seafood can be frustrating and wasteful. Many times food is discarded because the storage age is unknown. Although it is unlikely that properly frozen and stored food can become harmful at any age, top quality demands that extended storage be avoided. Label each package with the date, type of seafood, weight, and number of servings or pieces. A crayon or a grease pencil is ideal for this purpose. A record attached near the freezer will also be helpful and should carry the same information included on the package as well as the location of each package in the freezer, the package size, and a current record of the number of packages put into or removed from the freezer. This prevents unnecessary searching for a particular package and the harmful warming of the contents while the freezer door is open.

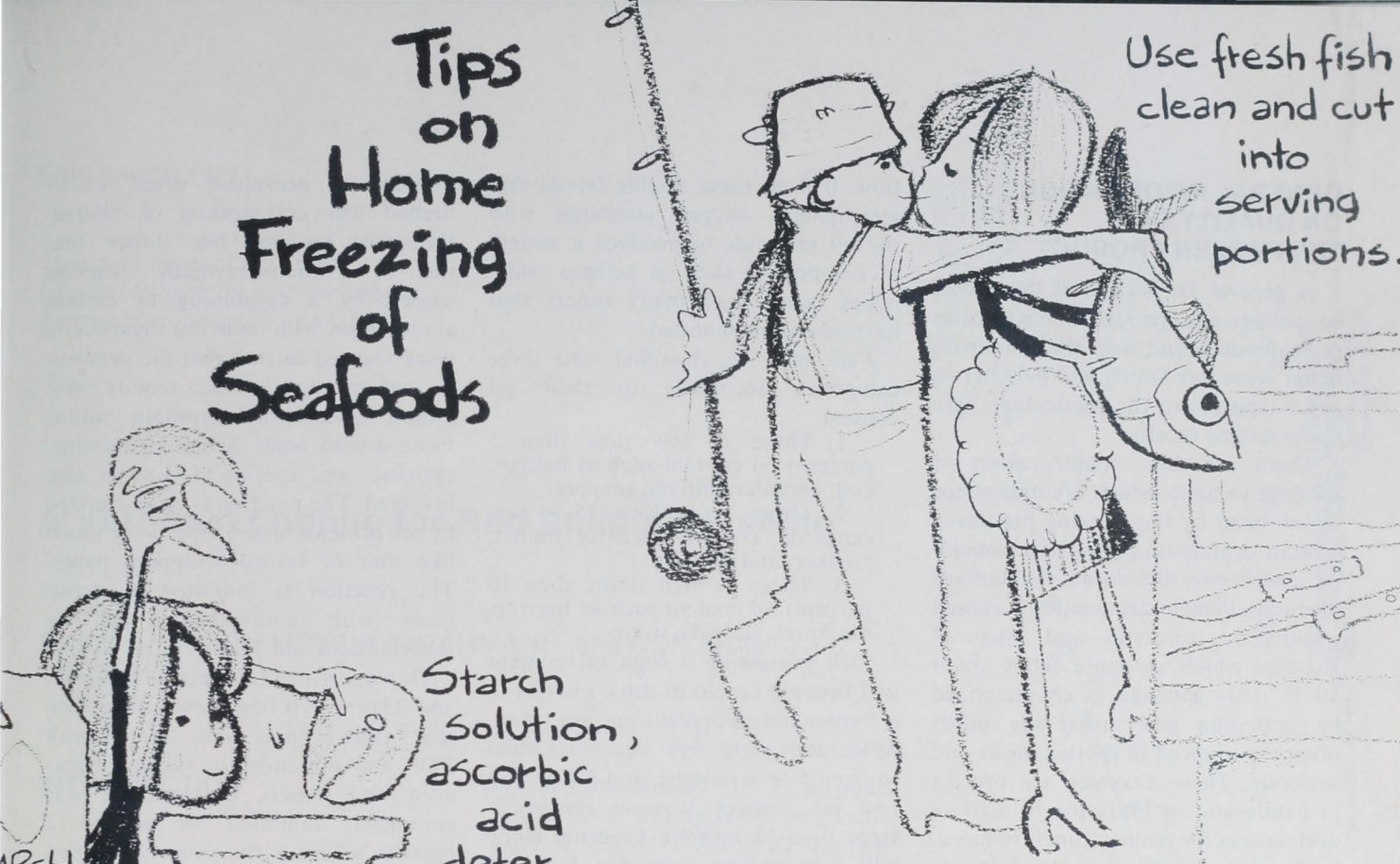
Figure 4.—Seafood properly spaced in home freezer to allow good air circulation.

