



Review

Current status and future trends of high-pressure processing in food industry

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ABSTRACT

The increased consumers' interest in high quality foods with fresh-like sensory and additive free attributes led to the development of non-thermal food processing technologies as alternative to conventionally heat treatments. This review describes the current application status and market trends of high-pressure processing (HPP) technology in food industry. As the most successfully commercialized non-thermal processing technology, HPP eliminates food pathogens at room temperature and extends the shelf life of foods circulated through the cold chain. These processes maintain the organoleptic properties and nutritional value of the foods, which is not possible using traditional thermal pasteurization. The U.S. Food and Drug Administration has officially approved HPP as a non-thermal pasteurization technology that can replace traditional pasteurization in the food industry. Clearly defined regulations and specifications will facilitate the development of the application market to improve product quality and consumer trust. The widespread application of HPP technology has boosted the development and market demand for HPP equipment. HPP has been widely used in the production of packaged vegetables, fruits, meat, seafood, and dairy products. By the end of 2015, more than 300 units of HPP equipment were operating globally. Despite the high price and high barriers to investment, the specialized original equipment manufacturer service sector has been gradually increasing, and the annual output value of global HPP market has approached \$10 billion. HPP technology also can be combined with existing food trends, as organic food, health food or clean label to boost the development in the food market.

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1. Introduction

Increasingly health-conscious consumers are demanding better food quality, such as improved food safety, nutritional value, freshness, and flavors. Clean label foods, which claim to be natural and fresh as well as free from chemical additives, have gradually gained attention among consumers (Zemser, 2015). Processors in the food industry must use processing technologies capable of reducing additives while maintaining natural flavors and food quality, which has increased the development of emerging non-thermal processing technologies. Traditional thermal pasteurization technology negatively affects sensory characteristics, flavors, and nutritional contents of food. Non-thermal processing technology has attracted widespread attention from food industry practitioners. Each year, numerous symposiums regarding non-thermal processing technologies are conducted worldwide to discuss high pressure, pulsed electric field, pulsed light, electron beam, plasma, and modified atmosphere packaging; however, high pressure processing (HPP) is the most successfully commercialized non-thermal processing technology (Farkas, 2016). Application of HPP technology as follows: food is hermetically sealed in a flexible container under an high pressure of 100–600 MPa applied at room temperature, using a liquid (typically water) as the pressure transfer medium, subjecting the interior and surface of the food to even pressure to achieve pasteurization (Balasubramaniam, Martínez-Monteagudo, & Gupta, 2015). The pasteurization effect of HPP is not affected by the packaging form and volume of the food, and thus foods of different volumes can be processed in the same batch. In addition, this technology ensures the microbial safety of food without the addition of preservatives and allows the processed food to maintain the natural flavors and nutritional value of the original food material. Therefore, HPP technology is recognized as a minimal processing technology that ensures both food safety and flavor (Daryaei & Balasubramaniam, 2012). Compared with traditional thermal processing technology, HPP is performed at room temperature, reducing energy consumption associated with heating and subsequent cooling. In addition, the food is in packaged form and does not directly contact the processing devices, preventing the secondary contamination of food after pasteurization. Additionally, the pressure transfer medium can be recycled after processing. With the advantages of low energy consumption and low contamination risk, HPP technology is an environmentally friendly processing technology (Rastogi, Raghavarao, Balasubramaniam, Niranjana, & Knorr, 2007).

The earliest HPP study was conducted in the United States in 1885, in which it was reported that high pressurization eliminated bacteria. Subsequently, researchers found that HPP extended the storage life of milk. These studies revealed the potential application of high pressure in the food industry. A number of universities, governmental departments, and research institutions actively conduct studies on high pressure pasteurization technologies using laboratory high pressure equipment with the goal of helping the food sector establish a common technical standard for the pasteurization of foods. Since HPP technology is a new pasteurization technology for the food industry, its health and safety aspects, economic value, and product forms should be assessed in detail before commercialized application. Additionally, the

