High Pressure Processing of Foods Basic Principles and Technology Applications

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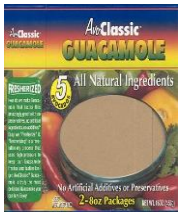
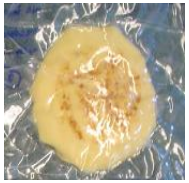
Application of High Pressure Processing is Expanding



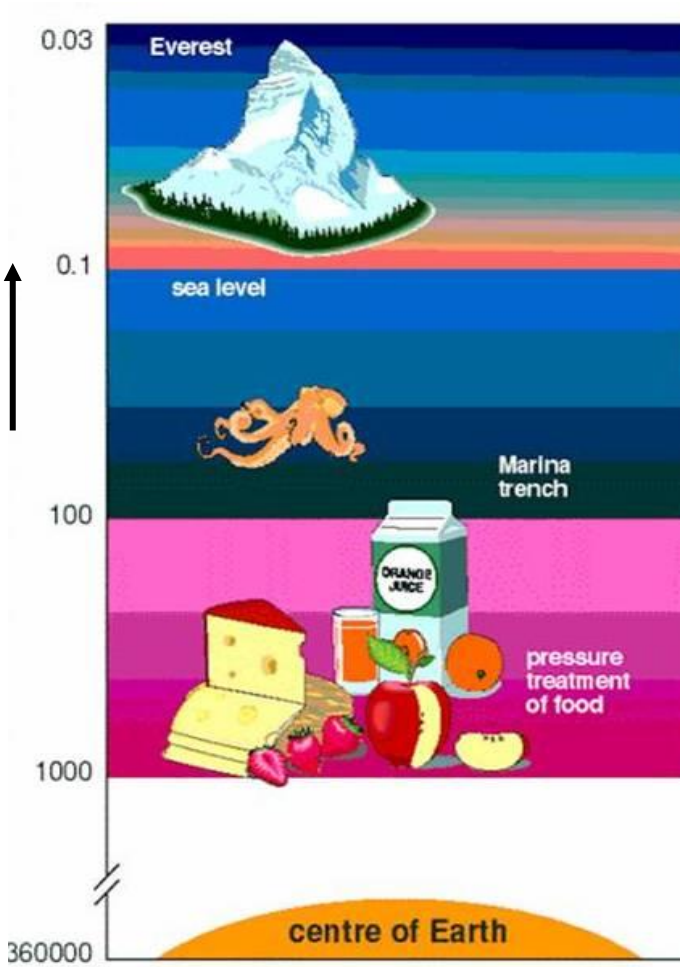
- **High pressure (up to 700 MPa) with or without addition of external heat**
  - **Shelf life Extension**
  - **Uniform application of pressure**
  - **Consumer acceptance**
- **Variety of pressure pasteurized products are commercially available**
  - 100-600 MPa at room or chilled temperature for couple of minutes
    - Juices, fruit snack, ham, oysters, jam, guacamole, poultry, chopped onion, sliced meat
    - Extend shelf-life by 2-3 fold over a non-HPP treated counterpart and improve food safety
- **Shelf-stable foods are not yet commercialized**
  - Combination of elevated pressure (500-700 MPa) and heat (90-120^{o}C)
  - Mashed potato, eggs, pasta, whole-muscle meats, coffee, tea, low-acid sauce
  - 2009 FDA issued no objection to an industrial petition



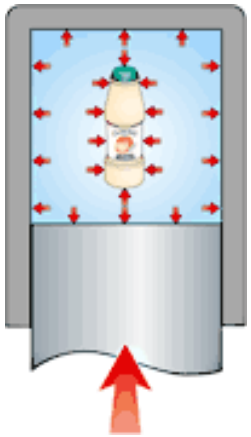
Examples of pressure applications

- Water jet cleaning
  - 25ºC/300 MPa
- Water jet cutting
  - 25ºC/400 MPa
- Gun barrel
  - 1000ºCC/ 600MPa
- Material densification
  - 1000ºCC/ 200MPa
- Crystal growth
  - 400ºC/ 200MPa
- Artificial diamond making
  - 3000 ºC / 600 MPa

- Pressure cooking /Canning
  - 121ºC / 100 kPa
- Conventional Homogenization
  - 20-30 Mpa
- Super critical fluid extraction



Principle



- **Isostatic Principle:**
  - Uniformity of pressure
  - Process time - independent of the size and the geometry of the food
- **Le Chatalier's:**
  - phenomenon accompanied with a decrease in volume will be enhanced by pressure increase
- **Arrhenius relationship:**
  - Temperature dependency of reaction

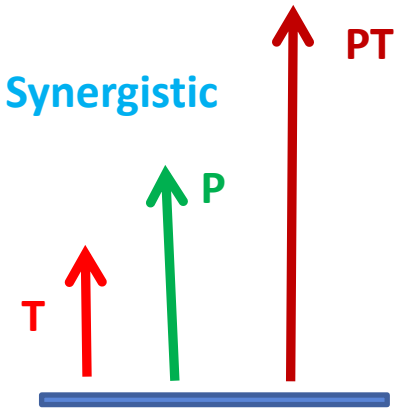
What are the unique advantages?

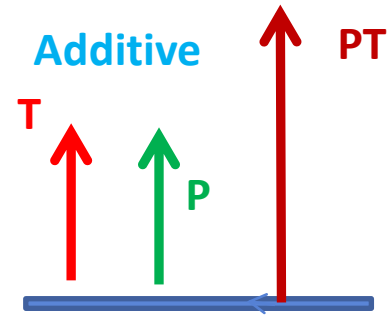
Description	Advantage
Pressure	Rapid & uniform distribution throughout the sample.
Thermal distribution	Reduced thermal impact. Result in better quality product.
Physical compression	Instant temperature increase and subsequent cooling upon depressurization.
Product handling	Suitable for both particulate and pumpable food.
Process time	Less dependence of product shape and size.
Functionality	Opportunities for new process/product development.
Reaction rate	Pressure accelerates traditional thermal inactivation kinetics.

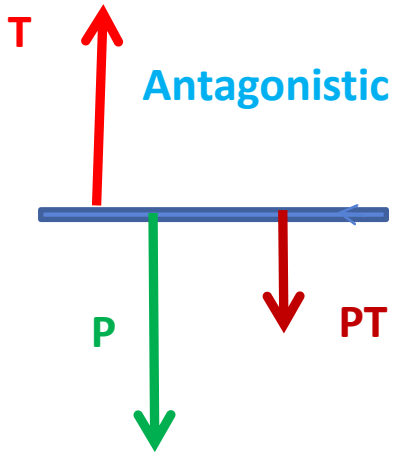
Perceived Food Processor Benefits

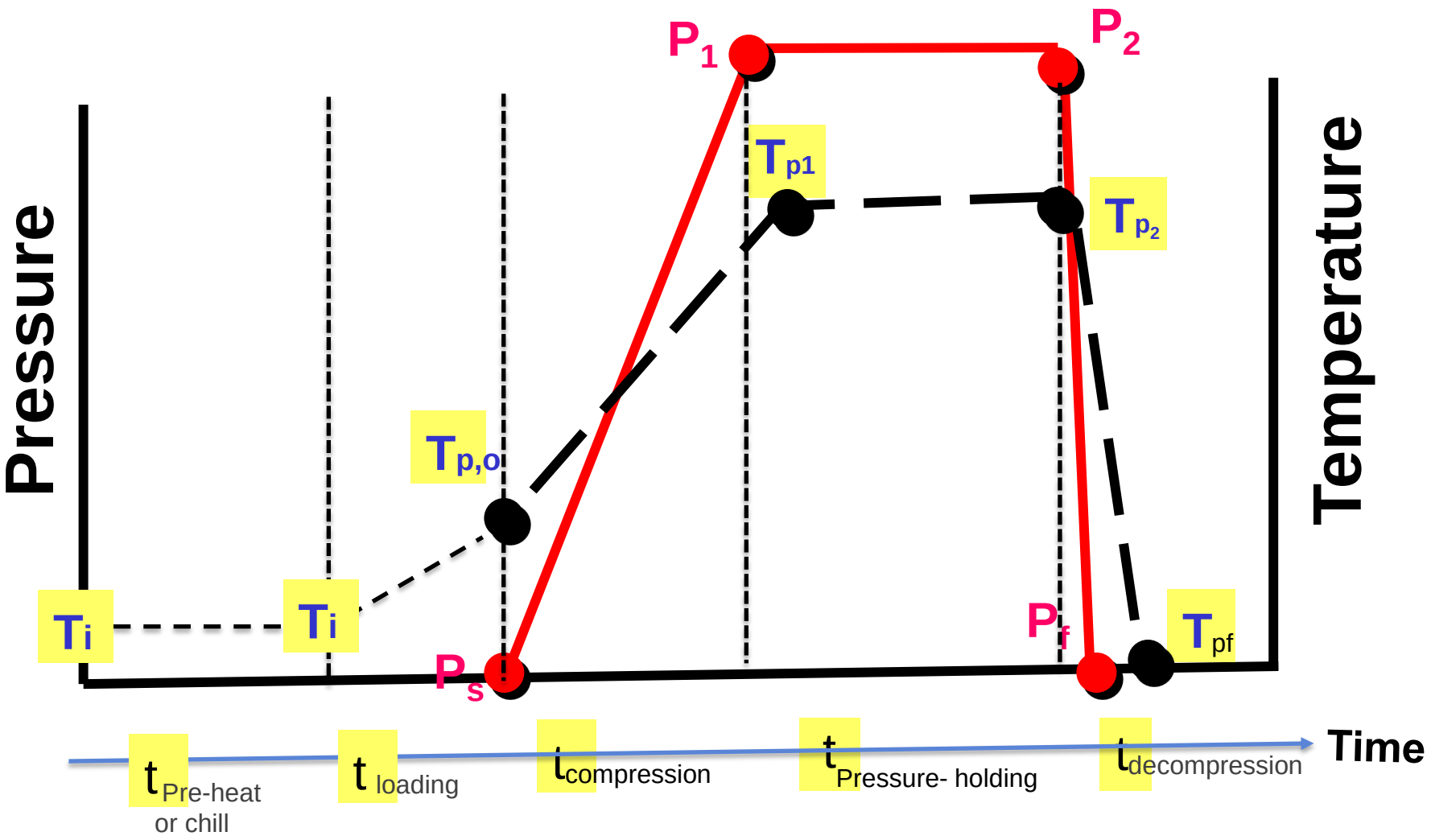
- Minimal use of preservatives
- Reduced sodium
- Products with fresh-like quality attributes
- Preserving heat sensitive nutrients and health promoting compounds
- Shelf life extension
- Consumer acceptance

- Reactions (microbial, chemical or enzymatic) during the treatment is influenced
  - Process Pressure
  - Process Temperature
  - Effect can be synergistic, additive or antogonistic
- Temperature effects are primarily based on vibrational kinetic energy
- Pressure effects that are based on thermodynamic based factors such as changes in volume & entropy .
  - 15-20% volume reduction
  - Reversible upon depressurization



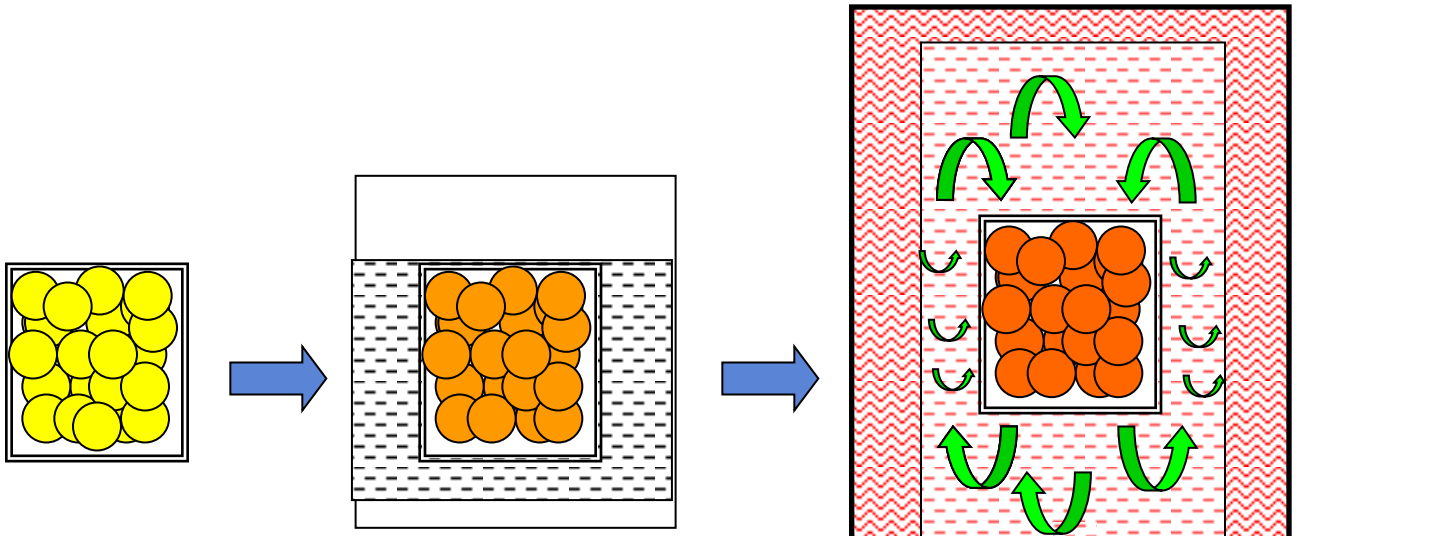





Pressure
Temperature
P1
P2
Tp1
Tp2
Tp,o
Ti
Ti
Ps
Pf
Tpf
Time
t Pre-heat or chill
t loading
tcompression
t Pressure- holding
tdecompression

High Pressure Pasteurization

Key Steps



Vacuum - packaged food sample

The initial temperature of

The sample is maintained

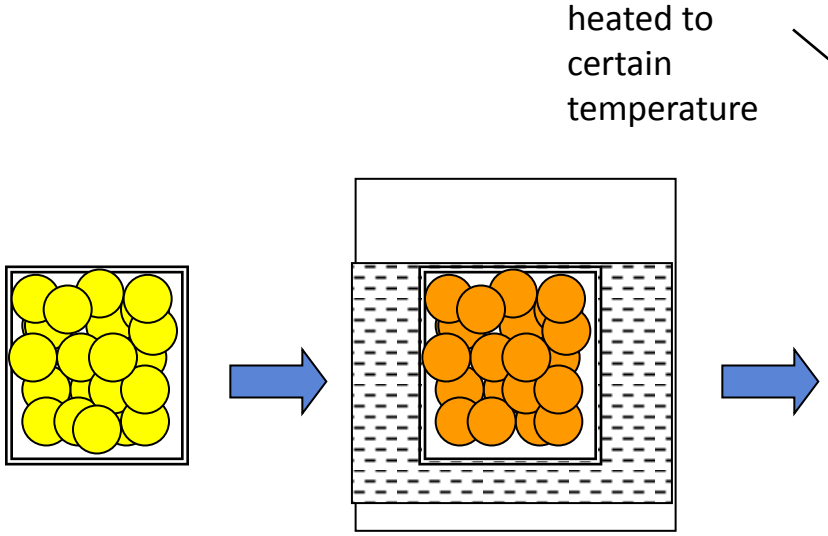
at chilled or ambient temperature

pressure transfer fluid

High Pressure Pasteurization

- Meat Products:
  - Listeria control in prepackaged ready to eat meats
  - *500 MPa-600 MPa at chilled conditions*
  - Sliced ham, turkey or chicken cuts, ready-to-eat products, whole pieces of cured ham
- *Sea Food:*
  - Moderate pressures (200-500 MPa)
  - Control Vibrio parahaemolyticus, Vibrio vulnificus
  - separates the muscle from the shell of shellfish, oysters, crab, lobster etc
- Fruit, Vegetable & dairy based beverages, products:
  - Escherichia coli O157:H7, Listeria monocytogenes, Salmonella
  - Shelf life extension & value addition
  - Variable effect on enzyme inactivation

Key Steps



Pressure vessel to be heated to certain temperature

Heat exchange between product, pressure transmitting fluid and surrounding

Product subjected to combination of pressure-thermal sterilization treatment

Vacuum - packaged food sample

Pre heat the sample 70-90°C through conduction and convection heat transfer

Rate limiting step for preserving product quality

Temperature conditioned pressure transfer fluid

Pressure Assisted Thermal Processing

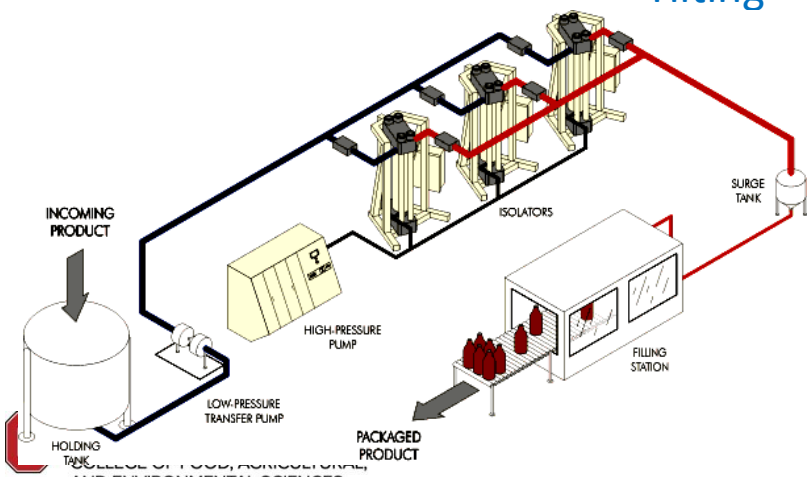
- Application of high pressure (400-600 Mpa) in combination with heat (90-120C)
- Ambient stable or Extended Shelf Stable (ESL)
  - Breakfast eggs, Stews, Soups, Tea, Coffee, Cream sauce, liquid flavor, herb
- 2009 FDA issued no objection to an industrial petition
  - No commercial product in the market

