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High Pressure Processing: A Novel Seafood Preservation Approach

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Abstract

In modern days, consumers are keen to buy convenient, minimal processed fresh food with high nutritive quality and safety. But, the most of the techniques in food processing are using heat treatment to improve the shelf life of the product. As a result, reduction in nutritional qualities i.e., loss of texture, colour, flavour, odour and also undesirable changes in the product have been noticed in these conventional preservation and sterilization. In this context, non thermal food processing techniques are useful to reduce these problems and also process good quality food products. Thus, high pressure processing emerges as the most convenient, which can make safe food and also preserve the qualitative parameters of foods. It can reduce the vegetative microorganism load which are the primary reasons for food borne illness. Hence, high pressure processing provides a novel approach to food technologists to procure foods with minimally processed and superior quality.

1. Introduction

With the continuation of making convenience food products to provide safe and quality foods, the rise of different thermal and non-thermal process is happening. But non-thermal processing techniques are one of the promising alternatives now-a-days with minimally processed concept and can deliver the convenient and high-quality foods compared to other one. While it talks about making functional foods, non-thermal processing such as high-pressure processing can ready to grab the opportunity to develop the next generation high quality food products. Alternative novel approaches i.e., high-pressure processing, pulsed light technology, pulsed electric field, irradiation etc. are getting overwhelm importance for their role in retaining sensory qualities and/or textural flavours in foods. Among these, the high-pressure processing has been widely commercially implemented preservation technique in seafood processing to offer safe, fresh-like, healthy foods without the use of chemical preservatives or heat.

2. High Pressure Processing (HPP)

HPP technology has been used in non-food applications for many

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years. Thereafter, 1899 was the pioneer year when high pressure was first applied to increase the shelf life of milk and related foodstuffs. Even though this technology makes known to world in 1990 when decontamination of foods was done and observed relatively low negative effect on nutritional and sensory qualities (Ohlsson, 1994).

The application of very high pressures up to 87,000 psi or 600 MPa for preserving the nutrients in foods with or without heat treatment and can be conducted at ambient or refrigerated temperatures is known as high pressure processing (HPP). The novel technology is also known as High Hydrostatic Pressure (HHP) / Ultra High Pressure (UHP) Processing or Pascalization (Rastogi et al., 2007). Generally, food is hermetically sealed in flexible container under a high pressure of 100-600 MPa. This process is applied to eliminate thermal effects, post cook off flavours and produced foods with better appearance, texture and nutritional value.

It can stabilize ready-to-eat seafoods and other value-added products with consumers' preference and also help to reduce the microbial loads as well as spoilage caused by enzymatic activities in seafoods. Therefore, it has an immense potential in Indian seafood industry. A number of HPP products have been commercialized in developed countries. Machines are now available with different operating pressures in between 400-700 MPa with 900 kg capacity per batch operation.

3. Principles of High Pressure Processing

The two main principles are involved in HPP: the Le Chatelier's Principle and the Isostatic Principle. Le Chatelier's addresses changes to equilibrium as a result of pressure application. Any change (changes in molecular configuration, chemical reaction or phase transition) accompanied by a decrease in volume is boosted by pressure. This means that high pressure stimulates reactions that result in a decrease in volume but opposes reactions that involve in an increase in volume. In the other hand, Isostatic principle presumes that pressure acts uniformly and equally in all the directions. A typical HPP system has got components, such as: pressure vessel and closures, pressure generation system, pressure transmitting fluid and temperature control device. In India, Central Institute of Fishery Technology, Cochin has acquired HPP machine. Commercially, HPP operation system includes three types of system: Batch system, Semi-continuous system and Continuous system.

