EMERGING METHODS OF FOOD PRESERVATION

Introduction

The need for enhancing microbial food safety and quality, without compromising the nutritional, functional and sensory characteristics of foods, has created an increasing world-wide interest in low-temperature innovative processes for food preservation. In contrast, to the traditional thermal processes, these emerging technologies are predominantly reliant on physical processes, including high hydrostatic pressures, pulsed electric fields and low-temperature plasmas, high hydrostatic pressure, oscillating magnetic field, ultra sounds that inactivate microorganisms at ambient or moderately elevated temperatures and short treatment times. The relatively slow commercial implementation of ionizing radiation (gamma and high energy electron beams) to meet the needs of the international food industry for food preservation has, by and large, been associated with concerns about consumer responses to use of these technologies. Inherent disadvantage of thermal processing like loss of original flavor taste, color and nutritional quality of foods have embraced the uses of high pressure, high power ultrasonics, pulsed ultraviolet light, pulsed electric fields and more recently low-temperature plasma of gases, these techniques render food free of pathogens and spoilage organisms and improve shelf life and texture of foods. 16.2 High Pressure Processing High Pressure Processing (HPP) is an emerging food treatment that makes food safer and extends its shelf life, while allowing the food to retain many of its original qualities and healthy attributes. High pressure processing is a non thermal processing. It was first commercialized in Japan in the early 1990s for pasteurization of acid foods for chilled storage. HHP subjects liquid or solid foods with or without packaging to pressure between 40 and 1000MPa for 1-20 min. The mechanism of action of HPP to breakdown the non covalent bonds and puncturing or the permeabilization of cell membrane i.e. vegetative cells at 300

MPa at room temperature (Figure 16.1). Spore formers >600 MPa at 60-700C, some enzymes at 300 MPa but effect is less at below 40% food moisture. Hydrostatic pressure is applied to food products through a water bath that surrounds the product. The hydrostatic pressure is transmitted to food products equally from all sides. This equal distribution of pressure is the reason why foods are not crushed during treatment. fig Fig. 16.1 High pressure process High Pressure Processing (HPP) has been used with hundreds of products, and can reliably: Inactivate food borne pathogens, Inactivate spoilage organisms, Activate or inactivate enzymes, Germinate or inactivate some bacterial spores, Marinate meats, Shuck oysters, Extend shelf life, Reduce the potential for food borne illness, Pressure-shift freezing or thawing, Promote ripening of cheeses, Minimize oxidative browning HPP products currently being marketed worldwide such as abalone, apple cider, apple juice, apple sauce (single serving packs), avocado (halves, pulp), beef, chicken, cod (both dried and salted), fruit purees, fruit smoothies, guacamole, jams/jellies, limeade, mussels, onions (chopped), orange Juice etc. The cell morphology is not significantly affected at the lower pressures, although membrane integrity is damaged. At elevated pressures, (500

700 MPa) progressive morphology changes become evident. Orange juice processed at 438M Pa for 60 seconds. 7log reduction of pathogens (E.Coli, Salmonala) can be obtained. Similarly, in case of meat process at 600M Pa, 3-4 log reduction of L.monocytogenes can be done. 16.3 Pulsed Electric Field (PEF) Processing PEF utilizes high intensity electric field pulses to inactivate microorganisms mainly in liquid foods at relatively low or moderate temperatures (<600C), whilst preserving the fresh flavour, color and integrity of heat sensitive components. A typical PEF food processing unit comprises of a high voltage pulse generator, a treatment chamber, a fluid handling system and control and monitoring devices (Figure 16.2). Depending on the particular PEF systems used, typical PEF treatment parameters include pulsed field intensity of 15-50 kV cm-1, pulse width of 1-5 ms, and pulse

