PACIFIC COAST PROGRAM ON THE IRRADIATION PRESERVATION OF FISH--PHASE REPORT

Studies on the use of nuclear radiation for the preservation of fish have been started by the U. S. Bureau of Commercial Fisheries in cooperation with the Quartermaster Food and Container Institute for the Armed Forces. This study is primarily a screening operation to select, for possible initial commercial utilization, those species of fish and shellfish that are most adaptable to this new method of preserving food. Two of the possibilities of fish preservation being investigated are: (1) use of ionizing radiation alone for "cold sterilization;" and (2) use of lower levels of ionizing radiation in combination with some conventional method of processing for "radio pasteurization."

On the Pacific Coast, the potentialities of using nuclear radiation for the preservation of fish is being studied at the Seattle Technological Laboratory and, under contract with the U. S. Bureau of Commercial Fisheries (1) at the Department of Food and Dairy Technology, Oregon State College, and (2) at the Food, Chemical, and Research Laboratories, Seattle, Wash.

All fishery products used in this investigation are irradiated at the Materials Testing Reactor Gamma Irradiation Facility at Idaho Falls, Idaho. The product to be irradiated must be packed in hermetically-sealed cans. These cans are placed in a rack that is lowered into a pool of water about 16 feet deep adjacent to spent fuel elements, the source of gamma rays. After being irradiated, each can is checked for radioactive contamination before being returned to the research laboratories.

At Oregon State College, the research is on the use of ionizing radiation in the preservation of Pacific Coast shellfish and smoked fish. At the Food, Chemical, and Research Laboratories, the research is on the effects of radiation on specific microorganisms that commonly are found associated with Pacific cod (Gadus macrocephalus) fillets during storage at the temperature of melting ice.

At the Seattle Technological Laboratory, Pacific cod fillets that have been subjected to increments of ionizing radiation within the dosage range of pasteurization are being studied to determine the effect of such radiation on the shelf life of the fillets at refrigerated temperatures. The irradiated products are being evaluated for changes induced during radiation treatment and in subsequent refrigerated storage by the following tests: (a) organoleptically, for color, flavor, odor, and texture; (b) chemically, for total volatile base, total volatile acid, and trimethylamine; and (c) bacteriologically, for total plate count.

To determine the maximum level of dosage possible before radiation-induced flavors and odors become objectionable, we irradiated cod fillets at levels of 0.23, 0.47, 0.70, 0.93, 1.4, and 1.9 megarads.[1/] Although some radiation odors and flavors were detected in all samples, their intensity generally increased with the level of dosage. The borderline of permissible dosage as judged by the organoleptic acceptability of the fillets appeared to lie between 0.93 and 1.4 megarads.

1/ A RAD IS AN ABSORPTION OF 100 ERGS PER GRAM OF MATERIAL. A MEGARAD IS A UNIT 1 MILLION TIMES AS LARGE.

In another screening experiment, cod fillets were irradiated at dosage levels of 0.23 and 0.70 megarads to determine their approximate storage life at 32° F. In this experiment, it was found that during storage, the cod fillets darkened slightly as the result of having been irradiated. During the first month of storage, a degradation occurred in the quality of irradiated fillets, owing to the darkening of the white meat and the loss of normal flavor of fresh fish. During the remainder of the shelf life, the white meat continued to darken gradually and the texture became tougher until the product was judged unacceptable. The usual odors and flavors of spoilage were not found. The 0.23 megarad samples had a storage life of about 56 days in ice, and the 0.70 megarad samples a storage life of about 112 days in ice. In contrast, the unirradiated samples had a storage life of 10 to 15 days in ice.

In experiments now in progress, cod fillets were irradiated at either 0.1 or 0.2 megarads to determine their storage life at 35° F. Evaluations of quality are being made by means of organoleptic, chemical, and bacteriological tests. The results will be reported at the conclusion of the tests.

--BY DAVID T. MIYAUCHI, CHEMIST,
FISHERY TECHNOLOGICAL LABORATORY,
U. S. BUREAU OF COMMERCIAL FISHERIES,
SEATTLE, WASH.

