

## **Introduction to Fish Processing Techniques**

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The demand for healthy and safe food products has driven significant interest and growth in the food processing industry. The focus on health, nutrition, and convenience is reshaping the global food industry. Fish products, in particular, have garnered attention due to their rich nutritional profile, including high-quality protein, essential vitamins, minerals, and healthful polyunsaturated fatty acids. The growth of fresh fish and seafood as a category is noteworthy, ranking third among the food categories with the fastest overall growth worldwide. This places it just behind drinkable yogurt and fresh soup, both of which have experienced an 18% growth rate. The increasing consumption of freshwater and seawater fish is expected to persist in the future. As fish is highly nutritious, it is also highly susceptible to spoilage, due to intrinsic and extrinsic factors. Proper processing and packaging help in maintaining the eating quality of fish for extended period. Worldwide, an array of processing and packaging methods are followed. This ranges from a simple chilled or ice storage, salted and drying to most recent and advanced high pressure and electromagnetic field applications, which attracts opportunities from both small scale and industrial level entrepreneurs. Fish products in live, fresh chilled, whole cleaned, fillets steaks, battered and breaded products, variety of dried products, smoked fish, fish sausage and traditional products are the range of low-cost processing methods which can be readily adopted by small-scale fishers. The processing methods like canning or heat processing, freezing, vacuum and modified atmosphere packaging, analogue products, high pressure processing, pulsed light processing, irradiation, electromagnetic field etc are the processing methods which requires higher investments can be adopted by large scale entrepreneurs, apart from the above-mentioned processing methods.

The advantages of food processing are numerous and play a crucial role in meeting the diverse needs of consumers, ensuring food safety, and contributing to economic development. Here are some key advantages:

1. Conversion of Raw Food: Processing transforms raw food into edible, usable, and palatable forms, making it more convenient for consumers to incorporate into their diets.
2. Preservation and Storage: Processing helps in the preservation and storage of

perishable and semi-perishable agricultural commodities. This is essential for preventing spoilage, extending shelf life, and reducing post-harvest losses.

3. **Market Stabilization:** Food processing helps avoid market gluts by enabling the storage and distribution of produce, ensuring a more stable supply throughout the year. This, in turn, reduces the impact of seasonal variations and helps manage market prices.
4. **Employment Generation:** The food processing industry generates employment opportunities across various stages of production, processing, packaging, and distribution, contributing to economic development.
5. **Ready-to-Consume Products:** The development of ready-to-consume convenient products saves time for consumers in meal preparation, aligning with the demands of modern, fast-paced lifestyles.
6. **Improvement of Palatability:** Processing enhances the palatability and organoleptic quality of food products through value addition, making them more appealing to consumers.
7. **Inhibition of Anti-nutritional Factors:** Certain processing methods can help inhibit anti-nutritional factors present in raw food, making the final products safer and more nutritious.
8. **Facilitation of Marketing and Distribution:** Processed foods are often easier to market and distribute, contributing to efficient supply chain management.
9. **Long-Distance Transportation:** Processing enables the transportation of delicate perishable foods across long distances, facilitating the availability of a wider variety of food products in different regions.
10. **Microbial Safety:** Processing helps make foods safe for consumption by controlling and eliminating pathogenic microorganisms through methods such as pasteurization, canning, and irradiation.
11. **Specialized Diets:** Modern food processing allows for the development of healthy foods tailored for individuals with specific dietary needs, such as those with allergies, diabetes, or other health conditions.
12. **Nutritional and Food Security:** Food processing can contribute to overall nutritional security by creating fortified products and enhancing the availability of nutrient-rich foods.

13. Export Potential: Processed food products can be exported, providing opportunities for earning foreign exchange and contributing to the growth of the national economy.

### **1. Chilled Fish Products**

Chilling is an effective method of maintaining the freshness of fish products. This normally involves keeping fishes in melting ice or slurry ice to maintain the fish temperature around 1- 4 °C, which delays the enzymatic action and microbial activity, thereby extending the shelf life of the products. Traditionally, chilling is carried out using melting ice, either flake ice or crushed block ice. Of late, slurry ice has been introduced for chilling. A wide range of fish and shellfish products varying from whole, headless, peeled gutted, headless gutted fish, fillets, steaks, loins, cubes can be preserved by chilling. Shelf life of fishes from different environment has been studied by the Division extensively. Shelf life of 12-15 days has been achieved for seerfish and black pomfret. Indian Mackerel and Indian oil sardine had very short shelf life in ice (3-7 days), due to rancidity and belly bursting. Tilapia from freshwater and brackishwater showed significant difference in shelf life when stored in ice. The former kept longer (14-15 days) than latter (8-10 days).

