

# Alternative Verfahren in der Lebensmittelherstellung zur Bekämpfung von Listerien

BfR-Symposium:

*Listeria monocytogenes* – Aktuelle Herausforderungen für die Lebensmittelsicherheit und den Verbraucherschutz

16. – 17. November 2020

Dr. Kemal Aganovic

# ADVANCED TECHNOLOGIES

INCREASING PROCESS EFFICIENCY, PRODUCT SAFETY AND QUALITY



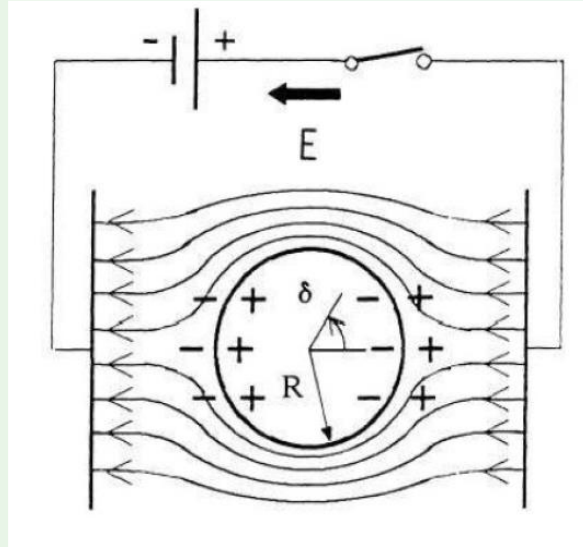
## focus on:

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



# PULSED ELECTRIC FIELDS

## WORKING PRINCIPLE

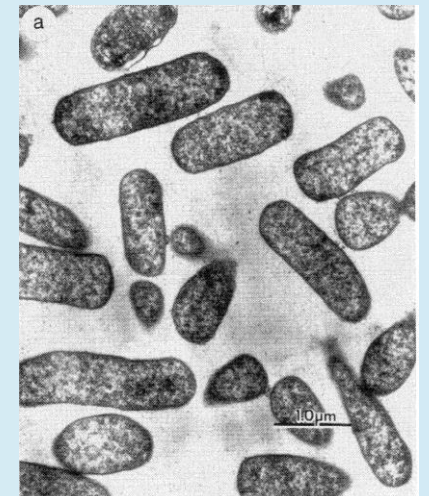
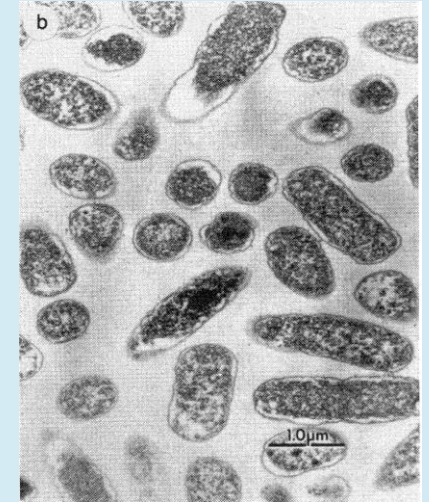
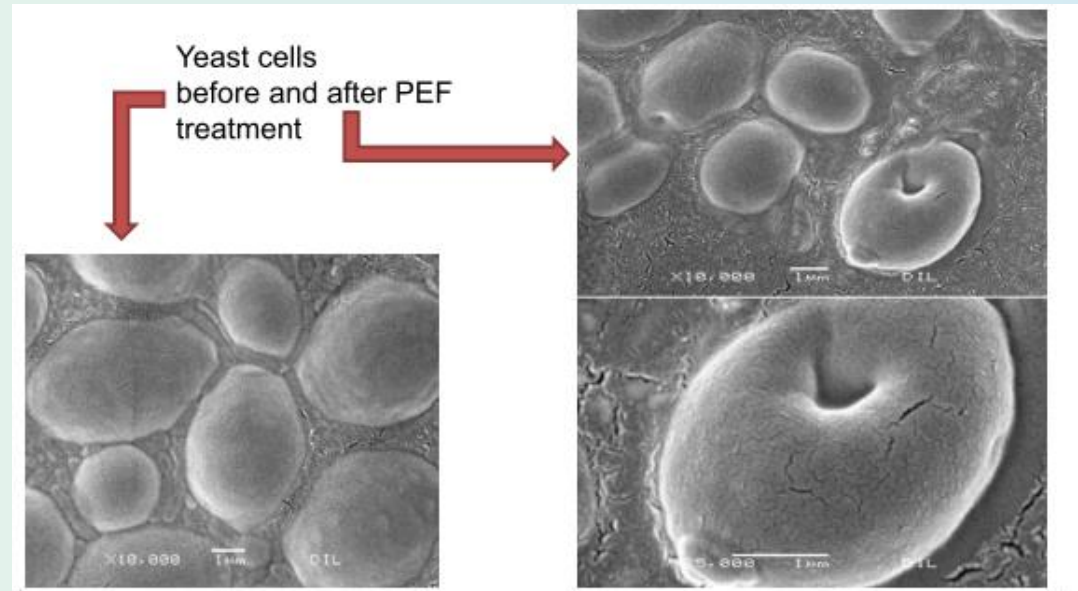


PEF is based on electroporation and is suitable for use in broad range of food and bio-process applications

Short treatment times: **microseconds**

Total PEF process time: **seconds**.

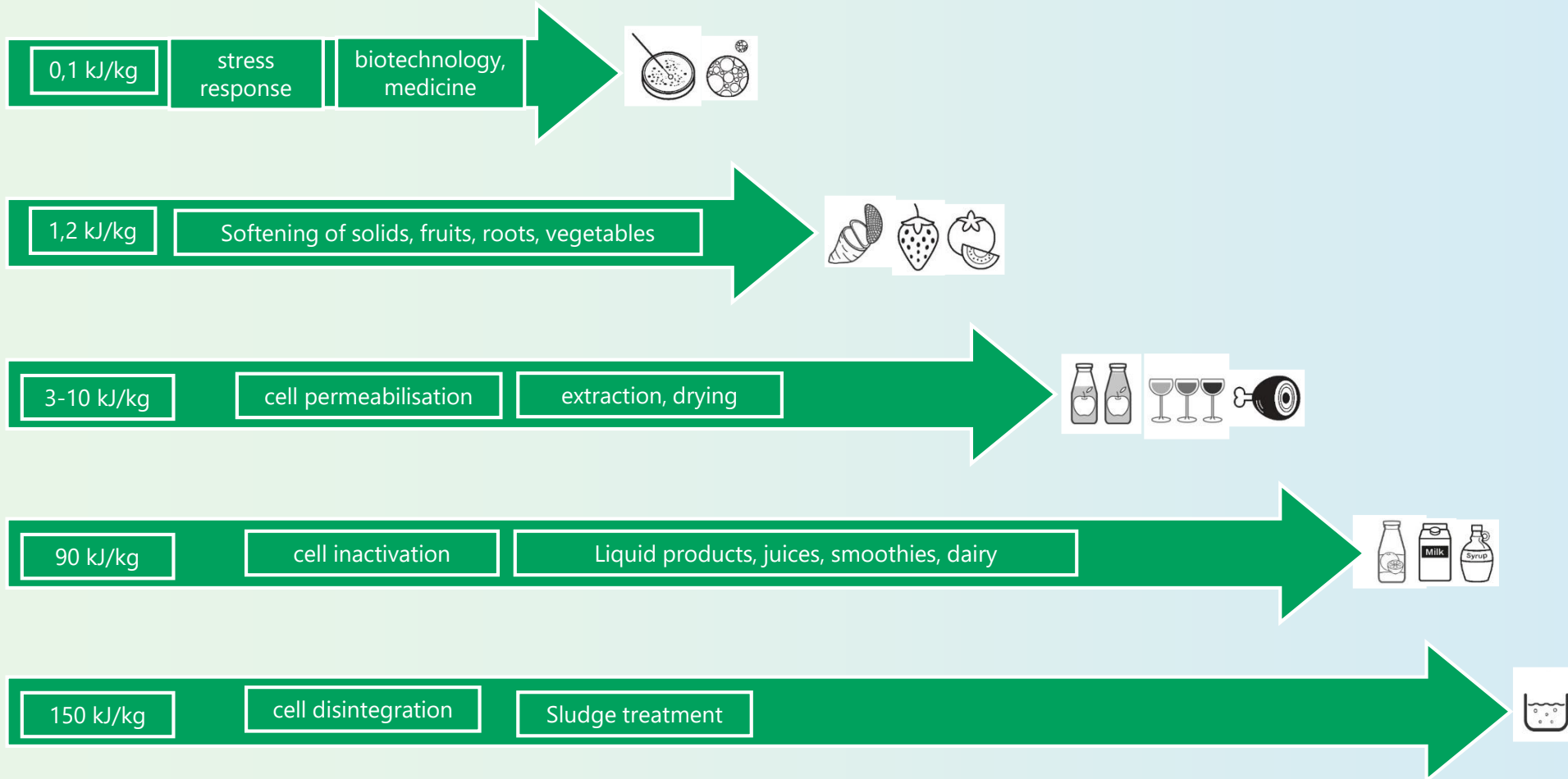
PEF produces the **electroporation** in bacterial, plant and animal cells.



