High Pressure Pasteurization of meat products

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Novel Processing Technologies are being introduced as alternatives to heat

These are occasionally described as ‘non-thermal’

Heat Processing and the conventional wisdom

- **Wide spectrum**
  - **Bacteria**
  - **Molds and yeasts**
  - **Viruses**
  - **Enzymes**

- **Good safety record**
  - **Pasteurization:** **$\geq$ 5 logs inactivated**
  - **Sterilization:** **~ 12 logs inactivated**

Alternative Processing, Why?

- **Unique solutions to lingering problems**
  - Processing heat-sensitive products (e.g., emulsions)
  - In-package pasteurization (e.g., sliced meat)
  - ….

- **Opportunity to introduce new products**
  - Guacamole
  - Safe fresh oysters
  - **….**

Selected Novel Preservation Methods

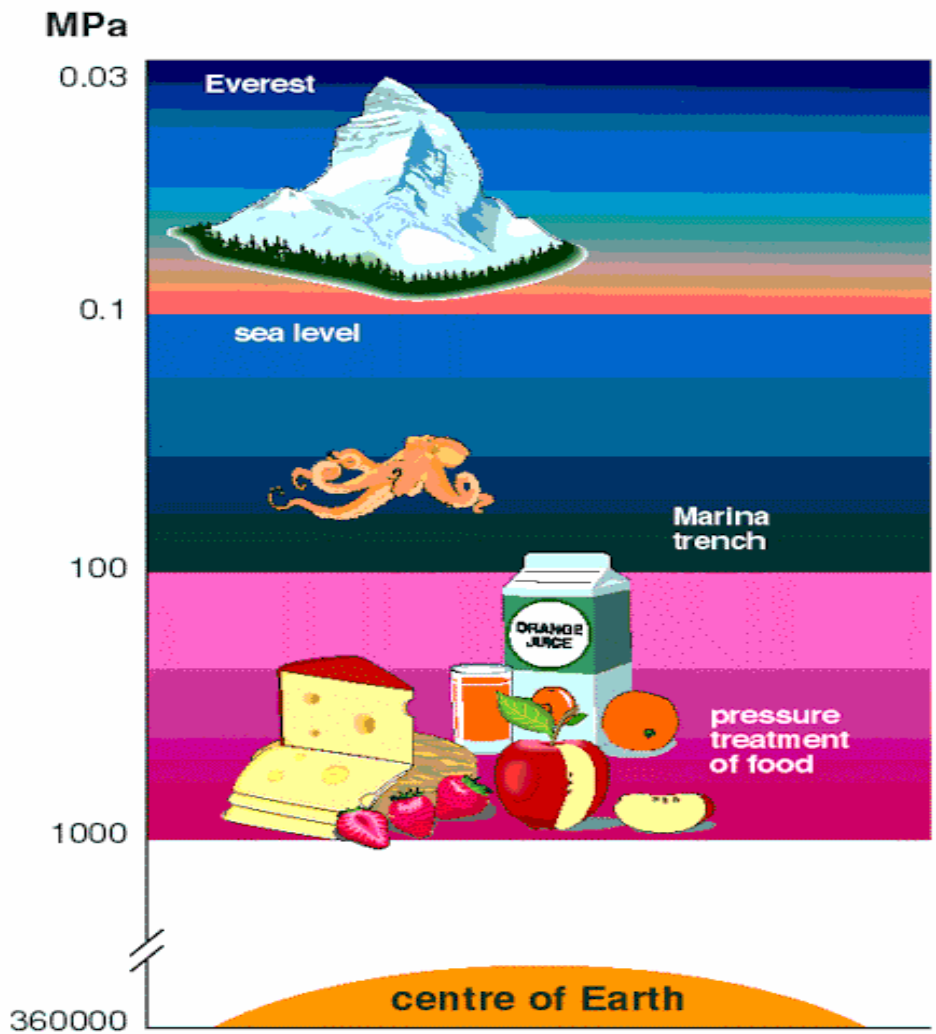
Method	Mode of action
• High Pressure Processing	Protein denaturing
• Pulsed Electric Field	Membrane rupture
• Biopreservation	Multi-mode
• Pulsed light	UV/Thermal effect
• Ionizing radiation	DNA damage
• Ozone	Oxidation

High Pressure Processing

- Hydrostatic pressure
- - 200 to 800 MPa
  Batch process
- Processing time: Minutes

- 230 lb football player
  on a dime → ~4 MPa.

Where can we find high pressure?