scientific theories and processing parameters for practical application should be further established. Basic pasteurization data should be established based on HPP research achievements to meet the actual needs of food practitioners in product development. Such pasteurization data can also serve as the criteria for hygienic safety assessment of HPP products (Huang, Lung, Yang, & Wang, 2014). Equipment manufacturers, such as Avure, Stansted Fluid Power, Baotou, Kobelco, and Toyo Koatsu, produce laboratory HPP equipment with different specifications and capacities of 0.3–10 L to meet different experimental needs. The earliest commercial product was the widely available HPP jam in Japan. Subsequently, various HPP food products were launched in Europe and North America. In recent years, the gradual widespread adoption of HPP equipment has become a key factor driving the development of HPP technology. An increasing number of machinery manufacturers worldwide have engaged in the research, development, and manufacture of HPP equipment, leading to better equipment manufacturing technology, continuously improved production performance, and long-term, stable production operation. Avure and Hiperbaric, which have gained most of the market share, developed HPP devices with a volume of 525 L and an annual production capacity of approximately 60 million tons (Balasubramaniam, Farkas, & Turek, 2008). This review introduces HPP equipment, the current application status of HPP equipment in various types of foods, and the technical bottlenecks for future applications.

2. Current status

With the gradual maturation of HPP equipment technology in recent years, various manufacturers in U.S.A, Spain, U.K, Japan, and China have developed the capacity to produce HPP equipment. Major global manufactures include Avure (Middletown, OH, USA), Hiperbaric (Burgos, Spain), and Multivac (Germany, formerly Uhde High Pressure Technologies, merged with Multivac in 2011); the largest manufacturer in China is Baotou Kefa High Pressure Technology Co., Ltd. (Baotou, China). There are more than 10 HPP equipment suppliers; the world's largest supplier is Hiperbaric, with a market share of more than 50%. HPP devices are divided into two types, the horizontal and vertical types. Most devices used in commercial applications are the horizontal type to facilitate the loading and unloading of containers in the production line (Marketsandmarkets, 2013). More than 300 sets of HPP equipment have been operating for mass production worldwide (Fig. 1), mainly in North America (54%), Europe (25%), and Asia (12%). Fig. 3 show a horizontal type HPP system from Multivac Inc., German. A set of HPP equipment costs approximately \$0.5–2.5 million depending on the capacity and operating parameter range of the equipment. HPP technology has been widely used in the production of meat products, dairy products, aquatic products, vegetable and fruit products, and various beverage products. The global market for HPP foods reached approximately \$9.8 billion in 2015 and will be expected to culminate in a market value of \$ 54.77 billion in 2025 (Fig. 2) (Visiongain, 2015). Manufacturers in Europe, North America, and Japan have been actively developing commercial applications, and the production output of HPP products has increased each year. Every year, approximately 500,000 tons of HPP products are

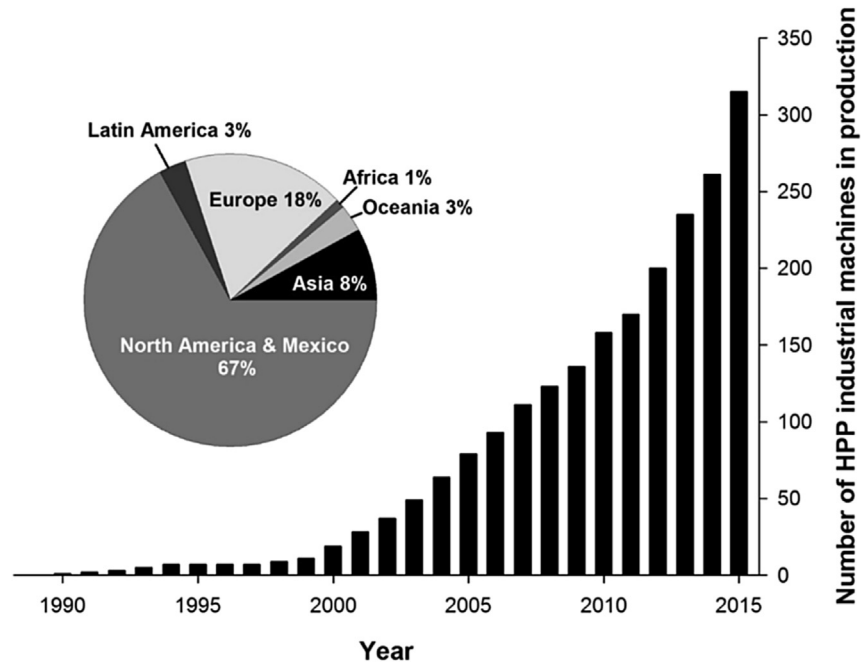


Fig. 1. World growth of the food industry use of high pressure processing technology (NC Hyperbaric, Burgos, Spain).