PROPER USE OF THE FROZEN PRODUCT

The method of thawing seafood is almost as important as proper freezing. Usually the quicker a product is thawed the better, but *never in hot water.* Surface spoilage can take place quickly when thawing at room temperature or in warm water if the surface of the package remains at that temperature for several hours. Schedule thawing so that seafood will be cooked soon after it is thawed. Thawed fish may be held safely for a day in the refrigerator before cooking. Place the package of frozen seafood in the refrigerator to thaw. Allow from 18 to 24 hours for thawing a 1-pound package. If quicker thawing is desired, place the packages of frozen seafood under cold running water. Allow 2 hours for thawing a 1-pound package. Thawed seafoods should not be refrozen.

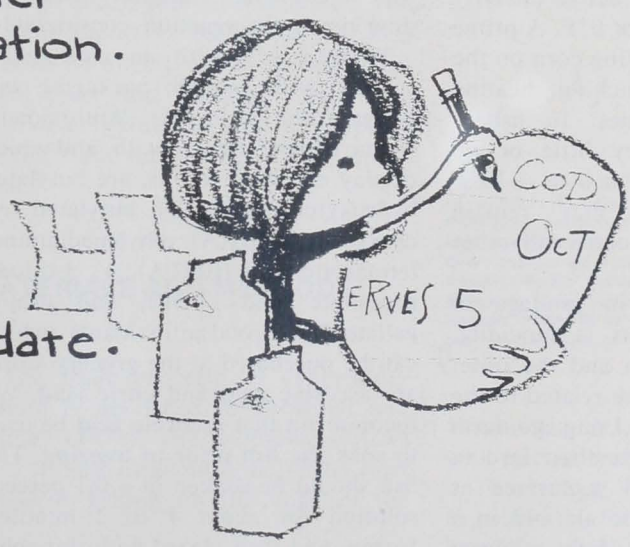
Some frozen seafood may be cooked without thawing. Breaded frozen fish should be cooked this way. In addition, frozen fillets may be cooked without thawing if additional cooking time is allowed. If the fillets are to be breaded or stuffed, they should be thawed before cooking.

Tips on Home Freezing of Seafoods

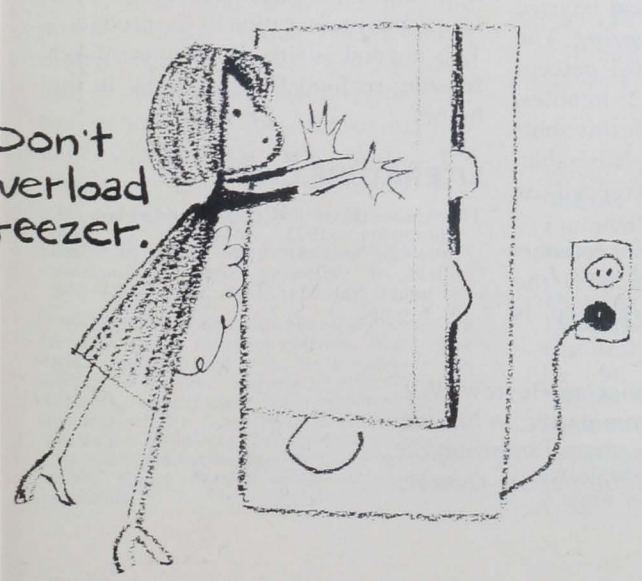


Use fresh fish clean and cut into serving portions.

Starch solution, ascorbic acid deter oxidation.

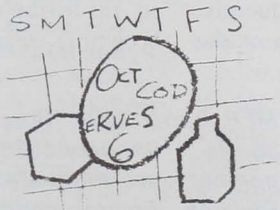


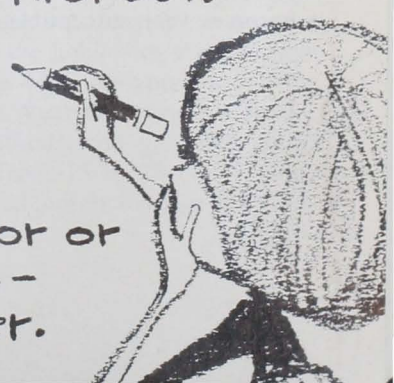
Wrap securely, label and date.



Don't overload freezer.

First package in - first out.





Thaw in refrigerator or under cold water -- never in hot water.

GENERAL INFORMATION ON QUALITY OF THE FROZEN PRODUCT

A general knowledge of the causes of spoilage and spoilage characteristics of seafoods would help the housewife better serve her family and help her to better appreciate the meticulous care seafood must receive.

