Review Article

A Review on High Pressure Processing and Ultrasound Processing in Food Industry

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Abstract

High Pressure Processing (HPP) is a promising processing technique that makes food safer and extends its shelf life, whereas allowing it to maintain many of its original character and healthy attributes. While, Ultrasound is composed of sound waves with frequency beyond the limit of human hearing and was created to limited processing, amplify quality and ensure the safety of food products. The current paper audits the principle mechanism, properties, process parameters, applications, benefits and disadvantages of the high pressure processing and ultrasound innovation in the food processing.

Keywords: Keywords: High pressure processing, ultrasound processing, minimize processing, maximize quality

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Introduction

High Pressure Processing (HPP) is also called high hydrostatic pressure (HHP) and ultra high pressure processing (UHP). It is a non-thermal innovation ready to creating high-quality foods, keeping up the characteristics of fresh products and expanding the shelf life. It is a cold pasteurization innovation by which products, effectively sealed in their final package, are introduced to a vessel and exposed to a high level of isostatic pressure (300–600 MPa). Pressure inside a vessel applying high pressure, food can be handled with the goal that it holds its new appearance, flavor, surface and supplements while crippling unsafe microorganisms and easing back deterioration.

Brief history of high pressure processing

Certes who was the first in history, in 1883 relate the impacts of high pressure on organisms [1]. Be that as it may, the impact of high hydrostatic pressure on nourishments was first found toward the finish of nineteenth century by Bert Hite and associates in agricultural trial station at West Virgina University, 1899. Hite was use high hydrostatic pressure upto 600MPa to save the milk and after that on vegetables and natural products in 1914 [2]. Later hardly any works have been done and no continued research was accessible about high pressure handling until 1980's. In 1982, the primary high pressure prepared item was discharge in the market of Japan [3].

Principle

According to Yordanov and Angellova [4] a number of physical and chemical changes result from the use of pressure. The pressure which physically applied brings about a volume decrease and rise in temperature and energy. The underlying principle for the use of HPP is in agreement with the three elements of physical and chemical principles.

Le Chatelier's principle

This principle delivers changes to equilibrium because of pressure application. It expresses that any incident (phase transition, change in molecular configuration, chemical reaction) joined by a reduction in volume is improved by pressure [5]. If pressure changes, the equilibrium moves in a direction that will in general lessen the adjustment in the relating serious variable (Volume). In this manner pressure moves the structure to that of the most reduced volume.

Principle of microscopic ordering

An increase in pressure expands the degrees of ordering of molecules of a particular substance, at constant temperature. In this manner pressure and temperature affect opposed forces on molecular structure and chemical reactions.

Isostatic principle

The main idea including the use of high pressure is the Isostatic principle, which presumes that the uniform utilization of weight acts similarly every which way. A genuine hydrostatic condition should be autonomous of time and space. It very well may be set up when a liquid is utilized to transmit the weight all through the food. In high pressure applications, the weight and all the more significantly, its belongings are immediately and homogeneously appropriated inside the food item, paying little heed to food geometry and size. This exceptional trademark has empowered the advancement of procedures that have been effectively popularized. This principle clarifies why nonporous nourishments with high-dampness content are not harmed perceptibly by pressure treatment [6]. Since air and water contrast in compressibility under tension, the structure and state of the nourishments containing air pockets might be modified upon pressure treatment, except if the food is completely flexible and comprises of shut cell froth from which air can't get away.

Mechanism of HPP

A typical high hydrostatic pressure system is appeared in **Figure 1**. The system comprises of a high pressure vessel and its closure, a pressure generation system, a temperature controller and a material handling system [7]. The flow diagram of HPP unit shows in **Figure 2**.

