Advanced Food Technologies

Increasing process efficiency, product quality and safety.
New structure generation and product development.

Workshop: Gebündelte Lebensmittelkompetenzen an der BOKU

10. November 2021

ADVANCED TECHNOLOGIES

INCREASING PROCESS EFFICIENCY, PRODUCT QUALITY AND SAFETY. NEW STRUCTURE GENERATION AND PRODUCT DEVELOPMENT.

Technology focus

- Pulsed electrical fields (PEF)
- High pressure
  - Static high pressure (HPP)
  - High pressure homogenisation (HPH)
  - Shockwaves (dynamic pressure)
  - Supercritical water and CO2
- Light systems (UV, Pulsed light, IR)
- Electron beam (irradiation)
- Ultrasounds
- Ohmic heating

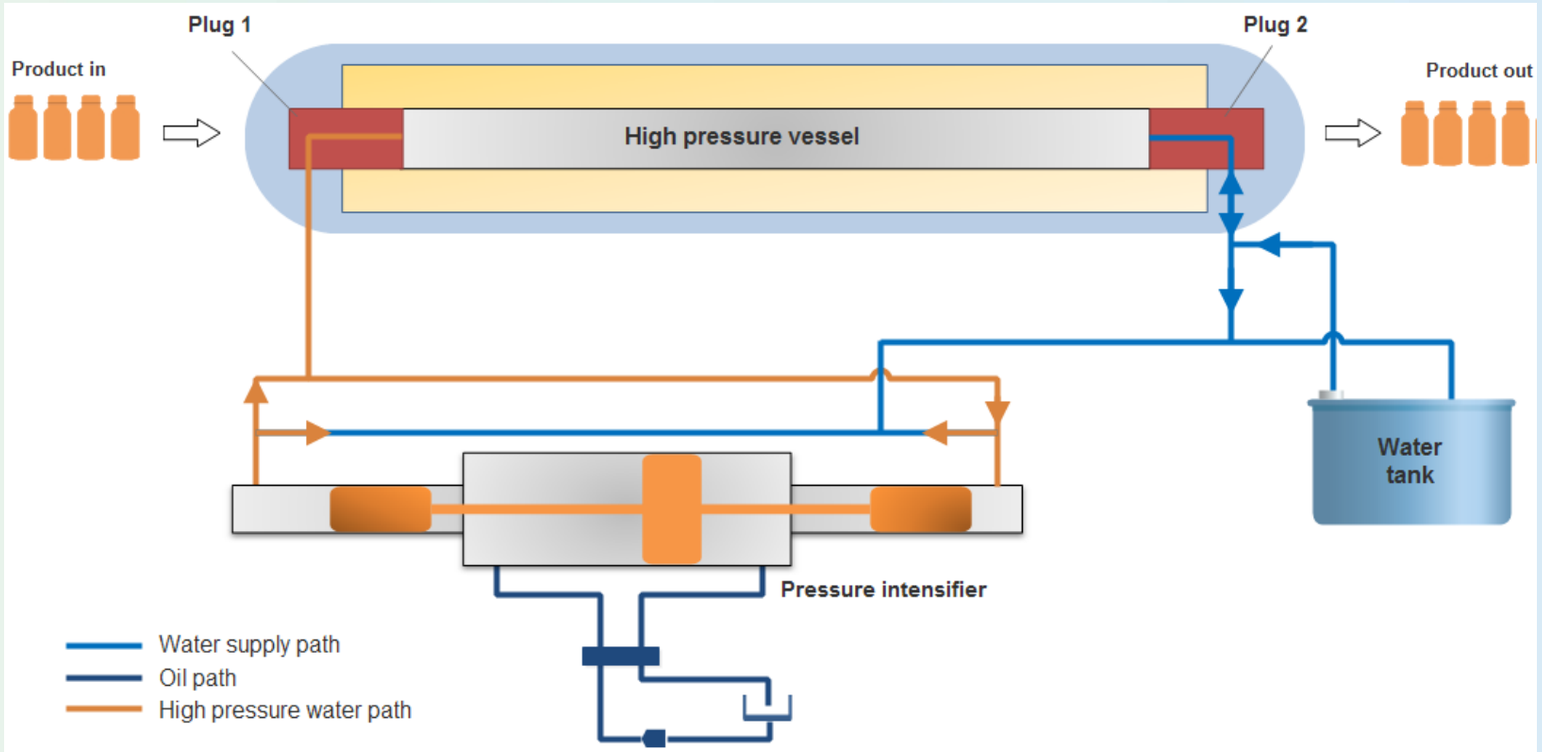
Research focus

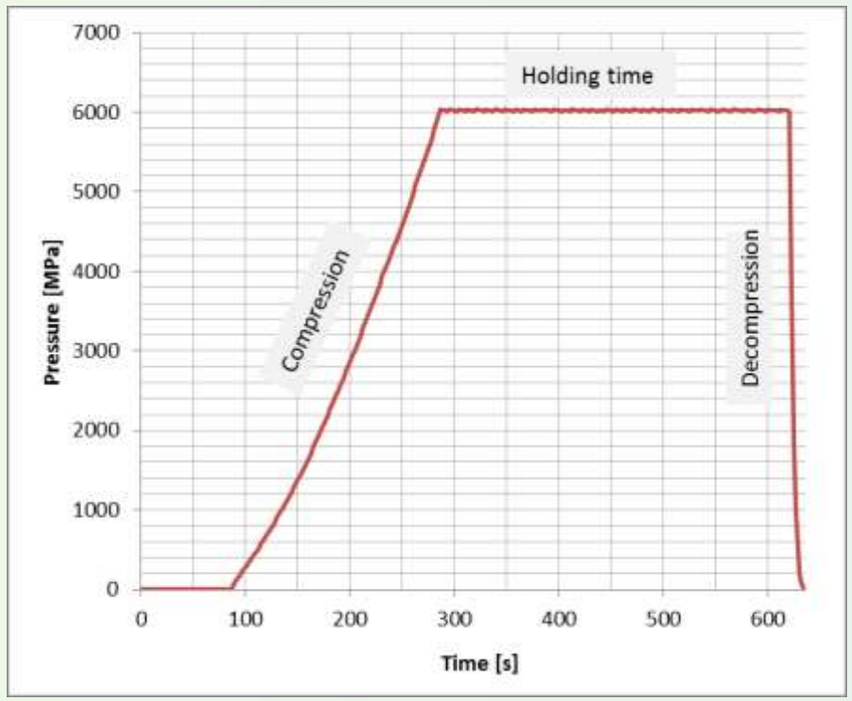
- Different applications
- Impact on food quality
- Impact on safety
- Microbial inactivation
- Process efficiency
- Process scalability
- Energy assessment
- Sustainability assessments
- Legal aspects

HIGH HYDROSTATIC PRESSURE

HIGH HYDROSTATIC PRESSURE

GOVERNING PRINCIPLES





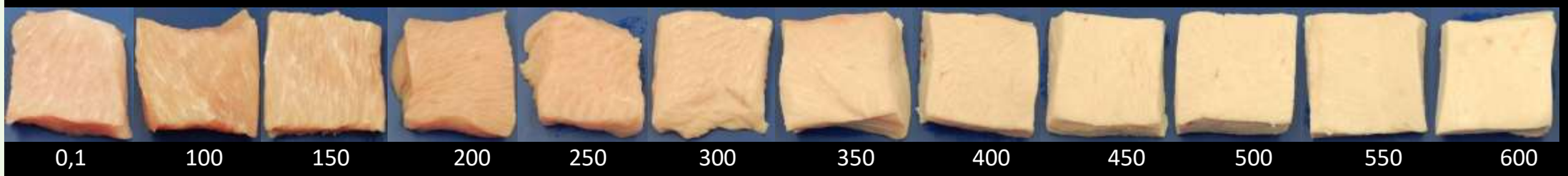
HIGH PRESSURE PROCESSING

EFFECTS ON PROTEIN – OBSTACLE OR OPPORTUNITY?

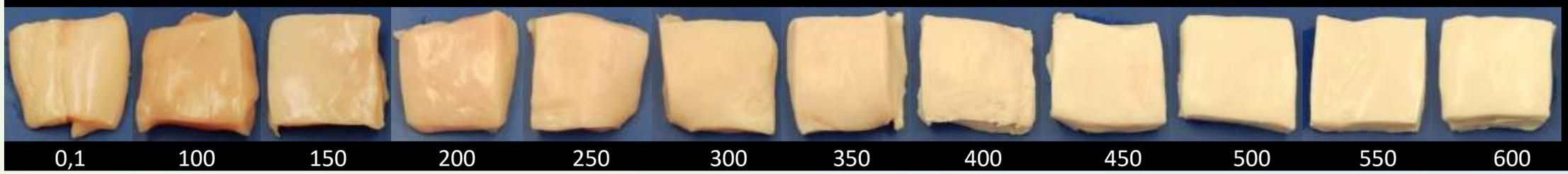
Colour changes in roast beef (*M. longissimus dorsi)* after 3 min. at 0,1 – 600 MPa and 18 °C

Colour changes in pork loin (*M. longissimus dorsi)* after 3 min. at 0,1 – 600 MPa and 18 °C

Colour changes in turkey breast *(M. pectoralis superficialis)* after 3 min. at 0,1 – 600 MPa and 18 °C



Colour changes in chicken breast *(M. pectoralis superficialis)* after 3 min. at 0,1 – 600 MPa and 18 °C