- Pressure-Ohmic Thermal Sterilization (POTS)
  - High pressure (400-600 Mpa) in combination with Ohmic heating (Sequential and simultaneous)
  - Being developed at The Ohio State University

High Pressure Equipment for Food Pasteurization and Sterilization

Vertical

Tilting



Horizontal

Source: Avure, Hiperbaric, Multivac

Sources of Technology Providers

Major Equipment Manufacturers

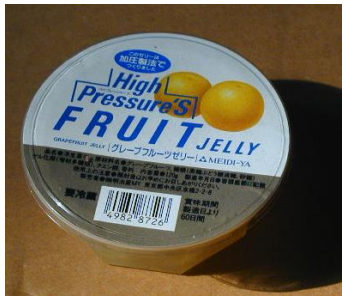
- Avure Technologies, Middletown, OH
  (http: www.avure.com)
- Hiperbaric S.A. Burgos, Spain
  (http://www.hiperbaric.com)
- Multivac, Kansas City, MO
  (http://us.multivac.com/our-products/hpp-high-pressure-preservation.html)

Toll Processors

- American pasteurization company, Ameriqual, Millard Refrigeration, Safepac, Universal Cold Pasteurization among others

University based laboratories

- The Ohio State University, Rutgers University, Virginia Tech, Delaware, Iowa State University, Illinois Inst Technology, Oregon State University, Washington State University among others

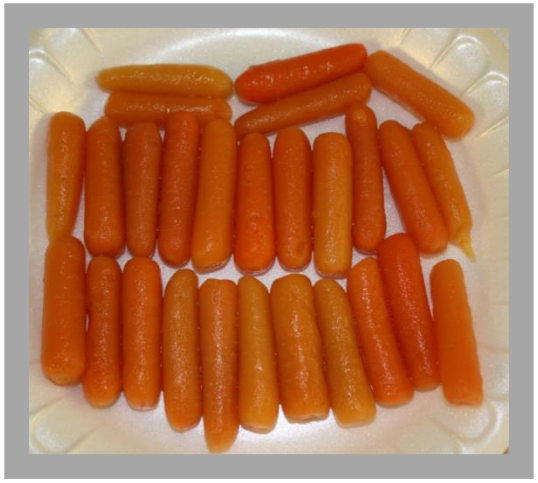


Packaging

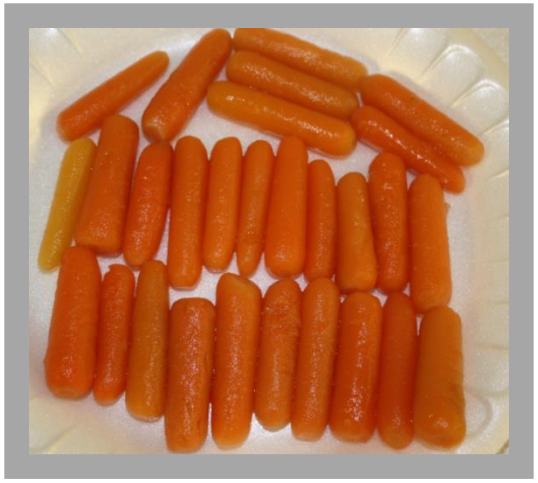
- **At least one flexible packaging interface for pressure transfer**
- Minimum headspace
- MAP option possible
- Ability withstand pressure and heat
  - » Consider packaging integrity
  - » Improper selection may result in barrier properties loss after pressure treatment
  - » Mechanical properties (tear strength, puncture resistance)

After 12 weeks at 25 °C

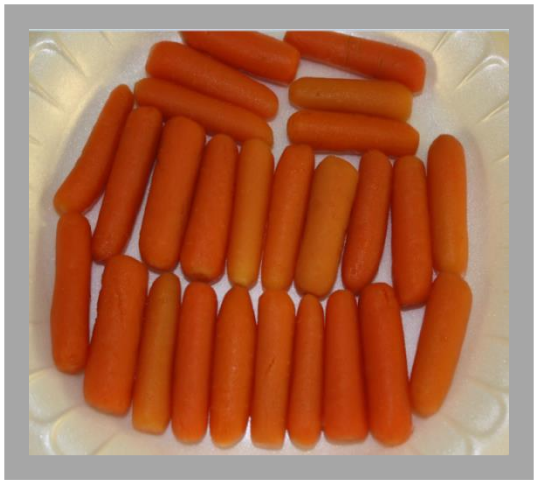
NYLON/EVOH/EVA

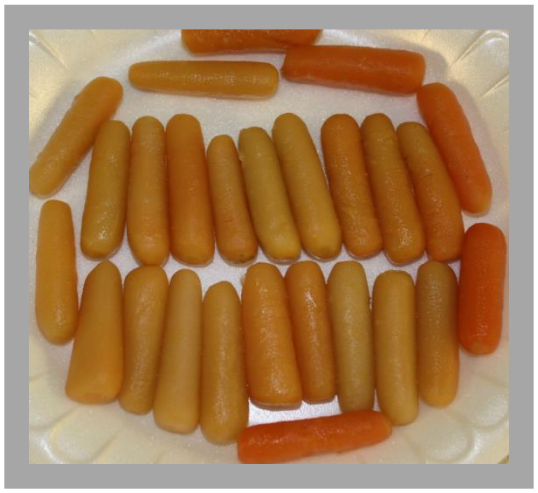


NYLON/EVA



MetPET/PE





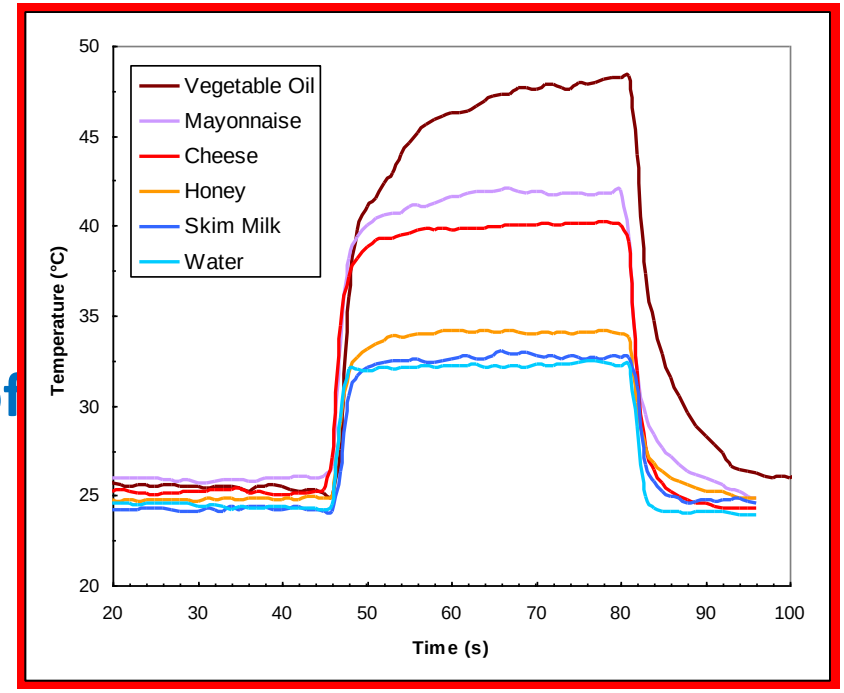
After 12 weeks at 37 °C

Source: Ayvaz et al. 2012

What happens to foods when subject to pressure treatment?

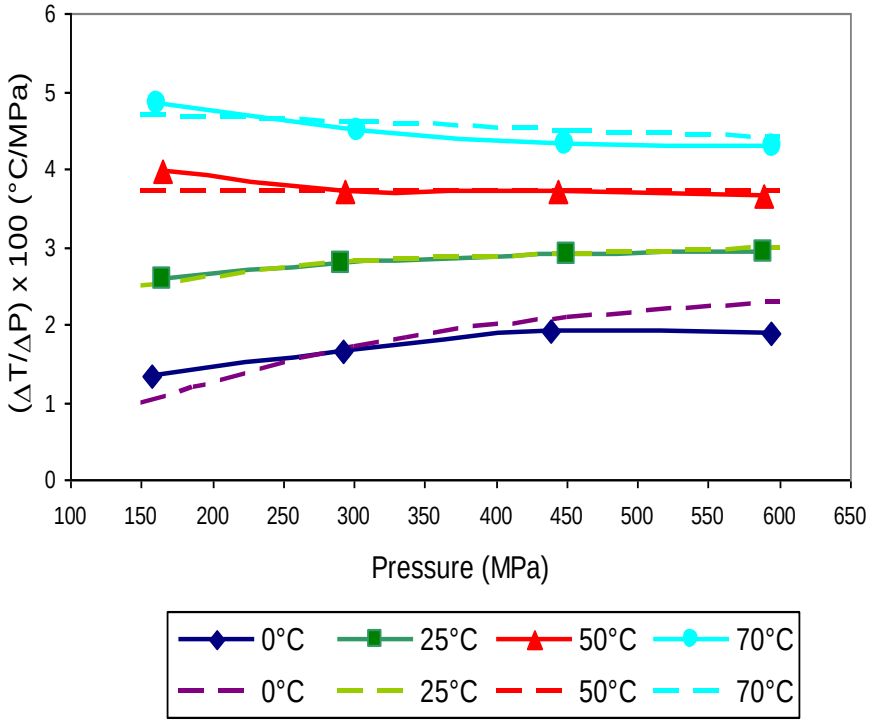
- Temperature increases with pressure and decreases with pressure release
- Nearly instantaneous
- Magnitude of change depends on compressibility and specific heat of the substance
- Molecular level phase change in some comp.

Temperature response during compression at 300MPa and 25°C



Patazca and Balasubramaniam, 2002

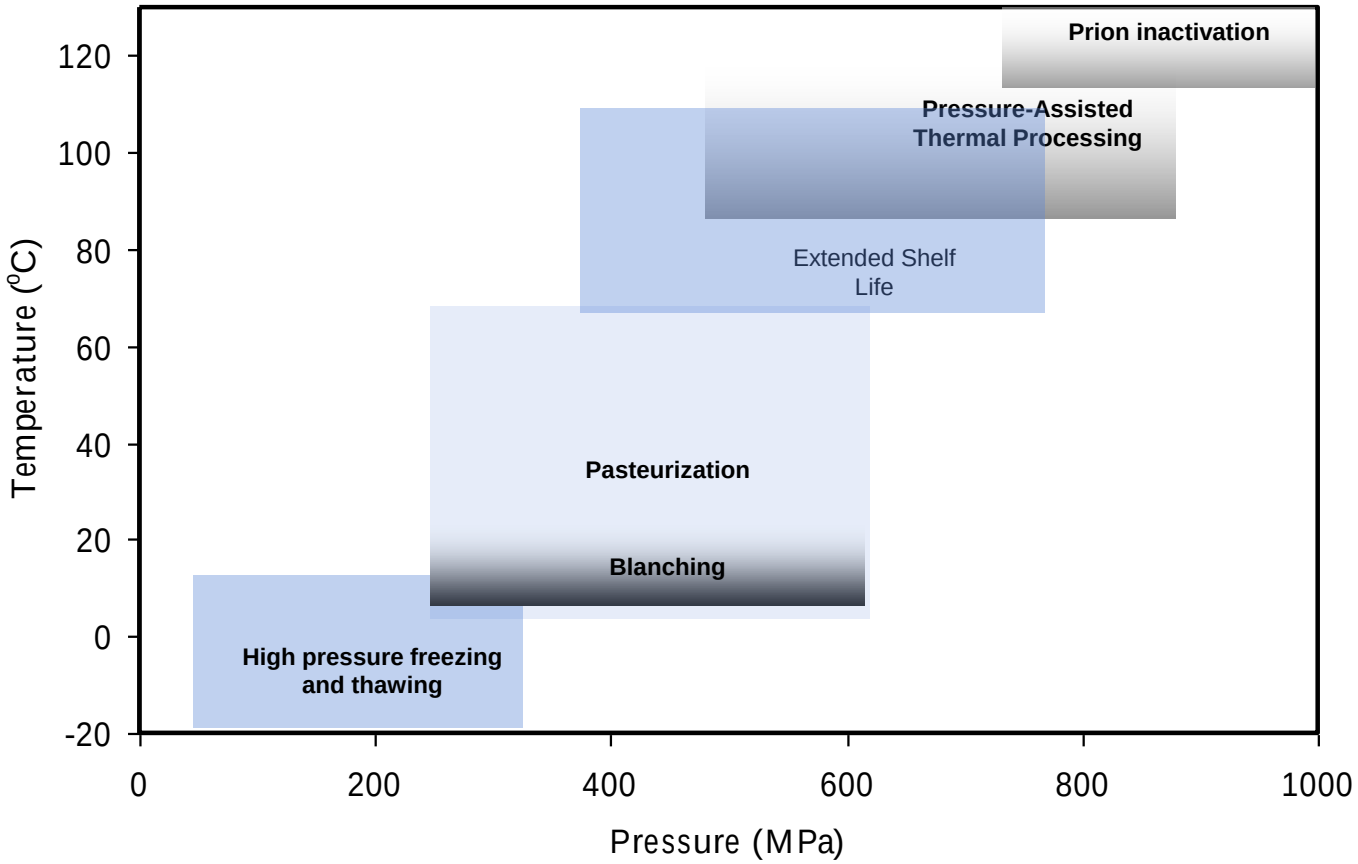
Compression heating factor



Substance	Compression heating factor (°C/100 MPa)	
	IT = 25°C	IT=70°C
Carbohydrates	2.6-3.6	3.6-5.3
Proteins	2.7-3.3	4.1-5.1
Fats	6.1-8.0	6.8-9.4

Patazca and Balasubramaniam, 2002

Microbiological treatment efficacy

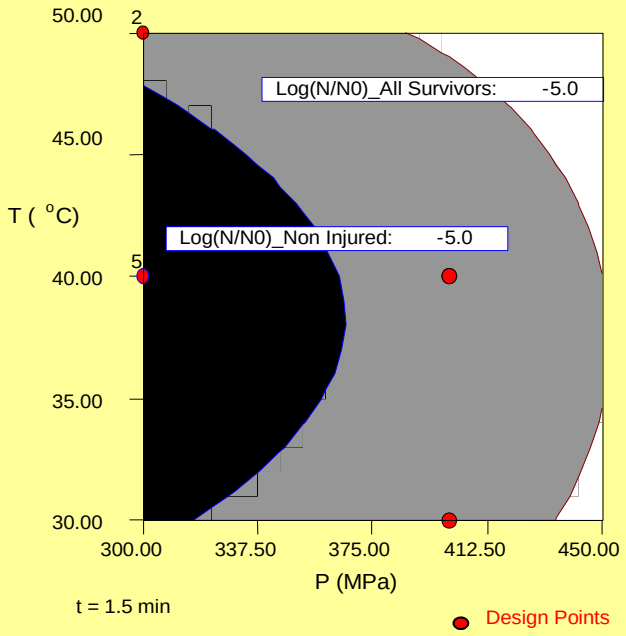


Nguyen et al. 2011

Factors Influencing Microbial Inactivation during high pressure treatment

- Process
  - Target pressure
  - Product initial temperature
  - Process temperature (under pressure; especially for sterilization)
  - Holding time
- Product
  - Food composition
  - pH
  - Water activity
  - Antimicrobial agents
- Consider potential injury and recovery of bacteria during extended storage

5-Log Inactivation *Listeria monocytogenes*



t = 1.5 min.