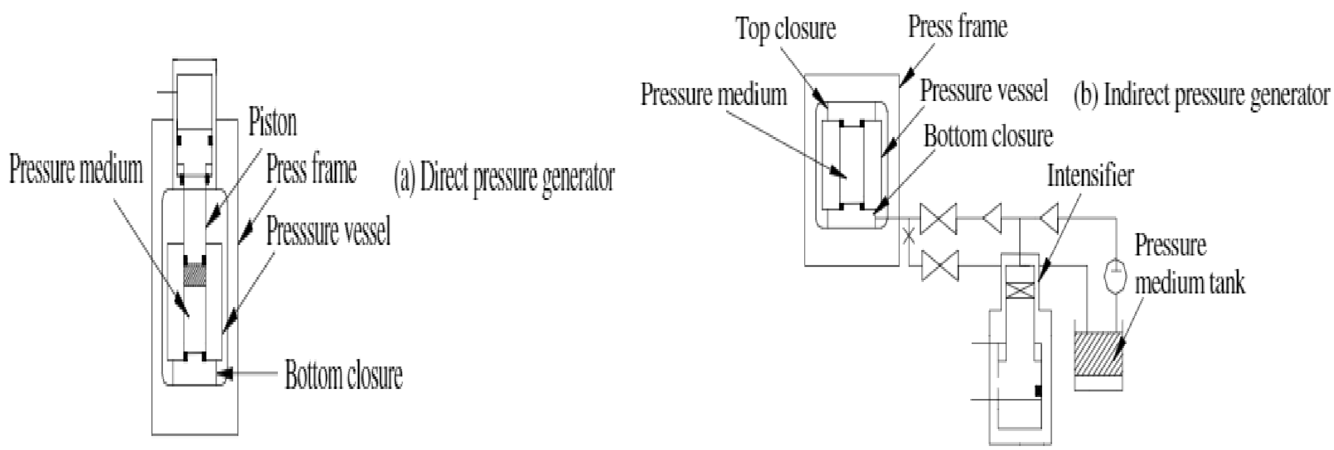

Figure 1 Methods for the generation of high hydrostatic pressure

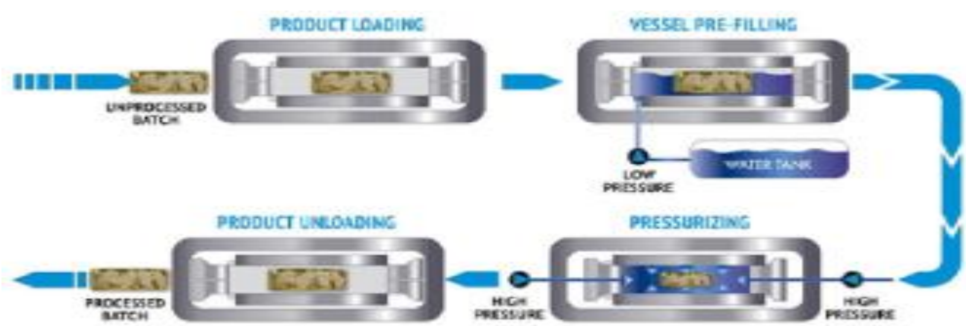

Figure 2 Flow diagram of operation of HPP unit

High pressure vessel

The heart of a high pressure processing system is in many cases, simply a forged monolithic, cylindrical vessel constructed by a low-alloy steel of high tensile strength. The wall thickness is controlled by the most extreme working pressure, the vessel width, and the quantity of cycles for which the vessel is planned. The necessary wall thickness can be decreased by utilizing multiplayer, wire-wound, or other pre-focused on structures.

Closures

Most quick cycling CIP systems utilize interfered with thread closures permitting extremely quick opening and shutting of the vessel and thus, least vessel down an ideal opportunity for stacking and emptying. These threaded closures are self focusing and can be automatically opened and shut by methods for a crane gadget, managing the conclusion with no thread friction.

Pressure transmitting medium

In most flow cold applications, the pressure medium is just water blended in with a limited quantity of solvent oil for oil and anticorrosion reason.

Pressure generation

After all air is expelled from the high pressure vessel, the high pressure is produced by direct compression (piston type) or circuitous pressure type (pump type). In direct piston type compression, the pressure medium in the high pressure vessel is straight forwardly pressurized by a piston. This technique permits quick compression yet is, limited too little diameter, research facility or pilot, high-pressure framework. The indirect compression technique utilizes a high compel intensifier to pump the pressure vessel until the ideal pressure is accomplished. For this technique, just static high pressure seals are required inside the high pressure vessel.

Types of High Pressure Processing of Foods

Batch type

Batch type has been trusted as the favored strategy for high pressure food treatments, essentially for its neatness, adaptability, and specialized reasons. This procedure is important for packaged foods. The food is readied and aseptically filled/fixed in plastic containers, at that point put in a pressure chamber for pressurizing, utilizing unadulterated water as the transmitting liquid. The process duration relies upon the food type and the handling temperature. The chamber is then decompressed, and the cycle starts again [8]. Batch type takes out any dangers that the food might be contaminated by oils or wear particles from machinery. The machinery needn't bother with cleaning between item changes, in this way taking out any threat of cross pollution by food particles.

Semi continuous type

Direct presentation of food into the high pressure chamber is a promising elective procedure contrasted with that of batch one. Up until now, this is accomplished modern just in a semi-persistent mode, which implies that the food is brought intermittently into the high pressure handling chamber. The general handling cycle incorporates various discrete advances like filling, pressurizing, holding, decompression and removal. The mix of numerous vessels, which consecutively, and which are taken care of by a focal high weight blower, can be utilized to make progression all the while. **Figure 3** shows a multi-vessel arrangement for food handling.

