SPOILAGE IN CANNED FISHERY PRODUCTS

Certain changes which occur in canned products after sterilization or processing are beneficial and improve the quality of the product. Canned salmon eaten immediately after packing may taste "flat" as if insufficiently salted or the taste may be excessively salty, depending on the portion of the contents tasted. Other cans of the same pack sampled after a short storage period will taste sufficiently salted. The salt added in filling requires time for an even and complete distribution throughout the contents. Sardines or tuna packed in oil may taste "raw" or "flat" if sampled immediately after canning. The oil in which these fish are packed is only absorbed gradually.

There are other changes which affect the product adversely. Strictly speaking, many of these changes should be called deterioration rather than spoilage. The commercial value of the food is lowered and it may be unappetizing but not absolutely inedible. However, since the product is of lower grade and frequently unmerchantable, it is considered spoiled. We have then two general types of deterioration in canned products; first, that due to physical and chemical changes, and second, spoilage brought about through micro-biological action. It is necessary to determine the type and cause of spoilage in order to determine whether the product was properly prepared, of suitable raw material, or to locate faults in materials or methods.

CLASSIFICATION OF SPOILED CANS

There are certain easily identifiable evidences of spoilage in canned foods which have been classified as follows:

Flipper.—A can which may be normal in appearance, but if one end is struck on a box or table, the other end becomes convex, though the convexity may be pressed down again. A flipper is the initial stage of a swell, but may also be caused by overfilling or lack of vacuum.

Springer.— A can having convex or bulging ends, which may be pressed flat again with the fingers, but will spring out again after pressure is released.

Swell.—A can with badly bulged ends resisting pressure with the fingers or if the ends are pressed down, they spring back immediately on the release of pressure.

NOTE.—[FL–89. Spoilage in canned fishery products. Pages 323–354 and 89–93 are reprinted from Research Report 7, Fish and Wildlife Service, U. S. Department of the Interior. The complete report (366 pp.) is a reference book on seafood canning and is obtainable from the Superintendent of Documents, Washington 25, D. C. Price $1 a copy.]

Flat sour.—A can whose contents have been spoiled by micro-biological action without the formation of gas and therefore gives no external indication of spoilage. The product has a sour taste and may or may not have a sour odor when the can is opened.

Hydrogen swell.—A can with swelled ends caused by the formation in the can of hydrogen gas as a result of corrosion of tin plate. Varying quantities of metal are usually dissolved in such cans. The contents are almost always sterile and often fit for food. Such swells are externally indistinguishable from swells caused by micro-biological action, and can only be identified by analysis of the gas in the head-space, and through the heavily etched interior of the container.

Buckles.—A type of swelled can which may be the result of improper cooling. The internal pressure during processing may be so great as to bulge or distort the can ends so that they cannot return to their normal position after cooling. The seams of such cans are usually strained so badly that they subsequently leak and the cans spoil through the entrance of micro-organisms. A buckled can may also represent the final stage of a swell.

Leakers.—These are cans exuding a portion of the contents. Cans may become leakers through (1) faulty seaming, either by the can maker or canner (usually the latter); (2) defective tin plate; (3) internal corrosion or external rusting; (4) buckling; (5) excessive pressure within the can as a result of gas formation caused by micro-biological action in decomposition, or by hydrogen gas through corrosion; (6) external damage such as battering, caused by excessively rough handling in manufacture or shipping; (7) nail holes occurring when cases are poorly or carelessly nailed or are damaged in shipment.

Paneled cans.—These are cans ruptured or distorted through excessive external pressure; that is, they are the opposite of buckles.

PHYSICAL AND CHEMICAL DETERIORATION

The most important factors in deterioration, loss, or spoilage brought about through physical or chemical means are: (1) Discoloration, (2) perforation and corrosion of tin plate; (3) foreign tastes; (4) undesirable textures; (5) freezing; (6) rusting; (7) faulty technique; and (8) unsuitable products.

DISCOLORATION

The problem of discoloration is most serious in packing shellfish and crustacea, but it may also be met with in canning salmon, chowders, fish cakes, kippered herring and other fishery products. It is usually due to physical or chemical action, but may be caused by micro-biological processes, for example, the "angry" or deep-red color sometimes observed near the backbone in tainted canned fish. This color tends to fade on exposure to the air.

BLACKENING

Blackening of the contents or inside of the can is most often encountered in packing crab, clams, shrimp and lobster, but may also be found in other canned products. It occurs most readily where the product has an alkaline reaction. Sulfur compounds in the flesh of these species break down in processing and unite with the iron base of the tin plate to form iron sulfide. This substance is not injurious to the consumer, but the product acquires a most unappetizing appearance and unpleasant flavor.

Formerly, sulfide blackening in canned marine products could only be combated by the use of parchment-paper can liners, preventing contact between food and container, and by the addition of small amounts of organic acid. Studies by the Research Laboratory of the National Canners Association indicated that zinc salts would reduce the formation of black in canned corn by combining with sulfide compounds to form zinc instead of iron sulfide. Zinc sulfide is harmless, white and is therefore unnoticed. This laboratory then developed a lacquer containing small amounts of zinc, to be used as an inside lining for cans used for products liable to blackening. As the zinc is contained in the lacquer and the sulfide formed is also trapped there, little or no zinc is found in the product. Difficulty in packing vegetables was the primary incentive for this research, but the enamel developed has done more than anything else to reduce or inhibit blackening in canned fishery products. Parchment paper linings and the use of organic acids are still necessary to some extent as blackening may otherwise occur at the side seam, where the enamel lining is occasionally fractured in can making.

COPPER SULFIDE DISCOLORATION

Some discoloration in fish and clam chowders has been traced to the use of copper lined can-filling machines. A thin film of copper oxide or copper salts gradually forms on the copper surface. The chowder coming in contact with the copper dissolves some of these copper salts which then react with sulfides formed in processing, resulting in copper sulfide and causing serious darkening throughout the product.

A dark, inky blackening may occur in canned clam products when the dark "stomach" or body mass is not removed in canning. The exact nature of this discoloration is not well understood. It is not invariably found in uncleaned canned clams, but appears irregularly and seems to be associated with the type of food material consumed. The only remedy known at present is thorough cleaning and washing of the clams previous to canning.

Some blackening of canned products has been traced to the use of rubber conveyor belts. There is a certain amount of sulfur on the surface of new rubber belts, which may be converted to sulfurous acid by water and heat, then into tin or iron sulfide by union with the metal of the can.

DISCOLORATION CAUSED BY PROCESSING TIMES AND TEMPERATURES

Processing temperatures and pressures may be a cause of discoloration. For instance, minced razor clams processed at 240° F. (10-lb. pressure) are appreciably darker in color than those processed at 236° F. (8-lb. pressure). Crab processed at 240° F. will acquire an unpleasantly dark color, while the color will not be affected if a longer process at lower temperature is used. Norwegian style fish balls lose their white color if processed over too long a period or at temperatures higher than 228° F. (5-lb. pressure). Packers of these products and others of similar type must control processing times and pressure very closely to prevent serious loss through discoloration. The use of processes at 10 pounds or higher pressure, considered necessary in packing most non-acid products, must be foregone if a merchantable product is to be secured. While processes used for clams, crabs and fish balls are of the "border line" type, loss through insufficient sterilization is generally slight.

STACK BURNING

This type of discoloration is similar to that caused by overprocessing; in fact, it is a form of over processing. A considerable amount of heat is retained over a long period when canned products are stacked or cased before they are sufficiently cooled. Cooking goes on over a much longer period than is intended, which affects both color and flavor unfavorably. Stack burning is usually thought of in connection with the canning of fruits, or possibly such marine products as clams or lobster. Nevertheless Clough (1937) points out instances of deterioration through stack burning in canned salmon and warns that discoloration through this cause must be guarded against in canneries with a large daily production, where it is a temptation to warehouse the pack at the earliest possible moment.