E  
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# PULSED ELECTRIC FIELDS

## TARGETED TREATMENT

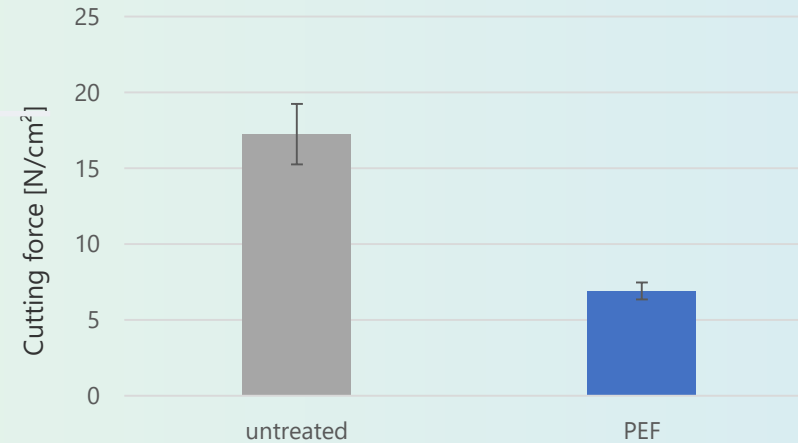
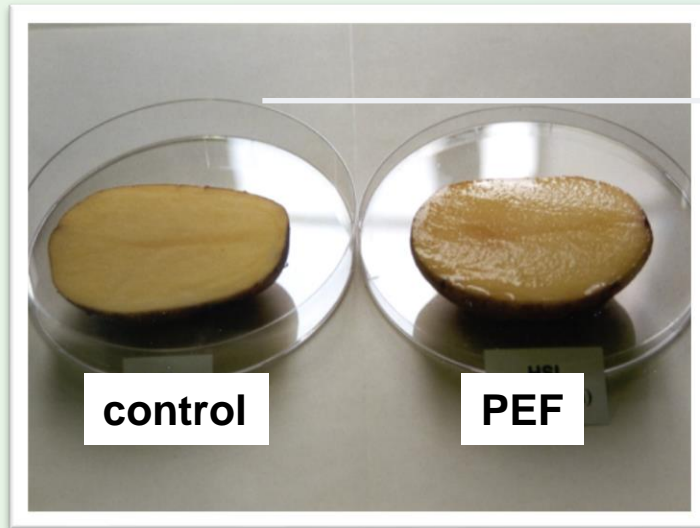


# PULSED ELECTRIC FIELDS

## STRUCTURE MODIFICATION IN POTATO PROCESSING

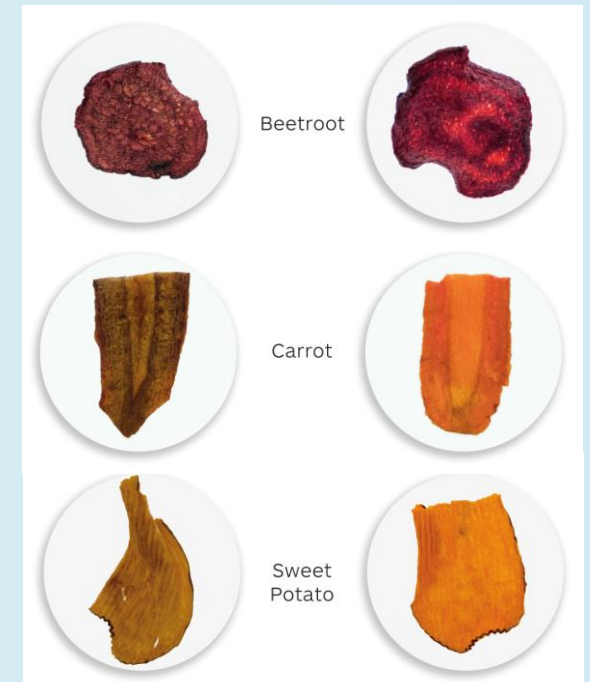
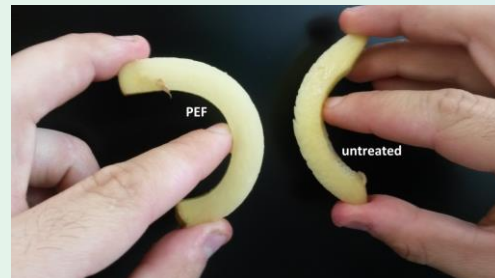


### Softening of tissue by loss of turgor pressure



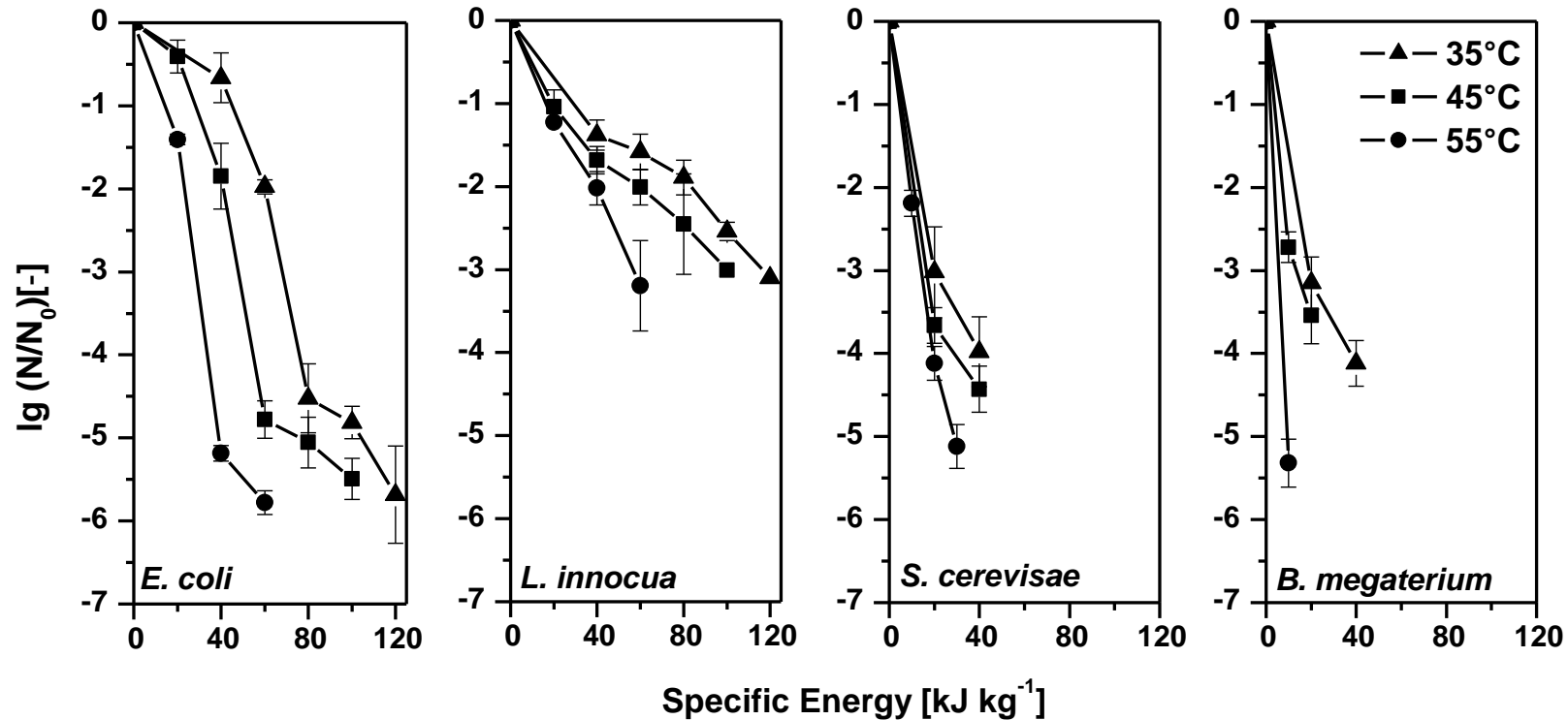
- ❖ Smoother cut and less feathering
- ❖ Flexible tissue, less breakage
- ❖ More even color
- ❖ Replacement of thermal preheater, less energy
- ❖ Less oil uptake by potato slices/fries
- ❖ Less starch in process water
- ❖ Longer knife durability

Influence of pulsed electric fields on hardness and cutting behaviour  
Tissue softening and significant reduction of cutting force



# PULSED ELECTRIC FIELDS

## VARIATION IN MICROBIAL RESISTANCE



Inactivation of *E. coli*, *L. innocua*, *S. cerevisiae* and *B. megaterium* in ringer solution with an electrical conductivity of  $1.25 \text{ mS cm}^{-1}$  after PEF treatment with graphite anode and a field strength of  $16 \text{ kV cm}^{-1}$

# PULSED ELECTRIC FIELDS PUBLICATIONS



## Letters in Applied Microbiology



Free Access

### Environmental factors influencing the inactivation of *Listeria monocytogenes* by pulsed electric fields

I. Álvarez, R. Pagán, J. Raso, S. Condón

First published: 11 December 2002 | <https://doi.org/10.1046/j.1472-765X.2002.01221.x> | Citations: 53

✉ Correspondence to: S. Condón, Tecnología de los Alimentos, Facultad de Veterinaria, Universidad de Zaragoza, Miguel Servet 177, 50013 Zaragoza, Spain. [scondon@posta.unizar.es](mailto:scondon@posta.unizar.es)

SECTIONS



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MICROBIOLOGY

## Applied and Environmental Microbiology

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Food Microbiology

### Selection and Identification of a *Listeria monocytogenes* Target Pulsed Electric Field Process Optimization

Beatrice H. Lado, Ahmed E. Yousef

DOI: 10.1128/AEM.69.4.2223-2229.2003

RESEARCH ARTICLE

### Inactivation of *Listeria monocytogenes* in Milk by Pulsed Electric Field **FREE**

Laura D. Reina; Z. Tony Jin; Q. Howard Zhang; Ahmed E. Yousef

*J Food Prot* (1998) 61 (9): 1203–1206.