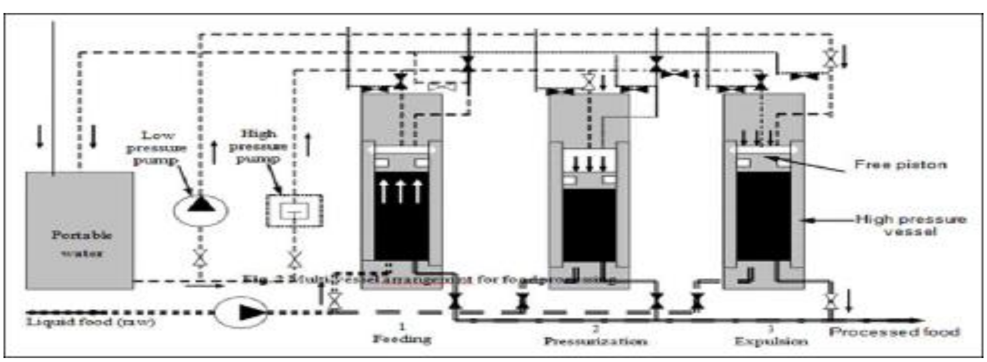

Figure 3 Multi-vessel arrangement for food processing

Factors affecting on microbial inactivation

1. The impact is more lethal to bacteria developing in log phase while spores are safer.
2. The different variables like time temperature (15-30°C) action is most extreme and diminishes at lower or higher temperature [9, 10].

3. Type of microorganism's species and strain. Generally, Gram-positive bacteria are more resistant to pressure than Gram-negative bacteria, moulds and yeasts (bacterial spores are more resistant).
4. Rich supplement media for example meat support the resistance of the microorganisms to HPP carbohydrates, proteins and lipids likewise have a defensive impact.
5. A low water activity protects microorganisms against pressure and tends to slow down pressure inactivation with clear retardation as water activity falls below 0.95 extent of pressure as pressure increases the inactivation increases.
6. Redox potential and medium composition likewise influence indirectly on microbial inactivation.

Advantages of HPP

HPP offer numerous advantages in food industry. This method is useful in dairy food processing contain inactivation of microorganisms, spores and enzymes, structural modification of proteins and depression of freezing point of water. Retains natural antimicrobial systems without changing the sensory and nutritional quality of foods and builds life span up to 2-3 folds. The significant focal points are critical decrease of heating, this will dimnish thermal degradation of food components. The product has maintenance of flavor, colour and nutritional value. Pressure is transmitted consistently and instant so that food product holds its shape. The process time is less reliance of product shape and size. Reduced requirement of chemical additives, and increased bioavailability [11].

Disadvantages of HPP

In spite of advantages this process has a few disadvantages. Food must contain water, as the whole phenomenon is based on compression. Some enzymes are very pressure challenging. May not inactivate spores so, extra heat treatment is required. Structurally fragile foods need special attention. This technique needs high installation cost [12].

Applications of HPP in Food

HPP used in food preservation in many ways. Some example of areas where HPP has more potential is discussed under the following headings.

Fruits and vegetables

HPP doesn't decrease the healthful and sensory attributes of food, and it keeps up the time span of usability contrasted the impact of HPP and water blanching on the microbial safety, quality (non-abrasiveness), and usefulness (poly phenol oxidase (PPO) movement, leaching of potassium, and loss of ascorbic acid) of vegetables. All out inactivation of microorganisms and PPO movement happened at 200°C (utilizing dilute citrus acid solution at 0.5 at 1.0 % as immersion medium). Water-balanced and high pressure rewarded potato cubes had comparative delicateness yet potassium leaching was decreased by 20 % also, ascorbic acid was better held (90% at 50°C to 35% at 500°C) in high pressure treated vacuum packaged samples [5].

Meat and Fish industry

The fundamental goal in industrial HPP is to annihilate the pathogenic and decay microrganisms and to broaden the time span of usability while keeping up the attributes and nature of meat and meat items practically flawless [13]. Analysts have examined the utilization of HPP in the meat business utilizing a few mixes of pressure, time and temperature. *Citrobacter freudii*, *Pseudomonas fluoresecens* and *Listeria innocua* were totally inactivated at pressure more than 280, 200 and 400 MPa, respectively at 200◦C. They additionally saw paler shading in samples of minced beef treated at pressures more than 150 MPa, and grayish shading in samples at pressures more than 350 MPa. All out restraint of microorganisms happened at 400-500 MPa. Nonetheless, *Pseudomonas spp*. was identified following 3-9 days at 30°C, which implies that they were not completely inactivated however anxious during HPP. Along these lines, HPP ought to be combined with some other treatment (e.g, moderate temperature of 500°C) to take out reasonable *Pseudomonas spp*. The impacts of HPP on shading and myoglobin substance of minced beef extract samples under vacuum, air or oxygen. They saw a pink shade of meat treated at 200-350 MPa (increment in gentility, shading esteems) which turned Gray earthy colored at 400-500 MPa (a reduction in L esteems). They proposed that meat staining during HPP is because of whitening impact of 200-300 MPa, brought about by globin denaturation, heam dislodging or discharge or oxidation of ferrous myoglobin to ferric myoglobin at 400 MPa.

Dairy and Egg Industry

Due to changes induced the functional properties of whey protein as well as in other milk components and native constituents, HPP also apply in the dairy and egg industries [14]. Functional properties of WPC were analyzed along with the connection between stability of WPC emulsions and degree of adsorption of the protein emulsifier. They saw that oil-in water emulsions (0.4 wt % protein, 20 vol % n-Tetradecane, pH 7) arranged with pressure treated WPC solutions gave a more extensive size appropriation than emulsions made with native untreated protein. An opposite relationship was obtained between emulsifying efficiency and applied pressure plus treatment time. The high pressure marginally improved the microbiological quality of milk without modifying lacto peroxidase activity. They accomplished that the coagulation properties of milk can improve by HPP and can also increase moisture retention of fresh cheese.

