GUIDELINES FOR THE PROCESSING OF HOT-SMOKED CHUB

UNITED STATES DEPARTMENT OF THE INTERIOR

U. S. FISH AND WILDLIFE SERVICE
BUREAU OF COMMERCIAL FISHERIES

Circular 331

UNITED STATES DEPARTMENT OF THE INTERIOR
Walter J. Hickel, *Secretary*
Russell E. Train, *Under Secretary*
Leslie L. Glasgow, *Assistant Secretary*
for Fish and Wildlife, Parks, and Marine Resources
Charles H. Meacham, *Commissioner*, U.S. FISH AND WILDLIFE SERVICE
Dayton L. Alverson, Acting Director, BUREAU OF COMMERCIAL FISHERIES

Guidelines for the Processing of Hot-Smoked Chub

By

H. L. SEAGRAN, J. T. GRAIKOSKI,
and J. A. EMERSON

Circular 331

Washington, D.C.
January 1970

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During the past several years, a number of botulism outbreaks have been attributed to the consumption of improperly handled or processed fish products, including smoked chub (Anonymous, 1968). Analyses have indicated that the causative agent in these outbreaks is a toxin produced by the bacterium Clostridium botulinum Type E. The development of this highly fatal toxin can be prevented, however, by eliminating the causative organism or by inhibiting its growth in a food product.

The purpose of this pamphlet is to provide descriptive guidelines for the preparation of hot-smoked chub that will be capable of meeting (1) the known requirements of the regulatory agencies concerned and (2) the economic requirements important to industry. These process recommendations are based on extensive research[1] that considered the importance and interrelations of sanitation, raw material quality, product storage and handling, and particularly the process variables of heat and additives (sodium chloride and sodium nitrite) in attaining a safe, wholesome, and acceptable smoked chub product.

PLANT SANITATION

Raw fish and their processing areas may have large numbers of micro-organisms that hasten the spoilage of smoked fish, that destroy its wholesomeness, and that may lead to food poisoning. It is therefore important to process and handle smoked fish in a clean and fastidious manner. This method of processing and handling may be achieved by taking all necessary precautions to avoid a buildup of bacteria in the plant and to prevent contamination of the cooked smoked fish product. A pamphlet has been published (Dougherty and Seagran, 1967) to provide effective and practical sanitation procedures for use in smoked fish plants.

RAW MATERIAL QUALITY

Proper handling and preparation of both raw and frozen fish are prime requisites for a quality product. As the bacterial contamination of the raw fish increases, the probable number of organisms surviving the subsequent smoking process likewise increases. As a result, storage capabilities of the product are impaired. Table 1 lists some essential characteristics of good quality raw material.

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[1] Petition to permit the addition of sodium nitrite in smoked chub. Submitted by the Bureau of Commercial Fisheries to the U.S. Food and Drug Administration, 1968. 22 pp.

TABLE 1.--Quality signs of good raw material

Fresh fish	Frozen fish
Firm, elastic flesh	Solidly frozen flesh; no browning or discoloration
Fresh, mild odor	Little or no odor
Bright, clear, full eyes	Packages not damaged
Red, clean gills	No signs of dehydrated or dried-out flesh
Shiny, bright skin	

NONFROZEN STOCKS

In the preparation of raw fish for brining, the worker should inspect each fish, remove all entrails and waste material as necessary, and then carefully wash the fish with a continuous rinse[2] of heavily chlorinated water. The use of heavily chlorinated wash water (continuously maintained at 50 - 100 parts per million (p.p.m.) active chlorine--see Appendix A) serves two main purposes: (1) It lowers the bacterial load and (2) it facilitates the removal of surface slime and residual blood in the visceral cavity. The cleaned fish are then placed within a clean container to await brining.

FROZEN STOCKS

Frozen chub should be kept at temperatures that will keep them frozen (preferably below 0° F.), except when being thawed for processing. Thawing can be carried out in one of several ways.

Air Defrosting

When frozen stock is thawed in refrigerated coolers, the temperature of the product should not exceed 45° F.

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[2] A continuous flow system is preferred; as an alternate, several changes of clean, chlorinated water (with agitation) can be used.

Water Immersion

When frozen stock is thawed by immersion in water, a continuous flow system of potable water should be used. The temperature of the water in the thawing tank should not exceed 70° F.

Adequate protection should be provided to prevent contamination when thawing the fish. Thus, after thawing and inspecting the fish, they should be finally rinsed with clean, chlorinated water as described in the previous section and placed in a clean container for brining.

PROCESSING

Based on present practices that are allowed by the U.S. Food and Drug Administration and the present capability of the industry, we recommend the following processing and control techniques for the preparation of smoked chub. If these techniques are applied appropriately, the product will have high quality and good yield, be adequately free from bacterial contamination, and be resistant to microbial spoilage at acceptable refrigeration temperatures. The techniques of brining and smoking are discussed separately in the sections that follow.

BRINING

Although common salt (sodium chloride) now is used primarily to add flavor to the smoked fish product, its original purpose in foods was to inhibit the growth of bacteria. This important factor is often overlooked in present-day practice. The extent to which salt inhibits bacterial growth, of course, will depend on its concentration in the fish flesh. Unfortunately, the level of salt required to independently limit the growth of all bacteria is unpalatable to the taste; however, since the growth of most bacteria of public health significance can be inhibited by about 5 percent salt (in the water phase of the flesh[3]), it is important to maintain as high and as uniform a concentration of salt in the smoked product as practical. A present requirement is that the finished smoked chub product have a water phase salt (sodium chloride) content of not less than 3.5 percent as measured in the loin muscle.

Besides sodium chloride (NaCl), the bacteriostatic effectiveness of sodium nitrite ($NaNO_2$) in inhibiting the growth of microorganisms in

[3] $$\frac{\text{Percent salt in product} \times 100}{\text{Percent salt in product} + \text{percent moisture in product}} = \text{percent salt in water phase}$$

foods has also long been recognized, particularly in meats (Jensen, 1954). Although the use of sodium nitrite as a general preservative in certain fishery products has been permitted since 1964, its use was only recently approved as a food additive, in combination with sodium chloride, to aid in inhibiting the outgrowth and toxin formation from C. botulinum Type E in the commercial processing of smoked chub (Federal Register, 1969). Sodium nitrite therefore may be safely used[4] for this purpose when incorporated (via the brining process) in the finished smoked product at the allowed concentration of not less than 100 p.p.m. (parts per million) nor more than 200 p.p.m., as measured in the loin muscle.