<https://doi.org/10.4315/0362-028X-61.9.1203> Article history

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Available online at [www.sciencedirect.com](http://www.sciencedirect.com)

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International Journal of Food Microbiology 103 (2005) 199–206

INTERNATIONAL JOURNAL OF  
Food Microbiology

[www.elsevier.com/locate/ijfoodmicro](http://www.elsevier.com/locate/ijfoodmicro)

### Modelling inactivation of *Listeria monocytogenes* by pulsed electric fields in media of different pH

N. Gómez, D. García, I. Álvarez, S. Condón, J. Raso\*

Tecnología de los Alimentos, Facultad de Veterinaria, Universidad de Zaragoza, Miguel Servet 177, 50.013 Zaragoza, Spain

Received 19 January 2004; received in revised form 6 September 2004; accepted 25 November 2004



Food Microbiology 21 (2004) 91–95

FOOD  
MICROBIOLOGY

[www.elsevier.nl/locate/jnlabr/yfmic](http://www.elsevier.nl/locate/jnlabr/yfmic)

### The inactivation of *Listeria monocytogenes* by pulsed electric field (PEF) treatment in a static chamber

Gregory J. Fleischman<sup>a,\*</sup>, Sadhana Ravishankar<sup>b</sup>, V.M. Balasubramaniam<sup>b</sup>

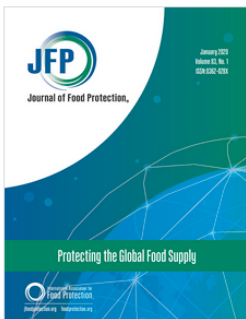
<sup>a</sup> US Food and Drug Administration, The National Center for Food Safety & Technology, 6502, South Archer Road, Summit-Argo, IL 60501, USA

<sup>b</sup> The National Center for Food Safety and Technology, Illinois Institute of Technology, Moffett Campus, 6502 South Archer Road, Summit-Argo, IL 60501, USA

Received 18 October 2002; received in revised form 22 January 2003; accepted 22 January 2003

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January 1998  
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ISSN 0362-028X

Protecting the Global Food Supply

Journal of Food Protection  
International Association of Food Protection Technicians

# PULSED ELECTRIC FIELDS

## APPLICATION FOR JUICES

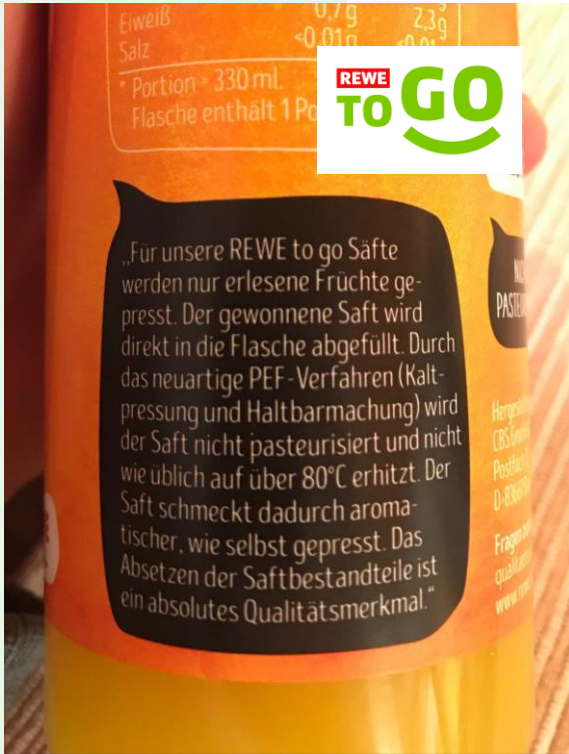


**FMP**

FMP (Fresh Micro Pulse), or pulsed electric field processing, involves treating the juice with high voltage pulses.

The FMP process delivers a series of electric pulses in a treatment chamber filled with fresh juice. This technique lengthens the storage life with no noticeable loss of quality. The juice isn't heated, so the aroma, color, texture and nutritional value stay intact.

FMP is a safe and reliable method involving no additives, and therefore a clean label technology.



*Supplier of freshness*



## GROM USES ELEA PEF FOR FRUIT PUREE PROCESSING

“Gromart has installed an Elea PEF system for use in the processing of their fresh fruit puree and have been very satisfied with the performance and operation of the system.” – Guido Martinetti, CEO of Gromart Srl

[Find out more about Grom and their high quality gelato](#)



# PULSED ELECTRIC FIELDS

## MICROBIAL INACTIVATION IN MILK



### Product:

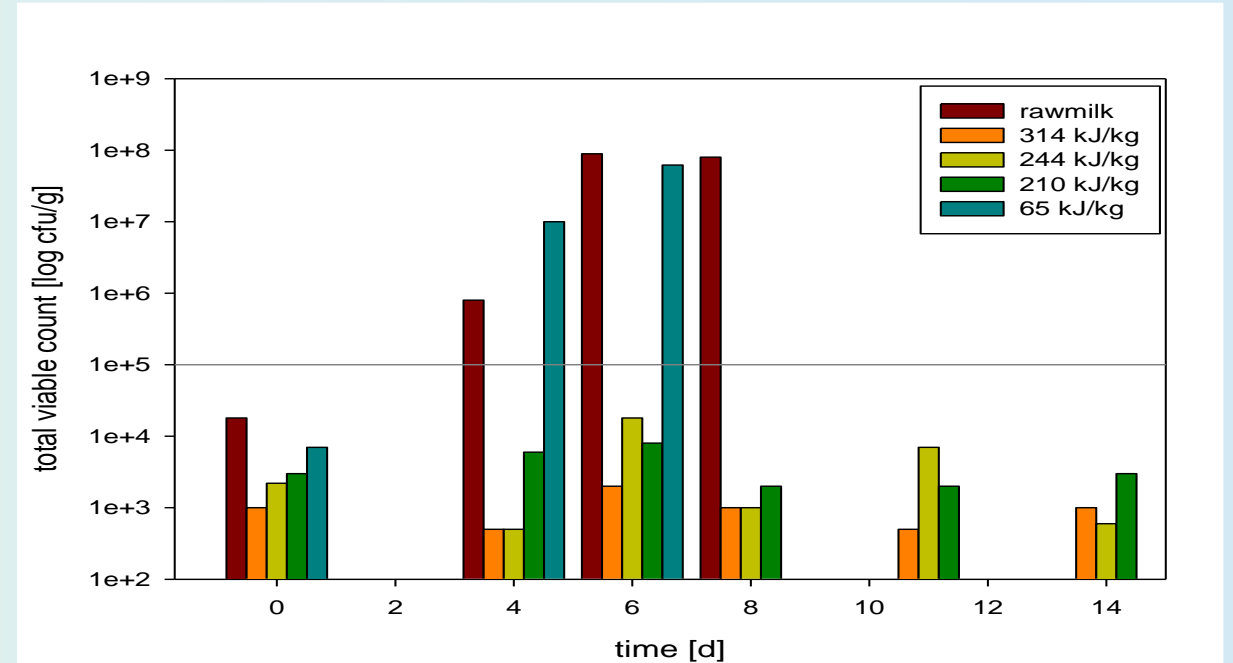
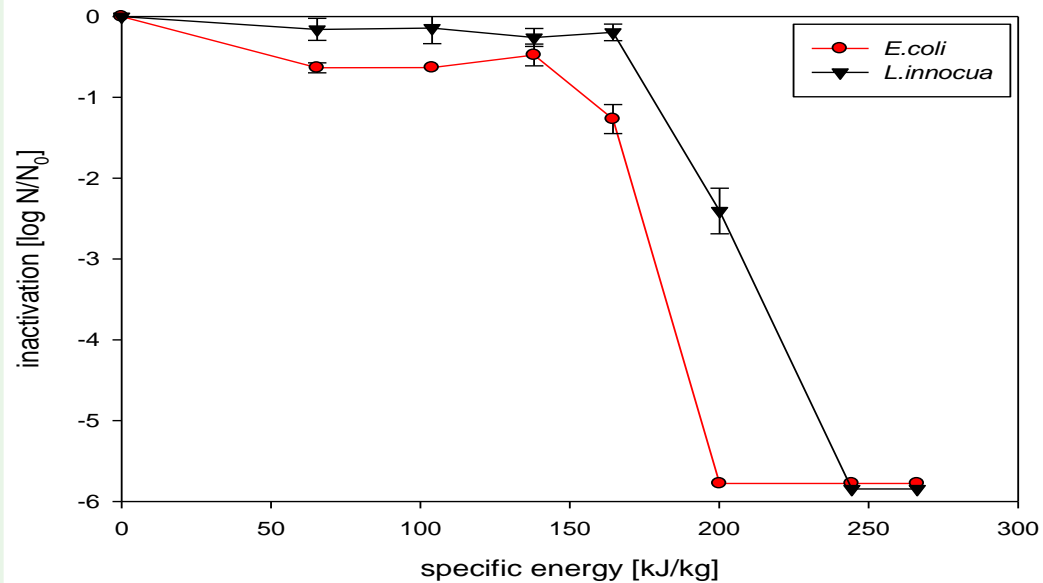
Raw milk

pH value: 6,9

Fat content: 3,7 to 5,1 %

Conductivity: 4mS/cm

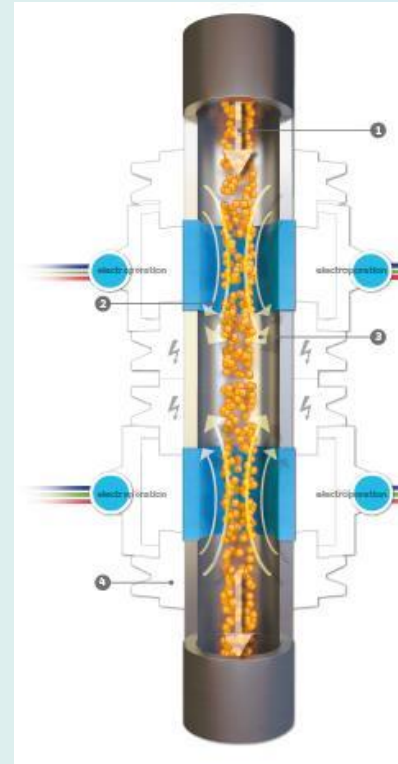
Applied electric field strength: 12 kV/cm



