

CHAPTER 10. EXAMINATION OF HEAT PROCESSED, HERMETICALLY SEALED (CANNED) MEAT AND POULTRY PRODUCTS

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10.1 Introduction

Thermally processed meat and poultry products in hermetically sealed containers include both shelf stable products as well as those that must be kept refrigerated (i.e. perishable product). There are a wide variety of packages designed to totally exclude air. These include traditional rigid containers, such as metal cans and glass jars; semi-rigid containers such as plastic cans, bowls and trays; and flexible containers such as retortable pouches and bags. The microbiological examination of these food products requires knowledge and a thorough understanding of food microbiology, food science, and packaging technology and engineering. Many books and scientific articles are available on the processing and the laboratory testing of these products. Individuals who perform these analyses should be familiar with the current procedures and methods. Some of these references are listed in section 10.6.

10.2 Important Terms and Concepts

a. Shelf Stability (commercial sterility):

The term "shelf stability" traditionally has been used by the Agency and is synonymous with the terms "commercial sterility" or "commercially sterile". Shelf stability is defined in CFR title 9, part 318, Subpart G, 318.300 (u) of the Food Safety and Inspection Service (meat and poultry) USDA regulations. Shelf stability (commercial sterility) means "the condition achieved by application of heat, sufficient, alone or in combination with other ingredients and/or treatments, to render the product free of microorganisms capable of growing in the product at non-refrigerated conditions (over 50°F, 10°C) at which the product is intended to be held during distribution and storage". Such a product may contain viable thermophilic spores, but no mesophilic spores or vegetative cells. These products usually are stable for years unless stored at temperatures of 115-130°F (46-55°C) which may allow swelling or flat sour spoilage to

occur because of germination and growth of the thermophilic spores. Many low acid canned meat/poultry products contain low numbers of thermophilic spores. For this reason, samples of canned foods are not routinely incubated at 55°C because the results usually will be confusing and provide no sound information. Canned food lots that are to be held in hot vending machines or are destined for tropical countries are exceptions to this rule.

b. Hermetically Sealed Container:

A container that is totally sealed to prevent the entry or escape of air and therefore secure the product against the entry of microorganisms.

c. Adventitious contamination:

Adventitious contamination may be defined as the accidental addition of environmental microorganisms to the contents of a container during analysis. This can occur if the microbiologist has not sterilized the puncture site on the container surface or the opening device adequately, or is careless in manipulating equipment or cultures. Strict attention to proper procedures is required to avoid this type of contamination.

d. Cured Meat/Poultry Products:

Many canned meat/poultry products contain curing salts such as mixtures of sodium chloride and sodium nitrite. When included in a canned meat/poultry product formulation, sodium chloride and sodium nitrite inhibit the outgrowth of bacterial spores, particularly clostridial spores. Lowering the pH and increasing the sodium chloride concentration enhance the inhibitory action of sodium nitrite. Thus, most canned, cured meat/poultry products are minimally heat processed and are rendered shelf stable by the interrelationship of heat, pH, sodium chloride, sodium nitrite and a low level of indigenous spores. Spoilage in canned cured meat/poultry products attributed to underprocessing is rare. When it occurs, it is usually the result of improper curing rather than inadequate heating. The heat processes used for canned, cured, shelf stable meat/poultry products are unique in that they usually

are not designed to destroy mesophilic bacterial spores but merely to inhibit their outgrowth.

e. Uncured Meat/Poultry Products:

Canned uncured meat/poultry products are given a much more severe heat treatment than canned cured products. The treatment given to canned uncured meat/poultry products is commonly referred to as a "full retort cook".

10.21 Classification of Containers

a. Metal and plastic cans with metal double sealed end(s):

Cans must be at room temperature for classification. Cans are classified as NORMAL if both ends are flat or slightly concave; FLIPPER when one end of a normal-appearing can is struck sharply on a flat surface, the opposite end "flips out" (bulges) but returns to its original appearance with mild thumb pressure; SPRINGER if one end is slightly convex and when pressed in will cause the opposite end to become slightly convex; SOFT SWELL if both ends are slightly convex but can be pressed inward with moderate thumb pressure only to return to the convex state when thumb pressure is released; HARD SWELL if both ends are convex, rigid and do not respond to medium hard thumb pressure. A can with a hard swell will usually "buckle" before it bursts. Hard swollen cans must be handled carefully because they can explode. They should be chilled before opening except when aerobic thermophiles are suspected. Never flame a can with a hard swell, use only chemical sanitization.

b. Glass jars:

Classify glass jars by the condition of the lid (closure) only. Do not strike a glass jar against a surface as you would a can. Instead shake the jar abruptly to cause the contents to exert force against the lid; doing so occasionally reveals a flipper. Scrutinize the contents through the glass prior to opening. Compare the contents of the abnormal/questionable jar with the contents of a normal jar (e.g., color, turbidity, and presence of gas bubbles), and record observations.

c. Flexible containers (pouches):

Pouches usually are fabricated from laminates consisting of two or more layers (plies) of material. Retortable pouches are the most common type of flexible container used for canned, shelf-stable products. Most pouches are 3-ply: an outer ply of polyester film, a middle ply of aluminum foil, and an inner ply of polypropylene. The polyester functions as the heat resistant, tough protective layer; the aluminum foil as a moisture, gas and light barrier; and the polypropylene functions as the food contact surface and the film for heat sealing. The polypropylene also provides added strength, and protects the aluminum film against corrosion by the food product. Not all retortable pouches contain an aluminum foil ply. Pouches and paperboard containers used for non-retorted, shelf stable products (e.g. pH-controlled and hot-filled product) or aseptically filled containers may be quite different from retortable pouches in construction. Pouches and other flexible containers are either factory-formed and supplied ready for filling, or are formed by the processor from roll stock.

10.22 Container Abnormalities

To determine the cause of product abnormalities, both normal and abnormal containers from the same production lot should be examined. All observed microbiological results should be correlated with any existing product abnormalities (Section 10.46 a) such as atypical pH, odor, color, gross appearance, direct microscopic examination, etc. as well as the container evaluation findings (Section 10.46, b,c). Non-microbial swells (such as hydrogen swells) are usually diagnosed by considering all product attributes because culture results are negative or insignificant.

a. Metal cans, plastic containers and glass jars:

Conditions such as "swells" are defined in Section 10.21 (a). The defects and abnormalities associated with these containers have been extensively detailed by others. Rather than include extensive descriptions for each of them in this section, the analyst is referred to several excellent references presented in Section 10.6. These references provide detailed information on the numerous defects and abnormalities that can occur with these containers. The analyst should be familiar with these conditions before beginning any analysis of a

defective or abnormal container. The effect of processing failures, such as overfilling, closure at low temperature or high altitude; container damage; and storage temperature changes, must be taken into consideration as the analyst evaluates possible causes for the defect or abnormality. For quick reference, a Glossary of Terms is provided in Appendices I and II.

b. Pouches:

A Glossary of Terms for these containers can be found in Appendix III. It is imperative to follow uniform procedures (Section 10.46,c) when examining defective or abnormal pouches. The APHA, 1966 reference (Section 10.6) provides detailed information on the analysis of pouch defects.