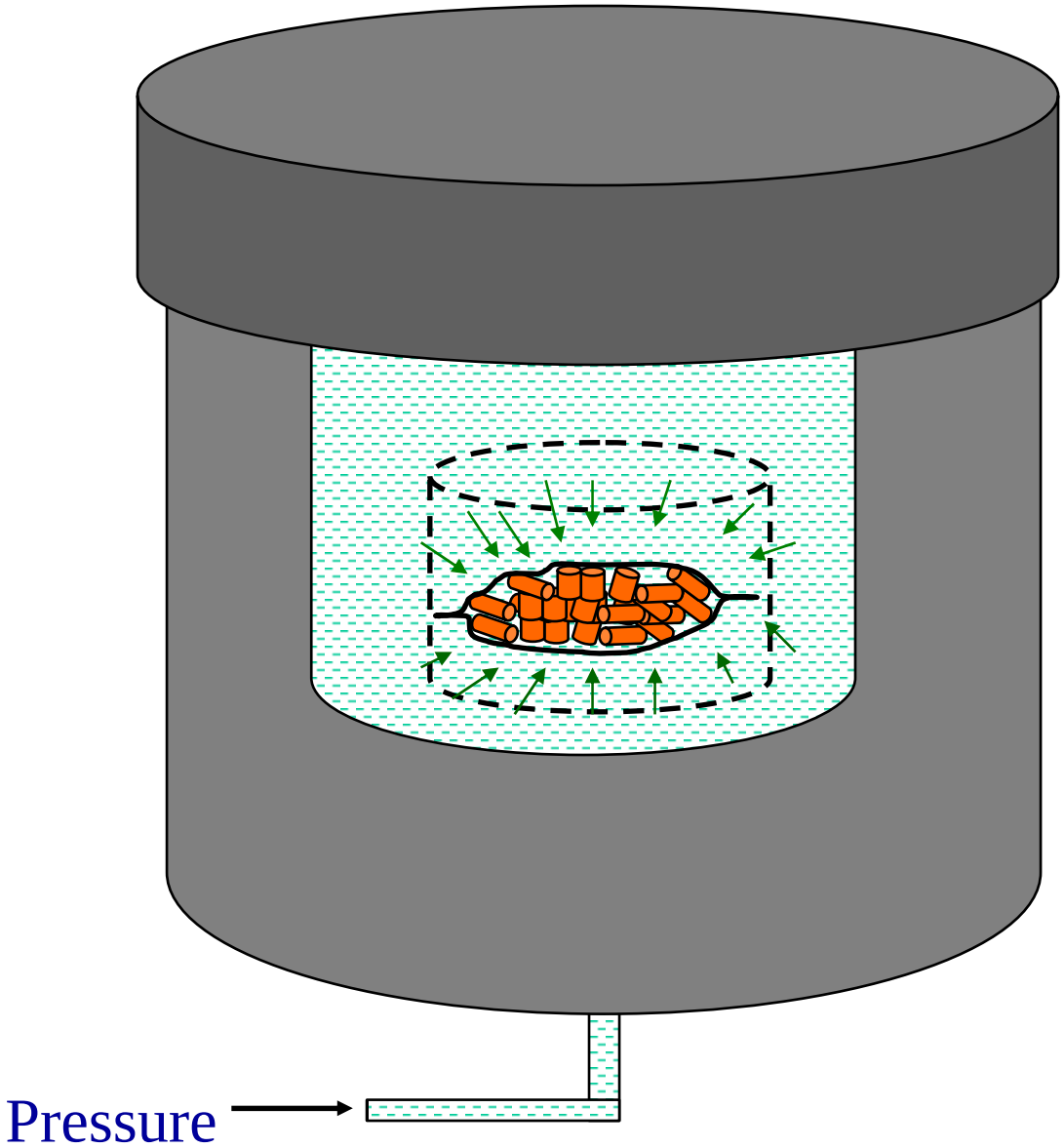


www.highpressure.org.uk

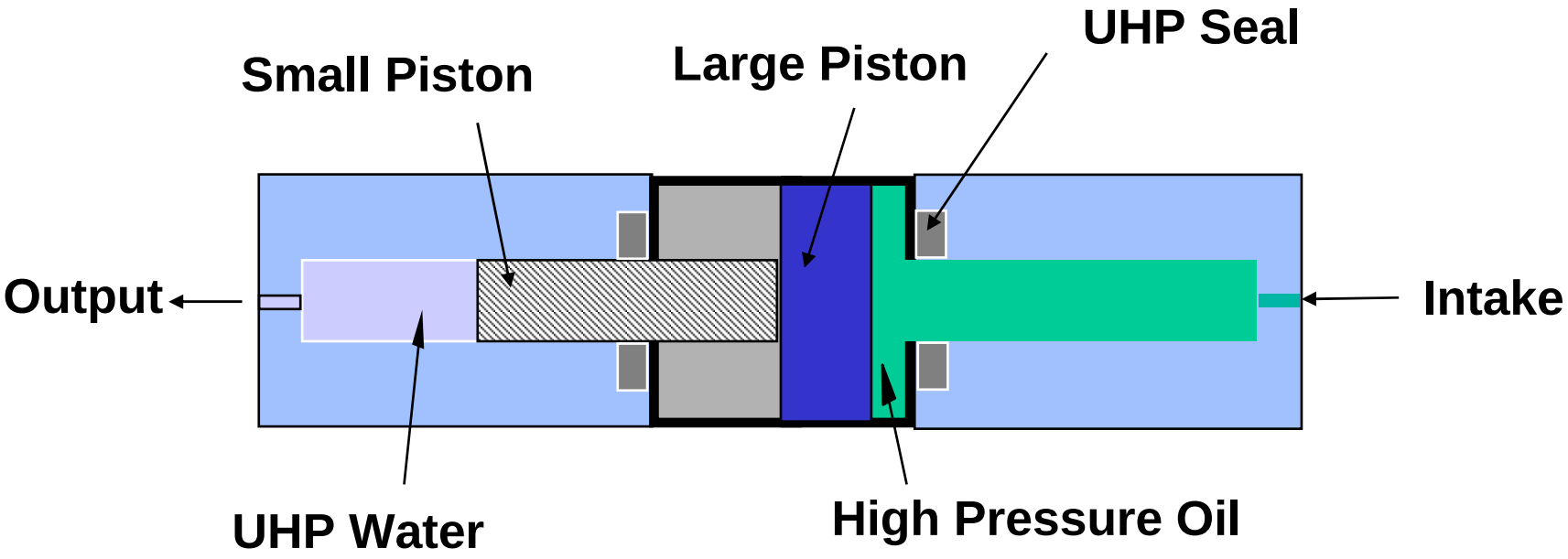
High Pressure Equipment

- Batch vs. semi continuous
- Two categories
  - Direct compression
    - Piston and cylinder
    - Small capacity, generally lab scale
  - Indirect compression
    - Chamber, pressure intensifier, reservoir
    - Industrial applications