Juices and Drinks

Juice products where flavor and nutritional values are truly undermined by heat treatment, would now be able to be high pressure processed (pomegranate, apple, carrot, broccoli, beetroot, etc).

Food Packaging

The type of food packaging used also plays a significant role in HPP. Currently, several different types of packaging are being used for HPP, similar to plastic stomacher bags, sterile tubes, polyester tubes, polyethylene pouches, nylon cast polypropylene pouches and various other flexible pouch systems, the physical and mechanical properties of the material incredibly impacts the value of HPP on the food material. The packages must be able to prevent any decay in the product quality during HPP and brilliant logistics should be applied to allocate the pressure- treated products. Foods to be treated by HPP might be either bulk or individually (consumer) packaged previously or after (direct) handling. In this manner, each package ought to be tested for permissible headspace because headspace cannot be stayed away from in practical circumstances. Film barrier properties and structural individuality of polymer based packaged material were influenced when treated at 400 MPa for 30 min at 25°C temperature was noticed.

Ultrasound Processing

Ultrasound is defined as sound waves which have frequency that exceeds the hearing limits of the human ear (~20 kHz). It is one of the rising advancements that were developed to minimize processing, maximize quality and ensure the safety of food products. Ultrasound is applied to report beneficial outcomes in food processing for example improvement in mass exchange, food preservation, assistance of thermal treatments and manipulation of texture and food analysis [15]. Ultrasound has three frequency ranges i.e. power ultrasound (16–100 kHz), high frequency ultrasound (100 kHz–1 MHz) and diagnostic ultrasound (1–10 MHz).

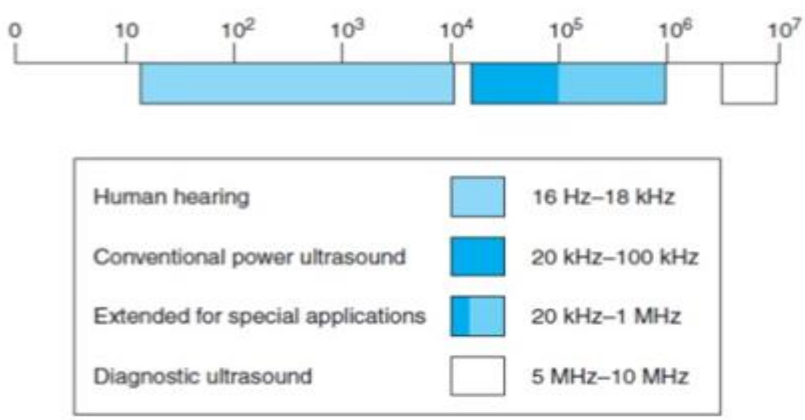

Figure 4 Frequency ranges of sound

Brief history of ultrasound

The advancement of ultrasound began in 1790 with the revelation of echo sounding utilized by bats. In nature, dolphins and bats utilize low intensity ultrasound waves to assault prey, while certain marine creatures utilize high intensity waves of ultrasound to set their casualties before catch [16]. The most discernible proof was given by Curie siblings through their examination on piezoelectric impact, which is the electric potential produced by a material in light of a temperature change [17]. 60 years prior, low-intensity ultrasound techniques were utilized to portray nourishments, yet it is as of late the capability of the strategy has been assessed. Since the primary genuine use of piezoelectricity for sonar in 1917, there has been considerable improvement in this industry [18]. Ultrasound was first utilized for clinical purposes in 1956 in Glasgow. Prior to World War II, uses of ultrasound were being produced for a scope of advances, including surface cleaning systems. During the 1960s, ultrasound innovation was entrenched and utilized in cleaning and plastic welding [19]. Regardless of the differing applications and incredible turn of events, ultrasound science is as yet thought to be an ongoing innovation in the food business. It in light of the fact that as of late just food businesses have begun utilizing this innovation for food safeguarding, microbial inactivation, food drying and protein inactivation. The progressing interest for low and high-recurrence uses of ultrasound will bring a lot progressively new open doors in future days.

Ultrasound Generation

The ultrasonic wave producing system contains generator, transducer and the application system.

Generator

Mechanical energy formed by the generator.

Transducer

At ultrasonic frequencies, transducer converts mechanical energy into the sound energy. Transducer has 3 types:

1. Fluid-driven
2. Magnetostrictive
3. Piezoelectric

Fluid-driven: The fluid-driven transducer makes vibration at ultrasonic frequencies by forcing liquid to thin metal blade which can be utilizing for mixing and homogenization systems.

