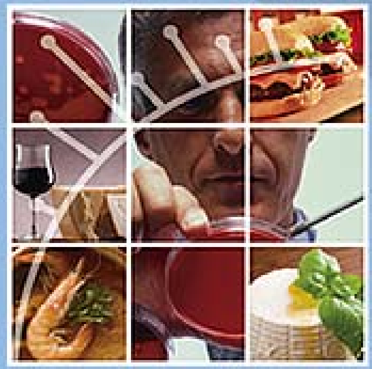


3rd International ISEKI_Food Conference

ISEKI_Food 2014

Athens, May 21-23, 2014

Bridging Training and Research for Industry and the Wider Community

Food Science and Technology Excellence for a Sustainable Bioeconomy

Challenges for Sustainable Innovation in Food Science and Engineering

Petros S. Taoukis

National Technical University of Athens, School of Chemical Engineering, Laboratory of Food Chemistry and Technology

Sustainable Development

The practice of sustainable development assures that the natural resources and energy we use to provide today's products and services will not deny future generations the resources necessary to meet their needs, while building and preserving communities that are economically, socially and environmentally healthy.

SUSTAINABILITY & FOOD

ERA-Net SUSFOOD definition of sustainability in the food area

A food system that

- supports food security
- makes optimal use of natural and human resources
- respects biodiversity and ecosystems for present and future generations

which is

- culturally acceptable and accessible
- environmentally sound
- economically fair and viable

and which

- provides the consumer with nutritionally adequate, safe, healthy and affordable food