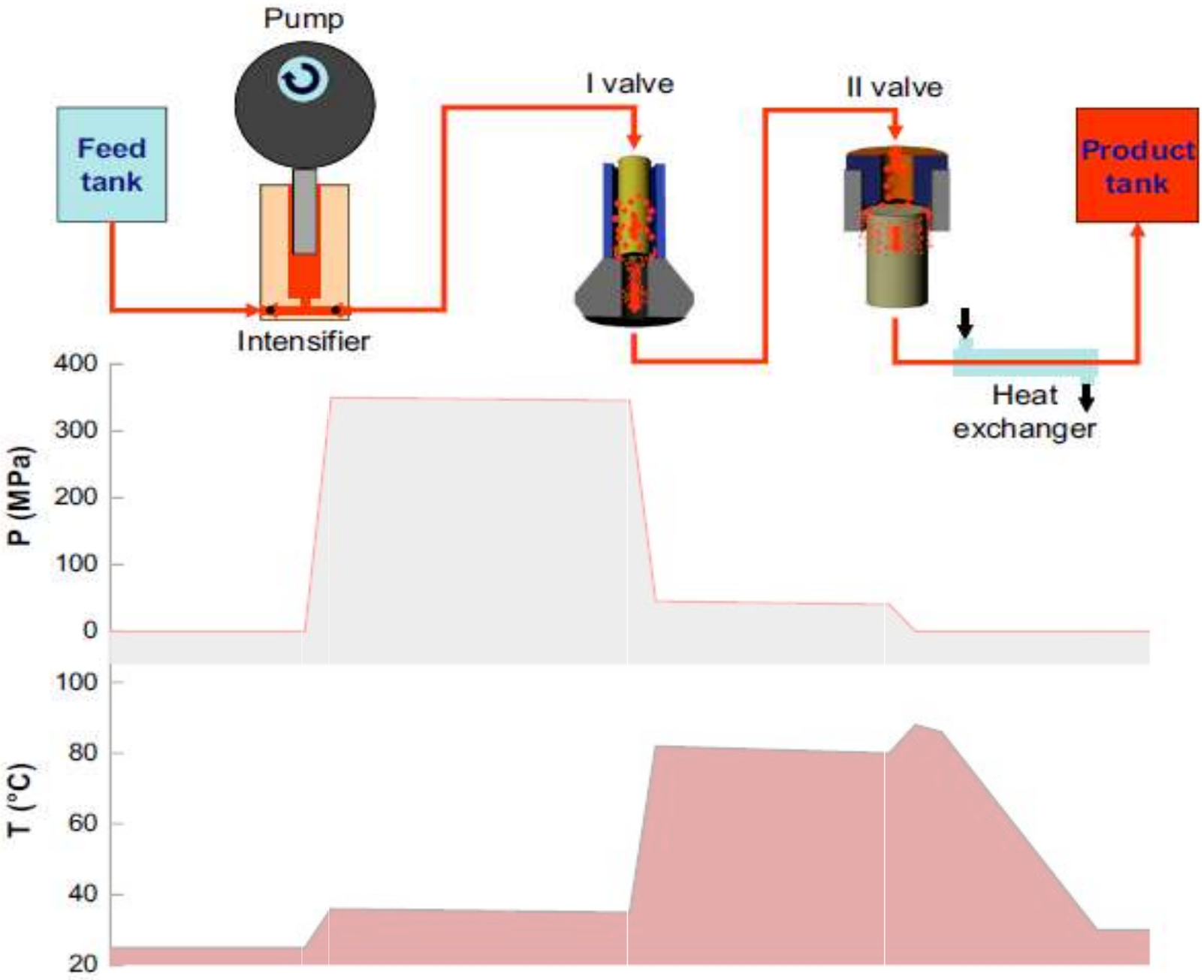
HIGH HYDROSTATIC PRESSURE EQUIPMENT

Equipment	Wave Hiperbaric 600/55	Nova Swiss	Unipress
Max. Pressure	600 MPa	600 Mpa	700 Mpa
Treatment chamber volume	55 L	2 L	5 mL
Pressure build up	150 MPa/min	100 (≤ 400 MPa) MPa/min 80 (> 400MPa) MPa/min	100 MPa/min
Temperature controle	No	Yes	Yes
Temperature range	Chilled to room temperature	-20 to +80 °C	-20 to +120 °C

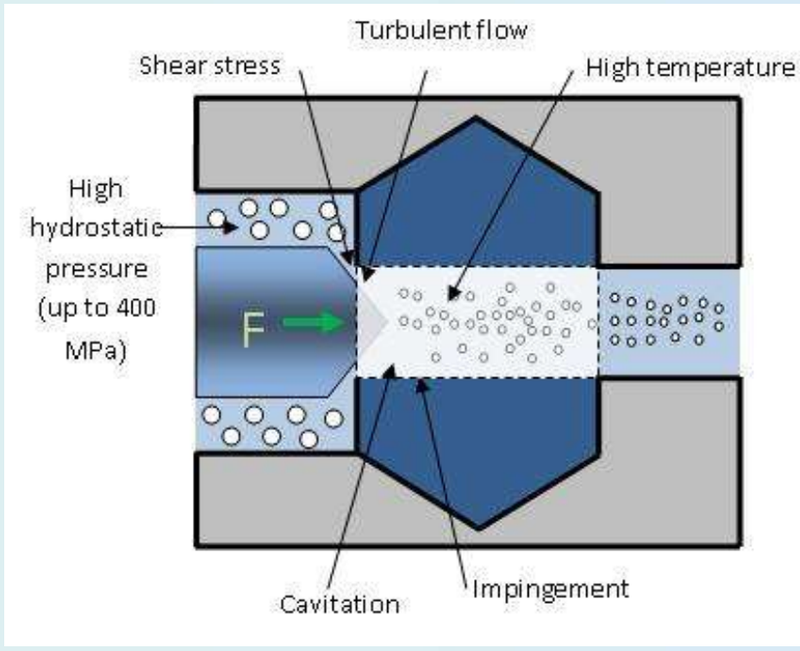
ULTRA HIGH PRESSURE HOMOGENISATION

HIGH PRESSURE HOMOGENISATION

DYNAMIC HIGH PRESSURE FOR PRESERVATION AND STRUCTURE MODIFICATION



Donsi et al. 2009



Fluid temperature increase due to:

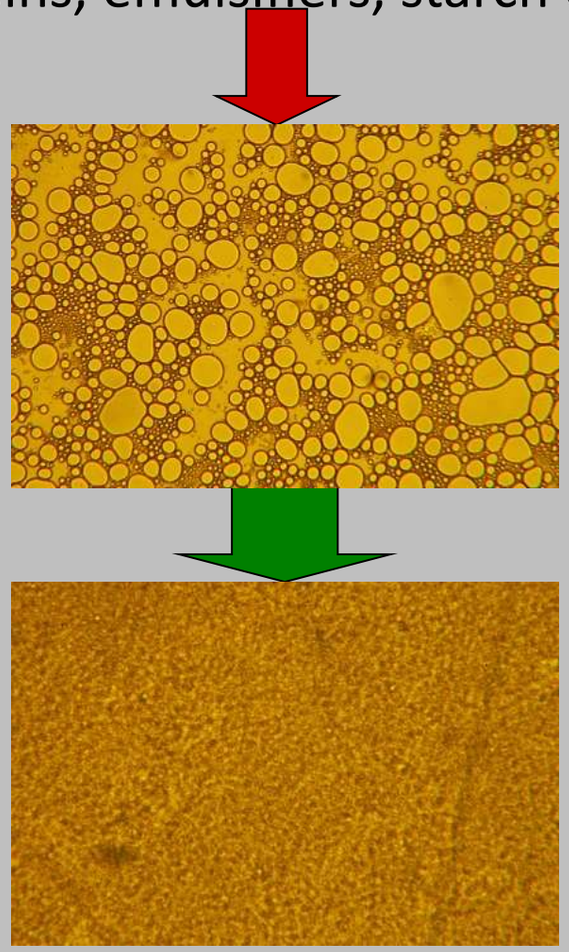
- Compression; Adiabatic heating
  (~3 °C/100 MPa)
- Shear effect
- Instantaneous pressure drop
  (15-20 °C/100 MPa)
- Conversion of kinetic energy to heat