### **2. Frozen Fish Products**

Freezing is an age-old practice to retain the quality and freshness of fishery products for a long time. This involves the conversion of water present in fishery products to ice i.e., a phase change from liquid to solid phase takes place in freezing. This retards the microbial and enzymatic action by reducing the water available for their action. This involves exposing fish products to very low temperature ( $<-35^{\circ}\text{C}$ ) to enable freezing of free water and maintained at  $-18^{\circ}\text{C}$  till it is consumed. Plate freezing, air blast freezing, cryogenic freezing and individual quick freezing are the methods adopted by the industry to preserve food products.

### **3. Dried and Salted Fishery Products**

Drying is probably one of the oldest methods of food preservation. It consists of removal of water to a final desired concentration, which in turn reduces the water activity of the product, thereby assuring microbial stability and extended shelf-life of the product. In some cases, common table salt (Sodium chloride) is also used to prolong the shelf life of fish. Salt absorbs much of the water in the food and makes it difficult for micro-organisms to survive.

#### **4. Smoked Fishery Products**

Smoking is one of the most widely used traditional fish processing methods employed in many countries to preserve fish. The preservation effect of the smoke is a result of drying of the product during the smoking as well as due to smoke particle absorption into the flesh. The smoke particles, mainly phenolic compounds, carbonyl and organic acids, being absorbed by the product, inhibit bacterial growth on the surface of the product. The smoke particles also have a positive effect on the taste and colour of the product and in many instances, smoking is normally practiced to improve these sensory characteristics.

#### **5. Retort Pouch Processing**

As in canning, retort pouch food is sterilized after packing, but the sterilizing procedure differs. The pouches are processed in an over pressure retort. The time and temperature will be standardized depending on the product. With the availability of retort pouches it can function as an excellent import substitute for metallic cans. Besides, cost reduction retort pouch packages have unique advantages like boil in bag facility, ease of opening, reduced weight and do not require refrigeration for storage. Processed food products can be kept for long periods at ambient temperature. The energy saving is more in processing in flexible pouches compared to cans. On a comparison of total costs, including energy, warehousing and shipping, the pouch looks even more favourable. There is 30 to 40% reduction in processing time compared to cans, solids fill is greater per unit, empty warehousing is 85% smaller and weight of the empty package is substantially smaller.

#### **6. Extrusion Technology**

In order to improve the utilization of underutilized fisheries resources, there is a need to minimize the post-harvest losses, develop innovative processing technologies and utilize processing waste for industrial and human use. One such technology, which will be suitable for utilization of low value fish or by catch, is extrusion technology. Use of fish mince with cereals for extrusion process will enable production of shelf-stable products at ambient temperature. Extrusion cooking is used in the manufacture of food products such as ready-to-eat breakfast cereals, expanded snacks, pasta, fat-bread, soup and drink bases. The raw material in the form of powder at ambient temperature is fed into extruder at a known feeding rate. The material first gets compacted and then softens and gelatinizes and/or melts to form a plasticized material, which flows downstream into extruder channel. Basically, an extruder is a pump, heat exchanger and bio-reactor that simultaneously

transfer, mixes, heats, shears, stretches, shapes and transforms chemically and physically at elevated pressure and temperature in a short time. At times, the extrusion cooking process is also referred as High Temperature Short Time process. In extrusion process gelatinization of starch and denaturation of protein ingredient is achieved by combined effect of temperature and mechanical shear. The conversion of raw starch to cook and digestible materials by the application of heat and moisture is called gelatinization. During extrusion the conditions that prevail are high temperature, high shear rate and low moisture available for starch may lead to breakdown of starch molecules to dextrins.

## 7. Irradiation

Irradiation is a physical treatment that consists of exposing foods to the direct action of electronic, electromagnetic rays to assure the innocuity of foods and to prolong the shelflife. Irradiation of food can control insect infestation, reduce the numbers of pathogenic or spoilage microorganisms, and delay or eliminate natural biological processes such as ripening, germination, or sprouting in fresh food. Like all preservation methods, irradiation should supplement rather than replace good food hygiene, handling, and preparation practices.