Black: Dead + Injured < 5-Log

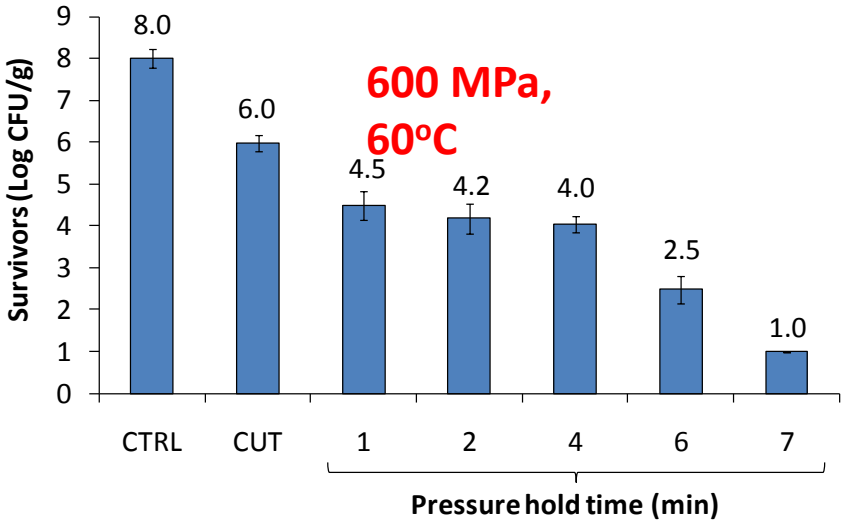
Gray: Dead + Injured > 5-Log; Dead < 5-Log

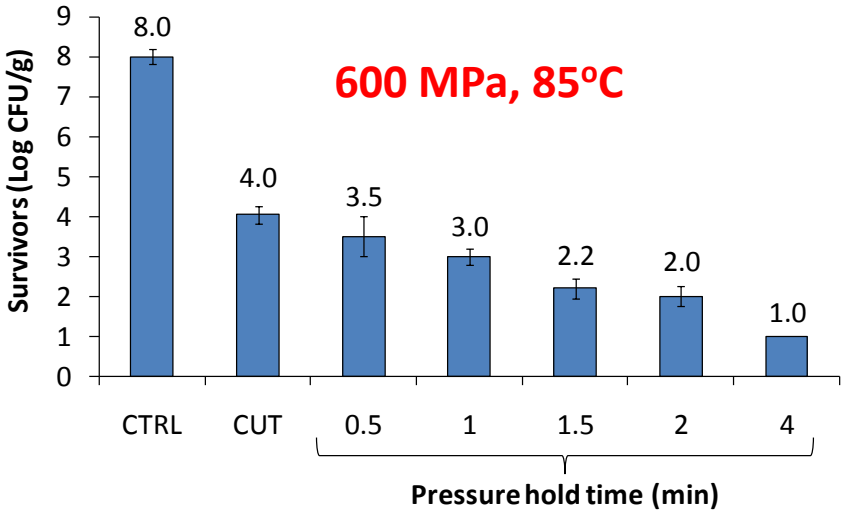
White: Dead > 5-Log

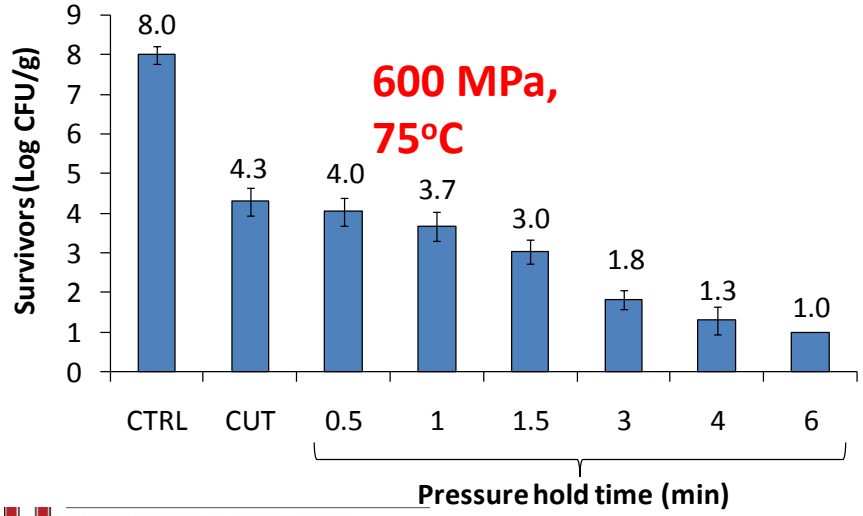
Slade and Balasubramaniam, 2002

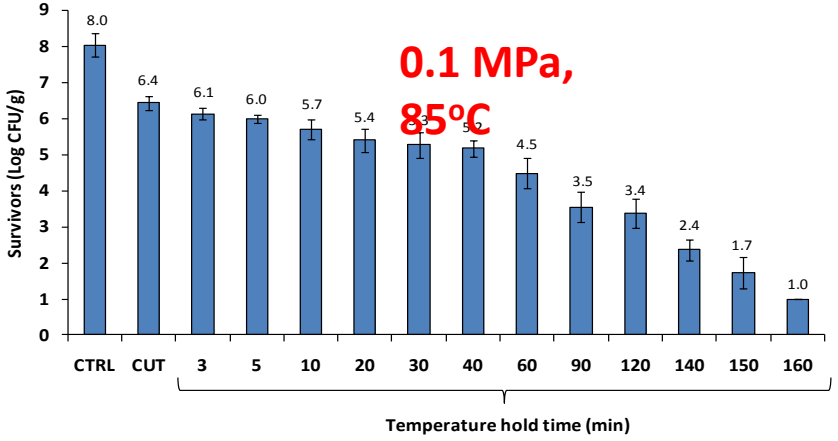
Slade and Balasubramaniam, 2002

Pressure-thermal inactivation of *B. cereus* spores in cooked rice



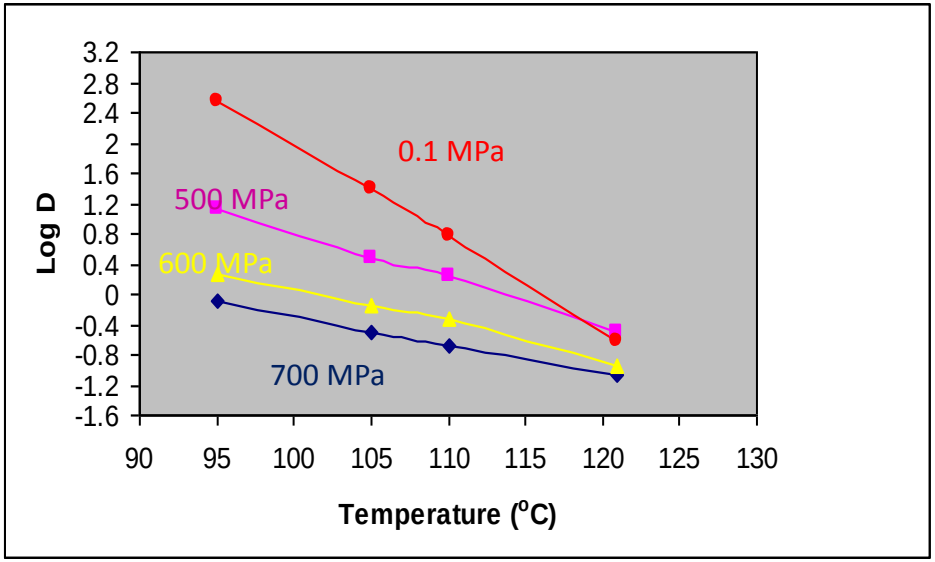


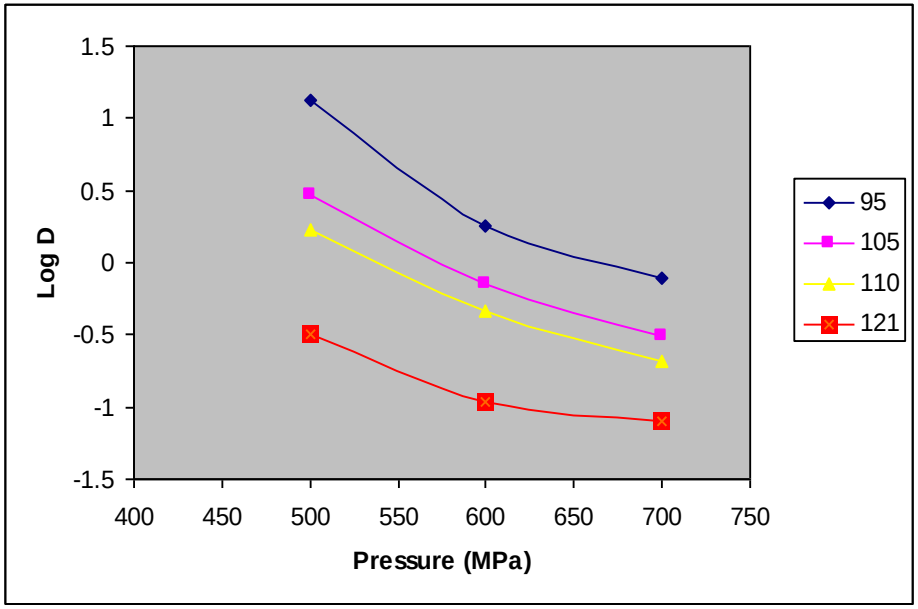




Daryaei et al. 2013

Inactivation of *B. amyloliquefaciens* spores as a function of pressure and heat





Z_T =8.2 °C @ 0.1MPa

Z_T =16.7°C@ 500 MPa

Z_T= 21.5°C@ 600 MPa

Z_T = 26.7°C@ 700 MPa

Z_p =170. 2MPa @ 95°C

Z_p =206.0 MPa @105°C

Z_p =220.2 MPa @110°C

Z_p =332.2 MPa @ 121°C

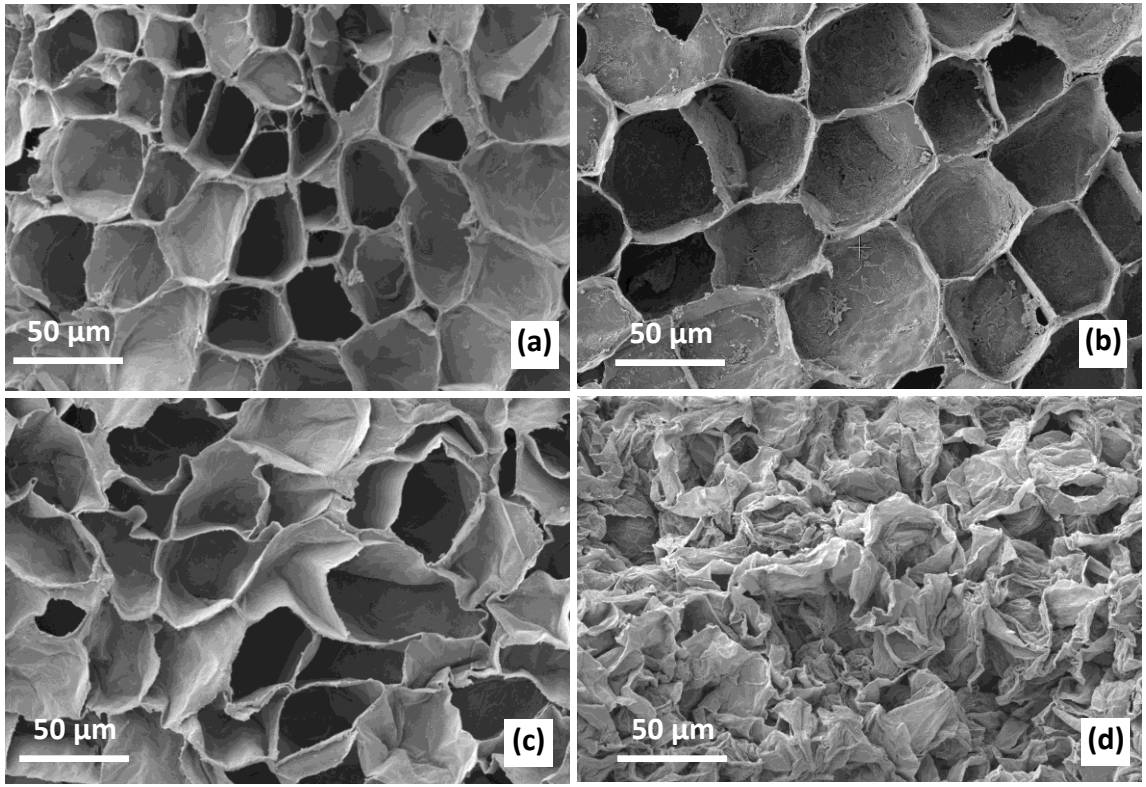
$\Delta V = -4.42 \times 10^{-5}$ m^3/mole @ 95°C

$\Delta V = -3.67 \times 10^{-5}$ m^3/mole @ 105°C

$\Delta V = -3.37 \times 10^{-5}$ m^3/mole @ 110°C

$\Delta V = -2.26 \times 10^{-5}$ m^3/mole @ 121°C

Rajan et al., 2006



Microstructure of carrot samples:

(a) Raw, untreated

(b) Pressure treated (700 MPa, 25 °C, 5 min)

(c) Pressure-assisted thermal processed (700 MPa, 105 °C, 5 min)

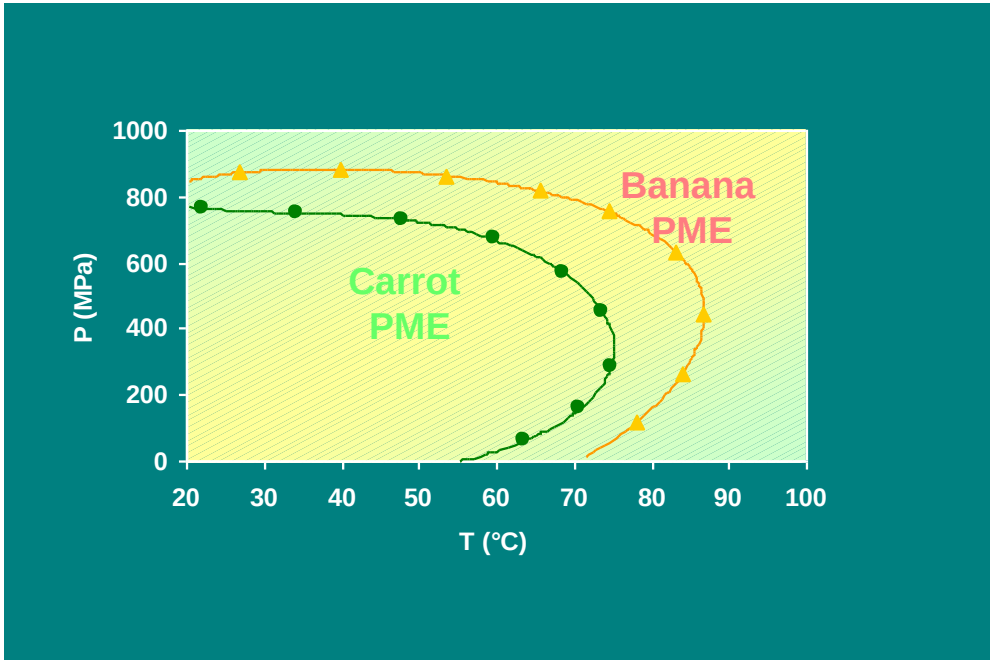
(d) Thermal processed (105 °C, 0.1 MPa, 30 min)

Enzyme inactivation

- **Reversible or irreversible, partial or complete inactivation**

➢ Efficacy varies depending on
  - Type of enzyme
  - Pressure level
  - Process time
  - pH value
  - Temperature

➢ 600 MPa (@25ºC) sufficient to inactivate most vegetative microorganisms but enzymes may not be inactivated



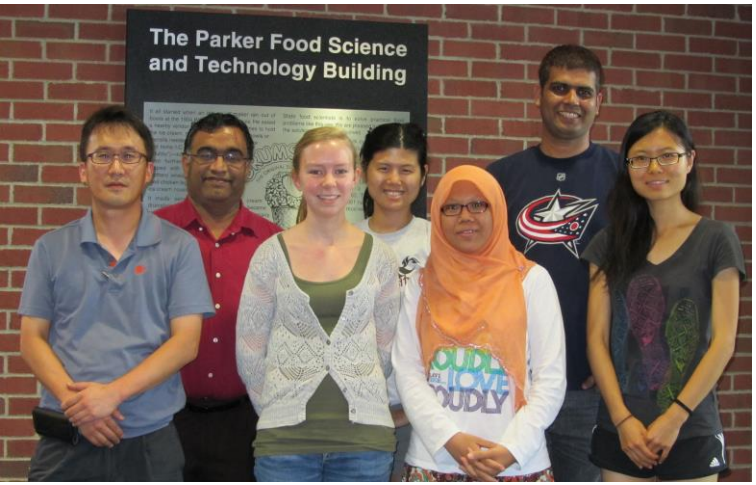
P-T contour plot 95% PME inactivation @ 30 min. process time

Source: Nguyen et al., 2005

Summary

- ✓ **High Pressure Based Technologies**
  - ✓ Useful tool for preserving nutritional and functional characteristics and extend shelf life
  - ✓ Watershed moment for industrial implementation
  - ✓ Pasteurized products are commercialized.
  - ✓ ESL and shelf-stable products are likely follow
  - ✓ **Consumer interested in food, not technology.**
  - ✓ **Important to understand "unique" advantages, limitations**
- ✓ **Identification of suitable products is critical**
  - ✓ **Improved understanding to facilitate the design and development of healthy, nutritious functional foods that satisfy consumer demand**

…a safer world through food safety and technology research



Thank you

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IFT

High Pressure Processing and Predictive Microbial Modeling

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US ARMY RDECOM

US ARMY NATICK SOLDIER RD&E CENTER

High Pressure Processing

- Innovative food processing and Microbial modeling methods ensure product safety and wholesomeness over shelf-life, while reducing costs of hazards and outbreaks, and decreasing losses from waste/spoilage.

- HPP – emerging Nonthermal food processing technology: Ensures Food Safety and produces fresher products, higher quality, extended shelf-life products with enhanced nutrient retention.

- The Enhanced Quasi-Chemical Kinetics (EQCK) model is an innovative, next-generation model that saves time, money, and labor while improving Food Safety.

High Pressure Processing

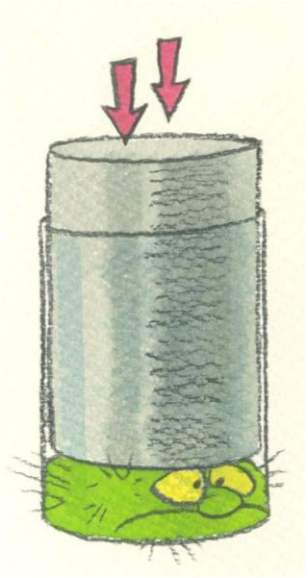
HPP is an emerging technology to reduce losses in food quality compared to thermal processing.

High pressure eliminates vegetative pathogens, prions, viruses, parasites, and spoilage organisms.

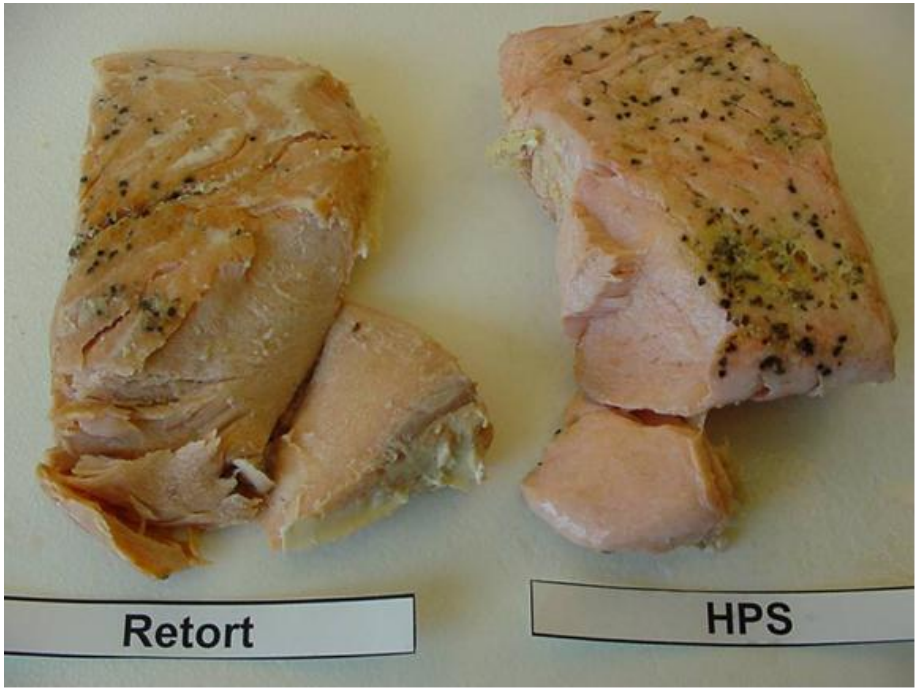
Bacterial spores are resistant and pose special challenges for the production of Commercially sterile foods.

