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Review on the High Pressure Technology (HPT) for Food Preservation

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Abstract

The high pressure technology (HPT) represents interesting and promising dimensions for food processing not only because of it inactivates micro-organism but also providing opportunities for development of value added food products. This method helps to food product by retaining their natural color, flavor and texture without loss of vitamins and nutrients, total inhibition of microorganism at 400-800 MPa, keeping the granules structure of pasteurized swelled starch & improving enzyme digestibility & gelatinized structure (without retrogation) and total inactivation of PPO (poly phenol oxidase) activity at 20^{0}C by using citric acid solution. The aim of this review is the different aspects and potential application of HPT and critically examines HPT related studies. Different types of food product (fruits and vegetables product, Dairy product, Meat product, Starch product etc.) are preserved and maintained the nutritional qualities for longer time.

Keywords: High Pressure Technology; Mechanism; Preservation; Nutrients

Introduction

High pressure Technology (HPT) is gaining popularity with food processors not only because of its food preservation capacity but also because of its potential to achieve interesting function effects [1]. High-pressure processed foods currently available in Japan include a range of jams that taste like fresh fruit, sauces, salad dressings, ready-to-eat desserts and grapefruit and mandarin juice with 'just squeezed' fresh flower.

In 1895, the use of high-pressure treatment is to kill bacteria. A few years later, Kimura K et al. [2] reported that pressures of 450 Pa or more could improve the keeping quality of milk .High-pressure Technology (HPT), also described as high hydrostatic pressure (HHP) or ultra high pressure (UHP) processing, subjects liquid and solid foods, with or without packaging, to pressures between 100 and 800 MPa process temperature during pressure treatment can be specified from below 0^{0}C to above 100^{0}C. Commercial exposure times at pressure can range from millisecond pulse (obtained by oscillating pump) to a treatment time of our 1200 seconds (20 minutes).

Pressure used in the HPT of foods appear to have little effect on covalent bonds [3,4] thus food subjected to HPT at or near room temperature will not undergo significant chemical transformations due to the increased demand by consumers for improved nutritional and sensory characterititics of food without loss of fresh taste. In recent years [5] commercial pressurized products in Europe are

- Orange juice by Ultifruit, Pernod Richard Company, France.
- Acidified avocado puree (guacamole) by Avomek Company in USA (Texas/Mexico).
- Sliced ham (both cured-cooked and raw cooked) by Espona Company, Spain.

The European "Novel Foods" Directive has introduced regulatory problems and slowed the introduction of new pressurized products. The capability and limitations of HPT have recently been reviewed and studied extensively by food scientists and food engineers.

Aim

The aim of this article is to provide current review of different aspects and potential applications of HPT and to critically examine HPT related studies.

Principle/ Mechanism

Any phenomenon in equilibrium (chemical reaction, Phase transition, change in molecular configuration) accompanied by a decrease in volume, can be enhanced by pressure [6]. Thus HPT affects any phenomenon in food systems where volume change is involved and favors phenomena, which results in a volume decrease. The HPT affects non-covalent bonds (Hydrogen, Comic, Hydrophobic bonds) substantially as some non-covalent bonds are very sensitive to pressure, which means that low molecular weight food components (responsible for nutritional and sensory characteristics) are not affected, whereas high molecular weight components (whose tertiary structure is important for functionality determination) are sensitive. Some specific covalent bonds are also modified by pressure.

High pressure technology acts instantaneously and uniformly throughout a mass of food independent of size, shape and food composition. Compression will uniformly increase the temperature of foods approximately 3^{0}C per 100 MPa. The temperature of homogenous food will increase uniformly due to compression. An increase in food temperature above room temperature and to a lesser extent a decrease below room temperature increases the inactivation rate of microorganisms during HPT treatment. Temperatures in the range of 45^{0}C to 50^{0}C appear to increase the rate of inactivation of food

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pathogens and spoilage microbes. Temperatures ranging from 90^{0}C -110^{0}C in conjunction with pressure 500-700 MPa have been used to inactivate spore forming bacteria such as *Clostridium botulinum.*

Techniques and equipment

High-pressure technology of foods in similar to conventional heat processing, using two main types of industrial equipment. One is a batch system for processing packed foods [7]. A typical high pressure system consists of a pressure vessel and pressure generating device. Food packages are loaded into the vessel and to top closed. The pressure medium, usually water containing a small amount of soluble oil, is pumped into the vessel from the bottom. Once the desired pressure can be maintained without further need for energy input. The process is isostatic, so pressure is transmitted rapidly and uniformly throughout both the pressure medium and the food with little or no heating. It is equal from all sides so there is no 'squashing' effect and product is not affected.

