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High Pressure Processing: A Novel Approach to Food Preservation and Safety

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The increased consumers' interest in high quality foods with fresh-like sensory and additive free attributes led to the development of non-thermal food processing technologies as alterative to conventionally heat treatments. "High Pressure Processing (HPP) of foods is a non-thermal preservation technique that involves subjecting food products to elevated levels of hydrostatic pressure, typically between 100 to 1000 megapascals (MPa), for a specified duration of time (1-15min)". This process is conducted in a specially designed chamber or vessel capable of withstanding high pressures. During HPP, pressure is uniformly applied from all directions, effectively penetrating the food product. The high pressure disrupts the cellular structures of microorganisms, including bacteria, yeasts, molds, and parasites, leading to their inactivation or death. This helps to ensure food safety by reducing or eliminating harmful pathogens while extending the shelf life of the product. Each year, numerous symposiums regarding non-thermal processing technologies are conducted worldwide to discuss high pressure, pulsed electric field, pulsed light, electron beam, plasma, and modified atmosphere packaging; however, high pressure processing (HPP) is the most successfully commercialized non-thermal processing technology.

Principles of HPP

1. Le Chatelier's principle: This principle addresses changes to equilibrium as a result of pressure application. A chemical system under equilibrium condition would experience a reaction change, accompanied by a decrease in volume when enhanced by pressure and vice versa. If pressure changes, the equilibrium shifts in a direction that tends to reduce the change in the corresponding intensive variable (Volume). Thus, pressure shifts the system to that of the lowest volume.

2. Isostatic principle: The first consideration involving the application of high pressure is the Isostatic Pressing (Pascal's Principle) in which the pressure is transmitted in a uniform manner in all directions. Following the decompression, the material returns to its initial shape.

3. Microscopic ordering principle: According to microscopic ordering principle, at a constant temperature, increasing the pressure mutually increases the degree of ordering of the molecules of a substance. As a result, pressure, as well as temperature, exerts antagonistic forces on molecular structure.

Effects of HPP on foods

a) Fruits and vegetables

High pressure technology does not depreciate the nutritional and sensory characteristics of food, and yet it maintains the shelf life. As compared the effect of HPT with water blanching on the microbial safety, quality and functionality poly phenol oxidase (PPO) activity, leaching of potassium, and loss of ascorbic acid) of potato cubes. Total inactivation of microbes and PPO activity occurred at 20 °C (using dilute citric acid solution at 0.5 at 1.0 per cent as immersion medium). Water-balanced and high pressure-treated potato cubes had similar softness but potassium leaching was reduced by 20 per cent in addition, ascorbic acid was better retained (90 per cent at 5 °C to 35 per cent at 50 °C) in high pressure treated vacuum packaged samples. HPP processed avocado paste is commercially available and is stable to the action of spoilage microorganisms during refrigerated storage. However, there are no prior reports on the effects of HP processing and storage time on the stability of health bioactive compounds present in avocados, particularly carotenoid profiles.

b) Dairy and egg industry

High pressure technology has many applications in the dairy and egg industries due to changes induced in the functional properties of whey protein as well as in other milk components and native constituents. The pressure was applied to the protein

before homogenization or to the emulsion prepared with native whey protein concentrate. Functional properties of WPC were examined along with the relationship between stability of WPC emulsions and degree of adsorption of the protein emulsifier. They found that oil-in water emulsions (0.4 wt per cent protein, 20 volumes per cent n-Tetradecane, pH 7) prepared with pressure treated WPC solutions gave a broader droplet size distribution than emulsions made with native untreated protein. HPP had little effect on the stability of WPC emulsions made with native protein. The high pressure slightly improved the microbiological quality of milk without modifying lacto-peroxidase activity (a native milk enzyme). The increase in cheese yield was found (at 300 and 400 MPa) in conjunction with additional lacto globulin and moisture retention. HPP can improve the coagulation properties of milk and can increase moisture retention of fresh cheese.

