QUALITY ISSUES IN THERMALLY PROCESSED FISHERY PRODUCTS

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Thermal processing

Thermal processing can be subdivided into several more or less overlapping groups based on temperature regime, method or equipment for thermal processing, fish species, packaging method or the microbial target of the process. The number of micro-organisms (either vegetative cells, bacteria or spores) present in the food is reduced by subjecting it to heat for sufficient time to ensure food safety or to reduce spoilage and increase shelf life. Sterilization is the classical method. The temperature regime during processing may vary from 110 to 135 ^{o}C. Much of the analysis of thermal processing has been developed for foods placed in metal containers, usually the cylindrical metal can made from thin tin-plated steel or aluminium, and heated by steam. This process is often referred to as ‘canning’. Pasteurisation is a form of thermal processing. Pasteurisation is a milder treatment than commercial sterilisation and therefore does not give a safe shelf-stable product without subsequent storage at refrigerated temperature.

Low acid canned foods and *Clostridium botulinum*

Clostridium botulinum is a highly heat resistant mesophilic, Gram-positive, rod-shaped spore-forming anaerobic pathogen, which produces the toxin botulin. Growth of *C. botulinum* is a risk in ‘low acid canned foods’ (LACF) having a pH above 4.6 including fishery products, where it is necessary to apply a time–temperature regime sufficient to inactivate spores of *C. botulinum*.

Commercial sterility

Canned fishery products are packed in hermetically sealed containers and shall have received a processing treatment sufficient to ensure commercial sterility. Commercial sterility is a condition achieved by the application of heat, sufficient alone or in combination with other appropriate treatments, to render the food free from microorganisms capable of growing in the food at normal non-refrigerated conditions at which the food is likely to be held during distribution and storage (FAO/WHO Codex Alimentarius Commission, 1983).

Spoiled cans-Types

1. **Flipper**: The can may be normal in appearance. But, when such a can is hit on the table, can end flips out and becomes convex. When the convex end is pressed, it becomes flat again. A flipper is the initial stage of a swell, but may also be caused by overfilling or lack of vacuum/under exhausting.
2. **Springer:** One end of the can remains permanently convex and if this end is pressed down, the other end flips out.
3. **Soft swell**: Permanently convex can ends and get depressed due to pressure by fingers.
4. **Hard swell**: Permanently convex can ends and do not get depressed due to pressure by fingers.

Causes of spoilage

1. **Pre-spoilage or incipient spoilage**: Takes place before the product or the ingredients are thermally processed. Caused by microbial or enzymatic action resulting in gas accumulation, development of off-odours and the presence of excessive numbers of dead microbial cells in the end product.
2. **Under processing**: The product did not receive sufficient heat treatment to become commercially sterile.
3. **Thermophilic spoilage**: Occurs, when the time-temperature conditions are conducive to the growth of thermophilic bacteria. Prevention of thermophilic spoilage can be achieved by cooling the retorted cans rapidly to reach a temperature <40 ^{o}C and storing finished products at less than 35 ^{o}C to inhibit the growth of any surviving thermophiles.
4. **Post-process spoilage**: Post-process contamination or leaker spoilage takes place, when microbial contaminants leak into the can after heat sterilization, due to failure of the container to maintain hermetic seal.

Types of spoilage

1. Microbial spoilage: It is caused almost entirely by heat resistant microorganisms.
    a. **Gaseous spoilage:** Swelled or bulging can end is the common indication of gaseous decomposition. Gas-forming heat-resistant organisms belong to *Clostridium sp*.
    b. **Non-gaseous spoilage/flat souring:** Some bacteria (e.g., *Geobacillus stearothermophilus*) do not produce gas, when it spoils food. There is no external indication of non-gaseous spoilage, but the product is sour in taste.