10.3 Analysis of Containers

The number of containers available for analysis will vary. However, it is important that the number be large enough to provide valid results. Unless the cause of spoilage is clear cut, at least 12 containers should be examined. With a clear cut cause, one half this number may be adequate. If abnormal containers have been reported, but are not available for analysis, incubation of like-coded containers may reproduce the abnormality. The "normal" cans should be incubated at 35°C for 10 days prior to examination. Incubation temperatures in excess of 35°C should not be used unless thermophilic spoilage is suspected. This incubation may reproduce the abnormality, and thereby document progressive microbiological changes in the product. Examine the incubated cans daily. Remove any swells from the incubator as they develop and culture them along with a normal control. After the 10 day incubation period, cool the cans to room temperature and reclassify. Swollen, buckled and blown containers should NOT be incubated but analyzed immediately along with a normal control. All steps in the analysis should be conducted in sequence according to protocol.

10.31 Physical Examination of Metal and Plastic Containers

- a. Before opening, visually examine the double end seam(s) and side seam (if present) for structural defects, flaws and physical damage; record pertinent observations.

- b. Run thumb and forefinger around the inside and outside of the double seams for evidence of roughness, unevenness, or sharpness.
- c. Using a felt marker, make three slash marks at irregular intervals across the label and the code-end seam. Remove the label and copy any label code-numbers to the side of the container along with a mark indicating the code end of the can. Correlate any stains on the label with suspicious areas on the side panel (can body) by returning the label to its exact position relative to the slash marks.
- d. Examine all non-seam areas of the can and ends for any evidence of physical damage. If the code is embossed, carefully examine it for any evidence of puncturing. Circle any suspect and/or defective areas with an indelible pen and record this information on the work sheet. For an illustration of these defects see the APHA, 1966 reference (Section 10.6).

10.32 Physical Examination of Glass Jars

- a. Before opening, remove the label and, using a good light source such as a microscope light, examine the container for apparent or suspected defects. Microorganisms may enter jars through small cracks in the glass. Make note of any residue observed on the outer surface and the location.
- b. Test the closure gently to determine its tightness. After sampling has been completed, examine the lid (closure) and the glass rim (sealing surface) of the jar. Look for flaws in the sealing ring or compound inside the closure; for food particles lodged between the glass and the lid; and for chips or uneven areas in the glass rim.

10.33 Physical Examination of Pouches

- a. Pouches should be examined using an illuminated 5X magnifier.
- b. Hold the pouch in one hand, examine it for abnormalities, such as swelling, leakage, overfilling, and defects such as delamination and severe distortion. Record any pertinent observations.

- c. Hold the pouch at both ends and examine both sides for noticeable cuts, cracks, scratches, food residues, punctures, missing labels, foreign materials or other abnormalities.
- d. Carefully examine all seal areas for incomplete fusion. Pay attention to such defects as entrapped product, wrinkles, moisture and foreign material in the seal. Particular attention should be given to the final or closing seal.
- e. All actual and suspected defects should be circled with an indelible marking pen for more detailed examination after all sampling is complete.

10.4 Analysis of the Contents

Processing errors occur infrequently with canned products, but may result in the improper processing of large quantities of product. Swollen cans, for instance, may signal a microbial spoilage problem. Each abnormality in a "canned" product must be investigated thoroughly and correctly. The following procedures should be followed carefully.

10.41 Equipment and Material

- a. Incubators 20°, 35° & 55 ± 1°C
- b. Vertical laminar flow hood
- c. Microscope, microscope slides & cover slips
- d. pH meter equipped with a flat electrode
- e. Felt-tip indelible marker
- f. Illuminated 5X magnifier
- g. Sterile Bacti-disc cutter or other suitable opening device
- h. Large, sterile plastic or metal funnel
- i. Large autoclavable holding pans
- j. Sterile towels
- k. Clean laboratory coat and hair covering(s)
- l. Sterile wide bore pipettes or 8 mm glass tubing with cotton plugs
- m. Sterile serological pipettes with cotton plugs
- n. Safety aspiration device for pipetting (e.g. pro-pipette)
- o. Sterile petri dishes, beakers, and large test tubes
- p. Sterile triers, cork borers, scissors, knives and 8" forceps. Triers can be made from the tail piece of

- chrome finish sink drain pipe, 1 1/2" in diameter, flanged on one end and sharpened on the other end.
- q. Sterile cotton swabs with wooden handles in glass test tubes, one per tube, or commercially sterilized swabs in paper sleeves
 - r. Sterile gloves
 - s. Small wire basket to hold pouches in an upright position
 - t. Seam analysis tools (micrometer, calipers, saw, countersink meter, metal plate scissors, nippers).
 - u. Vacuum gauge
 - v. Light source such as a microscope light
 - w. Sonic cleaning apparatus
 - x. Transparent acrylic plate with a hole and tubing to a vacuum source
 - y. Bituminous compound in strips (tar type strips usually available in hardware stores) stored in the 35°C incubator
 - z. Seamtest Type U (Concentrate), Winston Products Co., Inc Box 3332, Charlotte, N.C., Dilute 1:300 with distilled water for use.
 - aa. Wooden dowels, 1/2" diameter
 - bb. Gas cylinder clamp
 - cc. Abrasive chlorinated cleaner or a scouring pad

10.42 Media and Reagents

- a. Modified Cooked Meat Medium (MCMM) STEAM JUST BEFORE USE
- b. Brom Cresol Purple Broth (BCPB) or Dextrose Tryptone Broth
- c. Plate Count Agar
- d. APT Agar
- e. KF Broth
- f. Strong's Sporulation Medium
- g. Gram stain reagents
- h. Spore stain
- i. Dishwashing detergent
- j. Chlorine solution, (Commercial Bleach with approximately 5% available chlorine diluted 1:100 with 0.5 M phosphate buffer, pH 6.2)

10.43 Preparation

- a. The Analyst
 - i. The analyst must wear a clean full length laboratory coat.

- ii. Hair must be completely covered with a clean, disposable operating room type hair cover. A surgical face mask should be worn; if the analyst has facial hair such as beards and sideburns, the mask must completely cover it.
 - iii. Hands, forearms and face should be washed with germicidal soap and water.
 - iv. The analyst should wear safety glasses or goggles, preferably in combination with some type of face shield when opening swollen cans or cans suspected of being contaminated with *Clostridium spp.*
- b. Preparing the Environment
- i. If possible, the analysis should be done in a vertical laminar flow hood. If a hood is not available, the area used must be clean and draft-free.
 - ii. Flat cans should be opened in the laminar flow hood.
 - iii. Swells may explode or spew, therefore they should be opened outside the hood and the container transferred to the hood only after it is opened and all gas released.
 - iv. Disinfect the work surface before beginning any work.
- c. Preparing Metal Cans Prior to Opening
- i. Scrub the non-coded end of the metal can with abrasive cleaner or a scouring pad. This removes bacteria-laden oil and protein residues. Rinse well with tap water. Cans with an "easy open" end usually are coded on the bottom. Record the code exactly and prepare the code end as described above.
 - ii. Sanitize the cleaned end with chlorine solution (Section 10.42 j) either by placing clean tissues over the end and saturating it with chlorine solution or by immersing the end in a shallow pan containing the solution. Allow a 15-minute contact

time; wipe dry with sterile towels or tissue. (An alternative sanitization procedure which can be used on Normal-appearing cans ONLY is to heat the entire can surface using a laboratory burner or a propane torch until the metal becomes slightly discolored from the heat.) Proceed as outlined in Section 10.44.

