Non-Thermal Processing Technologies to Enhance Food Safety and Quality

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As consumer demand for minimally processed fresh foods that also meet the strict food safety standards enacted by the FDA and USDA is growing, food manufacturers are under increasing pressure to find alternate processes which provide a safe product, but utilize less destructive methods to achieve this goal. Foods which meet these standards are not only in higher demand, but consumers are willing to pay a higher price for these higher quality products. High pressure processing (HPP) is a novel non-thermal technique that emerged in food production for improving the shelf-life and safety of various food products by means of microbial inactivation. It provides instantaneous and homogenous transmittance of pressure in the product under treatment. Usually, a working pressure between 100-1000 MPa is used. HPP is considered as non-thermal, however some temperature increase is associated in the product through adiabatic heating (heat of compression). Microbial inactivation and shelf-life extension of meat and seafood have been the main reason (most perishable products) for the development of HPP technology in recent years. It has also been reported that HPP induces considerable physico-chemical changes in meat and seafood products. Some of these changes are beneficial for the acceptability of final product. The global high-pressure processing (HPP) product market has achieved ~ $3 billion in the year 2013. Fruit and vegetable products are at the first place, followed by meat products and then seafood and fish products. HPP provides an interesting alternative processing method to meet these requirements. Even though this processing method requires a greater initial financial investment, it pays off in higher quality, higher value (premium) products. HPP employs elevated pressures usually in the range of 100–1000 MPa (~ 14500 – 145000 psi) (table 1) with or without addition of external heat. A pressure vessel is a component of HPP, in which pre-packed food product is loaded and pressurized by using a suitable pressure transmitting medium i.e. water (or sometimes oil). This type of treatment is called as batch HPP process. There are two types of compressions: a) in the lab scale systems direct compression is used in which the volume of the vessel is reduced by the action of a hydraulic pressure applied to a piston, b) in the commercial systems an intensifier, or high-pressure pump is used to pump a pressure-transmitting fluid directly into the vessel to achieve a target pressure in indirect compression (Figure 1). High pressure processing does not work with all types of perishable items and is preferably applied to acidic products. Some products still require thermal processing in order to destroy pathogens and deactivate spoilage organisms.

Advantages of High-Pressure Processing

1. Minimal changes in freshness characteristics (taste, appearance, texture, and nutrition) of foods as it enable food processing at ambient or lower temperatures
2. Inactivates pathogens such as *Listeria, Salmonella*, *E. coli,* Norovirus to ensure the food safety
3. Extends product shelf life, expands distribution, improves customer satisfaction
4. Avoids or reduces the need for food preservatives, giving foods “clean labels”
5. Eliminates the need of size reduction as it enables instant transmittance of pressure throughout the system, irrespective of size and shape
6. Environmentally friendly: only requires electricity and water, which can be recycled
7. Suitable for both liquid and solid foods such as ready-to-eat meals, meat, avocado, salsa, dips, juice, salad, seafood etc.

HPP: process factors and their alteration during application of high-pressure

The foods in a vessel under high pressure follow the isostatic rule regardless of their size or shape. The generated pressure is instantaneously and uniformly transmitted throughout the product whether it is in direct contact with the pressure medium or hermetically sealed in a flexible package. Therefore, in contrast to thermal processing, the time necessary for HPP processing is independent of the sample size.

The effect of HPP processing on chemical and microbiological changes in food is governed by the Le Chatelier’s principle. High pressure stimulates some phenomena (e.g., phase transitions, chemical reactions, and changes in molecular configuration) that are accompanied by volume decrease and opposes reactions that involve volume increase. The effects on protein stabilization are also governed by this principle, i.e., the negative changes in volume that occur with an increase in pressure cause an equilibrium shift toward bond formation. The ionic bonds break due to the application of HPP and this leads to a volume decrease due to the electrostriction of water. Moreover, HPP stabilizes the hydrogen bonds a volume decrease occurs, however, pressure does not usually affect covalent bonds. By this means, HPP disrupts larger molecules (enzymes, proteins, lipids, and cell membranes) and microorganisms, while small molecules (vitamins and flavour components) are not affected (Linton and Patterson, 2000).

The application of HPP causes the isostatic compression in packaged product by the pressure-transmitting fluid, causing up to 19% reduction in the package volume (compressibility), which depends on the final pressure and temperature. Adiabatic heating occurs during compression and cooling occurs during decompression of air, water, and food materials. Adiabatic heat of compression is the instantaneous volumetric