It is not a simple procedure to achieve a uniform concentration of salt and nitrite at the prescribed levels in the finished product. If controlled procedures are followed (taking into account various raw-material variables), however, it is possible to obtain the desired level of the additives within acceptable limits. A single brining solution containing both the salt (sodium chloride) and sodium nitrite at prescribed concentrations is preferred. The concentrations of the additives in the brine will need to be varied somewhat from time to time, however, depending on certain brining variables, which are considered next.

Brining Variables

During brining many factors affect the uptake and uniformity of the salt and nitrite by the fish. These factors must be considered in order to obtain the desired level of the additives in the final product. First, the amounts of salt and nitrite required to achieve the desired brine concentrations must be completely dissolved in the water before the fish are added. An important factor that influences the uniform uptake of the additives by the fish is the agitation of the fish in the brine solution. The best way to agitate the fish is by slow, continuous circulation of the brine with a mechanical device. If this method cannot be used, the fish should be thoroughly stirred manually several times during the brining period. Care also should be taken that all the fish are kept continually below the surface if constant agitation is not used. The fish can be kept submerged by means of a weighted screen. To limit the growth of bacteria during brining, the operator should maintain the temperature of the brine at or below 38° F.

The size of the fish also influences the rate of salt and nitrite uptake and their uniformity in the final product. A large fish requires

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[4] Sodium nitrite is highly toxic; it should be used with extreme caution. The use of this compound should therefore be highly restricted to responsible plant officials.

more time to acquire a certain concentration of the additives than does a small one; therefore, it is important that fish of uniform size be brined in one tank.

The condition of the fish also influences the rate of salt and nitrite uptake and the uniformity of their concentration in the final product. For example, thawed fish absorb salt at a faster rate than do fish that have never been frozen. Likewise, as fish age or become less fresh, they absorb salt at a faster rate.

Experimental brining results (Weckel and Wosje, 1966) show that several other variables affect the degree of salt absorption and its uniformity in fish. Table 2 summarizes the more important of these variables. All of them must be considered in order to maintain a uniform concentration of salt and nitrite in the final product.

TABLE 2.--Variables affecting the absorption of salt and nitrite additives by fish during brining procedures

Variables	Effect on additive absorption by fish	Degree of effect	Effect on uniformity of additive absorption from fish to fish
Pertaining to the brining procedure:			
Increase in brine concentration (e.g., from 35° to 45° salometer)	Increases	Significant	Decreases
Increase in ratio of brine to fish (e.g., from 1:1 to 2:1)	Increases	Significant	Increases
Increase in time of brining (e.g., from 8 to 16 hours)	Increases	Slight	Increases
Increase in circulation of brine	Increases	Slight	Increases
Increase in temperature of brine	Increases	Slight	None
Pertaining to the fish:			
Freezing-thawing	Increases	Very significant	Increases
Age (quality) of fish	Increases (with increasing age)	Significant	Increases
Scaling	Increases	Slight	Increases
Size of fish	Decreases (with increasing age)	Significant	Decreases
Different parts of fish (loin vs. belly flap)	Varies (belly flap increases; loin decreases)	Very significant	Large variation

A Suggested Brining Procedure

On the basis that the finished smoked product will be processed to 160° F. for 30 minutes and will include in the loin muscle a salt (sodium chloride) concentration (in the water phase) of not less than 3.5 percent and a sodium nitrite concentration between 100 and 200 p.p.m., the following brining procedure when applied to fresh, medium chub, has generally provided satisfactory results. A change of brining conditions to accommodate different brine strengths[5] and/or brining times, fish to brine ratios, or raw material quality and condition, for example, is not only quite practical, but will prove necessary on occasion. To have uniform products, each processor will have to develop his own brining schedules, however, taking into account the likely variables operative in his plant.

For each 100 pounds of clean chub, use 200 pounds (22.4 gallons) of 35° salometer brine containing 1,000 p.p.m. of sodium nitrite at 38° F. (equivalent to 37.5° salometer at 60° F.). This amount and strength of brine can be approximated by dissolving 19 pounds of salt (sodium chloride) and 3.2 ounces (91 grams) of sodium nitrite in 181 pounds (21.7 gallons) of water. The brine strength should be checked with a salometer, preferably after the fish have been placed in the brine and have been stirred to ensure that it is 35° salometer (at 38° F.).

Brine the fish for about 16 hours with agitation as previously described.

The brined fish are hung on clean smoke sticks and should be rinsed briefly (spraying preferred) with chlorinated water. They should not be left immersed in fresh water for more than several minutes, however, for the salt and nitrite will leach from the fish. The rinsed fish should then be allowed to drain briefly in forced, chilled air before being placed in the smoke ovens.

SMOKING

Proper control of the smoking operation is important to the acceptability of the product and to the economics of the process. Smoking affects the yield, quality, composition, and storage characteristics of the product, and it also affects the safety of the product. Smoking, in addition to cooking and imparting both color and flavor to the fish flesh, is important in the control of microbial spoilage of the finished product. The ingredients of the smoke (for example, phenols) are harmful to bacteria; but, unless the concentrations are fairly high (such as in dark smoked fish), they do not contribute materially to

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[5] See Appendix B for charts to simplify the calculation of alternative brining schedules.

the inhibition of spoilage. It is possible to have a smoking and monitoring system that will aid greatly in obtaining an excellent product.

The Importance of Heat

From a public health standpoint, the primary reason for using heat during smoking is to destroy the bacteria on the fish. Most vegetative (growing) cells of bacteria (and their toxins) are readily destroyed by relatively mild heating (for example, 160° F. for 30 minutes). Some bacteria form spores, however, that are very resistant to heat. These bacteria include a number that are of public health significance, such as botulinum. If the plant has effective sanitation and if high quality of the raw material is maintained, however, such bacteria and their spores can be kept to relatively low numbers, although they cannot be assumed to be absent. The numbers of bacteria are further reduced significantly by the application of a sufficiently high level of heat during smoking. The higher the temperature and the longer it is applied, the greater are the number of bacterial spores destroyed. Once a total heating time is established for a given plant operation, however, it is well to not vary it significantly, because the level of nitrite residual in the processed product can be lowered gradually with an increase in heating time.

