High-pressure low-temperature processes to improve the quality of frozen food products

Identification

<table>
<thead>
<tr>
<th>Key words</th>
<th>high pressure freezing, high pressure thawing, high pressure induced crystallization, food quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latest version</td>
<td>2012/05/31</td>
</tr>
<tr>
<td>Completed by</td>
<td>KU Leuven LFT</td>
</tr>
</tbody>
</table>

How does it work?

| Primary objective                | Increase freezing and thawing rates and reducing the microbial load of frozen foods using a post-freezing process. |
When submitted to high pressure at different sub-zero temperatures, water undergoes different ice phases. If pressure is raised from ambient pressure, the freezing temperature is reduced which is related to the fact that water expands on freezing. The freezing curve reaches a minimum at 207.5 MPa where the freezing temperature has dropped to -22°C. This freezing point depression suggests the possibility of new applications such as storage at sub-zero temperatures without freezing, high pressure assisted freezing (HPAF), high pressure shift freezing (HPSF), high pressure assisted thawing (HPAT), high pressure induced thawing (HPIT), and high pressure induced crystallization (HPIC) (Figure 1).

Figure 1. (Theoretical) phase diagram of pure water indicating the most interesting High-pressure low-temperature pathways. ABCD: High pressure assisted freezing (HPAF). ABEFG: High pressure shift freezing (HPSF). HI: High pressure induced crystallization (HPIC) to ice III. GFEBA: High pressure induced thawing (HPIT). Reproduced from (1).

The primary food application of pressure in relation to the phase diagram of water is the increased freezing and thawing rates obtained during high pressure freezing and thawing processes. HPSF refers to a process in which cooling is performed at constant elevated pressure in such a way that the liquid-ice I phase transition line is not crossed and instantaneous nucleation of ice I occurs upon pressure release, followed by completion of the freezing process at atmospheric pressure. As ice crystals resulting from HPSF processes are small sized and uniformly distributed throughout the whole sample depth, HPSF can be used to improve the structural and textural quality of different food products including fruit- and vegetable-based products (2) and meat products (3).

The reverse processes of high pressure freezing, HPAT and HPIT, make thawing at temperatures below 0°C possible. Because of the large difference between the thawing medium temperature and the phase transition temperature (and the reduced latent heat at elevated pressure), the thawing process is faster at elevated pressure as compared to atmospheric thawing. Faster thawing under high pressure has been shown for many meat and fish products (4, 5).

Images

Additional effects
• The transient phase change of ice I to ice III during pressurization of frozen systems (HPIC) appears to be an effective way to reduce bacterial contamination (6, 7).
• Increased smoothness and mouth coating of HPLT treated frozen foam (11)

Important process parameters
Pressure and temperature conditions should be carefully chosen. Registration of the temperature and pressure in the food sample is strongly advised to assure complete phase transitions during the processes. In case of HPSF, appropriate frozen storage conditions should be chosen in order to maintain the optimal quality of the frozen product. Pressure medium should be carefully chosen to avoid freezing of the medium ((tap)water is not possible).

Important product parameters
water content, solids composition
What can it be used for?

**Products**
Frozen food products and products to be frozen (fruits, vegetables, seafood, meat, ....

**Operations**
Freezing, thawing, stabilization

**Solutions for shortcomings**
Reduced drip loss in fruit- and vegetable-based products (2) and meat products (3)

What can it NOT be used for?

**Products**
Continuous processing is not possible. High pressure, low-temperature processes are batch processes.

**Operations**
HPLT treatment can not replace mechanical aeration of separated air and liquid phases (11).

**Other limitations**
- Although bacterial contamination can be reduced during a post-freezing HPIC process, the process cannot be used as a post-freezing blanching step because important quality-deteriorating enzymes such as polyphenoloxidase are not inactivated during the HPIC process (9).
- Discoloration of fish products (4) and whitening of meat products (8) during HPT processes at elevated pressures has been observed.

Risks or hazards

Implementation

**Maturity**
Lab-scale equipment is available.

**Modularity/Implementation**
High pressure, low-temperature processes are not industrially implemented (yet).

**Consumer aspects**
A consumer study in Netherlands, Belgium, Spain and Finland showed that attitudes towards high pressure freezing were neutral (10).

**Legal aspects**
HPP foods fall in the scope of Regulation (EC) 258/97 on novel foods and novel food ingredients, article 1, item f. Among other categories, this legislation applies to foods and food ingredients to which a production process not currently used has been applied, and evaluates possible changes in nutritional value, metabolism and level of undesirable substances (5). In January 14th 2008, EU published a proposal for the amendment of Regulation (EC) 258/97. (6)

The competent authorities of the member states agreed in 2001 that the national authorities should decide on the legal status of high pressure treated foods, as it was no longer considered to be a novel process. Case-by-case assessment by national authorities must ensure the products’ safety.

**Environmental aspects**
Energy efficient, waste free technique
Facilities that might be interesting for you

<table>
<thead>
<tr>
<th>Title</th>
<th>Institute/company</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP FRIP unit</td>
<td>FRIP</td>
</tr>
<tr>
<td>HP Industrial scale IRTA</td>
<td>IRTA</td>
</tr>
<tr>
<td>HP Labscale IRTA</td>
<td>IRTA</td>
</tr>
<tr>
<td>HP lab-scale multivessel equipment KU Leuven</td>
<td>KU Leuven LFT</td>
</tr>
<tr>
<td>HP lab-scale single-vessel equipment KU Leuven</td>
<td>KU Leuven LFT</td>
</tr>
<tr>
<td>HPHT lab-scale multivessel equipment KU Leuven</td>
<td>KU Leuven LFT</td>
</tr>
<tr>
<td>HPP Pilot system DIL</td>
<td>DIL</td>
</tr>
<tr>
<td>HPPS Labscale System FBR</td>
<td>Wageningen UR - FBR</td>
</tr>
<tr>
<td>HPPS Pilot System FBR</td>
<td>Wageningen UR - FBR</td>
</tr>
</tbody>
</table>

Further Information

**Institutes**
- KU Leuven LFT, Wageningen UR - FBR, TU Berlin, VTT Technical Research Centre of Finland, GEPEA, Instituto del Frío

**Companies**
- Hiperbaric, APA Processing, Resato, Uhde-HPT

**References**