PERFORATION AND CORROSION

Loss in canning may occur through perforation, the product "eating" through the wall of the container, or the inside may become corroded or etched so that the product is unmerchantable

Loss is usually greatest in the canning of acid fruits, but may occur in the canning of fishery products though more rarely.

Corrosion depends to a large degree on the presence of oxygen. Cruess (1938) reported that in the presence of oxygen the can acts as a primary cell of the oxidation type. That is, the reactions which occur in the can may be explained upon the basis of an electrolysis in which oxides of tin and iron are formed and hydrogen is liberated.

Slack-filled cans are therefore more liable to corrosion than well filled cans of the same product held under the same conditions, for the headspace is greater and the volume of air contained is larger. Other things being equal, cans with low vacuum are more liable to corrosion than containers with a high vacuum. Air should be expelled from product and headspace as completely as possible.

The rate of corrosion and perforation in tin cans, like other chemical reactions, is dependent on the temperature; that is, it increases in rapidity as the temperature of storage is raised. For this reason it is advisable to store canned goods in a cool place, thus minimizing perforation by reducing the rate of corrosion.

Increased corrosion as well as stack burning may be the result of packing the cans while still warm or stacking them in large piles while insufficiently cooled. Cans should be thoroughly cooled before packing or stacking to reduce corrosion as well as for reasons given elsewhere.

FOREIGN TASTES

Canned fishery products have been ruined through such causes as lubricating oil dripping into the cans while passing through filling or sealing machines. Lack of sanitation in canning is apt to cause foreign tastes, as in poor cleansing of brine tanks or pipe lines leading to fillers in products such as soups or chowders. Foreign tastes may also be due to the presence of micro–organisms. Canned salmon is believed to have acquired disagreeable flavors because the salmon had consumed certain odoriferous plankton such as pteropods.[21] Insufficiently cleaned raw products such as clams may cause "foreign tastes" in the canned products.

UNDESIRABLE TEXTURES

In some areas hardness of the water used in canning may give the product an undesirable texture. Calcium salts are absorbed from such water, toughening the product. This defect is most apt to occur in vegetable and fruit canning, but is also possible, theoretically at least, in the canning of fishery products.

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[21] McMillin, Harvey. Abnormal odors in salmon. Bull. National Canners Association, Northwest Branch. 3 pp. Seattle.

Important instances of undesirable texture occur where fis are brined or salted previous to canning. If the degree of saltin is at all excessive, the texture becomes fibrous and stringy afte processing, in addition to being much too salty in flavor. Som fish such as albacore are canned after being frozen. If the fis are not properly frozen or are thawed out carelessly, the textur of the flesh is impaired. This is evidenced by perforations whic are the result of the formation of large ice crystals in the flesh These are quite distinct from the "honeycombing" sometime found in the canning of stale products.

FREEZING

Storage of canned foods at too low a temperature is just as in jurious as at too high a temperature. Much loss is caused by th freezing of canned goods. Data on loss through freezing are no extensive, but it is believed that some canned foods, includin salmon and tuna, are not affected. The amount of damage is usu ally greater when the products are thawed rapidly.

Condensation of moisture may occur, resulting in the formatio of drops of water on the exterior of the containers, if there is to great a difference between the temperature of the frozen produc and the room in which it is held. This may cause rusting of th cans or spotting of the labels, even if no greater damage is done For this reason canned products should be thawed slowly at temperature only slightly above 32° F.

In some products there may be a separation of liquid, causin a watery appearance. Freezing progresses from the outside o the can toward the center and forces out of solution and con centrates near the center of the can, the salts and other solubl constituents. The separated materials may not again regain thei uniform distribution on thawing.

RUSTING

Cans may rust both internally and externally. Rusting is form of corrosion, but must be considered separately as the for mation is influenced by factors of special importance and it i the most common yet most easily corrected type. Rust is forme through combination of iron with oxygen in the presence of mois ture, the rate of formation being influenced by temperature an also by acidity or pH. The latter is rarely, if ever, a factor i internal rusting in canned fishery products.

Internal rust may be formed during storage of the empty con tainer, especially along the side seam. If conditions after pack ing are favorable, the presence of small flecks of rust may ac celerate rusting. Rust may also be formed after packing. In this instance it is usually due to oxygen in the headspace, as the result of improper, that is, slack fill, with excessive headspace, and to insufficient exhaust. In some products such as oily fish like salmon, tuna or sardines, where the oxygen is absorbed by the product, there is little danger of internal rusting but in non-oily products, with considerable liquid, such as fish roe and clams, this possibility must be kept in mind.

External rusting is largely caused by poor storage and to a lesser extent by faulty packing methods. There should be no opening in a storage warehouse through which rain, snow or other atmospheric moisture may enter. Floor areas are apt to be moist in buildings of ordinary construction which may be otherwise dry. If cases are resting directly on such a floor the moisture gradually seeps through the case bottoms and may eventually rust the bottom layers of cans. The most common cause of rusting during storage is believed to be due to sweating. Sweating is most apt to occur if the temperature of the warehouse is high in contrast to the temperature of the product, or if the relative humidity of the atmosphere is high, and if there is excessive variation in temperature and lack of ventilation. Three rules should be observed to prevent rusting during storage:

1. The warehouse should be dry and well constructed.
2. The temperature should be uniform.
3. The warehouse should be well ventilated.

External rusting may also be caused by faulty packing procedures such as:

1. Processing in retorts:
   a. Improperly vented.
   b. Using a long coming-up time.
   c. Using low pressure steam containing considerable moisture.
2. Water cooling:
   a. To temperatures below 100° F., when residual surface moisture will not evaporate.
   b. Failure to remove surface water on cans after cooling mechanically.
3. Casing:
   a. In wooden boxes made from green lumber.
   b. In wooden cases which have become damp.
4. Chemical composition of water used in processing and cooling.
5. Label pastes. Instances have occurred where rusting was traced to label pastes with high hygroscopic (moisture absorbing) properties.

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FAULTY TECHNIQUE

Faulty technique is due to ignorance, carelessness and dependance on outdated or obsolete methods or equipment. Most of these factors have been mentioned incidentally in the discussion of physical and chemical factors in deterioration, but poor technique must also be considered a direct as well as a contributory cause of deterioration.

Ignorance may be corrected if the packer is willing to study the principles on which canning is based, rather than place dependance on the tedious and expensive trial and error method which often leads to false conclusions. Information on canning technique is available to the industry through the efforts of the National Canners Association, the research departments of the can and canning machinery manufacturers, trade journals and governmental agencies.

Carelessness may be combated only by vigilance on the part of the packer, who must insist on exactness in methods and penalize any infraction of rules. Dependance on outdated methods is itself a type of ignorance. Certainly a man who, having once learned the trade, refuses to study, cannot be called intelligent. Dependance on obsolete equipment is poor economy. Such equipment is apt to be defective resulting in higher packing costs and lower quality.

Faulty technique includes such factors as slack and overfill, insufficient exhaust of vacuum, excessive cook, insufficient cooling, and other factors too numerous to list. Strictly speaking, poor workmanship in packing, such as cross fill in salmon canning, visceral material in canned roe, or bits of shell and antennae in canned shrimp, cannot be included as this discussion is concerned with changes occurring after processing.

UNSUITABLE PRODUCTS

Because of changes taking place in canning, due to the structure or composition of the flesh, certain species of fish are not suitable for canning by any known method. Grayfish (dogfish) is appetizing and edible if used fresh, although the flesh contains urea. In processing, the urea is transformed into ammonia making the flesh inedible. During the World War grayfish were canned as a food conservation measure, but the pack was a total loss.

