INHIBITION OF MOLD ON SMOKED MULLET

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ABSTRACT

Modern refrigeration does not completely solve the problem of spoilage caused by bacteria, molds, and yeast. Four to six weeks at 37° F. is considered the maximum storage life for untreated commercially-smoked mullet. In the present study of mold growth on smoked mullet, potassium sorbate was used as a mold inhibitor along with vacuum packaging. In a first test series, potassium sorbate concentrations of 1-percent, 2-percent, and 3-percent were incorporated in the brine-soaking solution. In a second series, a 5-percent potassium sorbate solution was used as a dip prior to packaging. The smoked mullet were stored at 37° F. and examined biweekly. Results showed that smoked mullet can be stored successfully in a vacuum when aseptically packaged, either plain or treated with potassium sorbate, up to 14 weeks and possibly longer.

INTRODUCTION

In early days, salting, drying, smoking, and natural cold were the only means by which fish could be kept for any extended period. Since smoking fish was a means of preservation, little attention was paid to developing a desirable flavor. Today, with modern refrigeration facilities, the primary objective is to produce a product with a flavor that is distinctive.

Many species of fish of southern origin are smoked, producing an excellent product. The species most commonly smoked are mullet, Spanish mackerel, sturgeon, catfish, and flounder. Smoking methods may vary with different species.

Present commercial practices in that area do not utilize either a mold inhibitor or vacuum packaging to extend the storage life of smoked mullet. On the contrary, the fish are wrapped in cellophane with no means of excluding oxygen, which is essential for mold growth.

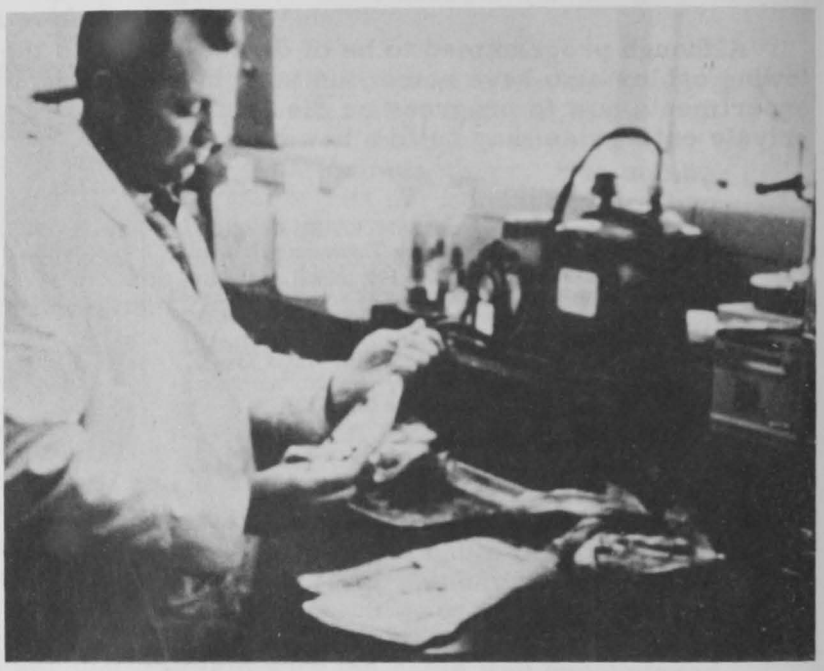

Fig. 1 - Scientist inspecting fish for mold development.

Development of mold is one of the chief causes of deterioration in smoked fishery products. Modern packaging methods employing special films such as polyethylene in conjunction with vacuum packaging have greatly reduced microbial spoilage. Frequently, in packaged fish, however, the sharp fins puncture the bags thereby releasing the vacuum. The hole permits entrance of microorganisms that grow well in the presence of air.

Sorbic acid was reported by several workers to retard mold growth on species of fish such as salmon, halibut, and sablefish (Boyd and Tarr 1955). In this experiment potassium

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sorbate, a derivative of sorbic acid, was used to inhibit mold growth on smoked mullet. It thus was easy to apply as an aqueous dip or to incorporate in the brine. (Since mold thrives on moisture, however, the fish must be thoroughly dry before being packaged.)