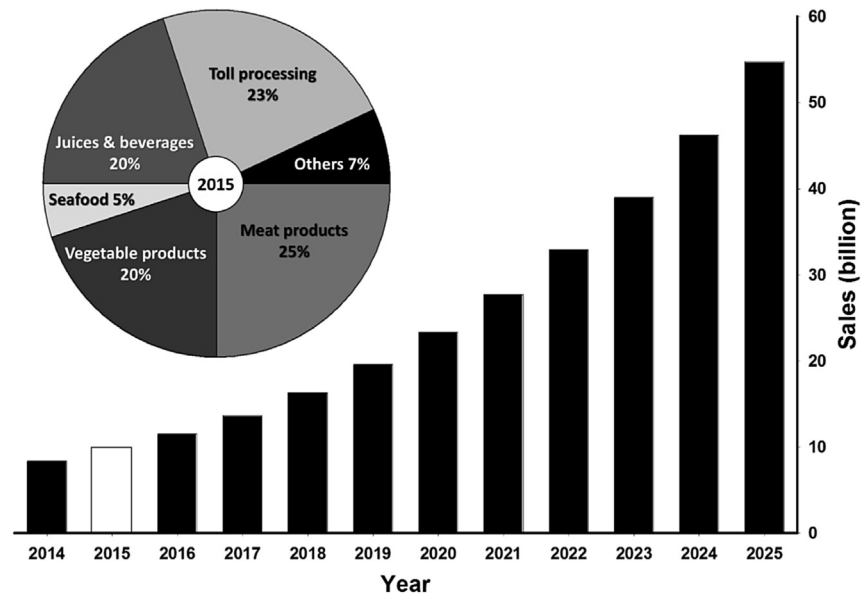


Fig. 2. Global HPP foods market forecast 2014–2015 and submarket share in 2015 (Visiongain, 2015).

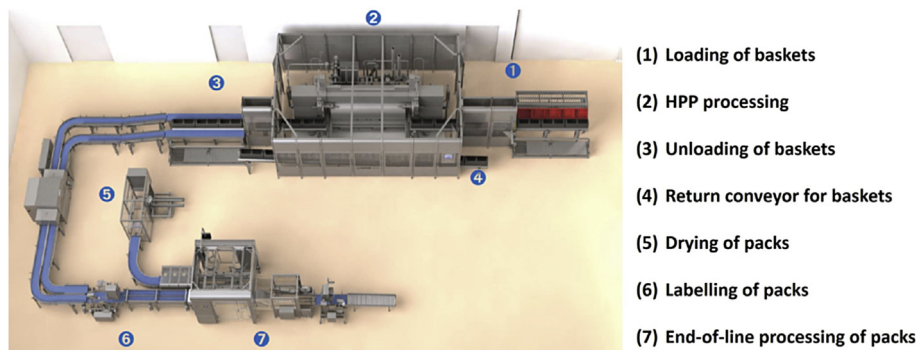


Fig. 3. A horizontal HPP production systems (Multivac, German).

circulated around the globe, with ready-to-eat meat products, such as burger patties, representing the largest application among all HPP products. In addition, the clean label trend in developed countries has boosted the development of HPP juices, which has become a popular topic in the field of HPP technology with a focus on coconut water. In the future, juice products may hold a higher market share than meat products in the HPP food market.