Seafood cocktails are packed in glass and are hermetically sealed without sterilization. Attempts to lengthen the period of preservation by processing have thus far failed, since the degree of heat necessary to process the seafood portion of the ingredients causes caramelization of the sauce, with consequent darkening in color and "burnt" flavor. Products such as bismarck herring or rollmops are prepared from salt herring or are salted in preparation. Processing these articles causes the texture to become tough and fibrous. Other instances may occur to the reader in his own experience.

SPOILAGE BY MICRO-ORGANISMS

Spoilage through micro-biological action may occur before or after canning. Spoilage before canning is dealt with at length in the discussions on raw material and sterilization. This discussion is concerned only with changes caused by micro-organisms *after* processing. Spoilage after canning may be caused by organisms of low or high heat resistance.

Spoilage by organisms of low heat resistance is due in most instances to leaky or improperly closed cans. Deterioration in these instances is primarily due to physical and chemical causes and bacterial spoilage is secondary, occurring only because these changes have already taken place. If living organisms of low heat resistance are found, the containers should be carefully examined for defects. Processes now in use are sufficient to destroy any organisms of this group. The organisms of low heat resistance in canned seafoods are predominantly of the cocci type.

The bacterial flora of canneries packing marine products have been carefully studied by Lang (1935), who concluded that micro-organisms in marine products canneries are largely of the cocci group and states that it is also apparent that they are readily destroyed by heat, and that the cleaning up of the premises after the butchering operation may be made sufficiently effective to prevent their dissemination to other departments of the packing plant. Assuming that these deductions are correct, it may be concluded that the presence of cocci is a more important factor in the preservation of the raw product after catching, in transit, and prior to precooking than it is in the canning and sterilization procedures.

Bacterial spoilage in canned fish and shellfish is caused almost entirely by organisms of high heat resistance, and may be divided into two general types, gaseous and non-gaseous.

GASEOUS SPOILAGE

Swelled or "bulging" can ends are a common indication of gaseous decomposition. The ends of the can may be pushed out by other causes but this cannot be determined by external examination. Any container with swelled ends should be regarded as unmerchantable.

The gas-forming organisms found in canned fishery products are almost always spore-formers of the anaerobic or facultative anaerobic types. Organisms found quite commonly are *Clostridium welchii* and *Clostridium sporogenes*. Gas formation is accompanied by an extremely foul and offensive odor. Cans of clams cultured with sporogenes and insufficiently processed became swells in from 10 to 90 days. The contents were almost entirely liquefied and discolored to an inky black hue (Jarvis and Puncochar, 1940).

Another gas-forming heat-resistant organism is *Clostridium botulinum*. Spoilage may not always be accompanied by the excessively disagreeable odor, but the product will have lost its normal odor and may have an "off" smell difficult to describe. *Clostridium botulinum* has been isolated from home canned fishery products within the last few years but it has not been found in any commercially canned fishery product since 1925. The toxin produced by this organism is a causative agent of food poisoning. In studying the bacterial flora of marine products Lang found evidence of the presence of gas-producing anaerobic thermophiles on fish carts and in slime previous to canning, but no gas producing thermophiles were isolated from among organisms found present after processing.

The resistance of these organisms varies. Some resist boiling for 4 and others for 12 hours. Certain organisms are destroyed by exposure of 110° C. (230° F.) for 10 minutes while others withstand 120° C. (240° F.) for 10 minutes. Heat processes in canning must be determined on the basis of maximum heat resistance in order to secure commercial sterility and eliminate the possibility of spoilage by putrefactive gas-producing organisms.

NON-GASEOUS SPOILAGE

There is no external indication of non-gaseous spoilage. The ends of the containers are flat and the contents may be normal in appearance. An "off" odor may or may not be noticeable, but the product is sour in taste. This type of spoilage is known as "flat souring." It has been studied most extensively in relation to the canning of vegetables, but also occurs in canned fish and seafoods. Fellers (1927) found spoilage of this type in chinook, coho and pink salmon; in crab, and in shrimp. It has also been found in clams and fish roe and its presence is possible in other seafoods.

Some of the organisms causing flat souring are aerobic spore formers such as *Bacillus cereus*, *B. mesentericus* and *B. vulgatus*. While flat souring has been most common in cans with a low vacuum, it has been noted in cans with vacuums of 8 to 10 inches.

It is believed that flat souring by aerobic spore formers is due to a heavily increased contamination of the raw material, insufficient process, or a combination of both. Fellers questions the theory that high vacuum is effective in preventing spoilage in certain marine products, and studies made during the past few years tend to confirm his belief.

It is also suggested that souring may occur previous to processing, especially in plants packing clams, crabs, oysters and shrimp. The rate of operation is often slow and trays of material may stand an hour or more before being filled into the cans. When operating at a slow rate, 45 minutes or more are required to fill three standard retort baskets. Where the partially filled retort baskets are also allowed to stand over the noon hour without being processed, the time may be much longer, sufficient for souring to develop, especially on hot days. Subsequent sterilization prevents decomposition but cannot remove any souring which has occurred.

While flat souring may be caused by aerobic spore formers if conditions are favorable, much of the flat souring in canned fishery products is due to the action of thermophilic micro-organisms which develop only at temperatures higher than those at which these products are normally held. Cans of salmon or other seafoods may be piled in large stacks while the cans are still warm, and left for several days. Cooling is delayed to such an extent that the contents remain at a temperature favorable to the growth of thermophilic organisms, long enough for spoilage to develop. Vegetable canners have long been warned against this practice, but its importance has not been recognized as a spoilage factor in canning marine products.

Storage temperature is also important. Thermophilic spoilage may develop in canned fishery products held in warm storerooms, while it would not have appeared if the temperature had not been unusually high. For example, canned fishery products may be placed in attic storerooms under a sheet iron roof, where the temperature may reach 100° F. or more in summer. Such temperatures are favorable to the development of thermophilic organisms as well as being a causative agent of chemical and physical deterioration. Storage at temperatures between 40 and 50° F. will greatly reduce the possibility of flat souring by thermophiles and deterioration of texture, such as softening. High storage temperatures are encountered most often during summer weather in inland regions and among retailers or small distributors. The packer may be unable to control storage conditions, except as he is able to educate jobber and retailer on the importance of proper handling in maintaining quality.

EXAMINATION OF CANNED FISHERY PRODUCTS

Laboratory examination of canned fishery products is made for two purposes, for the enforcement of food and drug regulations and for control purposes to enable the manufacturer to improve the quality, or as a means of determining the quality when the manufacturer is disposing of his pack.

The U. S. Food and Drug official uses much the same methods as the trade examiner to determine whether a canned product is good and wholesome, but if spoilage or inferior quality is indicated in addition, chemical analyses with elaborate and complicated analytical techniques are sometimes required. Chemical analyses are necessary in legal proceedings as the evidence must be sufficiently strong to convince the court that the canned food is not good and wholesome. Methods of analysis which are recognized in court are found in the manual of the Association of Official Agricultural Chemists (1940). In addition, food and drug officials and manufacturers' chemists may offer evidence based on analytical methods from other sources.

In most instances the food technologist in making examinations for control purposes does not require an elaborate analytical technique. He makes use of a few simple tests and depends principally on accurate observation and keenness of the physical senses.

The advantages of an adequate system of grading have been acknowledged from time to time, but little progress has been made in the establishment of grades. With a few exceptions, at the present time, grade depends on species and canning area or is based on the reputation of a brand, rather than on established quality factors. Methods of examination may vary between laboratories and the criteria of the individual examiner may vary from time to time. Published information of value is limited. Only in the case of salmon has a determined effort been made to work out a systematic practical method for the examination of a canned fishery product. The results of the study of the Northwest Branch, National Canners Association, on the examination of canned salmon should be carefully studied by all canning technologists (Clark, *et al.*, 1923).