2. Chemical spoilage: Hydrogen produced due to internal corrosion leads to can swell
3. Physical Spoilage: Occurs due to faulty retort operation, under exhausting, over filling & high vacuum in tall cans leads to panelling

Common quality problems/defects in canned fishery products

1. **Struvite formation:** Struvite is Magnesium ammonium phosphate hexahydrate [$MgNH_4PO_4.6H_2O$]. It appears as glass-like crystals in some canned fishery products such as brine packed shrimp, crab or tuna, particularly when the storage temperature is low. Use of hard water, stale raw material and presence of magnesium in salt/sea water used in canning are responsible for the formation of these crystals.
2. **Sulphide blackening:** The natural compounds in food can react with the metal in the lid to form black deposits. It is usually seen in canned shrimp, lobster, crab etc.
3. **Curd and adhesion:** Curd is salt soluble coagulated or precipitated protein, which is often found at the top of canned Salmon or Mackerel. The curd may adhere to can surface and the lacquer may get peeled off when the curd is removed. Use of less fresh fish & inadequate brining or precooking lead to curd formation.
4. **Copper sulfide/Blue discoloration:** This is commonly associated with canned crab meat. Copper in the haemocyanin of crab haemolymph react with sulfides formed in heat processing resulting in the formation of blue copper sulfide.
5. **Honey combing:** The meat in the can resembles a honey comb, when stale raw materials are used for canning. This was originally found in canned salmon but occurs in other products such as tuna and sardines.
6. **Retort burn:** This is usually associated with canned shell fishes like clam, mussel or oyster. This occurs due to insufficient filling medium to cover the solid food completely and the top is left dry.
7. **Case hardening:** Surface of fish meat gets dehydrated and hard cover is formed on the surface of meat. This is caused by high heat process and too quick heating process.
8. **Softening in shrimp:** The canned shrimp becomes soft due to decomposition of protein to soluble non-protein components. This can be avoiding by using fresh raw material and maintenance of high level of sanitation.
9. **Mush:** This is flabby condition seen in some species of pilchards caught at the end of its spawning season. This is caused by the invasion of the parasitic protozoan *Chloromyxum.*
10. **Miscellaneous aspects**: Externally rusted cans, damaged cans & cans with severe dents on the body.

Undesirable changes in canned fish/Influence of canning on the quality of fish

1. Colour changes
2. Degrades flavour and many fishes become soft in texture.
3. Denaturation, coagulation and precipitation of protein affects its digestibility & nutritive value.
4. Degradation of carbohydrates, which undergo caramelization at high temperatures.
5. Appreciable loss of fat-soluble vitamins A and D, if heated in the presence of oxygen.
6. Fat oxidation/rancidity, if there is no sufficient vacuum in the can.

Codex Alimentarius International Food Standards (FAO and WHO. 2020. Code of Practice for Fish and Fishery Products. CODE OF PRACTICE, CXC 52-2003)

Processing of canned fish, shellfish and other aquatic invertebrates- Identification of hazards:

1. Biological hazards
   - -Naturally occurring marine toxins
   - -Scombrotoxin/Histamine
   - -Microbiological toxins: *Clostridium botulinum, Staphylococcus aureus*
2. Chemical hazards: components of the containers (e.g., lead) and chemical products (e.g., lubricants, sanitizers, detergents)
3. Physical hazards: Materials such as metal or glass fragments

Critical Control Points (CCPs)

According to ICMSF, a CCP may be a location, procedure or processing step at which hazards can be controlled. Two types of CCPs may be identified: CCP-1 that will ensure full control of a hazard and CCP-2 that will minimize but not assure full control. Within the context of HACCP, the meaning of "control" at a CCP means to minimize or prevent the risk of one or more hazards by taking specific preventative measures (PM).

