

# Commercial opportunities and research challenges in the high pressure processing of foods

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## Abstract

High pressure processing (HPP) at refrigeration, ambient or moderate heating temperature can inactivate pathogenic and spoilage microorganisms with fewer changes to product “freshness” as compared to conventional food preservation processes. The essential equipment components are here described to help define low and higher cost applications. Specific opportunities are discussed that a food processor can consider to profit from the significant equipment investment required to implement this new processing technology. Although, HPP is the only alternative processing technology that has reached consumers with a variety of new products, there are many pending research questions to be answered to make it a reliable alternative and to have a fundamental understanding of the inactivation of microorganisms and enzymes by pressure. Approaches to generate the knowledge required and the information that is being generated is critically reviewed.

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## 1. Introduction

High pressure processing (HPP) at refrigeration, ambient or moderate heating temperature allows inactivation of pathogenic and spoilage microorganisms in foods with fewer changes in texture, color and flavor as compared to conventional technologies (Cheftel, 1995; Knorr, 1993; Velazquez, Gandhi, & Torres, 2002). Five decimal reductions in pathogens including *Salmonella typhimurium*, *Salmonella enteritidis*, *Listeria monocytogenes*, *Staphylococcus aureus* and *Vibrio para-*

*haemolyticus* can be achieved by HPP (An, Calik, He, Adams, & Morrissey, 2000; Mackey, Forestiere, Isaacs, Stenning, & Brooker, 1994; Metrick, Hoover, & Farkas, 1989; Patterson, Quinn, Simpson, & Gilmour, 1995; Stewart, Jewett, Dunne, & Hoover, 1997; Styles, Hoover, & Farkas, 1991).

Unlike thermal processing and other preservation technologies, HPP effects are uniform and nearly instantaneous throughout the food and thus independent of food geometry and equipment size. This has facilitated the scale-up of laboratory findings to full-scale production. Thermal processing is the prevailing method to achieve microbial stability and safety. Although this technology is effective, economical and readily available, in many cases it has undesirable effects on food quality that a food processor must understand to minimize. The key HPP equipment technologies are the pressure

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vessels and the high hydrostatic pressure generating pumps or pressure intensifiers. Oil at  $\sim 20$  MPa is fed on the high oil pressure side of the main pump piston which has an area ratio of 30:1 with respect to the high pressure fluid piston displacing into the high pressure vessel a food-grade contact fluid, typically purified water at  $\sim 600$  MPa (Fig. 1). When the main piston reaches the end of its displacement, the system is reversed and high pressure oil is then fed to the other side of the main piston and the high pressure fluid exits on the other pump side.

The casting limitation of pressure vessel construction from a single block limits them to  $\sim 25$  l for operating pressures in excess of 400 MPa. Prestressed wire-wound vessels are needed for safe, durable and reliable operation for larger volumes at higher pressures. Typically, the same technology is used for the yoke holding the top and bottom seals (Fig. 2). Wire winding increases equipment costs leading to the present definition of low cost operations such as oyster shucking requiring 200–400 MPa separated by a technology barrier at  $\sim 400$  MPa from higher cost operations such as guaca-

mole salsa production at  $\sim 600$  MPa (Fig. 3). A second technology barrier exists at  $\sim 680$  MPa and above this pressure level there are no vessels available for commercial applications. However, the next generation of equipment is expected to reach  $\sim 700$  MPa and operate at temperatures  $\sim 100$  °C to inactivate bacterial spores (Ting, 2003). Current HPP products rely on refrigeration, reduced water activity or low pH to prevent bacterial spore outgrowth.

The successful commercial introduction of avocado paste by Avomex Inc. has set an HPP quality standard in the USA. Pressure-treated juices can be found in many countries and were recently introduced in Mexico by Grupo Jumex. The quality retention in HPP is related to time–temperature–pressure treatments causing only minimum chemical changes and therefore minimum changes to sensory properties and nutritional values. Research has confirmed the excellent sensory characteristics of HPP products making them often *indistinguishable* from untreated controls (e.g., Shellhammer, Aleman, McDaniel, & Torres, 2003). Consumer interest in “fresh” products can be satisfied by

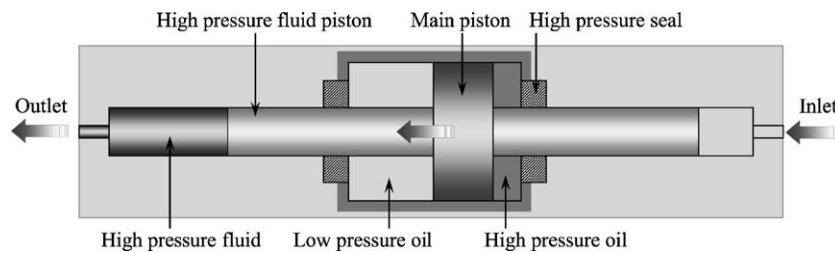


Fig. 1. High hydrostatic pressure pump or pressure intensifier.

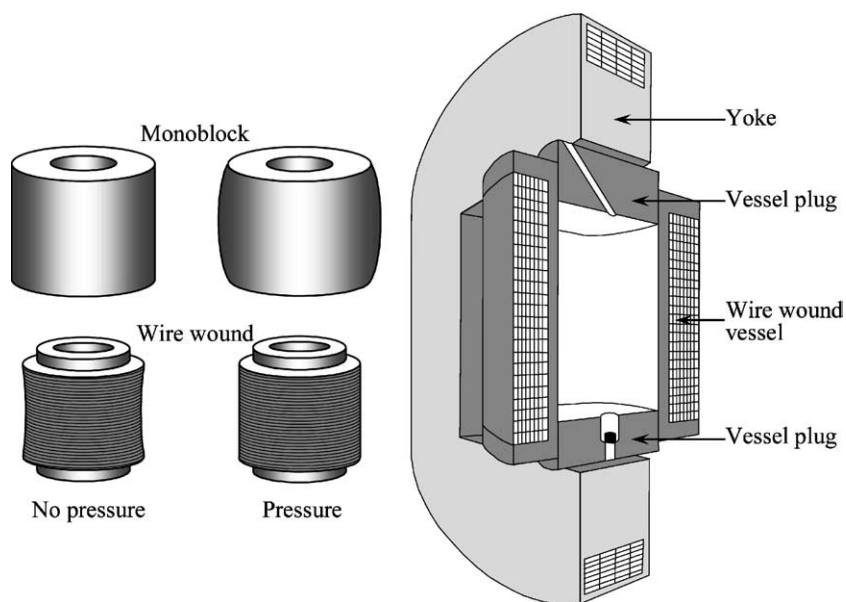


Fig. 2. Monoblock casting technology for moderate pressure/size vessels and wire-winding technology for vessels and yoke used in larger size and higher pressure applications.

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