Wood smoke has long been known to protect fish from bacterial and mold spoilage. Among the chemical constituents of the wood smoke causing this preservative action are carbon dioxide, formaldehyde, formic acid, acetic acid, methane, acetone, methyl and ethyl alcohols, and various phenols (Linton and Dyer 1946). In addition to the preservative action of the smoke, hot smoking temperatures of 130° to 180° F. produce a product with a very small microbial population.

Mold requires oxygen to live and reproduce. Vacuum packaging lowers the amount of oxygen sufficiently to cause molds to remain dormant.

When potassium sorbate solutions are applied to fish, the potassium sorbate hydrolyzes to sorbic acid thereby giving protection to the product. Researchers at Charles Pfizer and Company (1955) noted that dehydrogenation of fatty acids to the unsaturated fatty acids is one phase in the growth of molds in foods. This is accomplished by a dehydrogenating enzyme system, and without this reaction, the mold cannot reproduce. Potassium sorbate is an unsaturated fatty acid similar to those formed in the enzymatic dehydrogenation reaction, and when present in excess of the amount produced by the reaction, it tends to inhibit the reaction and, consequently, the growth of mold.

Potassium sorbate was preferable to sorbic acid because of its solubility in water. As stated above the potassium sorbate eventually hydrolyzes to sorbic acid. Various concentrations of the agent were necessary to determine the most effective level and yet be economical enough for commercial use.

It was desirable to compare adding potassium sorbate before and after smoking to determine the most economical and effective method of application. Potassium sorbate was also tested for its effectiveness under good and poor sanitary conditions.

Mold not only changes the flavor of the product but also produces undesirable changes in appearance. These factors result in great economic loss to the fishing industry and the consumer. The present project was therefore started to study the effect of (1) simulating commercial conditions, (2) soaking mullet in various concentrations of potassium sorbate prior to smoking, and (3) dipping mullet in a potassium sorbate solution after smoking.

EXPERIMENTAL PROCEDURES AND RESULTS

Mullet used in this experiment were purchased from a local dealer and were in excellent condition. They were caught 12 hours prior to processing.

The smoking procedure was carried out in a laboratory-scale smokehouse designed at this laboratory (Waters and Bond 1960). The design permits fairly accurate control of smoke temperature.

Three procedures were used as shown in the flow chart of figure 2. Details of the experiments follow:

EXPERIMENT 1: Procedure 1 - Preliminary study simulating commercial condition. Fish used in this experiment were packaged using commercial methods to determine the maximum storage life of commercially-smoked mullet. Packaging consists of cellophane-wrapped and vacuum-packaging in bags. This group was divided into four lots and treated as follows:

1. Lot A--Brined in 10-percent salt (37.7 salometer reading).

2. Lot B--Brined in 10-percent salt, plus 1-percent potassium sorbate.

3. Lot C--Brined in 10-percent salt, plus 0.1-percent butylated hydroxytoluene.

4. Lot D--Brined in 10-percent salt, plus 1-percent potassium sorbate and 0.1-percent butylated hydroxytoluene.

Approximately 50 pounds of fresh mullet, divided into four lots, were soaked in aforementioned solutions 30 to 60 minutes. The fish were well drained and smoked with pecan wood smoke for 12 hours at 130° to 180° F. The fish were then removed from the smokehouse with hands and instruments that had not been sterilized. Each lot was subdivided; one-half was packaged in vacuum bags (29-inch vacuum), and the other half was wrapped in cellophane. All fish were stored at 37° F. and examined biweekly.