# PULSED ELECTRIC FIELDS EQUIPMENT



- For liquid food products
- Capacities from 50 L – 10 000 L/h



# HIGH HYDROSTATIC PRESSURE

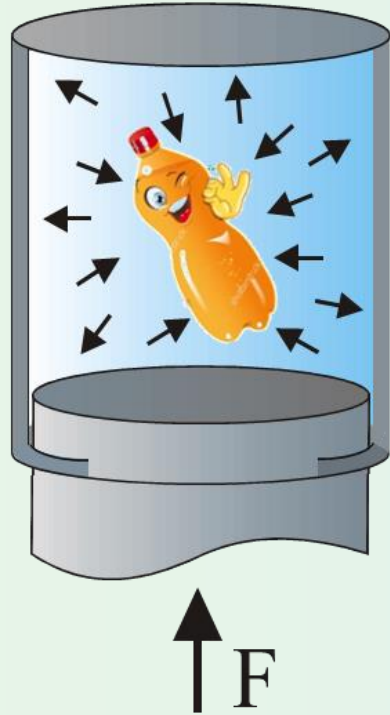
## LOW TEMPERATURE PRESERVATION OF FOOD



With permission Hiperbaric, 2018.  
Burgos, Spain

# HIGH HYDROSTATIC PRESSURE

## GOVERNING PRINCIPLES



### 1. Isostatic rule

*“pressure is equally and instantaneously transmitted through the vessel and product”*

*Pressure reduces the volume of the material without changing its shape – altering the distance between the molecules*

### 2. Le Châtelier’s principle

*“a system in equilibrium will shift to a new equilibrium, to counteract the impact change in temperature, concentration and/or volume”*

### 3. Compression heating

1<sup>st</sup> law of thermodynamics (the total energy of an isolated system is constant):

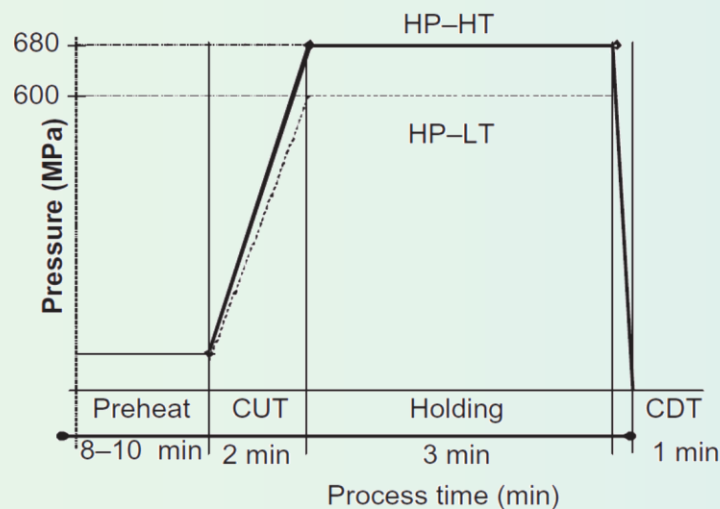
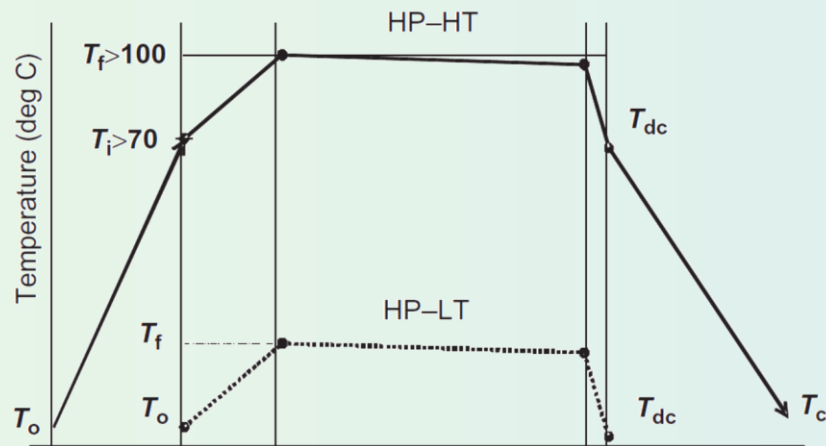
$$Q = W + \Delta U \quad \Delta U = Q - W$$

### 4. Microscopic ordering

increase in pressure at constant temperature increases the degree of ordering of molecules of a given substance

# HIGH HYDROSTATIC PRESSURE

## PROCESS CONDITIONS



Temperature and pressure during a processing cycle for:

### 1. high pressure pasteurization (HP-LT)

$$300 \text{ MPa} < P < 600 \text{ MPa}$$

$$4 \text{ }^\circ\text{C} < T < 30 \text{ }^\circ\text{C}$$

### 1. high pressure sterilization (HP-HT)

$$600 \text{ MPa} < P < 900 \text{ MPa}$$

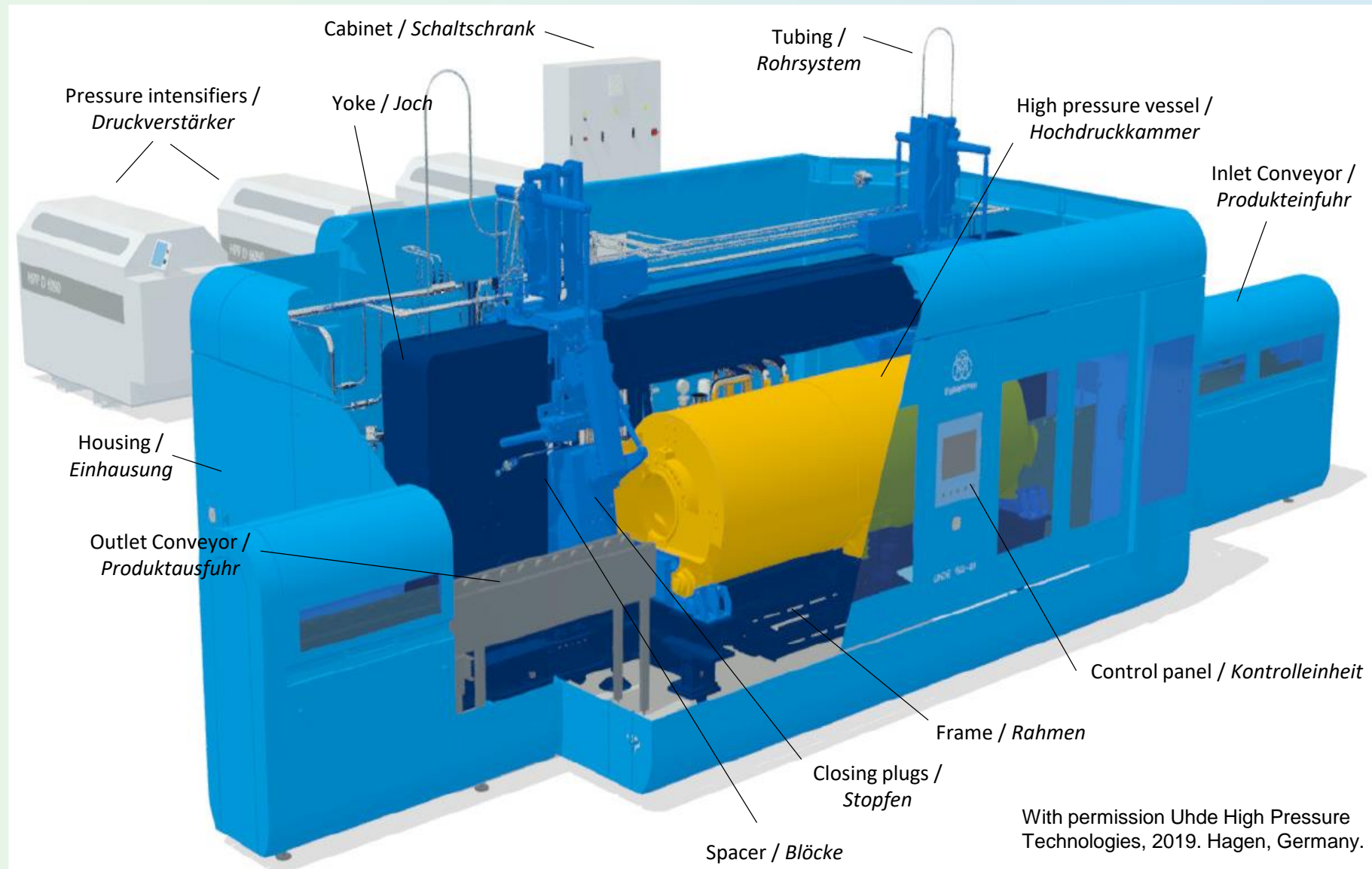
$$90 \text{ }^\circ\text{C} < T < 130 \text{ }^\circ\text{C}$$