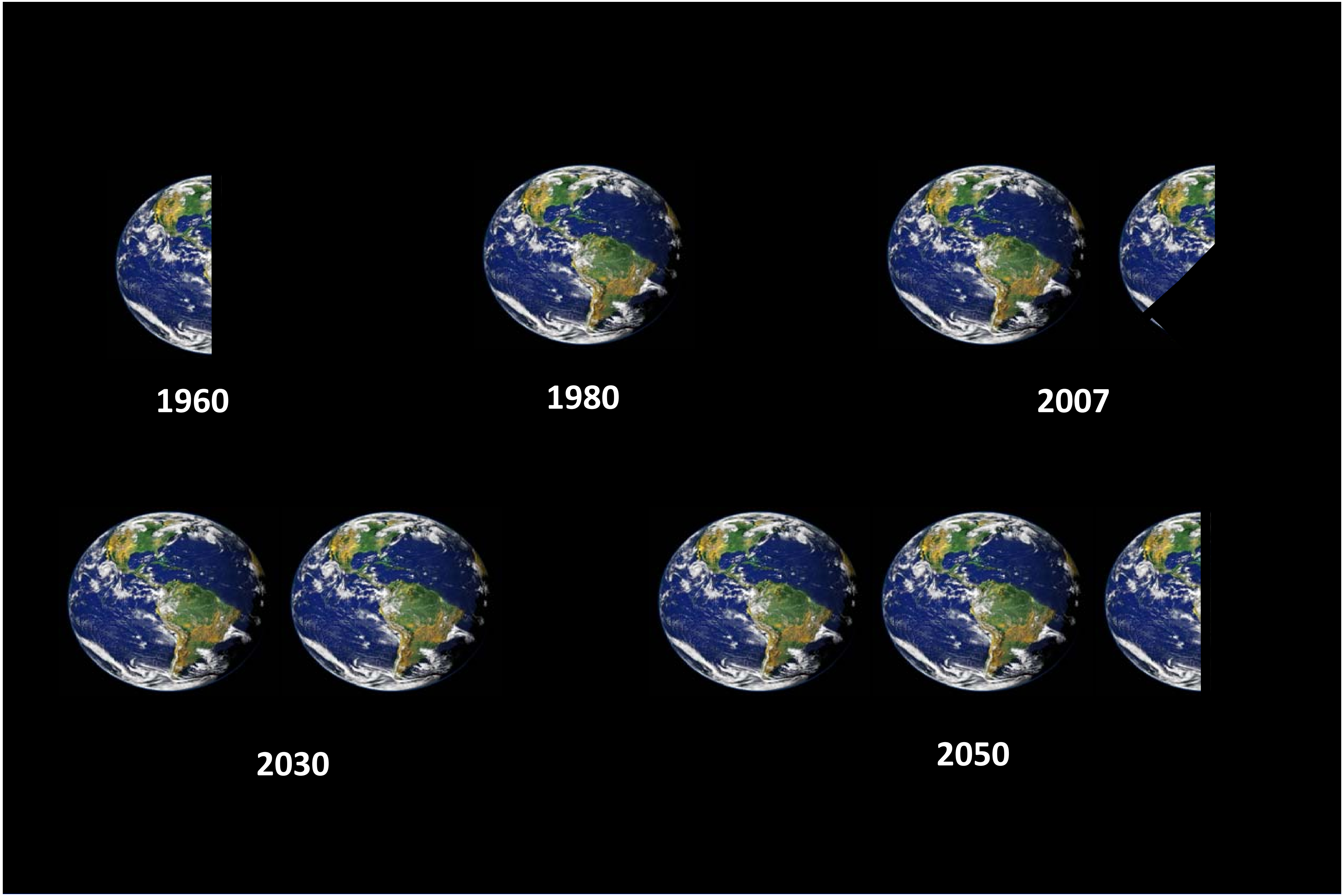
INNOVATION CHALLENGES IN FOOD SCIENCE AND ENGINEERING

Among the most significant challenges for the future are the <u>sustainable supply, storage and transport</u> of **energy**, clean **freshwater** and adequate **food** for all mankind at a reasonable cost .

Food science and process engineering is involved in all of these three main challenges directly or indirectly.

Decreasing amount of arable farmland and the growing human population require new concepts to feed the world and meet the consumer demands for food in the future.

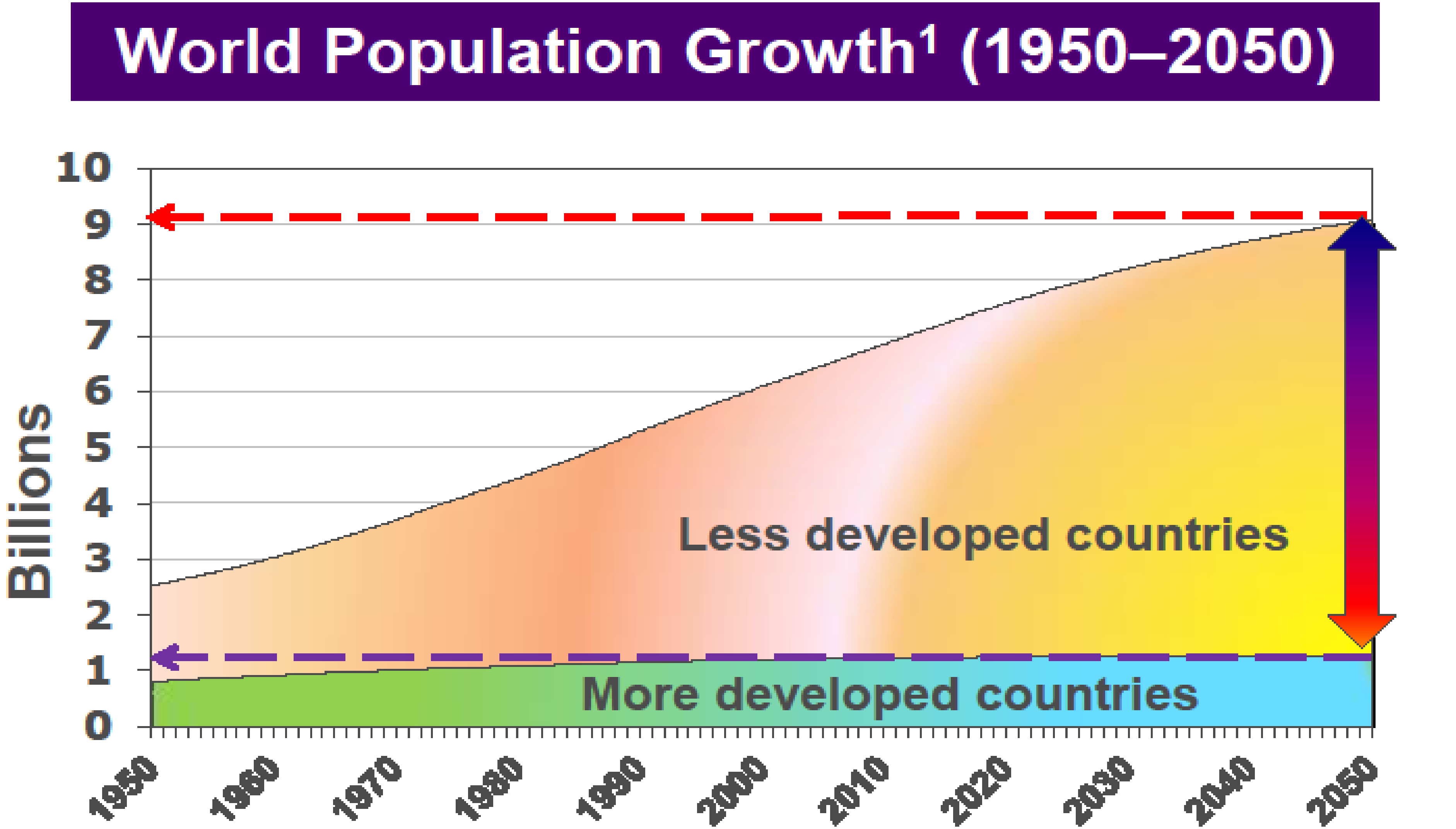
Research and innovations in the field of food process engineering and food packaging will have to also focus on **food security**, i.e., access to sufficient, safe, and nutritious food for all people at all times.