Smoking Variables

Many differences exist in industrial equipment for smoking fish--including the design and construction of the ovens and methods for providing and controlling heat and smoke. A variety of recommended designs for equipment to increase the efficiency of the smoking operation have been published. An evaluation of the relative merits of these various designs is beyond the scope of this pamphlet. Certain important factors, however, are involved in the smoking process. A better understanding of these factors will permit more efficient process design and equipment modification and replacement, which in turn will result in a product of higher quality in respect to yield, uniformity, and composition, and will permit closer conformance to prescribed practices. Heat, humidity, and smoke are of major importance.

1. Heat.--For proper use of heat, three needs must be satisfied. First is the need for an ample and continuous heat reservoir, such as can be provided by gas, electricity, or steam coils, that can introduce heat rapidly into the oven. Second, but of equal importance, is the need for a positive control of the rate of heat input, in order that the desired temperatures can be maintained in the oven. Third, for uniform quality and yield of

product, is the need to provide means for distributing heat uniformly throughout the oven. This uniform distribution of heat is most efficiently accomplished by mechanical forced-draft circulation, such as provided by modern, controlled smokehouses currently available from various suppliers of industrial ovens.

2. Humidity.--The introduction of moisture into the oven during certain stages of the smoking process allows better control over the yield of the product and the appearance of the product (especially the wrinkling of the skin and the development of the color). Even more important is the fact that bacteria are more effectively destroyed when the humidity is high. Also, increased levels of humidity provide for more efficient transfer of heat into the product and thus allow shorter total process times. Various simple methods can be used to increase the relative humidity in any given smokehouse. They, of course, vary in their efficiency and degree of control. The methods include injection of steam or water from a fog or spray nozzle in the oven itself or in the duct carrying the smoke to the oven.

3. Smoke.--To provide the necessary amount of smoke when required (perhaps continuously) without disturbing the temperature-humidity environment in the oven and to maintain product quality, the operator should be able to produce smoke outside the oven and then introduce this smoke into the oven. The simple charring of sawdust and the conveyance of the resulting smoke to the oven through a duct by use of forced draft are the means usually used. Numerous types of efficient smoke generators are available commercially.

Many designs and modifications of smoking ovens that take into account the various factors mentioned above may be used. Figure 1 shows a conceptual diagram of a smoke oven incorporating the requirements just discussed.

The minimum heating requirements for hot-smoked chub that contain the salt and sodium nitrite residuals described previously, as set forth by the Food and Drug Administration, calls for an internal fish temperature of at least 160° F. for at least 30 minutes. The heating of chub to this temperature may at first seem difficult to attain. However, with the incremental application of controlled heat to the oven, the addition of moisture during the early stages of the heating process, and application of dense smoke during the initial low-temperature drying period, an internal fish temperature of 160° F. for 30 minutes can be achieved and an acceptable product can be produced.

Figure 2 shows comparative temperature come-up times in the smoking oven and fish during a low- and a high-heat-input smoking

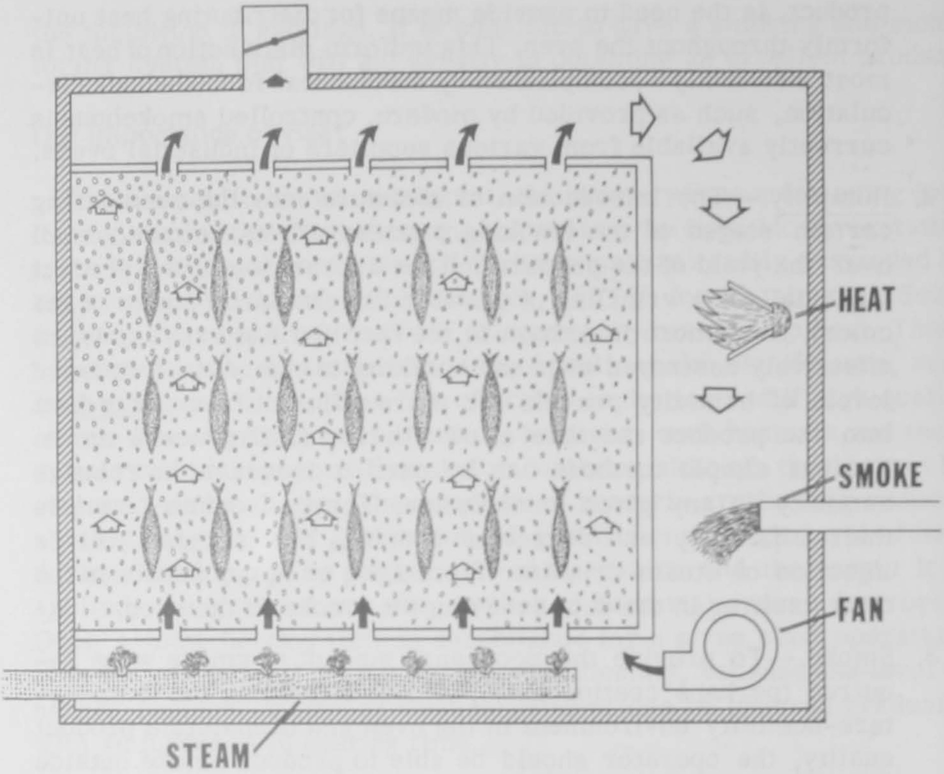

Figure 1.--Conceptual design of a controlled smoking oven.

run. Obviously, the temperature in the house can be quite different from that in the fish, particularly for short process periods. The temperature in the house, for example, may be from 40° to 60° F. higher than that in the fish. A temperature of 160° F. for 30 minutes can readily be attained in the fish within a total process time of 3 to 4 hours.

A Suggested Smoking Procedure

Although the exact method of smoking used will depend on the fish and equipment used, as well as on product and yield characteristics desired, the following procedures will produce generally satisfactory results.

After the brined fish are rinsed and drained, it is desirable that they be exposed to a predrying period in forced, cool air before being exposed to heat. This exposure can be accomplished before the fish (on sticks) are placed in the smoke-ovens or afterwards. In either event, depending on the degree of wetness of the skin of the raw fish, up to about one hour of forced, cool air circulation may be required to adequately dry the skin surface.