DESCRIPTION OF LOT

A systematic method for the examination of any canned fishery product begins with a description of the particular lot to be examined. Descriptive data must be very complete and should include the number of cases, size of the container, code mark, variety of product, brand or label and the location of the parcel. The place where the parcel is stored should be noted for several reasons, of which the most important is that the quality of the product may be affected by conditions of storage. The packer, cannery, date packed and any other points that may aid in identifying that particular lot should also be noted. It is suggested that a label from one of the sample cans be attached to the record sheet for reference in questions arising after disposition of the sample.

Coding has been developed to the extent that it is possible to determine even the retort load in which the cans were processed. However, a great deal of improvement is needed in the coding of fishery products. Some products are only coded to give the packer and season when packed, while other products are not coded at all. An accurately coded product not only simplifies the work of the food examiner, but enables him to furnish more accurate and detailed information to the packer.

SAMPLING

Many packers, when requesting laboratory examination of their product, send in samples of half a dozen cans or less, usually taken in a very haphazard manner. Several codes or portions of the pack may be included in a single parcel. Even where only a single code or portion of the pack is concerned such samples are too small to be representative and any examination will probably be inaccurate. Where the pack is uncoded or the codes not segregated, a single case may include cans from more than one lot. Under such circumstances the removal of a few cans from a single case does not constitute a representative sample and the probabilities are against securing accurate data.

Sampling is only possible on a systematic and representative basis, when the pack is coded and the sample is sufficiently large in size. Under such conditions sampling is simplified, the sample furnishes valuable data for control of packing methods, and can be considered as truly representative of the quality of the pack.

In the examination of salmon, Clark, *et al.* (1923) stated that all that can be done with uncoded packs is to attempt to get a representative sample by taking one or two cans from each of a considerable number of cases situated in all parts of the parcel. Ninety-six cans are usually drawn in this manner in parcels of 1,000 cases, and an increasingly smaller proportion from increasingly larger parcels.

A sample of any fishery product should consist of at least 24 cans, if the lot is less than 1,000 cases. If the pack is new to the examiner or if it is questionable, a larger number of cans is required. One half of the sample should be set aside for reference, while the remainder is examined. If the results of the examination are questioned, authentic samples are then available for use in any controversy, or as evidence in case of legal action. If the cans are found to be uniformly good in quality, the unopened portion of the sample may be returned to the packer if not needed.

When the sample is taken, the cases opened should be inspected and the external condition of the cans noted, especially the condition of the enameled ends, cleanness of the cans, condition of the labels, and the presence of swelled, leaky, rusted and dented or battered cans. While the percentage of defective or damaged containers should be determined, no can which is obviously abnormal should be included in a sample taken for examination.

A sample should not be examined immediately after it is drawn from the pack, but should be held in the examining laboratory until it has reached room temperature, preferably about 65° F., or for a period of about 48 hours. Samples examined immediately after removal from the warehouse may give misleading results. If they have been stored at very warm or cold temperatures, the significance of the vacuum obtained is difficult to interpret accurately. If the contents remain at a low temperature, it is more difficult to detect abnormal ("off") odors, or odors of decomposition.

BACTERIOLOGICAL EXAMINATION

A bacteriological or microscopic examination of a canned fishery or other food product is made to determine the number and types of any organisms present, to confirm data in heat penetration tests, to determine the quality of raw material used, the quality of the pack, or the cause of spoilage, if present. The number of samples examined bacteriologically will vary with the type of pack and character of information desired, but should not be less than 12 cans as a minimum and a sample of 24 cans is preferable. Data obtained as a result of bacteriological examination may be misinterpreted unless correlated with the results of a careful physical examination and is of the fullest value if processing data are also available.

Samples intended for bacteriological examination should be first incubated for at least a week at a temperature of 55° C. (131° F.), as thermophilic organisms develop only at high temperatures and physical changes are also hastened under such conditions. When possible, bacteriological examinations should be conducted in a room separated from the rest of the laboratory, to reduce the possibility of contamination.

PREPARING THE SAMPLE

The tops of the cans should first be washed thoroughly with soap and water, then dried. The top of the can is usually sterilized by flaming with a Bunsen burner, though it may also be done by pouring a small amount of alcohol on the can, and igniting.

When the top is sufficiently cool, the vacuum reading is taken, disinfecting the tip and rubber stopper of the vacuum gauge by dipping it in formalin. The can may then be opened with a sterile can opener flamed in a Bunsen burner each time used, or by punching a hole one-half inch in diameter using a screw driver or brad awl. The can top should be flamed again as an added precaution against contamination. If the container is abnormal, that is, a swell, a sterile towel should be wrapped around the tip of the punch when making the hole to prevent any of the liquid contents from spurting into the room.

TAKING THE SAMPLE

If the contents include considerable liquid the sample may be drawn out through a straight piece of glass tubing, sterilized before use. Tubing is preferable to pipettes as it is more easily cleaned, is not blocked as readily and a more representative sample may be obtained. A sample of approximately 1 cc. of liquid and small particles of solids is required for each inoculation. If there is not sufficient free liquid, a cut is made into the center of the contents with a sterile scalpel and a portion of about 1 gram is removed with sterile forceps for each inoculation. Aerobic and anaerobic plates and tubes should be inoculated for each container. Special media are not required in most cases. Dextrose agar and peptone broth are usually satisfactory culture media. As a rule plates and tubes are incubated 72 hours at 86° F. (30° C.) before being examined. If results are negative, an additional incubation of 48 hours at 131° F. (55° C.) may be given to confirm the negative results and test the presence of thermophilic, heat-resistant organisms, or two sets of cultures may be taken, one incubated at each temperature.

DIRECT MICROSCOPIC EXAMINATION

Microscopic examinations are made by removing a drop of liquid from the can with a sterile loop and placing it in a hanging drop or by preparing and staining a smear on a slide.

Clark, *et al.* (1923), describing the microscopic examination of canned salmon, a type of examination equally applicable to all canned fishery products, stated " * * * that direct microscopic examination of the liquor * * * is sometimes of value, in that often one may determine at once without waiting for the results of the bacteriological tests, whether active spoilage is present. It is also of value in confirming results of the physical and chemical examinations, because in canned decomposed salmon, even when properly processed, large numbers of dead bacteria may be found by use of the microscope. Canned fresh salmon shows few or no dead bacteria by this method. By the use of the microscope, certain parasites and pathological conditions may also be studied."

The results of microscopic examination are then interpreted in the light of available details of the process of manufacture and in correlation with data secured from physical and chemical examination. It should be possible to determine (1) whether further spoilage will occur, (2) whether bacteria gained entrance through defective seams or leaks, and (3) whether bacteria resisted the processing temperature. Inactive or dormant spore forms are not of great significance, as they do not develop due to unfavorable conditions. Bacteria common to the dust and soil, if present, probably come from dust in the empty can. The most common causes of non-sterility are believed to be poor seaming by the canner and under-processing.

PHYSICAL AND ORGANOLEPTIC EXAMINATION

Factors included under a physical and organoleptic examination may be separated into three groups: (1) Quality of the raw material when caught; (2) quality of the raw material when canned; and (3) workmanship in packing.

QUALITY WHEN CAUGHT

The quality of raw material when caught is not uniform for any species. Variation is best illustrated, and has been most thoroughly studied in salmon canning, but is found in other products. Salmon for canning are caught only during the spawning migration. Once started on the journey, they no longer feed, but depend on stored-up body fat for nourishment. "Therefore, the amount of this fat within their bodies gradually decreases, and fish which are caught late in their migration period are poorer in quality and lower in food value. Not only does the amount of fat decrease, but the color of the flesh fades out and the canned product has a poorer color. In general, salmon packed early in the canning season are of better quality than those packed later" (Clark, *et al.*, 1923).

In some products size is important in determining the quality when caught. Maine sardines are considered of higher quality if small, shrimp if they are large. Size may vary with the locality and time in the season when caught. It is also affected by the density of population on a fishing ground and amount of food present in the water, which may vary with the season in any given area. Degree of temperature and change in salinity may affect size ranges, as with oysters.