- d. Preparing Jars Prior to Opening
 - i. Scrub the surface of the jar closure with abrasive cleaner or scouring pads. Rinse well with tap water.
 - ii. Sanitize the jar closure with chlorine (Section 10.42 j) either by placing clean tissues over the closure and saturating it with chlorine solution or immersing the closure in a shallow pan containing the solution. Allow a 15-minute contact time; wipe dry with sterile towels or tissue.
- e. Preparing Plastic Containers Prior to Opening
 - i. Scrub the bottom surface of the container with abrasive cleaner or scouring pads. Rinse well with tap water.
 - ii. Sanitize the bottom with chlorine solution (Section 10.42 j) by placing clean tissues over the bottom and saturating it with chlorine or immersing the bottom of the container in a shallow pan containing the solution. Allow a 15-minute contact time; then wipe dry with sterile towels or tissue.
- f. Preparing Normal and Abnormal-Appearing Flexible Retortable Pouches Prior to Opening
 - i. Clean the outside of the pouch with a sanitizer and rinse well.
 - ii. Sanitize the entire pouch in a suitably sized pan with chlorine solution (Section 10.42 j). Allow a 15-minute contact time; then wipe dry with sterile towels or tissue.

- g. Preparing Swollen Cans Prior to Opening
 - i. Scrub the non-coded end of the chilled metal can with an abrasive cleaner or a scouring pad. This removes bacteria-laden oil and protein residues. Rinse well with tap water.
 - ii. Sanitize the cleaned end with chlorine solution (Section 10.42 j) either by placing clean tissues over the end and saturating it with chlorine solution or immersing the end in a shallow pan containing the solution. Allow a 15-minute contact time; then wipe dry with sterile towels or tissue.
- h. Opening Devices
 - i. The preferred type of opening device is the adjustable Bacti-disc cutter (available from the Wilkens-Anderson Company, 4525 W. Division Street, Chicago, IL.; a similar device is available from the American National Can Co., 1301 Dugdale Rd., Waukegan, IL. Order Number WT2437). The opener should be pre-sterilized or heated in a flame to redness. If this type of device is not available, individually packaged and heat sterilized regular, all metal, kitchen-type can openers may be used. The advantage of the Bacti-disc type opener is that it causes no damage to the double seam (simplifying later examination) and the size of the opening can be adjusted.
 - ii. Sometimes a large can (e.g. a #10 size can) may be difficult to open. The analyst could be exposed to pathogens or their toxins if the can is not properly secured. The container can be held tightly with a gas cylinder clamp secured in an inverted position in a shallow metal drawer or tray lined with a large disposable poly bag or an autoclavable tray to contain any overflow. Place the #10 container against the clamp and secure the strap. Rotate the can and continue cutting until the opening is completed. The metal tray and liner may be removed for cleaning and the clamp is autoclavable.

10.44 Sampling

- a. Normal-Appearing Metal Cans and Jars with Metal Closures
 - i. Prepare the area and can or jar closure as described in section 10.43.
 - ii. Shake the container to distribute the contents.
 - iii. Use a sterilized opening device to cut the desired size entry hole. Transfer samples immediately to the selected media with a sterile pipette or swab and proceed as outlined in Section 10.45.
 - iv. Aseptically transfer a representative amount of the product to a sterile test tube or other sterile container as a working reserve. Use a pipet or sterile spoon to accomplish this.
 - v. Caution: The contents from overfilled cans may flow out of the hole onto the surrounding lid surface at the time of opening. This material can then drain back into the can when the opening device is removed. Should this occur, terminate the analysis.
- b. Normal and Abnormal-Appearing Plastic Containers
 - i. Immediately after removing the container from the chlorine solution and wiping the excess liquid, use a very hot, sterilized opening device to cut the desired size entry hole. Transfer samples immediately to the selected media with a sterile pipette or swab and proceed as outlined in Section 10.45.
 - ii. Aseptically transfer a representative amount of the product to a sterile test tube or other sterile container as a working reserve. Use a pipet or sterile spoon to accomplish this.
- c. Normal and Abnormal Appearing Flexible Retortable Pouches
 - i. Place the disinfected pouch upright in a sterile beaker and cut a two inch strip about one quarter

of an inch under the seam edge using a sterile scissors. If possible, use a pipette to remove some of the pouch contents, otherwise use a swab. Transfer the samples immediately to the selected media with a sterile pipet or swab, proceed as in section 10.45.

- ii. Aseptically transfer a representative amount of the product to a sterile test tube or other sterile container as a working reserve. Fold the edge of the opened pouch over against itself several times and secure with tape until the microbiological analysis is complete.

d. Swollen Cans

- i. Cans displaying a hard swell should be chilled before opening. Most foods spoiled by *Bacillus stearothermophilus* will not produce gas (flat sour spoilage). However, if nitrate or nitrite is present in the meat/poultry product, gas may be produced by this microorganism. Cold usually will kill *B. stearothermophilus* resulting in no growth in Bromcresol Purple Broth. If possible, save one or two cans and store without refrigeration.
- ii. NEVER FLAME A SWOLLEN CONTAINER - IT MAY BURST. Place the container to be opened in a large, shallow, autoclavable pan. The side seam, if present, should be facing away from the analyst. A container with a hard swell may forcefully spray out some its contents, posing a possible hazard to the analyst if the contents are toxic. Therefore, these cans should be considered a biohazard and precautions must be taken to protect the analyst. Protective gloves should be worn and the lab coat should be tucked inside the cuffs of the gloves or at least secured around the wrist. Some type of facial shield is also recommended.
- iii. Place the sanitized container into a biohazard bag and cover with a sterile towel or invert a sterile funnel with a cotton filter in the stem over the can. Place the point of the sterile opening device in the middle of the container closure. Make a small hole in the center of the sterilized end/closure. Try to maintain pressure over the

hole. Release the instrument slowly to allow gas to escape into the towel or funnel.

- iv. After the gas pressure has been released, enlarge the opening to the desired size to permit sampling and aseptically remove some of the container contents. Sample as outlined in (a) above.

10.45 Culturing

a. Inoculation of Culture Media

- i. The sampling and transfer processes must be conducted aseptically; care must be taken to prevent contamination during the various manipulations.
- ii. Transfer the sample at once to the selected media, inoculating each tube at the bottom. Whenever possible, use a pipet and pro-pipette to remove 1-2 ml of product for inoculating each tube of medium. When the nature of the meat/poultry product makes it impossible to use a pipet, use a sampling swab (holding it by the very end of the shaft) to transfer 1-2 g of the product to each tube. This is accomplished by plunging the swab into the product, then inserting the swab as far as possible into the appropriate tube of medium and breaking off the portion of the shaft that was handled. Use one swab for each tube of medium. When inoculating MCMM, force the broken swab to the bottom of the tube by using the tip of another sterile swab.
- iii. For each sample, inoculate 2 tubes of MCMM which were steamed (or boiled) for 10 minutes and cooled just before use and 2 tubes of Bromcresol Purple Broth. If a tube of KF medium is inoculated at the same time, the presence of enterococci can be determined rapidly.
- iv. As a process control, place uninoculated swabs into each of two tubes of MCMM and BCP and one swab into KF broth (if used). Additionally, label two uninoculated tubes of each medium to serve as controls. If multiple samples are cultured at the same time, only one set of control tubes are needed for each medium and each temperature.