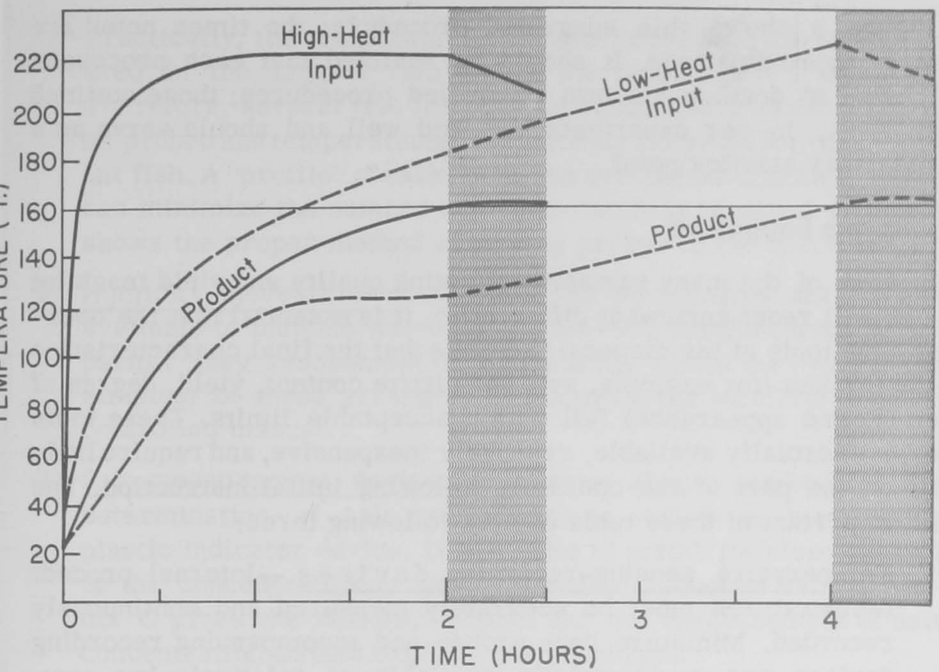

Figure 2.--Heating curves showing the relation between product and oven (input) temperatures, comprising high- and low-heat input ovens.

The next step, accomplished in the smoke-oven, involves a further drying of the raw fish tissues at a slightly elevated temperature (about 100° F.) to "set" the flesh. This step generally may be accomplished within 1 hour. This latter step is critical, because it prevents excessive distortion or splaying of the belly walls during the final, high-temperature cook. Smoke is generally introduced during this entire fixing period and may overlap slightly into the predrying and final heating periods, depending on the color intensity desired. Color intensity in the finished product increases with heating, however, even though smoking is discontinued. At the completion of the fixing period, it is desirable to begin introducing external moisture into the oven to develop and maintain a high relative humidity for the final cooking period.

The heat now may be raised rather quickly so as to reach an internal loin temperature of 160° F. Moisture introduction is maintained well into this period. Upon reaching 160° F, this temperature must be continuously maintained in the product for at least 30 minutes. After this heating requirement is met, heat can be shut off, smokehouse doors opened, and the product allowed to cool rapidly. After this initial cooling period, the product should be chilled promptly as discussed in a subsequent section.

Figure 3 shows this suggested procedure; the times noted are merely approximations. It should be realized that each processor will need to develop his own controlled procedures; those outlined here have, in our experience, worked well and should serve as a satisfactory starting point.

Monitoring Equipment

In view of the many variables affecting quality and yield (each lot of fish will react somewhat differently), it is essential that the operator have tools at his disposal to ensure that the final characteristics of the product (for example, salt and nitrite content, yield, degree of heating, and appearance) fall within acceptable limits. These tools are commercially available, relatively inexpensive, and require little skill on the part of the operator, following initial instruction. The most important of these tools are the following three:

1. Temperature sensing-recording devices.--Internal product temperatures must be accurately measured and continuously recorded. Miniature heat probes and accompanying recording devices are commercially available at relatively low cost. These devices can also be used to monitor concurrently the oven temperature to aid in overall heat-process control.

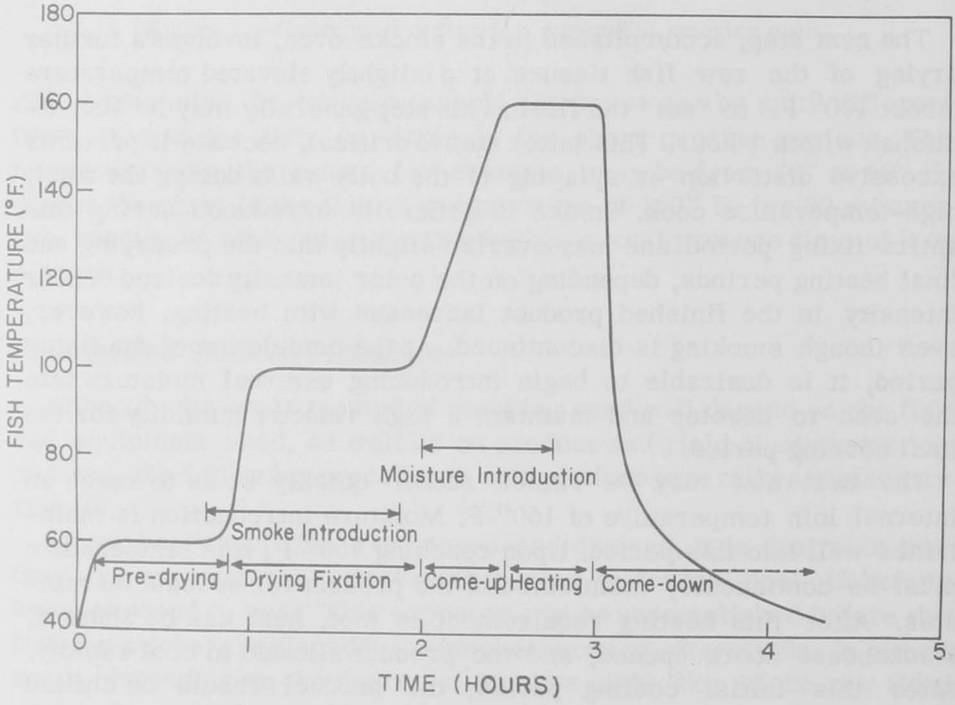

Figure 3.--Schematic drawing of the sequence of operations for smoking chubs.

Practically, the temperature during processing must be measured in the largest fish and in the coldest part of the oven. Therefore, several fish in different house locations can initially be probed and temperatures continuously recorded for the different fish. A "profile" of each house can thereby be obtained, which can minimize the number of probes routinely required. Figure 4 shows the proper method of placing probes in the fish flesh.