Color of the flesh is important for canned salmon, shrimp and crab. In fact, a characteristic color has been established for these species. Color is noted in the examination of other canned fishery products, but in them the color is a factor in workmanship in packing or in determining the quality when canned.

The amount of free liquid and oil may be used as an indicator of quality in such species as salmon, shad, alewife or river herring and mackerel. The average amount of oil and liquid per can has been carefully worked out for each species of salmon. In living fish the amount of water in the flesh tends to increase as the fat content decreases. If the amount of liquid is much higher than is usual, the amount of free oil is low, indicating low quality fish. This factor is not significant in products such as "wet-pack" shrimp and oysters packed in brine.

QUALITY WHEN CANNED

Fish and shellfish are more delicate in structure than other flesh foods, are readily injured and decompose rapidly. A fish may be of good quality when caught but poor when canned. The original quality may have been destroyed by the method or conditions of handling the catch, as described in the discussion of handling and transportation. Examiners for the enforcement of U. S. Food and Drug Administration regulations are especially interested in the condition of the fish when canned, *as the law stresses fitness for food, rather than standards or grades of quality.*

The factors used in determining quality when canned are odor, texture, reddening of the flesh, "honeycombing" and turbidity of liquid.

ODOR

Odor is the most important and most reliable indication of decomposition in the examination of canned fishery products, and is usually the factor which decides whether a can of fish shall be considered as fit for food. In determining the odor a great deal depends on the keenness of this sense in the examiner. Some persons have an abnormally sensitive sense of smell particularly those with a "weak stomach." Others have a deficient sense of smell. The sense of smell also may be affected by the use of liquor, or by smoking just before an examination.

In smelling salmon or other fish a handful of the contents of the can is broken between the hands, immediately after which it is opened up and held close under the nose. Odor may be classified as good, stale, tainted and putrid. Fishery products canned when fresh have a normal "marine" odor, not at all unpleasant or disagreeable. The odor may be lacking, but unless there is a definite odor of staleness, the classification should be "good."

If stale fish are canned, there is a definitely abnormal odor, which is best described as a slight odor of decomposition. The odor disappears after the contents have been broken up and exposed to the air for a few minutes. Such a product may be considered to be of poor quality, yet not unfit for food.

Fish canned when tainted, that is, after decomposition has definitely set in, will give off an unmistakable odor of decomposition which does not disappear after the cans have been opened and allowed to stand for a few minutes. The examiner lists such an odor as "tainted" and the product is regarded as unsalable, although it may not be actually harmful if eaten.

The classification of "putrid" is reserved for an extreme degree of decomposition. In some cases the odor is persistent and disagreeable, noticeable even at a distance as soon as the can is opened and by a person unacquainted with the examination of canned foods. Such cans, of course, are unmerchantable and the contents are inedible. Shellfish canned when spoiled, have the most offensive odor of putridity and if this odor is found in a sample of canned clams, for example, it will appear in almost every can, making a detailed examination impossible and unnecessary.

Some odors may be encountered which, while perhaps abnormal, are not odors of decomposition, and should not be considered as indications of spoilage. Canned crustaceans, such as "dry pack" shrimp, crab and lobster may give off a slight ammoniacal odor, which is probably due to degree of process and does not affect the quality or fitness for food. Sometimes a "musty" or "muddy" odor is detected, usually in fish taken in fresh water, which are soft fleshed and have not been given a pre-treatment to improve the texture. Clams may have a "seaweed" odor, but are perfectly edible, though the appetite appeal may be lessened.

Canned salmon sometimes has a "weedy" or "grassy" odor, which is usually associated with strongly "water-marked" fish. Fish which are caught with hook and line in salt water usually contain partially digested food and often have a characteristic odor not in any way due to decomposition of the flesh. Sometimes a "scorched" or "caramelized" odor is noted which may be due to over-cooking. Canned smoked fish have a "caramelized" or "creosote" odor if smoked too heavily before canning.

TEXTURE

The texture of the flesh may be used as an indicator in some products, but there is such variation that it must be used with caution and only in conjunction with other factors. Softening of texture usually accompanies and corresponds roughly in amount to the degree of decomposition as judged by the odor. It should also be remembered that fat fish will be softer than thin fish of the same species. The portion of the body may make a difference in texture, as for instance, belly flesh may be softer because it is more oily than other sections of the body. Excessive handling of the cans before examination may also adversely affect the texture.

REDDENING OF THE FLESH

Reddening of the flesh is especially important as an indicator of spoilage in the examination of canned salmon but may be used with other products. According to Clark, *et al.* (1923) "The flesh of raw salmon if not promptly canned takes on an unnatural bright red appearance and this color persists through the processing; but when the can is opened this unnatural or so-called 'feverish' red color quickly fades and can usually be distinguished from the true color of the fish. Furthermore, this unnatural reddening is unevenly distributed and most likely to be observed at the tips near the gills, next in the belly walls, and least of all in the back flesh."

Reddening of this type may also be observed in white fleshed fish such as canned herring or sardines, especially along the belly cavity. Reddening in canned roe may be due to poor washing, but roe packed when sour also shows a definite "bloody" color, evenly distributed throughout the mass.

HONEYCOMBING

Occasionally in packs where the contents of a can consist of two or three pieces solidly packed, it will be noticed that the flakes of flesh are perforated by small holes. The accepted theory accounting for this condition is as follows: When more or less decomposed fish is canned, there is a considerable production of gas in the flesh caused by the growth activity of gas forming bacteria. When such fish are processed, the gas expands and makes little pockets in the flesh. On cooling, the pockets remain and the flesh seems to be filled with small holes or air spaces. This appearance is called "honeycombing," and was originally found in canned salmon but may occur in other products such as tuna and sardines. If a small piece of "honeycombed" flesh is placed on the tip of the tongue and held there for a short time, a sharp biting taste is sensed, a flavor like that of "sharp" or "old" cheese. This test is not recommended if the can is obviously spoiled.

TURBIDITY OF LIQUID

The degree of turbidity or color of liquid is sometimes used as a factor in determining condition when canned. For instance, in canned oysters a grey liquid is considered a sign of old or inferior oysters. If the product is packed when fresh, the free liquid extracted in processing or the added brine is fairly clear. The degree of turbidity tends to increase with advance in decomposition. However, the liquid may also be turbid if the product has been handled roughly, is examined at a very low temperature or has been stored at a high temperature. Turbidity is useful as a corroborative index of spoilage but should not be considered apart from other evidence.

WORKMANSHIP IN PACKING

Workmanship in packing is an important factor in establishing the quality of the canned product and under this head are included all those canning operations, the effects of which may be observed in the canned product.

EXTERNAL APPEARANCE

Examination for workmanship begins with a determination of the external appearance of the container and is usually made in sampling or as the first stage in laboratory examination. If there are rust spots, the sides are dull and dirty, the enameled ends are scratched or show "peeled" spots, or if the cans are dented or battered, then the external condition of the container does not show good workmanship in packing. Labels should be fresh, clean and properly placed on the cans. Defective labels should not be used, nor should they be torn or scratched. The product may be of fancy grade, but if through carelessness or inattention it reaches the grocer's shelf with the faults listed above, the appearance will not favorably attract the consumer.

VACUUM

Vacuum is determined just before bacteriological samples are taken or the cans are opened. A gauge equipped with a hollow piercing point surrounded by a soft rubber gasket is pressed down into the lid, giving a reading indicating the amount of vacuum in inches. A vacuum of 7 inches or more is generally regarded as satisfactory, but it should average 9 to 12 inches to be classed as good. An average vacuum meeting this standard is not satisfactory if any considerable number of cans in the sample show an extremely low or no vacuum, though there may be no signs of internal pressure. Any appreciable percentage of low vacuum cans indicates defective seaming in the cannery, poor vacuumizing, overfilling or similar mechanical defects.