Compression approx. 15%

Temperature increase – adiabatic heating

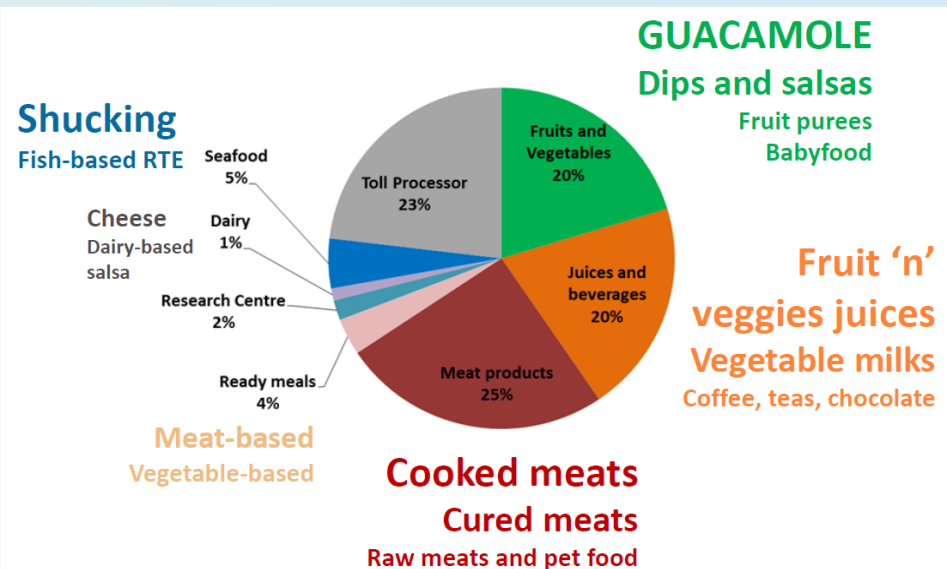
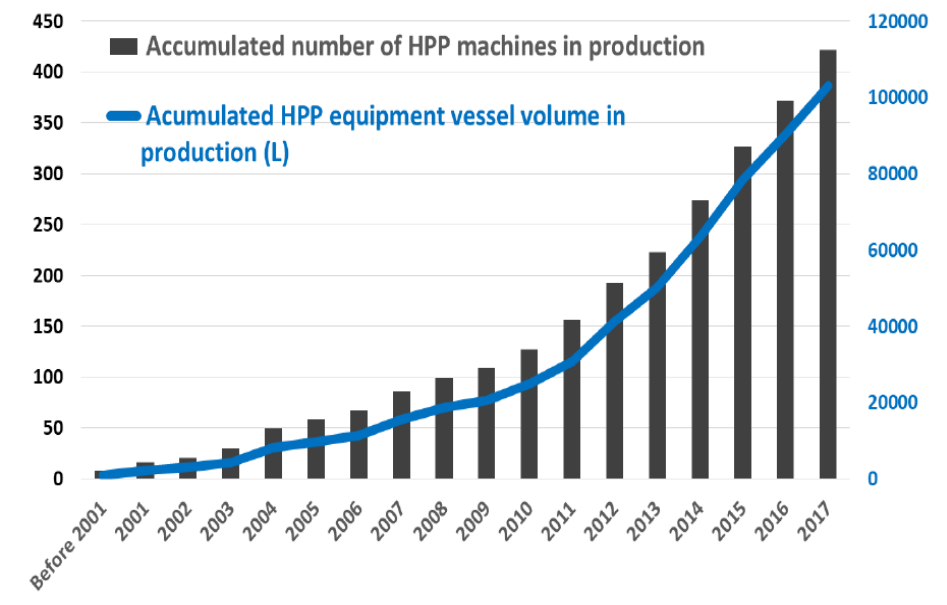
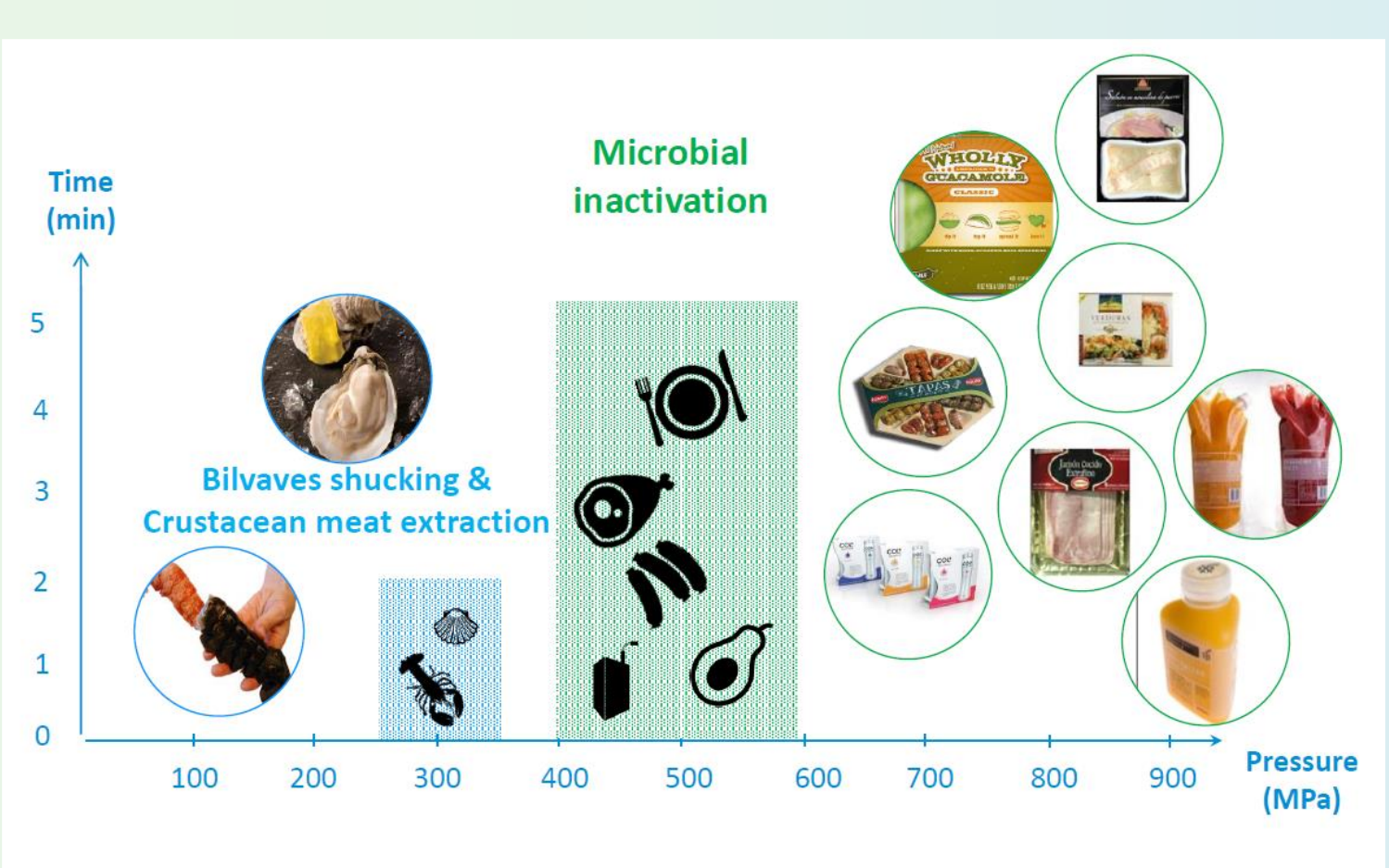
# HIGH HYDROSTATIC PRESSURE

## MACHINE COMPOSITION AND SETUP



# HIGH HYDROSTATIC PRESSURE

## MAJOR INDUSTRIAL APPLICATIONS



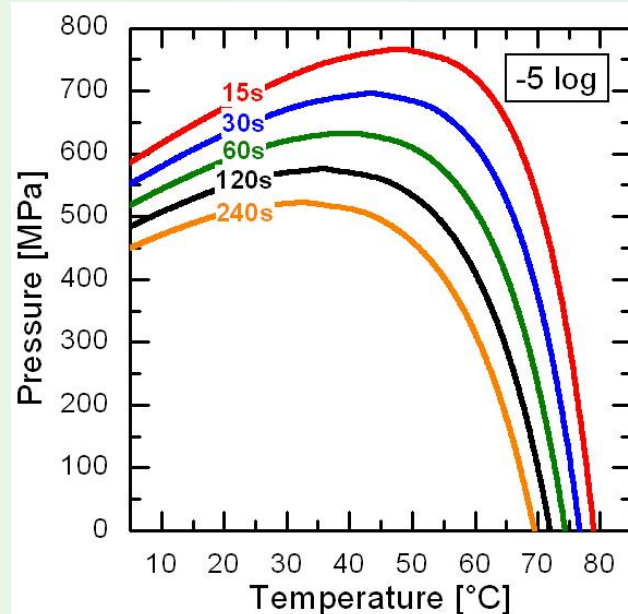
With permission Hiperbaric, 2018. Burgos, Spain

# HIGH HYDROSTATIC PRESSURE MICROBIAL INACTIVATION

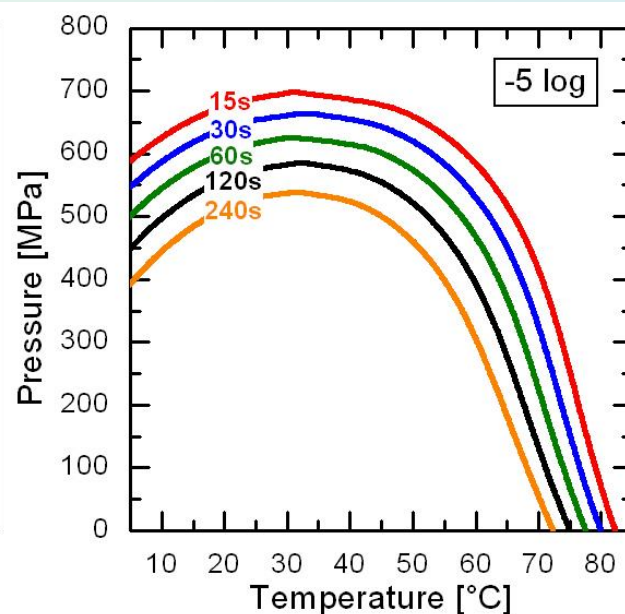


p-T isokineticity diagrams for 5 log inactivation of 3 pathogenic strains of *Listeria monocytogenes* in “Black Forest Prosciutto” (Ham) after 15-240 s.