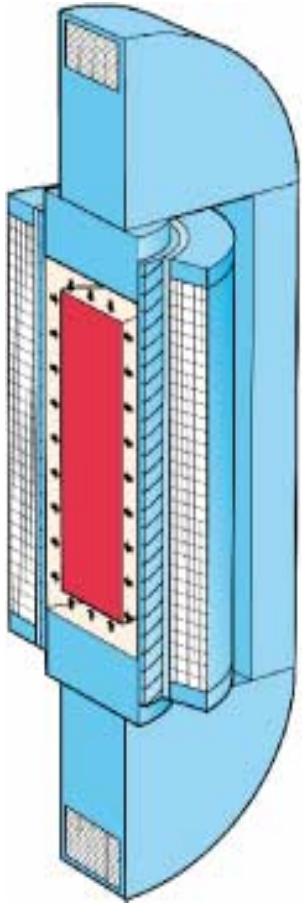
Pressure Vessel



Pressure Intensifier



Wire Wound Pressure Vessel

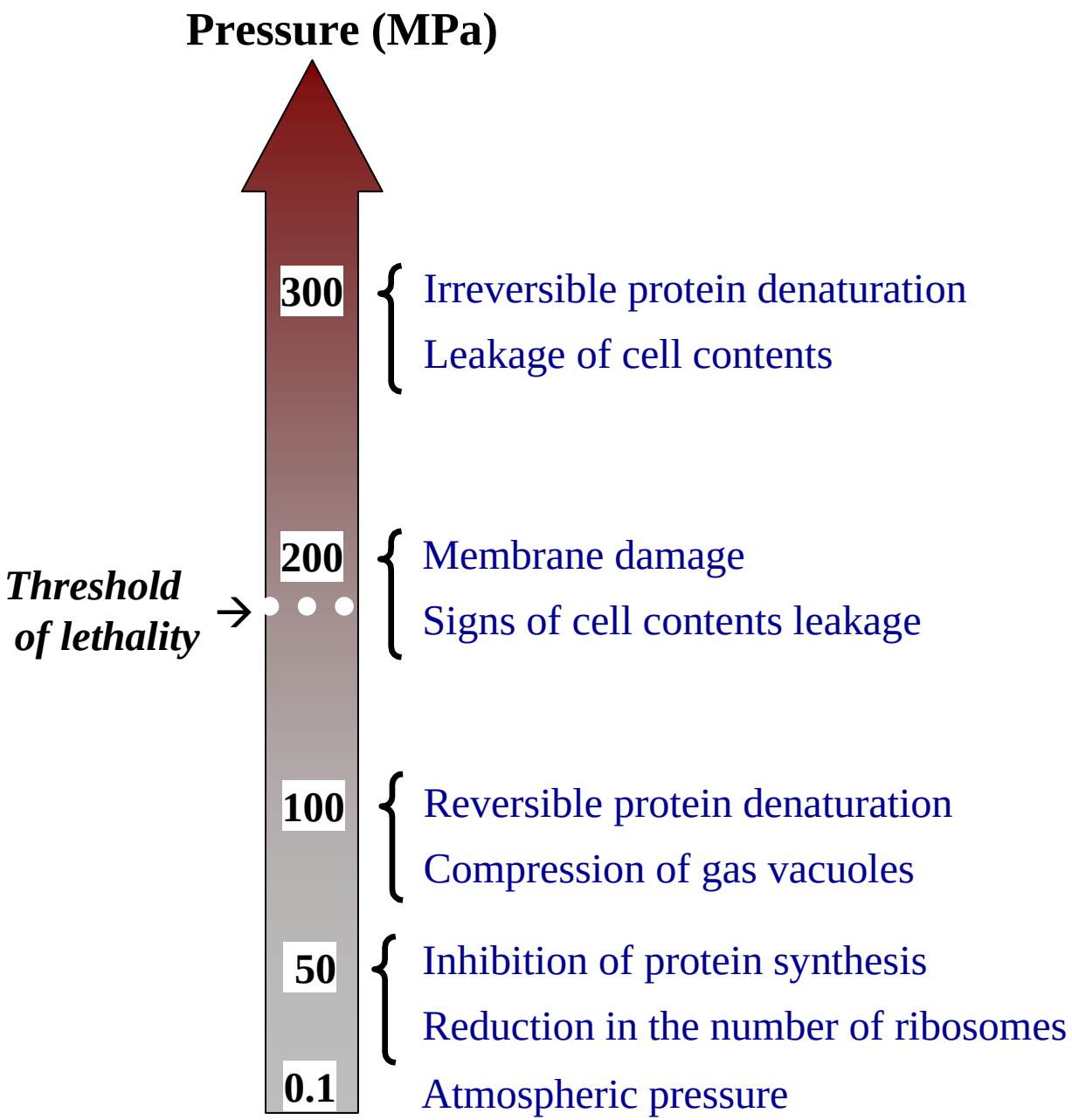


HPP Equipment

QFP-6 ABB HPP Unit

Principles of High Pressure Processing

- **The Le Chatelier's principle**
  - **A system at equilibrium tends to minimize the effect of an external perturbation**
    - **Lethality depends on what reaction is favored at pressure**
- **Molecules ordering**
  - **At constant temperature, an increase in pressure increases the degree of ordering of the molecules of a substance**
    - **Protein unfolding (denaturing) depends on water reordering**



Structural and functional changes in microorganisms at different pressures. Lado & Yousef, 2001

First usage!

WEST VIRGINIA

AGRICULTURAL EXPERIMENT STATION,

MORGANTOWN, W. VA.

BULLETIN 58. JUNE, 1899

The Effect of Pressure in the Preservation of Milk.

A Preliminary Report.

By B. H. Hite.

[The Bulletins and Reports of this Station will be mailed free to any citizen of West Virginia upon written application. Address Director of Agricultural Experiment Station, Morgantown, W. Va.]

At ten o'clock in the evening (May 15th) a number of tubes were filled with this milk in the usual way and subjected to pressures of seven to twelve tons, and temperatures of 152°—160° F. for one to three hours. The samples were kept at the temperature of the room for ten days, when a number of them were opened and found to be sweet. Six of the remaining samples were then packed in a tin box and shipped to New York City and back by mail. Two of the samples were then opened. They were sweet. Three days later two more samples were opened, with the same result. The other two samples were kept until the morning of June 4th, when this report went to the printer. They were still sweet.