Due to the high investment costs of HPP equipment, original equipment manufacturer (OEM) service is very popular in North America and Europe. For example, major HPP OEM service suppliers in the US include American Pasteurization, AmeriQual Foods, and HPP Food Services (Table 1); these companies mainly use devices supplied by Avure and Hiperbaric. According to a [Visiongain report \(2015\)](#), in 2015 the global HPP equipment and OEM service market was estimated to reach \$330 million, accounting for only 3–4% of the gross output value of HPP products, and will maintain double-digit growth in the future. Only a small number of food companies have HPP equipment, and these companies typically establish OEM cooperation platforms to provide OEM services to other food companies by using their excess production capacity. The OEM service not only allows the companies to recover the equipment investment within 2–3 years, but also spares small companies from investing in expensive equipment or expanding their workshops and eliminates costs related to equipment operation, repair, and maintenance. For example, juice products manufactured by US-based Vital Juice using HPP technology and local food raw materials are very popular among retailers and consumers and have shown considerable sales growth, and thus the company outsourced the OEM services for HPP and bottle-filling. Although the HPP/bottle-filling combined OEM mode was very rare in the past, other companies have adopted this mode because of increased

business demand. In addition, several manufacturers provide juice extraction service to meet diversified processing demands. For example, Calpack Foods offers a complete range of HPP services, including freezing, juice extraction, filling, and high-pressure pasteurization. In 2015, two major equipment manufacturers, Avure and Hiperbaric, two OEM manufacturers, American Pasteurization and Universal Pasteurization, and several food beverage manufacturers jointly established an industrial alliance to promote HPP technology as the foundation for future development. The innovative values created by HPP technology for the food industry have gradually been accepted by consumers. HPP technology has many advantages over traditional thermal pasteurization, as described below.

2.1. High pressure based hurdle technology

HPP technology eliminates bacteria in packaged food and can be used in this capacity as one of the antibacterial factors in hurdle technology, in combination with various processing technologies, without changing the original process. Numerous previous studies found that HPP promotes wine aging such that the wine has similar quality indicators, such as color, pH, acidity, and turbidity, with wine that has been aged for many years, shortening the duration of wine fermentation. In addition, HPP can inhibit the growth of yeast, lactobacillus, and acetobacter to reduce the possibility of microbial spoilage, thus replacing antibacterial agents such as sulfites, and meet the consumption demand for natural and wholesome foods ([Buzrul, 2012](#)).

HPP meat products mainly include vacuum-packaged ham, bacon, and ready-to-eat products, which have the same shape and mouthfeel as those of regular products. In addition, meat products are packaged and then subjected to high-pressure pasteurization. This reduces the possibility of secondary contamination without affecting the original process conditions, effectively maintaining the freshness of the meat products and extending their shelf life. Moreover, HPP technology effectively inhibits pathogens in ready-to-eat meat products and fresh meat products, reducing the defect rate of the product. The USDA Food Safety and Inspection Service approved HPP technology as a legitimate means for eliminating *Listeria monocytogenes* in processed meats ([Simonin, Duranton, & de Lamballerie, 2012](#)). In addition, HPP strengthens the activity of enzymes (such as protease), accelerates the aging and tenderization of meat products, and imparts special flavors and tenderness to meat products, making them more easily digestible by consumers. In the U.S.A, several major meat and poultry manufacturers including Hormel's Natural Choice, Applegate Farms, and Perdue Short Cuts have applied HPP technology to various meat products. For cured meat products, the bactericidal ability of high pressure reduces the salinity of the product and the addition of antibacterial agents, resulting in more wholesome meat products that meet Clean Label requirements ([Verma & Banerjee, 2012](#)). Due to the short storage life, processed meat products were previously sold in local markets. The widespread adoption of HPP technology will enable food manufacturers to penetrate additional overseas markets.

2.2. Maintaining organoleptic properties of vegetable and fruit products

With an annual growth of at least 1%, fruit beverages exhibit the fastest growth in output value in the HPP food market. Fresh, natural, and safe HPP juices have been widely accepted by consumers. HPP technology has been approved by governmental authorities in U.S.A, Europe, and Canada for reducing pathogens in juices and fresh-cut fruits and extending the shelf life of the products by more

Table 1
HPP toll processing facilities.