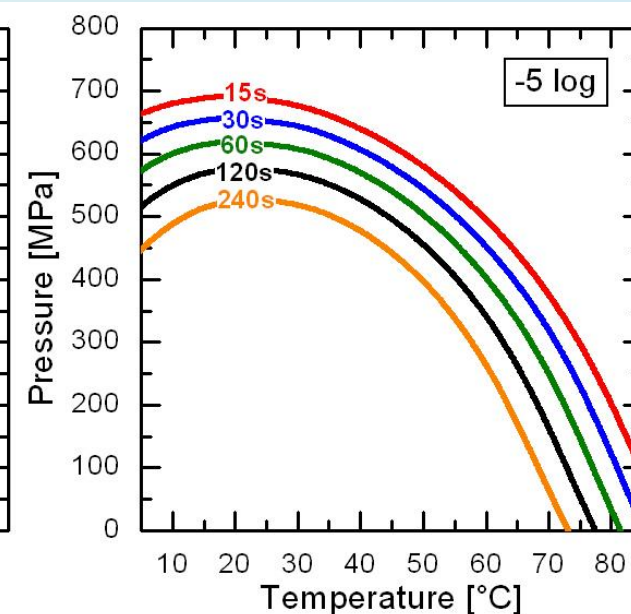
Serotype CLIP 74902 1/2a



Serotype CLIP 74903



Serotype 4b(3987/04)





# HIGH HYDROSTATIC PRESSURE

## SAFETY OF MEAT PRODUCTS



ESPUÑA (Spain), 1998



TOP QUALITY COOKED HAM IN SLICES.  
WITH SEPARATING FILM  
HIGH-PRESSURE PASTEURIZED PRODUCT (H.P.P.)  
REMAINS FRESH UNTIL EATEN



<https://www.espuna.es/tecnologia>

CAMPOFRIO (Spain), 2003



Abraham (Germany), 2004



### More applications:

- West Liberty Foods (USA)
- Fresh Press (GR)
- Zwaneberg (NL)
- Maple Leaf (CA)
- Rovagnati (IT)
- Angst (CH)

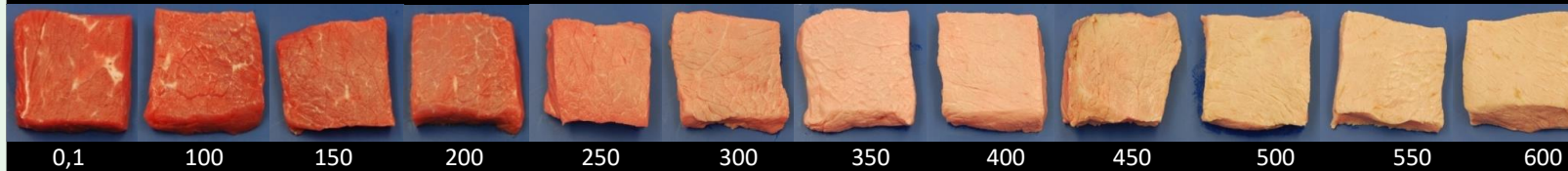
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# HIGH HYDROSTATIC PRESSURE

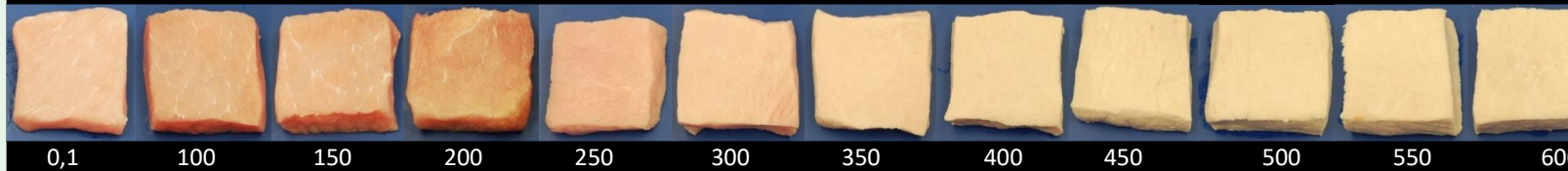
## EFFECTS ON RAW MEAT PROTEIN



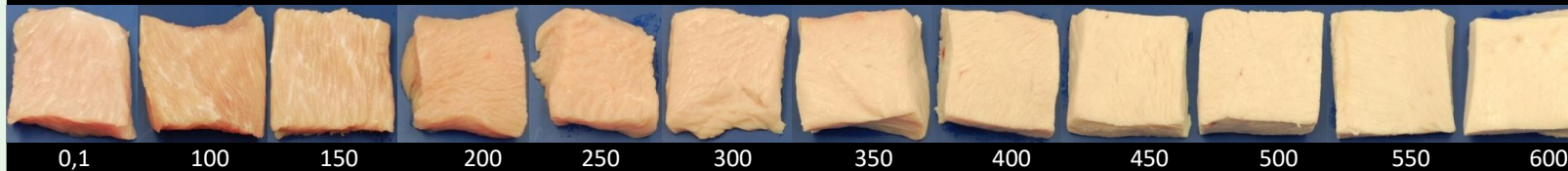
Colour changes in roast beef (*M. longissimus dorsi*) after 3 min. at 0,1 – 600 MPa and 18 °C



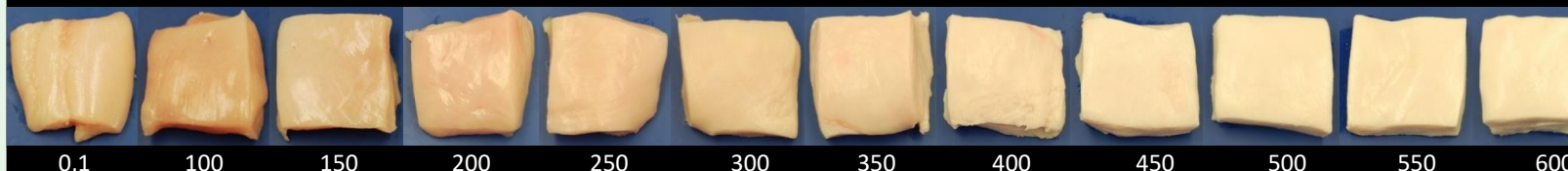
Colour changes in pork loin (*M. longissimus dorsi*) after 3 min. at 0,1 – 600 MPa and 18 °C



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



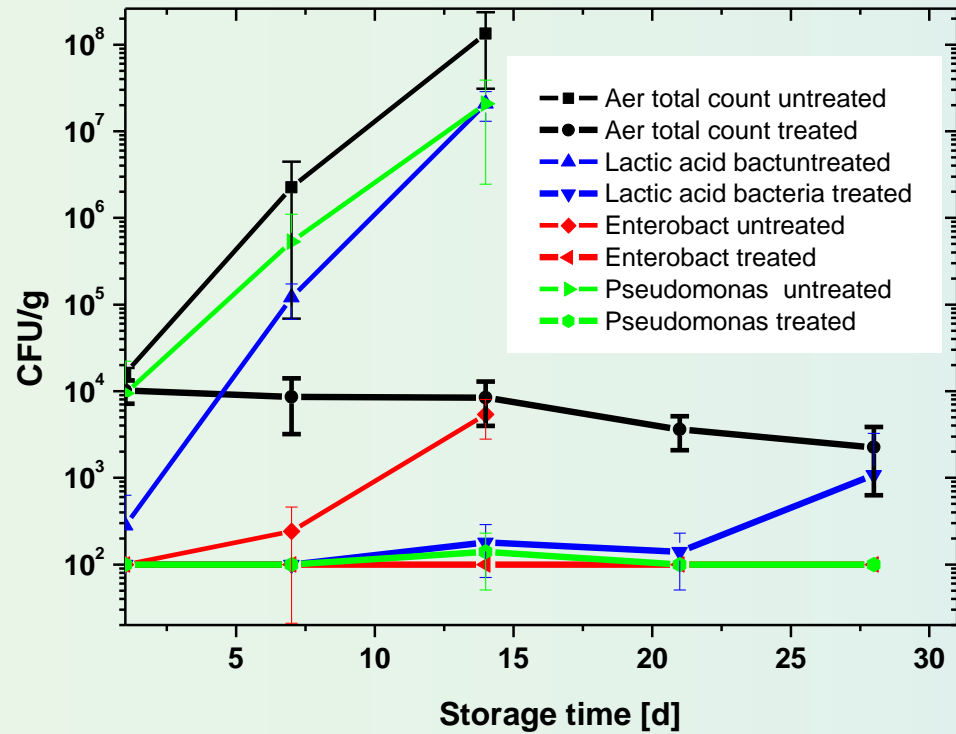
Colour changes in chicken breast (*M. pectoralis superficialis*) after 3 min. at 0,1 – 600 MPa and 18 °C



# HIGH HYDROSTATIC PRESSURE MICROBIAL INACTIVATION



- High pressure treated turkey fillet
- 6000 bar, 5min
- Shelf life > 30 days



# HIGH HYDROSTATIC PRESSURE COMBINATION WITH ANTIMICROBIALS



## ALGINATE-FILM WITH OREGANO EXTRACT COMBINED WITH HHP

*L. monocytogenes*-Cocktail:

FMCC-B-129, FMCC-B-131, FMCC-B-133

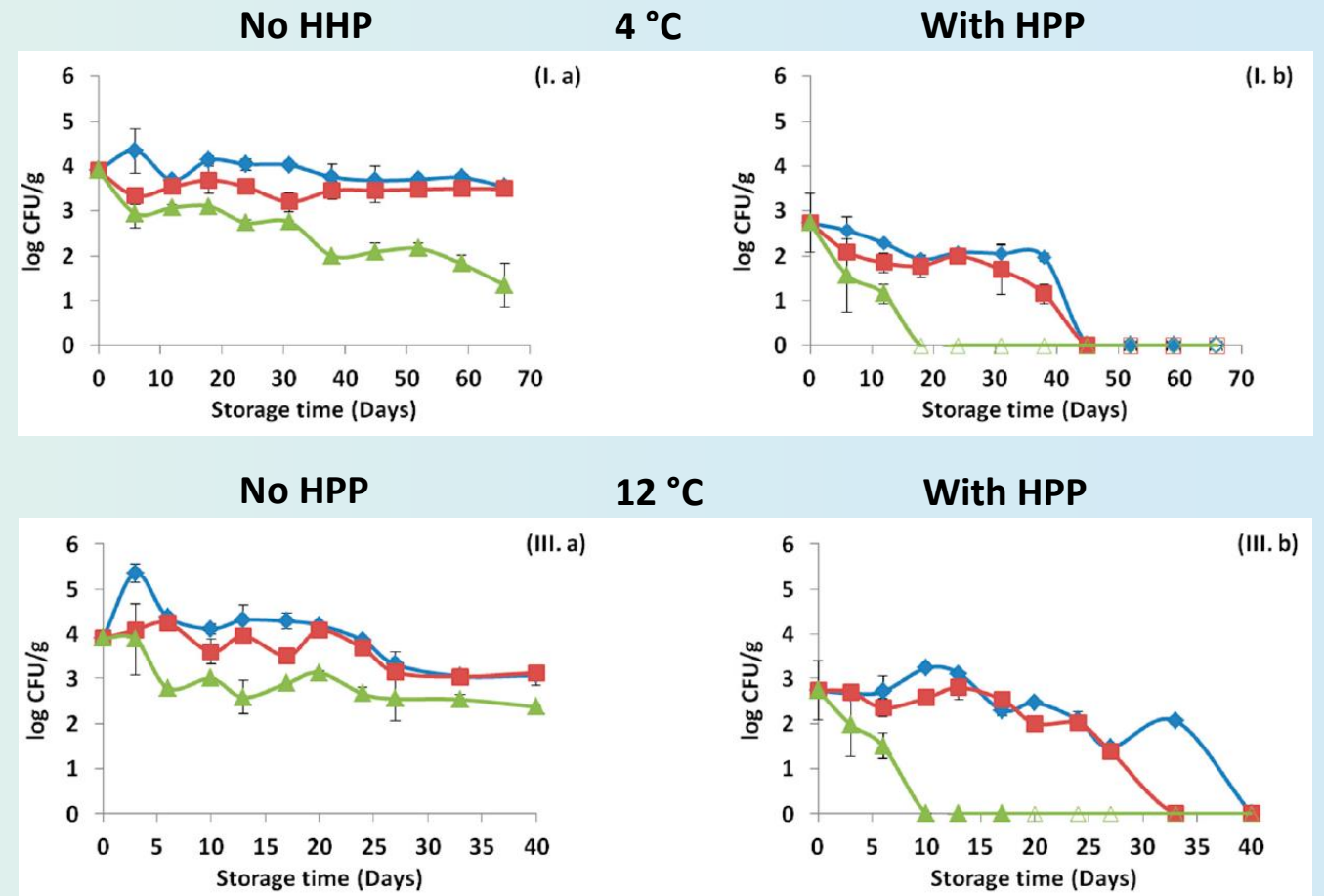
HHP: 500 MPa, 2 min., 20°C

### Film

Na-Alginate-Film with 1% oregano Essential Oil

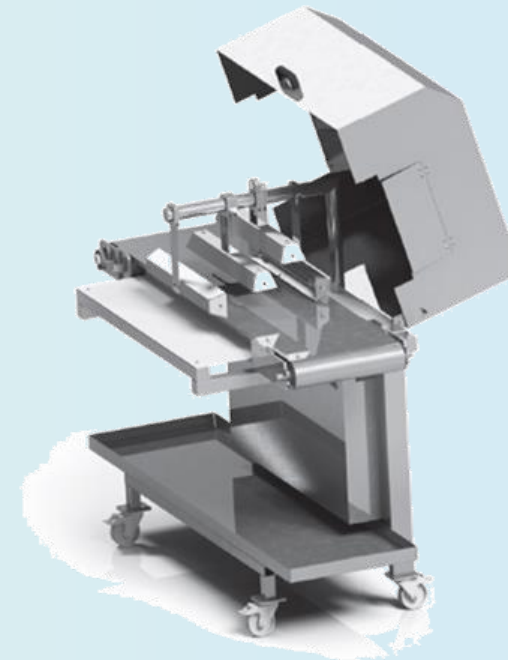
### Result

- Reduction of Listeria through oregano extract
- HPP: reduction in the beginning at 1 log CFU/g
- Synergistic effect during storage



Survival curves of *Listeria monocytogenes* cocktail strains in ham stored at 4 °C (I), 8 °C (II) and 12 °C (III), without (a) and after (b) high pressure processing treatment. (◆) Control samples, (■) samples with edible film free from oregano essential oil-OEOF and (▲) samples with edible film supplemented with oregano essential oil-OEOS. Open symbols (◇, □, △), indicate absence of *Listeria monocytogenes* after application of the enrichment method.

# TECHNOLOGIES FOR SURFACE DECONTAMINATION



# DECONTAMINATION OF SURFACES

## TREATMENT WITH LIGHT



Emitting light and energy:

$$E = h\nu = \frac{hc}{\lambda}$$

$h$  – Planck's constant

$\nu$  - Frequency

$\lambda$  – Wavelength

$c$  – speed of light in vacuum

### Pulsed Light

- Broad spectrum with significant **UV-C** (180 – 1100 nm)
- ( $\mu$ s) pulses produced by flash lamps

### Infrared

- Infrared light (780 – 1000 nm)
- Short term treatment by lamp or LED



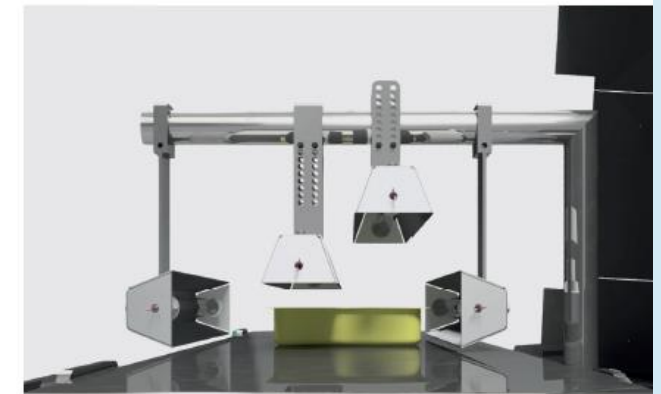
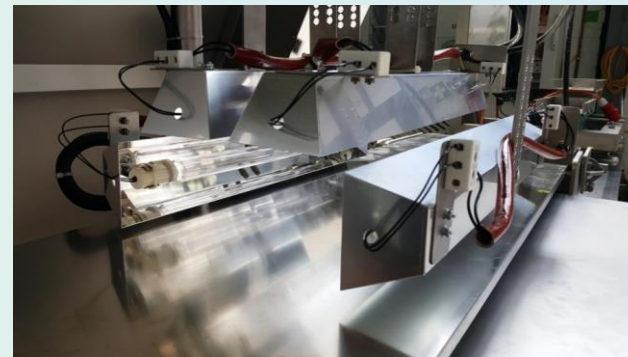
# SURFACE DECONTAMINATION

## 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

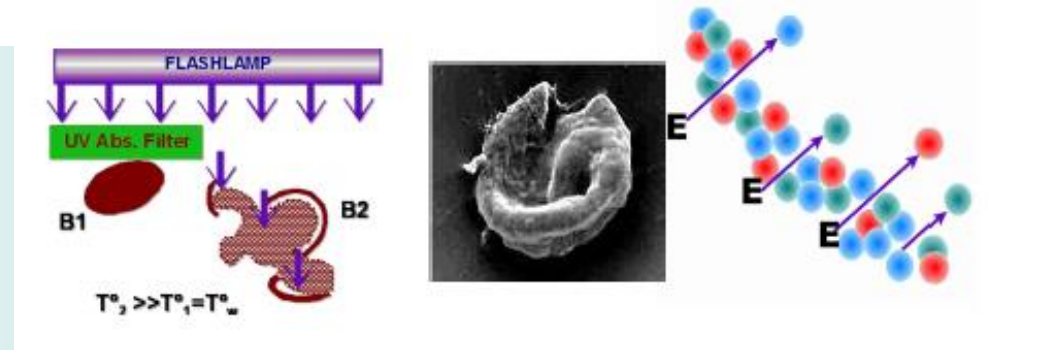
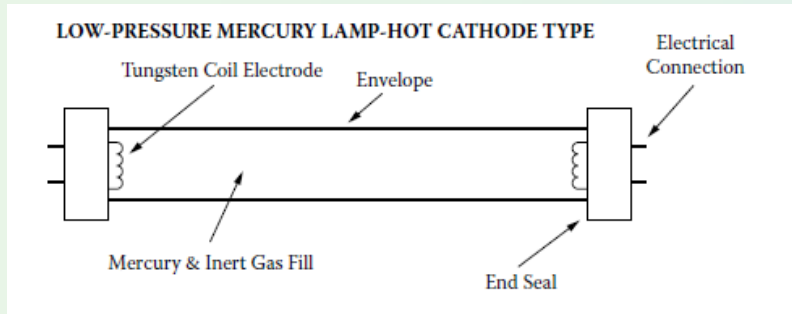