- v. After all tubes have been inoculated with a sample, aseptically transfer approximately 30 ml or a 30 g portion of the container contents to a sterile tube, Whirl-Pak® or jar for retention as a working reserve sample. Appropriately label the container and store it in a refrigerator at approximately 4°C.
 - vi. Finally, transfer a portion of the container contents to a sterile Petri plate, clean jar or beaker for pH, microscopic, organoleptic and other relevant analyses (10.46).
 - vii. Cover the hole made in the container with several layers of sterile aluminum foil, secure the foil with tape and then store the container in a refrigerator at approximately 4°C. This serves as the primary reserve. Re-enter it only as a last resort. If the sample is a regulatory sample, chain of custody records must be maintained on it.
- b. Incubation of Culture Media
- i. Incubate one tube each of MCMM and BCP at 35°C and one tube each at 55°C. If used, incubate the tube of KF medium at 35°C. For the MCMM and BCP controls, incubate one tube at 35° and one at 55°C.
 - ii. Observe all tubes at 24 and 48 h. Tubes incubated at 35°C that show no growth should be incubated for 5 days before discarding. Tubes incubated at 55°C should be incubated for 3 days before discarding. Subculture any questionable tubes, especially if the product under examination contributes turbidity.
- c. Identification of Organisms
- i. Use conventional bacteriological procedures to characterize the type(s) of microbial flora found in the contents of the container.

- ii. Use descriptive terms such as: mixed culture or pure culture, anaerobic or aerobic growth, spore former or non-sporeformer, mesophile or thermophile, cocci or rods.
- iii. Cultures should be examined using a Gram stain. Gram stains should be done only on 18-24 h cultures. Record the morphological types observed and their Gram reaction. If the container contents are examined microscopically using a methylene blue stain, record those observations as well. If endospores are present, the spore stain can be used for better definition of spore type and placement.
- iv. Record all biochemical test results in addition to any characteristic growth patterns on differential and/or selective media.
- v. MCMM tubes showing a bright yellow color with visible gas bubbles, and containing gram positive or gram variable rods should be suspected of containing gas-forming anaerobes. If *Clostridium botulinum* is suspected, sub-cultures should be made and incubated for 4-5 days. The original tube should be reincubated to check for spores. After 4 - 5 days incubation, test the cultures for toxin by the mouse bioassay (see Chapter 14).

10.46 Supportive Determinations

a. Examination of Container Contents

- i. Determine the pH of the sample (10.45, a, vii) using a flat electrode. Disinfect the electrode after taking this measurement.
- ii. If applicable, determine the water activity of the sample (Section 2.4).
- iii. Examine the sample microscopically by making a simple methylene blue or crystal violet stain. A Gram stain is of no value since the age of the cells is not known and Gram-stain reactions may not be dependable in the case of old cells. Prepare a spore stain if the contents of a swollen container show signs of digestion and few bacterial cells.

- iv. Note abnormalities observed in the container contents such as off-odors, off-color, changes in consistency and texture when compared with normal product. DO NOT TASTE!

b. Examination of Metal and Plastic Cans

NOTE: Whenever possible a "normal" companion can should be examined along with the abnormal one.

- i. After a reserve sample has been taken and all examinations are complete, discard any remaining product into an autoclavable bag and terminally sterilize.
- ii. Disinfect the inside of the container with a phenolic disinfectant and carefully clean it with a stiff brush or use an ultra sonic bath. Do not autoclave the container since this may destroy any defects.
- iii. Examine the interior lining of metal containers for blackening, detinning and pitting.
- iv. The container code should have been recorded prior to analysis; if it was not, do so now. Sometimes embossed codes are poorly impressed and can be revealed by rubbing a pencil on a paper held over the code. If this does not work, place a thin smooth piece of paper over the code, hold securely and rub the paper with a clean finger in order to impress the paper. Rerub the paper with a finger coated with graphite. This is superior to using a pencil to rub the code. If that fails, rub the code with carbon paper. Place transparent adhesive tape over the code and rub the tape with the back of a fingernail. Lift the tape and transfer it to any document requiring the can code. The latter two techniques allow a record to be kept of any partial numbers or symbols. It is also possible to wait until the can is emptied, then view the reverse of the code from the inside. If needed, the code can be viewed in a mirror.
- v. When leakage from double seams or side seams is suspected, remove excess metal from the opened end, leaving a 0.5 - 1 cm flange. Dry thoroughly,

preferably overnight, in the 55°C incubator. Add leak detection liquid (10.41z) to the can to a depth of 2-4 cm. Place a microleak detector on the open end of the container. The leak detector consists of a transparent acrylic plate with a vacuum gauge and connector for a vacuum source. Place a gasket (cut pieces of an automobile tire inner tube will do) between the apparatus and the can. If the fit is not tight (e.g., end seam is bent), use modeling clay to fill in the gaps. Large cans without beading or thin metal cans having a wider diameter than height may collapse when vacuum is applied. To prevent this from happening, use 1/2" wooden dowels cut to the appropriate length to support the can sides. Bituminous compound on the dowel ends will hold them in place. Generally, 4 dowels are sufficient for a #10 can. Apply the gasket and any bituminous compound, to the open can end and fit the leak detector plate in place. Connect the vacuum and apply 10 inches vacuum to the can. Swirl the liquid to dissipate bubbles formed by gases dissolved in the liquid. Examine seams by covering them with the diluted Seamtest. Leaks are identified by a steady stream of bubbles or a steadily increasing bubble size. After carefully examining all seams for leaks, increase the vacuum to 20 inches vacuum and re-examine the seams. Leave the can under vacuum until a leak appears or for a maximum of 2 h, and examine at half-hour intervals. Mark the location of leaks on the can's exterior using a marking pen. When reporting, note which seam, and the distance from the side seam or some other appropriate reference point. If no leaks were found, note test conditions (time and amount of vacuum drawn).

- vi. Perform a tear-down examination of the double seams. The following references in Section 10.6 will guide you through this process: APHA, 1966; Food Processors Institute, 1988; Double Seam Manual; Evaluating a Double Seam, FDA Bacteriological Analytical Manual, 1992.
- vii. The tightness of double seams formed by plastic cans and metal can ends may be evaluated by comparing the actual seam thickness to the

calculated thickness of the plastic flange, neck, or metal end. This would include three thicknesses of plastic and two of metal. Also, assess tightness by inspecting the pressure ridge, since it reflects the compression of the plastic body wall. The pressure ridge should be visible and continuous. Each packer may have different specifications for the finished seams; if necessary, the analyst must call the in-plant inspector and ask for specifications for the container of interest.

c. Examination of Pouches

- i. The best way to determine if a pouch has leaked is by the type of microorganisms recovered.
- ii. The pouch should be examined microscopically looking for points of light coming through the film. These are potential leakage sites.