Equipment brands	Country	Original equipment manufacturers
Avure	USA	American Pasteurization, Hope Foods, HPP Food Service, Natural Foodworks Group, Pressure Safe, Stay Fresh Foods, Universal Pasteurization & Universal Cold Storage
	Canada	Natural + L XTD,
	Mexico	Highland Fresh Food
	Greece	Mytilos, High Pressure Process
	Italy	HPP Italia
	Germany	Avure Deutsch land
	Netherlands	Fruity Line, Pascal Processing
	France	HPP Atlantique
	Spain	HPP Food Technology
	England	Agri-Food and Biosciences Institute
	Taiwan	Kee Fresh & Safe Food tech.
Hiperbaric	USA	AmeriQual, Arctic Cold Storage, Doras Naturals, Fresh Advantage Foods, Green Plant, Lineage Logistics, Nutrifresh, Safe Pac, Simply Fresco, True Fresh HPP
	Canada	Alberta Agriculture and Rural Development
	Ireland	HPP-Tolling
	Italy	Sterilparma
	Netherlands	Pascal Processing, Fruity Line
	Spain	APA Processing, Go Fruselva, MRM
	England	Deli24, Fruitapeel
	New Zealand	Pressure Foods
	Australia	Advance Packaging, Moira Mac's, Preshaford, Simpson Farms
	South Korea	Cheong Song
	Japan	Sanpo Kasei
Multivac	New Zealand	Food Innovation Network
	Australia	Longfresh

than 3-fold. The number of HPP fruit brands has increased several-fold over the last five years. In 2010, around 20 companies globally sold HPP juices, which has increased to more than 100 HPP juice brands in 2015. Previously, HPP juices were sold only in natural food stores, but they have now entered mainstream retail channels. Gradually increasing consumption demand has driven additional manufacturers such as U.S.A-based BluePrint, HarmlessHarvest, Evolution Juice, and Suja to produce HPP juices. Coconut water is a natural isotonic beverage and can be used to replace sports drinks. Thermal processing destroys nutrients and flavors in the product, whereas the quality of HPP coconut water is comparable to that of fresh coconut water, indicating large potential demand for the application of HPP technology in the production of packaged coconut water. In addition to fruits, a number of manufacturers have applied the HPP technology to fruit jams and purees. For example, HPP avocado products are very popular in North America, and HPP inhibits microorganism growth while suppressing the activity of polyphenoloxidase to prevent enzymatic browning (Terefe et al., 2014). The ability of HPP to maintain the fresh flavors of foods has also attracted the interest of the coffee giant Starbucks. In 2011, Starbucks acquired the juice chain Evolution Fresh at \$30 million and developed high-quality fresh juice based on HPP technology. Starbucks believes that high-pressure pasteurization is more effective than traditional thermal pasteurization for maintaining the natural flavors and nutritional ingredients in the fruit juice. Despite the high initial investment costs in HPP equipment, Starbucks remains confident in the HPP fruit juice, which is claimed to be of high quality, and plans to apply its successful marketing strategy previously used in the coffee industry to HPP fruit. They have developed different product price strategies and tailored commodities for different consumer groups. In the initial stage, the fruit juice will be sold at a high price of \$7.99/480 mL to differentiate the HPP fruit juice from other conventional fruit juice products and to establish a market segment for HPP fruit juice. After the international food giant Starbucks enters the HPP market, additional food companies will adopt HPP technology and develop various HPP foods.

2.3. Elimination of micro-organisms and shelf-life increase

The development of HPP technology is very significant for the quality and microbial safety of aquatic products. This is because the amount of aquatic products that are consumed raw is higher than that of any other type of food and pathogens are likely to be ingested along with the aquatic products, resulting in food poisoning incidents. In the past, a number of food poisoning cases were caused by *Vibrio marinopraesens*, *Vibrio parahaemolyticus*, and *Escherichia coli* in aquatic products that were not subject to high-temperature pasteurization. HPP inhibits the growth of pathogens, reduces the accumulation of biogenic amine compounds, maintains the fresh mouthfeel, and extends the storage life of aquatic products, all of which are impossible using traditional thermal processing technology (Mújica-Paz, Valdez-Fragoso, Samson, Welti-Chanes, & Torres, 2011). Another role of high pressure is to help in the shucking of aquatic products. Traditional shucking methods involving the use of a knife or tools are labor-intensive and time-consuming with low yield, and may destroy the integrity of the flesh during shucking. HPP easily separates the flesh from the shell, maintaining the integrity of the flesh with a meat recovery rate of up to 100% (Campus, 2010). Several aquatic products with high unit prices, such as oyster, lobster, and crab, are shucked using this technology. Given the unique features and appealing appearance of the products, they can be sold at a higher price with increased benefits. In addition, HPP extends the shelf life of the products by inhibiting pathogen growth.