HIGH PRESSURE HOMOGENISATION

DYNAMIC HIGH PRESSURE FOR PRESERVATION AND STRUCTURE MODIFICATION

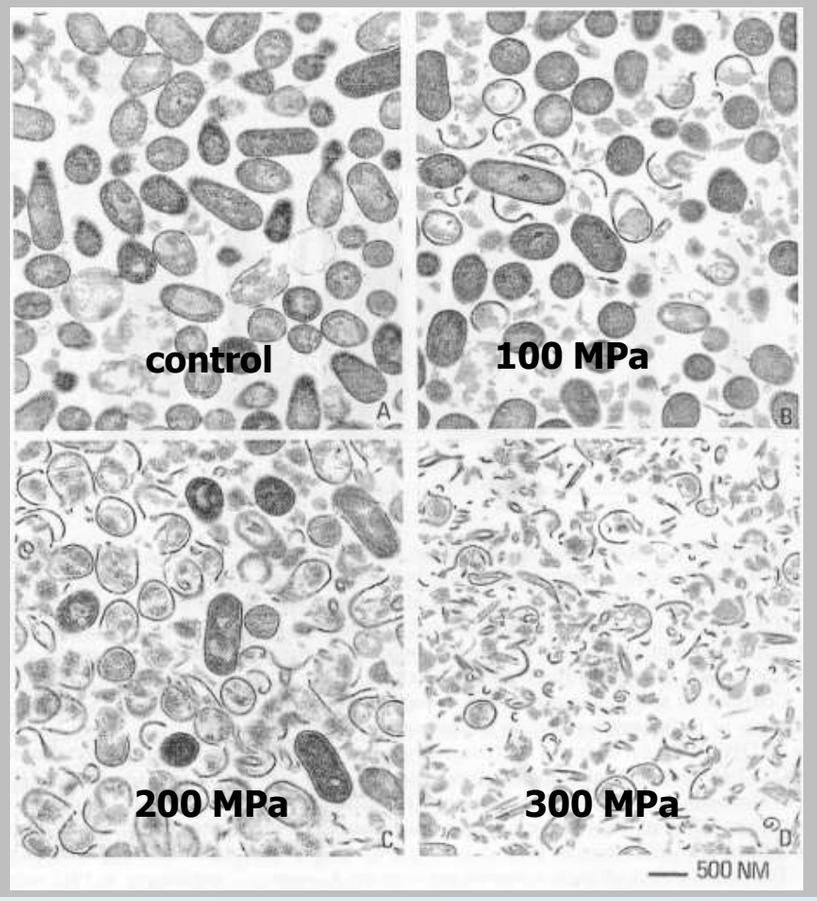
Structural modification

- Particle ad fat droplet size reduction (Nanoparticles, nanosuspensions)
- Modification of constituents (proteins, emulsifiers, starch etc.)



Cell disruption

- Reduction of microbial load
- Extraction of compounds (e.g. algae)



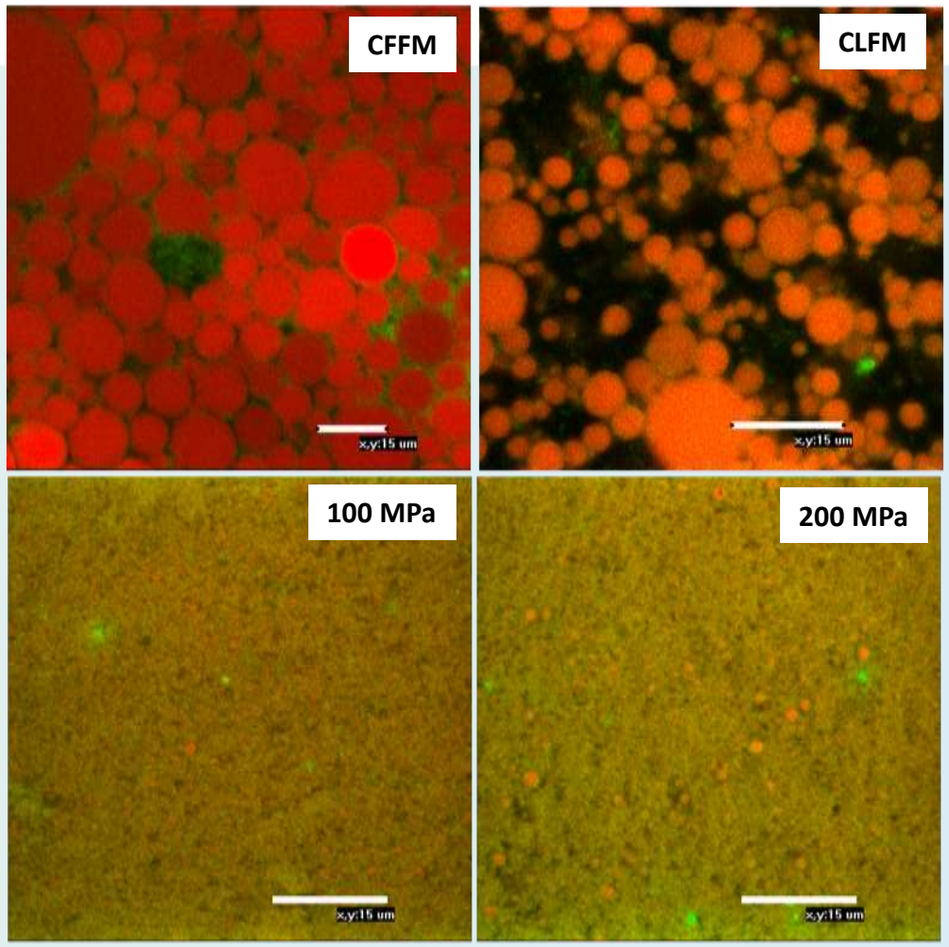
HIGH PRESSURE HOMOGENISATION

LOW FAT EMULSION

1. **Pre-emulsion preparation**
   - Water 56 %
   - Egg yolk (PLA2 modified) 8 %
   - Sugar 2 %
   - Mustard 1 %
   - Salt 1 %

2. **Addition of fat and acidic phase**
   - Liquid fat slowly added during mixing **28 %**
   - Finally:
     - Vinegar 3 %
     - Citric acid 1 %

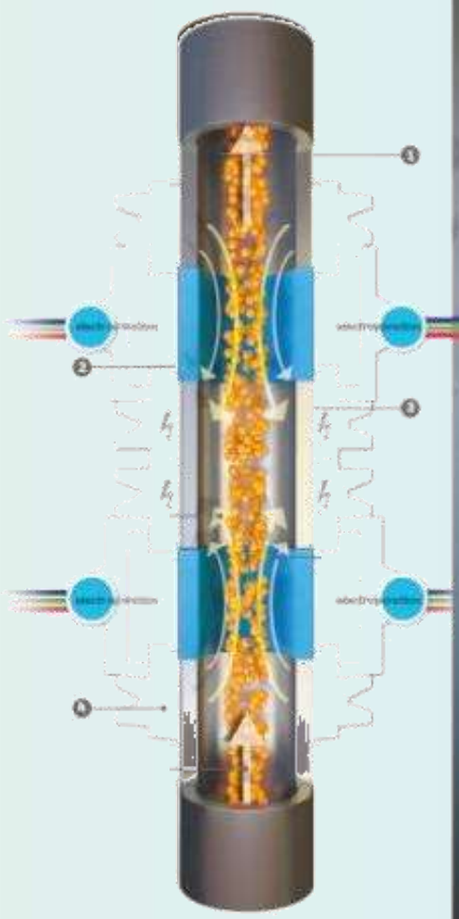
3. **High pressure homogenisation**
   - 100-350 MPa

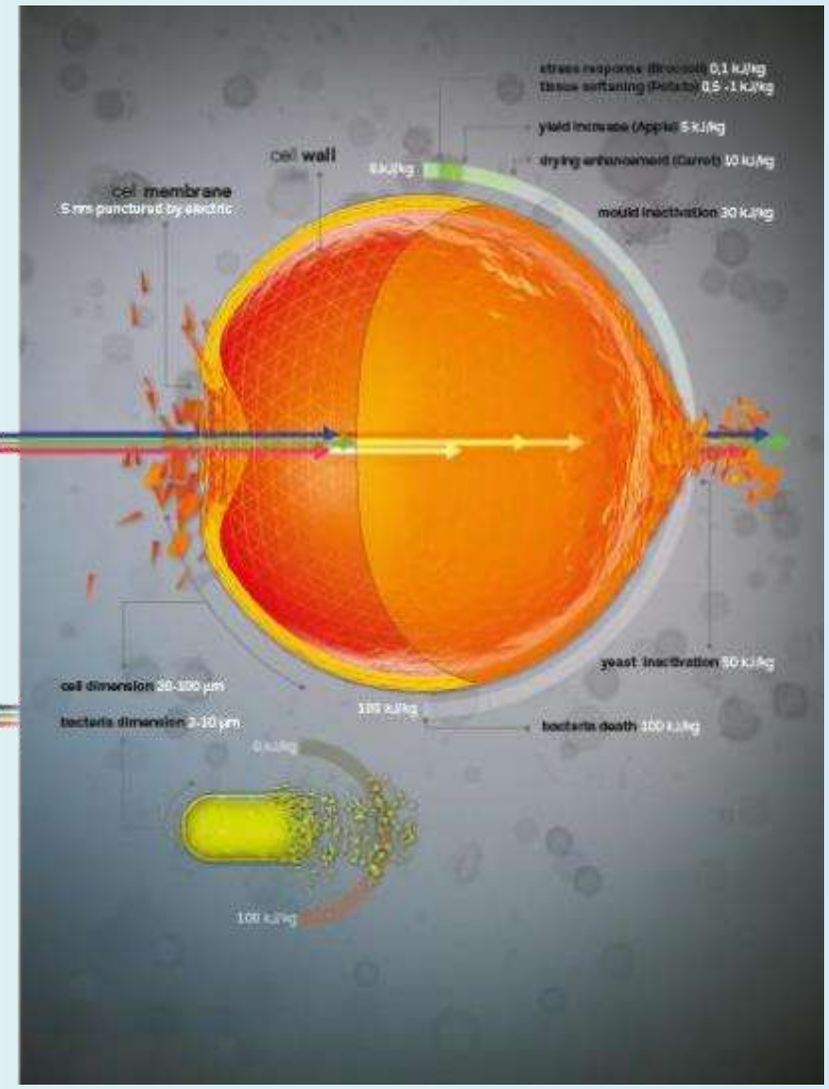


Confocal laser scanning microscopy (CLSM)

