



High-Pressure Processing: An Innovative Technique for Fish Preservation

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Modern fish preservation methods focus not only to increase shelf life but also improve quality and minimum loss in nutritional and sensory characteristics. High pressure preservation (HPP) is one of the modern techniques for fish preservation. When certain amount of pressure is applied on fish fillets these shows mild cooking effects and gives firmness and soft texture in fillets, HPP actions make storage of fish meat for longer duration, extends shelf life and maintains freshness of fish. When around 100-600 Mpa pressure is applied in fish meat, it inactivates food borne microorganisms such as psychotropic gram-negative bacteria. Extreme pressure treatment (around 300 Mpa) can reduce bacterial load as well as decrease enzyme activity to increase storage life and maintain quality of fish fillets. HPP also improve the textural properties of fish fillets by mediating gelation in fish muscles proteins due to alter bond in protein structure and change their structural enzyme transglutaminase (MTGase) helping protein binding and improve water holding capacity, which improve gel formation in surimi products. This article will explain the importance of HPP for fish preservation and textural improvement.

Keywords: Fish Preservation, High-pressure processing, Non-thermal Preservation, Nutritional value, Sensory characteristics.

Introduction

Fish are very good source of high protein, essential macronutrients and micronutrients present (iron, zinc, calcium), and important fatty acids (w-3 and w-6). These nutrients basically play important role in metabolism and prevent nutrient deficiency diseases like anaemia, weakened immune system, cognitive impairments etc. (Leroy *et al.*, 2023). The spoilage of fish and fishery products causes huge financial loss as its highly perishable commodity (Ashaolu *et al.*, 2023) as spoilage. To prevent financial loss, we need to stop/minimize spoilage fish and for that preservation of fish in ideal condition in very much necessary. There are several preservation techniques like canning, smoking, drying, salting etc. available for fish preservation. Some chemicals and additives are also being used from years to keep fish product for longer duration. The Fish muscle contain large amount of unsaturated fatty acids which are prone to rancidity and alter the flavour of fish when low temperature storage (Sin and Ko, 2017). However, HPP is more appropriate as compared to other preservation methods applied in fish commodity and processing industry. This is one of the most effective methods of modern preservation techniques which can maintain microbial and nutritional quality of the product at the same time. High-pressure processing methods give similar outcomes in case microbial and enzymatic effects like thermal processing technology, and gaining popularity at the fastest manner in European country in recent years (Kontominas *et al.*, 2021).

Principles and Mechanisms

In HPP, the food items are packed in a flexible pouch and loaded into a compressor chamber with a thick wall and filled with normal liquid after sealing the chamber with lock tight screw. The rest amount of air is removed through the vent which confirms only water present inside the chamber. In next steps, pressure rapidly increased by compressor system which add more amount of water. Increasing pressure inside chamber may be reached between 200-600 Mpa. Pressure should be equally distributed upon food surface to inactivate spoilage causing microbes and harmful bacteria. A major part of compressor chamber is pressure vessel which uses fluids such as “water and other liquids” to distribute pressure equally and quickly (Yaldagard *et al.*, 2008). After completing the action of HP technique, pressure may be released through valves. Then product is taken out from the chamber and kept in cool are for longer shelf life.

