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High Pressure Processing of Food Products

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ABSTRACT
High pressure processing is one of the novel techniques utilizing pressure at high level to achieve food safety and stability. It is helpful in maintaining the quality attributes and suitable especially for heat sensitive food. However, it is insufficient alone to ensure complete destruction of microbes. This necessitated researchers to find optimum solution for shelf life extension in combination with varying levels of other techniques. Thus, the article consists of brief introduction of the technique, its principle and working, advantages, limitations, researchable issues, economics, shelf life, operational safety and its perspective to Indian condition.

Packaging is the method of protecting products Food processing sector is heading towards non-thermal techniques with minimal application of chemicals or additives. It is meant for preservation without affecting the quality attributes of food. Such methods include irradiation, ultrasound filtration, oscillating magnetic fields, pulsed light, pulsed electric field and high hydrostatic pressure/ High pressure processing (HPP) etc. HPP is one of the advanced techniques that offer wide range of benefits from food preservation to modification of functional characteristics. It is based upon thermodynamic shifting towards equilibrium. Extended shelf-life with guaranteed food safety is achieved through keeping sealed packages under high iso-static pressure at ambient or lower temperature for inactivating the vegetative flora. Thus, high pressure inactivates most of the vegetative bacteria, while retaining the quality and natural freshness of food. It is found to be suitable for products sensitive to heat, while avoiding the thermal degradation and retention of freshness in taste, appearance, texture and nutrition.

Principle: High pressure processing is based on Le Chatelier's principle. It is meant for attaining equilibrium of the system, while nullifying the effect of any disturbance. It follows iso-static rule, which equalise the product of pressure and surface area throughout the packaging surface. Thus, system experiences equal pressure from all the sides following the Pascal's law. It is independent of the geometry and size of product packaging.

Working: The flexible packages viz. pouch or plastic etc. containing products are kept in a chamber of high pressure filled with hydraulic fluid for pressure transmission. Water is generally used as hydraulic fluid. A pump is meant for generating the pressure generally in the range of 400-600 MPa required for most of the foods for duration varying from 1 to 5 minute. The process kills most harmful microbes by damaging the cell components without altering nutrition, texture, flavour, taste or appearance. It acts uniformly irrespective of the container size or its thickness. Uniform pressure distribution and absence of heat application ensure retaining the food shape and sensory characteristics. The modes of inactivation are supposed to be the shear forces generated, membrane disruption, localized thermal damage and protein deformation.

Accompanying factors: The factors affecting its efficacy are duration of decompression and compression, food composition or its matrix, target bacteria to be killed during the treatment, treatment temperature and heat sensitivity of the food. In addition, pH level and water activity of the product and preservatives being used for shelf life extension play significant role.

Advantages: High pressure processing technology eliminates or reduces the requirement of heat, while killing harmful microbes. Thus, application of thermal energy is least in processing operation. It makes possible to treat heat sensitive products. It could extend shelf-life of the product from 3 to 10 times. The products obtained after treatment remains with fresh like characteristics of sensory and nutrition. It doesn't produce any off-flavour as in case of heat treatments. Products retain the original shape as it is subjected to uniform pressure at every point. Cross contamination with untreated product is not possible because treatment is performed in batch wise operation. It deals in a way to ensure safety of the workers involved in the operation. Moreover, water is used as the most common fluid and thereby the technology is friendly to environment.

Limitations: High pressure processing is insufficient to control enzymes resistant to pressure. Spores are not sure to be inactivated with the treatment itself. It needs huge amount of investment for installation of the technology. The system limited to batch wise operation restricts the throughput capacity.