TECHNICAL NOTE NO. 43 - CONSIDERATIONS ON THE USE OF REFRIGERATED BRINE FOR CHILLING AND STORING FRESH FISH[1/]

ABSTRACT

USE OF REFRIGERATED BRINE FOR CHILLING AND STORING FRESH FISH NOW HAS BECOME COMMERCIALLY IMPORTANT, OWING TO THE ADVANTAGES IN RAPID COOLING, REDUCED PRESSURES UPON THE FISH, AND LOWERED TEMPERATURES IN COMPARISON TO ICING. THE PRESENT PAPER STRESSES THE NECESSITY OF CONTINUOUSLY MAINTAINING BRINE TEMPERATURES OF 29° TO 31° F. AND OF PROPER CIRCULATION OF BRINE THROUGHOUT THE LOAD IF FISH OF EQUAL OR BETTER QUALITY THAN THOSE STORED IN ICE FOR SIMILAR PERIODS ARE TO BE LANDED.

BACKGROUND

The use of refrigerated brine[2/] or sea water for preserving fresh fish aboard a fishing vessel is increasing in commercial importance in the Pacific Northwest. This method of holding fish offers a number of potential advantages over the customary stowage of fish in ice. These include (1) greater speed of cooling, (2) reduced pressures upon the fish, (3) lower holding temperatures, (4) greater economy in handling the fish due to time and labor saved, and (5) longer effective storage life of the fish.

COMPARISON OF KEEPING QUALITY OF FISH IN REFRIGERATED BRINE AND IN ICE

It is important to compare differences between the keeping quality of fish preserved by refrigerated brine and by ice. For this comparison, the temperature range of fish in the brine must be similar to that of the iced fish. With proper icing, the temperature range of the fish varies from 32° to 34° F. For a comparative test, English sole (Parophyrs vetulus) from a single haul were divided into two lots. One lot was heavily iced, and the second lot was placed in refrigerated brine (3 percent salt by weight) at a temperature ranging from 32° to 35° F. Examinations

1/ PART OF THE WORK REPORTED WAS FINANCED BY FUNDS PROVIDED BY THE SALTONSTALL-KENNEDY ACT OF 1954. WORK WAS PERFORMED BY THE SCHOOL OF FISHERIES, UNIVERSITY OF WASHINGTON, SEATTLE, WASH., UNDER CONTRACT FROM THE U. S. FISH AND WILDLIFE SERVICE.

2/ APPROXIMATELY 3 PERCENT SALT BY WEIGHT.

NOTE: CONTRIBUTION NO. 33, SCHOOL OF FISHERIES, UNIVERSITY OF WASHINGTON, SEATTLE.

of these fish indicated that both lots remained in an edible condition for 13 to 16 days. Additional tests with English sole held in refrigerated sea water at 32° to 35° F. produced similar results. Thus, brine or sea water appeared to have no special properties for extending the storage life of fish when its temperature was within the range of that of fish held in ice.

ANTIBIOTICS

The possibility of adding tetracycline antibiotics to chilled brine as an aid to preservation of fish has been investigated at laboratories throughout the world. Use of antibiotics for the preservation of fish, however, is not permitted by the U. S. Food and Drug Administration. Accordingly, the use or presence of antibiotics in fish renders them subject to seizure.

IMPORTANCE OF TEMPERATURE CONTROL

From the viewpoint of keeping quality, the real advantage of refrigerated brine appears to be that the brine temperature can be lowered to 29° to 30° F., or just above the point at which the fish begin to freeze. The importance of this characteristic is related to the observation that temperatures near 32° F. are critical in the storage of fish. Bacterial and enzymatic activity is greatly depressed at temperatures slightly below 32° F. and greatly increased at temperatures slightly above 32° F. The importance of this factor in relation to proper control of temperature and to the keeping quality of fish held in brine can be seen from the following examples: If fish, immediately upon capture, were placed in refrigerated brine at temperatures of 29° to 31° F., it would be expected that the fish could be maintained in an edible condition for about 21 to 28 days, depending upon the species, and whether or not the fish were eviscerated. If the temperature of the brine were 34° to 36° F., however, the expected storage life would be approximately 10 days; and if the temperature were 36° to 38° F., the expected life would be approximately 7 days. For this reason, a temperature range of 29° to 31° F. is recommended for use with refrigerated brine.