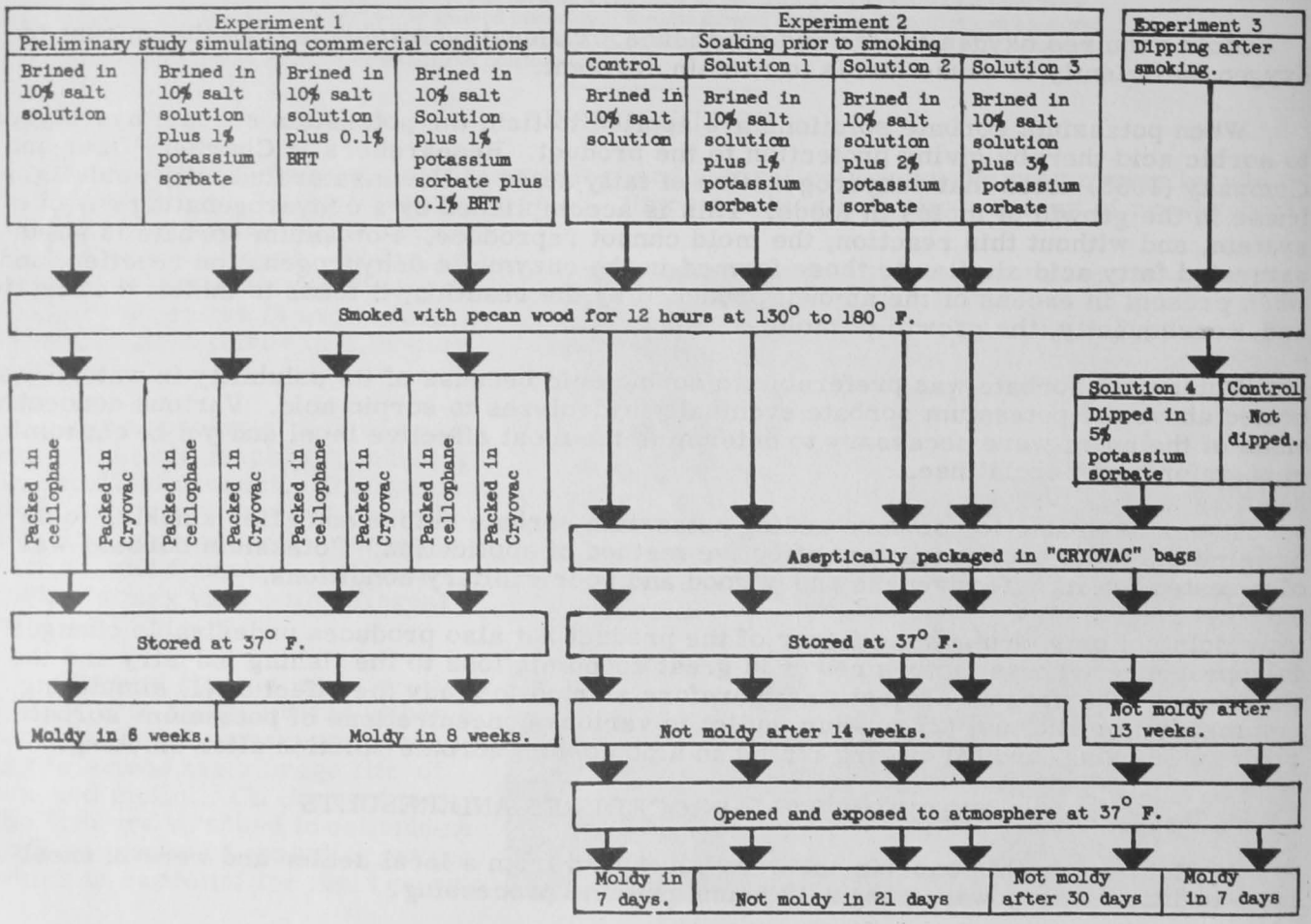

Fig. 2 - Flow diagram showing experimental procedures and results.

Results 1 - Owing to handling with hands and instruments that had not been sterilized, this group of fish molded quickly. Both the vacuum-packaged and the cellophane-wrapped lot containing only brine showed visible mold in 6 weeks. All other portions treated with BHT and potassium sorbate began showing a small amount of mold in 8 weeks. These results served to illustrate that careful aseptic methods are a prerequisite for extending storage life of smoked mullet.

The fish wrapped in cellophane was a duplication of commercial practices. The vacuum-packaged group was made to determine how much longer the storage life could be prolonged by excluding atmospheric oxygen. Butylated hydroxytoluene was used as an antioxidant and was not used in other experiments. Rancidity was not detected in samples treated or untreated with butylated hydroxytoluene.