Hazards and preventive measures in production of low–acid canned fish

Product flow	**Hazard**	**Preventive measure**	**Degree of control**

Reception of raw material at factory (fish and cans)	Substandard quality entering processing	Ensure reliable source Sensory evaluation	CCP–2
Primary processing			
Filling of cans	Uncontrolled heat penetration during thermal processing	Avoid inclusion of air, control weights of solids, liquids, product density and headspace	CCP–2
Evacuation, seaming	Recontamination	Standards of closures must be checked at regular intervals.	CCP–2
Thermal processing	Survival of pathogens	Time x temperature (Txt) control.	CCP–1
Cooling	Recontamination	Quality of cooling water. Chlorine level > 1–2 ppm.	CCP–2
Handling of filled (wet) cans	Recontamination	Handling of warm, wet cans must be avoided. Can handling should be designed to minimize mechanical shock.	CCP–2
Storage and distribution			

Technical guidance for quality maintenance

Quality of fish should be ensured by purchasing them from a reliable source and also by sensory evaluation. Quality of the cans should be confirmed by a documented quality assurance system by the can manufacturer. Correct filling is important to ensure proper heat penetration during thermal processing. Avoid inclusion of air, control weights of solids, liquids, product density and headspace. Standards of can closures must be checked at regular intervals to prevent recontamination during evacuation and seaming. The thermal processing is a Critical Control Point (CCP)–1 for eliminating all pathogenic organisms. Time x temperature (Txt) control is a measure to prevent survival of pathogens. Rapid cooling of canned fish and shellfish avoids the formation of struvite crystals. Struvite formation may also be prevented by the addition of chelating agent such as sodium hexametaphosphate or EDTA. Quality of water used for can cooling is very important to avoid recontamination. It must be chlorinated (Chlorine level > 1–2 ppm). Handling of warm, wet cans must be avoided. Sulphide blackening can be minimized by uniform lacquering of can and its careful handling for avoiding exposing of iron. Blue discolouration can be reduced by thorough bleeding of crab while dressing and use of chelating agent in the brine. Maintenance of proper acidity inside the can and use of parchment lining inside the can may also minimize sulphide blackening and blue discolouration. Curd formation can be avoided by cold blanching of fish in 10-15 % brine for 20-30 minutes and subsequent washing. Use of fresh raw material and slow thawing of frozen tuna without rough handling can reduce honey combing. Retort burn can be prevented by using sufficient filling medium to cover the solid food in the can. Case hardening can be prevented by adopting proper thermal processing process. Softening of shrimps can be avoided by using fresh raw material and maintenance of high level of sanitation.

Food Safety and Standards Authority of India (FSSAI)

Food Safety and Standards Authority of India (FSSAI) is an autonomous body established by the Government of India under the Ministry of Health & Family Welfare. It usually sets standards for food so that there is no chaos in the minds of consumers, traders, manufacturers and investors. As per Section 31(1) & 31(2) of FSS Act, 2006, every Food Business Operator in the country is required to be licensed/registered under the Food Safety & Standards Authority of India.

FSSAI (2011) standards for canned fishery products-Decomposition

The raw material (fish) shall not contain more than **100 mg/Kg of histamine** based on the average of the sample unit tested. This shall apply only to species of fish with potential to form hazardous level of histamine as mentioned in Food Safety and Standards (Contaminants, Toxins and Residues) Regulations, 2011.

FSSAI (2011) standards for canned fishery products-Final product

Sr. No.	**Characteristics**	**Finfish**				**Crustaceans**		**Molluscs**	
		Tuna	**Mackerel**	**Sardine**	**Pomfret/ Seer fish**	**Shrimp / Prawn**	**Crab**	**Mussel**	**Squid**
1.	Medium	Oil	Oil Brine Curry Tomato Sauce	Oil Brine Curry	Oil	Brine	Brine	Oil	Brine

2.	Drained wt. as % of water capacity*	70	65	70	66	64	65	65	64
3.	% of water in the drained liquid**	5	10	10	10			5	-
4.	Disintegrated portion as % of drained weight (max)	5	5	5	5	5	5	5	5
5.	Vacuum (Minimum)	For round cans 100 mm and negative pressure in flat cans							
6.	Head Space	5-10 mm							
7.	Can Exterior	shall not be rusted, dented or bulged							

*A tolerance of ±5 percent is permitted, ** Only applicable for oil medium.