2.4. Nutritional values retained

Japan has been one of the leaders in studies of HPP products in Asia and was the first country to produce commercial HPP food products. Diverse HPP food products have been developed in Japan and recently, manufacturers have adopted HPP technology for numerous applications. For example, Japan-based Echigo Seika Co., Ltd applied this technology to ready-to-eat steamed rice products to adjust the protein and starch in the product, accelerate the permeation of water into rice, and increase the degree of gelatinization for easier absorption and digestion of rice; the ready-to-eat steamed rice product can be stored for over a year. In addition, the company manufactures ready-to-eat steamed brown rice with a storage life of 7 months at room temperature. High pressure causes physical damage to brown rice and disrupts the cell wall inside the brown rice, resulting in an enhanced catalytic effect of glutamate decarboxylase on glutamic acid and accumulation of γ -aminobutyric acid (GABA) inside brown rice; the GABA content in HPP brown rice is 3-fold higher than that in regular brown rice. Using this technology in other foods containing functional components will enhance the nutritional value of the food without the addition of additives and allow consumers to increase nutrient intake without changing their dietary habits (Shigematsu et al., 2010). Due to high-pressure pasteurization, the Col Plus milk made in New Zealand contains twice the amount of bovine immunoglobulin as is present in thermally pasteurized milk.

2.5. Pre-treatment before extraction

HPP technology has the potential to be used as a pre-treatment step for food processing. High pressure causes physical damage to plant cells, enabling easy extraction of internal nutritional components. Physical damage makes cells more permeable to solvents, increasing the mass transfer rate and facilitating the release of extracts. In addition, high pressure is performed at room temperature, reducing the destruction of thermally sensitive components and increasing the extraction efficiency. In the future, HPP will become an important pre-treatment step in the research and development of components with healthcare functions for improving the production performance of functional components in the food and pharmaceutical industries. HPP has been successfully used to extract collagen from fish skin, flavonoids from propolis, anthocyanidin from grape skin, ginsenoside from ginseng root, and triterpenes from *Antrodia cinnamomea* (Huang, Hsu, Yang, & Wang, 2013), indicating its application potential in the health food and biotechnology industries.

3. Future trends

HPP technology extends the storage life, maintains the flavors and nutritional value, and increases the value proposition of products. In addition, it extends the shelf life, reduces the defect rate, and helps expand the target markets of the product. Its non-thermal processing nature makes HPP technology a preferred production choice for maintaining food quality. However, this technology has the following disadvantages: (1) most HPP products must be stored and transported under refrigeration because pressure treatment at ambient or chilled temperature is effective in reducing more than 5-logs of variety of vegetative pathogens, pressure treatment alone, is not sufficient to inactivate spores of harmful pathogens such as *Clostridium botulinum*. Low-acid HPP products may be caused potential microbial risks associated with survival of *Clostridium* spores. (2) This technology is not applicable to several food types, such as flour and powdery flavors with low water content or products containing a large number of air bubbles

because HPP requires the use of water as a pressure transfer medium and products containing air bubbles will be deformed under pressure. (3) The packaging material used in HPP must have a compressibility of at least 15%, so only plastic packaging materials are suitable for HPP. Thus, an important issue for the future growth of HPP technology in the food sector is the establishment of relevant laws and regulations. Clearly specified process conditions will ensure microbial safety, product quality, and compliance with food hygienic safety laws and regulations in countries where the manufacturers are located. HPP technology also can be combined with existing trends in the food sector to boost the development of the food industry. For example, high-quality organic food raw materials, fresh local foods with short food miles, and functional health foods are future development trends in the field of HPP.