Pressure in the range of 300, 700 MPa are used for foods (500 MPa is equivalent to 20 family cars bearing down on an area the size of postage stamp). These pressures, maintained for approximately 15 minutes, can cause more than a 10,000 fold reduction in numbers of food poisoning bacteria such as *Salmonella, Compylobacter* and *Listeria* in milk and poultry meat.

Application of HPT on Food Preservation

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

Fruits and vegetables

HPT does not depreciate the nutritional and sensory characteristics of food, and yet it maintains the shelf life (Table 1 and 2) [8]. As compared the effect of HPT with water blanching on the microbial safety, quality (softness), and functionality (poly phenol oxidase (PPO) activity, leaching of potassium, and loss of ascorbic acid) of potato cubs. Total inactivation of microbes and PPO activity occurred at 20^{0}C (using dilute citric acid solution at 0.5 at 1.0 % as immersion medium). Water-balanced and high pressure-treated potato cubes had similar softness but potassium leaching was reduced by 20 % in addition, ascorbic acid was better retained (90% at 5^{0}C to 35% at 50^{0}C) in high pressure treated vacuum packaged samples.

Meat and fish industry

Researchers have studied the application of HPT in the meat industry using several combinations of pressure, time and temperature (Table 3).

The high pressure inactivates *Citrobacter freudii, Pseudomonas fluoresecens, and Listeria innocua* were completely inactivated at pressures more than 280,200 and 400 MPa, respectively at 20^{0}C. They also noticed a paler color in samples of minced beef treated at pressures more than 150 MPa, and grayish color in samples at pressures more than 350 MPa. Total inhibition of microorganisms occurred at 400-500 MPa. However, *pseudomonas spp.* was detected after 3-9 days at 3^{0}C, which means that they were not fully inactivated but stressed during HPT. Therefore, HPT should be coupled with some other treatment (e.g, moderate temperature of 50^{0}C) to eliminate viable *pseudomonas spp.*

The effects of HPT on color and myoglobin content of minced beef samples packaged under vacuum, air or oxygen. They noticed a pink color of meat treated at 200-350 MPa (increase in lightness, color values) which turned Grey brown at 400-500 MPa (a decrease in L values). They suggested that meat discoloration during HPT is due to whitening effect of 200-300 MPa, caused by globin denaturation, heam

Product	Pressure(MPa)	Holding time (min)	Temperature (°C)	Reference
Potato cubes	400	15	5-50	8
Chopped tomatoes	400,600 or 800	3.5-7.0		25
Apricot necter,distillated water	600-900	1-20	20	21
Jams				2
White and red grape must	304-811	1-5	25	22
Angelica keiskei juice	0.01	7	25	5
Fresh apples, pears, bananas		6,15	25	20
Citrus juice	300-375	1-1.5	0-5	24
Orange juice	350	1	30	13
Vegetables juices ,carrot, cauli flower, spinach, tomatoes, strawberries	300,370	10	35	10
Guava puree	400,600	15	25	18
Extrac virgin olive and seed oils(grape seed, sunflower, soyaben, peanut	700	10	25	26

Table 1: Application of HPT in fruits and vegetables.

Product	Process and Quality attributes
Avocado puree	Prevent discoloration , Inhibit of undesirable browning reactions in presence of low pH
Banana puree	Prevent discoloration, reduction in polyphenol oxidase activity when combined with blanching
Black beans	Cooking ,increasing water absorption, reduced cooking time
Jam	Commertial production ,improved rentension of colour and flavor of fresh fruit
Orange juice, Pink grape juice,	Preservation ,retension of colour and cloud stability during storage
Potato	Freezing ,reduction in freezing time in potato cylinder
Tomato juice	Juice production ,modification of physical and sensory properties

Table 2: Application of HPT in retention of sensory and nutritional characteristics of fruits and vegetables.

displacement or release or oxidation of ferrous myoglobin to ferric myoglobin at 400 MPa.

Dairy and egg industry

High pressure technology may also have application in the dairy and egg industries due to changes induced the functional properties of whey protein as well as in other milk components and native constituents Table 4.