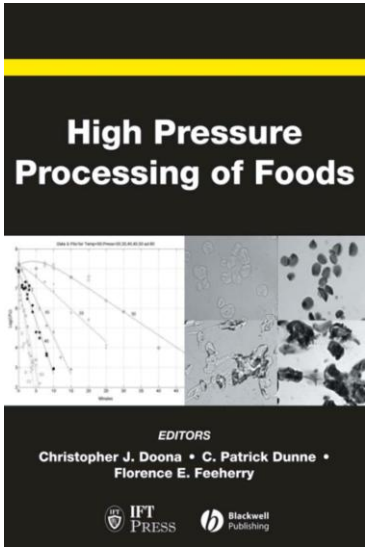
High Pressure Processing

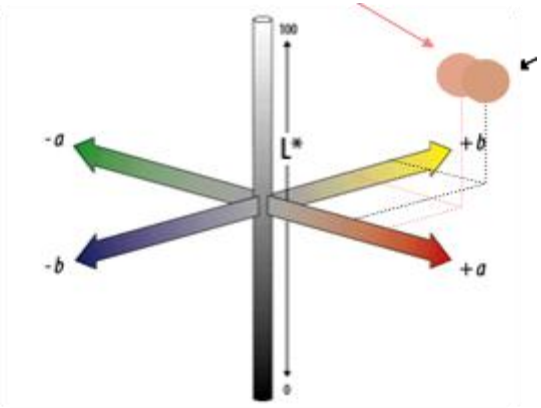
High Pressure (HPP) versus Retorting

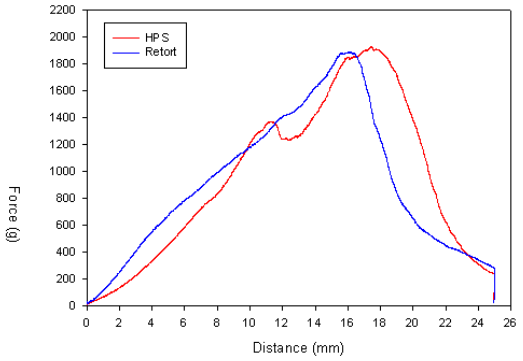


HPP versus Retorting – Salmon fillets





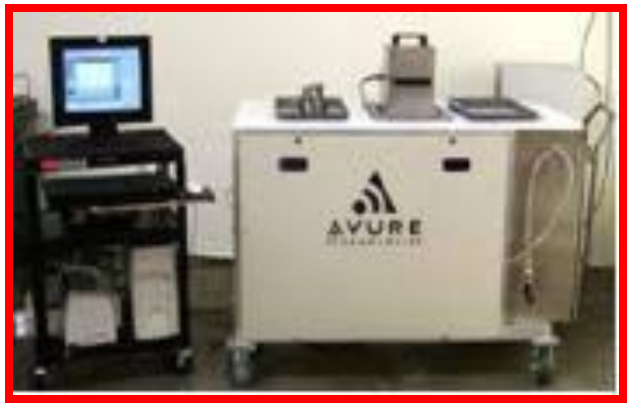




2-Liter Pressure Unit

HPP Kinetics Unit

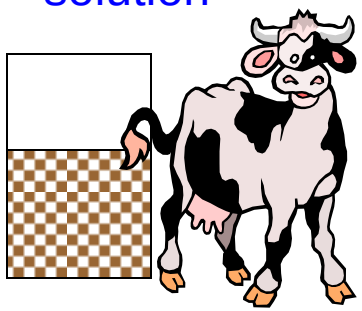
- Determine inactivation plots for *E. coli* , *L. monocytogenes*, bacterial spores using HPP.
- Evaluate kinetics Predictive Models.
- Predict HPP conditions to ensure safety.

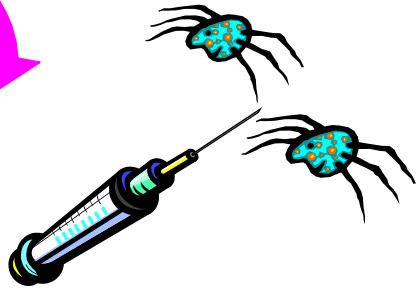


20 mL lab unit,
100 kPSI max.

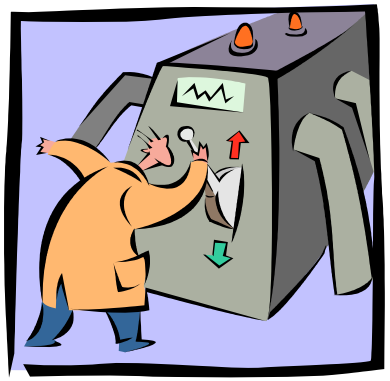
Methodology

Whey solution





Inoculate



High Pressure

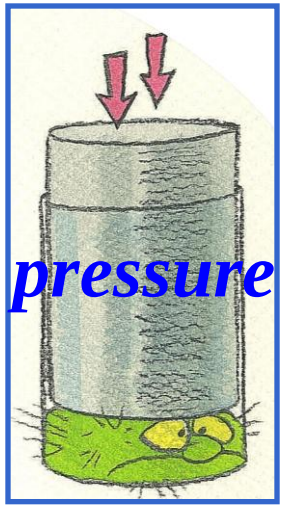


Plate on agar

Incubate

Predictive Microbial Modeling

- Convenient tools to assess microbial inactivation & ensure safety

- The Log linear (first-order) model may not always be the best model for High Pressue Processing (HPP) inactivation kinetics.

- The EQCK model useful for inactivation kinetics that are not strictly linear **(“shoulders” or “tailing”) .**

Quasi-Chemical Kinetics Model

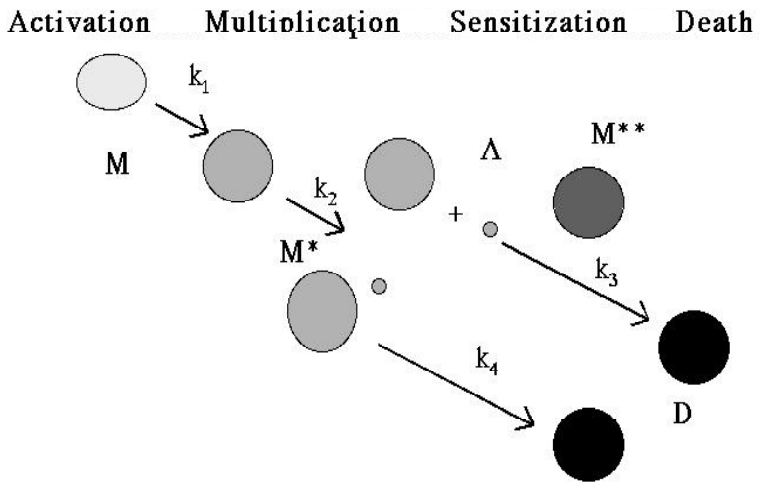
Mechanism

$$M \rightarrow M^*$$

$$M^* \rightarrow 2M^* + A$$

$$M^* + A \rightarrow D$$

$$M^* \rightarrow D$$



1. *quorum sensing*
2. fermentative LAB
3. nutrient depletion

Rate Eqn's

$v_1 = k_1 M$

$v_2 = k_2 M^*$

$v_3 = (10^{-9}) k_3 M^* A$

$v_4 = k_4 M^*$

Diff. Eqn's

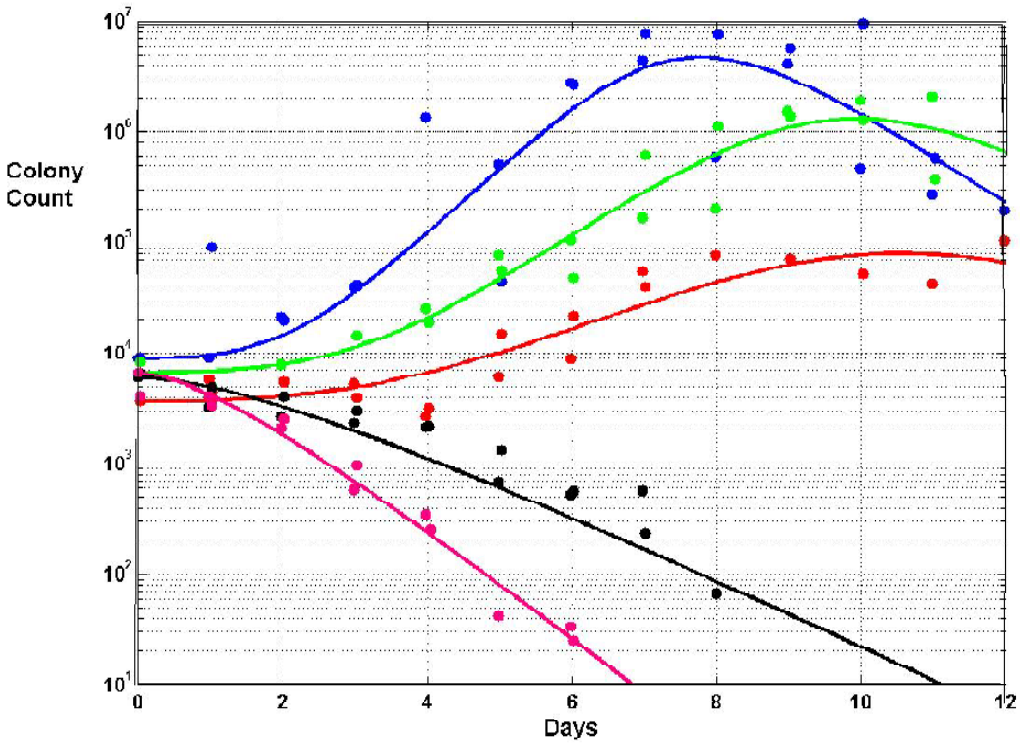
$dM/dt = -v_1$

$dM^*/dt = v_1 + v_2 - v_3 - v_4$

$dA/dt = v_2 - v_3$

$dD/dt = v_3 + v_4$

Growth/Death of *S. aureus* in Bread



Convention modeled either growth OR death, but not both continuously

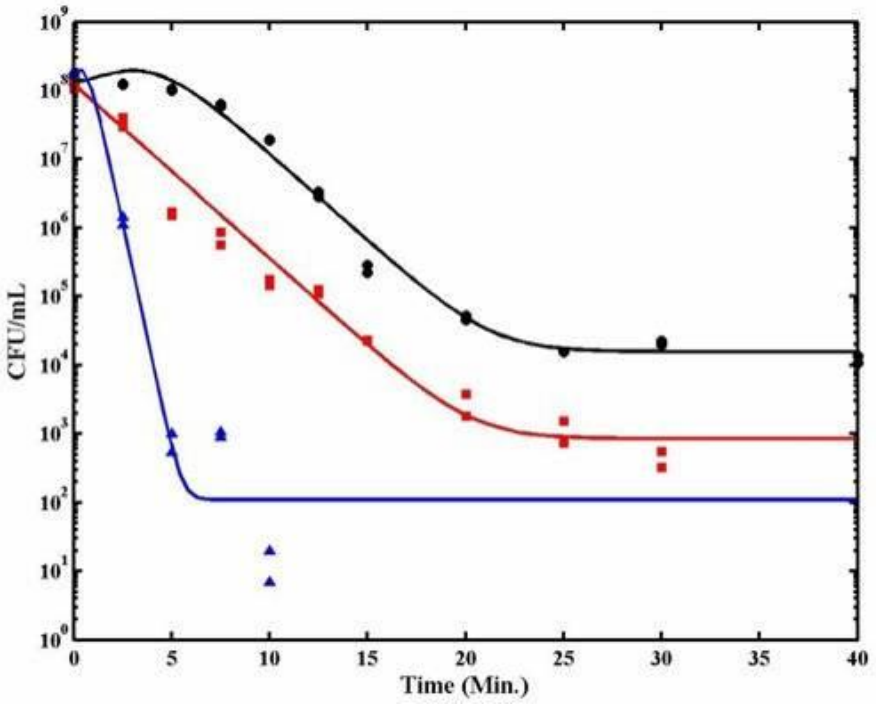
see USDA Pathogen Modeling Program
http://ars.usda.gov/Services/docs.htm?docid=6786

Role of food matrix

HPP of starch gels (Baik, Doona, Feeherry. 2006, J Ag Food Chem

E. coli, 45 kpsi, 40 ° C

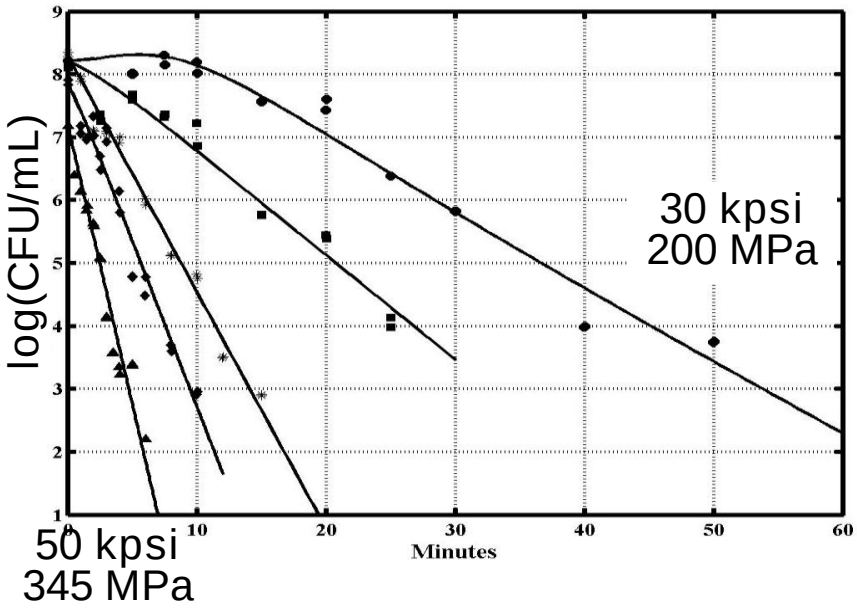
50% whey
50% insoluble starch
isotonic phosphate buffer

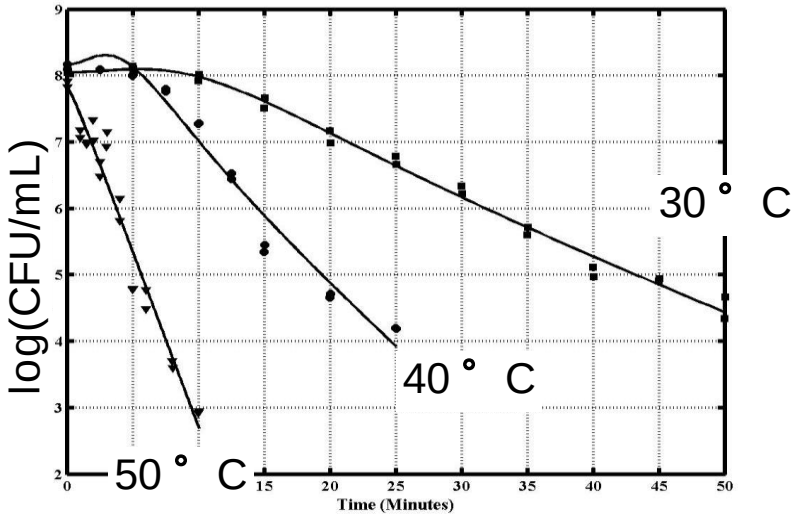


Whey has protective effect
- Gelation had no effect
- Multiple come-up times had no effect