2. Humidity measurement.--Simple and inexpensive devices are available to indicate wet-bulb and dry-bulb temperatures, which permit easy assessment of the humidity within the oven. If the simplest of these arrangements is used, the humidity must be controlled manually.

3. Salt-measurement devices.--A rapid, simple method for the determination of salt concentrations, using an inexpensive plastic indicator device, is available to permit the close control of the concentration of salt in fresh and smoked fish. Appendix C gives the detailed method for the measurement of salt concentration in fish flesh by this technique.

   Unfortunately, no equally simple method has yet been developed to permit the plant operator to routinely determine the sodium nitrite concentration in his finished product. Initially, it will therefore be necessary to have local testing laboratories determine this concentration. Then, correlating this value with the salt concentration determined on the same sample, and after

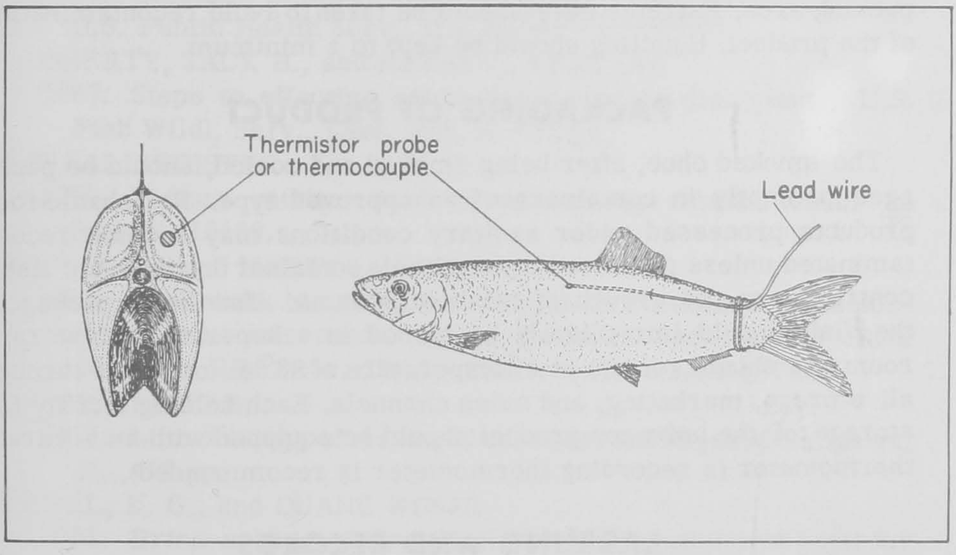

Figure 4.--Location of thermocouple or thermistor probe for measuring internal fish temperature.

adjusting the nitrite concentration in the brine accordingly, the processor should be able to stay within the acceptable nitrite tolerance by routinely checking salt concentrations in the finished product, with only occasional spot checks of nitrite concentration by analysis.

PACKAGING AND HANDLING

The smoked product must be handled properly to minimize recontamination by bacteria. After being smoked, the fish must be rapidly cooled under refrigeration, promptly packaged, labeled, and recorded. Thereafter, it must be held under constant refrigeration to minimize bacterial growth during the distribution and retailing of the product.

INITIAL COOLING OF PRODUCT

Immediately after being smoked, the fish should be allowed to cool as quickly as possible while still in the house. It should then be transferred to a clean, sanitized, refrigerated cool-room for rapid chilling (38° F. or below) before being packaged. This room should not be used for any other purpose than for the cooling of the non-packaged fish. During transportation to the cooling and packaging areas and while being cooled, the fish should be kept on the smoke sticks used during the smoking process and should not be handled. After being chilled to a temperature of 38° F. or below, the smoked fish should be transported promptly to an immediately adjacent packing area. Extreme care should be taken to avoid recontamination of the product. Handling should be kept to a minimum.

PACKAGING OF PRODUCT

The smoked chub, after being smoked and cooled, should be packaged promptly in containers of an approved type. Perishable food products processed under sanitary conditions may become recontaminated unless protected by a suitable container that does not itself contribute to the growth of microorganisms. After being packaged, the fish should immediately be placed in a separate cold-storage room and should remain at a temperature of 38° F. or below through all storage, marketing, and sales channels. Each holding facility for storage of the unfrozen product should be equipped with an accurate thermometer (a recording thermometer is recommended).

LABELING AND RECORDS

Using labels to identify the product provides the distributor and consumer with instructions on the safeguards necessary for the sale and the consumption of the product. Suitable records provide means of tracing suspected products.

All operations in the packaging and labeling of the smoked fish should be in compliance with those standards prescribed by State and Federal sanitary food laws and other regulations that are applicable to fishery products.

SUMMARY

In view of the many variables affecting product quality and yield of smoked chub, the processor must have at his disposal the proper methods and equipment to ensure that the final product will have characteristics that fall within acceptable limits. The characteristics of primary concern are (1) a uniform and adequate concentration of salt and nitrite, (2) an adequate degree of heating, (3) acceptable yield, and (4) good appearance and related acceptance factors (flavor, odor, and texture). By the judicious application of processing technology to attain these characteristics and by careful sanitation of plant and of raw materials, the resulting product will not only be wholesome and of acceptable quality but will resist microbial spoilage when held under adequate refrigeration.

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APPENDIX A

SANITIZING METHODS FOR USE IN THE FISHERY PLANT

Sanitizing is a two-operation process that involves: (1) removing visible and invisible dirt, residue, and films with a detergent or soap; and (2) killing the remaining bacteria with a bactericide.

Detergents

Detergents are materials that help perform thorough and efficient cleaning. Many detergents are available that will do the cleaning job required in a fishery plant. TSP (trisodium phosphate) and sodium carbonate (soda ash) are simple, easy to handle, and quite effective detergents. Either TSP or soda ash dissolved in water (1 to 2 ounces of solid detergent per gallon of water) are effective in penetrating under and dissolving slime, grime, and other wastes. Both TSP and soda ash, however, are moderately corrosive. In places where these compounds might cause trouble, regular soap or a syndet (synthetic detergent) should be used. These products are more expensive, but generally are efficient at penetrating dirt and films and floating them away. A local sanitation products distributor or a chemical supplier should be contacted for advice on choosing the best detergents and for ensuring that the products selected conform with applicable laws for plants processing food.