100 MPa **200 MPa** **300 MPa** **350 MPa**

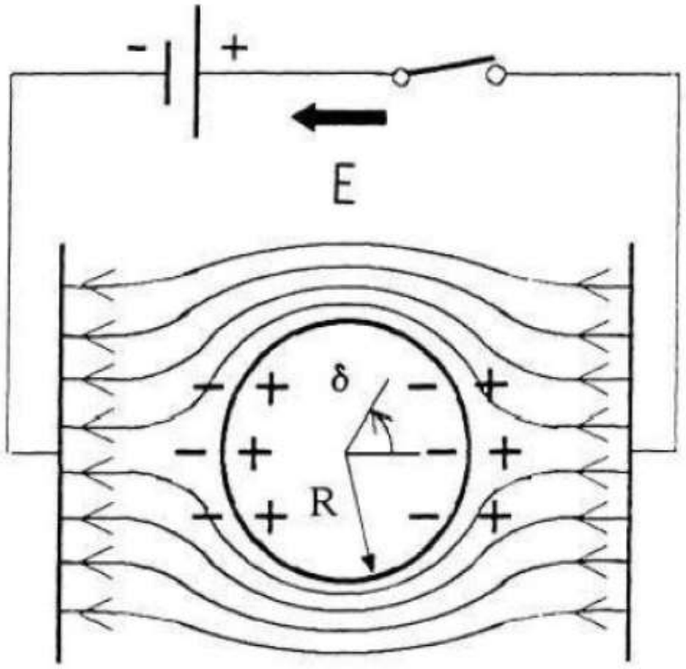
PULSED ELECTRIC FIELDS





PULSED ELECTRIC FIELDS

ELECTROPORATION



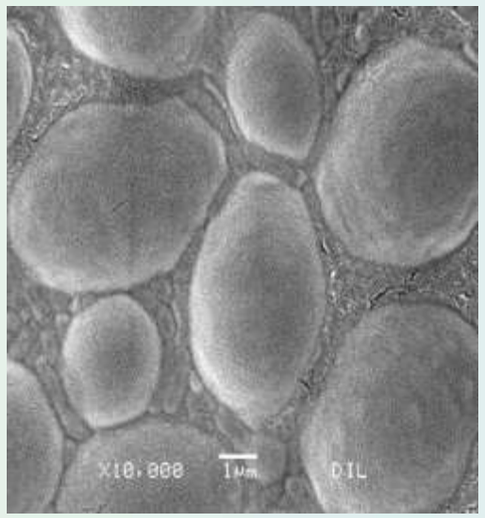
1. Pore induction
   (reversible)

   Induction of stress response

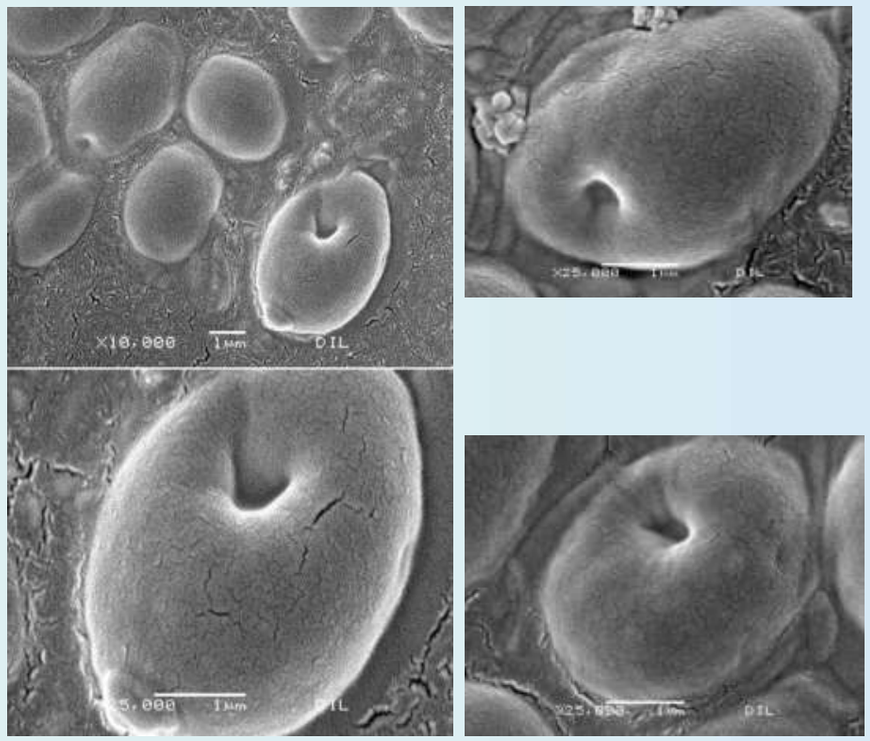
2. Expansion and Stabilisation
   (irreversible Pore)

   Loss of semipermeability
   Loss of vitality
   Loss of turgor pressure

Untreated



PEF-treated

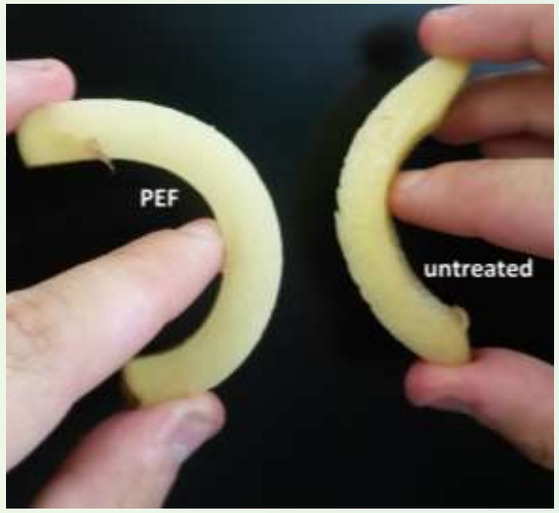


Aganovic, K., Siemer, C., Toepfl, S., Heinz, V. (2012). Microscopic analysis of yeast and *Listeria innocua* after PEF, HPP and temperature treatment in Ringer´s solution. Poster presentation at Kongress Lebensmitteltechnologie, Dresden, Germany

ADVANCED TECHNOLOGIES

INCREASING PRODUCT QUALITY AND SAFETY, AND PROCESS EFFICIENCY

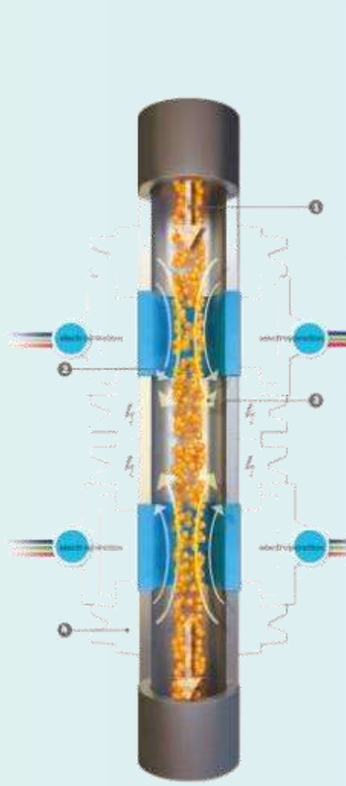
- **Pulsed electric fields**
  - Electroporation for structure modification
  - Gentle preservation
  - Improved mass transfer