Quasi-chemical model of *E. coli*

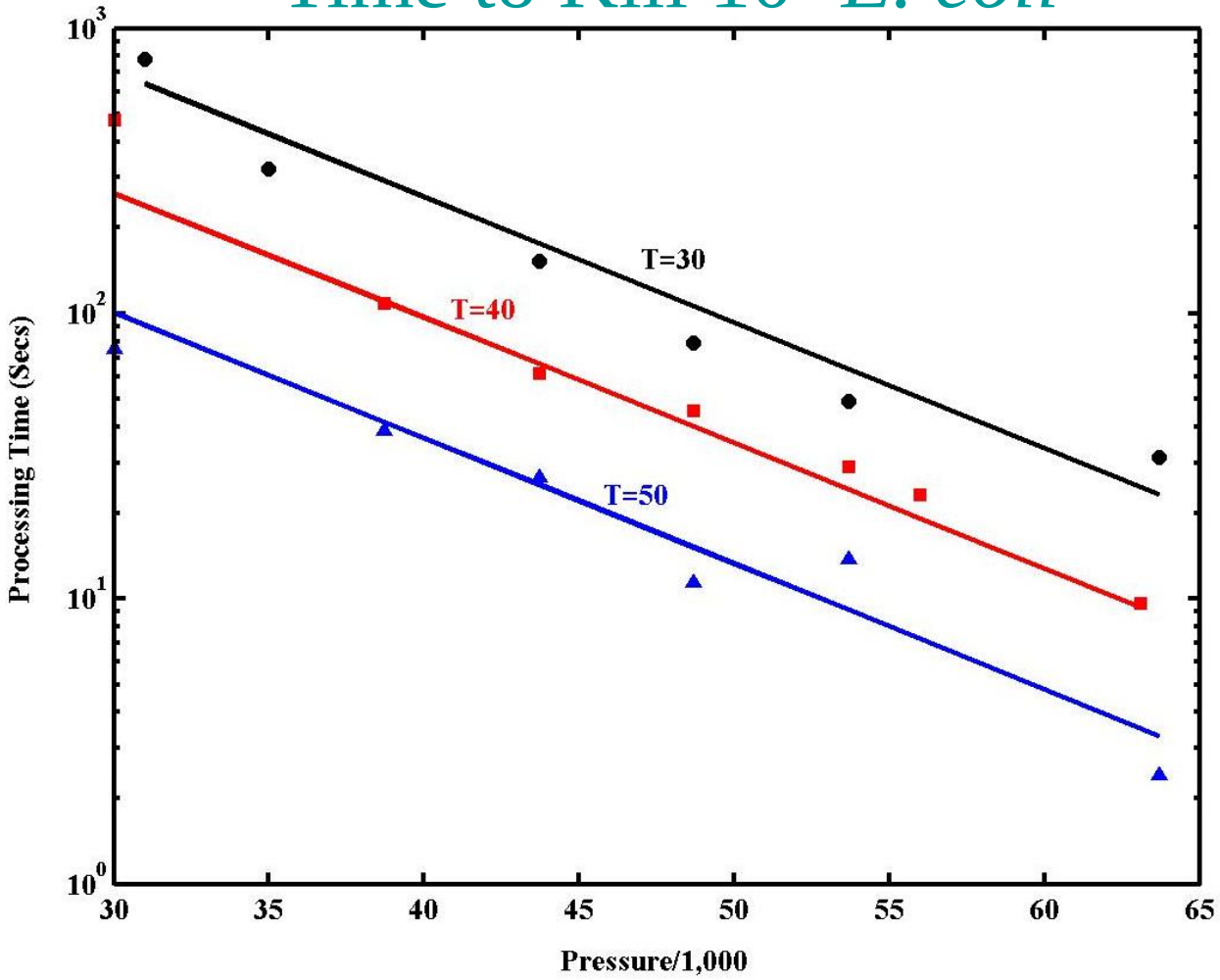
(vary P at T = 50 ° C and vary T at 45 kpsi)





Equivalence Chart
Predictive 2° model

Time to Kill 10^6 *E. coli*



The Weibull Model

- Survival curves are the cumulative form of the temporal distribution of mortality events
- Even under isothermal & isobaric conditions the logarithmic inactivation rate is time dependent

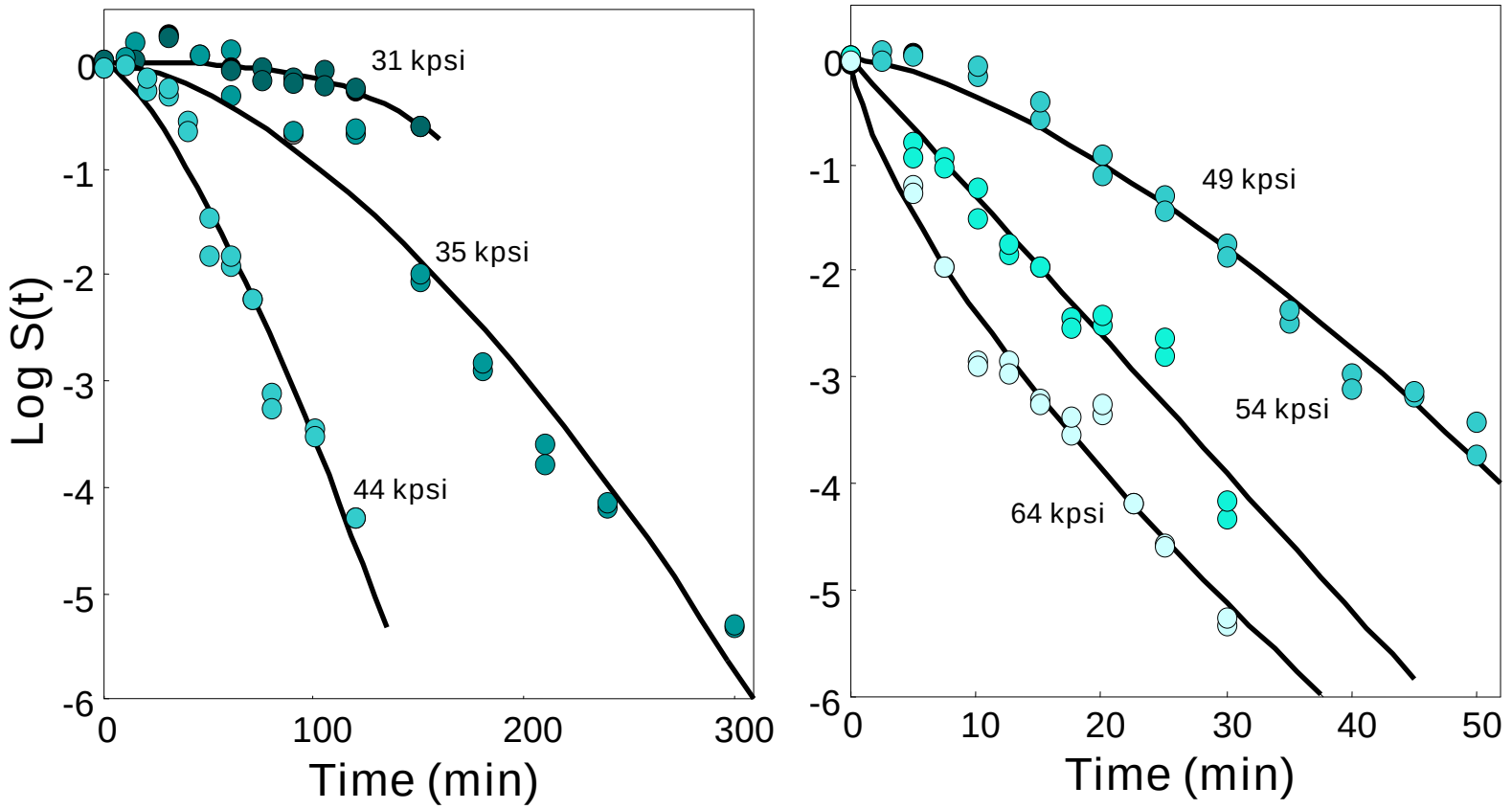
$$\log_{10} S(t) = -b(P,T)t^{n(P,T)}$$

- b(P,T)
  - 'rate parameter'
  - a measure of the survival curve's steepness
- n(P,T)
  - 'shape factor'
  - a measure of the isothermal & isobaric semi logarithmic survival curve's concavity

Isothermal survival curves of *E. coli*

Fitted with the Weibull Model

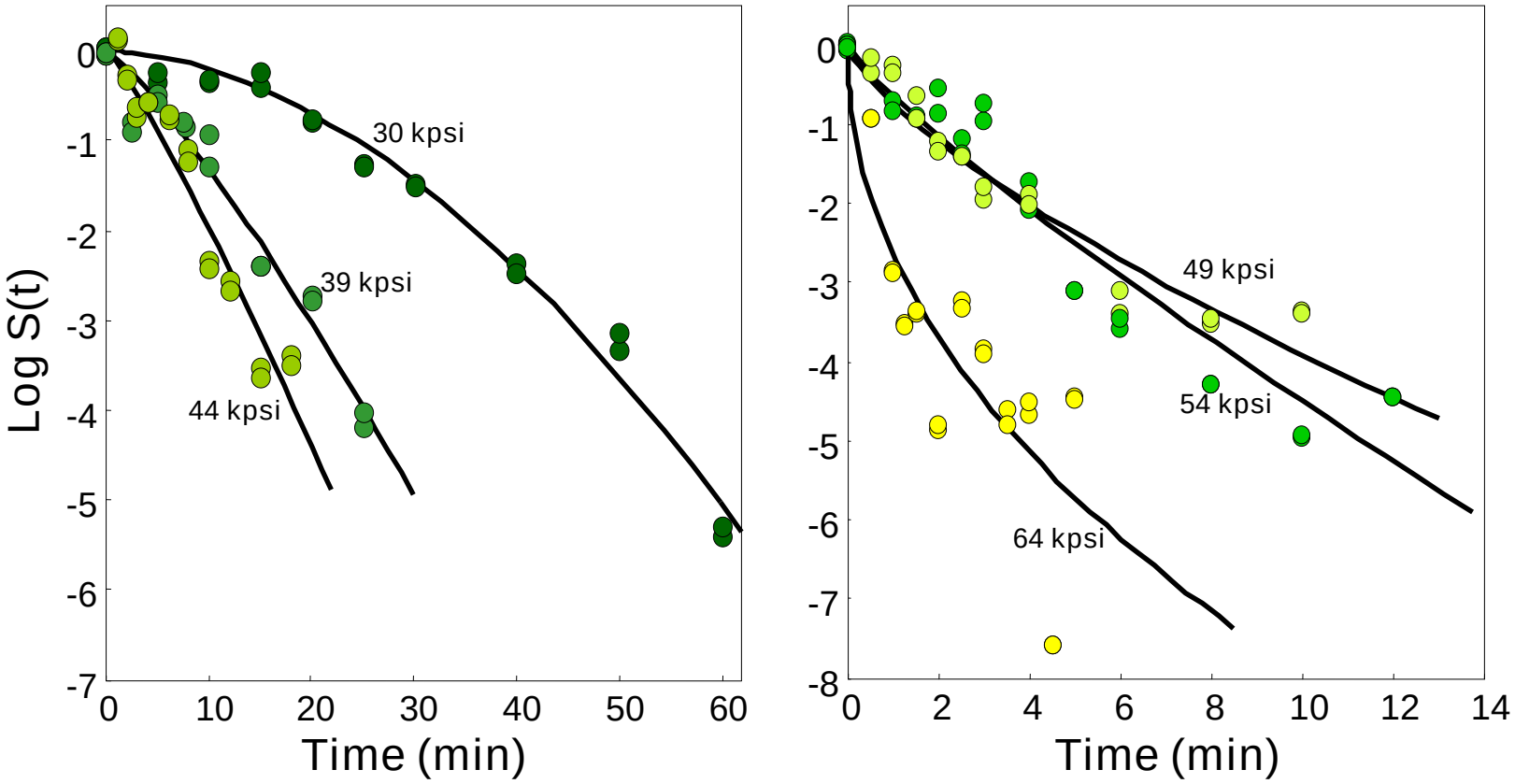
Temperature = 30° C



Isothermal survival curves of *E. coli*

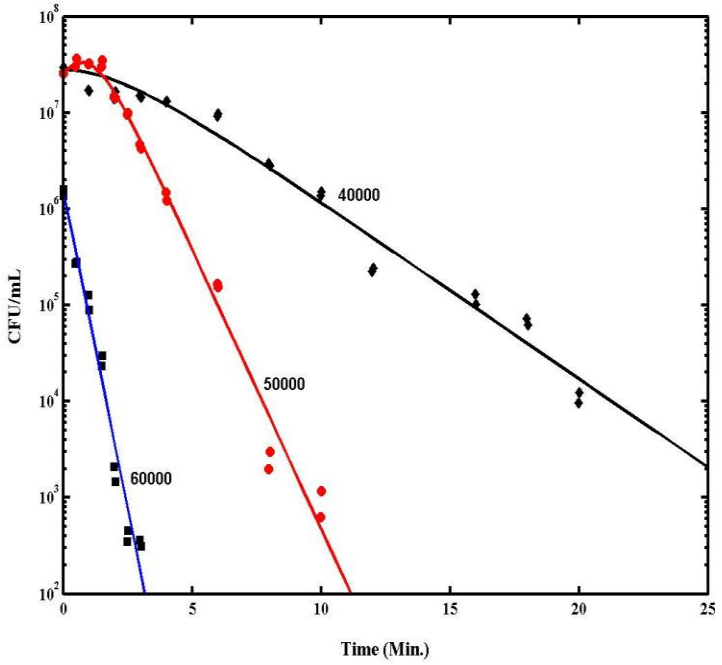
Fitted with the Weibull Model

Temperature = 50° C

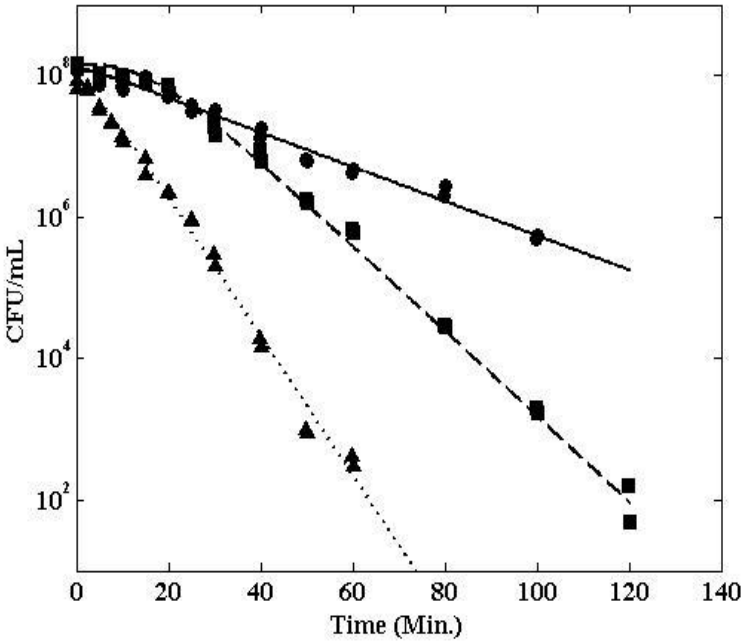


QC model fits of *L. monocytogenes* inactivation kinetics by HPP

P = 40-60,000 psi
T = 40 °C



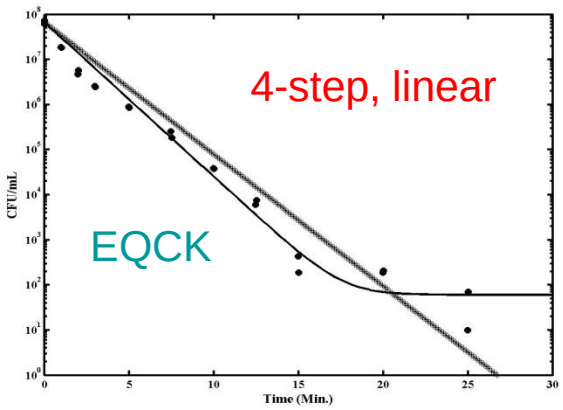
P = 40,000 psi
T = 20, 30, and 40 °C

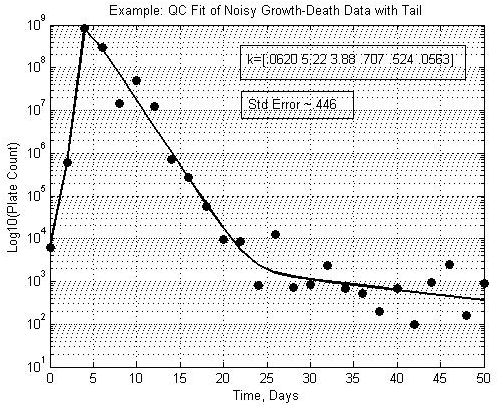


Enhanced QC kinetics model

In some case, inactivation kinetics with baro-resistant of *L. monocytogenes* show tailing.

Tailing requires EQCK model.





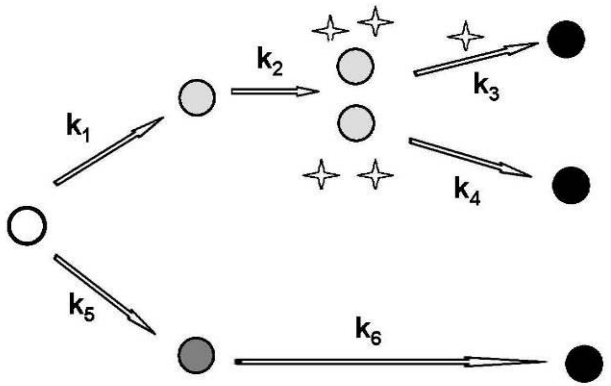
EQCK model fits growth-death-tailing

Enhanced QC Kinetics Model

Table 1. The QC Kinetics model.