10.47 Interpretation of Results

Use Tables 2, 3 and 4 to arrive at possible causes of spoilage based on all laboratory results. Caution: The tables are based on a single cause of spoilage. If there are multiple causes, the tables may not help.

10.5 Examination of Canned, Perishable Meat/Poultry Products

Perishable meat and poultry products, such as hams, luncheon meats, and loaves are packaged in hermetically-sealed containers and then heat-processed to internal temperatures of not less than 150°F (65.5°C) and usually not greater than 160°F (71°C). "Perishable, Keep Refrigerated" must appear on the label of these products. Although they are not shelf stable, good commercial processing usually will destroy vegetative bacterial cells. The combined effects of sodium nitrite, salt, refrigeration, and low oxygen tension retard the outgrowth of the few vegetative cells and/or spores that may survive the process. Such products can retain their acceptable quality for 1 to 3 years when properly processed and refrigerated.

10.51 Analysis of Containers

See Sections 10.3 - 10.33

10.52 Analysis of the Contents

a. Equipment and Material

See Section 10.41

b. Media and Reagents

See Section 10.42

c. Preparation

See Section 10.43

d. Sampling

i. Using procedures already described (Section 10.44) remove approximately 50 g of sample with a sterilized trier, large cork borers, scissors, knife or forceps.

ii. Place the sample into a sterile blender jar or Stomacher bag, add 450 ml of sterile Butterfield's Phosphate Diluent and homogenize for 2 minutes. This is a 1:10 dilution; make additional dilutions through at least 10^{-4} . Proceed with the culturing steps given in Section 10.52 (e, f & g).

iii. After sampling, cover the container opening with sterile aluminum foil several layers thick and secure with tape. Place the opened sample unit in the freezer until the analysis is complete.

e. Aerobic Plate Counts

i. Pipet 1 ml of each dilution prepared in 10.52 (d) into each of two sets of duplicate pour plates according to the instructions given in Section 3.4.

ii. Prepare one dilution set with Plate Count Agar. Incubate this set at 35°C for 48 h.

iii. Substitute APT agar for the Plate Count Agar in the other set of plates. Incubate this set at 20°C for 96 h.

- iv. Count and record the results from both sets as described in Section 3.4.
- f. Gas-Forming Anaerobes (GFAs)
- i. Steam tubes of MCMM for 10 minutes and cool just prior to use.
 - ii. Inoculate each tube with 1 ml of each dilution prepared in 10.52 (d). Begin with the 1:10 dilution and continue with subsequent dilutions. Use a separate pipet for each dilution. Dilutions must be sufficiently high to yield a negative endpoint. Be sure that the inoculum is deposited near the bottom of the tube.
 - iii. Incubate these tubes for 48 h at 35°C, but read daily.
 - iv. Consider any MCMM tubes showing a bright yellow color, containing visible gas bubbles, and containing gram positive or gram variable rods as positive for GFAs.
 - v. Based upon the highest dilution showing these organisms, report the approximate number of gas-forming anaerobes per gram, calculated as the reciprocal of the highest positive dilution. If skips occur, disregard the final actual dilution and calculate the end point at the dilution where the skip occurred. This is only an approximation of the gas forming anaerobe count. A minimum of three tubes per dilution and an MPN table must be used for a more accurate determination.
 - vi. If *Clostridium botulinum* is suspected, representative tubes that have not been opened should be reincubated for a total of 4 - 5 days and then tested for botulinum toxin using the mouse bioassay (Chapter 14).
- g. Enterococci
- i. Transfer 1 ml of each dilution prepared in 10.52(d) to individual tubes of KF broth. Use a separate pipette for each dilution. Begin with the 1:10 dilution and continue with each subsequent

dilution. Dilutions must be sufficiently high to yield a negative end point.

- ii. Incubate these tubes at 35°C for 48 h. Tubes showing a yellow color, turbidity and buttoning of growth are presumptive positives.
- iii. Confirm all presumptive positives microscopically. Either wet mounts examined under low light or gram stained preparations are suitable for these microscopic determinations. Microscopic determinations yielding cells with ovoid streptococcal morphology shall be considered confirmed positive.
- iv. Report the approximate number of enterococci per gram, calculated as the reciprocal of the highest positive confirmed dilution. If skips occur, disregard the final actual dilution and calculate the end point at the dilution where the skip occurred. This is only an approximation of the number of enterococci. A minimum of three tubes per dilution and an MPN table must be used for a more accurate determination of organisms as described in 10.43-10.45 and Tables 2, 3 and 4.

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Appendix I

Glossary of Metal/Plastic Can Seam Terminology
for Container Components and Defects

The same terms that are used to describe an all-metal seam apply equally well to the metal end/plastic body seam.

Base Plate: Part of a closing machine which supports cans during seaming operation.

Beaded Can: A can which is re-enforced by having ring indentations around the body. The bead tends to keep the can cylindrical and helps to eliminate paneling of the can body.

Body: Principal part of a container - usually the largest part in one piece containing the sides (thus sidewall or body wall).

Body Hook: Can body portion of double seam. Prior to seaming, this portion was the flange of the can.

Bottom Seam: Factory end seam. The double seam of the can end put on by the can manufacturer.

Buckling: A distortion in a can end.

Can Size: Two systems are commonly used to denote can size:

- i. An Arbitrary system (1, 2, etc.) with no relation to finished dimension.
- ii. A system indicating the nominal finished dimensions of a can; e.g. "307 x 512." In this example, the first group of digits ("307") refers to the can's diameter and the second set ("512"), the can's height. The first digit in each set represents inches, and the next two digits represent sixteenths of an inch. Hence, the example can has a diameter of 3-7/16 and a height of 5-12/16 (or 5-3/4) inches.

Chuck: Part of a closing machine which fits inside the countersink and in the chuck wall of the end during seaming.

Closing Machine: Also known as a double seamer. Machine which double seams the lid onto the can bodies.

Compound: Rubber or other material applied inside the end curl to aid in forming a hermetic seal when the end is double seamed on the can body.

Contamination in Weld Area: Any visible burn at one or more points along the side seam of a welded can. This is a major defect.

Countersink: On a seamed end, the perpendicular distance from the outermost end panel to the top seam.

Cover: Can end placed on can by packer. Also known as top, lid, packer's end, canner's end.

Cover Hook: That part of double seam formed from the curl of the can end.

Cross Over: The portion of a double seam at the lap.

Cross Section: Referring to a double seam, a section through the double seam.

Curl: The semi-circular edge of a finished end prior to double seaming. The curl forms the cover hook of the double seam.

Cut Code: A break in the metal of a can due to improper embossing-marker equipment.

Cut-Over: During certain abnormal double seaming conditions, the seaming panel becomes flattened and metal is forced over the seaming chuck forming a sharp lip at the chuck wall. In extreme cases the metal may split in a cut-over.

Dead-Head: An incompletely rolled finished seam. Also known as a skip, skid or spinner.

Double Seam: The joint between the end and the can body formed by rolling the curl under the flange (1st operation) and then pressing the metal together (2nd operation).

