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Review Article

HIGH PRESSURE PROCESSING FOOD TECHNOLOGIES

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High pressure processing (HPP)

Synonym: Pascalization, High hydrostatic pressure processing, Ultra high pressure processing.

History: 1st invented by Bertie Hite (1899) – U.S. 1st Experimented in milk and inferred an reduced microbial load and increased shelf life.

Introduction

Relatively novel non-thermal food processing, developed as an alternative to traditional food processing methods. Designed for both solids and liquids. Main advantage is that it can be used in foods with (or) without packaging (in former case eliminates possibility of post-treatment contamination). It uses a wide pressure range of 50-1000 mpa., and it varies with type of food and with microbes intended for destruction.

Principle

Lechatliers principle

States that when a system at equilibrium is disturbed the system will respond in such a way that tends to minimize the disturbance (Pauling, 1964). This means that high pressure stimulates reactions that results in decrease in volume but opposes the reactions that involves an increase in volume.

Pascal (or) Iso-static principle

States that Instantaneous (rapid) and uniform pressure throughout the sample. Irrespective of the weather sample contact with pressure medium (or) sealed hermetically (Olsson, 1995). This means that as the pressure is distributed uniformly through out the food sample so the processing time is totally independent of sample size. Where as in case of conventional processing technologies it involves surface heating where by product quality is

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lost and also the heat transfer is by conduction and convection so the processing time is totally dependent on the volume of sample.

Methods of HPP:

a) Batch method – for solid foods.

b) Semi-continuous – For liquid foods (Ting and Marshall, 2002).

Process of HPP

a) Pressurization by compression: Done by 2 ways

1. By reducing of the volume of (MONOBLOC) pressure vessel
2. Pumping the pressure medium (WATER) into the vessel

b) Holding for certain period of time

c) Depressurization (relieving by decompression)

d) Aseptic packaging

NOTE 1: Holding time varies between microorganisms and foods. (e.g) for fruit juices it is around 400-600 Mpa for 5 min at 20^{o}C. This results in inactivation of vegetative cells of key food borne pathogens (Table 1)

Table 1 The efficiency of high pressure processing (HPP) against *E. coli* O157:H7, *L. monocytogenes* and *C. jejuni.*

Pathogen	Food product	Treatment conditions	Log reduction
E. coli O157:H7	Apricot juice (pH 3.8)	250 MPa, 5 min, 30 °C	4.85
	Orange juice (pH 3.76)	250 MPa, 5 min, 30 °C	5.1
	Sour cherry juice (pH 3.3)	250 MPa, 5 min, 30 °C	5.28
	Apple juice (pH 3.5)	500 MPa, 5 min, 20 °C	5
	Tomato juice (pH 4.1)	500 MPa, 5 min, 20 °C	5
	Orange juice (pH 3.8)	500 MPa, 5 min, 20 °C	1–2
	Raw minced meat	700 MPa, 1 min, 15 °C	5
	Hungarian salami	600 MPa, 6 min, 25 °C	> 4
L. monocytogenes	Human milk	400 MPa, 1.5 min, 31 °C	≈ 6
	Turkish white cheese	600 MPa, 5 min, 25 °C	4.3–4.4
	Raw milk	500 MPa, 10 min, 20 °C	> 4
	Fish slurry	400 MPa, 5 min, 20 °C	≈ 3
C. jejuni	UHT whole milk	325 MPa, 10 min, 25 °C	≈ 2.5

Pathogen	Food product	Treatment conditions	Log reduction
	UHT skim milk	325 MPa, 10 min, 25 °C	≈ 2.5
	Soya milk	325 MPa, 10 min, 25 °C	≈ 3
	Chicken puree	325 MPa, 10 min, 25 °C	≈ 3.5
	Phosphate buffer	325 MPa, 10 min, 25 °C	8
	Milk	300 MPa, 10 min, 20 °C	0.4–1[a]
	Broth	300 MPa, 10 min, 20 °C	3–6.7[a]
	Chicken meat slurry	200 MPa, 10 min, 20 °C	0.2–2.2[a]

[a] Results obtained in different strains.

NOTE 2: Aseptic packaging

Package should withstand pressure and it should maintain quality. Needs airtight packages which can withstand volume changes which occur during compression and decompression (Hugas *et al.,* 2002). O_2 impermeable, opaque to light are necessary to keep the product fresh – plastic films are suitable for this purpose. Metal cans & glass wares are generally not used.