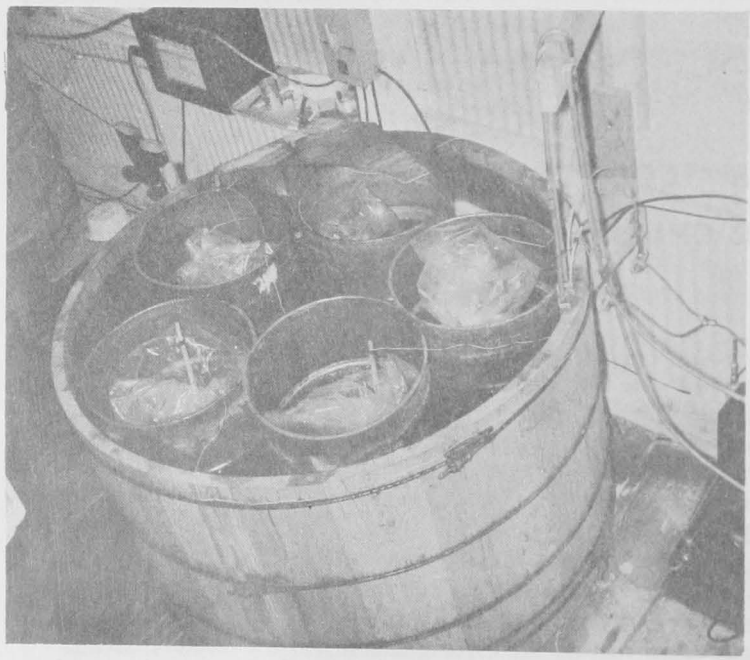

FIG. 1 - EXPERIMENTAL INSTALLATION OF REFRIGERATED SEA-WATER TANKS AT THE SEMIAHMOO CANNERY OF ALASKA PACKERS ASSOCIATION, BLAINE, WASH. THE FIVE DRUMS HELD THE FISH IN REFRIGERATED SEA WATER. THE DRUMS ARE CHILLED BY THE CIRCULATION OF THE SEA WATER IN THE LARGE WOODEN VAT.

NEED FOR PROPER EQUIPMENT

To take full advantage of the potential of refrigerated brines, the user must give attention to the selection of equipment and its operation. Recent work in our laboratories with English sole, true cod, and sockeye salmon (figure 1), and in other laboratories with other species, has indicated that difficulties may be encountered in the use of refrigerated brine storage aboard commercial fishing vessels unless appropriate equipment is available and is operated in a proper manner.

It is possible to obtain and maintain the recommended temperature range by the use of properly engineered and operated refrigerated brine systems. With all refrigeration systems, however, the temperature range of the cooling coils varies between the cut-off and cut-on points of the compressor. The brine temperature normally will be higher than the coil temperature, and the temperature fluctuation of the brine will be smaller than that of the coils, assuming efficient brine circulation and proper tank insulation. With installations in which the brine temperature is controlled by a thermostat in the brine, the thermal inertia of the mass of brine will cause slightly greater fluctuations in the brine temperature than the range for which the thermostat is adjusted. With good equipment and proper controls, the range of temperature variation of the brine may be reduced to 2° F. If the mid-temperature is adjusted to 30° F., the brine therefore will have a maximum of 31° F. and a minimum of 29° F.

With inadequate refrigeration, inefficient brine circulation, or poor thermostat control, the fish is in danger of spoiling, owing to the effect of brine temperatures above 32° F. If continuous refrigeration is not available in combination with adequate brine circulation, local "hot" spots may develop in the corners or at the bottom of the tank. Fish in these locations may deteriorate rapidly. A danger also exists if the refrigeration capacity is not adequate to maintain continuous low brine temperatures during periods of peak loading. In tanks lined with refrigerated coils, poor circulation may lead to excessive icing of the coils which in turn lessens the efficiency of heat transfer from brine to coils. Unrestricted, vigorous circulation of brine around the coils is essential at all times. If proper equipment and temperature control cannot be maintained to provide adequately low temperatures uniformly throughout the brine under all conditions of loading, the addition of crushed ice to the brine will be necessary to insure against loss of quality.