frequency of 200-400 Hz (pulses/s). PEF treatment at an electric field intensity greater than a critical threshold of trans-membrane potential of 1 V across the target cells causes irreversible pore formation and destruction of the semi-permeable barrier of the cell membrane and structural changes in enzymes. PEF treated bacterial cells substantially damaged at the cellular level. PEF treatment at up to 25 kV cm_1 and 350C for 400 ms caused less than 1 log reduction in E. coli O157:H7 in apple juice. Examples of pulse field processed foods are apple juice, milk, orange juices, green pea soup etc. PEF processing is restricted to foods that do not contain air bubbles and have low electrical conductivity. PEF is not suitable solid foods can not be pumped. PEF and thermal processing in combination lower the temperature of pasteurization and improve the quality of food. fig Fig. 16.2 A typical PEF food processing unit 16.4 Ultrasonic Food Processing Ultrasound is an efficient non-thermal alternative. Ultrasonic cavitation creates shear forces that break cell walls mechanically and improve material transfer. Generally, ultrasound equipment uses frequencies from 20kHz to 10MHz. Higher-power ultrasound at lower frequencies (20–100kHz), which is referred to as ''power ultrasound'', has the ability to cause cavitation that could be used in food processing to inactivate microorganisms. Low frequency ultrasound refers to pressure waves with a frequency of 20 kHz or more. Ultrasonic waves generate gas bubbles in liquid media, which produce a high temperature and pressure increase when they immediately burst. When the bubbles produced during ultrasonic treatment collapse, the compression/expansion cycles generated are thought to be responsible for cell disruption, microbial and enzyme inactivation in preservation of fruit juices and sauce. Ultrasound has potential to destruction of food borne pathogens like E.coli, Salmonella, Giargia, poliovirus etc. This method has application in the preservation of jam, marmalade or toppings e.g. for ice cream, fruit juices and sauces, meat products and dairy. 16.5 Ohmic Heating of Foods Ohmic heating (sometimes also referred to as Joule heating, electrical resistance heating, direct electrical resistance heating, electro heating, and electro conductive heating) is defined as a process wherein (primarily alternating) electric currents are passed through foods or other materials with the primary purpose of heating them. The heating occurs in the form of internal energy generation within the material. Ohmic heating is an advanced thermal processing method wherein the food material, which serves as an electrical resistor, is heated by passing electricity through it. Electrical energy is dissipated into heat, which results in rapid and uniform heating. Ohmic heating is also called electrical resistance heating, Joule heating, or electro-heating, and may be used for a variety of applications in the food industry. Ohmic heating can be used for heating liquid foods containing large particulates, such as soups, stews, and fruit slices in syrups and sauces, and heat sensitive liquids. The technology is useful for the treatment of proteinaceous foods, which tend to denature and coagulate when thermally processed. At low-frequency (50–60 Hz), electrical charges can build up and form pores across microbial cells and causes death of those microbial cells. 16.6 Intense Pulse Light Pulsed light (PL) is a technique to decontaminate surfaces by killing microorganisms using pulses of an intense broad spectrum, rich in UV-C to near IR (180-1100nm) which is produced using xenon discharge lamp light (Figure 16.3). One pulse is 1-20 flashes/seen for duration of 1μs to 0.15, energy density is 0.01- 50 J/cm2. PL kills microorganisms using short time high frequency pulses of an intense broad spectrum, rich UV-C light. The germicidal effect of UV light on bacteria is primarily due to the formation of pyrimidine dimers, mainly thymine dimers. The dimer inhibits the formation of new DNA chains in the process of cell replication, thus resulting in the inactivation (inability to replicate, called clonogenic death) of affected microorganisms by UV. On bacterial spores, UV-C treatment results mainly in the formation of the ‘‘spore photoproduct’’ 5-thyminyl-5,6dihydrothymine, and in single-strand breaks, double-strand breaks and cyclobutane pyrimidine dimers. PL has been used to successfully inactivate Escherichia coli O157:H7 on alfalfa seeds and

Aspergillus niger spores on corn meal. Surface microorganisms are controlled in various foods. Such as meat products, cheese, baked goods, fish, shrimp, reduction of Pseudomonas on dry cottage cheese, inactivation of spoilage and pathogens in milk. fig Fig. 16.3 Pulse light technology 16.7 Plasma Light Plasma is defined as a neutral ionised gas. It is constituted by particles in permanent interaction. The particles include photons, electrons, positive and negative ions, atoms, free radicals and excited or non-excited molecules (Figure 16.4). Electrons and photons are usually designed as “light” species in contrast to the other constituents defined as “heavy” species. Consequently, the term “plasma” is considered to describe a state of matter in which the heavy species are neutral or ionised particles which result from an energetic transfer to a gas. Non-thermal plasma technology relies on electric discharge into air or liquid to produce energetic atoms, highly reactive radicals, ozone, etc., that can kill microbes in contact. In non-thermal plasma, electric energy is mostly used to generate nonthermal plasma species instead of heat. Therefore, this technology is energy-efficient and will cause minimal heat-induced damages to food products. Potential applications include pasteurization of liquid food products, produce wash, disinfection of processing equipment, plant floors, and packaging materials, city water and wastewater treatment and air pollution control. The primary advantages of plasma processing as a potential tool in the inactivation of microorganisms are (1) minimal thermal denaturation of nutritional and sensory properties, (2) reduced energy requirement for adequate processing, and (3) potential treatment of foods inside a flexible-film package. Non-thermal plasma was capable of killing Escherichia coli and Salmonellae in liquid foods. At the flow rate of 1000 mL/min, the 5 logs reduction in the bacteria counts has been achieved. This suggests that non-thermal plasma pasteurization can kill the food borne pathogens such as Escherichia coli and Salmonellae in liquid foods with minimal damage to active ingredients in foods. fig Fig. 16.4 Plasma sterilization mechanism 16.8 Oscillating Magnetic Fields (OMF) OMF applied in the form of pulses reverses the charge for each pulse, and the intensity of each pulse decreases with time to about 10% of the initial intensity. Preservation of foods with OMF involves sealing food in a plastic bag and subjecting it to 1 to 100 pulses in an OMF with a frequency between 5 to 500 kHz at temperatures in the range of 0 to 50oC for a total exposure time ranging from 25 to 100 ms. Frequencies higher than 500 kHz are less effective for microbial inactivation and tend to heat the food material. Magnetic field treatments are carried out at atmospheric pressure and at moderate temperatures. The temperature of the food increases 2-5oC. Exposure to magnetic fields causes inhibition in the growth and reproduction of microorganisms. OMF of intensity of 5 to 50T and frequency of 5 to 500 kHz was applied and reduced the number of microorganisms by at least 2-log cycles. Within the magnetic field of 5-50 T, the amount of energy per oscillation coupled to 1 dipole in the DNA is 10-2 to 10-3 EV. Inactivation of microorganisms may be based on the theory that the OMF may couple energy into the magnetically active parts of large critical molecules such as DNA. Within 5-50 T range, the amount of energy per oscillation coupled to 1 dipole in the DNA is 10-2 to 10-3 EV. Several oscillations and collective assembly of enough local activation may result in the breakdown of covalent bonds in the DNA molecule and inhibition of the growth of microorganisms. Examples of food preserved with OMF milk, yoghurt and orange juice.