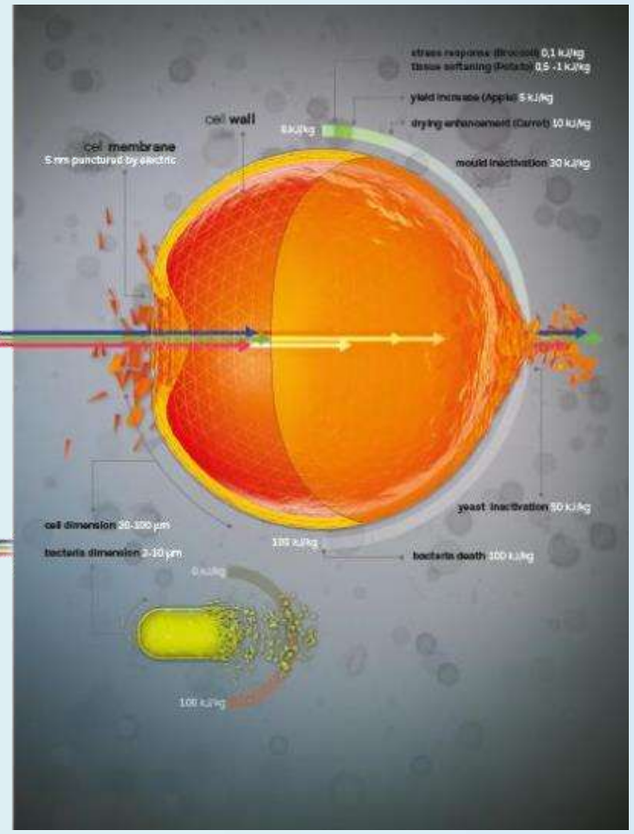


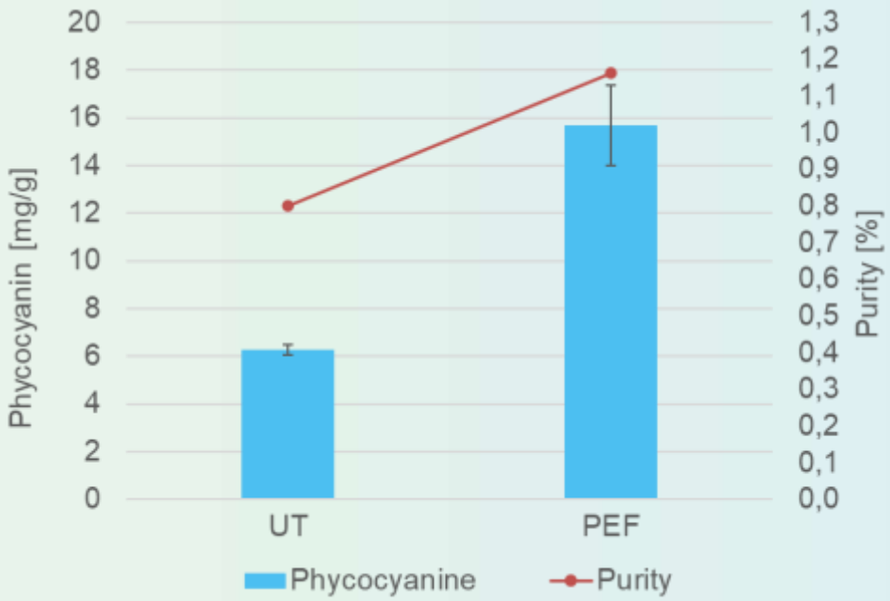
Freshly squeezed, untreated

Thermally treated

PEF treated







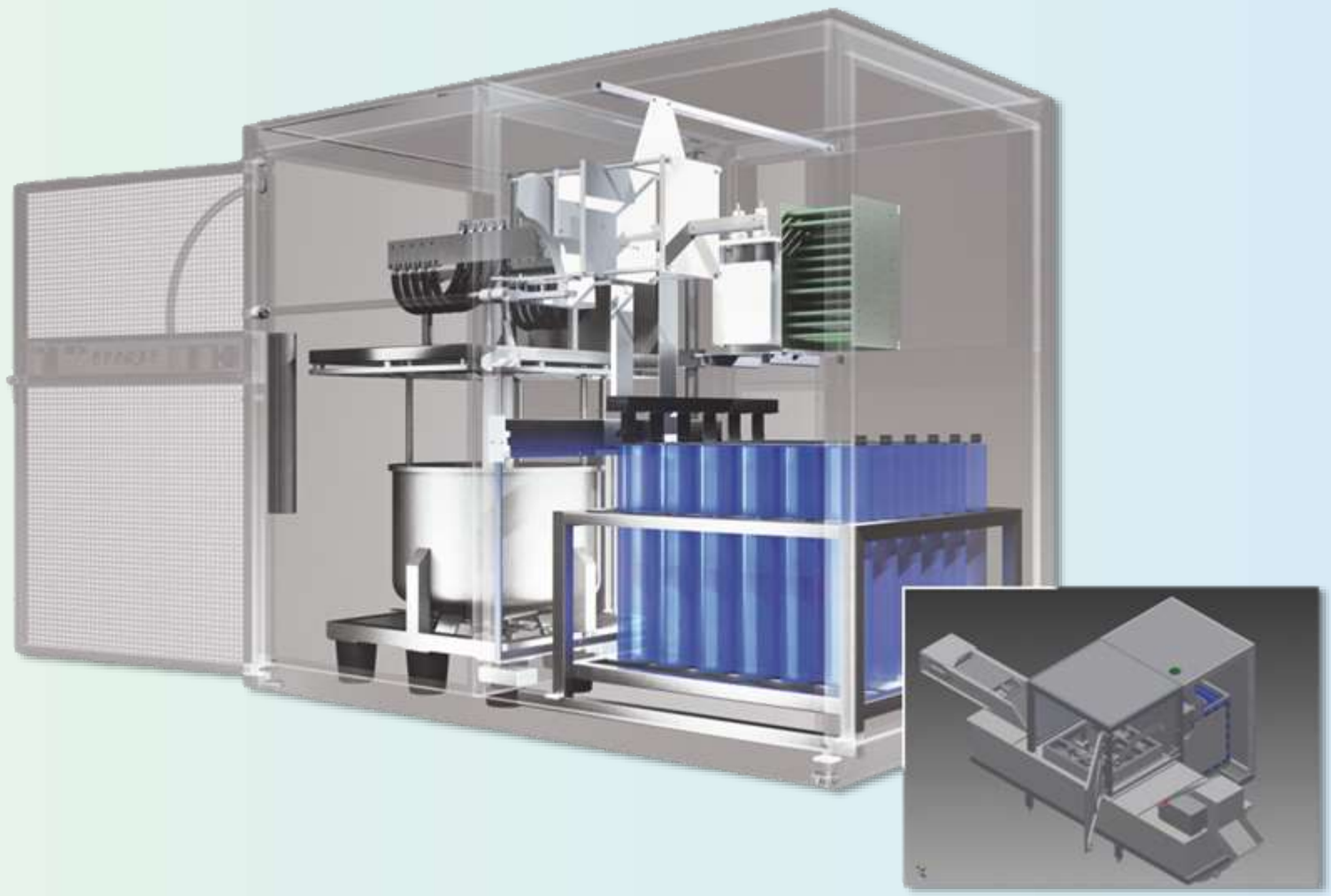
PEF

Untreated

PULSED ELECTRIC FIELDS

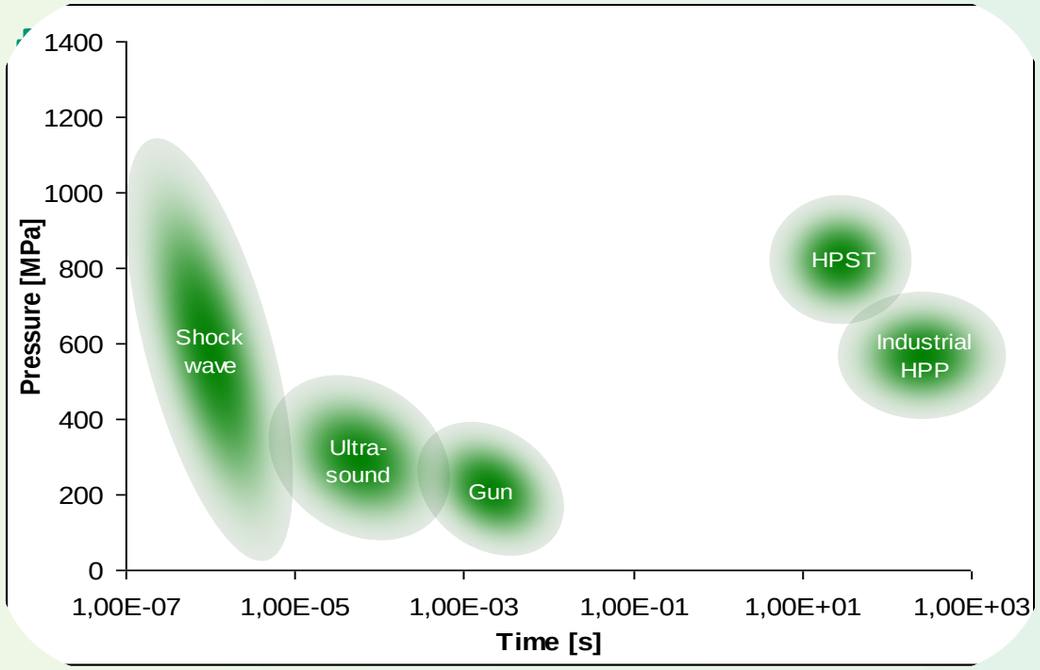
GENTLE JUICE PRESERVATION

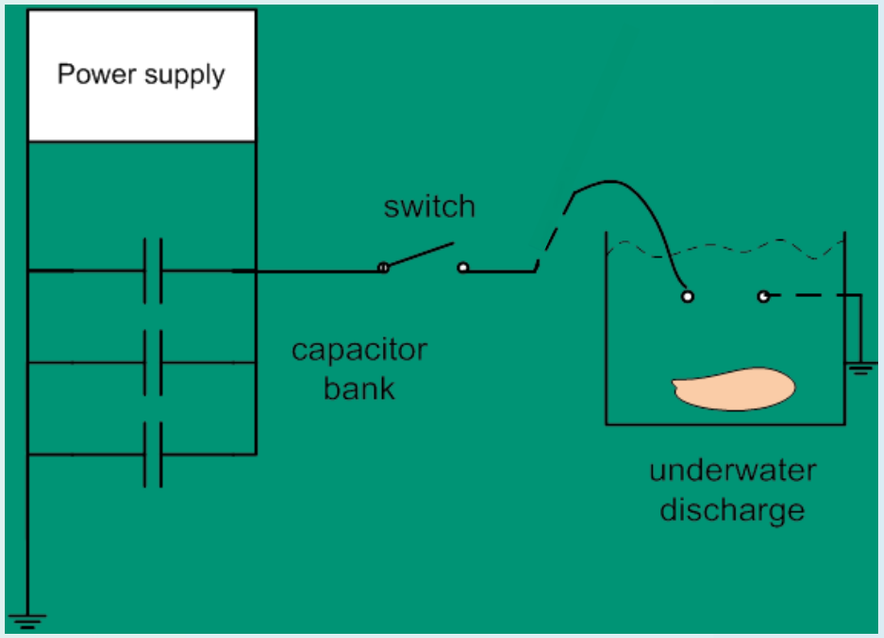
SHOCKWAVE PROCESSING

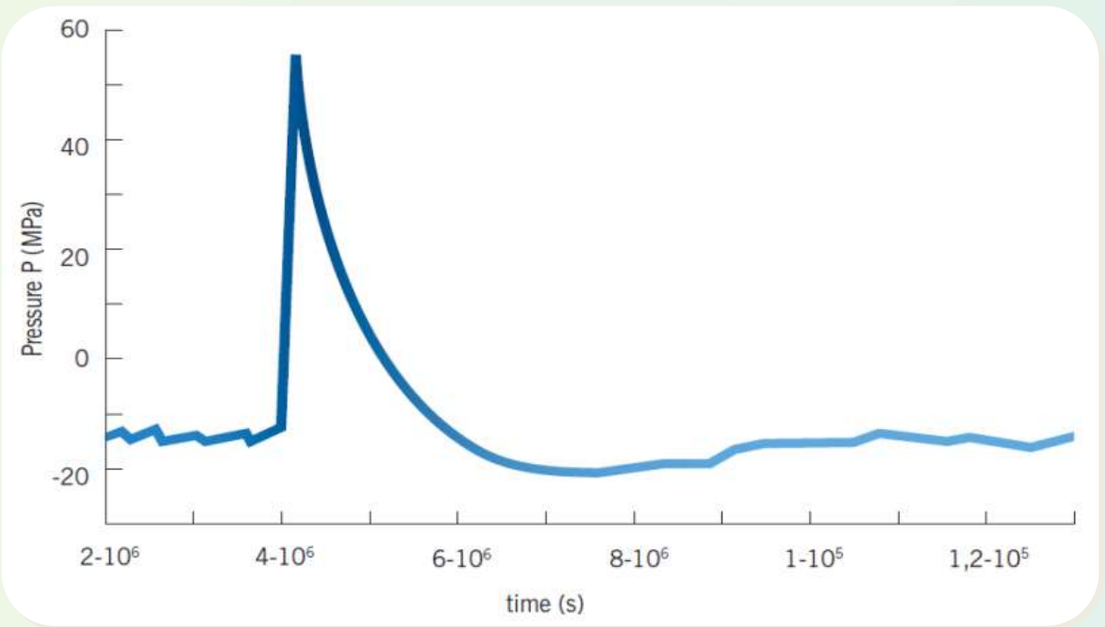


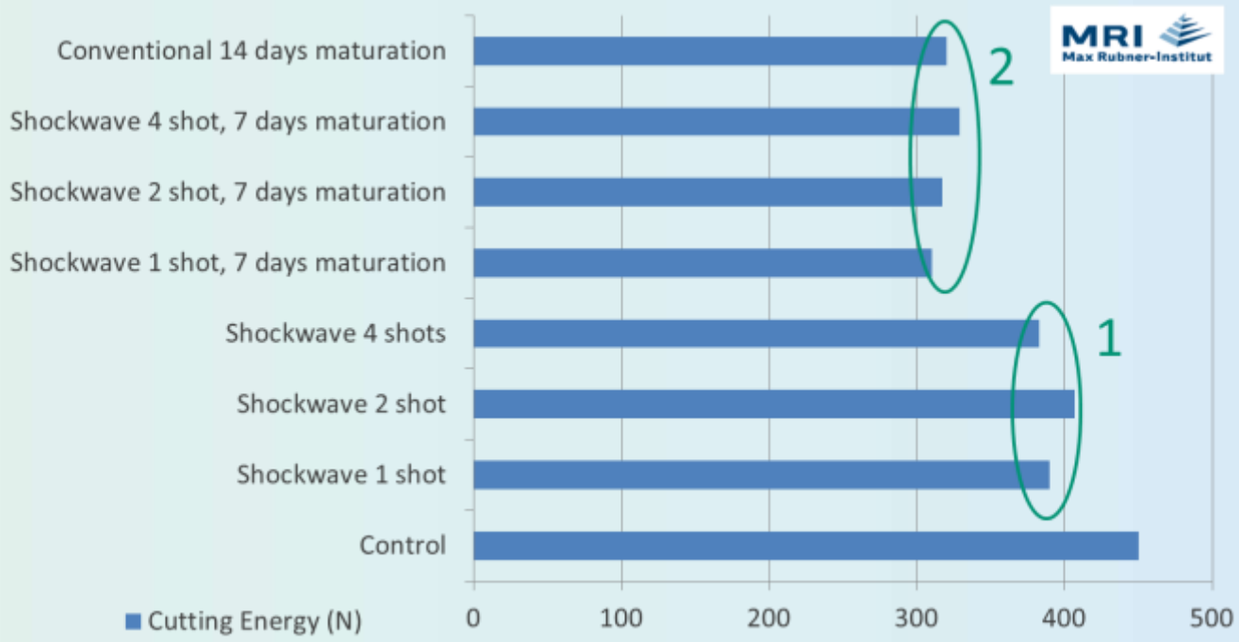
SHOCKWAVE