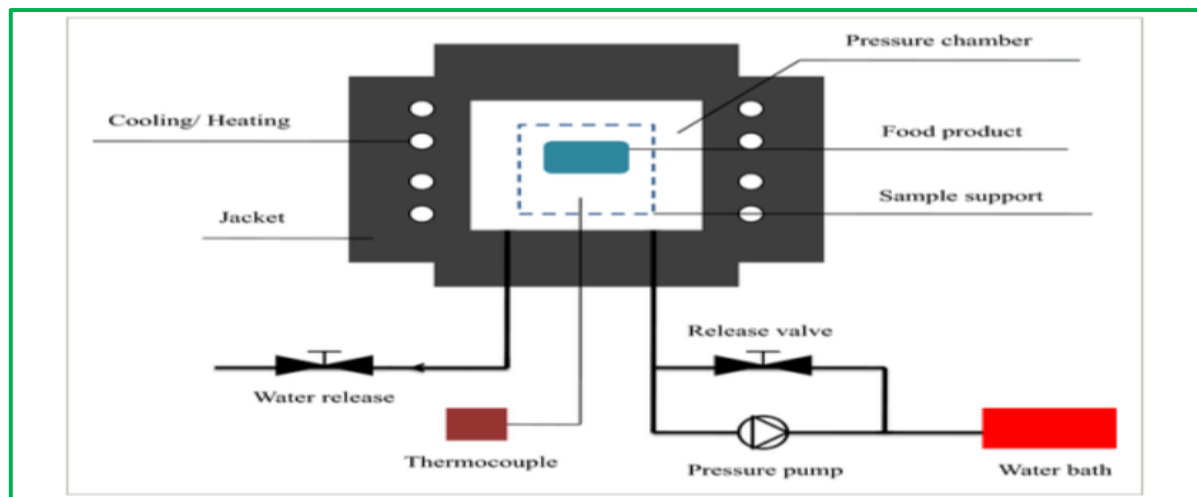


Figure 1: Layout High Pressure Processing with Labelled Diagram (Zhang *et al.*, 2019)

The Pressure applied very high amount (for example 700 Mpa), most probably chance to breaks noncovalent bonds in case of sarcoplasmic and myofibrillar proteins, alteration in protein structure, certain changes in colour and texture of proteins and gives minimum slight cooking like effects. Le Chatelier's Principle states that phase transitions, chemical reactions, and intermolecular interactions brought on by pressure reduce size of the fish fillets. Isostatic pressure is fundamental principle of high-pressure processing as it enables product to revert to its exactly size upon the release of force. Denatured proteins open and cluster together, which may alter the texture and water-holding capacity of muscles while also making them softer by weakening muscle fibres. The change in protein such as sarcoplasmic gives considerable effect on meat colour and enzymes work (Bolumar *et al.*, 2021). The change in pressure directly affects the emulsification quality of products and direct change in the phase action of lipid stage. This process contributes to directly affects stability of fat changes and quality of muscles and shelf life. Water soluble vitamin such as B- complex affected under high pressure compare than fat soluble vitamins (A, E) is more vulnerable to HPP (Bolumar *et al.*, 2021).

Effect of HPP on preservation of Fish

Shelf life of fish fillets: High pressure processing increases shelf life of fish fillets. It was reported by Ismaiel *et al.* (2025) that sea bass fillets treated in extreme pressure (100-600 Mpa) increased its storage life up to 60 days at 4°C. High pressure also changes sensory and physical characteristics of fillets characteristics. In extreme pressure, morphology and cell structure of food borne pathogen change and cause deactivation of microbes and slow down spoilage in raw fillets (Castrica *et al.*, 2021). Production of biogenic amines (Histamine) and total volatile base nitrogen by specific bacteria also be reduced by high-pressure treatment (Tsai *et al.*, 2022).

Effect on microbes in fish fillets: Microbial growth is the main factor of fish spoilage which develops rancid flavour and odour when ammonia produces in spoilage processes. HP treatments can deactivate spoilage causing microbes and reduces load of pathogenic bacteria

in total aerobic plate counts (APC), which includes coliforms and psychotropic gram-negative bacteria like pseudomonas species and vibrio species (Tsai *et al.*, 2022). It also works same on *Listeria monocytogenes* (Tsevdou *et al.*, 2023). High processing treatment able to maintain bacterial or microbial profile upto 10-12 days (Tidwell *et al.*, 2023)

Effect on Fish Protein Gelation: The gel forming ability of fish muscle protein can be increased by HPP. The method of treatment can increase the transglutaminase enzyme's potential to access the proteins, which can improve the gel strength and cross links within intermolecular structure and provide binding effects (Ribeiro *et al.*, 2018).

Conclusion

High-Pressure Processing (HPP) has emerged as a promising non-thermal preservation technology that significantly enhances the safety, quality, and shelf life of fish and fishery products. Unlike conventional thermal processing methods, HPP effectively inactivates spoilage microorganisms and foodborne pathogens while preserving the nutritional value, natural flavor, texture, and sensory attributes of seafood. Overall, High-Pressure Processing represents an innovative and sustainable approach to fish preservation, offering substantial benefits to the seafood industry by improving product quality, extending marketability, and ensuring food safety.

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