CC 7 Unit 4: CANNING OF FISH

Canning is a method of preserving foods in hermetically sealed containers by application of heat. The technique involves placing the food in a container and closing air tight. The food as well as the container will be carrying several microorganisms that are destroyed by heating. In addition, the food becomes cooked making it either ready to consume or ready to prepare. The function of container is essentially to prevent any further entry of microorganisms from the surroundings enabling the product to be stored at room temperature for relatively long periods. Metal cans are expensive. Retort pouches are cheaper and they reduce the processing time by 30 – 35 % and minimize quality damage. They have long shelf life and very convenient for processing, transportation and serving.

The following aspects are dealt with in this topic.

1. Type of cans
2. Principles of canning
3. Unit operations for canning
4. Retort pouch processing
5. Quality of canned fish
6. Inspection of processed cans

1. TYPE OF CANS

The growth of microorganisms is affected when the pH of the surrounding medium is lowered from their optimum pH. In addition, the resistance to heat is reduced. Accordingly, the extent of heating required to be given to canned product also varies.

Container and its functions

Food packaging performs several functions

- Holding the product securely and safely
- Preserving the original quality of food
- Extending the shelf life of the product
- Preventing mechanical damage to the product
- Provides information, ingredients, cooking instruction etc

Special requirements of containers in canning

In canning, the container has certain additional requirements such as

- Suitable for speedy air tight closures
- Withstand high temperature and pressure
- No reactivity with food or atmosphere

- Sufficiently sturdy and rigid
- Reasonably priced and locally available

The materials used for manufacturing containers are metals, plastic, glass and flexible laminates (composites). Tin plate and aluminium containers represent the traditional materials for fish. Commonly round cans, referred as open top sanitary (OTS) type are used. They are easy to clean, fill and close. The rectangle and oval shaped cans are also in use. The capacity of cans range between 100 g to 1 kg. The aluminium can are light weight, easy to open, but has low impact resistance. Majority of the cans are easy open end (EOE) cans, the lid can be easily opened, using a ring (tab) or key fixed to the lid.

Flexible restorable pouches, have replaced rigid cans to some extent. They are multi-layered combinations of polymers and aluminium foil with each layer performing a specific function such as strength, barriers properties, heat sealability etc. They promote good heat transfer and help in reduction of energy usage during thermal processing. Pouches require careful heat treatment by maintaining a high retort pressure without generating high process temperature.

2. PRINCIPLES OF CANNING

Canned foods are broadly classified into three groups based on pH, viz, high acid foods (pH below 4.5) and medium acid foods (pH between 4.5 - 5.3). The micro flora of these groups varies greatly. Spores of spore forming bacteria generally have high heat resistance and hence have greater survival in canned foods. The two important genera among them are Bacillus and Clostridium.

Bacillus B. Stearothermophilis : 30^0C, pH > 5.0
Clostridium botulinum : Mesophyll, 37^0C, produces lethal toxin, pH > 4.6

An organism has certain ability to tolerate heat which is called its heat resistance. The destruction of microorganism is a function of time and temperature. With increase in temperature, the time required for destruction is lowered.

The heat resistance of bacteria is expressed as

i. *Thermal death time (TDT):* Time in minutes required to kill a given number of organisms at a constant temperature.
ii. *Decimal reduction time (D value):* The time in minutes required to destroy 90% of given number of organisms at a constant temperature.
iii. *F – value:* TDT of an organism at a reference temperature (121^0C or 250^0F) for bacterial spores and 100^0C (212^0F) for non - spore formers.

Factors influencing heat resistance of bacteria

i. *Age of organism:* Heat resistance increases with age

ii. *Concentration:* TDT of an organism at a given temperature increases with increase in concentration.
iii. *The pH:* Deviation from optimum pH of growth adversely affects the heat resistance.
iv. *Food components:* Oil, protein and salt have a protective effect against heat. Spices, preservatives, antibiotics and gamma radiation reduce heat resistance.

Most seafoods have pH 6.0-6.8 and hence belong to the category of low / non - acid foods (pH > 5.3). Most microorganisms including the highly heat resistant spore forming bacteria can thrive well near the neutral pH. Therefore low acid foods are to be rigorously heat processed for canning at temperature well above 100^0C. This is generally done in the equipment called retort, and the process is called retorting. This involves heating the cans in steam or water under pressure. The enzymes present in the food are destroyed by mild heating irrespective of type of food.