The percentage of sodium chloride in the final product of sardine and mackerel shall be 3.5 percent in the case of brine treated cans. The acidity of brine as citric acid anhydrous shall be between 0.06 and 0.20 percent (m/v).

Microbiological Requirements for Thermally Processed Fishery Products

-Hygiene Indicator Organisms

Product Category*	**Aerobic Plate Count**				**Stage where criterion applies**	**Action in case of unsatisfactory results**
	Sampling Plan		Limits (cfu/g)			
	n	c	m	M		
Thermally Processed Fishery Products	Commercially Sterile**				End of Manufacturing process	Revalidation of thermal process
Test method	IS: 5402/ISO 4833					

**Commercial sterility should be established as per APHA (2015). Canned Foods—Tests for Commercial Sterility. Compendium of Methods for the Microbiological Examination of Food

Microbiological Requirements for Thermally Processed Fishery Products – Safety Indicator Organisms

Product Category*	***Clostridium botulinum***			
	Sampling Plan		Limits (cfu/g)	
	n	c	m	M
Thermally Processed Fishery Products	Absence of viable spores or vegetative cells of *Clostridium botulinum*			
Test method	IS: 5887, Part 4 or ISO 17919			

Sampling Plan: The terms n, c, m and M used in this standard have the following meaning: n = Number of units comprising a sample. c = Maximum allowable number of units having microbiological counts above m. m = Microbiological limit that may be exceeded number of units c. M = Microbiological limit that no sample unit may exceed.

FSSAI standards for Ready–to-Eat Finfish or Shell Fish Curry in Retortable Pouches

Decomposition

The total volatile base nitrogen (TVBN) level of raw material (fin fish or shell fish) should not exceed 35 mg/100g.

Final Product

The finished product shall have the odour, flavour and colour characteristic of the product. The bones shall be soft and yielding. The contents of the pouch on opening shall not display any appreciable disintegration. Pieces from which portions have separated out would be treated as disintegrated units. The percentage disintegrated portions of the fish, calculated on the basis of the drained mass shall not exceed 5 % based on the average of five pouches. The product shall be free from foreign materials such as sand, dirt and insects, objectionable odour or flavour. The residual air in the pouch after processing shall be less than 2 % of the volume of the pouch contents. The average proportion of fish to curry in retort pouch shall be in the ratio of 60: 40. The percentage of salt in the product shall be 1 % to 2 %, maximum.

Processing

The material shall be packed in retortable pouches, exhausted or vacuumized and heat-sealed. Exhausting can be done either by steam injection or hot filling to achieve residual air level of less than 2 %. Processing (Retorting) shall be done in over pressure autoclave till the product reaches a F_0 value of 8-10 minutes at the slowest heating point. The water used for cooling of retort pouches shall be as per IS 10500:2012 standards and chlorinated to maintain free residual chlorine of less than 2 mg/l.

Packaging and Labelling

The retort pouches shall be packed in suitable retail containers to prevent physical impact during transportation. Retort pouch materials of food grade quality having the configuration of polyester/aluminium foil/cast polypropylene or four layers consisting of polyester/aluminium foil or aluminium oxide/nylon and cast polypropylene may be used. Other suitable packaging materials which can withstand high temperature and pressure can also be used. The pouches shall be of food grade quality. The retort pouch shall have the mechanical properties as under:

Sr. No.	Characteristics	Requirement
1.	Tensile strength (Kgf/15 mm) machine direction	3.0-5.25
2.	Bond Strength (Kgf/15 mm)	0.225 – 0.750
3.	Heat seal strength (Kgf/15 mm), Min	4.60
4.	Bursting strength (Kg/cm^2), Min	1.74

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