Mechanism of inactivation

High pressure processing is generally considered to affect bacterial cell membranes and impair their permeability and ion-exchange and its effect on microorganisms is affected by critical pressure threshold, when the pressure applied exceeds critical pressure threshold it gets destroyed and when the pressure applied is less than critical pressure threshold only sub-lethal injury occurs (McClements *et al.,* 2001) and also inactivates some of the enzymes vital for the survival and reproduction of bacterial cells.

HPP and Adiabatic Heating

The work of comparison will increase the temperature of foods the by approximately 3°C/100MPa by adiabatic heating (Balasubramaniam and Balasubramanian, 2003). It depends on the composition of foods. Adiabatic heating has synergistic effect on inactivation of microbes. Keeping sample under extended period of time, does not require any additional energy (Cheftel and Culioli, 1997).

Although all food borne pathogens are inactivated by HPP *E. coli O157:H7* were resistant (Linton *et al.,* 2001) and *Staphylococcus* exhibits relative resistant to high pressure processing (Erkmen and Keratas, 1997).

Table 2: Factors affecting microbial inactivation

Micro organisms	Pressure required for log reduction (Mpa)	Temperature (^{o}C)	Time (min)
Yersinia	275	20	15
Salmonella	350	20	15
Listeria	375	20	15
E.coli (O157:H7)	650	20	15
S. aureus	700	20	15

Stage of Microbial growth

Organisms were resistant during stationary phase of growth and susceptible during Log phase of growth (McClements *et al.,* 2001).

Gram +ve and Gram –ve

Gram +ve bacteria more resistant than Gram –ve bacteria (Patterson and Kilpatrick 1998).

Spores

Spores requires pressure of greater than 800 MPa. Heat along with pressure is very effective on spores. So heat of 80-100 C and pressure of 600 MPa is used. *Bacillus* and *Clostridial* spores were for inactivated at these conditions (Meyer *et al.,* 2000).

Fungi

Yeast & Mould were inactivated at relatively low pressures. At about 100 MPa the nuclear membrane of yeast gets destroyed and about 300 – 600 MPa mould gets inactivated (Smelt, 1998).

Viruses

Made of protein coat called capsid which is made of to of subunits called capsomeres. Viruses possess a remarkable Baro resistance to HPP (Smelt, 1998). They require pressure rates of 800 MPa at this pressure viruses were not destroyed, it gets merely inactivated and the virus thus retains its immunogenic properties. This virus inactivation technology used in preparation of vaccines. Development of vaccine for AIDS is in process.

Prions

Causes BSE in cattle Creutz feld – Jackob disease in humans. More difficult to destroy. Meat requires >1200 MPa for prions inactivation (Brown *et al*., 2003)

EFFECTS OF HPP ON FOOD QUALITY

- **Colour**

It causes denaturation of proteins. In case of red meat, destruction of globin in myoglobin leads to cooked like appearance of meat (Mor-Mur and Yuste, 2003). In case of cured meat and white meat (fish) there is no colour change (Cheftel and Culioli, 1997). Stimulates lipid oxidation in fish and meat. This is avoided by active anti-oxidant (O_2 scavenging) vacuum package.

- **Texture**

HPP treated meat develops rubbery consistency (Hugas *et al.,* 2002), this is because of adiabatic heat induced gelation of sarcoplasmic proteins (Angusupanich *et al*., 1999). It causes coagulation of albumin in eggs in combination with temperature. HPP causes proteolysis of bovine milk (Okamoto et al.,, 1990).

Advantages: Environment friendly, can be used for both solids and liquids, with or without packaging.

Disadvantages: High cost of initial investment, needs to be optimized for many products.

Commercial status in food industry: The commercial production of pressurized foods has become a reality in Japan, France, Spain, the USA and many other countries. This is a result of an extensive scientific research, technological and technical advances in HPP equipment production and decrease in the processing costs (Cheftel and Culioli, 1997). Nowadays, a commercial application of high hydrostatic pressure has found its place in the production of juices, sauces, smoothies, ready-to-eat meat products, guacamole, oysters etc (Patterson *et al*., 2007).

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