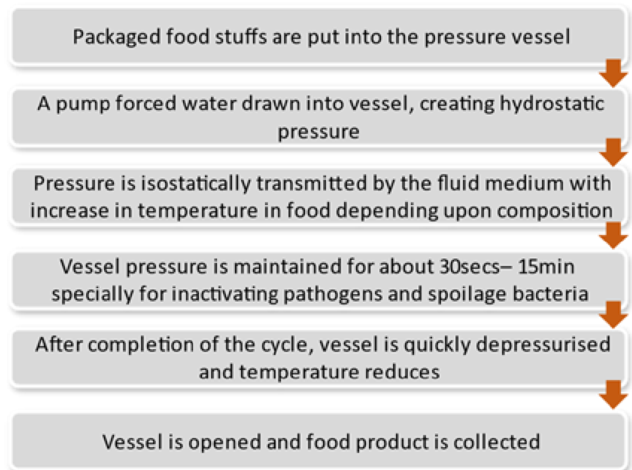

Figure 1: Processing cycle of HPP

4. Advantages of the Technology

• First of all, it is an eco-friendly approach where minimum or no waste are generated. It can also be performed in room temperature reducing the thermal energy used in other conventional process.

• Even distribution of treatment throughout the food particles can be done.

• Covalent bonds are not damaged after treatment. Thus, unnecessary flavours are prevented and retained the natural qualities.

• It takes the less amount of processing time because pressure generated is not time/mass dependent and also independent of size/shape of the products.

5. Limitations of the Technology

• Some bacterial spores or enzymes are highly resistant to pressure and need very high pressure to inactivate them.

• Maximum times, the processed foods should be undergone to low temperature storage as well as distribution chain to retain maximum nutritional and sensory value.

• Sometimes enzymatic or oxidative degradation have been noticed.

6. Applications in Seafoods

Being a highly perishable commodity, seafood is vulnerable to rapid post-mortem changes when compared to any animal products. Trimethylamine oxide (TMAO) is basically degraded to trimethyl amine (TMA) with the help of bacterial enzyme. Various volatile substances are also developed in fish muscle after death through autolysis or microbial putrefaction or chemical reactions. Therefore, HPP has an important role in minimising the production of the unnecessary substances and can retain the products quality intact with prolonged shelf life. So, without altering the product's colour or flavour or sensory attributes, HPP can be used to make gel-based products in the fish processing industry. It can be used to kill seafood pathogens like as *E. coli*, Salmonella, and Listeria, as well as spoilage microorganisms (Ohshsima et al., 1993). Functional properties of the seafoods can be also modified using high pressure. Smoked, salted or marinated food products are observed to have extended shelf life with improved quality after HPP treatment (Montero et al., 2007; Gudbjornsdottir et al., 2010). Another related technology such as pressure assisted freezing and pressure assisted thawing are also performed in seafood products to reduce drip loss.

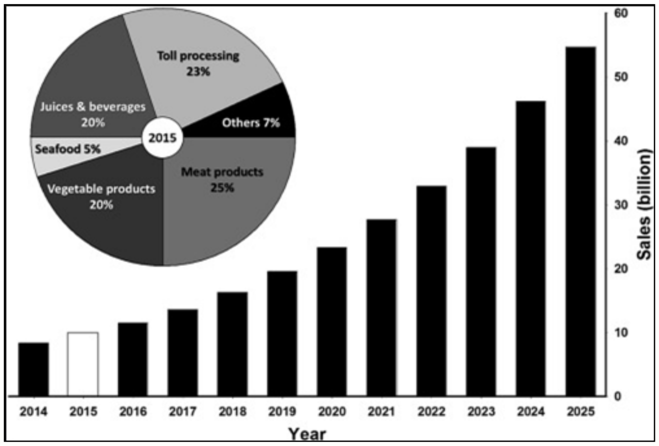

Figure 2: Current status and future trends of high-pressure processing in food industry, (Huang et al., 2017)

7. Impact of HPP on Proteins and Enzymes

HPP does not alter the low compressibility-covalent bonds and also do not break within the ranges of pressures normally applied. Ionic bonds, some hydrogen bonds, hydrophobic and electrostatic interactions can be affected. Therefore, the primary structure of proteins remains intact (Considine et al., 2008) and the secondary & tertiary structure of large protein molecules are disrupted. Thus, activity of autolytic enzymes i.e., neutral protease, calpain, cathepsin etc. decreased after pressurization (200-500 MPa) (Truong et al., 2015).