Reaction steps	Rate functions	Rate equations
$Q \rightarrow M$	$v_1 = k_1 Q$	$dQ/dt = -(v_1 + v_5) = -(k_1 + k_5)Q$
$M \rightarrow 2M + E$	$v_2 = k_2 M$	$dM/dt = v_1 + v_2 - v_3 - v_4$ $= k_1 Q - M(G - \varepsilon E)$
$M + E \rightarrow D$	$v_3 = k_3 ME$	$dE/dt = (v_2 - v_3) = M(k_2 - \varepsilon E)$
$M \rightarrow D$	$v_4 = k_4 M$	$dD/dt = (v_3 + v_4 + v_6) = M(k_4 + \varepsilon E) + k_{6B} R$
$Q \rightarrow BR$	$v_5 = k_5 Q$	$dBR/dt = v_5 - v_6 = k_5 Q - k_{6B} R$
$BR \rightarrow D$	$v_6 = k_6 BR$	

EQCK MODEL



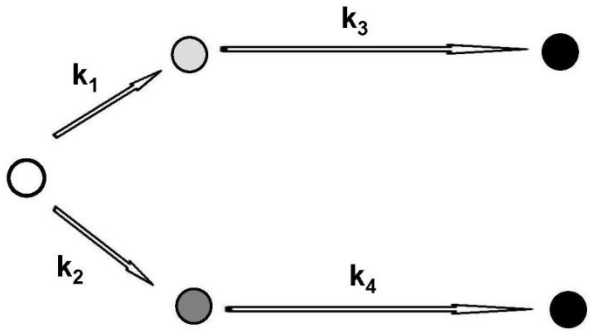
○ = lag phase cell (M)

● = baro-resistant sub-population (BR)

○ = growing & dividing cells (M*)

✧ = antagonistic metabolite (E)

● = dead cells (D)



○ = lag phase cell (M)

● = baro-resistant sub-population (BR)

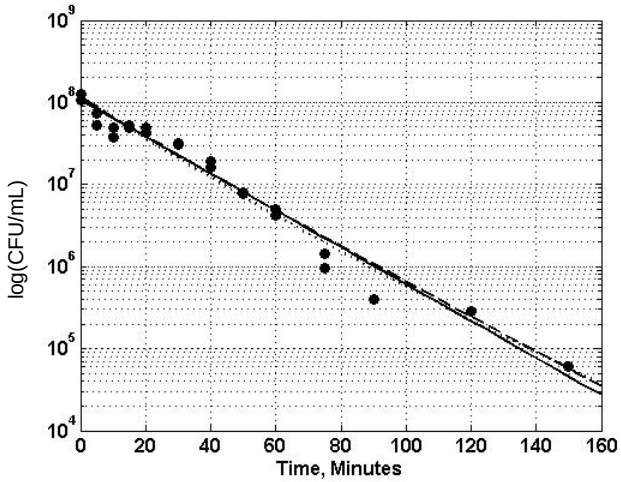
○ = active cells (M*)

● = dead cells (D)

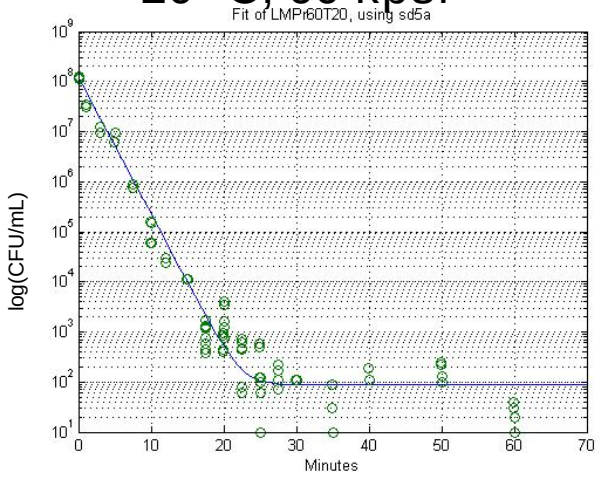
Inactivation Kinetics of *L. monocytogenes* by HPP

6-parameter EQCK model for inactivation kinetics of ***L. monocytogenes*** **by HPP showing "tailing."**

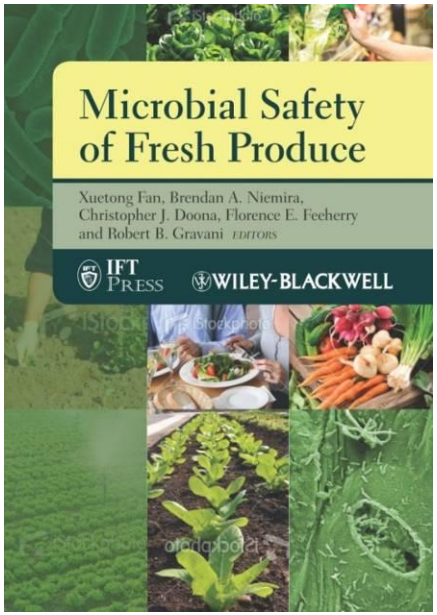
40 °C, 30 kpsi

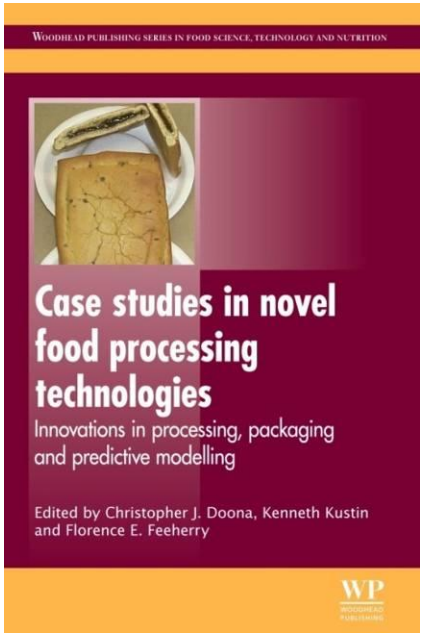


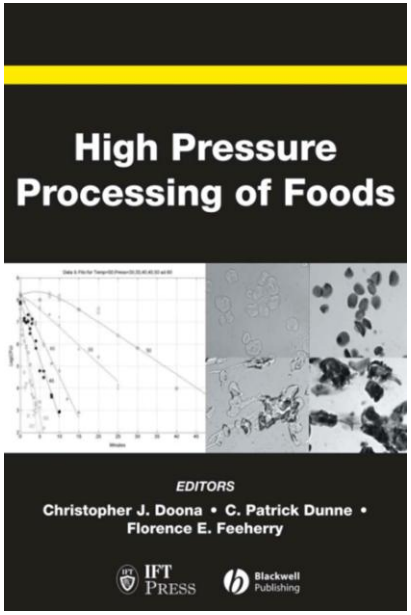
20 °C, 60 kpsi



Research Team and Available Books







Hiperbaric
HIGH PRESSURE PROCESSING

Industrial High Pressure Processing equipment & HPP commercial products

Carole Tonello Samson, PhD
Application and Process Development Manager

Hiperbaric.com

Hiperbaric highlights

Hiperbaric is the world market leader of High Pressure Processing industrial food equipment.

Our company has installed more than 125 industrial HPP machines : more than 50 % of world machines currently in production

Our machines are installed in more than 75 differents companies processing : meat, seafood & fish, fruits, vegetables and dairy products.

- 2013 sales of 38 M€ (95% exported) / 24 HPP machines

Where is Hiperbaric?

Hiperbaric factory is located in Burgos - Spain

Hiperbaric USA, is located in Miami, FL.

Hiperbaric range

The world largest range for industrial production performing 10 cycles / h with 2 min holding time at 600 MPa (6000 bar – 87,000 psi) from 250 kg (550 lbs)/hour at up to more than 4,000 kg (9,000/lbs) / hour with the new Hiperbaric 525.

HIPERBARIC | 55

The Hiperbaric 55 is ideal equipment for small/medium production, product development and market tests. For instance: SME's with relatively low production environments, food companies servicing "niche" markets, seasonal production, or installed in a R&D centre willing to not only investigate High Pressure Processing, but to provide real food concepts to the market and test them before upscaling.

Its robust and compact design, with one integrated single intensifier, makes it easy and quick to install in almost any facility. It is a perfect fit for the first steps into High Pressure Processing.

Equipment	Throughput (Kg/h)	Vessel Volume (liters)	Vessel Diameter (mm)	Footprint (sqm)
Hiperbaric 55	255 (562)	55 (14.5)	200 (7.9")	22 (237)

HIPERBARIC | 120

The Hiperbaric 120 is designed to service medium sized industries in need of consistent production while minimizing the initial investment. Together with the Hiperbaric 135, it is part of our range of equipment solutions for food industries with average to high production.

Hiperbaric 120 brings a highly innovative concept to High Pressure Processing. It is the first HPP equipment in the world with two integrated, but independent, high pressure intensifiers; it has no external modules, thus minimizing space requirements and facilitating hygiene of the area.

This piece of equipment was developed by integrating the most reliable components with the most advanced designs, to provide highly productive and profitable High Pressure Processing.

Equipment	Throughput (Kg/h)	Vessel Volume (liters)	Vessel Diameter (mm)	Footprint (sqm)
Hiperbaric 120	525 (1157)	120 (31.7)	200 (7.9")	37 (3989)

HIPERBARIC | 135

Hiperbaric 135 is targeted for medium-high food production environments. Its 135 litre capacity vesse together with its bigger diameter, 300 mm, provide an improved filling ratio and allows the processing of large products (whole hams, large formats etc.), enables it to achieve throughputs of more than 500 Kg/h.

Its horizontal design and a contained footprint make it very easy to install, operate in an ergonomic way, and perform maintenance. The standard configuration includes two high pressure intensifiers which can work separately for optimized reliability and uptime, an exclusive characteristic of the Hiperbaric High Pressure Processing range.

A pioneer middle sized industrial equipment, it has been installed in 4 continents (America, Europe, Asia and Oceania) and in such a variety of sectors such as: meat, fruit and vegetable, juices, seafood and dairy. Many technological centers, international reference in new and innovative food products development, have this equipment as one of its main R&D tool.

Equipment	Throughput (Kg/h)	Vessel Volume (liters)	Vessel Diameter (mm)	Footprint (sqm)
Hiperbaric 135	650 (1500)	135 (36.7)	300 (11.8")	39 (420)

HIPERBARIC | 300

Since its conception back in 2002, Hiperbaric 300 very rapidly became the benchmark in big Hiperbaric units. Developed from the start as a game changer in the High Pressure Processing world, it has surpassed expectations. Its optimized vessel volume (300 L) and diameter (300 mm) along with outstanding cycle times, make it the classic high production equipment; the target for any food industry with demanding throughput requirements.

Constant improvement of Hiperbaric 300 by our Engineering Department has made it become the fastest industrial HPP equipment in the world, in its 6 high pressure intensifier version, and provided it with maximum reliability.

Equipment	Throughput (Kg/h)	Vessel Volume (liters)	Vessel Diameter (mm)	Footprint (sqm)
Hiperbaric 300	1300 (2874)	300 (79.3)	300 (11.8")	61 (657)

HIPERBARIC | 420

The Hiperbaric 420 is the best-selling HPP equipment in the market. Its productivity and profitability have been far ahead of any other equipment in the world and it represents an important improvement in efficiency and economy for food industries.

Hiperbaric 420 includes all the new features and developments in components and material design that our engineers from the R+D Department achieved, making it the most reliable and highly productive from a new generation of industrial high pressure processing equipment. Its 420 litre capacity and 380 mm diameter vessel together with its 8 high pressure intensifiers, allow this equipment to process more than 2 Tonnes per hour.

The Hiperbaric 420 was awarded the IFT Innovation Award (Institute of Food Technologist) in 2008.

Equipment	Throughput (Kg/h)	Vessel Volume (liters)	Vessel Diameter (mm)	Footprint (sqm)
Hiperbaric 420	2200 (4800)	420 (111)	380 (15")	56 (601)

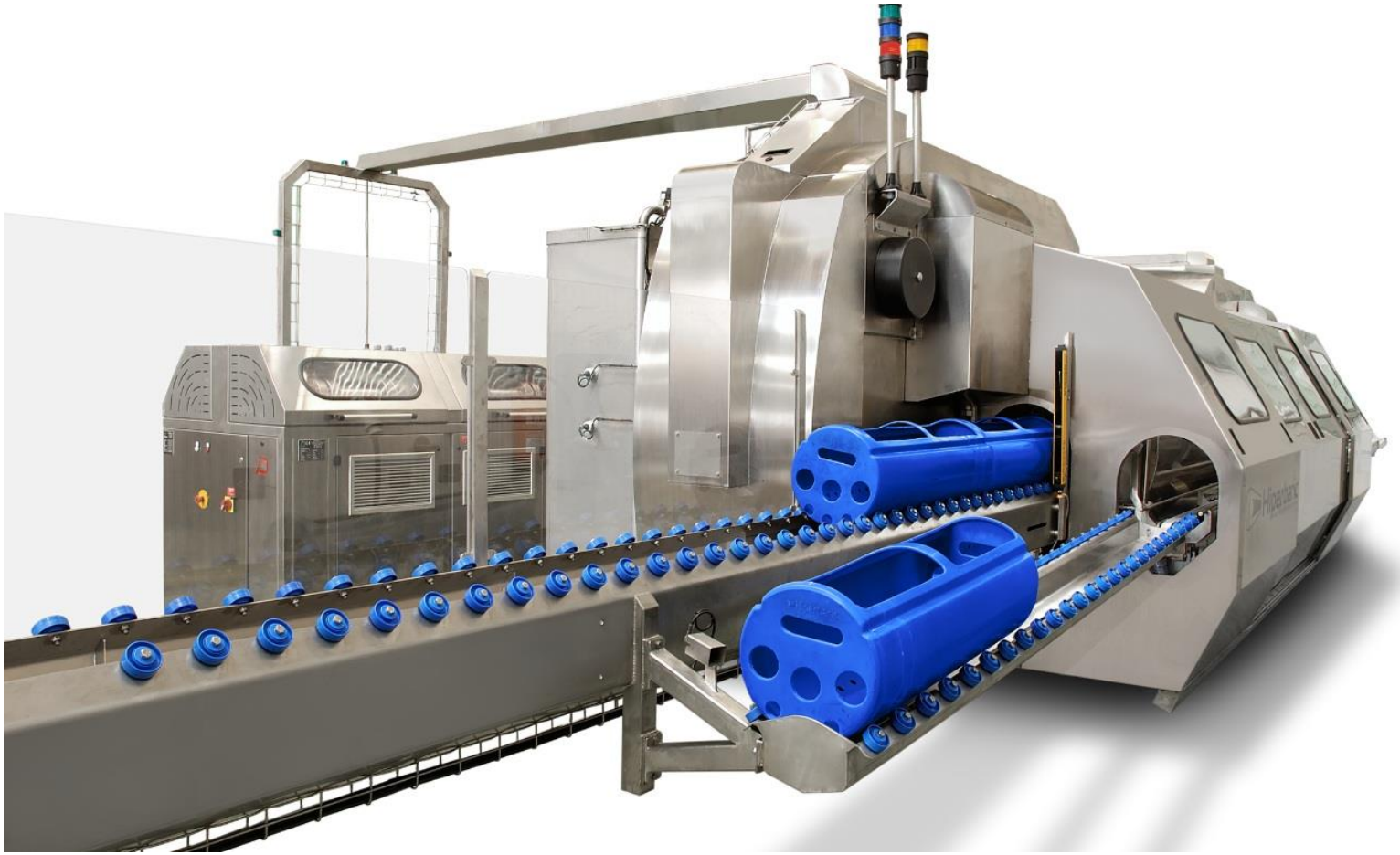
HIPERBARIC | 525

Our latest addition, following the demands of those customers with the largest production environments. The biggest, and most productive, HPP system in the world.

With a 525 litre capacity and large 380 mm diameter, it shows throughputs of over 3,000 Kg of product per hour. It's capacity is unmatched and the resulting costs per Kg of product being processed, are the cheapest ever possible.

Equipment	Throughput (Kg/h)	Vessel Volume (liters)	Vessel Diameter (mm)	Footprint (sqm)
Hiperbaric 525	3000 (6000)	525 (14.5)	380 (15")	61 (657)

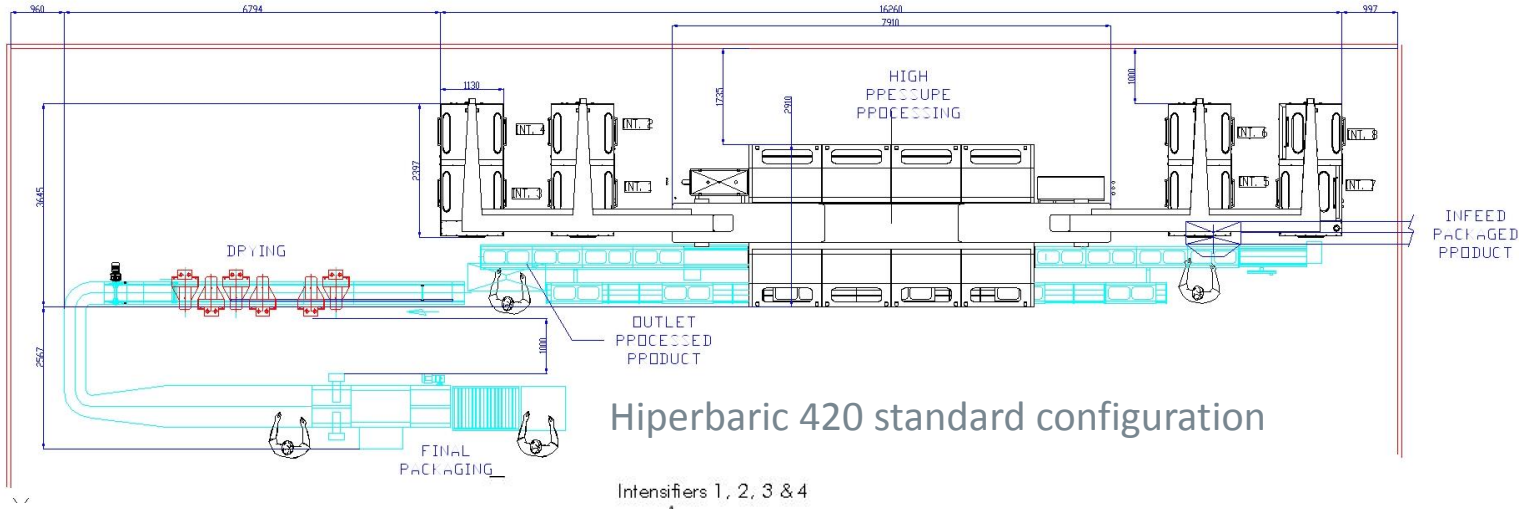
HPP Equipment



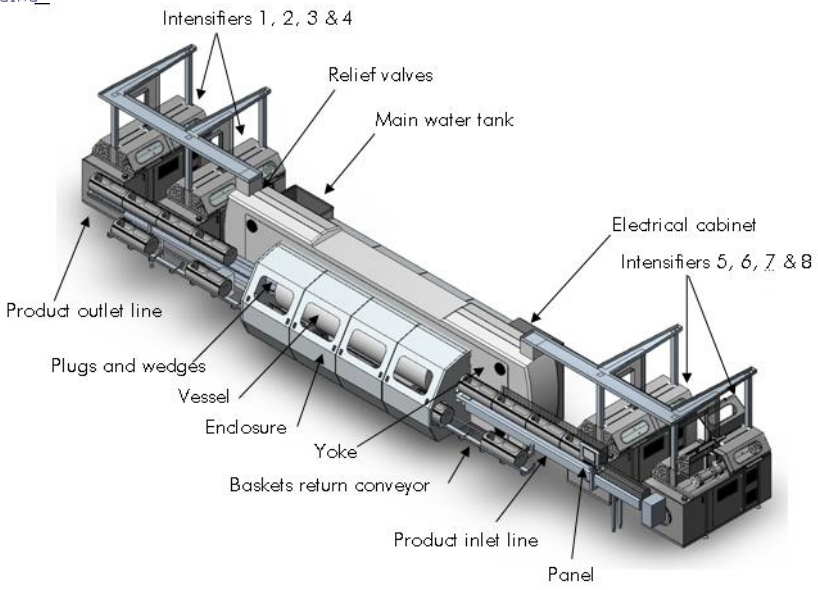
The standard in HPP industrial equipement

