How does it work?

**Primary objective**
Inactivation of vegetative pathogenic and spoilage microorganisms

**Working principle**
High-pressure carbon dioxide (HPCD) is proposed as an alternative non-thermal pasteurization technique for foods (3). HPCD technique, food is contacted with either (pressurized) sub-or supercritical CO2 for a certain amount of time in a batch, semi-batch or continuous manner. Supercritical CO2 is CO2 at a temperature and pressure above its critical point values (Tc=31.1 °C, Pc=7.38 MPa), and exists as a single phase (8).

A pressurization step with CO2 for a set treatment time is done to allow the penetration of the applied gas into the microbial cells, and a subsequent explosive decompression, resulting from a rapid gas expansion within the cells. The technology has been shown to inactivate microorganisms. CO2 pressure applied for the preservation purposes is much lower (generally < 20 MPa) and critical temperature (31.7°C). Microbial inactivation strongly depends on the water content of the product during HPCD treatment. Vegetative cells with low water content are poorly inactivated, and that their resistance to inactivation increased with decreasing water content, that’s why HPCD treatment in general results in great or complete microbial inactivation. HPCD treatment would not be applicable to dry substances. Very few researchers investigated the possibility to exploit the treatment on solid foods, since high-pressure CO2 is often used for extractions in the food industry, HPCD treatment on solid foods could possibly extract essential food compounds. The extraction problem is considerably less for liquid foods as the extracted materials, with the exception of highly volatile compounds, are retained in the vessel in a static apparatus (8).

**Images**
Among 13 enzymes identified in untreated cells, some significantly lost their activities, whereas others were only little affected by pressurized CO2 (3).

**Additional effects**
HPCD treatments can also improve the physical quality of liquids. Continuous processing for liquid foods is possible and applicable to acid foods (8).
Increasing the temperature the solubility of CO2 decreases. The presence of other substances in the liquid food could have a positive or negative effect on solubility (11).

There is limited literature on CO2 solubility in real liquid foods, that's why the solubility of CO2 in liquid foods at different temperatures, pressures, and compositions that correspond to real foods is not known. Process temperature can range to avoid the thermal damage to processed foods (1). The CO2 pressure applied for the preservation purposes are much lower (generally < 20 MPa) compared to the hydrostatic pressures employed in HHP (300 - 600 MPa) (2). The treatment times can range from about 3 and 9 minutes to about 120 and 140 minutes depending on the HPCD equipment (continuous, semi-continuous or batch) and the kind of food that is processed.

### What can it be used for?

**Products**
- Liquid food (eg. liquid whole egg, juices, tomato puree, grape must, beer, milk, wine)

**Operations**
- Pasteurization, inactivation, stabilization

**Solutions for shortcomings**
- Improve the shelflife while maintaining its nutritional and organoleptic properties
- Improve food quality No loss of nutrients or quality changes (e.g. no taste or aroma changes are perceived, vitamin quality is maintained) Microbial inactivation “Freshness” being top priority

### What can it NOT be used for?

**Products**
- Microbial sensitivity to HPCD treatment varies greatly among species. The inactivation rate is strongly affected by the constituents of the suspending media and nature of foods during HPCD treatment (8).

**Operations**
- Depend on the food system (e.g. color can change resulting in a cooked appearance)

**Other limitations**
- The effect of a HPCD treatment on the sensory and nutritional quality of both liquid and solid foods is more investigated (8).

### Implementation

**Maturity**
- Liquid food (mainly beverages, juices, milk and wine) HPCD pasteurization is operational and almost ready to be employed at commercial scale. A commercial-scale unit of 150 L/min was also constructed (6) and tested at an orange juice processing plant. HPCD processing extends also the shelf life (e.g. liquid whole egg up to 5 weeks at 4 °C (1)) and improves the physical quality of liquid (e.g. cloud stability of orange juices processed by HPCD is retained after refrigerated storage (e.g. enzyme inactivation)), and could prevent the browning of apple juice. Praxair developed a continuous process system which utilizes HPCD processing as a non-thermal alternative to thermal pasteurization (6).

**Modularity**
- Liquid food HPCD pasteurization is operational and almost ready to be employed at commercial scale. Membrane contactor consisting of several hollow fibre membrane modules for the continuous HPCD pasteurization of liquid foods.
**Consumer aspects**
No negative effects

**Legal aspects**
HPCD pasteurized foods probably must be regarded as novel foods. Before a novel food can be placed on the EU market, applications must be submitted in accordance with Commission Recommendation 97/618/EC, that concerns the scientific information and the safety assessment report required.

**Environmental aspects**
Environmentally benign nature of the HPCD process (CO2 is nontoxic)

**Facilities that might be interesting for you**

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<td>Clean room – Histocell</td>
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<td>Video observation system for market research and product development tasks - Keki</td>
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**Further Information**

**Institutes**
INRA, VITO, Ghent University - LFMFP, University of Trento, University of Padova

**Companies**
Separex, Feyecon, ACP

**References**