SPOILAGE PATTERN

When fish are stored in refrigerated brine, the development of spoilage appears to be essentially the same as when fish are held with ice. There are, however, slight differences. Usually, there is an odor of hydrogen sulfide emanating from the gill area of fish in the round that have been stored in refrigerated brine. This odor is believed to be due to the growth of anaerobic bacteria in the gill tissue and slime. Normally, in ice, such odors may be dissipated by the bathing action of the melting ice and the drainage of blood and slime to the bilge; or they may not be produced, for the anaerobic bacteria are not able to grow in the presence of air.

Generally, this sulfide odor is not important in estimating the quality of fish, as it is restricted to the nonedible gill area and dissipates upon short exposure to air. Upon long storage in brine, however, the odor becomes apparent in the meat of the fish and, at that time, is indicative of spoilage.

If the fish are dressed (gills and viscera removed), this sulfide or anaerobic type of spoilage is less likely to occur, since the viscera and the bloody mass of the gills provide not only a higher level of contamination but also are more apt to spoil under anaerobic conditions. On the other hand, dressed salmon held in refrigerated brine for long periods may show bleaching or "washing-out" of the meat color in the belly walls as well as greater absorption of salt in these areas.

Proper cleaning and sanitation of the brine tanks, coils, and circulation system at the end of every trip or load is most important. Otherwise a heavy inoculation of bacteria may be carried over into the next load of fish. Both a good detergent and a chlorine-type sanitizing agent should be used.

The rate of formation of certain spoilage compounds, including hydrogen sulfide, depends not only upon the methods used to handle and dress the fish but also upon the type of refrigerated brine system used--whether circulating brine, still

brine, or aerated brine. Further investigation, however, will be necessary to establish the relationship between the type of refrigerated brine system used and the patterns of spoilage that develop.

Current studies at the Seattle Technological Laboratory include consideration of these factors in addition to the relation of prior storage of fish in chilled brines to their subsequent keeping quality if iced or frozen for later marketing purposes. Present evidence indicates that if use of chilled brine storage is restricted to improving the quality of fish when landed, there is no problem in subsequent handling under good commercial practice.

--BY JOSEPH STERN, ASSISTANT PROFESSOR,
SCHOOL OF FISHERIES, UNIVERSITY OF WASHINGTON,
SEATTLE, WASH.

JOHN A. DASSOW, FISHERY PRODUCTS TECHNOLOGIST,
FISHERY TECHNOLOGICAL LABORATORY,
U. S. BUREAU OF COMMERCIAL FISHERIES,
SEATTLE, WASH.

WHITING FILLETS

Whiting is a lean fish that cooks easily and quickly, whether fried, baked, or broiled. One of the popular forms in which this fish can be purchased is as fillets--fresh or frozen in the handy one-pound consumer package or in the economical five- and ten-pound packages for those who wish to stock their freezers.

The frozen fillets are used quite extensively throughout the eastern half of the United States, and particularly in the Middle West where they are featured in fried fish sandwiches.

The home economists of the U. S. Bureau of Commercial Fisheries suggest that you serve Pan-Fried Whiting as the main course for a dinner.

PAN-FRIED WHITING FILLETS

- 2 POUNDS WHITING FILLETS
- 1½ TABLESPOON MILK OR WATER
- DASH PEPPER
- 1 EGG, BEATEN
- 1 TEASPOON SALT
- 1 CUP DRY BREAD CRUMBS, CRACKER CRUMBS, CORNMEAL, OR FLOUR

Combine egg, milk, and seasonings. Dip fish in egg mixture and roll in crumbs. Place fish in a heavy frying pan which contains about $\frac{1}{8}$ inch of fat, hot but not smoking. Fry at moderate heat. When fish is brown on one side, turn carefully and brown the other side. Cooking time approximately 10 minutes, depending on thickness of fish. Drain on absorbent paper. Serves 6.