The pressure was applied to the protein before homogenization or to the emulsion prepared with native WPC. Functional properties of WPC were examined along with the relationship between stability of WPC emulsions and degree of adsorption of the protein emulsifier. They found that oil-in water emulsions (0.4 wt % protein, 20 vol % n-Tetradecane, pH 7) prepared with pressure treated WPC solutions gave a broader droplet size distribution than emulsions made with native untreated protein. An inverse relationship was obtained between emulsifying efficiency and applied pressure plus treatment time. Also, HPT had little effect on the stability of WPC emulsions made with native protein.

The high pressure slightly improved the microbiological quality of milk without modifying lacto peroxidase activity (a native milk enzyme). $-lactalbumin and bovine serum albumin were pressure resistant (400 MPa for 60 min.). The increase in cheese yield was found (at 300 and 400 MPa) in conjunction with additional $-lactoglobulin and moisture retention. They concluded that HPT can improve the coagulation properties of milk and can increase moisture retention of fresh cheese.

Commercial high pressure food processing

The potential for high pressure technology of food has been known since 1899 the application high pressure to food products was not possible until the early when suitable equipment become available. In the United States, guacamole was first commercially available processed product. Research and development of other products including meals is continuing in Europe , fruit juice are available in France and a delicate style ham is available in Spain .The technique is not yet being used commercially in UK but trails and tasting are being carried out.

Microbial inactivation

Application of HPT as a method for microbial inactivation has stimulated considerable interest in the food industry. The effectiveness of HPT on microbial inactivation has to be studied in great detail to ensure the safety of food treated in this manner. Currently, research in this area has concentrated mainly on the effect of HPT on spores and vegetative cells of different pathogenic bacteria species. Detectable effects of HPT on microbial cells include an increase in the permeability of cell membranes and possible inhibition of enzymes vital for survival and reproduction of the bacterial cells. The physiochemical environment can adversely change the resistance of a bacterial species to pressure. In most case, the effect of HPT on Gram-positive bacteria is less pronounced than Gram-negative species. Factors such as the water activity and pH also influence the extent to which foods need to be treated to eliminate pathogenic microorganisms.

Food packaging

The type of food packaging used also plays an important role in HPT. Currently, several different types of packaging are in use for HPT, like 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 greatly influences the effectiveness of HPT on the food material.

The packages must have the ability to prevent any deterioration in

Meat type	Pressure(MPa)	Holding time (min.)	Temperature (ºC)	Reference
Minced beef muscle	230	20	4,25,35,50	14
Minced beef muscle	50-400	20	20	14
Minced beef muscle	200-450	20		8
Minced beef muscle	200-500	20	25	15
Pork slurries	300	10		27
Surimi pate	100-600	10	05	22
Minced macked meat	203	60	2-8	-
Creamed salamon	700	03	2 or 25	-
Freshly ground raw chicken meat	408-818	10		23
Minced pork	800	20	20	12
Fresh beef	800-1000	20	25	12
Lamb meat	200	30	30	-
hams	300	5,15,25	20	-

Table 3: Application of high pressure technology in the Meat industry.

Milk type	Pressure (MPa)	Holding time (min)	Temperature (ºC)	Reference
Raw milk	100-400	10-60	20	1
Whey protein concebtrate	200,400 or 800	10,20 or 40	20	16
Skim milk	310	0.05	25	9
Goat milk	500	10	25 or 50	15
Skim milk	250,450 or800	10,20 or 40	25	17
Fresh goat milk cheese	400 or 500	5,10 or 15	2,10 or 25	11
Whipped and coffee cream	100-550	10	10-24	-
Milk	50-350	12	20	14

Table 4: Dairy and egg industry.

the product quality during HPT and excellent logistics should be applied to distribute the pressure- treated products. Foods to be treated by HPT may be either bulk or individually (consumer) packaged before or after (direct) processing. He also stated that the presence of headspace must be kept as small as possible because air and other gases are compressed to zero volume under high pressure, leaving deformation strains on the packages. Therefore, each package should be tested for permissible headspace because headspace cannot be avoided in practical situations. Film barrier properties and structural characteristics of polymer based packaged material were affected when treated at 400 MPa for 30 min at 25°C temperature was reported.