Bactericides

Bactericides are compounds that can be used to kill bacteria. Although any of several bactericides can be used under certain specific conditions, the most common and economical bactericide depends on free (available) chlorine for its action. Solutions having free chlorine kill most surface bacteria quite efficiently; furthermore, they tend to reduce undesirable odors. Chlorine solutions (for use in a fishery plant) may be prepared in any of three ways: (1) by mixing chlorine gas from a steel cylinder directly with water (2) by diluting a liquid chlorine compound, or (3) by dissolving a solid chlorine compound. A system using chlorine gas appears to be simple but requires special equipment designed and installed by experts. Liquid chlorine compounds are solutions of hypochlorite, such as household liquid bleaches. Dry chlorine compounds are powdered hypochlorites. Any chemical supply house can provide either liquid or solid chlorine compounds. An efficient way to introduce concentrated liquid chlorine into special washing systems is through the use of a metering pump (which can be furnished by a supplier of chlorine equipment and compounds), a plastic tank to hold the hypochlorite solution, and suitable piping.

Caution

Detergents and bactericides should be stored in approved containers, suitably labeled, in areas removed from food processing to prevent accidental contamination of the fish.

APPENDIX B

CHARTS FOR CALCULATING BRINE STRENGTH

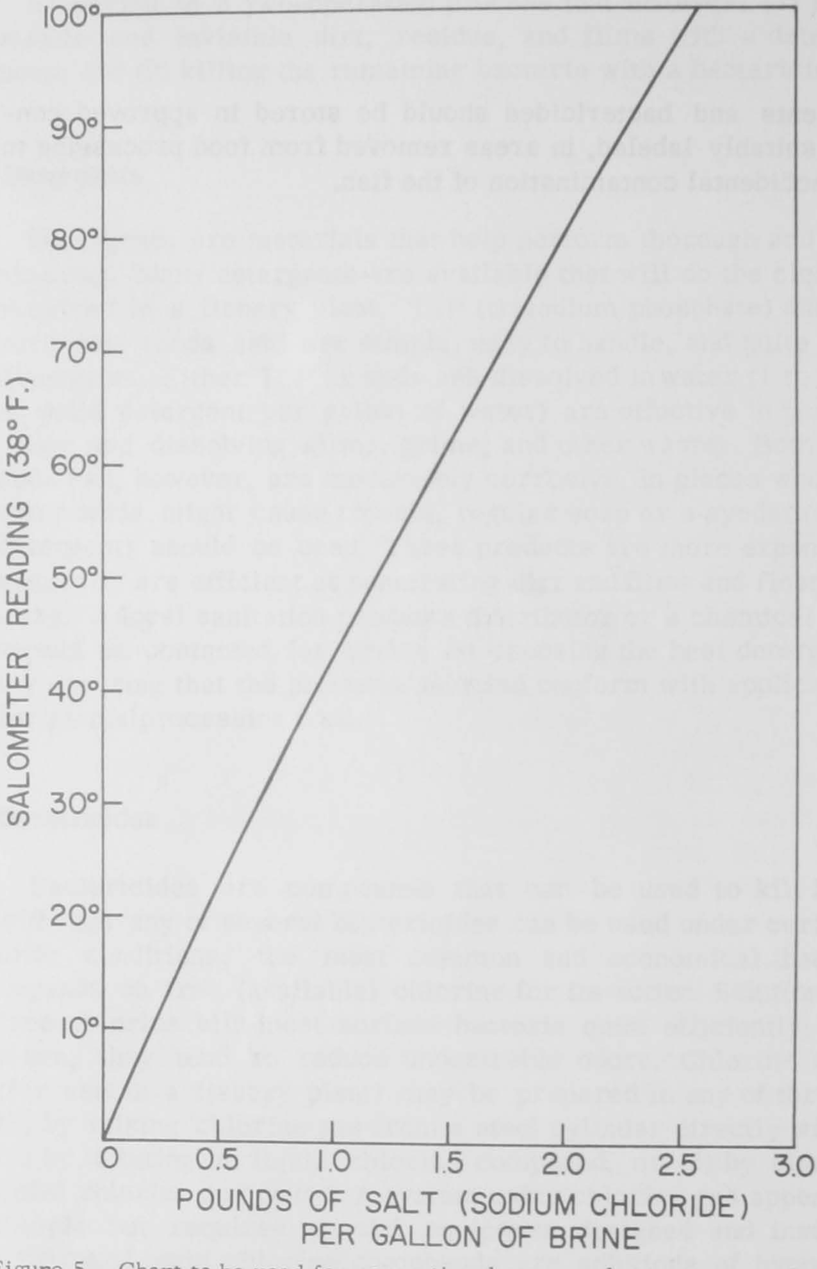

Figure 5.--Chart to be used for converting degrees salometer to pounds of salt (sodium chloride) per gallon of brine at 38° F.