HYDRODYNAMIC HIGH PRESSURE

High pressure levels but at µs



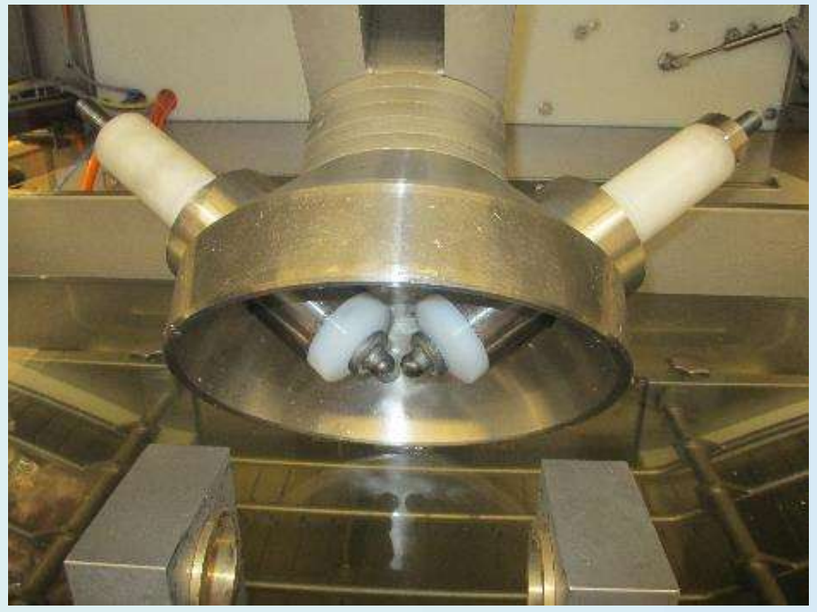




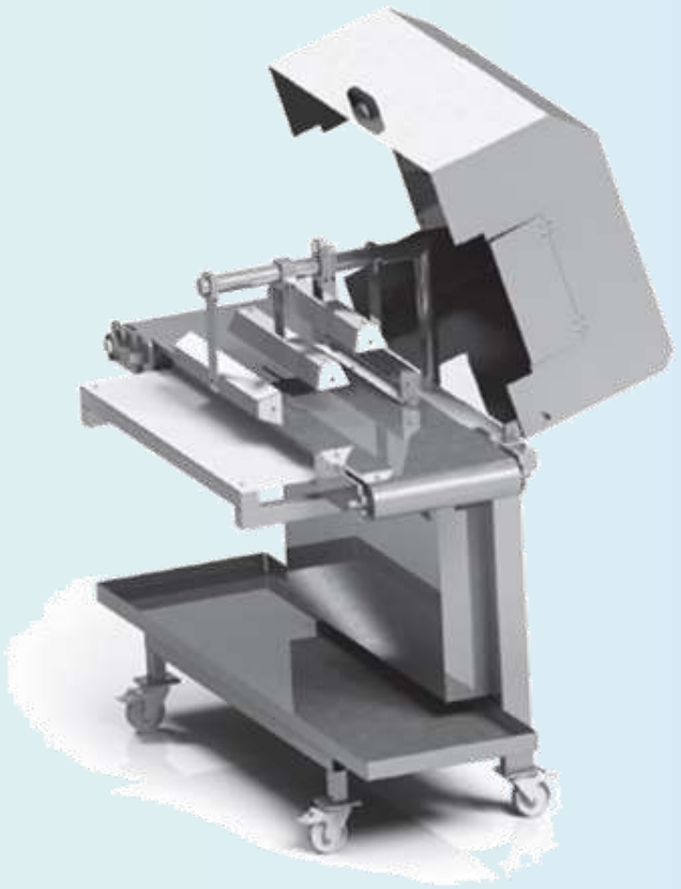


SHOCKWAVE
HYDRODYNAMIC HIGH PRESSURE

Continuous system for tissue disintegration and meat tenderisation



TECHNOLOGIES FOR SURFACE DECONTAMINATION



Technologies for surface decontamination

CONTINUOUS UV LIGHT

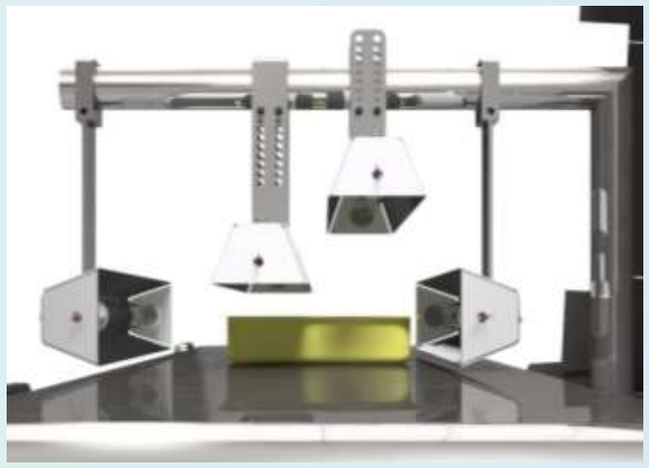
Surface decontamination of packed product