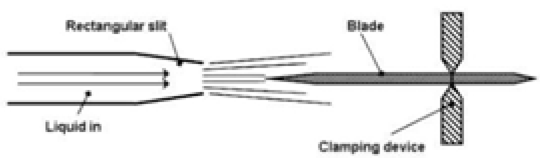

Figure 5 Fluid driven

Magnetostrictive Transducer: It is made from a kind of ferromagnetic material such as iron or nickel. The frequency of oscillator can be adjusted by changing the capacitance of conductor C. A magnetostriction generator produces ultrasonic waves of nearly low frequency upto 200 kHz.

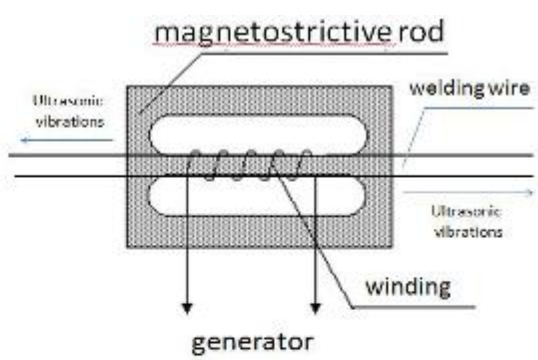

Figure 6 Magnetostrictive transducer

Piezoelectric Transducer: Some normally piezoelectric happening materials incorporate berlinite cane sweetener, quartz, Rochelle salt and bone. Man-made piezoelectric material incorporates barium titanate and lead zirconate titanate. It produces ultrasonic waves in excess of 300 kHz.

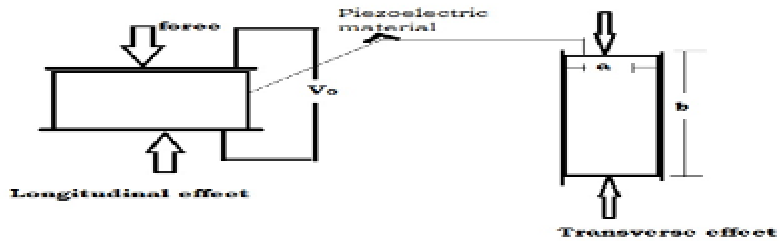

Figure 7 Piezoelectric transducer

Types of Sonication

Ultrasound can be utilized for food preservation in blend with different treatments to expand the productivity of the method. There have been numerous investigations consolidating ultrasound with pressure, temperature, or weight and temperature.

- **Ultrasonication (US):** It is the utilization of ultrasound at low temperature which may cause high energy prerequisite and requires long treatment time to inactivate stable enzymes and microorganisms.
- **Thermosonication (TS):** It is a combination technique of ultrasound and heat. The product is exposed to ultrasound and moderate heat at the same time. This technique makes a more noteworthy effect on inactivation of microorganisms than heat alone.
- **Manosonication (MS):** It is a method which is used to inactivate enzymes and microorganisms and where, ultrasound and pressure are applied together.
- **Manothermosonication (MTS):** It is a combined strategy of heat, ultrasound and pressure. MTS treatments inactivate some enzymes at lesser temperatures as well as in a shorter time than thermal treatments at the similar temperatures.

Principle of ultrasound

The basic principle where in ultrasound is depending is cavitation. Ultrasound is a type of energy created by sound waves having frequency that is in-discernible to human ears. When sound waves propagated through any product, there will be a production of high amount of energy due to compression and rarefaction of the medium particles. Thus, cavitation is the formation, growth and collapse of bubbles that generate a localized mechanical and concoction viability [20]. When ultrasound waves passes through a fluid medium, formation of gas bubbles inside a fluid due to cavitation occurs. It is the interaction among sound waves, liquid and dissolved gas. It brings about weight change around the broke down gas cores and lead to motions. Further, the dissolved gas and solvent vapour spread in and around the oscillating bubbles. Then the bubbles will get expanded in successive cycles to an unstable size and burst. Bursting of bubbles release very high pressure and heat around the collapsing bubbles which break the compounds in the liquid. It cause molecule scattering and cell disruption and provide localised sterilisation or pasteurization effect depending on the intensity of applied sound.

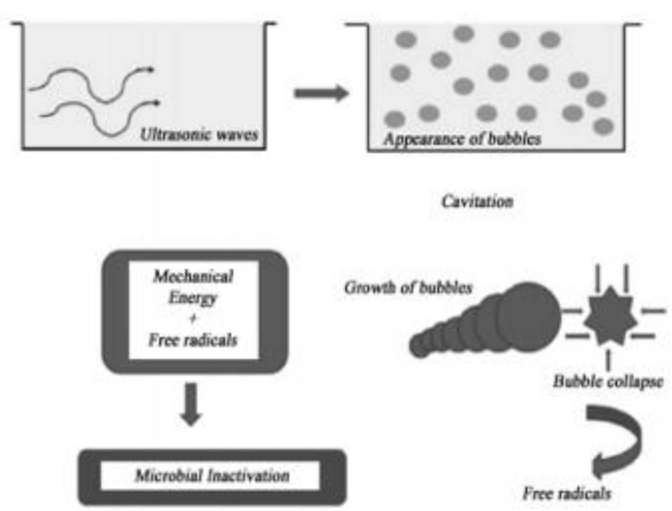

Figure 8 Ultrasound waves and cavitation phenomenon [21]

Advantages of ultrasound

Ultrasound processing has numerous advantages. Waves of ultrasounds are chemical-free, safe and ecological. The waves are shared with many thermal and non-thermal methods and used as helpful against inactivation of microbes. This method is used juice extraction which is more proficient in rising yield than other methods. The time of processing by 55% and temperature of processing by 16% is decrease by this method [22]. The products treated with ultrasound processing will get least amount of loss in flavour, colour and other nutritional compounds. Ultrasound has gained vast applications in the food industry such as preservation, processing, extraction, emulsification, centrifugation homogenization, etc.