Current Applications of HPP

Product	Process condition	Manufacturer
Jams, fruit jelly, fruit sauce topping, fruit dressing	400 MPa, 10-30 min, 20°C	Meidi-ya Company, Japan
Grapefruit juice	120- 400 MPa, 2-20 min. 20+°C	Pokka Corp., Japan
Mandarin Juices	300-400 MPa, 2-3 min. 20°C	Wakayama Food Ind., Japan
Non-frozen tropical fruits	50-200 MPa,	Nishin Oil Mills, Japan
Tenderized beef	100-150 MPa, 30-40 min. 20°C	Fuji Ciku Mutterham, Japan
Orange Juice	500 MPa, 5-10 min. cycles plus 1 min hold	Ultifruit, France
Avocado	700 MPa, 600-800 L/h	Avomex, USA

Commercial HPP Products

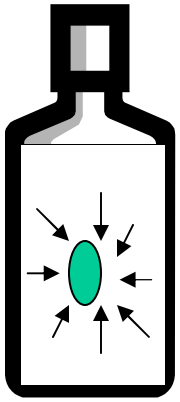
Successful Processing

- **Maintain food quality**
  - **Nutrients preserved**
  - **Unfavorable chemical and microbial alternation are minimized**

- **Enhance food safety**
  - **Pathogens of concern are killed or inhibited**
  - **No toxicants are generated**

Quality & High Pressure Processing

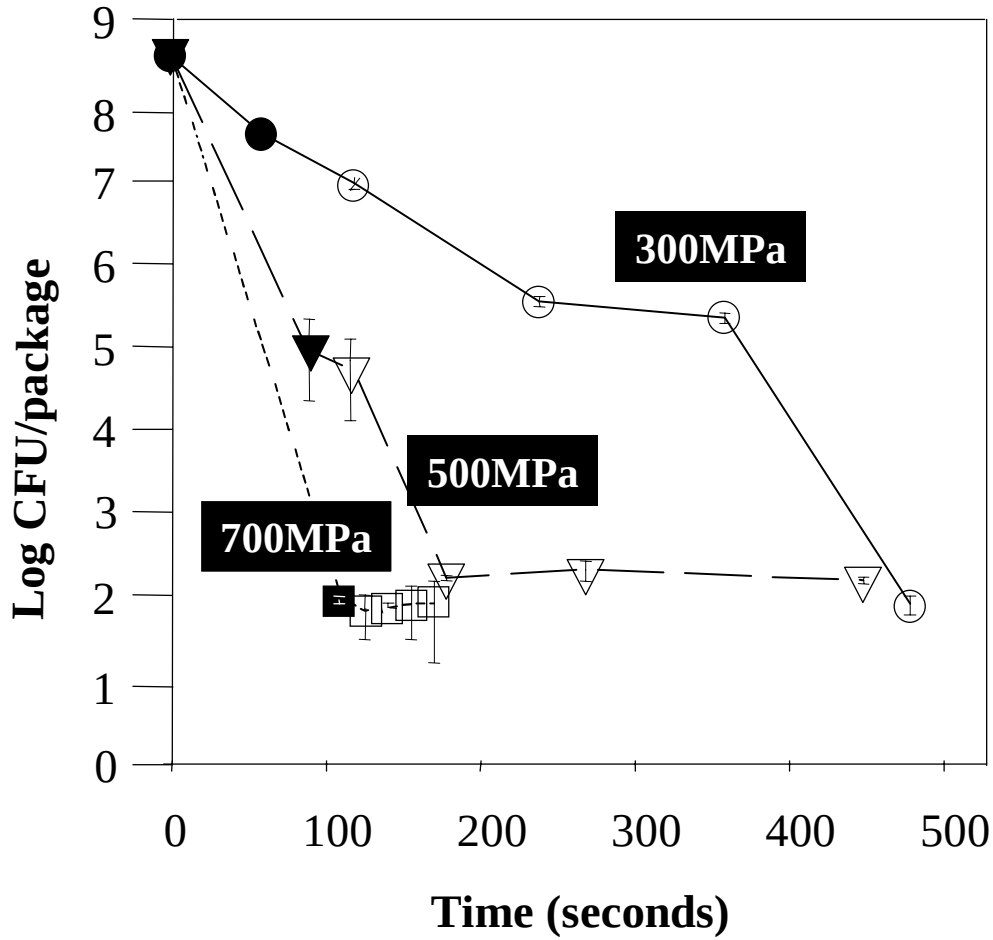
- **No breakage of covalent bonds**
  - **Maintain the product natural qualities**
- **Mild temperature**
  - **Minimal thermal energy is generated**
  - **Thermal alternation is eliminated**
- **Isostatic**
  - **Uniform treatment**
  - **Independent of size and geometry of the food**
  - **No deformation of packaged foods**



