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An Overview of High-Pressure Processing: Principles, Advantages

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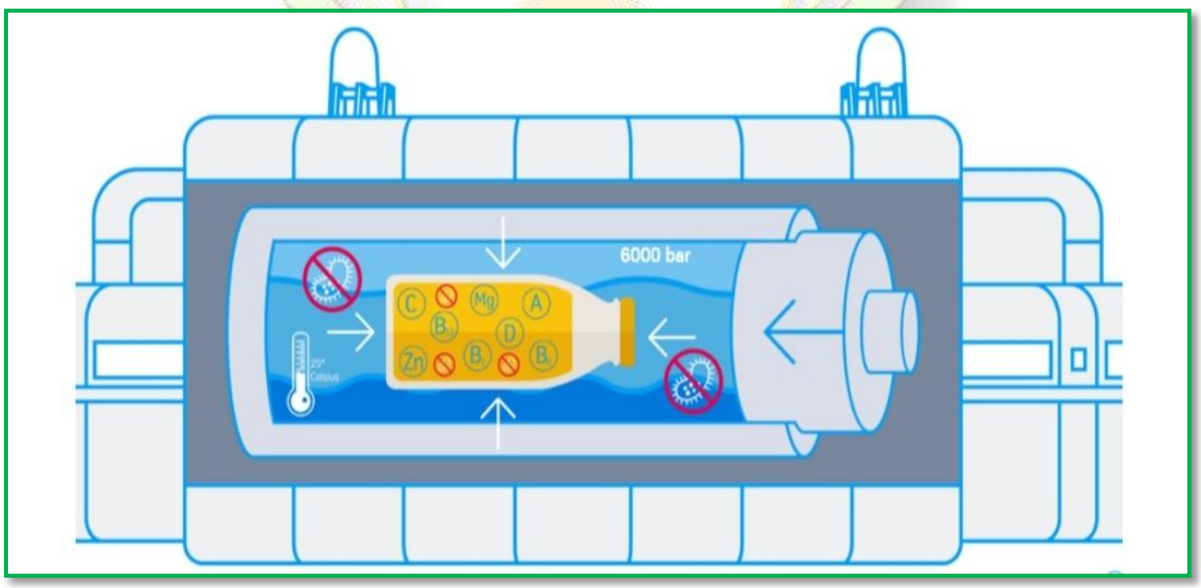
High Pressure Processing (HPP) is a promising "non-thermal" technology for food preservation that has been developed with the goal of 'obtaining microbiologically safe food products while avoiding undesirable changes in the sensory, physiochemical, and nutritional qualities of food'. It is a technique for *preserving* and *sterilizing* food, in which a product is treated under *very high pressure*, leading to the inactivation of certain *microbes* and *enzymes* in the food. It maintains both the product's sensory and nutritional qualities by having a little impact on the covalent bonds within the food product. Intense pressure in the 400–600 Mpa range is also maintained. High pressures exerted at short periods of time (20 minutes). It is also known as Pascalization, Bridgmanization or High Hydrostatic Pressure (HHP) processing, ultra-high-pressure processing. Blaise Pascal, a 17th-century French physicist whose work includes describing the effects of pressure on fluids, was the inspiration for the technique's name. In honour of scientist Percy Williams Bridgman, Pascalization is also referred to as bridgmanization.

History

Blaise Pascal, a French scientist who researched the effects of pressure on fluids, lived in the 17th century. Throughout his research, he came to the conclusion that yeast, mould, and bacteria may be inactivated by using more over 50,000 PSI for about 15 minutes. Experiments employing high pressure and their effects on microorganisms started in the late 1880s, with a focus on milk. It was found that the method had no impact on the product's flavour. A study on the effects of pressure to sterilize food products such fruits, fruit juices, and some vegetables was published in the early 1900s.



Working Principles

According to Yordanov and Angellova (2010) a number of physical and chemical changes result from the use of pressure. Physical pressure throughout pressure processing brings about a volume decrease and an increment in temperature and energy. The rationale for the use of HPP is in conformity with the three elements of physical and chemical principles.

The use of high pressure in food processing is governed by two fundamental principles:

1. Le Chatelier's principle
2. Principle of microscopic ordering:
3. Isostatic principle

- **Le Chatelier's principle:** Any phenomenon (phase transition, modification of the molecular structure, chemical reaction) accompanied by a reduction in volume is enhanced by pressure. Pressure therefore causes the system to go to the lowest volume state.
- **Principle of microscopic ordering:** at consistent temperature, an expansion in pressure expands the degrees of ordering of molecules of a particular substance. In this manner pressure and temperature apply opposed forces on molecular structure and chemical reactions.
- **Isostatic principle:** Food products are compressed by constant pressure applied from all sides, and when the pressure is released, the products regain their original shape.

