MICROWAVE HEATING

The technological revolution, nutritional awareness, and continuous demand of the new generation have necessitated search for new or improved food processing technologies.

Thermal processing has been a major processing technology in the food industry. The purpose of thermal processing was to extend the shelf life of food products without compromising food safety.

Various thermal treatments such as pasteurization and sterilization for inactivation of pathogens but thermal treatment can also result in some other desirable changes, such as protein coagulation, texture softening, and formation of aromatic components.

However, this process has also got some limitation by way of partial destruction of quality attributes of food products, especially heat-labile nutrients, and sensory attributes.

The principal mechanisms involved in microwave heating are dipole rotation and ionic polarization. Heat is generated rapidly as a result of internal molecular friction.

The second major mechanism of heating with microwaves is through the polarization of ions as a result of the back and forth movement of the ionic molecules trying to align themselves with the oscillating electric field.

Microwaves are a form of electromagnetic radiation, characterized by frequency (300 MHz to 300 GHz). Microwaves used in the food industry for heating are of ISM (industrial, scientific and medical) frequencies (2450 or 900 MHz, corresponding to 12 or 34 cm in wavelength).

The water content is an important factor in the microwave heating performance of foods. Water in the food is the primary dipolar component responsible for the dielectric heating. Microwave heating in foods occurs due to coupling of electrical energy from an electromagnetic field in a microwave cavity with the food and its subsequent dissipation within food product. This results in a sharp increase in temperature within the product.

Microwave energy is delivered at a molecular level through the molecular interaction with the electromagnetic field, in particular, through molecular friction resulting from dipolerotation of polar solvents and from the conductive migration of dissolved ions.

Microwave heating is also affected by the state of the constituents, whether they are bound or free, e.g., bound ions have much lower microwave absorptivities.

Microwave heating is preferred for pasteurization and sterilization over the conventional heating for the basic reason that the process is fast and requires minimum come-up time (CUT) to the desired process temperature.

The volumetric heat generated by microwaves can significantly reduce the total heating time and severity at the elevated temperatures needed for commercial sterilization whereby bacterial destruction is enhanced, but thermal degradation of the desired components is reduced.

Dairy industry applications of microwave processing include- enhancement of pasteurization efficiency, thermising milk prior to cheese manufacturing, inactivation of bacteriophage, in package paneer making, clarification of butter into ghee, thermization of yoghurt, cooking of cheese curd, plasticizing provolone and mozzarella cheese and thawing butter.

HIGH HYDROSTATIC PRESSURE PROCESSING

High Hydrostatic pressure is a physical treatment that will not cause extensive chemical changes in the food system. This emerging technology receiving a great deal of attention is high hydrostatic pressure Once the desired pressure is reached, it can be maintained without the need for further energy input.

Liquid foods like milk can be pumped to treatment pressures, held, and then decompressed aseptically for filling as with other aseptic processes.

The application of high pressure processing to food preservation started around 1900 when Hite and his coworkers investigated its effects on food microorganisms by subjecting them to pressures of 650 MPa and found a reduction in the viable numbers of microbes.

HPP equipment has the following necessary components

• a pressure vessel and its closure

• a temperature control device

• a pressure generation system

• a material handling system

Most pressure vessels for HPP applications are made from a high tensile steel alloy and called 'monoblocs' (forged from a single piece of material), able to withstand pressures of 400–600 MPa.

Foods with high quality and more fresh-like attributes are in demand; consequently, less extreme treatments or fewer additives are required. To satisfy such demands; some changes in the traditionally used preservation techniques must be achieved.

. The basis of high hydrostatic pressure is the Le Chatelier principle, according to which any reaction, conformational change, or phase transition that is accompanied by a decrease in volume will be favored at high pressures, while reactions involving an increase in volume will be inhibited.

However, owing to the complexity of foods and the possibility of changes and reactions that can occur under pressure, predictions of the effects of high-pressure treatments are difficult, as are generalizations about any particular type of food.

High pressures can be generated by direct or indirect compression or by heating the pressure medium. High pressure presents unique advantages over conventional thermal treatments for retention of food quality. High-pressure treatments are independent of product size and geometry, and their effect is uniform and instantaneous.

The application of hydrostatic pressure to food results in instantaneous and uniform transmission of the pressure throughout the product independent of the product volume. The hydrostatic treatment is unique in that the effects do not follow a concentration gradient nor do they change as a function of time. Other advantages include the absence of chemical additives and operation at low or ambient temperatures so that the food is essentially raw.

The food industry employs the technique of isostatic pressing for applying high pressures to foods. A high-pressure system consists of a high-pressure vessel and its closure, pressure generation system, temperature-control device, and material-handling system.

Once loaded and closed, the vessel is filled with a pressure-transmitting medium. Air is removed from the vessel by means of a low-pressure fast-fill-and-drain pump, in combination with an automatic deaeration valve, and high hydrostatic pressure is then generated.

Recent instances of commercialization of HPP in dairy industry can include HP treated Yogurt and Cheese spread.