There are three major causes of spoilage in foods which are minimized or inhibited by the freezing process—protein degradation, oxidative rancidity, and brown discoloration (Maillard reaction). Protein degradation is caused mainly by autolytic and bacterial enzymes which are quite active about 40°F. This spoilage is characterized by ammonia and amine-like odors often experienced in spoiled meats and seafoods. These enzymes are protein in nature and mobilization or activity decreases as the temperature is reduced. Some enzymes remain active (activity is low), however, even at 0°F. A prime example of this is freezing corn on the cob without first blanching; heating inactivates the enzymes. In fishery products there is very little or no enzymatic degradation at 0 to −10°F and these products may remain palatable for many months, all other factors being equal.

The big problem in spoilage of frozen fishery products is rancidity. The uptake of oxygen and the onset of rancidity seems to be related to the unsaturation of the fat. Long ago, farm women learned to store their lard in crocks with as small a surface as possible exposed to the air and in a dark, cool place. Heat, light, oxygen, and the presence of heavy metal ions, such as copper and iron, enhance the development of rancidity. The oil in fish is long chain fatty acids containing many double bonds and consequently, it becomes very susceptible to oxidation. It is at these double bonds that atmospheric oxygen combines with the oil molecule to produce a variety of compounds such as ketones, aldehydes, acids, and many others that have not been identified.

Fish may be classified into three categories according to their oil content:

1. Those of low (less than 5 percent) oil content such as halibut, cod, flounder, and red snapper.
2. Those of moderate (5-10 percent) oil content such as mullet, croaker, and salmon.
3. Those of high (more than 10 percent) oil content such as herring, mackerel, and lake trout.

Fish possessing a high oil content will become rancid in three months in a freezer unless precautions are taken. Moderately oily fish become rancid in from 5 to 8 months, and fish with a low oil content become rancid in from 9 to 12 months. Freezing alone will not prevent rancidity but will slow down the reaction considerably.

Treating fish with an antioxidant coupled with vacuum packaging will increase the shelf life. Antioxidants we have experimented with, and which display excellent results, are butylated hydroxytoluene (BHT), butylated hydroxyanisole (BHA), ethylenediaminetetraacetic acid (EDTA), 3′, 3-thiodipropionic acid (TDP), and propyl gallate. Other good antioxidants (which can be purchased at the grocery store) are ascorbic acid and citric acid. We recommend that ascorbic acid be used to soak the fish prior to freezing. The fish should be soaked in a 0.1 percent solution for about 1 to 2 minutes, frozen, and then glazed with this solution. A second glazing is advisable. The fish may then be wrapped as previously described.

The third type of spoilage encountered in frozen fishery products is the browning reaction. This reaction is particularly prevalent when white-fleshed fish are steaked or filleted. Extensive research has shown that this is a non-enzymatic reaction caused by a combining of certain amino acids with reducing sugars. The work showed further that the pentoses (5 carbon sugars) react readily with amino acids which contain sulfur, those amino acids being methionine, cysteine, and cystine. Lysine is also involved. The reaction is characterized by the presence of a brown color much like that of brown wrapping paper. The reaction is inhibited by treatment with antioxidants such as ascorbic acid and TDP.

Our experimental work (Thompson and Thompson) has shown that when red snapper fillets were treated with TDP and subsequently vacuum packaged and frozen, the reaction was completely inhibited for up to 12 months whereas the controls turned brown in 2 to 3 months. Bleaching of the red pigment in the skin of frozen snapper fillets was also inhibited by the antioxidant.

Seafood is very tasty, nutritious, easy to prepare, economically priced, and commands high priority on a list of preference for any family meal. Consequently, these delicacies of the sea deserve to be served at their peak of quality. We say to the commercial processor, "keep the product clean, keep it moving, keep it cold, and keep it stored at a temperature sufficient for proper preservation of the product." This is good advice to the homemaker freezing seafood for her family in the home.

LITERATURE CITED

Thompson, Harold C., Jr., and Mary H. Thompson. 1972. Inhibition of flesh browning and skin color fading in frozen fillets of yelloweye snapper (*Lutjanus vivanus*). Nat. Mar. Fish. Serv., SSRF-644, iii + 6 pp.

MFR Paper 1026. From Marine Fisheries Review, *Vol. 36, No. 1, January 1974. Copies of this paper, in limited numbers, are available from D83, Technical Information Division, Environmental Science Information Center, NOAA, Washington, DC 20235.*