Advantages of High Pressure Technology (HPT)

- HPT is suitable for products with high water content and can be modified for both batch processing and semi-continuous processing.
- HPT especially useful because it can be used to process raw product without significantly altering their flavor, texture or appearance.
- HPT develops product packaging to withstand a changed in volume up to 15 % followed by a return to its original shape without losing seal integrity or barrier properties.
- HPT has been used with hundreds of products to activated food Bourn packages, inactivates spoilage causing organisms, inactivated enzymes, germinate or inactivate some bacterial spores, extend shelf life ,reduce the potential for food borne illness ,promote ripening of cheese and minimize oxidative browning.
- HPT does not destroy the food because it is applied evenly from all side.
- HPT is equally effective on molds, bacteria, virus, and
- HPT reduce the processing time physical and chemical change, retention of freshness, flavor, texture, appearance and color elimination of vitamin C loss, reduces ice crystal damage and reduces functionally alteration comparative traditional thermal processing.
- HPT curtails many of the diseases with compassion of raw products shown that many micro-organisms are destroyed by customary HPT operating pressure.

Limitation of High Pressure Technology

- HPT is not practiced because the capital cost for a commercial scale.
- HPT shown substantial economic losses because there is implementation of comprehensive quality assurance programmed to eliminate or reduce micro-organism in processing.
- HPT system consist of high pressure vessel, a means to close the vessel off ,a system for temperature and pressure control and a material handling system so, machinery required is complex and requires extremely high precision in its construction, use and maintenance.
- HPT unit immediately becomes rate limiting steps in most processing operation.

Summary

High pressure technology holds promise since food materials treated by this method must retain their natural flavor, color and texture without loss in vitamin or nutrient content. Furthermore, predictable changes in functional characteristics of proteins and complex carbohydrates (where little work has been done), mean that there are some exciting avenues of work in HPT treatment of foods that remains to be explored. Although a lot of research has been conducted in the area of high pressure technology a lot remains to be done in terms of understanding the critical limits of the process and the extent to which this might ensure appropriate treatment of food material. Research has been done in various researches (FDA, 2000).

The critical process factors in HPT include pressure, time at pressure, time to achieve treatment pressure, decompression time, treatment temperature (including adiabatic heating), product initial temperature, vessel temperature distribution at pressure, product pH, product composition, product water activity, packaging material integrity and concurrent processing aids. Other processing factors present in the process line before or after the pressure treatments were not included.

Although HPT shows promise in its ultimate usefulness for food processing, limitations with respect to difficulty in data comparison and complexity associated with understanding interactive components of the process currently limit full acceptance of the practice.

References

1. Lopez FR, Carrascosa AV, Olano A (1996) The effect of high pressure whey protein denaturation and cheese making properties of raw milk. J Dairy Sci 79: 929-936.
2. Kunio K, Masao I, Yasuhiro Y, Kunihito O, Takayuki F, et al. (1994) Comparison of keeping quality between pressure processed jam and heat processed changes in flavor components, hue and nutrients during storage. Bio Sci Biotech Biochem 58: 1386-1391.
3. Tauscher BK (1998) Effects of high and chemical reactions effects on nutrients pressure treatment to nutritive substances and natural pigments & fresh novel foods by high pressure. VTT symposium 186.Technical research center for Finland Helsinki, Finland.
4. Tauscher BK (1999) High pressure and chemical reactions effects on nutrients and pigments. Emerging food Sci Tech Tempere Finland 58: 22-24.
5. Cheftel JC (1995) Review: High pressure microbial inactivation and food preservation. Food Sci Technol Int 1: 75-90.
6. Leadly CE, Williams A (1997) High pressure technology of food and drinks an over-view of recent developments and future potential in: New Technologies Bull.No.14, Mar CCFRA, Chipping Campden, Glos, Uk.
7. Bridgman PW (1914) The coagulation of albumen by pressure. J Biol Chem 19: 511-512.
8. Erkmen O, Karatas S (1997) Effects of high hydrostatics pressure on *Staphylococcus aureus* in milk. J Food Eng 33: 257-262.
9. Adapa S, Schmidt KA, Toledo R (1997) Functional properties of skim milk processed with continuous high pressure throttling. J Dairy Sci 80: 1941-1948.
10. Buchheim W, Frede E (1996) Use of high pressure treatment to influence the crystallization of emulsified fats. Lebensm U Milchwirts 117: 228-237.
11. Butz P, Edenharder R, Fister H, Tauscher B (1997) The influence of high pressure technology on anti mutagenic activities of fruits and vegetables juices. Food Res Int 30: 287-291.
12. Carlez A, Chefel JC, Veciana NT (1995) Changes in colour and myoglobin of minced beef due to high pressure processing. LWT Food Sci Technol 28: 528-538.
13. Lee DU, Park JY, Kang JI, Yeo IH (1996) Effect on high hydrostatic pressure on the shelf life and sensory characteristics of angelica keiskei juice. Korean J Food Sci Technol 28: 105-108.
14. Donshi G, Ferrari G, Matteo MD (1996) High pressure stabilization of orange