HEADSPACE

The cans are opened by any cutter which will remove the entire end, either just within the top seam or cutting around the side just below. Headspace is measured from the top of the contents to the bottom of the lid and is recorded in fractions of an inch, usually sixteenths. The amount of headspace necessary for good canning practice varies to some extent with size of container, especially when products are packed in the larger sizes of cans. For the great bulk of fishery products, 3/16 inch may be considered satisfactory. If the variations are too wide, the amount of headspace is an indication of over or under filling.

Checking the headspace is especially important since the amendment of July 8, 1930 (also known as the McNary-Mapes Act) was added to the Food and Drug Act. Under this Act, it has been ruled that if the headspace forms 1/10 or more the height of the can, the product is slack filled and sub-standard, even though the declaration of weight on the label is correct. This requirement is included in the new Food, Drug and Cosmetic Act (Act of June 25, 1938; 52 Stat. 1040; 21 U. S. C. 301-392).

AMOUNT OF LIQUID

When the headspace has been determined, the drained weight may be taken, if necessary, after which the contents of the cans are emptied into dishes. Shallow white enamel pans are very satisfactory for this purpose. The amount of liquid is measured by pouring into glass cylinders, graduated in cubic centimeters. In products where turbidity determinations are made on individual containers, a 100 cc. cylinder is used, but when, as in the examination of salmon, free liquid and oil are judged on the basis of a dozen containers, a 1000 cc. graduate is necessary.

FILL

Fill includes not only the total area of the container taken up by the contents as determined by headspace and net weight, but also *how* the contents are packed. Fill varies with the product, and to some extent, depends on whether the can has been filled in mechanically or by hand. In products such as salmon, shad or tuna, there should not be more than two or three pieces, and the cut ends should be packed facing the can ends with the sides parallel to the sides of the containers. Pieces should not be jammed or crumpled in. Ends should not be ragged and uneven, but cut clean and smooth.

In products such as Maine sardines, the fish should be packed with tails to the center and with sides at an angle, so that only the silver skin shows. In sardines and herring the skin and flesh should not be broken in filling. Fill is judged by the drained weight, amount of liquid and headspace in products such as shrimp and oysters. In products such as chowders, fill is judged by the proportion of the ingredients, that is, has an even mixture been obtained?

As a rule, under proper supervision, hand filled packs show a more attractive appearance. If large herring or mackerel are packed in tall cans, the contents should be removable in an almost solid single cylinder. It is bad filling practice in this type of pack to use small ends to fill the center of the can or spaces caused by the size and shape of the fish. If the fish are properly selected for size, trimmed and filled in carefully, alternating heads and tails, there should be little if any need to use scraps and the fill will be more attractive. An occasional unsatisfactory fill may be disregarded, as a small percentage will be found in the most carefully filled packs, but if such cans occur with any degree of frequency, the fill must be classed as poor.

Consistency of the product is distinguishable from texture in some products, where the degree of consistency is affected by and is an indicator of workmanship in packing. In chowders or soups, for instance, consistency, that is, the amount of liquid or "thickeners," is variable at will. The consistency is poor when the chowder is too thin or if too much thickener has been used. In products such as fish pastes, if the texture is rubbery and the pastes are difficult to spread, the consistency is regarded as unsatisfactory. If canned fish cakes crumble when formed into cakes, consistency is poor.

CLEANING

Cleaning varies to some extent with the type of product. The presence of skin in any amount in fish flakes, fish chowder or fish cakes would be considered poor cleaning, but not in other products. The presence of fins is normal in sardines, but indicates poor cleaning in salmon. As a rule, intestines or other offal should not be found and all clotted blood which is removable should have been washed out. Blood may settle behind the backbone and sometimes fish are bruised before the blood has congealed, leaving a discolored bloody area in the flesh. Such blood clots are not removable and are not considered as evidences of poor cleaning.

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The presence of foreign objects in the container or extraneous dirt originating from the empty cans or the salt used in packing should be considered as poor cleaning.

COLOR

Color may be affected by workmanship in packing. Clams given an over process will show discoloration. Improper preparation before canning will adversely affect the color of fish chowder or fish cakes and these products are easily discolored by processing at too high a pressure or for too long a period. "Stack-burning" may be a serious cause of discoloration, if canned fishery products are not promptly cooled. Some discoloration or "off" shades of color may be due to insufficient cleaning or washing.

COOK

Sufficiency of cook or process may be determined accurately only on the basis of heat penetration studies and by the results of bacteriological examination. In some products, especially canned salmon, where the contents include relatively large vertebrae friability of vertebrae is used in this determination. The vertebrae should crumble easily when rubbed between the finger tips, and rib bones should be brittle, snapping off readily without bending. According to Clark, *et al* (1923), there does not seem to be any close relationship between sterility and softness of the bones. Cans containing soft bones have sometimes been found to contain living bacteria, while on the other hand, cans with hard bones are often sterile. Hardness of bone varies with species and size of fish. The gelatinous substance within the vertebrae should be well coagulated and opaque.

SEASONING

Seasoning in the canned product depends on the individual taste and should not be subject to rigid standards. Salt or the various condiments should be added only in an amount to satisfy the average taste. The product should not be flat and insipid but neither should it be too heavily salted. Some products are salted more heavily than others to improve the texture, or in other cases to mask a "muddy" flavor. "Water-marked" salmon for example are salted more heavily than fish not in this condition. Increased salt seems to improve flavor in the more poorly flavored fish. It should also be remembered that salt and condiments, or sauces such as oil, require several months after canning to penetrate the flesh thoroughly. Tuna, salmon or sardines may seem insufficiently salted immediately after canning, yet will be found satisfactory a few months later.

FLAVOR

Flavor, as distinguished from amount of salt, should be observed in some products, especially those containing a variety of ingredients. The salt or other seasoning may be sufficient, yet the combination may not give a pleasing flavor. Clam chowder, fish pastes, soups, fish cakes and most specialty products may be cited as belonging to this category. In simple products which have not undergone an elaborate process of manufacture, a caramelized or overcooked flavor may indicate over-processing. This applies especially to products such as minced razor clams or Norwegian style fish balls where the upper and lower limits of processing are close together.

NET WEIGHT

Each can must be correctly marked as to the net weight of the contents to comply with the requirements of the Food, Drug and Cosmetic Act. The examiner should weigh at least 12 unopened and 3 empty cans, calculating the net weight as an average. It is sometimes desirable to record also the net weight of each container. The net weight requirement is a minimum requirement. The average must at least equal, but may exceed it without violation of the law. It should be remembered that if there is a wide variation in net weight between individual containers of the sample, workmanship is poor, even though the average net weight meets the requirement. As a rule the actual net weight of fishery products is in excess of that declared on the label.

It is also necessary to ascertain the drained weight in the examination of certain products such as clams, oysters and wet pack shrimp to which considerable brine or liquid is added in filling, or which are liable to shrinkage in processing. The method for obtaining drained weight is given in Service and Regulatory Announcement 134, U. S. Food and Drug Administration. In order to secure results which may be checked against data from other sources, the examiner should follow the procedure as it is official and accepted by all laboratories.

CHEMICAL EXAMINATION

Chemical examination of a canned fishery product follows the same general method as the examination of any other protein food. As stated in the introductory paragraphs to this discussion, a chemical analysis is required in the regular examination of canned fishery products almost solely as confirmatory evidence where the question of spoilage is involved. As physical evidence obtained by the senses may be questioned in court, determination of freshness or the presence of decomposition products must be established by exact methods with the minimum possibility of mechanical error.

Several analytical procedures are or have been used to determine decomposition. A great deal of research has been conducted on this subject in the last twenty years, but a generally satisfactory method has not yet been developed. Volatile acid content in canned salmon may be useful as an index of decomposition, but this method has not yet been accepted for the examination of salmon and it is not known whether it can be adapted to the examination of other types of canned fishery products. Electrometric methods to determine the freshness of fish fillets have not yet been adapted for use with canned fishery products. The indol test, long used as the principal indicator of decomposition, is now discarded, as are methods based on the determination of ammonia or various nitrogen fractions.

