High-Pressure Processing: The Clean Technology

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Introduction

Globally, with increasing rate of population, changing lifestyles and food consumption trends of people and some environmental factors lead us to preserve food. Food preservation have many benefits as it ensures stable food supply, reduces waste, maintain food at the peak of freshness together with maintaining its nutritional value. There are various new thermal and non-thermal technologies & treatments like pulse electric field, ohmic heating, radio frequency treatment, hurdle technology that are nowadays used. Non-thermal techniques are preferred more as these are less harmful to the quality of food. High pressure processing is one of the non-thermal food preservation techniques. High pressure is highly efficient technique in those foods which are prone to microbial contamination as it can kill vegetative microorganisms, inactivate parasites and fungal spores which increases the shelf life of the food, without affecting the nutritional quality of the food.

High-pressure processing

High-pressure processing (HPP) is a non-thermal technology. HPP efficiently inactivates microorganisms and increases the microbial quality of the food. For vegetative cells, a pressure of 400 – 600 MPa is required but for some bacterial spores, the pressure goes above 1000 MPa. HPP inactivates pathogenic microorganisms such as *L. Monocytogenes* and increase the microbial quality of the product.

HPP can be used for changing some quality attributes of different products such as apple juice. HPP treated apple juice have higher total phenolic content as compared with untreated apple juice. HPP helps in reducing the enzymatic activity of polyphenol oxidase and peroxidase in tender coconut water (Reddy *et al.,* 2024). HPP can efficiently increase the microbial stability of the jack fruit.

Equipment used for High Pressure Processing consists of following components-

- A pressure vessel and its closure system
- A pressure generation system
- A temperature control device
- A material handling system

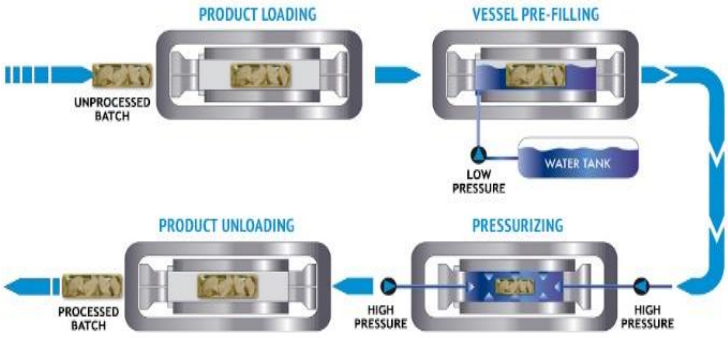

Fig. 1: Diagram of High-Pressure processing process

Principles of High-Pressure Processing-

There are two basic principles behind High-Pressure Processing (Mandal *et al.,* 2017).

Le Chatelier's Principle- It states that "if a change in condition is applied on a system in equilibrium, then the system will try to counteract that change and restore the equilibrium".

Isostatic Principle- It states "if the volume is constant, then pressure is transmitted instantaneously and uniformly throughout the sample".

Mechanisms of High-Pressure Processing-

Cell Membrane Disruption

As the pressure increases, the outer lipid bilayer structure will be changed. Eventually increases the permeability of the membrane and due to high pressure, the cell membrane will be ruptured and loss of cell constituents, resulting in cell lysis.

Protein Denaturation

Due to high pressure, the protein will denaturise in the cell. Eventually results in protein unfolding and precipitation. The activity of essential enzymes will be disturbed and the biological activity will be hindered, leading to inactivation of the cell.

Enzyme Inhibition

High pressure will disrupt the tertiary and quaternary structure of the enzyme which affects the enzyme's ability to catalyse various biological metabolism. Various pathways will be compromised and the cell will lose its vitality.

Cellular Morphological Changes

High pressure will induce various morphological changes in the cell such as changes in shape, size, and cell constituents. The cytoplasmic membrane and biological pathways are compromised leading to cell inactivation.

Spore Inactivation

High pressure applied on spores causes irreparable damage to structural components, enzymes, DNA, and proteins and inactivates the spores. Although Spores are highly resistant to High pressure, continuous treatment will efficiently work on spores.

Applications of High-Pressure Processing

Fruits and Vegetables

Low molecular weight compounds such as vitamins concentration do not change by HPP. HPP causes less reduction in colour pigments. Flavour compounds which are low in molecular weight are not altered by HPP.

Salads and Ready to Eat Foods

Inhibit the growth of *L. monocytogenes, S. aureus,* and *E. coli*. Two exposure treatments can efficiently inactivate bacterial spores.

Egg

No off-flavour production and destruction of necessary vitamins takes place. HPP can increase the foaming and emulsion properties of eggs.

Milk

HPP treatment for milk using 1000 MPa pressure at 60° C destroys the spores of pathogenic microbes and extends the shelf life of milk. No change in vitamins and minerals concentrations.

Advantages of High-Pressure Processing-

- Retention of heat-sensitive nutrients
- Preservation of flavour and texture
- Reduction in oxidative changes
- Enhanced bioavailability of nutrients
- Minimal impact on macronutrient composition
- Safety and quality of various food

Limitations of High-Pressure Processing-

- High initial investment
- Regulatory and labelling issues
- High energy consumption
- High operating and maintenance costs

Conclusions

High-pressure processing is a non-thermal technique with a wide range of applications in food and dairy industry. HPP efficiently reduces the microbial load and enzymatic browning. There is no loss of nutrients in the HPP processed product. HPP can increase the foaming and emulsifying properties of the eggs. There is no effect of flavouring compounds of fruits and vegetables. Heat sensitive nutrients are retained in the HPP treatment. Although the initial cost of establishment is high but long-term benefits are there in high-capacity processing plant. HPP is an efficient method for preservation of various food products with increased microbial and antioxidant stability.

References

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