Droop: A smooth projection of double seam below the bottom of a normal seam. While droops may occur at any point of the seam, they usually are evident at the side seam lap. A

slight droop at the lap may be considered normal because of additional plate thickness incorporated into the seam structure.

Excessive Slivers: One or more slivers which are 1/32" or longer. This is a minor defect of welded cans.

Factory End: Bottom or can manufacturer's end.

False Seam: A seam fault where the end and body hook are not over-lapped (engaged), although they give the appearance of a properly formed seam. Also see Knockdown Flange.

Feather: Beginnings of a cut-over. See Sharp Edge.

First Operation: The first operation in double seaming. In this operation, the curl of the end is tucked under the flange of the can body which is bent down to form cover and body hook, respectively.

Flange: The flared portion of the can body which facilitates double seaming.

Flange Crack: Any crack at the flange or immediately adjacent to the weld of welded cans. This is a major defect.

Headspace: The free space above the contents of a can and the can lid.

Heavy Lap: A lap containing excess solder. Also called a thick lap.

Hook: (i). The bent over edges of a body blank, which form the side seam lock (ii). The body and cover hooks in a double seam.

Internal Enamel: A coating applied to the inside of the can to protect the can from chemical action by the contents or to prevent discoloration. A lacquer is usually clear; an enamel is pigmented and opaque.

Jumped Seam: A double seam which is not rolled tight enough adjacent to the crossover caused by jumping of the seaming rolls at the lap.

Knockdown Flange: A seam defect in which the flange is bent against the body of the can. The cover hook is not tucked

inside the body hook, but lies outside of it. False seams, knockdown flanges and soft crabs are degrees of the same effect. In order to distinguish the degree of the defect, the following terminology is suggested:

False Seam: The cover hook and body hook are not tucked for a distance of less than an inch. Thus it may not be possible to detect a false seam until the can is torn down.

Knockdown Flange: As above, but more than an inch in length. Body hook and cover hook in contact, but not tucked.

Soft Crab: A defect in which the body of the can is broken down and does not contact the double seam. Thus, there is a wide open hole in the can below the double seam where the body was not incorporated into the seam.

Lap: The soldered but not locked portions of a side seam at the ends of the can body before seaming and removing the can from the chuck at completion of the operation.

Lid: See Cover.

Lip, Spurs or Vees: Irregularities in the double seam due to insufficient or sometimes absent overlap of the cover hook with the body hook, usually in small areas of the seam. The cover hook metal protrudes below the seam at the bottom of the cover hook in one or more "V" shapes.

Loss of Overlap: Any observable loss of overlap along the side seam of a welded can. This is a critical defect.

Loose Tin: A metal can which does not appear swollen, but slight pressure reveals a looseness.

Mislock: A poor or partial side seam lock, due to improper forming of the side seam hooks.

Neck: The thickness of the top of the sidewall (body wall) of a plastic tub, one tenth of an inch below the junction of the flange and the sidewall.

Notch: A small cut-away portion at the corners of the body blank. This reduces droop when double seaming.

Oozier: An imperfect can which allows the escape of the contents through the seam.

Open Lap: A lap failed due to various strains set up during manufacturing operations. Also caused by improper cooling of the solder (See Weak Lap). A lap which is not properly soldered so the two halves are not properly joined.

Over Lap: The distance the cover hook laps over the body hook.

Paneling: A flattening of the can side. Also used to define concentric (expansion) rings in can ends.

Peaking: Permanent deformation of the expansion rings on the can ends due to rapid reduction of steam pressure at the conclusion of processing. Such cans have no positive internal pressure and the ends can be forced back more or less to their normal position.

Perforation: Holes in the metal of a can resulting from the action of acid in food on metal. Perforation may come from inside due to product in the can or from outside due to material spilled on the cans.

Pleat: A fold in the cover hook which extends from the edge downward toward the bottom of the cover hook and sometimes results in a sharp droop, vee or spur.

Pressure Ridge: A ridge formed on the inside of the can body directly opposite the double seam, as a result of the pressure applied by the seaming rolls during seam formation.

Pucker: A condition which is intermediate between a wrinkle and a pleat in which the cover hook is locally distorted downward without actual folding. Puckers may be graded the same way as wrinkles.

Sanitary Can: Can with one end attached, the other end put on by the packer after the can is filled. Also known as packer's can or open top can.

Sawtooth: Partial separation of the side seam overlap at one or more points along the side seam after performing the pull test on a welded side seam. This is a critical defect.

Seam Arrowing: A readily visible narrowing of the weld at either end of the can body. This is a major defect.

Seam Width: The maximum dimensions of a seam measured parallel to folds of the seam. Also referred to as the seam length or height.

Seam Thickness: The maximum dimension measured across or perpendicular to the layers of the seam.

Second Operation: The finishing operation in double seaming. The hooks formed in the first operation are rolled tight against each other in the second operation.

Sharp Edge: A sharp edge at the top of the inside portion of the double seam due to the end metal being forced over the seaming chuck.

Side Seam: The seam joining the two edges of a blank to form a body.

Skipper / Spinner: See Deadhead.

Uneven Hook: A body or cover hook which is not uniform in length.

Vee: See Lip.

Weak Lap: The lap is soldered and both parts are together. However, strain on this lap (e.g. by twisting with the fingers) will cause the solderbond to break.

Weld Crack: Any observable crack in a welded side seam. This is a critical defect.

Worm Holes: Voids in solder usually at the end of the side seam. May extend completely through the width of the side seam.

Wrinkle: The small ripples in the cover hook of a can. A measure of tightness of a seam.

Appendix II

Glossary of Glass Container Parts

From a manufacturing standpoint, there are three basic parts to a glass container based on the three parts of glass container molds in which they are made. These are the finish, the body and the bottom.

Finish: The finish is that part of the jar that holds the cap or closure. It is the glass surrounding the opening in the container. In the manufacturing process, it is made in the neck ring or the finish ring. It is so named since, in early hand glass manufacturing, it was the last part of the glass container to be fabricated, hence "the finish". The finish of glass containers has several specific areas as follows:

Continuous Thread: A continuous spiral projecting glass ridge on the finish of a container intended to mesh with the thread of a screw-type closure.

Glass lug: One of several horizontal tapering protruding ridges of glass around the periphery of the finish that permit specially designed edges or lugs on the closure to slide between these protrusions and fasten the number of lugs on the closure and their precise configuration is established by the closure manufacture.

Neck Ring Parting Line: A horizontal mark on the glass surface at the bottom of the neck ring or finish ring resulting from the matching of the neck ring parts with the body mold parts.

Sealing Surface: That portion of the finish which makes contact with the sealing gasket or liner. The sealing surface may be on the top of the finish, or may be a combination of both top and side seal.

Vertical Neck Ring Seam: A mark on the glass finish resulting from the joint of matching the two parts of the neck ring. **NOTE:** Some finishes are made in a one-piece ring and do not have this seam.

Body: The body of the container is that portion which is made in the "body-mold" in manufacturing. It is the largest part of the container and lies between the finish and the bottom.

The characteristic parts of the body of a glass container are:

Heel: The heel is the curved portion between the bottom and the beginning of the straight side wall.