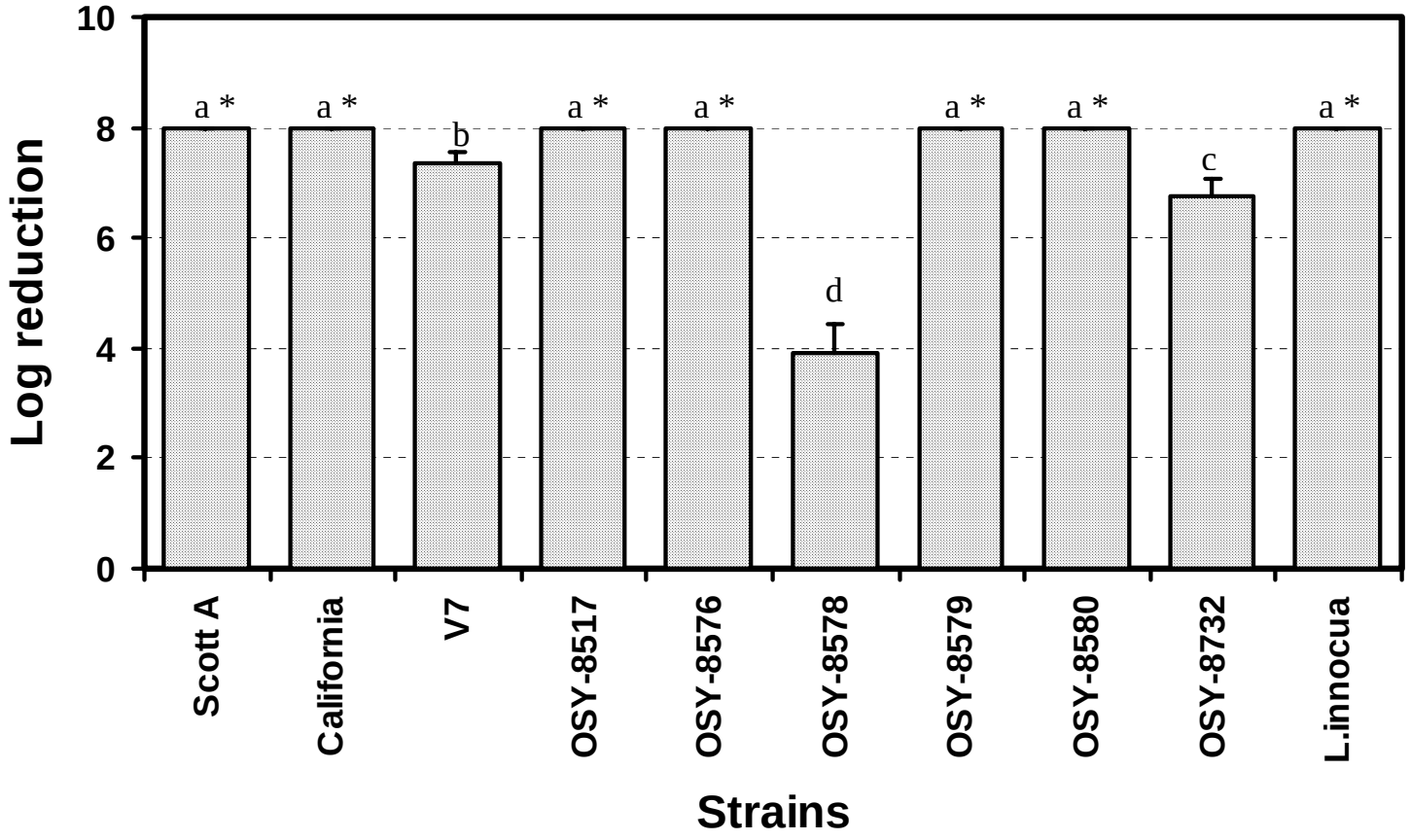
Quality of Pressure-Processed Meat Products

- **Raw meat**
  - **Color deterioration**
- **Frankfurters and sausages**
  - **Minimal changes**
- **Others**

Safety of Pressure-Processed Meat Products



Inactivation of *Listeria monocytogenes* in Frankfurters by high pressure processing (Lucore et al., 2000)