For detailed procedures in the determination of decomposition, the reader is referred to the standard texts on food examination such as Official Methods of Analysis of the Association of Official Agricultural Chemists, and on the analysis of organic substances such as Leach (1920) and Mitchell (1932).

RECORDS

It is necessary to keep systematic records of examinations for several reasons. In the first place the examiners' work may be readily questioned if this is not done. It is also essential for control purposes, especially in tracing responsibility for certain practices. Improvement of quality requires an immense amount of information on methods in present use. This is accurate and reliable only if detailed records have been kept of the examination of many sample cans of the product, packed at various times in the season, under varying conditions, and from as many locations as possible in the area where the product is canned.

The form used by the technological laboratory of the Fish and Wildlife Service is illustrated on an adjacent page. Where a great deal of control work is done on a single product, a record form should be worked out particularly adapted to that product. Use of a general form such as illustrated might result in the loss of valuable data. The laboratory should first consider its particular needs and the type of information desired before binding itself too closely to a particular form.

Number .... Product .... Brand or label ....

Obtained from .... Place packed .... Code mark ....

Type and size of container .... Number of containers ....

Date examined .... Examined by ....

Container Number		1	2	3	4	5	6	7	8	9	10	11	12
Appearance of container	External												
	Internal												
Vacuum, inches													
Headspace													
Fill	Good												
	Average												
	Poor												
Texture	Firm												
	Sl. soft												
	Soft												
Color	Clear												
	Average												
	Discolored												
Cleaning	Good												
	Average												
	Poor												
Odor	Normal												
	Stale												
	Tainted												
Flavor	Good												
	Average												
	Poor												
Salt	Insufficient												
	Good												
	Excessive												
Liquid (cc.)	Normal												
	Sl. turbid												
	Turbid												
Net weight													
Drained Weight													
Bacteriological:													
Aerobic plates													
do tubes													
Anaerobic plates													
do tubes													
Direct microscopic examination													
Remarks (*)													
Suitability for canning													
General remarks													

(*) Type of organism, etc

CANNERY INSPECTION

Canneries packing fishery products are subject to inspection for regulatory purposes and for the purpose of checking on the methods in use, or to gather information which may enable canners to improve the quality of their pack, correct errors or increase efficiency in methods of production. The latter type is usually voluntary and is organized by trade associations for the benefit of their various members, or it may be a strictly private service operating as a part of the research department of a large canning firm.

Regulatory inspection may be under either State or Federal control. State control may vary from casual inspections by local public health or food and drug officials, to a constant control and check on every lot of canned fishery products processed. Federal control may vary from a general supervision which endeavors to remove adulterated or unfit goods from passing into interstate commerce, but does not set up standards of quality, to an inspection system devised for the supervision of packing individual products such as shrimp, and may control methods of production, packing and processing in individual canneries. Both types of Federal inspection are under jurisdiction of the U. S. Food and Drug Administration, Federal Security Agency. The Fish and Wildlife Service of the U. S. Department of the Interior does not exercise any regulatory powers governing methods of canning fishery products.

TYPES OF INSPECTION

For purpose of illustration, a good example oɪ state cannery inspection is found in California. The canning of fishery products is controlled by state health authorities who prescribe equipment and processing methods. Automatic temperature control and recording devices are required. The pack must be coded and complete records must be kept of each lot canned. No product may be sold until the cannery inspection service is convinced that it is sufficiently processed and complies with all regulations. Packing and processing regulations are based on the result of research studies, data obtained from the packing industry and from the Federal government. Regulations are revised from time to time whenever the need of change is indicated.

Federal inspection has been proposed for several of the more important products, such as salmon or tuna, but to date this system has only been placed in operation in the shrimp canning industry. This inspection service is optional with the individual packer. To obtain it he must make application to the Food and Drug Administration, Washington, D. C., agreeing to comply with regulations prescribing a standard of sanitation for the plant, the equipment required, the processes to be used and sanitary measures to be observed in the canning procedure (Food and Drug Administration, 1938). Inspection is for periods of 6 months, and the packer is charged a fee based on the size of his pack, to pay for the cost of inspection.

Shrimp packed under inspection and certified as complying with the regulations of the Food and Drug Administration bears a legend on the label, "Production supervised by U. S. Food and Drug Administration." Only shrimp so inspected may carry this statement. It is of considerable advantage to a packer to be able to use such a label, as the market tends to consider it as a guarantee of quality. The inspection of shrimp has caused the elimination of undesirable practices in canning and reduced processing difficulties, where it has been put in effect.

In canning salmon, most important of the canned fishery products, dependence is placed on inspection of the pack rather than on inspection of production. The Northwest Branch, National Canners Association, inspects about 90 percent of the salmon packed in the United States and Alaska. Most of this work is performed at its laboratory in Seattle, Washington. This inspection is primarily intended for the detection and elimination of any lots of canned salmon which might be considered unfit for food, but if the packer so desires, a complete organoleptic examination is made, obtaining considerable information on workmanship in packing and similar factors, which has made it possible to improve methods of production and quality.

This Association formerly maintained an inspection service in Alaska. Cannery inspectors visited the plants of member firms, reporting on sanitation and methods of procedure. Methods were made more efficient, sanitation was improved and the quality of the pack was bettered. When these objects were accomplished inspection was abandoned because of cost of operation and difficulties in obtaining trained personnel.

In the Canadian salmon canning industry the pack is not inspected by a trade association or other organization within the industry, but by a governmental agency, the Board of Inspection, operating under the "Meat and Canned Foods Act" of 1907, created by an Order in Council of April 4, 1932, subsequently amended. All salmon canned in Canada must be inspected before it is marketed by the packer. The board is made up of three experienced canned salmon examiners, who make an inspection of each lot packed, reporting on its condition and quality. If the examiners regard it as "fresh, firm, well packed and in good merchantable condition," a certificate to this effect is issued to the packers.

Canned salmon which is determined "to be sound, wholesome, and fit for human food," but which does not fulfill the requirements for a first quality product, is graded as "Second Quality." This legend is embossed on can ends which are clinched on over the original end or ends, so as to conceal the word "Canada" usually embossed thereon (Clough and Clark, 1934). Canned salmon which cannot be included under either of these classes is seized and condemned. If it is not required by the Department of Fisheries for feeding purposes at fish hatcheries, it is destroyed. Additional requirements of the Canadian regulations are that each can must be code marked in such fashion as to indicate the species of salmon, the date of pack and the name of the packer.

ADVANTAGES AND DISADVANTAGES

Inspection at the cannery is regarded as more effective than inspection of the pack at the primary marketing point. The advantages of pack inspection are that it can be handled by a much smaller personnel and the cost of inspection is not as great. The disadvantages of pack inspection are that it is often made too late to change the current pack. Any alterations necessary must be instituted the following season, except that if improper sealing is noted it is possible to telegraph the cannery so that the necessary changes may be made. With pack inspection it is more difficult to pin down the exact cause of defects appearing in the pack or recommend changes necessary for improvement.

The disadvantages of cannery inspection are greater cost of operation and the difficulty of obtaining a properly trained personnel. Such work is apt to be seasonal with a comparatively brief period of employment. Properly qualified men with the necessary technical or practical knowledge do not ordinarily care to accept employment under such conditions, or if they do, must be frequently replaced, which requires the training of new men with a loss of efficiency during the training period.

REQUIREMENTS FOR A CANNERY INSPECTOR

Men hired as fish cannery inspectors should meet certain requirements. They should have training in chemistry and bacteriology. Courses in sanitation and public health are desirable and also education in the fundamental principles of food preservation. Practical experience in the fish canning industry is also very useful. A man with academic training only will acquire a knowledge of methods in time, but as this is gained largely by observation it is never as intimate or accurate as when gained by active participation. Over dependance on observation and on literature dealing with the industry is apt to lead to erroneous conclusions. On the other hand the man who has practical training only may not realize the importance of the fundamental principles of canning. A well balanced combination of practical experience with academic training should give the best results.