3. UNIT OPERATIONS FOR CANNING

Handling and treatment for varieties of fish: Fish canning lines are usually dedicated to one type of product which allows for high degree of automation of unit operations. Variations in unit operations for canning of shrimp, crab, clams and mussels and tuna are given below.

Fishes : Dressed, washed and brined before filling in cans

Shrimp : Beheaded, peeled, deveined and blanched. They are dried, graded and packed

Crab : Received in live condition, back shell and carapace are removed, blanched, cooled in ice water, meat is picked from body and legs, treated with 0.3% citric acid for 2 - 3 min, packed with parchment paper and a teaspoon of blanched. Juice is then added

Clams and mussels : Received in live condition, kept in running water for depuration, steamed shucked to separate meat from shells. Blanched in brine and filled in cans.

Tuna : The fishes are of large size, gilled, gutted washed and precooked to reach a centre temperature of 70 ^{0}C. The precooked fishes are air cooled overnight, manually deskinned and loins are separated to collect the white meat. The meat is size cut and filled in cans. The red meat or dark meat is packed separately as pet food.

General unit operations for the canning of fish include pre - and post - processing steps as briefly mentioned below.

Pre-processing steps

- Raw material receiving, washing and grading the fish usually brought in ice or frozen. If frozen, they are thawed. Shell fishes such as crabs are brought in live condition. The fish are then dressed which includes scaling, beheading, gutting and filleting. Small fishes such as sardines, mackerel are beheaded and gutted only. Tuna are semi dressed to remove gills and gut.
- Brining small size fishes (sardine, mackerel) for 10 min in saturated salt solution
- Filling - packing in cans
- Precooking at 100 ^{0}C for 30 min
- Draining for 10 min
- Addition of cooking media such as oil, brine, tomato sauce, curry, added to required weight
- Exhausting - Removal of air using exhaust box or vacuum seamers.
- Sealing / Seaming the cans
- Thermal processing

The role of each pre - processing step is mentioned below.

Brining: Absorbs salt, removes some water, blood and slime, firms up the texture

Blanching: Destroys enzymes and microorganisms, stabilises moisture content and gives pinkish colour to shrimps

Precooking: Loss of weight, reduction in moisture content, slight loss of protein, vitamins and flavouring compounds

Filling: Size cut pieces must be arranged properly with even surface, liquid like brine, oil, curry, tomato sauce are added after filling

Exhausting: Removes air and other gases in order to create partial vacuum

Seaming: The seam formed between curl of the can end and flange of the can body is called the double seam, because the operation takes place in two stages of hooking and pressing.

The process of seam formation in metal can by the seaming equipment (Seamer) in is shown in Fig. 1 and the cross section of the double seam in Fig. 2. The cross section of the double seam shows that the seam is composed of five layers.. Proper setting, replacing of defective parts of the seamer and checking of can seam for defect are critical for the safety of the product. After the pre - processing steps as mentioned above, the most critical processing step is thermal processing.

The flow diagram of variations in essential steps for the canning of different fish, viz., shrimp, crab, clams and mussels and tuna is presented in Fig. 3.

Thermal processing

Thermal processing is the critical step of sterilising canned food. It is the application of sufficient heat to destroy all pathogens and most spoilage organisms so that the food remains safe and unspoiled during normal conditions of handling and storage. However, the heat applied should not adversely affect the sensory characteristics and nutrients. The spores of some highly heat resistant non – pathogenic organisms, if at all they are present, may survive the thermal process, but remain dormant. The product may not achieve absolute sterility in its strict sense but should attain the so called "Commercial sterility".

The cans are loaded in the retort and closed air tight. Steam produced in a boiler is let in, which flushes out the air from inside followed by building up pressure. Once the process pressure is (process temperature) is attained, the pressure is maintained constant for the required period. After this, the steam is let out to lower the pressure back to the atmospheric pressure. Retorts used for heat processing operations are of two types, viz., batch and continuous. Batch retorts can be vertical and horizontal. For pouches, over pressure retorts are used by immersing the pouches in water heating to the required temperature by pressurised steam and excess pressure is ensured by compressed air.

Thermal processing step is followed by post processing steps which are mentioned below.