Disadvantages of ultrasound

The free radicals created during cavitation might be cause harmful outcome on the consumer. Ultrasound may cause physico-chemical effect which may be dependable for off-flavour, discoloration and degradation of components. High initial investment and frequency of ultrasound waves can compel resistance to mass transfer [23].

Application of ultrasonic as processing techniques

Ultrasound is a non thermal processing technique that can be used in a broad range of applications. This technology can increase process efficiency through enhanced yields and reduced processing costs as well as modify biomaterial structure. The range of applications of ultrasonic processing in the food and other industries is expanding rapidly.

Use of high intensity ultrasound in food processing

The basics of ultrasound applications are mainly three different methods:

- Direct application with the product.
- Coupling to the device.
- Using ultrasonic bath submergence.

Applications of ultrasound in food processing

Drying

Conventional method of dehydrating food products is done by hot air. This method is an economical process but the main problem of this is interior moisture retaining. The main problem is in this method is high temperatures can damage the food, which may have an effect on the colour, taste and nutritional value of the food products [24]. By utilizing lower solution temperatures, at the contrary ultrasonic osmotic dehydration technology get higher water loss and solute gain rates [25]. In this way, oxidation or degradation is diminshed in the foodstuff by using this probability. The colour, flavor and nutritional value also remain unaffected by using this technology. The drying which is enhanced sonically can be carried out at lower temperatures due to which probability of oxidation or degradation reduces in the material. This technique of drying is useful in case of heat sensitive material [26]. For drying of pistachios (Akbari variety), the combination of high power ultrasound and convective air was performed during a laboratory scale ultrasonic dryer [27].

Filtration

The separation of solids from liquids, to produce solid-free liquid or to isolate solid from its mother liquor, is an important step in the food industry. Acoustic filtration also called as ultrasonically assisted filtration is successfully used to increase the vacuum filtration of difficult mixtures to separate like coal slurry. But the main problem in filtration is deposition of solid materials on the surface of filtration membrane. Ultrasound is helpful in the filtration processes as it can enhance the flux by breaking the concentration polarization and cake layer on the surface of membrane without creating an effect on the permeability of membrane. This method is mainly useful to extract the fruit juice and drinks from the pulp.

Depolymerization

This is one of the oldest applications of ultrasound which is involved in the degradation of polymers. The mainly two possible mechanisms involves in depolymerization:

a) By collapsed cavitation bubble mechanical degradation of the polymer.
b) Chemical degradation

The reaction between the high energy molecules and the polymer involves in chemical method. The high energy molecules like hydroxyl radicals are produced from cavitation phenomenon [28]. Ultrasound has important potential for the conversion of raw materials like carbohydrates which are polymeric in nature to useful less weight molecules or its simpler components. In food industry, the area in which the use of ultrasound is active is to depolymerise starch [29]. So due to its progress in sonochemical engineering it may play a big role in the carbohydrate industry.

Defoaming

Foam is a colloidal system and dispersion of gas in liquid. They are thermodynamically unstable and have density approaching that of the gas. The distance between individual bubbles are very small. Foam has applications in a variety of industrial processes eg. cosmetics and food production etc. But the intensive foaming or persistent foams are undesirable in various processes. This is so because it may lead to problems like loss of products, decrease in productivity etc. High intensity ultrasonic waves have a distinctive method of foam breaking because they does not need high air flow, prevent chemical contamination and also it is operated under sterile conditions or in a contained environment.

Demoulding and extrusion

When the industrial cooking of foods is done, it leads to adhesion of the products to the cooking vessel or mould. If this product is removed easily it makes cleaning easy and also container is reusable in less time. But the cooked product is difficult to remove from the mould because of product adhesion to the mould by cooking. To counteract this difficulty the moulds are fabricated with a surface coating of white grease, thin layer of silicone or PTFE (Polytetrafluoroethylene). So to replace them over a span of time is expensive and also not absolutely successful. So in these days this problem is solved by using mechanical methods such as knocking vibration for the removal of adhered products. The alternative solution to the earlier conventional methods is achieved by coupling the mould or vessel to a source of ultrasound to release the food products. So, by using this technique the cleaning of residual material from the mould become easy and is done automatically. Extrusion is also a similar property of ultrasound which is its ability to release material from a surface, by virtue of reducing drag. In this ultrasound is provided by energy input by ultrasonic excitation of the metal tubes, so the food is extruded. The ultrasonic source is attached to tube at right angle for providing radial vibration. So this process improves the fluidity of sticky or highly viscous materials through tube by reducing the drag resistance. It also has property of modification of structures of food products [30].

