AdvancedTechnologies in Food Preservation

B. V. V. Balaram Bhagath, Nazma Hafeeza
[1]*Assistant Professor, SVKR Engineering College, Bhimavaram.*
[2]*Assistant Professor, College of Food Science and Technology, Pulivendulla.*
[1]*Email Id: bhagath5cae@gmail.com*

Abstract: *Food preservation has been practiced by humans for millennia through fermentation, salting and drying. The industrialization of food manufacture brought processes like canning and freezing to control microbial safety and enzymatic spoilage of foodstuffs. However, this often comes at the expense of nutritional and sensorial quality attributes and, thus, novel food processing technologies continue to be developed to serve the increasing demand for healthy and eco-friendly food products. In contrast to thermal processing, these new technologies make use of physical stressors other than just heat to kill microorganisms, using high pressure, electric fields, cool plasma or ultraviolet irradiation. The underlying inactivation mechanisms, efficiencies and limitations of these technologies are currently still under investigation and will be highlighted in this paper.*

Keywords: **Fermentation, Ultraviolet irradiation, Cool plasma and Physical stressors.**

High pressure processing

High pressure processing (HPP) is a way to modify and preserve food without using heat. HPP normally involves subjecting food to hydrostatic pressures of 300 to 700 MPa for periods of a few minutes. This treatment inactivates vegetative microorganisms and some enzymes at room temperature, whilst valuable low molecular constituents, such as vitamins, colours and flavourings, remain largely unaffected. Therefore, HPP is increasingly used by the food industry to produce safe and fresh-like food with enhanced nutritional and functional properties and extended shelf life. Currently, there are approximately 200 industrial HPP systems installed worldwide, producing more than 300,000 tons of food per annum. In the Australian market, HPP food includes small goods, fruit juices, vegetable purees, and wet salads.

The efficacy of HPP is governed by Le Chatelier's principle, which states that reactions or phase transitions associated with a decrease in volume are favoured, whilst those accompanied with a volume increase are inhibited. Low molecular weight molecules in food such as peptides, lipids and saccharides are rarely affected by HPP because of the very low compressibility of covalent bonds at high pressures. On the other hand, macromolecules, such as proteins and starches, can change their native structure during HPP, in a manner analogous to thermal treatments.

The viability of vegetative microorganisms is affected by inducing structural changes at the cell membrane or by the inactivation of enzyme systems which are responsible for the control of metabolic actions. At pressures higher than 300 MPa, significant inactivation of vegetative bacteria, yeasts and viruses has been observed at ambient temperature. The rate and magnitude of microbial inactivation is dependent on the applied pressure and temperature as well as environmental factors such as pH, water activity, salts and other antimicrobials. Food borne pathogens such as enterohemorrhagic Escherichia coli and Listeria monocytogenes, and food spoilage organisms including Lactobacillus spp. (in acidic food), often exhibit high pressure tolerance compared with other bacteria; possibly because of their relatively higher tolerance to other physical and chemical stressors such as heat or acid. Bacteria may also develop increased resistance to pressure due to their prior growth history, e.g. growth of L. mono cytogenes at higher temperatures or stationary phase cells being more pressure resistant.

High pressure thermal processing

Low-acid food (LAF) that is microbiologically safe and stable is not obtainable by HPP at low or ambient temperature. High pressure thermal (HPT) processing can inactivate bacterial spores through high-pressure treatment at 600 MPa with initial temperatures above 608C. Accelerated and homogeneous heating and cooling of food occurs during HPT processing from the increase in temperature accompanying the physical compression of the product. This facilitates uniform heating of all food packs and also reduces the need for excessively long heating times. HPT products have improved food quality attributes, such as flavor, texture, nutrient content and color, compared with thermal processing, as they receive less heat damage. Of particular interest for ambient stable LAF is the ability of a HPT process to inactivate spores of the major bacterial spore-forming pathogens of concern, which are proteolytic strains of Clostridium botulinum. HPT processed LAF with extended chilled shelf-life will need to have demonstrated safety with respect to psychrotrophic C. botulinum. HPT processing conditions for the inactivation of non-proteolytic C. botulinum spores are more moderate than required for inactivation of proteolytic C. botulinum.