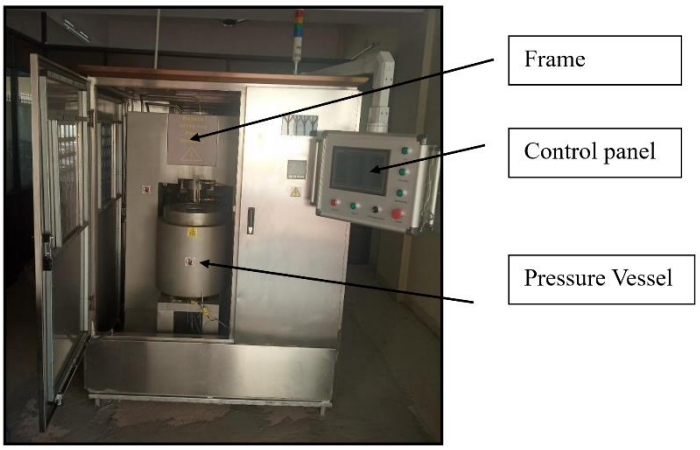

Fig. 1 HPP equipment

Components of HPP

- **Pressure Vessel**: The core component of HPP equipment is the pressure vessel, also known as the pressure chamber or autoclave. This vessel is designed to withstand high pressures and is usually made of stainless steel or other robust materials.
- **Seal**: The pressure vessel is equipped with a secure sealing mechanism to prevent any leakage of pressure during processing.
- **Hydraulic System**: HPP equipment includes a hydraulic system responsible for generating and maintaining the high pressures required for processing. This system consists of pumps, intensifiers, or hydraulic cylinders that exert force to generate pressure.
- **Control Panel**: It allows operators to set and monitor processing parameters such as pressure, temperature, and processing time.
- **Safety Features**: HPP equipment incorporates various safety features such as pressure relief valves, interlocks, and alarms to ensure the safe operation of the system and protect against overpressure situations.
- **Loading**: The food products to be processed are loaded into the pressure vessel either manually or automatically, depending on the design of the equipment.
- **Pressurization**: Once the pressure vessel is sealed and the food products are loaded, the hydraulic system begins to pressurize the vessel. Pressure is gradually increased to the desired level, typically ranging from 100 to 1000 MPa, depending on the specific requirements of the food product.
- **Holding**: Once the desired pressure is achieved, the food products are held under pressure for a predetermined duration of time, typically ranging from a few seconds to several minutes. This holding time allows for the inactivation of microorganisms and enzymes within the food.
- **Depressurization**: After the holding period, the pressure is slowly released from the vessel, and the food products are depressurized. This gradual depressurization helps to prevent any sudden changes in the structure or texture of the food.
- **Unloading:** Once depressurization is complete, the pressure vessel is opened, and the processed food products are unloaded from the equipment.

Advantages of HPP

- High pressure used in this process is independent of size and shape of the food.
- High pressure is not dependent of time/mass, that it acts instantaneously thus reducing the processing time.
- It does not break covalent bonds; therefore, the development of flavours alien to the products is prevented, maintaining the natural flavour of the products.

- It can be applied at room temperature thus reducing the amount of thermal energy needed for food products during conventional processing.
- This process has Potential for reduction or elimination of chemical preservatives.
- In-package processing is possible in this technology and the process is environment friendly since it requires only electric energy and there are no waste products.

Disadvantages of HPP

- Food enzymes and bacterial spores are very resistant to pressure and require very high pressure for their inactivation.
- The residual enzyme activity and dissolved oxygen results in enzymatic and oxidative degradation of certain food components.
- Most of the pressure-processed foods need low temperature storage and distribution to retain their sensory and nutritional qualities.
- Foods should have approximately 40% free water for anti-microbial effect

Conclusions

High pressure processing has the potential to develop into a preservation technique that is applied on a large scale in the food industry, in particular for products where retention of flavours and nutrients is desired. HPP not only improves safety of foods but also extends its shelf life, while maintaining the food attributes normally associated with "minimally processed" foods. Although, HPP technology has extremely many strong points in food processing since the 1990s, there are still some gaps regarding the investment in this sector. Commercial benefits of HPP technology require more research to fill the gaps and to fully understand the process, to reduce the cost of production

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