





Associated with concerns about consumer responses



Loss of original flavor taste, color and nutritional quality of foods



In contrast to traditional thermal processes, emerging technologies are predominantly reliant on physical processes including high hydrostatic pressure, pulsed electric fields and low-temperature plasmas, high hydrostatic pressure, oscillating magnetic field, ultra sounds inactivate microorganisms at ambient or moderately elevated temperatures and short treatment times.



High Pressure Processing (HPP)

- 1. Makes food safer and extends its shelf life, while allowing food to retain many of its original qualities.
- 2. First commercialized in Japan in early 1990s for pasteurization of acid foods for chilled storage.
- 3. HPP subjects liquid/solid foods with or without packaging to pressure between 40 and 1000MPa for 1-20 min.
- 4. Mechanism of action: Breakdown of non covalent bonds and puncturing/permeabilization of cell membrane i.e. vegetative cells at 300 MPa at room temperature.
- 5. Spore formers >600 MPa at 60-70 C, some enzymes at 300 MPa but effect is less at <40% food moisture.
- 6. Hydrostatic pressure is applied to food products through water bath that surrounds product and pressure is transmitted equally from all sides.

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- 7. Inactivate food borne pathogens, inactivate spoilage organisms, activate or inactivate enzymes, inactivate some bacterial spores, reduce potential for food borne illness, promote ripening of cheeses, minimize oxidative browning.
- 8. HPP products currently marketed worldwide: apple cider, apple juice, apple sauce, beef, chicken, cod (both dried and salted), fruit purees, fruit smoothies, jams/jellies, onions, orange juice etc.
- 9. At elevated pressures, (500-700 MPa) progressive morphology changes become evident.
- 10. Orange juice processed at 438 MPa for 60 secs leads to 7 log reduction of *E. coli, Salmonella*.



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Pulsed Electric Field Processing (PEF)

- Utilizes high intensity electric field pulses to inactivate microorganisms mainly in liquid foods at relatively low/ moderate temperatures (<60 C), whilst preserving fresh flavour, color and integrity of heat sensitive components.
- Typical PEF food processing unit comprises of high voltage pulse generator, a treatment chamber, a fluid handling system and control and monitoring devices.
- 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).

Pulse generator produces high voltage pulses, treatment chamber that handles the product to be treated and associated with controlling and monitoring devices. Food product is placed in treatment chamber equipped with electrodes connected with each other by nonconductive material which prevents flow of electricity from one to other. High voltage electrical pulses are generated that are transferred to product. Product placed between electrodes experiences a force per unit charge which ruptures bacterial cell membranes.





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- PEF treated bacterial cells substantially damaged at the cellular level.
- PEF treatment at up to 25 kV cm_1 and 35 C for 400 ms caused <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 and thermal processing in combination lower temperature of pasteurization and improve quality of food.

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Ultrasonic Food Processing

- Ultrasonic cavitation creates shear forces that break cell walls mechanically and improve material transfer. Ultrasound equipment uses frequencies from 20kHz-
- Higher-power ultrasound at lower frequencies (20–100 kHz) which is referred as "power ultrasound" has ability to cause cavitation that are used in food processing to inactivate microorganisms.
- Low frequency ultrasound refers to pressure waves with frequency of 20 kHz or more.
- Ultrasonic waves generate gas bubbles in liquid media, which produce high temperature and pressure increase when they immediately burst. When bubbles collapse, compression/expansion cycles generated are thought to be responsible for cell disruption, microbial and enzyme inactivation in preservation of fruit juices and sauce.
- Destroy E. coli, Salmonella, Giargia, poliovirus etc.
- Preserve jam, marmalade or toppings e.g. for ice cream, fruit juices and sauces, meat products and dairy.



Phenomenon involves rapid expansion and contraction of micro bubbles of gas in liquid being treated with ultrasound. Energy is created by formation of pressure waves. Sudden and instantaneous collapse of bubbles at rate of tens of thousands of times a second generates extremely high, localized temperatures and pressures. These lead to high shear forces and free radical generation, which can be used to improve food processing operations.





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Ohmic Heating

- Known as (Joule heating, electrical resistance heating, direct electrical resistance heating, electro heating, and electro conductive heating) is defined as a process wherein electric currents are passed through foods or other materials.
- Heating occurs in form of internal energy generation within material.
- 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 used for heating soups, stews, and fruit slices in syrups and sauces.
- Treats 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.

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Intense Pulse Light

- Decontaminate surfaces by killing microorganisms using pulses of an intense broad spectrum, rich in UV-C to near IR (180-1100 nm) which is produced using xenon discharge lamp light.
- One pulse is 1-20 flashes/seen for duration of 1 μs to 0.15, energy density is 0.01- 50 J/cm2
- Short time high frequency pulse of intense broad spectrum
- Germicidal effect of UV is primarily due to formation of thymine dimers that inhibits formation of new DNA chains, thus resulting in inactivation of affected microorganisms by UV.
- Surface microorganisms are controlled in meat products, cheese, baked goods, fish, shrimp, reduction of *Pseudomonas* on dry cottage cheese.



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Plasma Light

- Plasma is defined as a neutral ionised gas.
- Constituted by particles (photons, electrons, positive and negative ions, atoms, free radicals and excited or non excited molecules).
- Electrons and photons are usually designed as light species
- Plasma is a state of matter in which 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 kill microbes in contact.
- In non-thermal plasma, electric energy is used to generate non-thermal plasma species instead of heat.
- Energy-efficient and will cause minimal heat-induced damage food products.



Potential applications include pasteurization of liquid food products, produce wash, disinfection of processing equipment, plant floors, packaging materials, city water and wastewater treatment and air pollution control.

Reduced energy requirement for adequate processing Minimal thermal denaturation of nutritional and sensory properties

Potential treatment of foods inside flexible-film package

Primary Advantage



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Oscillating Magnetic Field (OMF)

- Preservation with OMF involves sealing food in plastic bag and subjecting it to 1-100 pulses in an OMF with frequency between 5-500 kHz at 0 to 50 C for total exposure time ranging from 25-100 ms.
- Frequencies >500 kHz are less effective for microbial inactivation and heat food material.
- Magnetic field treatments are carried out at atmospheric pressure and at moderate temperatures.
- Temperature of food increases 2-5 C.
- OMF of intensity 5-50 T and frequency of 5-500 kHz was applied and reduce number of microorganisms by at least 2-log cycles.
- Within the magnetic field of 5-50 T, amount of energy per oscillation coupled to 1 dipole in the DNA is 10-2 to 10-3 EV.



- Several oscillations leads in breakdown of covalent bonds in DNA molecule and inhibition of growth of microorganisms.
- Food preserved with OMF: milk, yoghurt and orange juice.