Mold Seam: A vertical mark on the glass surface in the body area resulting from matching the two parts of the body mold.

Shoulder: That portion of a glass container in which the maximum cross-section or body area decreases to join the neck or finish area. Most glass containers for processed foods have very little neck. The neck would be a straight area between the shoulder and the bottom of the bead or, with beadless finishes, the neck ring parting line.

Side Wall: The remainder of the body area between the shoulder and the heel.

Bottom: The bottom of the container is made in the "bottom plate" part of the glass container mold. The designated parts of the bottom normally are:

Bearing Surface: That portion of the container on which it rests. The bearing surface may have a special configuration known as the "stacking feature" which is designed to provide some interlocking of the bottom of the jar with the closure of another jar on which it might be stacked for display purposes.

Bottom Plate Parting Line: A horizontal mark on the glass surface resulting from the matching of the body mold parts with the bottom plate.

Appendix III

Glossary of terms - Flexible Retortable Pouches.

Adhesive: A substance applied to ply surfaces to cement the layers together in a laminated film: (a). Polyurethane adhesive for the outer layer (b). Maleic anhydride adduct of polypropylene for the inner layer.

Blisters: Bubbles/gaseous inclusions/particulate material, may be present between layers of laminate, usually are found in the seal area.

Bottom of Closing Seal: Portion of closing (packer) seal adjustment to the pouch contents.

Bottom Seal: A seal applied by heat and pressure to the bottom of a flexible pouch.

Cosmetic Seal: Area above the primary seal designed to close the edges of the pouch thus preventing the accumulation of extraneous material.

Cuts, Punctures, Scratches: Mechanical defects that penetrate one or more layers of the pouch.

Delamination: Any separation of plies through adhesive failure. This may result in questionable integrity of the package and safety of the product.

Dirty: Smearred with product or product trapped in top edges (where there are no cosmetic seals).

Disintegrated Container: Evidence of delamination or degradation after retorting.

Final Seal: A seal formed by heat and pressure by the packer after pouch filling and prior to retorting.

Foil Flex Cracks/Foil Roll Holes: Visible cracks in the aluminum foil layer caused by flexing of the pouch or pin holes (roll holes) in the foil caused through manufacture of the aluminum ply.

Foreign Materials: Any material (solid food, condensate, grease, voids, blemishes) that may be entrapped between the plies but usually found in the seal area.

Fusion Seal: A seal formed by joining two opposing surfaces by the application of heat and pressure.

Hard Swell or Blown: Distention or rupture due to internal gas formation.

Inner Ply: Polypropylene coating bonded to the food surface side of the aluminum foil.

Laminate: Two or more layers of material held together by adhesive(s).

Leaker: Product leaking through any area of the pouch.

Outer Ply: The polyester film bonded to the exterior surface of the aluminum foil.

Over Carton: A separate container (usually cardboard) in which the flexible pouch is packaged for additional protection.

Package Dimensions: The measurements of retortable flexible pouches stated as length, the longest dimension (LGT), width the second longest dimension (W), and thickness, the shortest dimension (HGT). All are given as internal measurements.

Pin Holes, Roll Holes: Holes in the aluminum foil layer only, originating during manufacturing; usually do not leak.

Preformed Seals: Seals formed by heat and pressure, by the manufacturer of the pouches, along the sides and at the bottom of the pouches.

Primary Seal: A fusion seal formed by the food processor by applying heat and pressure immediately after filling.

Seal: A continuous joint of two surfaces made by fusion of the laminated materials.

Seal Width: The maximum dimension of the seal measured from the leading outside edge perpendicular to the inside edge of the same seal.

Severely Damaged: Punctures, cuts or ruptures which penetrate all layers of the pouch and expose the product to contamination.

Side Seals: Seals formed by applying heat and pressure to the sides of the pouch's laminates to form the "preformed pouch".

Tear Nicks or Notch: Notches near the final seal to aid the consumer in opening the pouch.

Wrinkle: A crease or pucker in the seal (Packer or Factory) areas.

Appendix IV

Table 1. Normal pH Values for a Few Representative Canned Meat/Poultry Products.

| Kinds of Food | pH |
|---------------------------|-----------|
| Beans with Wieners | 5.7 |
| Beef Chili | 5.6 |
| Beef Paté | 5.7 |
| Beef Stew | 5.4 - 5.9 |
| Beef Taco Filling | 5.8 |
| Beef and Gravy | 5.9 - 6.1 |
| Chicken Noodle Soup | 5.8 - 6.5 |
| Chicken Soup with Rice | 6.7 - 7.1 |
| Chicken Broth | 6.8 - 7.0 |
| Chicken and Dumplings | 6.4 |
| Chicken Vegetable Soup | 5.6 |
| Chicken Stew | 5.6 |
| Chicken Vienna Sausage | 6.1 - 7.0 |
| Chorizos | 5.2 |
| Corned Beef | 6.2 |
| Corned Beef Hash | 5.0 - 5.7 |
| Egg Noodles & Chicken | 6.5 |
| Ham | 6.0 - 6.5 |
| Lamb, Strained Baby Food | 6.4 - 6.5 |
| Pork Cocktail Franks | 6.2 |
| Pork with Natural Juices | 6.2 - 6.4 |
| Pork Sausage | 6.1 - 6.2 |
| Roast Beef | 5.9 - 6.0 |
| Spaghetti and Meatballs | 5.0 |
| Spaghetti Sauce with Beef | 4.2 |
| Stuffed Cabbage | 5.9 |
| Sloppy Joe | 4.4 |
| Turkey, Boned in Bouillon | 6.1 - 6.2 |
| Turkey with Gravy | 6.0 - 6.3 |
| Vienna Sausage | 6.2 - 6.5 |
| Wieners, Franks | 6.2 |

Appendix V

Table 2. KEY TO PROBABLE CAUSE OF SPOILAGE IN CANNED FOODS

Group 1.- Low-Acid Foods
pH Range 5.0 to 8.0

| Condition of cans | Characteristics of Material in Cans | | | | | | |
|-------------------|-------------------------------------|---|---|-------------------------------------|---|---|---|
| | Odor | Appearance | Gas (CO ₂ & H ₂) | pH | Smear | Cultures | Diagnosis |
| Swells | Normal to "metallic" | Normal to frothy (Cans usually etched or corroded) | More than 20% H ₂ | Normal | Negative to occasional organisms | Negative | Hydrogen swells |
| | Sour | Frothy; possibly ropy brine | Mostly CO ₂ | Below Normal | Pure or mixed cultures of rods, cocci, yeasts or molds | Growth, aerobically and/or anaerobically at 35°C., and possibly at 55°C. | Leakage |
| | Sour | Frothy; possibly ropy brine, food particles firm with uncooked appearance | Mostly CO ₂ | Below Normal | Pure or mixed cultures of rods, coccoids, cocci and yeasts | Growth, aerobically and/or anaerobically at 35°C., and possibly at 55°C. (If product received high exhaust, only spore formers may be recovered) | No process given |
| | Normal to sour-cheesy | Frothy | H ₂ and CO ₂ | Slightly to definitely below normal | Rods, med. Short to med. long, usually granular; spores seldom seen | Gas, anaerobically at 55°C., and possibly slowly at 35°C. | Post-processing temperature abuse Thermophilic anaerobes |
| | Cheesy to putrid | Usually frothy with disintegration of solid particles | Mostly CO ₂ ; possibly some H ₂ | Slightly to definitely below normal | Rods; usually spores present | Gas anaerobically at 35°C. | Underprocessing - mesophilic anaerobes (possibility of Cl. botulinum) |
| | Slightly off - possibly ammoniacal | Normal to frothy | | Slightly to definitely below normal | Rods; spores occasionally seen | Growth, aerobically and/or anaerobically with gas at 35°C and possibly at 55°C. Pellicle in aerobic broth tubes. Spores formed on agar and in pellicle. | Underprocessing - <u>B. subtilis</u> type |