Degassing/deaeration

A liquid contains gases within the mixed type of a liquid may contain oxygen, carbon dioxide and nitrogen gas. Degassing in an ultrasonic field is done when acoustic waves cause quick vibration of gas bubbles and nearby bubbles move inside the liquid and coalesce. Degassing in ultrasonic field turns out to be highly visible phenomenon when an ultrasonic cleaning bath is utilized with tap water used regularly inside. It happens when the acoustic waves bring the fast vibration of gas bubbles and these bubbles grow to sizes which get up through the liquid, against gravity, until they reach the surface. During the processing of carbonated drinks, its main role is to get rid of or displace the air from the liquid surface. So by doing this a damage caused by bacteria and oxygen is avoided. Mainly this method is employed to degas carbonated beverages like beer before bottling. Deaeration process by ultrasound involves coupling a transducer to the bottles outside results in degassing. Ultrasonically assisted degassing is helpful in case of aqueous systems but is difficult in case of viscous liquids to get rid of gas as an example like melted chocolate.

Defrosting/thawing

Freezing is a technique which is widely used for increasing the shelf life of various food products. But if thawing conditions are optimized it can be successful. Acoustic thawing is a promising technology in the food industry if optimum frequencies and acoustic power are chosen. To thaw frozen food products is a slow process and is also very inconvenient and costly process. Thawing is a slow process so also involves damaging food stuffs by the contamination of microorganisms through chemical and physical changes with time. So it is imperative to fast thawing at low temperature for the great food quality and to get away from unnecessary drying out of food. The work on the relaxation technique established that when a frequency in the relaxation frequency range of ice crystals in the food was applied, the more acoustic energy could be consumed by frozen foods [31]. So it was seen that the thawing process in this relaxation frequency was faster than the process using only conductive heating. So it is accepted that acoustic thawing is great machinery in the food industries if the acoustic power and frequencies are optimal. So acoustic thawing has advantages like cutting the time or shortening the thawing time so reducing drip loss the improvement in the product quality.

Freezing and crystallization

Ultrasound plays a role in the crystal formation too. From the ranges of ultrasound i.e. 20 kHz to 100 kHz is very supportive in crystallization process. These two processes are linked due to both of these involve initial nucleation followed by crystallization. When ultrasound is uncovered to the medium it enhances both the nucleation rate and rate of crystal growth by the production of various number of nucleation sites in the medium. The basic to this is because the cavitation bubbles behave as nuclei for crystal growth. Freezing or cooling is a technique of food preservation which is used from a long time ago by preserving food in natural ice or over winter storage. During freezing the water content present in the food material get converted into ice crystals. While if there should be occurrence of conventional freezing, the issues like non-uniform crystal advancement and destruction or texture as a result of the continuous formation of little ice crystals. So because of issues like non-uniform crystal advancement, defeat in sensory food quality in case of conventional methods new creative advancements such as air blast, immersion freezing, cryogenic freezing, fluidized-bed freezing, high pressure freezing and their combinations are presently the most generally and normally used technique in the food industry. At the point, when ultrasound is applied, even conventional cooling gives substainally faster and seeding, because of which dwell time is diminished. Sonication is thought to upgrade both the nucleation rate and rate of crystal development in a saturated or supercooled medium by creating countless nucleation sites in the medium all through the ultrasonic exposure. This may be due to cavitation bubbles acting as nuclei for crystal growth and/or by the disruption of seeds or crystals already present within the medium thus increasing the number of nucleation sites.

Cooking

In conventional cooking method either by frying or boiling the exterior of the food may be overcooked as compared to the interior. This may reduce the quality of the product. Ultrasound has the ability to provide improved heat transfer characteristics so there is no problem such like the conventional method. So this technology has been utilized in the cooking. So, cooking by ultrasound leads to greater cooking speed. It also provides an energy efficient and rapid method which also improves the textural attributes of food. The post-cooking moisture content is also preserved by using this. The use of high-intensity ultrasound thus has the potential to increase the water-binding properties of meat [16]. So ultrasound is useful in cooking of moist meats and hence is useful in the food industries for food processing. A patent describes a cooking vessel within which ultrasound is applied to a hot oil to produce better and more even overall frying and it’s claimed to cut back energy consumption.

Meat tenderization

The traditional method of meat tenderization is mechanical pounding. But this method makes poor quality of meat. Power ultrasound is one of the methods which are very useful in this technique. Ultrasound act by using two methods:

- By the breakage of integrity of muscular cells or
- By increasing the rate of enzymatic reactions by using biochemical effect.

Ultrasonic tenderization can be achieved with poultry meat, veal and beef. So, producing processed meats, ultrasound is also very useful. Meat products are present in the recombined form such as beef rolls. These meat pieces are detained mutually by a protein gel which is produced by the myofibrillar proteins free during processing. Tumbling the meat pieces by sonication or adding salt help in tenderization of meat. So the samples which are treated with these are superior in quality. So, ultrasound helps in improving physical properties of meat products which includes tenderness, water-binding capacity and cohesiveness.