EXPERIMENT 2: Procedure 2 - Soaking in potassium sorbate prior to smoking. This group of fish was packaged under sanitary conditions to determine the effectiveness of

potassium sorbate incorporated in the brine solution. Storage life, economics of application, and concentration of solution were studied. The fish were divided into the following four classifications according to the types of brining solution:

1. Control--ten percent salt (37.7 salometer reading).

2. Solution 1--ten percent salt, plus 1-percent potassium sorbate.

3. Solution 2--ten percent salt, plus 2-percent potassium sorbate.

4. Solution 3--ten percent salt, plus 3-percent potassium sorbate.

Four packs of 20 mullet, approximately $\frac{1}{2}$ pound each, were immersed for 60 minutes in the above solutions and drained 30 minutes at room temperature. They were then smoked with pecan wood smoke for 12 hours at 130° to 180° F. The fish were removed from the smokehouse nearly sterile because of being subjected to 180° F. smoke. They were aseptically placed in bags using gloves that had been sterilized by immersion in boiling water. Theoretically, the product was still nearly sterile. A vacuum (29 inches) was pulled on the bags to exclude the oxygen. The fish were stored at 37° F. and inspected visually for mold growth at 2-week intervals.

Results 2 - After a few days storage, the vacuum was lost, apparently owing to fish fins puncturing the bags. Even so, controls and treated fish of all three concentrations of potassium sorbate showed no growth of mold after storage for 14 weeks at 37° F. The moisture content varied somewhat within the controls and within the treated fish. No mold developed on these moist samples, however, even when the vacuum had been released. After 14 weeks of storage, all the bags (controls and treated fish) were opened at one end, contaminated by handling, and left exposed to 37° F. atmosphere. The controls began to mold in 7 days, and soon, the product in all the control packages was moldy. The treated fish remained free of mold after 21 days of exposure to the atmosphere. This finding illustrated the effectiveness of potassium sorbate in suppressing the growth of mold even when the package becomes punctured and the food is exposed to the atmosphere. This portion of the experiment was terminated, as it was apparent that the treated fish would not mold within the period of extension of storage life desired by the industry.

EXPERIMENT 3: Procedure 3 - Dipped in potassium sorbate after smoking. This method was expected to deposit 0.05-percent to 0.1-percent of the agent on the surface of the fish to prevent the growth of mold if the bag became punctured. The fish were packaged under sanitary conditions. They were divided in two parts according to the type of dipping solution:

1. Control--no potassium sorbate.

2. Solution 1--five percent potassium sorbate (no salt).

The control consisted of 20 fish, approximately $\frac{1}{2}$ pound each, soaked 60 minutes in a 10-percent salt solution. The fish were well drained and smoked 12 hours with pecan wood smoke at 130° to 180° F. They were removed from the smokehouse and packaged in bags using aseptic techniques. The packages were stored at 37° F. and examined biweekly.

Another group of fish were processed the same as the control except that the fish were dipped in a solution (5-percent potassium sorbate), drained 15 minutes at room temperature, and aseptically packaged in bags. They were stored at 37° F. and examined biweekly.

Results 3 - Controls and fish dipped in a 5-percent potassium sorbate solution remained free of mold growth after 13 weeks of storage at 37° F. Again the bags lost the vacuum, but still no mold appeared. The bags were opened, contaminated, and exposed to the atmosphere for the remainder of the experiment. The fish were examined every 2 or 3 days. Controls began to mold in 7 days, but the treated fish did not show growth of mold in 30 days of exposure. This finding again demonstrated the effectiveness of potassium sorbate in inhibiting the growth of airborne mold spores. The experiment was terminated at this point.

DISCUSSION

Results of these experiments show that aseptic handling and packaging is of utmost importance. When packaged with conventional handling, the fish become moldy in 6 to 8 weeks. When aseptic techniques were employed, along with vacuum packaging, smoked mullet was successfully stored up to 14 weeks without development of mold.

Potassium sorbate is an antimycotic or fungistatic agent insofar as it does not kill molds but inhibits their growth by blocking their metabolism. Heavily contaminated foods or foods prepared under poor sanitary conditions will not benefit from the use of potassium sorbate.

Good sanitation is a must in plants processing perishable foods. The extreme perishability of fish and the necessity for much hand-processing increase the need for good sanitation. The plant and its furnishings, equipment, processing practices, and personnel must meet certain minimum sanitary requirements, including those of the Food and Drug Administration.

SAFETY REQUIREMENT

The spores of Clostridium botulinum are ubiquitous and airborne. They are extremely difficult to exclude from any food-packaging process. This bacteria's spores will germinate and produce toxin, however, only under certain conditions: (1) a low oxygen tension such as in a vacuum package, (2) presence of a suitable media such as moist protein, and (3) presence of a suitable temperature, usually quoted by authorities as 77° to 98° F. These conditions apply to any food and not only to smoked fish. The usual cautions to keep under refrigeration, therefore, apply to this as to other foods such as canned ham and cooked turkeys packed in polyethylene films.

