URI Sea Grant Program

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Fresh Fish Preservation: Glucose Oxidase Dip and Ice Systems

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Seafood technologists have long sought effective ways of preserving fresh fish. Using ice to slow spoilage has been only partly successful. It does offer the advantages of rapid chilling, maintaining a uniform low temperature, and a gentle washing and cleansing of the fish as it melts. For fish caught in cold water and iced, however, the temperature differential is so small that the ice only slightly reduces physiological and microbiological spoilage. It is also difficult in some cases to provide enough ice for effective preservation of large amounts of fish.

In today's marketing system, where consumers demand high-quality products and where fish are marketed a long distance from the source, icing alone is often inadequate for preservation. Freezing is not an acceptable substitute because the final product will not be comparable in quality to fresh fish. Freezing changes the texture of the flesh and results in a loss of water when the fish thaws. A better technique is needed either to replace or to supplement the present icing process.

Biotechnology now offers a possible solution to the fish preservation problem. At URI, researchers have spent over ten years investigating the use of the enzyme glucose oxidase as a substitute for microbial fermentations and preservation of milk products. In the mid-seventies, an undergraduate, Kevin Finnie, was conducting a senior research project on minced fish, and it was discovered that glucose oxidase slowed the spoiling process. This experience led to a project

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supported by Sea Grant to investigate the enzyme as a preservative for fresh fish.

The investigation included the role of the enzyme in preserving fresh fish, the effects of the enzyme on the microbial spoilage of fish, incorporating glucose oxidase into ice systems used to hold and store fish, and, finally, the interaction of the enzyme system with hypobaric storage (reduced pressure and low temperature).

Dip System

A graduate student, Cynthia Field, found that the preservative effects of glucose oxidase on fresh whole winter flounder or fillets were remarkable. Dipping the fish in the enzyme solution, or packing it in layers separated by algin blankets containing immobilized glucose oxidase, resulted in a 50 percent increase in shelf life at refrigerated temperatures when compared to the same product packed in conventional ice. Taste and smell tests indicated that the physiological spoilage process was slowed by this treatment. This was borne out by Torrymeter and pH measurements, which established that the integrity of the fish skin surface was maintained for a longer time by enzyme preservation. The generation of ammonia which accompanies spoilage and poor smell was reduced in the treated fish.

Another graduate student, Lauren Haft, demonstrated that the glucose oxidase preservation process also retarded bacterial deterioration. The enzyme treatment decreased the total population of microbes on the fish. It also modified the usual pattern of microbial spoilage-which normally occurs in three distinct phases--by delaying the onset of the first and second phases by a week.

Ice System

Robert Collette then incorporated the enzyme into ice in an effort to improve the quality of the fish before it is unloaded from fishing vessels and afterwards. The glucose oxidase ice was found to be effective in delaying spoilage on board ship and on shore in winter flounder and scup. It worked equally well in all storage situations in which it was tested, including boxing and chilling fish in seawater. Fishermen as well as seafood processors could benefit from the use of enzyme ice, since fish would remain appetizing and edible longer without any change in current handling practices.

Glucose Oxidase in Hypobaric Storage

When the enzyme preservation process was used in fish stored in a laboratory hypobaric chamber developed by Dr. Stanley Barnett, a faculty member in the Department of Food Science, and student Wen-Yi Yen, there was a remarkable synergistic effect; that is, the success of the combined techniques was greater than one might expect of either process by itself. Winter flounder fillets dipped in the glucose oxidase solution and stored under reduced pressure at low temperature had a 90 percent extension of their shelf life compared to fish stored in conventional ice. Current studies in a full-scale hypobaric chamber, loaned by Grumman Allied Industries, bore out the laboratory tests on dressed winter flounder (see Fresh Fish Preservation: Hypobaric

Storage by Patti Anne Kelly, URI Sea Grant Program Report #1, 1983).

Glucose oxidase apparently offers those who market fish a new and useful technique for extending the shelf life of this perishable product. Enzyme preservation is flexible and can be adapted to different situations. The enzyme allows the preservation system to react to changes in the environment and thus prolongs the enzyme's preservative effects.

Glucose Oxidase Dip System

The glucose oxidase/catalase enzyme dip system consists of unit/ml glucose oxidase made in a 4 percent glucose solution. Glucose oxidase, which contains traces of catalase, is available as a food grade enzyme, and has been employed in the U.S. food industry since the 1950s. The glucose used in the system must also be food grade.

The Dipping Procedure

1. Prepare a 4 percent glucose (Food Grade Dextrose) solution by dissolving 3.4 lbs. (54 oz. or 1.52 kilograms) of glucose into 10 gallons (38 liters) of cold tap water. This solution can be used for 2-3 days if it is covered securely and kept at refrigerated temperatures.

2. Immediately prior to dipping the fish, mix 1.7 oz (50 ml) of glucose oxidase enzyme into the cold glucose solution.* The enzyme must be well distributed before proceeding to the next step.

3. Dip the fish for a minimum of one minute; longer periods are not necessary. Drain the excess solution and store the fish under appropriate conditions.

Glucose Oxidase Enzyme Ice System

The glucose oxidase/catalase enzyme system, consisting of 1 unit/ml glucose oxidase made in a 1 percent glucose solution, can be incorporated into ice to preserve fish fillets. It can extend the life of iced fish by approximately 50 percent.

The Ice Manufacture Procedure

1. Prepare a 1 percent (Food Grade Dextrose) solution by dissolving 0.8 lbs. 13 oz. (380 grams) of glucose into 10 gallons (38 liters) of cold tap water. This solution must be covered securely and chilled to approximately 0 (32 F).

2. Immediately prior to freezing, mix 1.7 oz. (50 ml) of glucose oxidase enzyme into the cold glucose solution.* The enzyme must be well distributed before proceeding to the next step.

*NOTE: The formulation described above utilizes a commercial glucose oxidase enzyme preparation containing traces of catalase and having an activity of 750 units/ml. The concentration of glucose oxidase in the final prepared solution should be approximately 1000 units/liter (3785 units/gal.).

3. This enzyme and glucose mixture should be quickly frozen, stirring occasionally during the freezing process. After freezing, the ice blocks must be crushed, placed in plastic bags, and stored until utilized. (Larger scale ice manufacture can be accomplished by metering each

solution into a conventional ice-making machine.)

Suppliers of glucose oxidase:

1. Fermco Biochemics Inc.
   2020 Lunt Avenue
   Elk Grove Village, IL 60007
   312-640-1112

2. Miles Laboratories, Inc.
   Biotechnology Group
   P.O. Box 932
   Elkhart, IN 46515
   291-262-7453

Suppliers of glucose (Food Grade Dextrose):

1. Corn Products (Unit of CPC)
   International Plaza
   Englewood Cliffs, NJ 07632
   201-894-4000

2. A.E. Staley Co.
   2200 E. Eldorado
   Decatur, IL 62525
   217-423-4411

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