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A CASE STUDY

High pressure processing in food and beverage industry

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SUMMARY : Consumers demand high quality and convenient products with natural flavor and taste, and greatly appreciate the fresh appearance of minimally processed food. In order to harmonize or blend all these demands without compromising the safety of the products, it is necessary to implement newer preservation technologies in the food industry. High pressure processing kills microorganisms and preserves food" was discovered way back in 1899 has been used with success in chemical, ceramic. Hite (1899) investigated the application of high pressure as a means of preserving milk, and later extended the study to preserve fruits and vegetables. The ability of high pressure to inactivate microorganisms and spoilage catalyzing enzymes, whilst retaining other quality attributes, has encouraged Japanese and American food companies to introduce high pressure processed foods in the market. High pressure is required to produce the packaged foods that are safer, longer lasting, more natural and better tasting. In addition, high pressure processing (also called high pressure pasteurization) provides the food industry with new product development opportunities that can fully exploit the functional properties of ingredients such as proteins, etc. Pressure is applied uniformly throughout a food material, independent of its mass and time. HPP is a method of food processing where food is subjected to elevated pressures (87,000 pounds per square inch or approximately 6,000 atm), with or without the addition of heat, to achieve microbial inactivation or to alter the food attributes in order to achieve consumer-desired qualities. Pressure inactivates most vegetative bacteria at pressures above 60,000 pounds per square inch. HPP retains food quality, maintains natural freshness, and extends microbiological shelf life.

Key Words : HPP, Food and beverage industry, Natural food, Pure food, Long lasting food

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In the last decade of 20th century, high pressure science and technique have found application in new areas of biology, biochemistry and production of novel foods. Consumer demands for high quality foods fresh in taste and high in nutritive value have created considerable interest in the development of new food-processing techniques. Such techniques primarily involve the ability of high pressure to inactivate microorganisms and spoilage catalyzing enzymes, whilst retaining other quality attributes. In addition, high pressure processing provides the food industry with new product development opportunities that can fully exploit the functional properties of ingredients such as hydrocolloids, proteins, etc.

High- pressure treatment of foods involves subjecting food materials to pressures as high as 9000 times the atmospheric pressure. Pressure is applied uniformly throughout a food material, independent of its mass and time. Use of high pressure in food processing is an extension of a technology that is commonly employed in many other industrial processes since the early 1990s. The effects of high pressure in inactivating microorganisms have been known for more than a century.

These early studies demonstrated that application of high pressure had effects similar to the use of high temperature on proteins and microbial population in foods.

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Working principle:

According to Le Chatelier's principle, pressure enhances the reactions that lead to volume decrease, and the reactions involving increases in volume are generally inhibited or reduced by pressure application. High Pressure Processing (HPP) is a method of food processing where food is subjected to elevated pressures (up to 87,000 pounds per square inch or approximately 6,000 atmospheres), with or without the addition of heat, to achieve microbial inactivation or to alter the food attributes in order to achieve consumer-desired qualities. Pressure inactivates most vegetative bacteria at pressures above 60,000 pounds per square inch. HPP retains food quality, maintains natural freshness, and extends microbiological shelf life. The process is also known as high hydrostatic pressure processing (HHP) and ultra high-pressure processing.

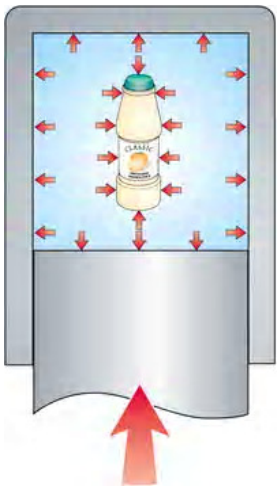


Fig. 1 : Working principle

Pressurizing systems:

Two types of pressurization systems defined as indirect and direct are commonly employed in the industry.

In an indirect pressurization system, the pressurizing medium (e.g., water) is first pumped through an intensifier, into the pressure vessel. The intensifier is a high-pressure pump used to increase the pressure to desired levels. The intensifier is separate from the high-pressure vessel. This system requires high-pressure.

In a direct pressurization system, the pressure intensifier is located within the pressure vessel. In this system, both pressure intensifier and the vessel are fabricated as a single unit, and the total size of the vessel can be quite large. A piston is used to deliver the high pressure to the pressure vessel. In high-pressure processing, inert gases or water are the most commonly used pressure media roduct. The decrease in volume of water is about 5 per cent when its pressure is increased. When water is used as a pressure medium while subjecting the food materials to high pressures, there is an instantaneous and uniform transmission of the pressure throughout the product being treated.

Modes of operation:

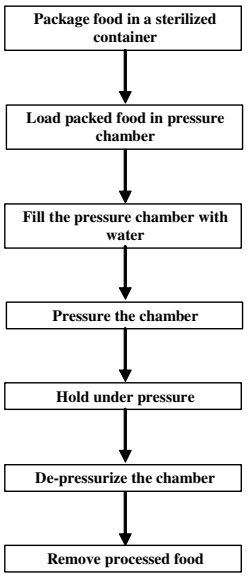
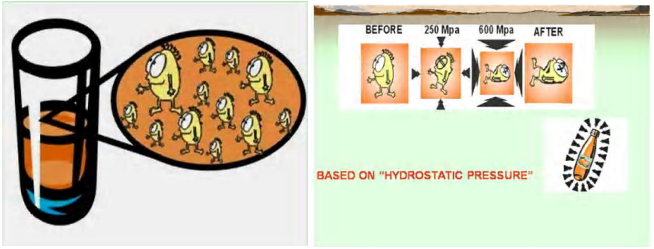


Fig. 2 : A schematic flow diagram of high-pressure processing

A simplified mode of operation used in a high-pressure processing system is shown in figure. In a high-pressure process, the pressure vessel is filled with a food product and pressurized for a desired time, following which it is depressurized.