CONCLUSIONS AND RECOMMENDATIONS

Treated smoked mullet stored at 37° F. for 14 weeks were served to a taste panel of local citizens. The only criticism was that the fish had a very slight rancid taste. They nevertheless were well accepted.

Soaking in a potassium sorbate solution prior to smoking the mullet was more economical than the dip method. Dipping and draining is another step in the process that is time consuming. Inhibitor results were the same for both methods. Since the fish treated with 1-percent, 2-percent, and 3-percent potassium sorbate did not mold, a 1-percent solution as a pre-smoke treatment is recommended from a cost standpoint.

This study indicates that careful sanitation with aseptic handling, followed by vacuum packaging, will produce smoked fish with a storage life of 14 weeks or more. Although untreated mullet did not become moldy, it is suggested that a 1-percent potassium sorbate be used as added protection to the fish if the bag becomes punctured and exposed to the air. Storage at 37° F. is another factor insuring against rapid development of mold.

By extending the storage life of smoked mullet, reduced returns and extended lines of distribution should more than compensate for the cost of additional sanitation care, vacuum packaging, and addition of potassium sorbate.

SUMMARY

One group of mullet was smoked to simulate commercial practices in handling and packaging. Another pack was smoked using three different concentrations of potassium sorbate

in a 10-percent salt solution as a presmoke treatment. A third pack was smoked using a 5-percent potassium sorbate solution (no salt) as a dip prior to packaging. The control consisted of soaking the mullet in a 10-percent brine prior to smoking. The fish were left in their respective solutions for 1 hour. They were then drained 30 minutes before being smoked with pecan wood smoke at 130° to 180° F. The first group was divided into halves; one-half was wrapped in cellophane and the other half was vacuum packaged. The second and third groups were aseptically vacuum packaged in bags and stored at 37° F. The maximum storage life of the first group was 8 weeks. The other two variations were examined every 2 weeks up to 14 weeks of storage. No mold developed on any of the mullet in those two groups. At this point, it was decided to open all the bags and expose the mullet to the atmosphere to determine if potassium sorbate was effective in inhibiting mold growth. Mold appeared on the opened controls after 7 days of exposure, but treated fish remained free of mold for at least 21 days after exposure.

A caution is given in regard to the development of Clostridium botulinum. The growth of this organism on any food product seriously menaces public health.

LITERATURE CITED

BOYD, J. W., and TARR, H. L. A
1955. Inhibition of Mold and Yeast Development in Fish Products. Food Technology, vol. 9, no. 8, pp. 411-412, Chicago, Ill.

CHARLES PFIZER and CO., INC.
1955. Sorbistat (Sorbic Acid, Pfizer). Data sheet no. 510, Charles Pfizer and Co., Inc., Brooklyn, N. Y., p. 4.

LINTON, E. P., and DYER, W. J.
1946. Keeping Quality of Smoked Fillets. Fisheries Research Board of Canada, Progress Reports of the Atlantic Coast Station, no. 36, pp. 19-23.

WATERS, MELVIN E., and BOND, D. J.
1960. Construction and Operation of An Inexpensive Fish Smokehouse. Commercial Fisheries Review, vol. 22, no. 8 (August), pp. 8-12. (Also Separate No. 597.)

SOCKEYE SALMON USE THE SKIES TO NAVIGATE

Early sea captains and desert wanderers may have been the first humans to discover celestial navigation, but apparently the fish beat them to it. Evidence that sockeye salmon use the skies and the stars to orient themselves while migrating has been found by scientists of the Fisheries Research Board of Canada at its Biological Station at Nanaimo, B. C.

Observations on adult salmon have produced evidence that migration is limited to particular pathways at particular times, and the influences of daily, lunar, and seasonal cycles in activity or behavior, of weather changes, and of hydrodynamic forces have been substantiated.

Experimental studies on orientation in sockeye smolts has indicated consistent directional tendencies when visions of only the sky is permitted; overcast skies or artificial covering has resulted in the fish pointing in random directions.

Moonlight, sunset after-glow, or even city lights may interfere to some extent, but the studies indicate that celestial orientation is an essential component for the successful migration of the sockeye out of lakes and towards the sea. (Canadian Trade News, January 1961.)