Three types of ionizing radiation are used in commercial radiation to process products such as foods and medical and pharmaceutical devices (International Atomic Energy Agency (IAEA), radiation from high-energy gamma rays, X-rays, and accelerated electrons.

- Gamma rays, which are produced by radioactive substances (called radioisotopes). The approved sources of gamma rays for food irradiation are the radionuclides cobalt-60 ( $^{60}\text{Co}$ ; the most common) and cesium-137 ( $^{137}\text{Cs}$ ). They contain energy levels of 1.17 and 1.33 MeV ( $^{60}\text{Co}$ ) and 0.662 MeV ( $^{137}\text{Cs}$ ).
- Electron beams, which are produced in accelerators, such as in a linear accelerator (linac) or a Van de Graaff generator at nearly the speed of light. Maximum quantum energy is not to exceed 10 MeV.
- X-rays or decelerating rays, which can be likewise produced in accelerators.

Maximum quantum energy of the electrons is not to exceed 5 MeV

Different forms of irradiation treatment are radurization (for shelf life extension), radicidation (for elimination of target pathogens) and radappertization (for sterilization). Radiation processing is widely used for medical product sterilization and food irradiation. Moreover, the use of irradiation has become a standard treatment to sterilize packages in aseptic processing of foods and pharmaceuticals.

Irradiation produces some chemical changes, which, although lethal to foodborne bacteria, do not affect the nutritional quality of the food but lead to the production of small amounts of radiolytic products. Gamma irradiation has been considered as an interesting method of preservation to extend the shelf life of fish and also to reduce qualitatively and quantitatively the microbial population in fish and fish products. Irradiation doses of 2–7 kGy can reduce important food

pathogens such as *Salmonella*, *Listeria*, and *Vibrio* spp., as well as many fish-specific spoilers such as *Pseudomonaceae* and *Enterobacteriaceae* that can be significantly decreased in number.

### **8. Microwave Processing**

The applications of microwave heating on fish processing include drying, pasteurization, sterilization, thawing, tempering, baking etc. Microwaves are electromagnetic waves whose frequency varies within 300 MHz to 300 GHz. Microwave heating is caused by the ability of the materials to absorb microwave energy and convert it into heat. Microwave heating of food materials mainly occurs due to dipolar and ionic mechanisms. Microwave heating also occurs due to the oscillatory migration of ions in the food which generates heat in the presence of a high frequency oscillating electric field. Studies showed that chemical changes involved during different microwave cooking practices of skipjack tuna and will retain omega-3 fatty acids compared to frying/canning. Microwave blanching can be carried out for color retention and enzyme inactivation which is carried out by immersing food materials in hot water, steam or boiling solutions containing acids or salts. Microwave drying is used to remove moisture from fish and fishery products. Microwave drying has advantage of fast drying rates and improving the quality of product. In microwave drying, due to volumetric heating, the vapors are generated inside and an internal pressure gradient is developed which forces the water outside. Thus, shrinkage of food materials is prevented in microwave drying. Microwave combined with other drying methods such as air drying or infrared or vacuum drying or freeze drying gave better drying characteristics compared to their respective drying methods or microwave drying alone.

### **9. Ohmic heating**

Ohmic heating is an emerging technology with large number of actual and future applications. Ohmic heating technology is considered a major advance in the continuous processing of particulate food products. Ohmic heating is direct resistance heating by the

flow of an electrical current through foods, so that heating is by internal heat generation. Ohmic heating is defined as a process wherein electric current is passed through materials with the primary purpose of heating the object. During ohmic heating, heating occurs in the form of internal energy transformation (from electric to thermal) within the material. Therefore, it can be explained as an internal thermal energy generation technology and it enables the material to heat at extremely rapid rates from a few seconds to a few minutes. Ohmic heating has a large number of actual and potential future applications, including its use in blanching, evaporation, dehydration, fermentation, extraction, sterilization, pasteurization and heating of foods. The microbial inactivation due to ohmic heating can be explained by the presence of electric field. The additional effect of ohmic treatment may be its low frequency (usually 50e60 Hz), which allows cell walls to build up charges and form pores. As a main consequence of this effect, the D value observed for the microbial inactivation under ohmic heating is reduced when compared to traditional heating methods. More research is needed to completely understand all effects produced by ohmic heating to food products, effects of applied electric field, the applied electric frequency during ohmic heating over different microorganisms and foods, cold spot determination etc.