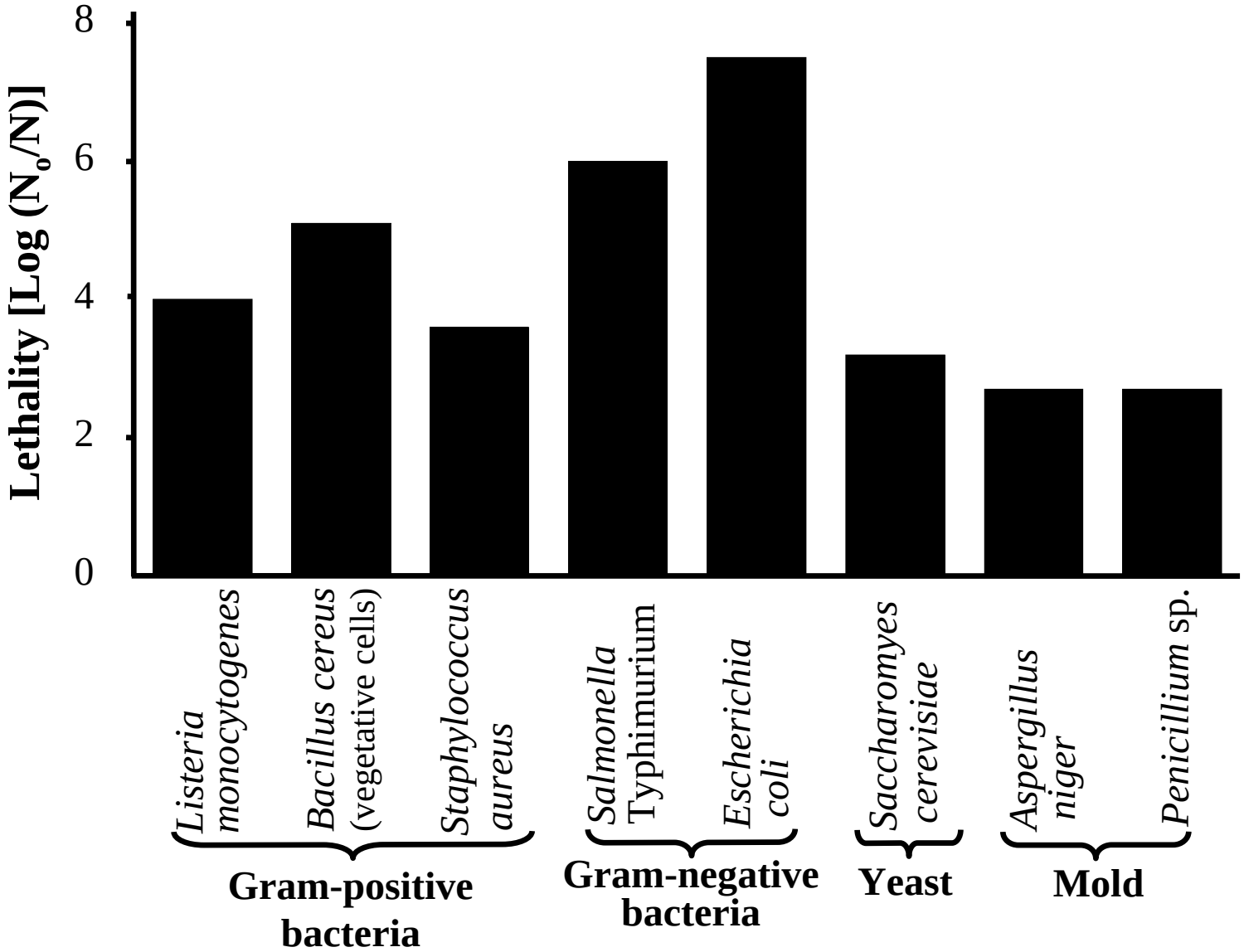
Variability in pressure tolerance among strains of *Listeria monocytogenes* (500 MPa, 1min, and 30°C)