Post - processing steps

- Cooling cans with chlorinated water
- Drying cans
- Storage and bulk packing

After retorting, the cans are cooled. During cooling, water may be let into the retort itself or the cans may be submerged under water after unloading from the retort. Precautions during retorting and cooling are

- Complete venting of air before building up pressure
- Cans are loaded as 'Jumble pack' to ensure proper circulation.
- Steam should be let in at optimum rate.
- Temperature must remain steady during process time.
- Lowering out pressure after processing should be done gradually.
- Cooling of cans should be rapid to room temperature and surface of can should be dried.
- The water used must be chlorinated sufficiently to prevent post process contamination.
- Temperature of can cooling water should be maintained constant.

Canning of fish must be done very carefully. Any mistake done in unit operations leads to certain risks which are listed in Table 1.

4. RETORT POUCH PROCESSING

Retort pouch products are also called as "Heat and Eat" food products. Food is packed in flexible material, sealed and sterilized at 121 ºC. This makes the product shelf stable like canned foods. Filling should be accurate and there should not be contamination of sealing area. Head space should be removed before sealing to prevent bursting during retorting due to increased pressure inside. The head space interferes in uniform heat transfer. Quick heat penetration helps in better quality retention. Retort pouch products are processed to commercial sterility and are shelf stable without refrigeration.

Retort: Different kinds of retorts are used for pouch processing. Non – agitating and still retort either vertical or horizontal type is widely used retort. Vertical retorts handle more number of pouches per unit retort volume. They require less floor space and hence are more efficient than horizontal retorts. Continuous agitating of pouches while processing needs less processing time.

Retortable pouches: Retort pouches are light, convenient and useful for defence personnel. Sterilizable flexi – bags are newer developments, which reduce damage on meat. These are sealed multilayer laminates with or without aluminium foil. They are heat resistant plastics suitable for thermal processing at 121 ºC. They are heat sealable with good barrier properties. They reduce the processing time by 30 – 35 % and minimize quality damage. They have long shelf life and very convenient for processing, transportation and serving. In India, the 3 – ply laminate of PET / Al foil / PP is commonly used. Retort processing schedule depends on F value and needs to be arrived at based on product quality as done for canning of foods (Fig. 4). The main limitations of retort pouch processing are: (i) Major capital investment, (ii) Filling is slower and needs skilled personnel and (iii) Detection of leakage in flexi - pouch is more difficult.

5. QUALITY OF CANNED FISH

Cans may rust on the outside due to inadequate drying. Rough handling may cause them to rupture. Swelling of cans indicates the presence of gas producing bacteria giving foul smell and / or discolored product. Bacterial spoilage is caused by the use of a poor quality raw material, under processing, infection of the can contents with polluted water or improper sealing of can. Chemical spoilage is caused by the leaching of compounds and / or metals from the can walls in to the product. Leakage of iron sulphide (FeS) from the can in to the product causes black discoloration of meat. Lining the can with the carbon enamels or addition of parchment paper liners between the product and can eliminates this problem.

Struvite, glass - like crystals, result from the formation of magnesium – ammonium phosphate. Ammonium phosphate results from the reactions of magnesium in sea water and

ammonia produced from fish muscle protein during heat processing. The crystals form after heat treatment during cooling period. Appearance of crystals gives unpleasant appearance but seems to be harmless. The crystal formation may be prevented by removing the magnesium compound from the product before canning. This is usually achieved with the addition of chelating agent.

6. INSPECTION OF PROCESSED CAN

Samples are taken at random. The number of cans selected depends on the size of the lot. The selected cans are incubated at 37 ^{0}C and 55 ^{0}C for 2 weeks. The cans are inspected for seam defects, dents, damage and rusting. The particulars on the label, code, product name and gross weight are noted. The cans are tested for vacuum using sterilised vacuum gauge, opened and the head space measured. The contents are drained, the liquid quantity is measured, the volume, turbidity, colour and brix of the drained liquid are noted. The solids are transferred to a plate. The number of pieces, breakage, color, texture, odor and flavor are assessed. Also the contents are examined for foreign matter, if any. The bottom and inside of the cans are examined for adhesion, blackening and lacquer peeling. The empty cans are washed, dried and weighed to calculate the net weight of the product. After inspection, the cans are labelled and packed in master cartons. The strapped cases are stacked in warehouse and maintained cool and dry till transport.