Applications

Using HPP, a variety of high moisture foods, including solid, liquid, or semi-liquid items, can be preserved. For successful microbial inactivation, a minimum moisture content of 40% is generally recommended. Suitable for HPP preservation are:

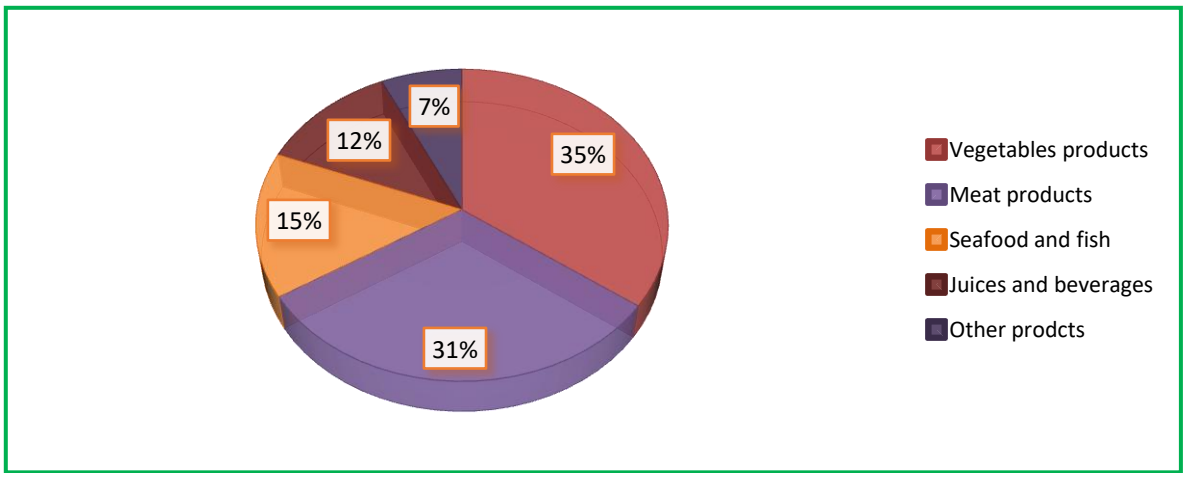
Low-medium moisture, semi-solid or solid foods packed under vacuum packaged: dry-cured or cooked meat products, cheeses, Fish, sea-food, marinated products, RTE like packaged meals, salads, soups, and hummus, dips; sauces

High moisture solid foods in plastic cups or pouches: fruits jellies, jams, marmalades, compotes, purées

High moisture liquid foods in plastic bottles/ flexible packaging: dairy products like yoghurt & yoghurt-based dressings, cream products, cream cheese and milk; fruit and vegetable juices, bioactive beverages.

Foods with entrapped air (bread, cakes, mousses, strawberries, marshmallows, leafy vegetables) or with insufficient/very low moisture content (powders, dried fruits, spices) will be crushed or compacted under high pressure.

Product Wise Application of HPP



HPP Packaging Requirements

- ✓ Under high pressure of 6000bar, the product and packaging undergo a temporary volumetric reduction of 15% (flexible packaging), which is reversed upon depressurization.
- ✓ Extra tight seal.
- ✓ Reinforced and Rounded and edges.
- ✓ Very little head space
- ✓ Packaging for HPP must be elastic enough, at least on one side, to transmit pressure and allow volume reductions of up to 19 percent without compromising seal integrity or barrier properties.
- ✓ Plastic bottles, pouches, cups, and trays made of PET, PE, Nylon/PP and EVOH (or combinations thereof) work very well with HPP due to their good water barrier properties and flexibility.
- ✓ Pouches laminated with aluminum foil;
- ✓ PET/Al/PP
- ✓ Nylon/Al/PP
- ✓ Glass, metal, rigid plastic containers, plasticized cardboard carton packages undergo irreversible deformation or tend to fracture under compression.
- ✓ Vacuum and modified atmosphere packaging (MAP) work very well with HPP.

HPP Affects Shelf Life

HPP effect on shelf-life extension depends on process and product parameters. High pressure and longer holding time generally favour microbial inactivation and decrease of enzyme activity. Water activity, pH value, fat or carbohydrate content can affect barsoresistancy of the microorganisms. Therefore, HPP effect on inactivation of the same microorganism can vary from product to product. Storage temperature after HPP is also the factor that can influence shelf life of the product. HPP can increase shelf life to 10 times in comparison to non-treated fresh products. In industrial practice. the pressure level and holding time are optimized to ensure maximum safety without impairing the organoleptically and functional properties of the product.

Advantages

- **High pressure is not dependent of size and shape of the food.**
- **Characteristics of the fresh product are retained; sensorial and nutritional properties remain almost intact:** Greater food quality.
- **Destroys pathogens** (*Listeria, Salmonella, Vibrio, Norovirus, etc.*): Food safety and exportation.
- **Extends product shelf life:** Lower returns, improved customer satisfaction.
- HPP results in foods with better taste, appearance, texture, and nutrition.
- **Avoids or reduces the need for food preservatives:** Clean label foods (Natural/Additive Free).
- **New innovative food propositions. Products that can not be thermally treated can now be High Pressure Processed:** Innovation and competitive advantages.
- **Only needs water (which is recycled) and electricity:** Environmentally friendly.

Disadvantages

- High capital cost of equipment.
- Food enzymes and bacterial spores are very resistant to pressure and require very

High pressure for their inactivation.

- HPP is not the ideal preservation method for all kinds of food, neither is it effective against all microbial forms.
- HPP can cause undesirable sensory changes in certain foodstuffs. In foods like eggs, the denaturation of protein can be visually apparent.
- Very high pressures can also damage the appearance of delicate foods like strawberries or leafy greens.

Conclusions

HPP being non thermal process, it is an attractive and innovative technique that allows new product development, for example product that cannot be thermally treated can now be processed using HPP. It is a consumer acceptable, environmentally friendly, significantly recognized method to achieve higher quality in certain foods. This proposes a great potential to develop new "minimally" treated foods with high nutritional and sensory quality novel texture and with an increased shelf life. The novelty of this technology and high equipment cost are barriers to its commercialization but increase consumer's demand for fresh-tasting foods. In Processing, pressure transmission is instantaneous, uniform, short processing times, assured safety in whole pack, suitable for solids and liquids. Quality: retains flavor and nutrition.

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