EIN PROJEKT DER INDUSTRIELLEN GEMEINSCHAFTSFORSCHUNG (IGF) GEFÖRDERT VIA / A PROJECT OF INDUSTRIAL COMMUNITY RESEARCH (IGF) FUNDED VIA

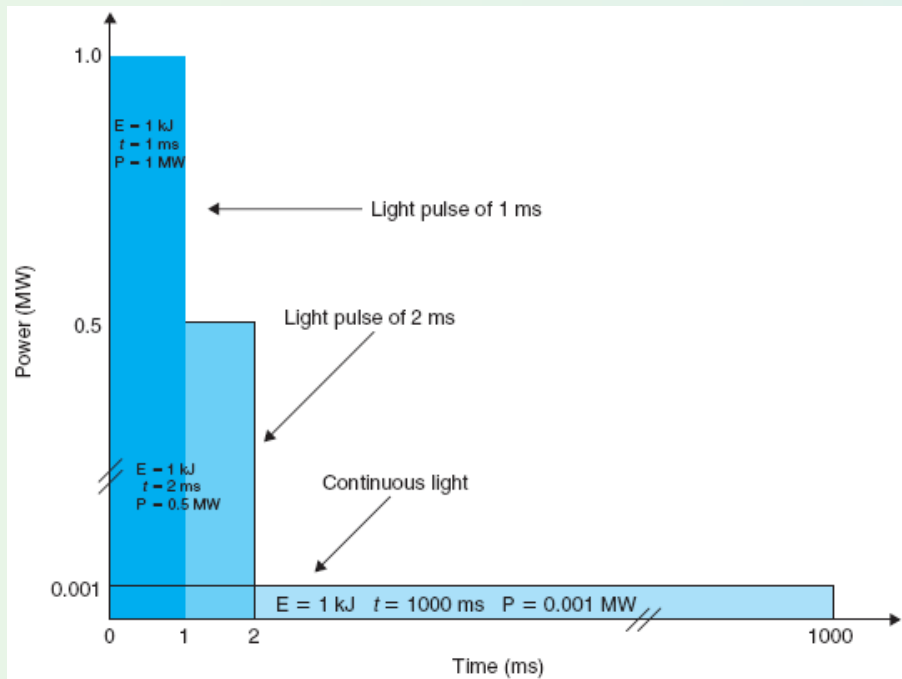


# SURFACE DECONTAMINATION

## PULSED LIGHT



Photothermal, photochemical and photoelectrical effect



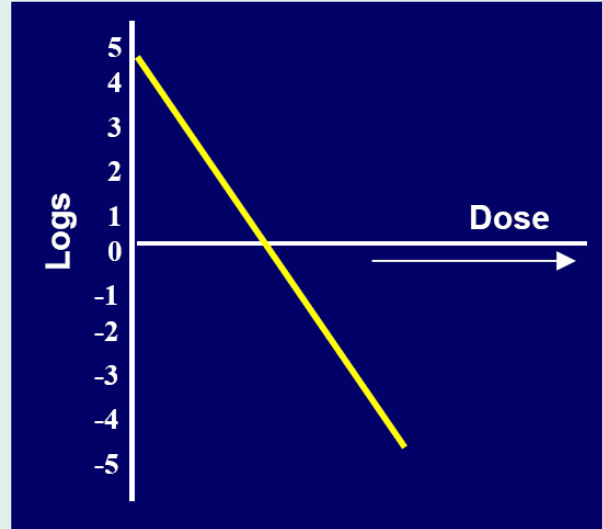
**Ultraviolet energy dose for 1 log destruction of various Microorganisms (mJ/cm<sup>2</sup>)**

Bacteria	Energy Dose
<i>Bacillus anthracis</i>	4.5
<i>Escherichia coli</i>	4.5
<i>Listeria monocytogenes</i>	8.0
<i>Salmonella enteritidis</i>	4.0
<b>Mold Spores</b>	
<i>Aspergillus niger</i>	132
<i>Aspergillus flavus</i>	60
<i>Penicillium roqueforti</i>	13
<i>Mucor mucedo</i>	70



# SURFACE DECONTAMINATION

## DECONTAMINATION USING ELECTRON BEAM



**D-Wert:**  
Strahlendosis zur Inaktivierung von 90 %  
(1-log)

*Clostridium botulinum*

D-Wert kGy

2-3,5

*Salmonella typh.*

0,2-1

*Staph. aureus*

0,2-0,6

*E. Coli* 0157:H7

0,1-0,34

### Treatment of pallets or bulk material

Radio frequency (RF) linear electron accelerator  
(LINAC, type CIRCE III from Thomson-CSF/Linac Technologies S. A. (Orsay, France))

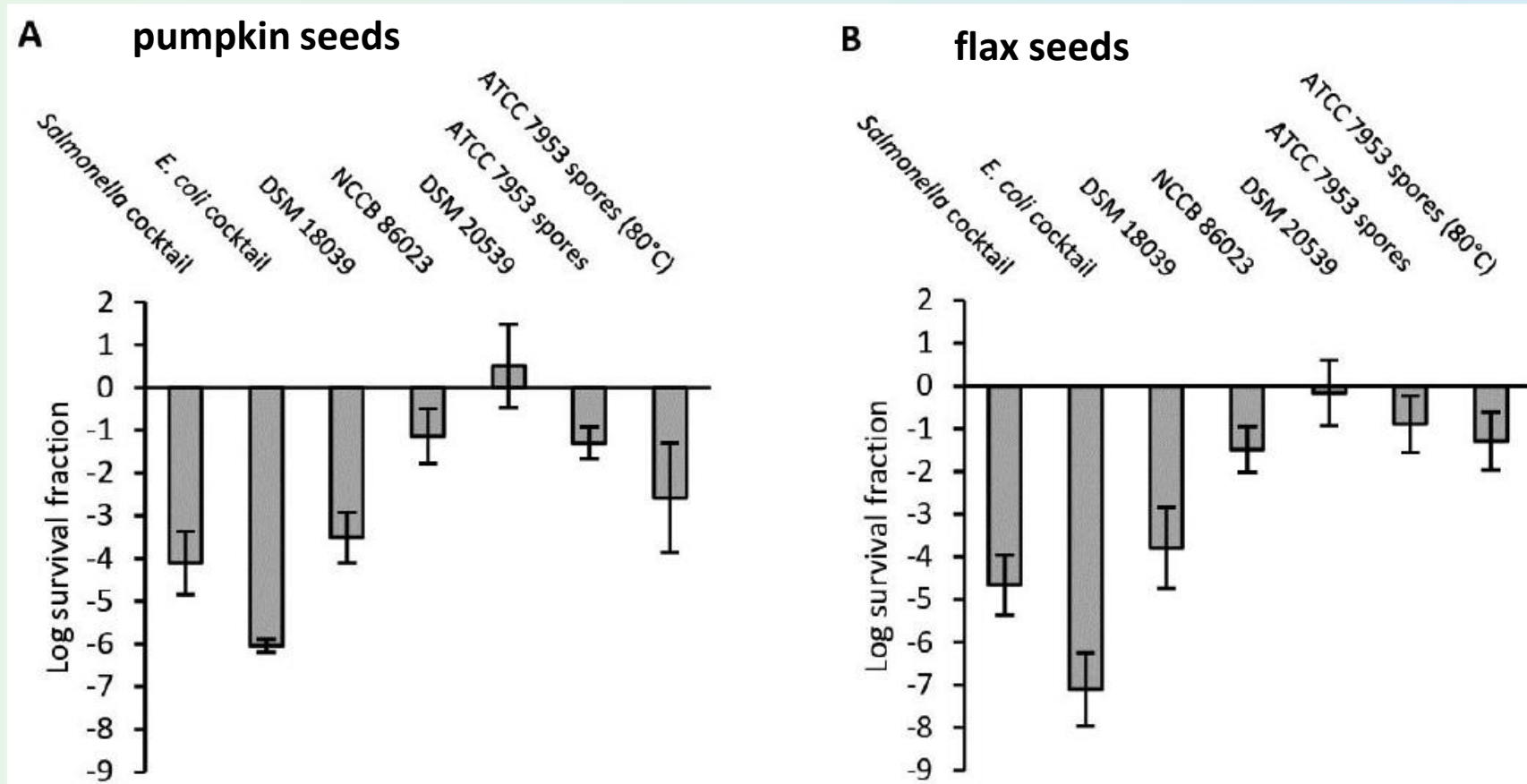
Acceleration energy	5-10 MeV
Irradiation power	max. 10 kW
Dose	0,25 to 50 kGy (max. dose for food 10 kGy)
Dose tracked by	alanine pellet dosimeters
Irradiation direction	vertical down
Irradiation area	75x75 cm (tin plate size)
Conveyer belt speed	1 to 1000 mm/sec

### Strahlungsenergie begrenzt auf

Gammastrahlung	<1,3 MeV
Röntgen-/ Bremsstrahlung	<5 MeV
Elektronenstrahlung	<10 MeV

# E-BEAM TECHNOLOGY

## SURROGATE FOR E-BEAM INACTIVATION OF SALMONELLA



Log survival fractions on irradiated (4 kGy, 5 MeV) inoculated with different strains and cocktails: Salmonella cocktail (serovars *Enteritidis*, *Gammaria*, *Oranienburg*, *Rubislaw*, and *Typhimurium*), *E. coli* cocktail (*E. coli* DSM 19206 and DSM 5923), DSM 18039 (*E. coli* DSM 18039, nonpathogenic), NCCB 86023 (*E. faecium* NCCB 86023), DSM 20539 (*D. radiodurans* DSM 20539), and ATCC 7953 (*G. stearotherophilus* ATCC 7953) spores.

# Thank you for your attention!

**DIL Deutsches Institut für Lebensmitteltechnik e.V.**

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