Conclusion: Fish canning is well established in developed industrialised countries. A number of tropical countries produce variety of canned seafood products. Hermitically sealing the food in a container, heat sterilising the sealed unit and cooling the cans to ambient temperature for subsequent storage are three main stages in the canning process. Regular supply of large qualities of suitable fish, (eg. sardines, mackerel, tuna), adequate supply of cans at an economic price, suitable infrastructure (energy, water, transport) and market for the finished product are the prerequisites for establishing fish canning industry. The preparation of fish and canning operation vary according to the species. Canning is an expensive operation and in many countries the high cost of cans has hindered the development of canning industries. Canned fish have the potential for keeping almost indefinitely because the bacteria, which cause deterioration, are killed during the heating process. Retort pouches are cheaper, reduce the processing time by 30 – 35 % and minimize quality damage. They have long shelf life and very convenient for processing, transportation and serving.

Table 1. Mistakes in unit operations of canning and the risks involved

Mistake	Risk
Incomplete venting	Under processing
Sudden pressure build up	Panelling
Compact loading of cans in retort	Steam circulation affected - under processing
Letting out of steam suddenly from the retort	Buckling and strain on can seam
Slow cooling	Overcooking of the product and germination of surviving spores
Inadequate cooling	Stacks burn if stored while still hot
Insufficient chlorination of can cooling water	Post - process contamination due to temporary leak in seam during cooling
Rise in cooling water	Slow cooling temperature

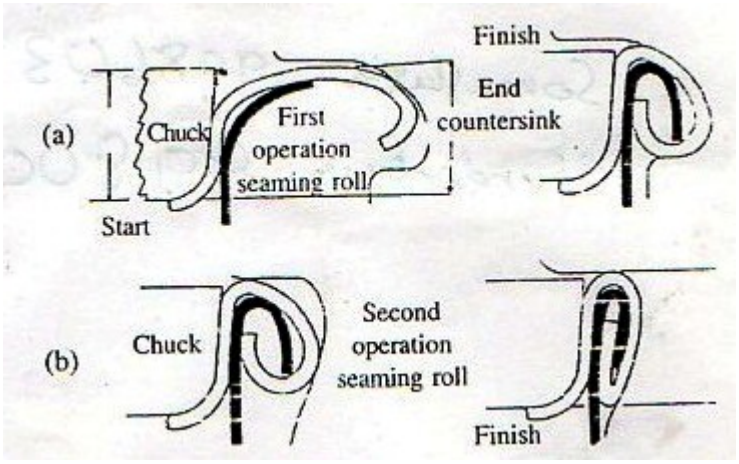

Fig. 1. Formation of seam in metal can in seaming equipment (Seamer)

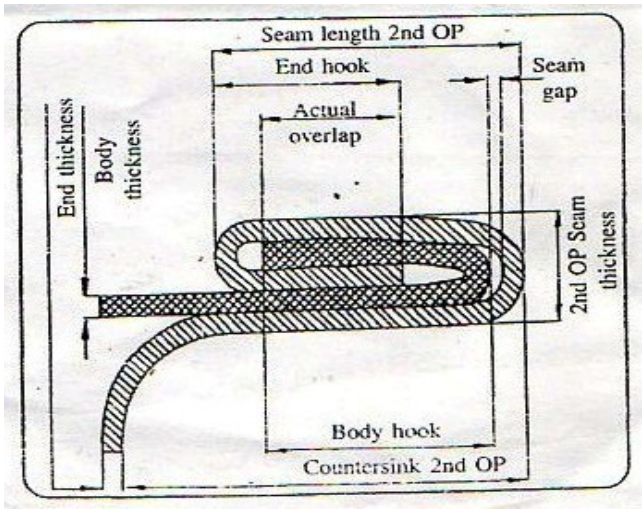

Fig. 2. The cross section of the double seam in metal can showing 5 layers

Step nr	Shrimp	Tuna	Clams and green mussels	Crab (live)
1	Washing	Fresh / Frozen, thawing if frozen	Raw material whole live shells	Washing
2	Weighing	Weighing	Washing and keeping under water for 1 day	Weighing
3	Beheading	Semi dressing (gilling and gutting)	Steaming 15 min at 100 ^{0}C	Removal of back shell
4	Peelinng	Washing	Shucking the meat	Washing
5	Deveining	Precooking at 100^{0}C for 40 - 90 min until centre temperature is 70^{0}C	Cleaning and grading	Blanching
6	Washing	Cooling - Air cooling over night at room temperature	Blanching in 5% table salt for 5-10 min at 100 ^{0}C	Cooling in ice water
7	Blanching 10% salt +0.3 % citric acid solution for 10 min	Cleaning	Fan drying	Meat picking Leg meat and body meat separately
8	Fan drying	Deskinning - separating bones collecting white loins and the dark meat is canned as pet food (dogs and cat)	Grading	Acid treatment 0.3% citric acid for 2 - 3 min
9	Grading	Size cutting	Filling in cans, Addition of cooking media	Filling in cans with parchment paper
10	Filling in cans Addition of cooking media	Filling Addition of oil	Exhausting and seaming	Addition of juice - a tea spoonful of concentrated blanching juice
11	Exhausting and seaming	Exhausting and seaming	Thermal processing	Exhausting and seaming
12	Thermal processing	Thermal processing		Thermal processing