Mechanisms of microbial inactivation:

Microorganisms are affected to various degrees by processes that cause structural or functional damage to the cell. The results of such functional or structural damage include:

- inhibition of growth
- loss of the ability of cells to multiply (loss of viability)
- cell death (inactivation)

The most common types of structural damage affect both the cell wall and the cytoplasm membrane, leading to cell injury in mild treatments or cell lysis in case of severe processing. Microorganisms are also inactivated when subjected to

processes that impair the functions of enzymes, DNA, ribosome, or other essential constituents of the cell. High pressure is believed to disrupt the secondary and tertiary structures of macromolecules such as enzymes and to alter their function.

Effect of high pressure on enzymes and proteins:

Enzymes are a special class of proteins in wherein the biological activities arise from active sites, brought together by the three -dimensional configuration of the molecules. The changes in active site or protein denaturation can lead to loss of activity, or changes the functionality of the enzymes.

Pectin methylesterase:

Pectin methylesterase (PME) is an enzyme, which normally tends to lower the viscosity of fruits products and adversely affect their texture fruit products containing PME (e.g. orange juice and tomato products) are heat pasteurized to inactivate PME and prolong shelf life. However, heating can deteriorate the sensory and nutritional quality of product.

Proteins :

High pressure denatures protein depending on the protein type, processing conditions, and the applied pressure. During the process of denaturation, the proteins may dissolve or precipitate on the application of high pressure.

Commercial applications of high pressure processing:

Today, the market for the high pressure processed foods is reaching 2 billion dollars annually. HPP applications include:

- Ready-to-eat whole muscle and sliced meats
- Processed fruits and vegetables
- Fresh juices and smoothies
- Deli salads and dips

High pressure processing in juice and beverages industry:

Consumers expect the fruit products not only to be safe but also to be fresh. Without any additives and preservatives, food products like salads, purees, juices, etc. are prepared to be subjected to a very high pressure for less than few minutes resulting in the reduction of harmful and pathogenic microorganisms as well as reduction of enzymatic activity. Food products retain original quality, texture, better appearance, natural colour, flavour and nutritional content yielding great value to the consumers.

Batch process:

Fruit juice is subjected to a very high elevated pressure (up to 87,000 psi) for less than few minutes to obtain fresh, pure and processed foods free from pathogenic microorganisms. This process results in the inactivation of harmful and spoilage microorganisms including yeast, mould pathogens.

High pressure processing of ready-to-eat (RET) meat:

High pressure processed meats retain their original sensory qualities such as texture, colour and nutritional content throughout their shelf-life. HPP can also more than double the shelf-life of products using alternative preservation methods.

High pressure processing is a science-based post-lethality intervention step for ready-to-eat meats. HPP is not merely a surface treatment, but effective throughout the product package, whatever its size or shape. This is especially important to those meat processors producing sliced deli meats, where the risk of re-contamination with harmful pathogens, particularly *Listeria monocytogenes*, may be greatest. The science and technology behind HPP systems are well proven

— exposing the food to the pressures generated by HPP (600 MPa/87,000 psi) which inactivates food borne pathogens while leaving the natural organoleptic qualities of food intact. HPP enables the consumers to get the natural and safe RTE meat products they demand, right on their local grocer's shelf.

Advantages:

Increasing the shelf life of foods and creating unique structural changes in foods that provide benefit for desired functions. Many of these changes influence the quality characteristics of foods *viz.*

– It enables food processing at ambient temperature or even lower temperatures.

BATCH PRESSURIZATION
in the consumer package

– It enables instant transmittance of pressure throughout the system, irrespective of size and geometry, thereby making size reduction optional, which can be a great advantage.

– It causes microbial death whilst virtually eliminating heat damage and the use of chemical preservatives/additives, thereby leading to improvements in the overall quality of foods.

– It can be used to create ingredients with novel functional properties.

Conclusion:

The term high pressure processing (HPP) is used to describe the technology whereby products are exposed to very high pressures in the region of 50 - 800 MPa (500 - 8000 Atmospheres). The potential application of HPP in the food industry has gained popularity in recent years, due to developments in the construction of HPP equipment which makes the technology more affordable. Applying HPP to food products results in modifications among the interactions between individual components, rates of enzymatic reactions and inactivation of microorganisms.

The first commercial HPP products appeared on the market in 1991 in Japan, where HPP is now being used commercially for products such as jams, sauces, fruit juices, rice cakes and desserts.

While food safety is a dominant concern, consumers are increasingly demanding foods that maintain their natural appearance and flavor, while free of chemical preservatives. HPP offers the food industry the possibility of achieving these twin goals as this technology can lead to reduced microbial loads without detrimentally affecting the nutritional or sensory qualities of the product.

The development of food ingredients with novel functional properties offers the dairy industry an opportunity to revitalize existing markets and develop new ones. HPP can lead to modifications in the structure of milk components, in particular protein, which may provide interesting possibilities for the development of high value nutritional and functional ingredients.

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