High pressure thermal sterilisation (HPTS)

Identification

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How does it work?

Primary objective: Inactivation of spores.

Working principle:
High pressure processing (400-600 MPa) at low, ambient or moderate temperature inactivates vegetative microorganisms only (pasteurisation). In case spores need to be inactivated (sterilisation), high pressure (600-800 MPa) needs to be combined with elevated temperatures (100-120°C processing temperature). During pressure build-up, due to adiabatic heating, the packed food product heats up very fast (initial temperature typically 70-90°C) and homogeneously to the required process temperature. This technology is therefore sometimes called pressure assisted thermal processing (PATP) or high pressure assisted sterilisation (HPS) (1). During pressure holding, measures are taken to maintain that temperature as homogeneously as possible (isolation, external heating, etc.) (2,3). Especially for food products that heat up due to conductive heating (solid and highly viscous products), the heating time is drastically reduced compared to conventional retort sterilisation. Thus, also the thermal load and quality loss is reduced.

Additional effects:
- Enzyme inactivation
- Textural changes (polymers). For instance, in carrots, where the texture is dominated by the cell wall polymer pectin, high pressure processing at elevated temperature results in a better texture retention (4).
- Depending on the type of compound, pressure can have a promoting or reducing effect on the thermal losses in vitamin, flavour and colour retention. However, as the processing times are generally shorter than for conventional thermal processing, the food product is expected to have a better quality (4).
- Structure modification (swelling)
- Gelation
- High pressure slows down the Maillard reaction, thereby reducing the risk of acrylamide formation (4).

Important process parameters:
temperature of vessel wall (preferably at process temperature to avoid non-uniformity in temperature), temperature of pressure transferring medium, pressure build-up rate, pressure leve, treatment time, preheating time of food product) (5)

Important product parameters:
initial product temperature (preheating is required), pH, composition (sugar, fat, protein content), initial microbial load, compressibility and heat capacity (influencing temperature increase during compression)
What can it be used for?

**Products**
This technology is most interesting for food products that heat through conduction. HPHT processing allow fast heating of these products and thus shortens the process time. The technology can also be used for packed conductive heating food products, but in that case, HTST processing followed by aseptic filling might be economically more feasible. Typical applications: meat, fish, seafood, vegetable and fruit products.

**Operations**
Sterilisation, structure forming

**Solutions for short comings**
Sterilisation of heat-sensitive conductive heating foods (solid or highly viscous fluid foods).

What can it NOT be used for?

**Products**
Dry food products

**Operations**
• Pasteurisation
• Unpacked foods

**Other limitations**
• The technology is performed in batch on prepacked products and consists of three steps: preheating of the product to the initial temperature (typically 70-90°C), pressurisation and cooling. This results in a low capacity (e.g. 4 tons/h).
• High pressure in combination with high temperature puts a high stress on the high pressure vessel and seals.
• High pressure vessel wall is best set at processing temperature (typically 100-120°C) to avoid temperature non-uniformity. This is however an issue when water is the pressure transferring medium (as is usual in food industry).
• High investment and maintenance costs.
• Packaging needs to withstand high pressure and high temperature.
• Undesired changes of functional and technological properties of polymers (e.g. proteins) are possible.

**Risks or hazards**
• Target strains (*Cl. Botulinum*) for thermal processing are not necessarily the target strains under high pressure, high temperature; more research is needed for the most resistant strain and its heat inactivation kinetics.
• The issue of temperature uniformity needs to be addressed to assure process impact uniformity.
• A reliable continuous online measurement of food temperature during HPTS treatment is needed to adjust the process for each batch.

Implementation

**Maturity**
While many applications exist for high pressure processing at low to moderate temperature, the applications of high pressure high temperature processing are mainly limited to pilot scale. Temperature control and temperature uniformity remain the greatest challenges. Tools to asses the temperature uniformity include thermosensors (6), numerical modelling (5) and pTTls (7). A new control system for a continuous online measurement of temperatures inside the vessel has been developed within the frame of i3Food eu-project, which can modulate the process for each batch and assure the process impact. At the moment, no products are on the European market that have been sterilised using a combination of pressure and temperature.
Modularity/Implementation

High pressure thermal sterilisation is performed in-pack and specific packaging material and geometry (to optimize the load of the vessel) is required. Prior to pressurization, the food product needs to be heated to the initial temperature (typically 70-90°C), which requires a separate heating unit. The process is scalable by the use of multiple machines or pressure vessels. A tandem equipment (one pressure intensifier for two pressure vessels) allows to optimize the production capacity.

Consumer aspects

Consumers perceive high pressure processing as environmental friendly and are positive to naturalness of the product. There is no reason to expect that their attitude to high pressure thermal sterilization would be different.

Legal aspects

In Europe, food products produced using this technology are potentially subject to the Novel Food Regulation (Regulation (EC) No 258/97). However, many high pressure pasteurised food products have been placed on the market (e.g. Spain, Czech Republic) without specific approval by the European Commission, as the national competent authority decides on the legal status on the basis of appropriate data provided by the manufacturer. If “substantial equivalence” to existing food products can be shown, the Novel Food Regulation does not apply. This “substantial equivalence” requires compositional analysis, information on the expected consumption pattern and its effect on the consumers’ nutritional status, toxicological data and information on the allergenic potential of the food (HP pasteurised fruit-based preparations). Significant changes induced by high pressure processing need to be assessed on a case-by-case basis.

To date, only one approval under the Novel Food Regulation has been given (Danone case in 1998), for an application of high pressure at low temperature, albeit the product was never released on the market.

High pressure processing does not have to be mentioned on the label. Producers of high pressure processed foods should be aware that in some cases other approval than under the Novel Food Regulation may be required.

The FDA has approved pressure assisted thermal processing for low-acid foods (2009). In this filing, the idea was followed that high pressure is merely a means to reach thermal processing conditions.

Producers of high pressure equipment need to comply with the Pressure Equipment Directive (97/23/EC). Furthermore, the high pressure equipment needs to be inspected at the food manufacturing plant (8).

Specifically for high pressure thermal sterilisation, protocols to achieve the required process impact (i.e. spore inactivation) and process uniformity have to be elaborated.

Environmental aspects

The specific energy input required for sterilization of cans can be reduced from 300 to 270 kJ/kg when applying the HHP treatment on flexible packaging. In case of HHP processing, a compression energy recovery rate of 50% can be estimated when a two-vessel system or pressure storage is used. This means that, by making use of energy recovery, a specific energy input of 242 kJ/kg will be required for sterilization, corresponding to a reduction of 20% in the total energy requirements (9).
### Facilities that might be interesting for you

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<td>HP Industrial scale IRTA</td>
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<td>HP Labscale IRTA</td>
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<td>HP lab-scale multivessel equipment KU Leuven</td>
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### Further Information

#### Institutes
- DIL, KU Leuven LFT, Wageningen UR - FBR, IRTA, CSIRO, TU Berlin

#### Companies
- Hiperbaric, Resato, Uhde-HPT

#### References
2. de Heij et al. (2003) High-pressure sterilization: Maximizing the benefits of adiabatic heating, Food Technology 57 (2003), pp. 37-41
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9. Toepfl et al. (2006) Review: Potential of high hydrostatic pressure and pulsed electric fields for energy efficient and environmentally friendly food processing, Food Reviews International 22, 405–423