The combination of high pressure and heat is often more effective than under equivalent heat-only conditions, i.e. synergistic, for various species, including C. botulinum (psychrotrophic and non-psychrotrophic strains), and relevant spoilage-associated spore formers. The amount of synergy observed, however, is affected by both the product and the bacterial strain under observation.

The mechanism of spore inactivation has been primarily studied in Bacillus subtilis; high pressure initiates spore germination via at least two mechanisms dependent on the magnitude of pressure applied. At moderately high pressure (50–300 MPa), the spore nutrient receptors are activated and germination proceeds down the nutrient-triggered pathway. Very high pressures (400-800 MPa), however, trigger the release of calcium dipicolinic acid (DPA), possibly by opening the DPA channels in the inner membrane or via another action on the inner membrane, and subsequent germination and heat sensitivity.

Cool plasma

Cool plasma is an ionised gas state, generated from gas or liquids treated with a power source such that it becomes temporarily excited to the point of partial ionisation. Interest in cool plasma for food processing has increased with technology breakthroughs allowing processing at larger scale and at atmospheric pressures. For food applications, nitrogen, air or oxygen are typically used.

Cool plasma is only suitable for surface treatments; however, it has advantages over most other methods of decontamination as it does not require water or chemicals, leaves no chemical residues, and may be applied to thermally sensitive materials. Cool plasmas consist of a number of components affecting biological systems, including charged particles (electrons and ions) as well as free radicals, excited state atoms and molecules, other reactive species, ultraviolet (UV) photons and transient electromagnetic fields.

There are a number of chemical and physical mechanisms, probably acting synergistically, by which cool plasma treatment may inactivate microorganisms. Microbial nucleic acids (DNA and RNA) damage may be induced by direct UV radiation; cell membranes may be damaged by diffusing free-radicals or excited state molecules; unstable compounds may be formed at the microbial surface through adsorption of

radicals; membranes may be disordered through the electrostatic tension of plasma electrons and ions accumulated at the cell surface; or plasma ions may induce oxidation reactions within the cell causing inactivation.

Possible applications for cool plasma treatment include food contact surface decontamination, where it can be very effective for the inactivation of microorganisms, including bacterial spores, on glass, stainless steel and plastics. Cool plasma treatment of more complex surfaces, including food, is more challenging due to the limited penetrative capacity of plasmas; however, sufficient inactivation of pathogens has been observed on meat and produce surfaces. Research on the influence of factors such as microbial load, microbial growth history, biofilms and the role of critical processing parameters on cool plasma effectiveness is still ongoing.

Ultraviolet light processing

UV light (200–310 nm) has been widely used in the food industry for disinfection of food and surfaces such as packaging materials or bottles. Similar to cool plasma, UV light, especially wavelengths around 250 nm, damages microbial DNA preventing microorganisms from replicating their genetic material. The sensitivity of microorganisms to UV light is dependent on their cell wall structure and thickness, their ability to repair UV damage, and the environment such as pH or the presence of UV absorbing proteins. In general, Gram-positive bacteria are more resistant to UV light than Gram-negative bacteria, however, the difference between vegetative bacteria like E.coli K-12 and Listeria innocuous was not considerable. Protozoa and algae are very UV resistant, possibly because of enhanced DNA repair mechanisms. The efficacy of UV light to decontaminate food and food surfaces is dependent on its penetration capabilities which may be affected by food composition including the presence of colour compounds, organic solutes and suspended matter. For example, UV absorption of milk is approximately 10 and 10^5 times higher than clear apple juice or water, respectively.