- No toxic substances
- Decontamination using UV, PL
- Contact-free
- Continuous process from all sides
- Treatment in packaging
- Moderate costs

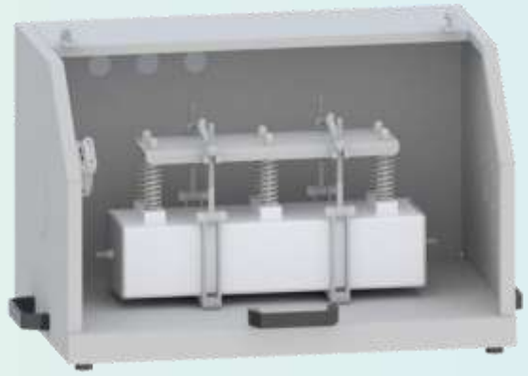
ADVANCED TECHNOLOGIES

INCREASING PRODUCT QUALITY AND SAFETY, AND PROCESS EFFICIENCY

- **Technologies based on radiation energy**
  - UV Light
  - Pulsed light
  - Infra red light
  - Electron beam



OHMIC HEATING



Ohmic heating

RAPID HEATING, COOKING, THAWING, …

Principle

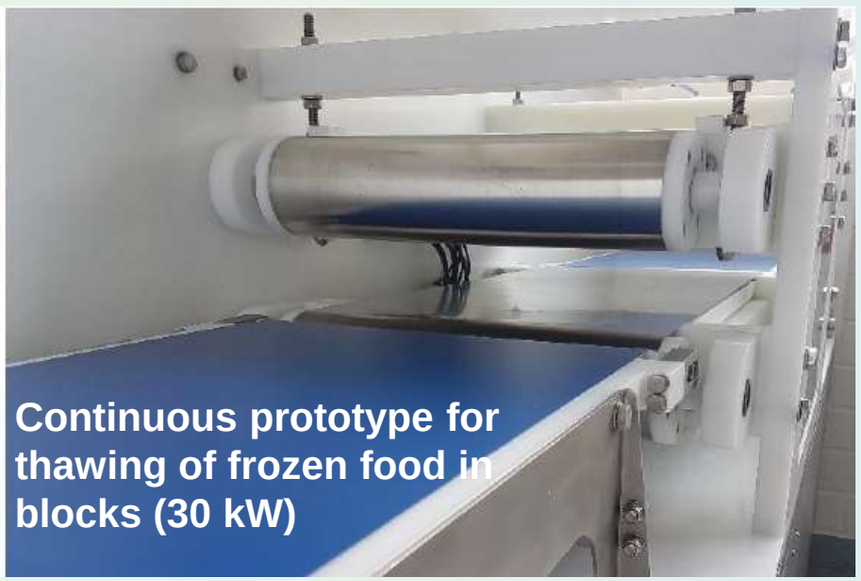
The passage of an alternating electrical current through a product acting as a resistor and in contact with electrodes causes heat generation within the product

→ heat is generated rapidly and volumetrically, resulting in faster and uniform heating

Applications

Thawing, heating, cooking, blanching, evaporation, dehydration, fermentation, pasteurization or sterilization

→ most promising applications for meat and meat products



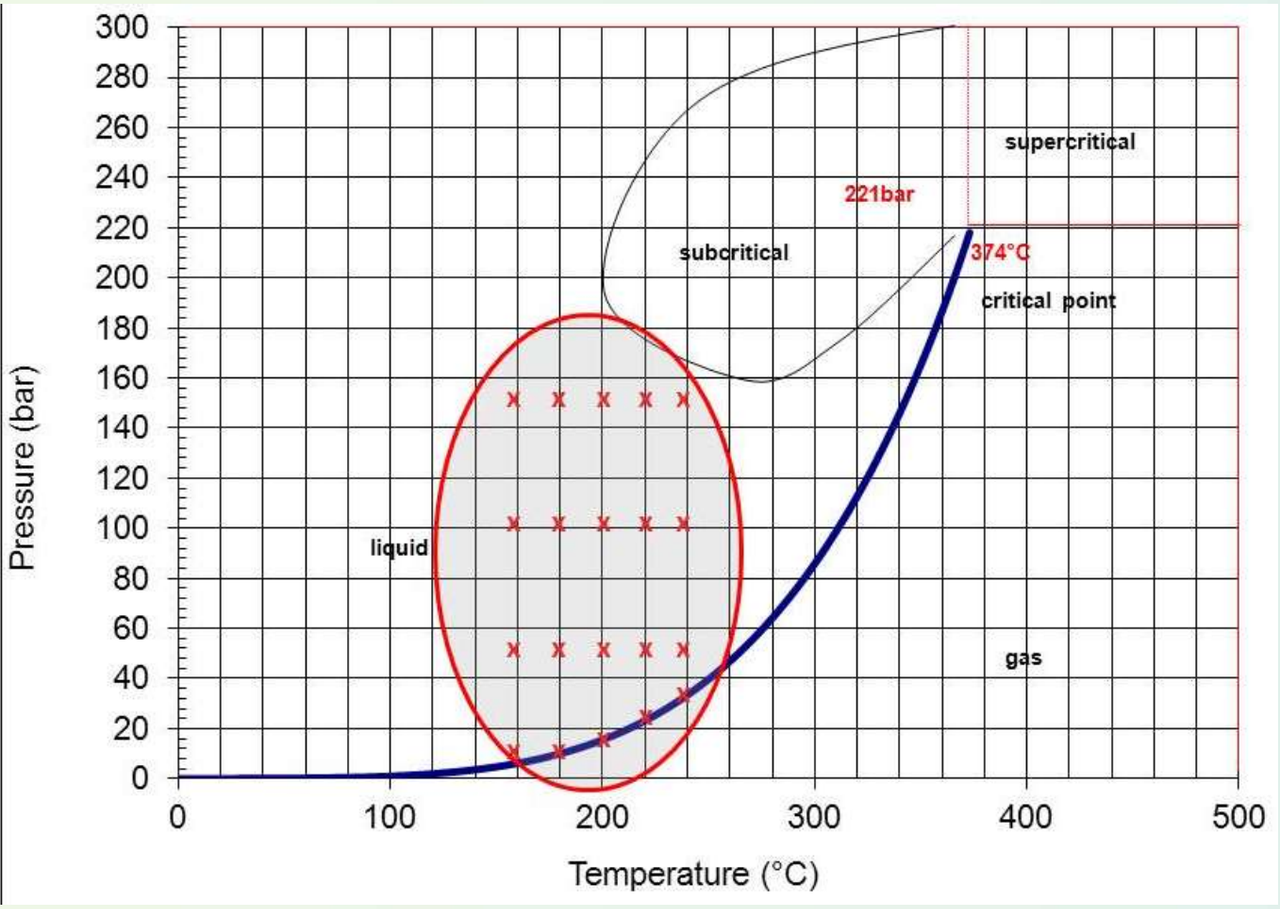
Continuous prototype for thawing of frozen food in blocks (30 kW)

Batch system for tests (5kW)