| | | | | | | | |
|---------------------------------------|-----------------------|---|-------------------------|--|---|---|--|
| <p>No vacuum and/or Cans buckled</p> | <p>Normal</p> | <p>Normal</p> | <p>No H₂</p> | <p>Normal to slightly below normal</p> | <p>Negative to moderate number of organisms</p> | <p>Negative</p> | <p>Insufficient vacuum, caused by: 1) Incipient spoilage, 2) Insufficient exhaust, 3) Insufficient blanch, 4) Improper retort cooling procedures, 5) Over fill</p> |
| <p>Flat cans (0 to normal vacuum)</p> | <p>Normal to sour</p> | <p>Normal to cloudy brine</p> | | <p>Slightly to definitely below normal</p> | <p>Rods, generally granular in appearance; spores seldom seen</p> | <p>Growth without gas at 55°C. Spore formation on nutrient agar</p> | <p>Post-Processing temperature abuse Thermophilic flat sours.</p> |
| | <p>Normal to sour</p> | <p>Normal to cloudy brine; possibly moldy</p> | | <p>Slightly to definitely below normal</p> | <p>Pure or mixed cultures of rods, coccoids, cocci or mold</p> | <p>Growth, aerobically and/or anaerobically at 35°C., and possibly at 55°C.</p> | <p>Leakage</p> |

Appendix VI

Table 3. KEY TO PROBABLE CAUSE OF SPOILAGE IN CANNED FOODS

Group 3. Semi-Acid Foods
pH Range 4.6 to 5.0

| Condition of cans | Characteristics of Material in Cans | | | | | | |
|--|-------------------------------------|---|---|-------------------------------------|--|--|---|
| | Odor | Appearance | Gas (CO ₂ & H ₂) | pH | Smear | Cultures | Diagnosis |
| Swells Note: Cans are Sometimes flat | Normal to "metallic" | Normal to frothy (Cans usually etched or corroded) | More than 20% H ₂ | Normal | Negative to occasional organisms | Negative | Hydrogen swells |
| | Sour | Frothy; possibly ropy brine | Mostly CO ₂ | Below Normal | Pure or mixed cultures of rods, coccoids, cocci, yeasts or molds | Growth, aerobically and/or anaerobically at 35°C., and possibly at 55°C. | Leakage |
| | Sour | Frothy; possibly ropy brine, food particles firm with uncooked appearance | Mostly CO ₂ | Below Normal | Pure or mixed cultures of rods, coccoids, cocci and yeasts | Growth, aerobically and/or anaerobically at 35°C., and possibly at 55°C. (If product received high exhaust, only spore formers may be recovered) | No process given |
| | Normal to sour-cheesy | Frothy | H ₂ and CO ₂ | Slightly to definitely below normal | Rods - med. long, usually granular; spores seldom seen | Gas, anaerobically at 55°C., and possibly slowly at 35°C. | Post-processing temperature abuse Thermophilic anaerobes |
| | Normal to cheesy to putrid | Normal to frothy with disintegration of solid particles | Mostly CO ₂ ; possibly some H ₂ | Normal to slightly below normal | Rods; possibly spores present | Gas anaerobically at 35°C. Putrid odor | Underprocessing - mesophilic anaerobes (possibility of <i>Cl. Botulinum</i>) |

| | | | | | | | |
|--------------------------------|------------------------------------|--|------------------------------------|-------------------------------------|--|---|---|
| | Slightly off - possibly ammoniacal | Normal to frothy | | Slightly to definitely below normal | Rods; occasionally spores observed | Growth, aerobically and/or anaerobically with gas at 35°C and possibly at 55°C. Pellicle in aerobic broth tubes. Spores formed on agar and in pellicle. | Under-processing - <i>B. subtilis</i> type |
| | Butyric acid | Frothy, large volume gas | H ₂ and CO ₂ | Definitely below normal | Rods - bipolar staining; possibly spores | Gas anaerobically at 35°C. Butyric acid odor | Under processing - butyric acid anaerobe |
| No vacuum and/or Cans buckled | Normal | Normal | No H ₂ | Normal to slightly below normal | Negative to moderate number of organisms | Negative | Insufficient vacuum, caused by: 1) Incipient spoilage, 2) Insufficient exhaust, 3) Insufficient blanch, 4) Improper retort cooling procedures, 5) Over fill |
| Flat cans (0 to normal vacuum) | Sour to "medicinal" | Normal to cloudy brine | | Slightly to definitely below normal | Rods, possibly granular in appearance | Growth without gas at 55°C. and possibly at 35°C. Growth on thermoacidurans agar | Underprocessing <i>B. coagulans</i> |
| | Normal to sour | Normal to cloudy brine; possibly moldy | | Slightly to definitely below normal | Pure or mixed cultures or rods, coccoid, cocci or mold | Growth, aerobically and/or anaerobically at 35°C., and possibly at 55°C. | Leakage |

Appendix VII

Table 4. Characteristics of Normal and Abnormal Perishable Canned Meat/Poultry Products

| Condition of Cans | Odor | Appearance | pH | Smear | Cultures | Probable Cause |
|--------------------------------|---|---|--|-------------------------------------|--|--|
| Flat Cans (0 to Normal Vacuum) | Normal | Normal | Normal | Negative to occasional organisms | 0 to low # APC, APT agar count | Normal product |
| 0 to degrees of swelling | Sour to off odor | Normal to mushy, possible gel liquification | Slightly to definitely below normal | Mixed culture of rods & enterococci | Low # mesophiles, high # psychrophilic non-spore formers (enterococci, lactobacilli) | 1. Prolonged storage at low temperatures 2. Abnormal high levels in raw materials 3. Substandard process |
| Swell | Sour or off odor, possibly putrid | Normal to mushy, possible gel liquification | Slightly to definitely below normal | Mixed culture of rods, cocci | High # mesophilic spore formers and non-sporeformers | Product held without refrigeration |
| Swell | Normal to sour | Normal | Below normal | Cocci, rods or both | Enterococci, rods or both | Leakage if shell higher than core. Underprocessing if core higher than shell |
| Swell | Off odor | Normal to off color | Below normal | Rods | Psychrotrophic clostridia (rarely occurs in U.S.). | Low brine levels |
| Swell | Normal to putrid, depending on length of storage. | Ranges from uncooked appearance to digested | Normal to low, depending on length of storage. | Vary | Vary | Missed processing cycle. Most of these are detected soon after distribution. |