juice evaluation of the effect of process conditions .Ital J Food Sci 8: 99-106.

15. Eshtiaghi MN, Knorr D (1993) Potato cubes response to water blanching and high hydrostatics pressure. J Food Sci 58: 1371-1374.

16. Felipe X, Capellas M, Lawm AJR (1997) Comparison of the effect of high pressure treatment and heat pasteurization on the whey proteins in goat's milk. J Agri Food Chem 45: 627-631.

17. Gaucheron F, Famelart MH, Mariette F, Raulot K, Michel F, et al. (1997) Combined effects of temperature and high pressure treatment on physiological characteristics of skim milk. Food Chem 59: 439-447.

18. Yen G, Lin H (1996) Comparison of high pressure treatment and thermal pasteurization effect on the quality and shelf life of guava puree. Int J Food Sci technol 31: 205-213.

19. Hite BH (1999) The effect of pressure in the preservation of milk bulletin of the west virginia University Agricultural Experiment Station 58: 15-35.

20. Kloczko I, Radomski M (1996) Preservation of fruits & vegetables and juices by high hydrostatics pressure. Przemysl Spozywczy 50: 25-26.

21. Maggi A, Gola S, Spotti E, Rovere P, Mutti P (1994) High pressure treatment of ascospores of heat resistant moulds and patulin in apricot nector and water. Ind Conserve 69: 26-29.

22. Moio L, Pietra LLa, Cacace D, Palmieri L, Martino Ede, et al. (1995) Application of high pressure treatment for microbiological stabilization of must. Vernevin 22: 3-6.

23. O'brien JK, Marshall RT (1996) Microbiological quality of raw ground chicken processed at high isostatic pressure. J food Prt 59: 146-150.

24. Pehessson PE (1996) Application of high pressure pasteurization to citrus processing in: Institute of Food technologies. Ann Meet Book of Abstracts: 108.

25. Sandei L, Colombi A, Ghiretti G, Carpi G, Dall'aglio G, et al. (1997) Effects of high pressure treatments on chopped tomatoes .Ind Conserve 72: 3-12.

26. Severini C, Romani S, Dall'aglio G, Rover P, Conte L, et al. (1997) High pressure effects on lipid oxidation of extra virgin olive oils and seed oils. Ital J food Sci 9: 183-191.

27. Shigehisa T, Ohmori T, Saito A, Taji S, Hayashi R (1991) Effects of high hydrostatics pressure on characteristics of pork slurries and inactivation of microorganisms associated with meat products. Int J food Microbiol 12: 207-215.

28. Marta C, Montserrat MM, Esther S, Reyes P, Buenaventura G (1996) Population's aerobic mesophils and inoculated *E.Coli* during storage of fresh goat's milk cheese treated with pressure .J Food Prot 59: 582-587.

29. Carlez A, Chefel JC, Rose JP, Richard N, Saldana JL, et al. (1992) Effect of high pressure and bactiostatic agents on the destruction of *citrobactor freundii* in minced beef muscle in Balny, Hayashir.

30. Carlez A, Chefel JC, Rosec JP, Richard N (1993) High pressure inactivation of *Citrobacter freundii* ,*Pseudomonus fluroescens* and *Listeria innocua* in inoculated minced beef muscle. LWT-Food Sci Technol 26: 357-363.

31. Carlez A, Chefel JC, Rosec JP, Richard N (1994) Bacterial grown during chilled storage of pressure treated minced meat. LWT-Food Sci Technol 27: 48-54.

32. Cheah PB, Ledward DA (1996) High pressure effect on lipid oxidation in minced pork. Meat sci 43: 123-134.