Sterilization/pasteurization

Conventional thermal pasteurization and sterilization are the widely used techniques till date for inactivating microorganisms and enzymes in the food products. But these methods take great time for the processing and may lead to loss of nutrients, development of undesirable flavor and deteriorating the quality of food products. By the use of ultrasound such processes can be improved on the basis of the effects of cavitation. At a great high acoustic power inputs, it break cells but at lower intensity a cell can be inactivated [32]. The ultrasound is effective in the dairy industry for the processes like pasteurization. It is found effective for killing the micro-organisms like *E.coli*, *Pseudomonas* etc. and it does not have detrimental effect on the total protein or casein content of milk [33].

The microbes are killed mainly by thinning of cell membranes and by the production of free radicals. Ultrasound is also effective to inactivate the enzymes which are responsible for deteriorating the fruit and vegetable juice. These enzymes are mainly pectinmethylesterase, polyphenoloxidases and peroxides etc. The utilization of ultrasound in pasteurization keeps on being of extraordinary enthusiasm on dairy industry. It has proved effective for the annihilation of *E. coli*, *Pseudomonas fluorescens* and *Listeria monocytogenes* with no adverse impact on the total protein or casein content of pasteurized milk. The method of microbial killing is mainly because of thinning of cell membranes, localized heating and creation of free radicals. Examination on ultrasound effectiveness has likewise demonstrated the inactivation of enzymes for example pectinmethylesterase, polyphenoloxidases and peroxidases liable for decline of fruit and vegetable juice and various enzymes pertinent to milk quality.

Emulsification/homogenization

It is a technique of delivering the hydrophobic bioactive compounds into different food products. Acoustic emulsifications have different improvement over the conventional methods. The emulsion produced from this technique has sub-micron distribution. These emulsions are more stable as compared to conventional ones. In this case there is no need of adding surfactants. This method utilizes less energy than the older conventional methods. Ultrasonic emulsification is developing area for in-time treatment. It is used in food industry for various products like fruit juices, mayonnaise and tomato ketchup etc. It is also comparable like microfluidity for generating sub-micron dispersions [34].

Ultrasound in food preservation

Ultrasound processing is one of these new methods. While its application in food processing is moderately later, it has been demonstrated that high-intensity ultrasonic waves can crack cells and denature enzymes, and that even low-intensity ultrasound is able to change the metabolism of cells. In combination with heat, ultrasonication can quicken the rate of sterilization of foods, hence decreasing both the span and force of thermal treatment and the resultant harm. The advantages of ultrasound over heat sterilization contain: the limiting of flavour loss, more noteworthy homogeneity; and significant energy savings.

Applications of ultrasound in food preservation can be isolated into two main categories relying on its area of utilization:

Directly related to food

Microorganism inactivation

It has been indicated that microorganism's don't all respond similarly to ultrasound treatment.
The factors which affect effectiveness of microbial inactivation are given below:

- Amplitude of ultrasound waves.
- Disclosure or contact time.
- Amount of food processed.
- Composition of food.
- Management temperature

Spore inactivation

Microbial spores are resistant to intense conditions like high temperatures and osmotic pressures, high and low pH, and mechanical shocks. That bacterial spore might be strictly restrict the life span of thermally processed foods and survives heat treatment due to spoilage and poisoning.

Enzyme inactivation

An enzyme has to remain its native conformation for prevent the denaturation. Hydrophobic interactions, hydrogen bonding, vander waals interactions, ion paring, electrostatic forces and steric constraints become stable the three-dimensional molecular structure of globular proteins.

Indirectly related to food

One of the major since quite a while ago settled industrial applications of power ultrasound are in surface cleaning and it has end up being a very productive innovations. Ultrasound is particularly significant in surface decontamination where the inrush of fluid that goes with cavitational breakdown near a surface is non-symmetric.

Food industries using ultrasonic food processing

- Cheese
- Fish
- Prepared meats
- Vegetable
- Bakery and snack foods
- Candy and confectionery
- Health bars

Conclusion

Foods which meet the principles are not only in higher demands, but consumer has to pay higher rate for good quality of products. So, High pressure processing and ultrasonic processing are the novel methods which provide an interesting alternating processing methods to fulfil these requirements. The HPP and ultrasonic processing are the novel methods and each method has its own advantages and disadvantages. High pressure processing has the potential to develop into a preservation technique that is applied on a large scale in the food industry, in particular for products where retention of flavours and nutrients is desired and also increase the shelf life of the product. While, by utilizing ultrasound, full reproducible food procedures would now be able to be finished in short order or minutes with high reproducibility, diminishing the handling cost, streamlining control and stir up, giving higher immaculateness of final product, taking out post-treatment of waste water and expending just a small amount of the time and energy typically required for ordinary procedures. So from the applications and favorable circumstances of ultrasound and high pressure processing it is clear that they are the new advances which have colossal future in the food business.

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