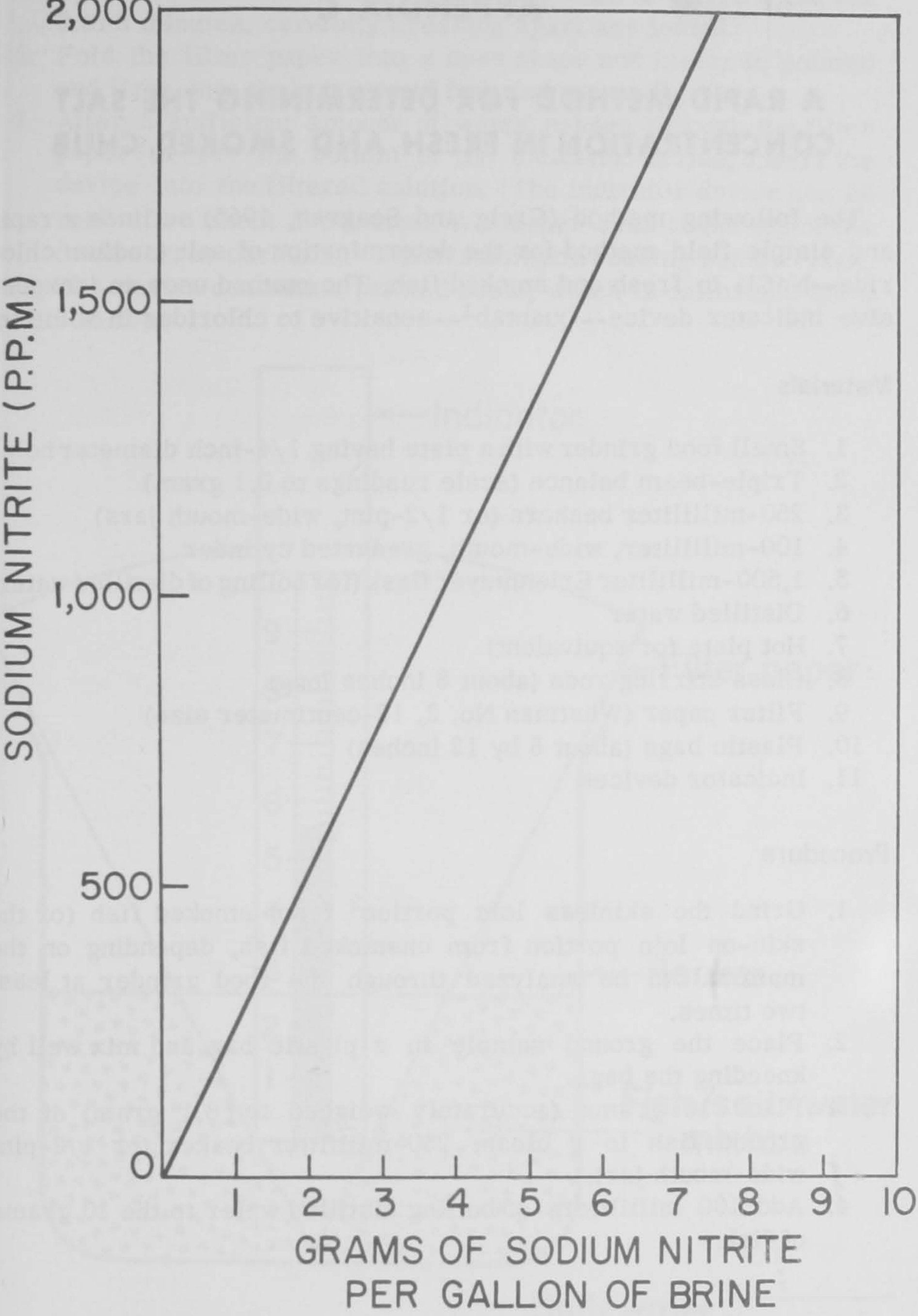

Figure 6.--Chart to be used for converting parts per million (p.p.m.) sodium nitrite to grams of sodium nitrite per gallon of brine at 38° F.

APPENDIX C

A RAPID METHOD FOR DETERMINING THE SALT CONCENTRATION IN FRESH AND SMOKED CHUB

The following method (Greig and Seagran, 1965) outlines a rapid and simple field method for the determination of salt (sodium chloride--NaCl) in fresh and smoked fish. The method uses an inexpensive indicator device--Quantab[1]--sensitive to chlorides in solution.

Materials

1. Small food grinder with a plate having 1/4-inch diameter holes
2. Triple-beam balance (scale readings to 0.1 gram)
3. 250-milliliter beakers (or 1/2-pint, wide-mouth jars)
4. 100-milliliter, wide-mouth, graduated cylinder
5. 1,500-milliliter Erlenmeyer flask (for boiling of distilled water)
6. Distilled water
7. Hot plate (or equivalent)
8. Glass stirring rods (about 8 inches long)
9. Filter paper (Whatman No. 2, 12-centimeter size)
10. Plastic bags (about 8 by 12 inches)
11. Indicator devices

Procedure

1. Grind the skinless loin portion[2] from smoked fish (or the skin-on loin portion from unsmoked fish, depending on the material to be analyzed through the food grinder at least two times.
2. Place the ground sample in a plastic bag and mix well by kneading the bag.
3. Place 10 grams (accurately weighed to ± 0.1 gram) of the ground fish in a clean, 250-milliliter beaker (or 1/2-pint wide-mouth jar).
4. Add 100 milliliters of boiling distilled water to the 10 grams of fish.

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[1] Quantab, type 1176, Ames Company, Elkhart, Ind. (Trade names referred to in this publication do not imply endorsement of commercial products.)

[2] The proper portion of the product to be taken for salt determination is the loin muscle (the thick meaty part adjacent to the backbone, rather than the meat adjacent to the rib cage). This portion of the fish will contain the minimum concentration of salt and the maximum concentration of moisture.

5. Mix the fish and water thoroughly with a stirring rod for 2 to 3 minutes, carefully breaking apart any lumps.
6. Fold the filter paper into a cone shape and insert it, pointed end first, into the mixture of fish and water (fig. 7.)
7. After a sufficient amount of water passes through the filter paper to wet the bottom of the indicator device, insert the device into the filtered solution. (The indicator device can be read after about 5 minutes. A marker area at the top of the device turns dark blue to indicate when a reading can be taken. The device contains a printed scale, which is calibrated from 0 to 10).