- ✓ Maximum working pressure: 600 MPa (6000 bar – 87 000 psi)
- ✓ Working temperature range: from +5ºC (40ºF) to room temperature
- ✓ Horizontal design for traceability and easy installation
- ✓ Special design for food industry (stainless steel, cleanable…)
- ✓ Automatic carriers loading / unloading system
- ✓ Manual loading & unloading of the products in the carriers

Equipment implementation



Hiperbaric 420 standard configuration



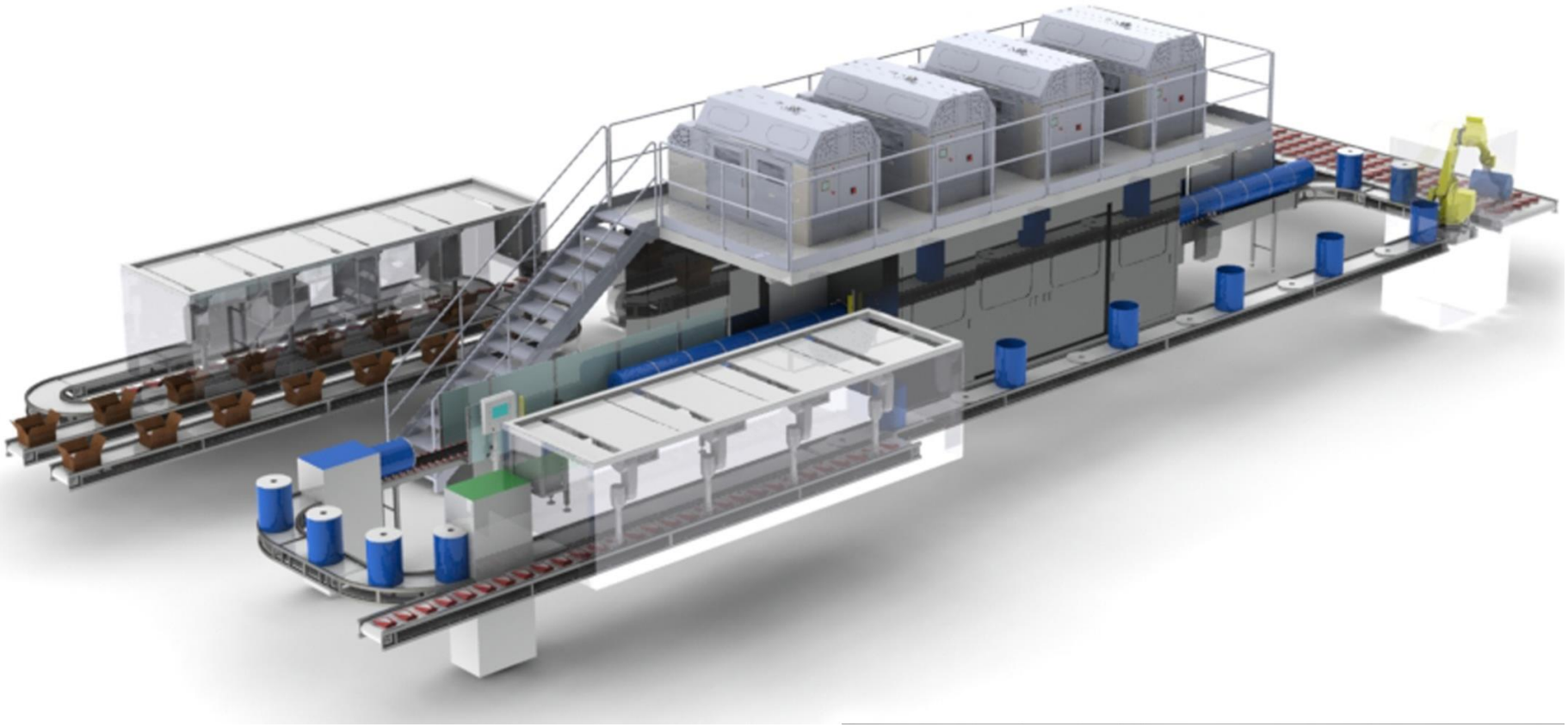
Millard Refrigeration (USA)

HPP Co-processing

Manual operations helped by peripherals

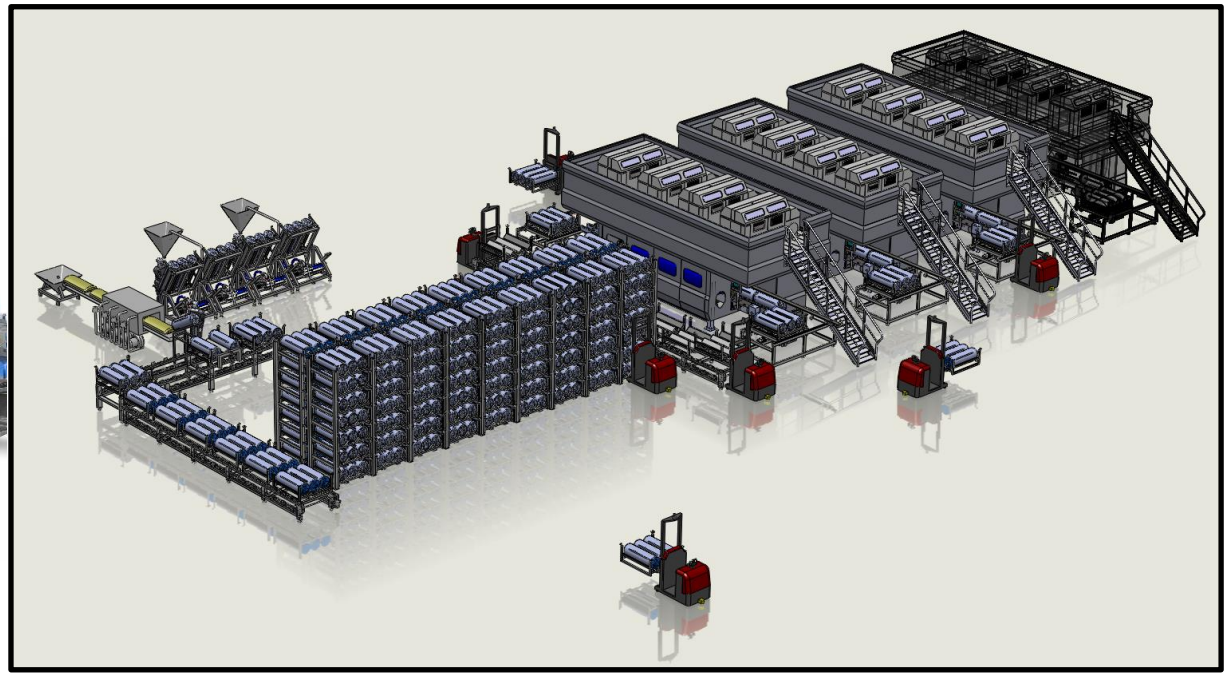
Automation example 1: tilting stations&robots

Fully automatic line with Hiperbaric 420 integrated machine



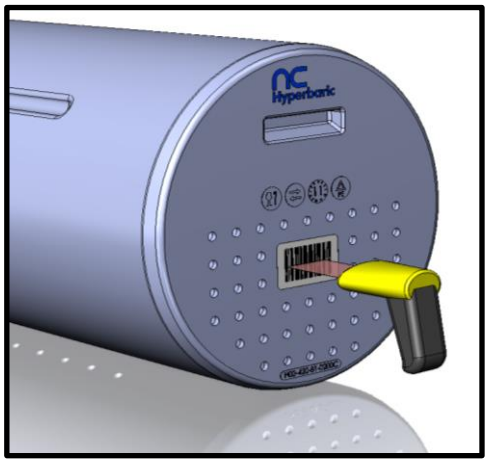
Automation example 2: processing of big bags (1)

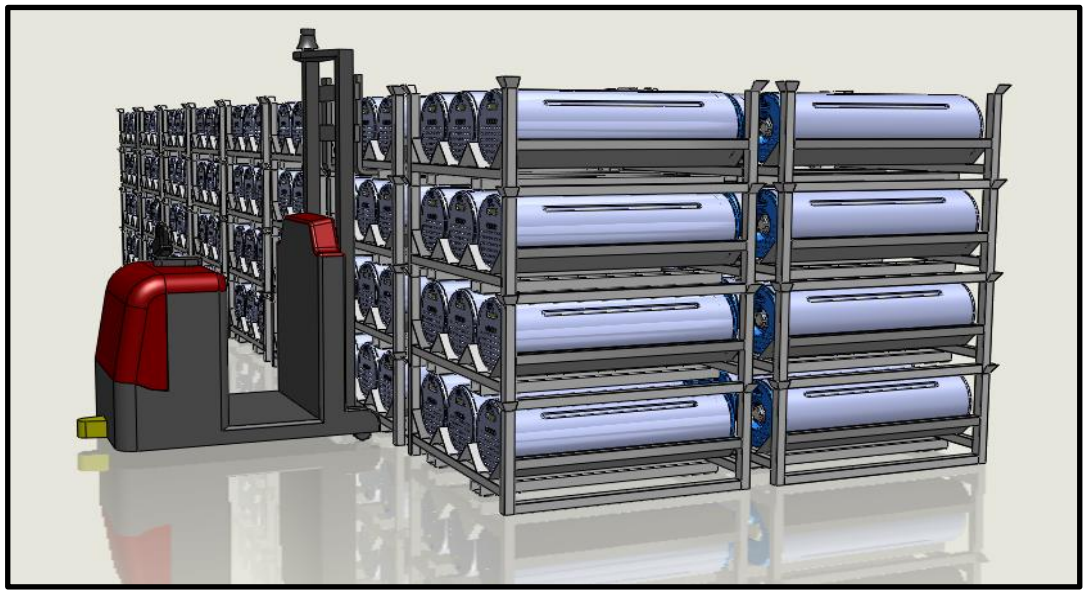
- Fully automatic line with 3 x 420 L machines
- Automatic transport of carriers with Automatic Guided Vehicles (AGV)
- Maximum production: 97.5 Millions lbs – 45 000 tons/ year



Automation: example of processing of big bags (2)

- Traceability thanks to code bar tag on the carrier
- Code bar is entered in the ERP at the filling of the carrier
- AGV equipped with code bar lectors
- Carriers storage area to buffer HPP and non-processed products to adjust the production shifts





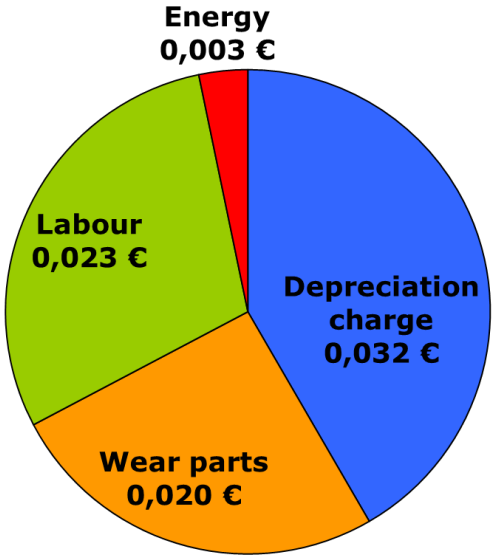
Automation: example of processing of big bags (3)

Processing cost

Examples of processing costs for manually and automatic 420 L machines

Manual processing line:

4 operators + 0.3 maintenance people / shift



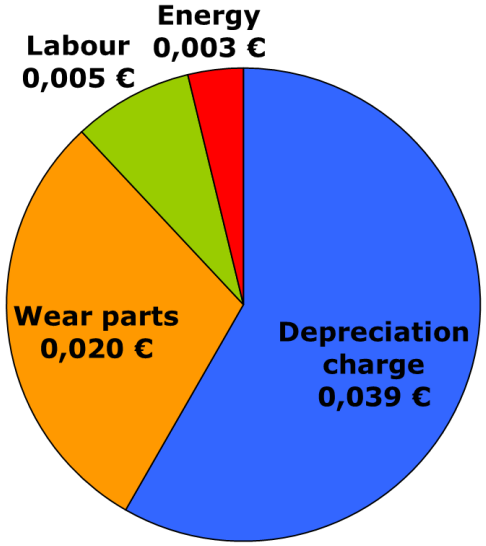
Total production cost :

0.077 €/Kg – 0.046 $US/lbs

Automatic processing line:

0.5 operator + 0.3 maintenance people/ shift

+ 400 000 € (550 000 US$) / investment



Total production cost :

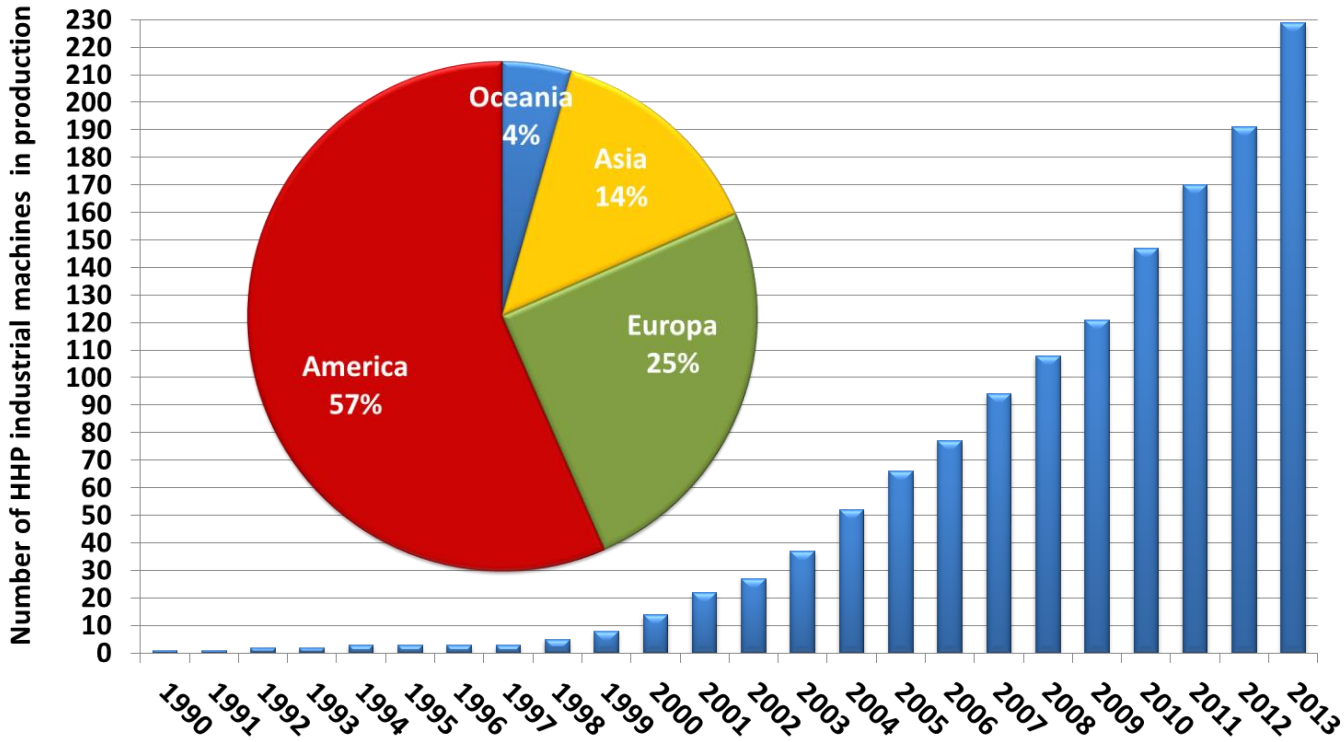
0.067 €/Kg - 0.039 $US/lbs

Processing & depreciation conditions :

- Processing conditions: 600 MPa - 87 000 psi during 3 min
- Total cycle time: 7.5 min
- Number of cycles/h: 8
- Volumetric efficiency (vessel filling ratio): 60%
- Depreciation period: 5 years
- Intensive use: 6000 hours / year (2 shift of 20 hours during 300 days / year)

HPP commercial products

Evolution of total number of HPP industrial machines



Total machine number in production at end 2013 : 229
(Not included : 15 dismantled machines (all installed before 2003)

Industrial HPP machines versus food industries

Pathogens-free sliced cooked meats

Preservative-free deli meats

Listeria-free dry-cured products

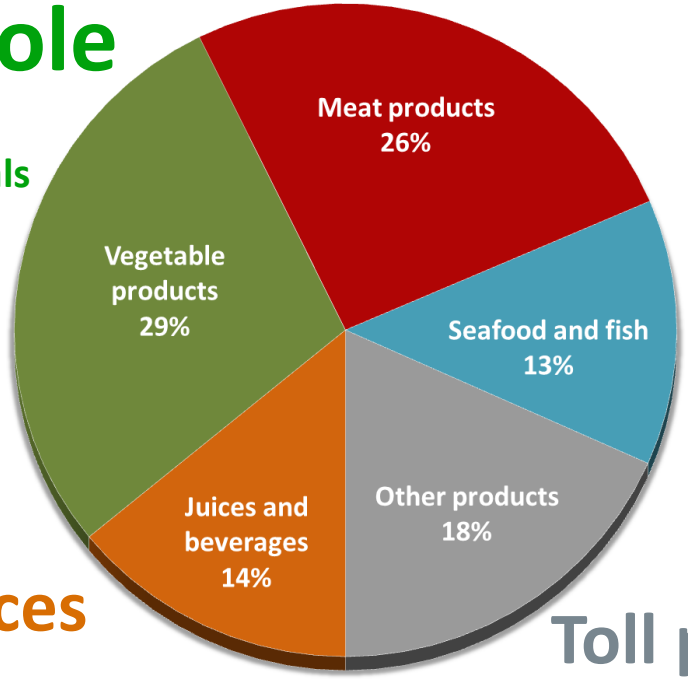
Raw beef products

Preservative-free sausages

Guacamole

Wet salads

RTE vegetable meals



Oysters shucking

Lobster meat extraction

Clams & mussels shucking

RTE seafood meals

Fruit juices

Smoothies

Vegetable juices

Toll processing

Cheese products

Global HPP food production in 2013 : + 400 000 000 Kg / + 880 000 000 lbs

HPP Commercial Products

Meat Products

- Shelf life increase
- Destruction of pathogens : Listeria, *Salmonella*, coliforms…
- Stabilisation of preservative-free or low salt content products