Fig. 3. Processing steps for canning of different types of fish

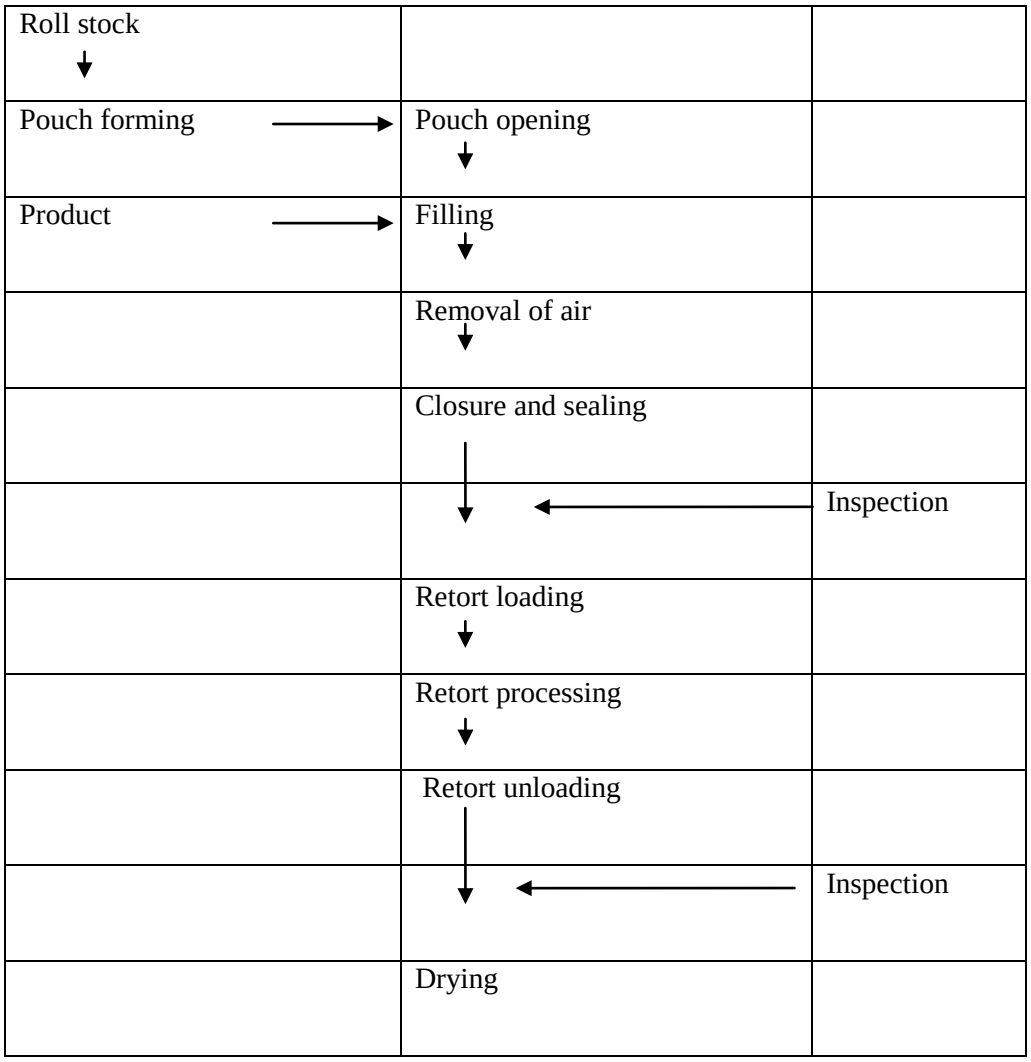

Fig. 4. Processing steps for meat products in retort pouch

Source: Prabhat Kumar Mandal 2011.