The personality of the inspector is as important as his training. He should be tactful and, while insisting on the enforcement of inspection regulations, should avoid an arbitrary attitude. Common sense is a necessary requisite. Lack of this factor is one of the principal causes of antagonism to inspection. For example, a regulation required that the raw material must not come in contact with wood during preparation and packing. A parcel of the *canned* product was packed in wooden shipping containers. The inspector refused to certify the parcel on the grounds that the product was in contact with wood. While his decision was ultimately reversed, the packer was caused loss and annoyance, which might have been avoided with application of common sense.

CONDUCT OF A CANNERY INSPECTION

Regulations issued by the inspection agency making the inspection usually give complete instructions adapted to the situation. To summarize very briefly, inspection begins with the raw material and ends with the shipping of the finished product, and to be effective, must control any factor within this period affecting the quality of the pack.

The cannery inspector should avoid issuing orders directly to the cannery crew whenever possible. If he wishes anything done, a request should be made to the cannery foreman which does not mean that the foreman should be frequently bothered by minor requests. However, the order should be issued by the cannery foreman if it is necessary to take a man from his regular tasks to perform some work in connection with the inspection.

The inspector should have his records up to date at all times and should take care to avoid possible errors. For this reason, records should be checked frequently. If the packer claims error even though the inspector feels him to be at fault, the claim should not be disputed at length but referred to the central inspection authority. Cordial relations should be maintained with the packer, but the inspector should not allow himself to perform duties outside of the field of inspection or fraternize to such an extent that he is forgetful of his obligations to the inspection service.

In a few instances inspectors are selected from among the employees of a cannery. They are paid by the inspection service, which is reimbursed by the packer. Inspections carried out under such conditions are apt to be ineffective. The inspector is too closely identified with the interests of the packer to insist on enforcement of regulations if the packer disobeys, or the plant is so familiar that he is unable to see clearly the errors he is supposed to eliminate. If it is necessary to choose inspectors from among cannery employees, they should not be stationed with the packer from whom they were obtained.

SANITATION IN CANNING

WHY SANITATION IS NEEDED

Strict sanitary measures are necessary in the canning of fishery products not only for hygienic and esthetic reasons, but also to reduce operating losses and maintain a high quality of product which can be sold at a satisfactory price. Sanitation should not be confused with superficial cleanliness, a tendency observed in certain canneries. The occasional use of a disinfectant such as calcium hypochlorite (chloride of lime) cannot serve as a substitute for the regular and thorough application of generous quantities of water or steam (Hunter, 1934).

Sanitation in canning begins with catching the raw material. Bacterial contamination and consequently decomposition is increased by the misuse of catching apparatus or by the use of types of gear by which the fish may be damaged, causing deterioration to occur before landing. As a measure to improve sanitation, if for no other reason, types of apparatus landing the catch in best condition should be used.

The holds of fishing boats or craft used to transport raw material to the cannery should be so constructed that slime, offal or other waste will not accumulate in the bilges and so that the bilges may be cleaned easily and thoroughly at frequent intervals. Hold linings of wood should be painted regularly or otherwise treated to render them non-porous. Holds, decks, bins, boxes or other equipment used in transporting should be washed down and scrubbed after each delivery of raw material, using clean unpolluted water under considerable pressure.

The use of salt water pumped up from the vicinity of a cannery dock is not desirable as it is usually heavily contaminated with spoilage organisms. The efficient application of a hypochlorite solution is an additional safeguard but cannot serve as a substitute or reduce the necessity for thorough washing.

PUBLIC HEALTH REGULATIONS AND SANITARY CODES

Bare compliance with local public health regulations is not sufficient because requirements are sometimes loosely drawn or incomplete and are not always strictly enforced. Canning research authorities have drawn up excellent sanitary codes but it is not enough to pledge adherence to such a code. Pledges must be backed by close and constant attention to every detail which may reduce contamination from the gathering of the raw material to the cleansing of containers after processing.

REFRIGERATION

Refrigeration is sometimes necessary to maintain raw material in a proper condition of sanitation. Ice should be used even on short hauls when the temperature is much higher than normal. This ice should be finely crushed or it will bruise the raw material, and used in generous quantities, at least 50 pounds of ice per 100 pounds of raw material.

RAW MATERIAL HANDLING

Raw material should be inspected carefully on arrival at the cannery and only fresh, clean and undamaged raw material should be accepted. Rough handling in unloading should not be tolerated. Raw material found unfit for use should be destroyed immediately or sent to a reduction plant.

Washing and cleaning of raw material preparatory to canning must be supervised carefully since sanitary control at this stage is one of the most important factors in reducing losses through spoilage. Offal or other debris should not be allowed to accumulate on the floor or around the cleaning equipment but should be carried off immediately. Discharge of waste by chutes or flumes into water near the cannery should not be permitted even if the tides are strong. The use of individual containers such as barrels or garbage cans in handling fish offal should also be discouraged as such containers are difficult to keep clean, are not always removed promptly from the cannery area, covers are lost or are placed on carelessly, all encouraging the breeding of flies. Wherever economically possible, cannery waste should be utilized immediately in the manufacture of by-products. In some plants, cannery waste may be discharged directly into a sewer but this presents certain difficulties especially where sewage treatment systems are in use.

If raw material is permitted to remain in cleaning, washing or blanching tanks longer than necessary the delay often results in an extremely heavy contamination with spoilage organisms. To avoid prolonged exposure and subsequent contamination material in small pieces should be carried through these operations in heavy wire mesh baskets or similar containers and tanks should be drained completely and scrubbed at short intervals throughout the day.

No attempt should be made to economize in the use of water since large quantities are required to efficiently remove blood, slime, scales, viscera and dirt, or other waste. Furthermore the use of large quantities of water reduces bacterial contamination, where the water itself is uncontaminated.

USE OF WOODEN EQUIPMENT

The National Canners Association (1939) stated in Bulletin 26-L:

> In general, the use of wood in canning equipment is hazardous, for bacteria may become seeded in the pores and once established may contaminate food materials to such an extent that spoilage may occur with a process that has been satisfactory for years. Any wooden equipment with which food materials may come in contact, such as brine and hot water tanks, conveyors, blanchers, canning tables and even such items as paddles and rollers may act as a carrier of contamination. For example, wooden tanks used for storage of hot water for general plant purposes have been responsible for contaminating a whole canning system. Wooden brine tanks, at the beginning of a day's run, have been found to supply large numbers of organisms to the product being canned. Owing to dilution their number decreases markedly during steady operation only to build up again during a shutdown. Wood, being porous, is able to retain bacteria and hold them mechanically immune from scrubbing and other cleaning processes.

Wherever possible, tanks, filling tables and other articles coming in frequent contact with the fish in canning should be made from some non-corroding metal.

PERSONAL HYGIENE

Freedom from contagious or infectious disease should be made a condition of employment for all cannery employees and no one who contracts such a disease should be permitted to return to work until public health authorities certify that reemployment will not endanger fellow employees or infect the product. Processes used in canning fishery products are believed sufficient to destroy anything less than a gross infection of disease organisms. The principal danger is infection of other employees followed by a decrease in the quality of their workmanship.

Employees should be required to observe proper habits of cleanliness. Such habits as spitting on the docks or in and about the various cannery buildings; smoking in the cannery; urinating elsewhere than in the toilets; befouling the toilets, and carelessness in throwing lunch bags, empty cans, bottles, or other waste elsewhere than in receptacles provided for the purpose, should be punished by instant discharge. All employees handling the product should be required to keep finger nails short and well-cleaned, and to wash their hands thoroughly on each absence from work.