New opportunities in HPP may include exploring HP induced changes in milk giving functional ingredients, preservation of colostrum and human milk by HPP treatment, which may be of interest to the entrepreneurs.

More research is required for optimization of the process in the future to fully establish it in the dairy industry.

Application-

HPP have provided a detailed understanding about the complex changes that take place in milk under high pressure like the dissociation of caseins micelles from the colloidal to the soluble phase, influence turbidity of milk etc.

Effect of HHP on casein HHP greatly influences the physico-chemical and technological properties of milk. The varied physico-chemical and sensory properties obtained using the HPP offer exciting opportunities for the dairy industry.

High pressure treatment also enhances pepsin hydrolysis.

Lactose in milk and milk products may isomerise to lactulose by heating and then degrade to form acids and other sugars

Micelle disintegration induced by HHP treatment also affects milk colour

HHP treatment induces fat crystallization, shortens the time required to achieve a desirable solid fat content and thereby reduces the ageing time of ice-cream mix and also enhances the physical ripening of cream for butter making.

PULSED ELECTRIC FIELD

The pulsed electric field (PEF) technology is an alternative to traditional thermal pasteurization for milk with the advantages of minimizing sensory and nutritional damage, therefore providing fresh-like products as very little heat is generated during PEF processing. Thermal processes used for food preservation can alter the sensory, organoleptic and nutritional properties of milk.The most common organoleptic change in pasteurized milk is the generation of “cooked” flavor. Vitamins B and C and bioactive compounds can also be affected.

The PEF process is considered to be energy efficient since the microbial inactivation is achieved at ambient temperatures by the application of short bursts of high intensity electric fields to liquid food flowing between two electrodes. PEF technology involves the application of pulses of high voltage to liquid or semi-solid foods placed between two electrodes.

The pulsed electric field technology, also known as high-intensity electric field pulses (HELP), refers to the application of high voltage pulses (20–80 kV cm^{-1}) in a product situated between two electrodes. The basic principle of PEF technology is the application of short pulses of high electric fields with duration of micro seconds micro- to milliseconds. The inactivation of pathogenic and spoilage bacteria, yeasts, and some enzymes related to food quality have been demonstrated by several authors, although bacterial spore is not eliminated through this treatment. Regarding to this limitation, other methods are used in combination with irradiation technologies for the elimination of bacterial spores.The processing time is calculated by multiplying the number of pulses times with effective pulse duration.

A typical PEF system consists of the following components-

A pulse generator

A number of energy storage capacitors

A high-voltage power supply

A treatment chamber (either static or continuous) that houses the electrodes

A pump to pass the liquid food through the treatment chamber.

Application of PEF in milk processing

Application of pulsed electric fields technology has been successfully demonstrated for the pasteurization of foods such as juices, milk, yogurt, soups, and liquid eggs. The maximum particle size in the liquid must be smaller than the gap of the treatment region in the chamber in order to ensure proper treatment. Application of PEF processing is restricted to food products with no air bubbles and with low electrical conductivity.

*****Gram-positive bacteria are more resistant to PEF treatment than Gram-negative. Yeasts are more sensitive to electric fields than bacteria, although at low electric fields they were more resistant than Gram-negative bacteria. Two mechanisms have been proposed for the mode of PEF action on microbial membrane: electroporation (cell exposed to high voltage electric field pulses temporarily destabilizes the lipid bilayer and proteins of cell membranes) and electrical breakdown.

*The shelf life for raw pasteurized milk by 30 pulses with an electric field intensity of 30- 50 Kv/ cm at 70-80C° was estimated around 15 to 22 days. More shelf life for milk can be developed by pulsed electric fields with a more gentle thermal process. Additionally, this technology can improve shelf life and reduce the number of yeasts and molds in flavored milk and yogurt.

*****The alkaline phosphatase enzyme activity in simulated milk ultrafiltrate (SMUF) subjected to electric field strength of 22 kV/cm and seventy pulses using static chamber was reduced by 65%

PEF treatment at a dose of 21.5 kV/cm achieved 60% reduction in the milk lipase activity. A 90% reduction in plasmin activity in SMUF was attained by use of PEF at strength of 30 kV/cm.

Inactivation of protease and lipases produced by psychrotropic microorganism such as Bacillus and Pseudomonas by use of PEF is of significance in dairy industry

*****Milk vitamins such as Thiamine (B1), Riboflavin (B12), Cholecalciferol (D3) and Tocopherol (E) remain unchanged after PEF process and only the amount of ascorbic acid would be slightly affected.

Limitations of PEF the technical drawbacks or disadvantages of PEF technology are:-A high initial cost; no effect on spores, adverse effect of electrolysis on milk, no energy efficiency etc. PEF is only suitable for thermal treatment of particles in liquids, therefore any other preservation method should be applied along with PEF to improve it’s efficiency. The presence of bubbles may lead to non-uniform treatment as well as operational and safety problems; Limited application, which is restricted to food products that can withstand high electric fields.