Degradation of food quality can occur as a result of photochemical reactions during UV light processing. The following nutrients are considered “light sensitive”: vitamins, tryptophan, and unsaturated fatty acid residues in oils, solid fats and phospholipids. Thus, UV processing is not suitable for most dairy products but has potential to extend shelf-life of clear fruit juices and wines with minimal effects on their colour and flavours.

Pulsed electric field processing

Pulsed electric field (PEF) processing involves the application of very short, high voltage pulses to a food which is placed between or pumped through two electrodes. Typically, several thousand volts per cm applied for 20 to 1000 ms are required for effective microbial inactivation. The sensitivity of microorganisms to PEF depends on cell characteristics such as structure and size. In addition, extrinsic factors such as product pH, water activity, soluble solids and electrical conductivity affect the decontamination efficiency of the technology.

Although the underlying mechanisms are not yet fully explained on a molecular basis, PEF treatment disturbs and perforates microbial cell membranes. It is likely that the loss of cell membrane functionality through PEF is due to formation of hydrophilic pores in the membrane and the forced opening of protein channels. The applied electrical field causes changes in the conformation of phospholipids, leading to rearrangement of the membrane and formation of hydrophilic pores.

PEF, when combined with low to moderate temperatures (<508C), effectively inactivates microbial cells but does not significantly change flavour or nutrients. This makes it a promising alternative to conventional thermal preservation processes for liquid food that contains heat labile bioactive or volatile components such as fruit and vegetable juices. Currently, PEF is commercially used in Europe to extend the chill-stability of fresh fruit juices and smoothies from 6 to 21 days.

Conclusions

The advanced food preservation technologies presented here rep-resent many opportunities for the food industry to meet contemporary retail and consumer desires for convenient food that is fresh tasting, reduced in (chemical) additives, microbiologically safe and have an extended shelf life. Technological breakthroughs, advances in equipment design and methodologies for measuring the critical process factors will improve our ability to assess and control the performance of novel processes. Continued research into inactivation kinetics and the mechanisms of microbial inactivation will contribute to the validation of these processes and, therefore, possible applications and uptake by the food industry.

References

1. *Jatindra Kumar Sahu (2016) Introduction to Advanced Food Process Engineering. A Text Book in Food Engineering.*
2. *Roman Buckow and Michelle Bull (2013) Advanced Food Preservation Technologies. Journal of Food Microbiology. 107- 111*
3. *Fernández, A. and Thompson, A. (2012) The inactivation of Salmonella by cold atmospheric plasma treatment. Food Res. Int. 45, 678–684.*
4. *Kong, M.G. (2012) Microbial decontamination of food by non-thermal plasmas. In: Microbial Decontamination in the Food Industry, 472–492.*
5. *Olivier, S.A. et al. (2011) Strong and consistently synergistic inactivation of spores of spoilage-associated Bacillus and Geobacillus spp. by high pressure and heat compared with inactivation by heat alone. Appl. Environ. Microbiol. 77, 2317–2324.*
6. *Heinz, V. and Buckow, R. (2010) Food preservation by high pressure. J. Verbrauch. Lebensm. 5, 73–81.*
7. *Bull, M.K. et al. (2009) Synergistic inactivation of spores of proteolytic Clostridium botulinum strains by high pressure and heat is strain and product dependent. Appl. Environ. Microbiol. 75, 434–445.*
8. *Oey, I. et al. (2008) Effect of high-pressure processing on colour, texture and flavour of fruit- and vegetable-based food products: a review. Trends Food Sci. Technol. 19, 320–328.*
9. *Black, E.P. et al. (2007) Response of spores to high-pressure processing. Compr. Rev. Food Sci. F. 6, 103–119.*
10. *Black, E.P. et al. (2007) Analysis of factors influencing the rate of germination of spores of Bacillus subtilis by very high pressure. J. Appl. Microbiol. 102, 65–76.*