Researchable issues: High pressure processing involves high operating expenses per unit weight of the product. As the treatment needs other technologies in combination to ensure control of the microbes completely, it is called as semi-processing. The machinery involved is complex and needs gradual simplification. Fields of research encompasses shelf stability through ensuring the microbial safety, quasi-adiabatic temperature gain, increasing throughput capacity and interaction effect of food composition with packaging. Efficacy of the treatment needs to be optimized as effect of food composition and their characteristics, processing conditions, combined effect with application of other techniques at varying levels. Moreover, optimization of package design and mathematical modelling for effect of various factors need to be investigated.

Additional functionality: High pressure processing doesn't affect flavour, vitamins and pigments of the product in contrast to thermal processing and thereby retains freshness. Instead, the process creates novel texture of protein or starch based foods through forming protein gels or increasing viscosity without application of heat.

Economics: The technology installation needs initial investment depending upon the capacity of processing operation and extent of automation involved in the same. Operating cost is greater than the same for corresponding thermal processing. The capital and operating costs will decrease with increase in the rate of production.

Suitability: It is generally applicable for high value commodities with higher acidity viz. avocado product (guacamole), orange juice, apple sauce, tomato salsa, oysters and ready-to-eat cooked meats. It is yet insufficient to attain shelf-stability of low acid foods viz. milk, soup and vegetable etc. However, extended shelf life of low acid products is achievable, if processed under refrigerated condition. It can eliminate the risk of food-borne pathogens viz. *Salmonella*, *Escherichia coli* and *Listeria*. The process is limited to foods containing water without any air pocket inside. This is the reason why food materials like marshmallows and strawberries with entrapped air or dry solids with water deficiency are not suitable for high pressure processing. Product remains relatively undamaged as the pressure applied uniformly from all the directions irrespective of its magnitude.

Shelf life: It is equally effective as thermal pasteurization for shelf life extension. But, refrigerated storage becomes essential for microbial stability of low acid foods and in preserving the flavours of acidic foods during long term storage. However, heat labile products are well cared, while retaining texture, colour and flavour with 2-3 times extended shelf-life. Microbial and sensorial testing are the bases for determining the shelf-life of newly developed products.

Commercially available products: United States, Japan and European countries are leading in commercialisation of high pressure processed products. Such products in the markets of United States are guacamole, oyster, chicken strips, salsa, smoothies, ready meals of vegetables and meat etc. It is equally suitable for nutritious, fresh, safe and high quality dairy products viz. milk, cheese, colostrum, yoghurt, cream, cheesecakes, probiotic, custard, protein and cheese based snacks, eggnog, dairy spreads, sandwich spreads, dressings etc. without any artificial additives.

Indian perspective: Although, the technology is growing rapidly in developed countries, it is yet to find space in Indian market. It is preferable for consumers aware of nutrition and sensory quality. The main hurdles between research and commercialization of the technique in India is high cost and insufficiency of its application to ensure complete safety for all food universally. Cost is expected to be reduced in future because of potential of the country with large consumer base and ongoing research at different places of the country. IIT Kharagpur is already carrying out research activities on high pressure processing application. Recently high pressure processing system has been installed in India at DFRL (Defence Food research laboratory) of DRDO wing. One of the companies named as NuTy (Tutila Ahara Pvt Ltd.) has also launched high pressure processed ready to eat vegetable curries in Indian market during January 2020.

Components: Pressure vessel, pressurizing system and heating and cooling components etc. are major components in the system.

Operational safety: The equipments and vessels are manufactured as per the guidelines specified by the American Society of Mechanical Engineers (ASME). It requires a little training of personnel before operating the

system. It doesn't create issues regarding labelling or any other regulatory matters related to food.

Conclusions: High pressure processing is helpful in extending the shelf life, while avoiding application of heat or chemical preservatives. This is the reason why it is spreading in developed countries with most of the consumers prioritizing quality produce over cost. Despite all the advantages associated with application of high pressure processing technology, it is taking time to mitigate the cost difference from techniques available in the market. Further, India is supposed to diminish the cost significantly through large consumer base. Hence, the technology has great potential in the country with growing population aware of nutrition and sensory quality.