8. Impact of HPP on Microorganisms

High pressure changes the primary site -cell membrane and cell wall of microorganisms and decreases the membrane fluidity. Hence, a phase transition of membrane lipid bilayer (Hygreeva and Pandey, 2016) and membrane-bound proteins denaturation occur. The overall structural and morphological changes will lead to microbe's inactivation. A significant antibacterial effect can be obtained by appropriate HP treatment (300-600 MPa) with elimination of bacterial spores. According to Rivalain et al. (2010), gram negative bacteria are less pressure resistant than gram positive bacteria, due to structural differences in the cell envelope. *Campylobacter spp., Salmonella spp., Listeria monocytogenes, Staphylococcus aureus, Escherichia coli, Vibrio spp.* etc. are the major concerned bacteria to eliminate.

Yeasts and molds have a greater degree of structural complexity. Therefore, more susceptible to pressure than bacteria, and can be inactivated using relatively low pressures. Cytochrome C may be released from mitochondria after pressure treatment (300-400 MPa) and cause cell death. Due to the huge variations found in viruses, they can have different pressure resistance capability. Generally, enveloped viruses are less pressure resistant than the non-enveloped ones. It has been suggested that HP can denature viral capsid proteins, impede the binding of viruses to their host cellular receptors, and subsequently prevent the virus infection (Rivalain et al., 2010).

9. Impact of HPP on Different Quality of Food

9.1. *Textural Quality*

Tenderness in meat products has been improved by applying pressure, rages from 100 to 200 MPa. Glossy, soft and superior quality surimi-gel can be produced with a smooth and uniform texture. Gelation of sarcoplasmic proteins can be achieved. Some reports show the decrease in elasticity of muscle but the same has been maintained in storage (Campus et al., 2010).

9.2. *Sensory attributes*

Sometimes, the undesirable changes in the flavor in plant-based products are noticed. Due to oxidative rancidity, meat products carry off-flavours with decreased the aroma strength while undergone to HPP (Kruk et al., 2011). Seafood seems to be more tendered.

9.3. *Colour of the seafood muscle*

It has been reported that the redness of marine fish has been reduced due myoglobin denaturation (Carlez, 1995). Muscle of seabream (*Sparus auratus*) has also showed yellowish or whitish after HPP application (Amanatidouet al., 2000, Chevalier et al., 2001, Hurtado et al., 2000 and Ohshima et al., 1993). Cured meat has not affected that much due to nitrosyl myoglobin.

10. High Pressure Freezing and Thawing

Now a days these two mentioned approaches have been extensively used in seafood processing. Phase transitions in seafoods is occurred during the process.

Pressure shift freezing (PSF) is a better technology than Pressure assists freezing (PAF). PSF generates homogeneous, uniform ice crystals after releasing the pressure, thus inducing super cooling and phase transition period is also shorter than PAF. Some studies showed that the high-quality texture is obtained by PSF compared to conventional freezing (Zhu et al., 2003).

In case of thawing, pressure assisted thawing is better, because high pressure is able to decrease the melting point of ice, thus enlarging the temperature difference between the heat source and frozen sample. Furthermore, pressure assisted thawing can also lead to the decrease of drip loss in several types of food, such as fish and shellfish (Rouille´ et al., 2002). At the end both processes play a vital role in minimizing the microbial growth as well as elimination of partial population of microorganisms.

11. Conclusion

HPP as a non-thermal method of food preservation or packaging, generally meets the consumer's preferred food with no additives, fresh-like or minimally processed. Therefore, HPP can produce organic, healthy and clean label products maintaining the nutritional quality and food safety. The USFDA and the European Union has approved HPP technology to be used in the food industry.

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