*** Detection level is 10 CFU/mL**

Tay et al., 2003

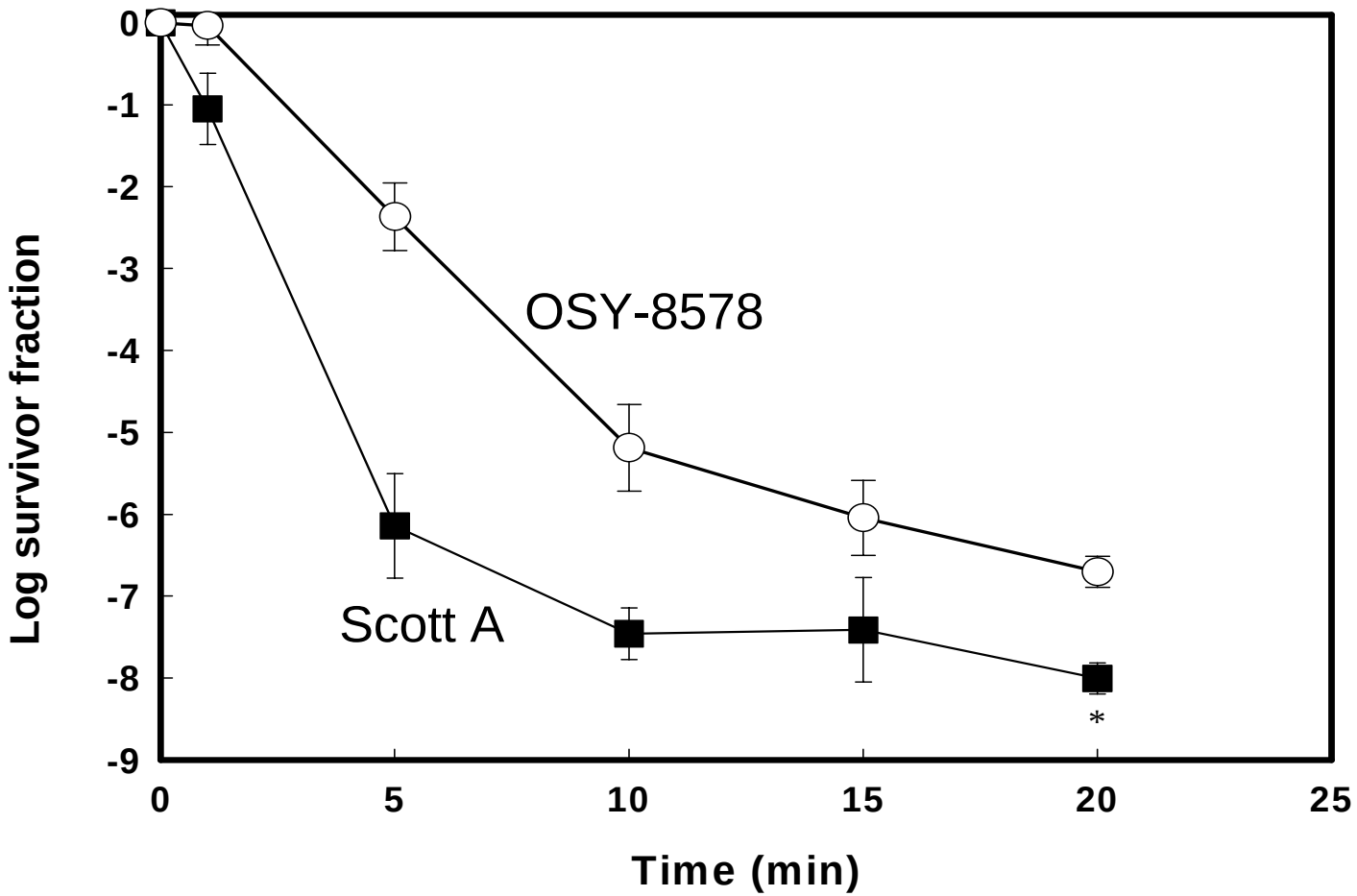
At 700 and 800 MPa, all strains were undetectable (i.e., > 8 log kill)

Tay et al., 2003



Lethality of microorganisms after high pressure processing at 300 MPa (5°C) for 30 min. Adapted from Arroyo et al. (1999). N: Count after treatment; N0: initial count.

Lado and Yousef, 2002



Tailing during pressure inactivation of *Listeria monocytogenes* at 350 MPa and 30°C

[1]Come-up time excluded

Tay et al., 2003

Spore Inactivation by High Pressure

- **Bacterial spores survive pressure up to 1200 MPa**
- **Combination of temperature and pressure has synergistic effect**
- **Example: *Bacillus stearothermophilus***
  - **Pressure at 800 MPa, 60°C, 1 hr → 4 log reduction**
  - **Pressure at 800 MPa, 25°C, 1 hr → No change**

Limitations Summarized

- Large variability in barotolerance among strains of the same species
- Tailing death behavior
- Resistance of bacterial spores
- Resistant enzymes
- Refrigeration may be requires to retain sensory qualities

Potential Remedies

Combination preservation strategies

- heat
- acid
- bacteriocins
- ozone
- gamma radiation
- cold storage

Example:

A thermal blanching step prior to HPP control enzyme residuals. A similar approach was required for irradiated meats.

Conclusions

Current high pressure technology is suitable for pasteurization of meat products.

Commercial sterility is not feasible using the current technology

Commercial sterility is possible when combing pressure and other preservation factors (e.g., heat).