### **10. Infrared and Radiofrequency Processing Technologies**

Electromagnetic radiation is a form of energy that is transmitted through the space at an enormous velocity (speed of light). The heat generation in material exposed to EMR could be due to vibrational movement (as in case IR) or rotational movement (as in case of RF and MW) of molecules. Application of EMR heating is gaining popularity in food processing because of its definite advantages over the conventional processes. Faster and efficient heat transfer, low processing cost, uniform product heating and better organoleptic and nutritional value in the processed material are some of the important features of EMR processing. In conventional heating systems like hot air heating, the heat is applied at the surface which is carried inwards through conduction mode of heating. In case of EMR/dielectric heating, the waves can penetrate the material to be absorbed by inner layers. The quick energy absorption causes rapid heat and mass transfer leading to reduced processing time and better product quality.

The main advantage of electromagnetic heating over conventional electric and gas oven-based heating is its high thermal efficiency in converting the electrical energy to heat in the food. In ordinary ovens, a major portion of the energy is lost in heating the air that surrounds the food, fairly a good amount escapes through the vent, besides being lost

through the conduction to the outside air. In contrast, almost all the heat generated by electromagnetic radiations, which reach the interior of the oven, is produced inside the food material itself. According to the reports the energy efficiency of EMR based systems is 40-70%, as compared to approximately 7-14% in case of conventional electric and gas ovens.

### **11. High Pressure Processing**

High pressure processing (HPP) is an emerging and innovative technology that has a great potential for extending the shelf-life with minimal or no heat treatment. It is also effective in preserving the organoleptic attributes of many foods. High pressure Processing is a non-thermal technology in which the food product to be treated is placed in a pressure vessel capable of sustaining the required pressure and the product is submerged in a liquid, which acts as the pressure transmitting medium. Water, castor oil, silicone oil, sodium benzoate, ethanol or glycol may be used as the pressure transmitting medium. The ability of the pressure transmitting fluid to protect the inner vessel surface from corrosion, the specific HP system being used, the process temperature range and the viscosity of the fluid under pressure are some of the factors involved in selecting the medium.

### **12. Ultrasound Processing**

Ultrasound refers to sound that is just above the range of human hearing, i.e. above frequency of 20 MHz. Ultrasound when propagated through a biological structure induces compressions and depressions of the medium particles imparting a high amount of energy to the material. The sound ranges for food applications employed can be divided into two, namely, low energy, high frequency diagnostic ultrasound and high energy low frequency power ultrasound. Low energy applications involve the use of ultrasound in the frequency range of 5-10 MHz at intensities below 1 W/cm<sup>2</sup>. Ultrasonic waves at this range are capable of causing physical, mechanical, or chemical changes in the material leading to disrupting the physical integrity, acceleration of certain chemical reactions through generation of immense pressure, shear, and temperature gradient in the medium. Ultrasonics has been successfully used to inactivate *Salmonella* spp., *Escherichia coli*, *Listeria monocytogenes*, *Staphylococcus aureus* and other pathogens.

### **13. Bio Preservation**

Bacteriocins are a heterogeneous group of antibacterial proteins that vary in spectrum of activity, mode of action, molecular weight, genetic origin and biochemical properties.



Various spices and essential oils have preservative properties and have been used to extend the storage life of fish and fishery products. Natural compounds such as essential oils, chitosan, nisin and lysozyme, bacteriocins have been investigated to replace chemical preservatives and to obtain green label products.

#### **14. Application of enzymes**

Enzymes have been used for the production of various cured and fermented fish products from centuries. Because of their appreciable activity at moderate temperature, products and process have emerged that utilizes enzymes in a deliberate and controlled fashion in the field of food processing. Cold active enzymes including elastase, collagenase, chymotrypsin extracted from Atlantic cod were used in various food processing applications. The other applications of cold active enzymes include caviar production, extraction of carotenoprotein etc. Treatment with protease under mild treatment conditions extending for a few hours can result in the recovery of the proteins from fish frame or shrimp shell waste. The role of transglutaminase in surimi production is well established. The gel strength of surimi can be improved by the application of extracellular microbial transglutaminase. Lipase extracted from *Pseudomonas* spp can be used to produce PUFA enriched cod liver oil. Enzymatic de-skinning of fish fillets was done by partial denaturation of skin collagen using a gentle heat treatment followed by immersion in enzyme solution for several hours at low temperature (0-10°C). De-skinning of tuna, Herrin, Squid were also carried out by using different enzyme technology.