Country	Year	Products
Spain	1998	Sliced cooked ham and “tapas”
USA	2001	Sliced cooked products and proscuitto ham
USA	2001	Poultry products
USA	2002	Pre-cooked chicken and beef strips
Spain	2002	Sliced cooked meats products, Serrano cured ham
Italy	2003	Proscuitto ham, salami & pancetta
Germany	2004	Cured and smoked sliced and diced ham
Japan	2004	Nitrites-free bacon, sausages and sliced meat
USA	2005	Ready-to-eat meat based products
Spain	2005	Cured meat products & Serrano ham
Canada	2006	Cured & cooked meat products
USA	2006	Whole roasted chicken
USA	2006	Sliced cooked turkey and chicken
Canada	2006	Ready-to-eat meat meals
USA	2007	Chicken sausages
USA	2008	Cooked pork & beef sliced products
USA	2008	Pet food
Canada	2008	Sausages and bacon
Canada	2009	German style cooked meat products
USA	2009	Sliced RTE meats
Canada	2010	Proscuitto ham and cured meats
Australia	2010	Sliced and diced preservative free poultry products
Switzerland	2011	Cooked pork sliced products and sausages
USA	2011	Proscuitto ham and cured meats
USA	2011	RTE sliced meats
Rumania	2011	RTE pork products
Spain	2011	Serrano ham and cured meats

Our equipment on site

WLF West Liberty Foods

Home | About Us | Our Products

Our Focus on Food Safety

West Liberty Foods (USA)

Meat Products – 3 x Hiperbaric 420

"West Liberty Foods is committed to producing food safe products. High pressure pasteurization is another technology that allows us to do so," says Gerald Lessard, Vice President and Chief Operations Officer for West Liberty Foods. "We are pleased to become part of the history of Hiperbaric with their 100th unit now installed at West Liberty Foods."

WLF Awarded SUBWAY 2012 Vendor of the Year

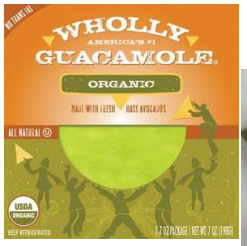
On August 14, 2012, West Liber Foods was named by the SUBW brand, and its Independent Purchasing Cooperative (IPC), a the 2012 Vendor of the Year at the recent SUBWAY convention Orlando, Florida.

HPP Commercial Products

Vegetable Products

- Sanitisation and shelf life increase.
- Preservation of colour, flavour and vitamins.
- Reduction of PPO activity in avocado.
- Reduction of the starch retrogradation of the rice.

Country	Year	Products
Japan	1990	Fruit jams and fruit and vegetable sauces
Japan	1994	Pre-cooked & hypoallergenic rice
USA	1997	Avocado products : guacamole, sauces
Italy	2001	Fruit jams
USA	2002	Avocado products
Mexico	2003	Avocado products
Mexico	2003	Avocado products
Mexico	2003	Avocado products
Canada	2003	Apple products : jam and sauce
USA	2004	Tofu
Spain	2005	RTE vegetable meals
USA	2006	Tomato sauces
Australia	2008	Fruit pures & coulis
Mexico	2008	Avocado products
Peru	2008	Avocado products
Chile	2008	Avocado products
Peru	2010	Avocado products
N. Zeland	2010	Avocado products
China	2010	Fruit jams
Mexico	2010	Avocado products
España	2011	Avocado products

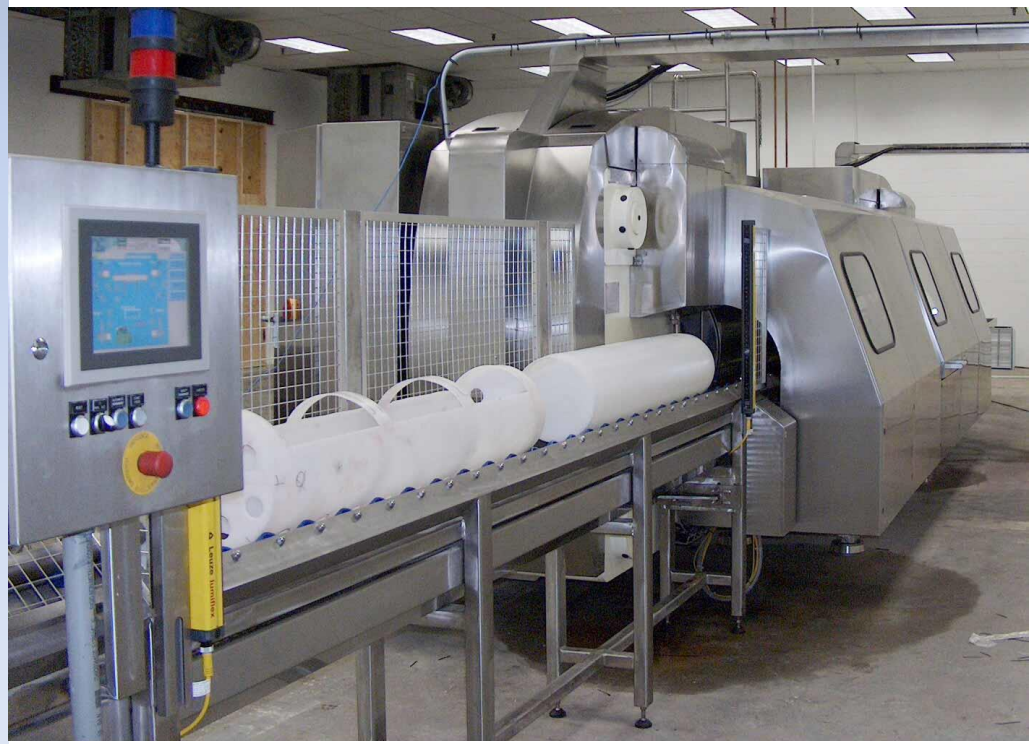


Our equipment on site

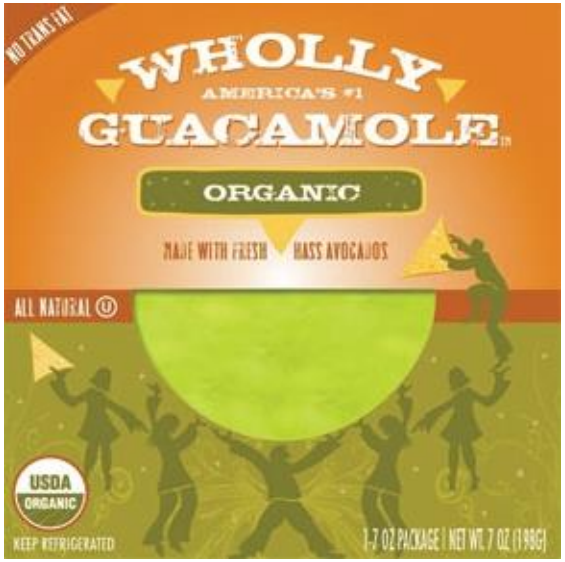
All Natural
Organic

Fresherized Foods (USA)

2 x Hiperbaric 300 (in Chile & Peru) for avocado



Fresherized FOODS
Fresherized means flavor.



HPP Commercial Products

Dairy products

- Shelf life increase
- Destruction of pathogens
- Retaining bioactivity of functional components

Country	Year	Product
Spain	2007	Cheese and mayonnaise sandwich filling
USA	2007	Dairy based dressings
New Zealand	2008	Colostrum shots
USA	2009	Cheese Jerky
UK	2010	Cheese based snacks
Spain	2012	Fresh cheese
Spain	2012	Smoothies with yogurt
Korea	2013	Drinkable yogurt
Mexico	2013	Milk

Click Here For
More Information...

Our equipment on site

Shelf-life increase
Pathogen-free

Deli 24 (UK)

Hiperbaric 135 for cheese and meat snacks

HPP Commercial Products

Seafood

- Shelf life increase
- Shucking bivalves
- Easy shellfish extraction
- Destruction of Vibrio

Country	Year	Products
USA	1999	Oysters
USA	2001	Oysters
USA	2001	Oysters
USA	2001	Oysters
USA	2003	Crab
Canada	2004	Seafood
Canada	2004	Lobsters
N. Zealand	2004	Mussels shucking for meds
Italy	2004	Desalted cod
USA	2005	Lobsters
Canada	2006	Seafood
Japan	2007	Shellfish
USA	2008	Crab
Spain	2009	RTE fish meals
USA	2010	Oysters
Canada	2010	Lobsters
New Zealand	2010	Green mussels
France	2011	Losters & clams

Our equipment on site

Hiperbaric
HIGH PRESSURE PROCESSING

Hautes pressions

Cinq Degrés Ouest en action

En mai dernier, nous vous annoncions la création d'une unité de traitement hautes pressions destinée à décortiquer les homards et les crustacés. Voici en images, la solution développée par la jeune société Cinq Degrés Ouest.

C'est à Riec, au bord de la rivière du Belon, dans une partie des bâtiments des Huîtres Cadoret, que la jeune société Cinq Degrés Ouest réalise une première en France : le traitement par hautes pressions des homards et coquillages.

Dans le local, des ogives sortent d'une enceinte, elles contiennent des « bleus », des homards bretons. Ils viennent d'être traités par hautes pressions. Ils sont aussitôt déchargés sur des tables où les opératrices coupent les élastiques des pinces, les pinces et sortent la chair de la carapace, aussi facilement qu'un esquimau de son étui !

Les corps sont déposés sur le tapis d'un tunnel de surgélation Cryoline de Linde. A la sortie, ils sont conditionnés sous-vide un par un. Il aura fallu moins d'une demi-heure pour décortiquer et emballer les queues de homards.

Hautes pressions, haute qualité

Ainsi, depuis quelques mois, Cinq Degrés Ouest crée de la valeur ajoutée grâce à son cycle de traitement hautes pressions breveté et à la cryogénie. L'association de technologies permet de restituer dans l'assiette les qualités organoleptiques des homards, à l'identique d'un produit sorti du vivier.

Les queues de homards, traitées ce matin-là, ont été expédiées vers la cuisine d'un grand restaurant parisien. *« Les chefs ont été saisis par la qualité. Le produit reste dans son jus tout au long du traitement, il conserve le goût et la texture du frais »*, souligne Alexis Taugé, créateur de Cinq Degrés Ouest. Ce qui ne surprend pas puisque dans les procédés hautes pressions, c'est l'eau qui est le vecteur de la pression. Et dans cette application, c'est de l'eau de mer qui est utilisée. Pour le moment, seuls les coques et les homards sont traités ainsi.

Actuellement, les Canadiens sont les principaux fournisseurs du marché français (30 à 35 tonnes) mais Alexis Taugé espère prendre 15 % de parts de marché. Et déjà, il envisage d'autres types de produits. Un projet Valorial, avec le fabricant de plats cuisinés Guyader vient de commencer avec des applications pour les produits traiteurs. Une ouverture vers d'autres marchés. ●

ISABELLE DULAU

LA PAROLE À » **Alexis Taugé**, gérant de la société

Nous travaillons, pour les restaurateurs, du homard de pêche reconnaissable aux antennes longues, à la carapace dure et bien remplie.

La cellule hautes pressions NC Hyperbaric, 55 l, installée dans l'atelier de Cinq Degré Ouest chez l'ostréiculteur Cadoret.

❶ Après traitement hautes pressions, le homard se décortique facilement sans perte de matière.

❷ Les queues tout juste décortiquées sont disposées sur un film plastique qui va les convoyer à l'intérieur du tunnel de surgélation Linde.

❸ Après cryogénie, les queues sont mises en poche avant d'être conditionnées sous-vide.

84 | PROCESS • Septembre 2011 – N° 1284

Cinq Degrés Ouest (France)

Hiperbaric 55 for seafood meat extraction

http://www.youtube.com/watch?v=uBRi9LA13LU

HPP Commercial Products

Juices & beverages

- Sanitisation and shelf life increase.
- Preservation of colour, flavour and vitamins.
- Destruction of pathogens

Country	Year	Product
France	1994	Citrus juices
Portugal	2001	Apple & citrus blended apple juice
Italy	2001	Fruit and vegetable juices
Czech Republic	2004	Broccoli & apple, beetroot, carrot juices
USA	2007	Juices and superfood smoothies
Spain	2007	Smoothies & juices
Australia	2008	Smoothies & juices
Northern Ireland	2008	Wheatgrass & Broccoli sprout juices
The Netherlands	2009	Smoothies & Juices
USA	2010	Citrus juices
Korea	2010	Juices and smoothies
Brazil	2010	Zumos
Italia	2010	Smoothies
UK	2011	Apple juices
USA	2011	Coconut water
Korea	2011	Citrus juices

Evolution Fresh – Starbucks group (USA)

Starbucks Acquires Evolution Fresh to Enter Wellness Space

With this acquisition, Starbucks will reinvent the $1.6 billion super-premium juice segment, its significant next step in entering the larger $50 billion Health and Wellness sector.
Press Release Nov 2011

http://www.bevnet.com/news/2014/video-a-behind-the-scenes-look-at-evolution-freshs-new-70-million-juicery-interview-with-founder-jimmy-rosenberg

Toll processing companies

16 co-processing companies running 26 machines

- USA: American Pasteurization Company, Ameriqual, Safepac, Millard Refrigeration, Quantum, GL Foods, Universal Cold Pasteurization, Eddy Packing, HPP Food Services, Stay Fresh.
- Canada: Natur+l XTD and the technical centre: CDBQ
- Taiwan: Kee Fresh
- The Netherlands: Pascal Processing
- UK: Deli 24
- Spain: APA Processing and the technical centre CENTA
- Portugal: Aveiro University

APAPROCESSING
ALTAS PRESIONES EN ALIMENTACIÓN

Processing of Coldpress juices in APA Processing (Spain)

Validations studies

HPP is non thermal post-packaging lethal intervention approved by FDA, USDA, Health Canada, European Food Safety Authorities approved.

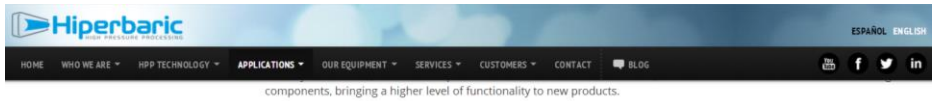
- **In the USA, the food producer has to demonstrate through challenges-studies the high pressure process achieve the required log reduction (5 log reduction) for relevant pathogens (*Listeria monocytogenes*, *E. coli* O157H7, *Salmonella*…) throughout the shelf-life.**
- **In Europe, after several scientific files have been submitted, France Safety Agency emitted an opinion confirming HPP foods were not significantly different from the same non-processed foods. Novel Food file submission is no more required (for processing up to 600 MPa). Nevertheless HPP users should perform challenges- tests and shelf-life studies, and packaging migration measurements.**
- **In Canada a novel food file for HPP food is required including: microbial, chemical, toxicological and nutritional studies. Applesauce and fruit blends, RTE cooked meats, raw ground meat and avocado products has been approved. Fruit / vegetable juices is pending.**

Health Canada
www.hc-sc.gc.ca

Table of Novel Food Decisions

Decision Date (YYYY/MM/DD)	Product	Proponent
2013/06/21	Insect Resistant and Herbicide Tolerant Maize Event 4114	Pioneer Hi-Bred Canada Inc.
2013/06/07	Herbicide Tolerant Soybean DAS-44406-6	Dow Agrosciences Canada Inc.
2013/05/01	High Pressure Processing (HPP)-Treated Raw Ground Beef (73% protein, 19% fat)	Gridpath Solutions Inc.
2013/02/22	Insect Resistant Maize Event 5307	Syngenta Canada Inc.
2012/11/28	Avocado Pulp, Guacamole and Tomato-Based Salsas treated by High Pressure Processing (HPP)	Gridpath Solutions Inc.

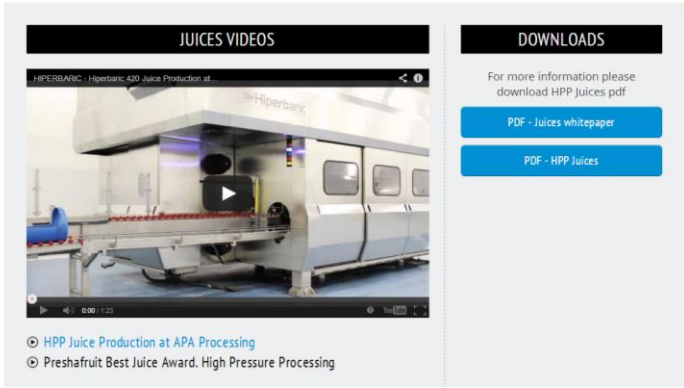
More information / Contact us



More information on www.hiperbaric.com

- Download HPP product flyers & whitepapers:

- HPP users videos:
  http://www.youtube.com/user/HiperbaricHPP/



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Hiperbaric thanks

Thanks to all our clients in Europe, America, Asia and Oceania who made Hiperbaric the world market leader of HPP industrial food equipment, since 2005.

Thank you for your attention !