3.1. Regulations and directives

HPP equipment production is subject to considerable technical barriers; therefore many food companies must import HPP equipment from other countries. Given the large investment required, many food companies maintain a conservative attitude towards HPP despite the widespread attention on HPP technology from food industry practitioners. In recent years, the production capacity of HPP equipment has increased considerably; however, HPP is still performed in a batchwise manner, making it impossible to apply HPP to high-speed production lines. If the pasteurization time for each batch is shortened to increase production capacity, insufficient pasteurization may occur. Existing production conditions for HPP are typically as follows: pressure: 200–600 MPa; duration: approximately 5 min. To establish production conditions for HPP foods, manufacturers, governmental agencies, colleges, and research institutions should jointly assess in detail the pressure-resistant characteristics and dynamic parameters of indicator microorganisms for food safety under high pressure and different environmental conditions. The establishment of such basic data will ensure microbial safety and product quality, and the data can be used as criteria for hygienic safety assessment for both HPP products under development and commercially available HPP products. Only a few countries have established relevant laws, regulations, or specifications (Table 2). The USDA has approved HPP as a non-thermal pasteurization technology that can be used to replace traditional pasteurization in the food industry. Comparisons of pressure resistance among vegetative food-borne pathogens revealed that strains of *Escherichia coli* O157:H7 were the most resistant so far encountered. USDA (2012) has requirements *E. coli* O157:H7 as the indicator strain for reprocessing, an HPP process that achieves a 5-log *E. coli* O157:H7 reduction should be sufficient for product produced to ensure microbial safety. In Europe, HPP is regarded as a novel technology subject to the Novel Food Regulation and HPP containers must comply with the provisions of the Pressure Equipment Directive. Clearly defined regulations and specifications will facilitate the healthy development of the application market to improve product quality, development speed, and consumer trust.

3.2. Organic food

Since the production cost of HPP foods is slightly higher than that of traditional thermally pasteurized foods, HPP products have higher unit prices than non-HPP products with similar properties. High unit prices of HPP products adversely affect the development of HPP foods. To highlight the fact that the high price is derived from the product's excellent quality, HPP products should be segmented from thermally pasteurized products in various marketing channels, and consumers should be informed of the

advantages of HPP technology. A Marketsandmarkets (2011) report found that in 2015, the global market for packaged organic food & beverages reached \$104.5 billion, which was ten-fold the output value of HPP products. The consumption preference of consumers for natural organic food raw materials is reflected in their food consumption choices. HPP maintains the organoleptic characteristics and nutritional value, and thus the quality of the raw material directly affects the quality of HPP products. Various food distributors rely on the advantages of their own brands to establish specialized sales channels for organic products and actively explore the organic product market. Organic foods have been widely recognized as high-quality, natural, and wholesome foods with low risks of pesticide and antibiotic exposure, and thus consumers accept the high prices of organic foods. Therefore, HPP foods should be combined with high-quality organic foods to improve the growth of both types of foods and to enhance the acceptability of the high price for HPP foods among consumers.

3.3. Health food

The global aging issue and the gradual adoption of the preventive healthcare concept provide an excellent environment for the development of health foods. Although commercially available HPP food products with healthcare functions are not available yet, Ganeden Inc., based in the U.S.A, launched the first fruit juice product containing probiotics in 2014. Brown rice with high GABA content and HPP milk containing active immunoglobulins have the potential to become functional HPP products. Natural functional materials extracted from medicinal herbs, plants, and animals can be combined with HPP products. Consumer groups have accepted commercially available health foods and their high prices. Therefore, an important strategy in HPP product development for increasing the acceptability of HPP products is to maintain the original flavors, reduce additives, and increasing healthcare functions of various products.

3.4. Clean label

In recent years, a number of food safety incidents have led to growing concerns among consumers in Taiwan regarding food additives. In response to the consumers' demand for natural foods and their expectation for limited use of artificial additives, Clean Label foods are gradually gaining popularity. This kind of products meets the following requirements: (1) free of chemical additives; (2) simple ingredients; (3) minimally processed. Owing to a global trend towards Clean Label safe products with simple formulations and limited additives, the market for Clean Label foods is undergoing a steady and continuous growth by launching increasing number of new products. Recently, Clean Label foods have received growing attention from numerous international food manufacturers including Kellogg's, General Mills, Nestle USA, Cambell Soup, Kraft, Subway, Panera, Taco Bell, Chipotle, Panera Bread, Papa John's, Noodles & Company and Pizza Hut, and their operating strategies have been modified accordingly. High pressure processing is an important technology to manufacture Clean Label products, as it reduces the use of additives while maintaining the desired food quality and microbial safety. Adding the food processing as a part of the hurdle technology, high pressure processing reduces the microbial food safety risk and decreases the use of other additives. Additionally, it prolongs the shelf life of foods stored under cold chain circulation and thus, aid in maintaining the natural color, flavor, and taste of foods. Such minimal processing technology helps to retain food safety and reduces the amount of additives used in processed meat products.