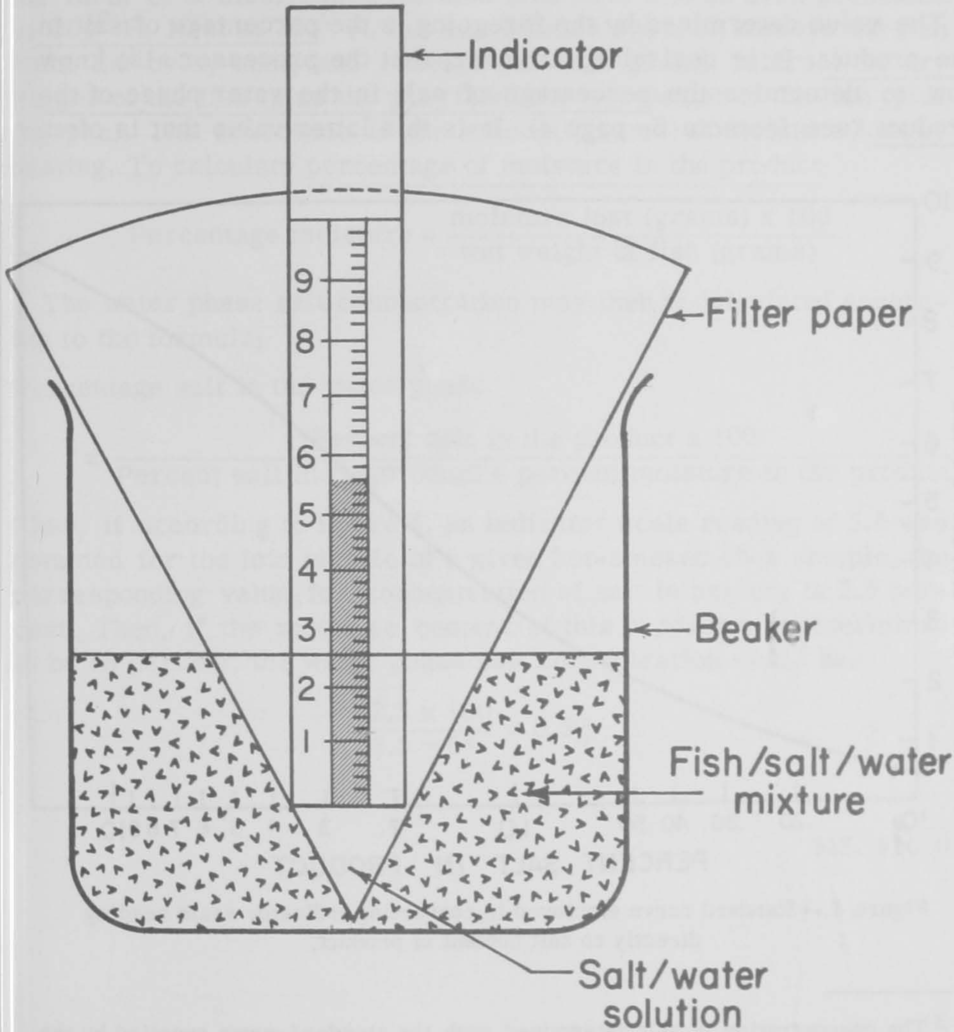

Figure 7.--Rapid determination of salt (NaCl) concentration by a direct-reading method, showing placement of indicator inside the filter paper cone.

8. Accurately note the scale reading.
9. Find this number on the indicator scale of the standard curve used in converting the indicator-scale readings directly to the concentration of salt in the product (fig. 8.).[3]
10. Draw a horizontal line from the number on the indicator scale to intersect the curve.
11. At this point of intersection, draw a vertical line to intersect the percent-salt-in-product scale.
12. Record this value as the percentage of salt in the product.

Calculation

The value determined by the foregoing is the percentage of salt in the product. It is desirable, however, that the processor also know how to determine the percentage of salt in the water phase of the product (see footnote 3, page 4). It is this latter value that is often

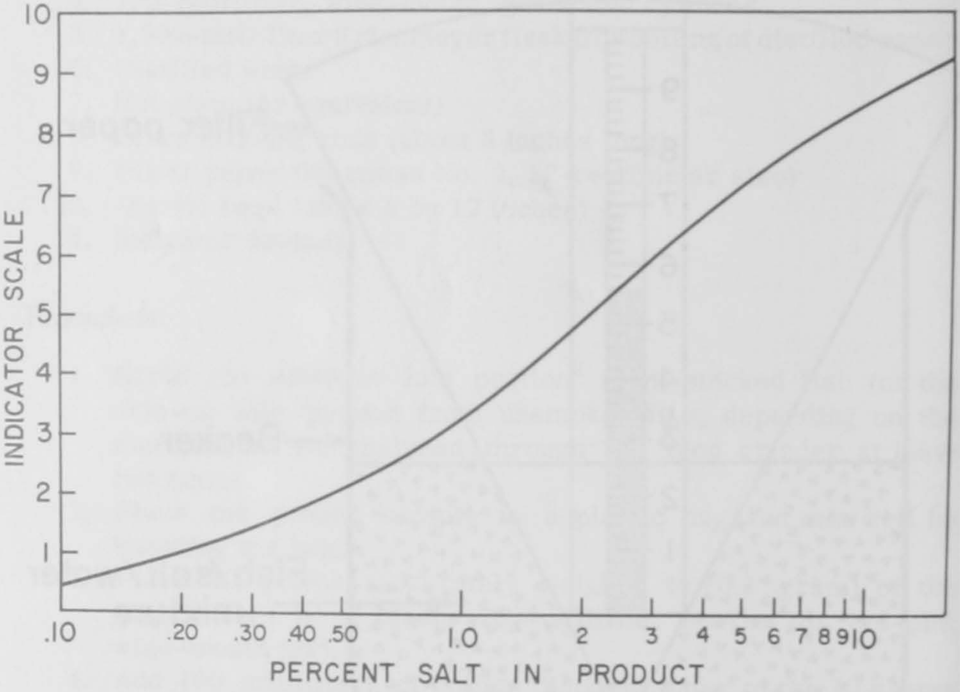

Figure 8.--Standard curve employed in converting indicator scale reading directly to salt content of product.

[3] The concentration of salt determined with the standard curve supplied by the manufacturer of the indicator device must be multiplied by 10 to give the concentration of salt in the fish product. This factor has been incorporated in the scale of figure 8.

referred to in relation to safety of the product and is the value that will be of interest to the public regulatory agency official. To calculate the percentage of salt in the water phase, one must know not only the percentage of salt in the product but also the percentage of moisture in the product.

The percentage of moisture in the final smoked product can be determined relatively easily by drying a sample of the mixed loin muscles to constant weight in an oven. To do this, proceed through step 2 of the Procedure for determining salt concentration. Then, place about 70 grams (accurately weighed to $\pm$ 0.1 gram) of the ground fish on a preweighed piece of heavy-gage aluminum foil molded into the form of a dish. Place the dish (and fish) into an oven preheated to 300° F. Heat at 300° F. for 4 to 6 hours and then remove the fish from the oven, cool, and reweigh (to $\pm$0.1 gram). Subtract the dry weight of the fish (plus the pan) from the wet weight of the fish (plus the pan). The difference is the amount (grams) of moisture lost by heating. To calculate percentage of moisture in the product:

$$\text{Percentage moisture} = \frac{\text{moisture lost (grams)} \times 100}{\text{wet weight of fish (grams)}}$$

The water phase salt concentration may then be calculated according to the formula:

Percentage salt in the water phase

$$= \frac{\text{Percent salt in the product} \times 100}{\text{Percent salt in the product} + \text{percent moisture in the product}}$$

Thus, if according to figure 8, an indicator scale reading of 5.6 was obtained for the loin muscle of a given hot-smoked chub sample, the corresponding value for concentration of salt in product is 2.5 percent. Then, if the moisture content of this product was determined to be 68 percent, the water phase salt concentration would be:

$$\frac{2.5 \times 100}{2.5 + 68} = 3.5\%$$

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