SUPERCRITICAL FLUIDS

Sub- and supercritical water

DECOMPOSITION OF POLYMERS



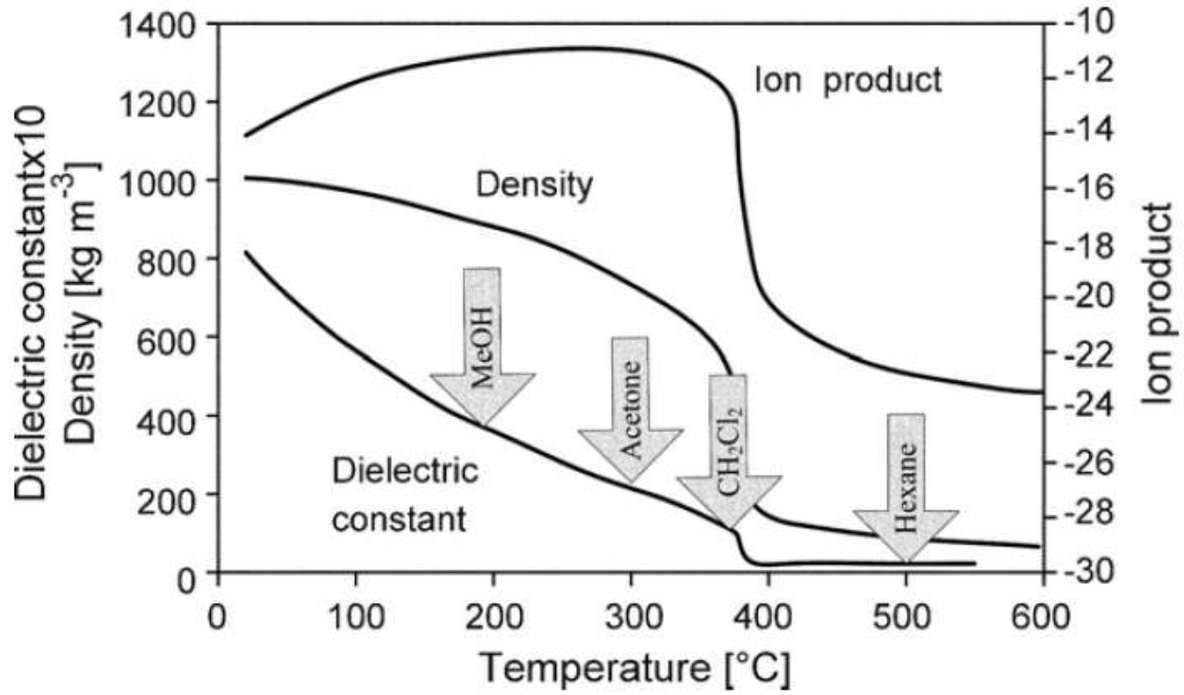
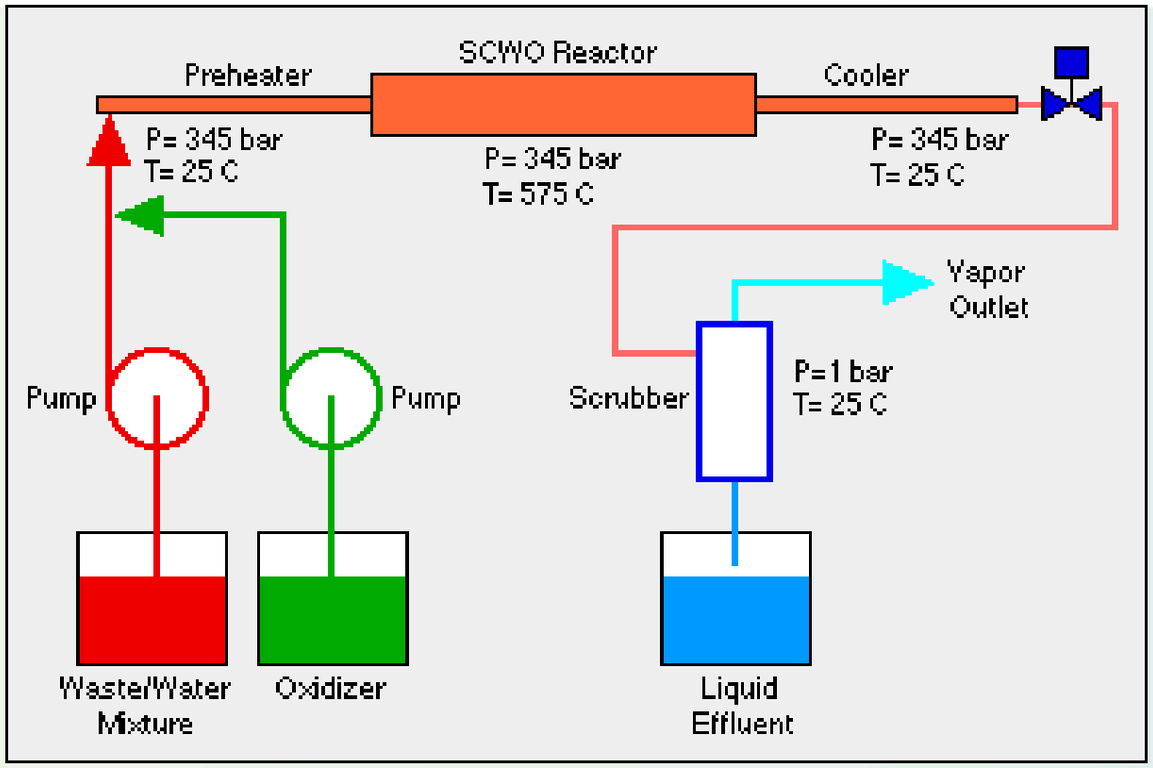
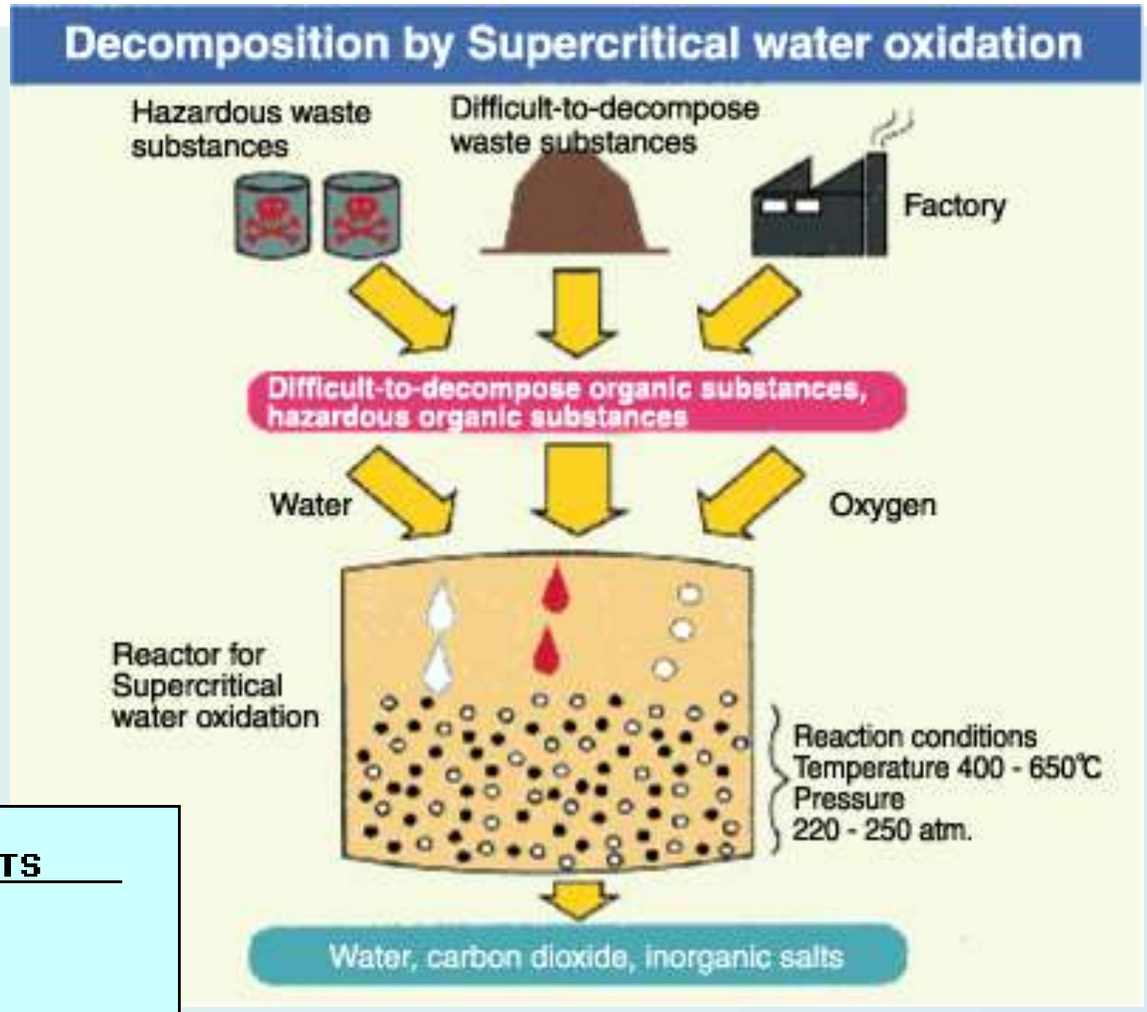


Fig. 1. Physical properties of water at a pressure of 24 MPa vs. temperature (dielectric constants of typical organic solvents at room temperature are indicated) (Kritzer and Dinjus, 2001).

Sub- and supercritical water

DECOMPOSITION OF POLYMERS





WASTE	SCWO REACTANTS		SCWO PRODUCTS
Cellulose	$C_6H_{10}05 + 6O_2$	→	$6CO_2 + 5H_2O$
Methane	$CH_4 + 2O_2$	→	$CO_2 + 2H_2O$
Benzene	$C_6H6 + 7.5\ O_2$	→	$6\ CO_2 + 3\ H_2O$
Dioxin (PCDD)	$Cl_2-C_6H_2-O_2-C_6H_2-Cl_2 + 11\ O_2$	→	$12\ CO_2 + 4\ HCl$
Chloroform	$CHCl_3 + 0.5\ O_2 + H_2O$	→	$CO_2 + 3\ HCl$
TNT	$CH_3-C_6H_2-(NO_2)_3 + 5.25\ O_2$	→	$7\ CO_2 + 2.5\ H_2O + 1.5\ N_2$
Ferrous Chloride	$FeCl_2 + 0.25\ O_2 + H_2O$	→	$0.5\ Fe_2O_3 + 2\ HCl$
Nerve Agent HD	$Cl-C_2H_4-S-C_2H_4-Cl + 7\ O_2$	→	$4\ CO_2 + 2\ H_2O + 2\ HCl + H_2SO_4$

Applications

Thank you for your attention!

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