Table 2

Food policy of HPP from different countries.

Country	Definition of HPP	Policy	References
USA	High Pressure Processing (HPP) is an antimicrobial treatment for use on meat, poultry, and processed egg products without prior-approval from FSIS. HPP is capable of either reducing or eliminating biological food safety hazards in these foods, depending upon the intended use of the treatment by the establishment.	Inspection program personnel (IPP) verification of establishment activities. A. HPP as an antimicrobial treatment, IPP are to verify that the hazard analysis supports the use of the HPP treatment in controlling pathogens in the product. IPP are to perform a HACCP Verification task to verify compliance with 9 CFR 417.2(a)(1) and 417.2(a)(2). B. HPP as support for decisions in the hazard analysis, IPP are to perform a HACCP Verification task to verify compliance with 9 CFR 417.5(a)(1) and 417.4(a)(1). C. When an official establishment uses HPP to achieve food quality characteristics and does not include HPP in its food safety system, IPP are to verify that the establishment maintains decision-making documents to support the exclusion of the antimicrobial treatment from its hazard analysis and food safety system. D. When an establishment sends product to another official establishment that performs the HPP treatment and ships the product into commerce, IPP are to verify that originating establishment's flow chart, hazard analysis, and HACCP plan includes the HPP process step and all supporting documentation. E. If an establishment follows reprocessing criteria, in order to eliminate an adulterant, it is important that good manufacturing practices (GMPs) are followed to minimize further cross-contamination and additional growth of pathogens (e.g., temperature abuse). IPP are to verify the establishment has supporting documentation to achieve the specified log reductions.	(USDA, 2012)
Europe	Novel food or novel food ingredients to which a production process not currently used has been applied, where that process gives rise to significant changes in the composition or structure of the food or food ingredient, which affects its nutritional value, metabolic effect or level of undesirable substances.	Notification and a single safety assessment through a Community procedure.	(European Commission, 2004)
UK	Novel food and process: foods and food ingredients to which has been applied a production process not currently used, where that process gives rise to significant changes in the composition or structure of the foods or food ingredients which affect their nutritional value, metabolism or level of undesirable substances.	Application for authorisation to market fruit preparations pasteurized using a high pressure treatment for the fruits listed when processed in the manner described in the application dossier only. Significant changes to the operating conditions or to the types of foods to be processed would require a further application for approval.	(Food Standards Agency, 2001)
Canada	Novelty determination of an HPP-treated food product: a food that has been manufactured, prepared, preserved or packaged by a process that has not been previously applied to that food.	Any food not previously treated with HPP, and any HPP-treated food product that is subjected to a new set of treatment conditions (e.g., pressure, holding cycle time, etc.) and/or treated for a different purpose than those previously approved by Health Canada, will require a premarket notification to determine the safety of these HPP-treated food products.	(Health Canada, 2014)
Australia & New Zealand	Novel food: food derived from new technologies.	Safety evaluation of novel foods involves consideration of a variety of toxicological and nutritional issues together with information on chemistry and dietary intake of the product.	(FSANZ, 2005)
Germany	Novel food or novel food ingredients to which a production process not currently used has been applied.	An individual case-by-case safety evaluation is needed for a new high pressure treated product.	(Eisenbrand, 2005).

4. Conclusion

The food industry is a sector closely related to the health of consumers, and thus food-processing technologies are typically subject to higher hygienic standards than other sectors are. Consumers are willing to purchase a product only if they believe the product is safe. Although thermal pasteurization technology remains a core technology in the food industry, it may affect the appearance, flavors, and nutritional value of foods and does not necessarily meet the demand of modern society for natural, fresh, and aesthetically appealing foods. HPP offers opportunities for food manufacturers to develop new foodstuff with extended shelf life, maintains the organoleptic properties and nutritional values. These processing characteristics cannot be achieved using thermal pasteurization technology, and thus the emerging HPP technology better meets the consumer demand for safe, wholesome, new foods containing fewer additives.

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