1960
1980
2007
2030
2050

With China and India - 2050

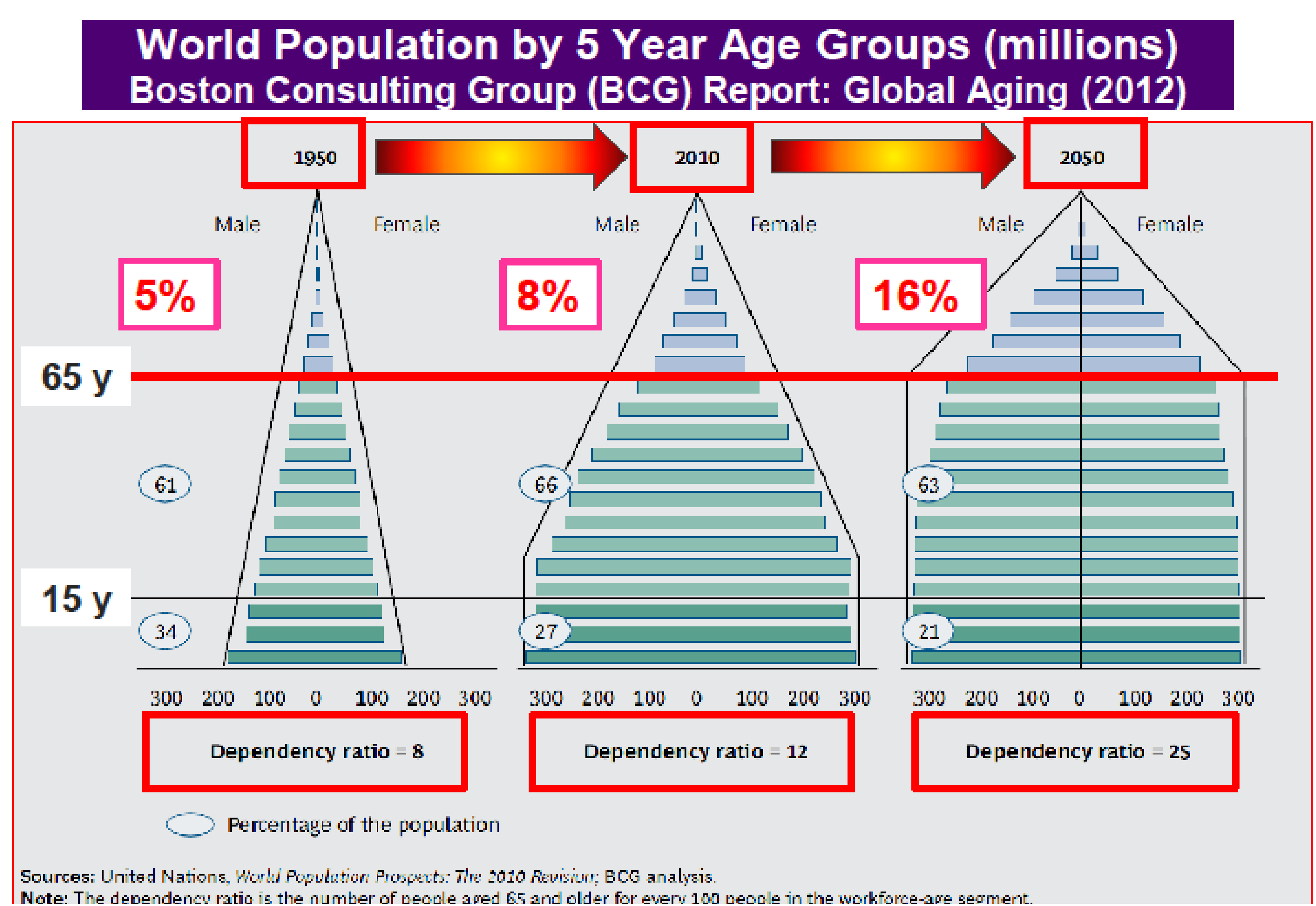
Practical Sustainability Strategies: How to Gain a Competitive Advantage 2014
Avlonas and Nassos

World population growth & aging

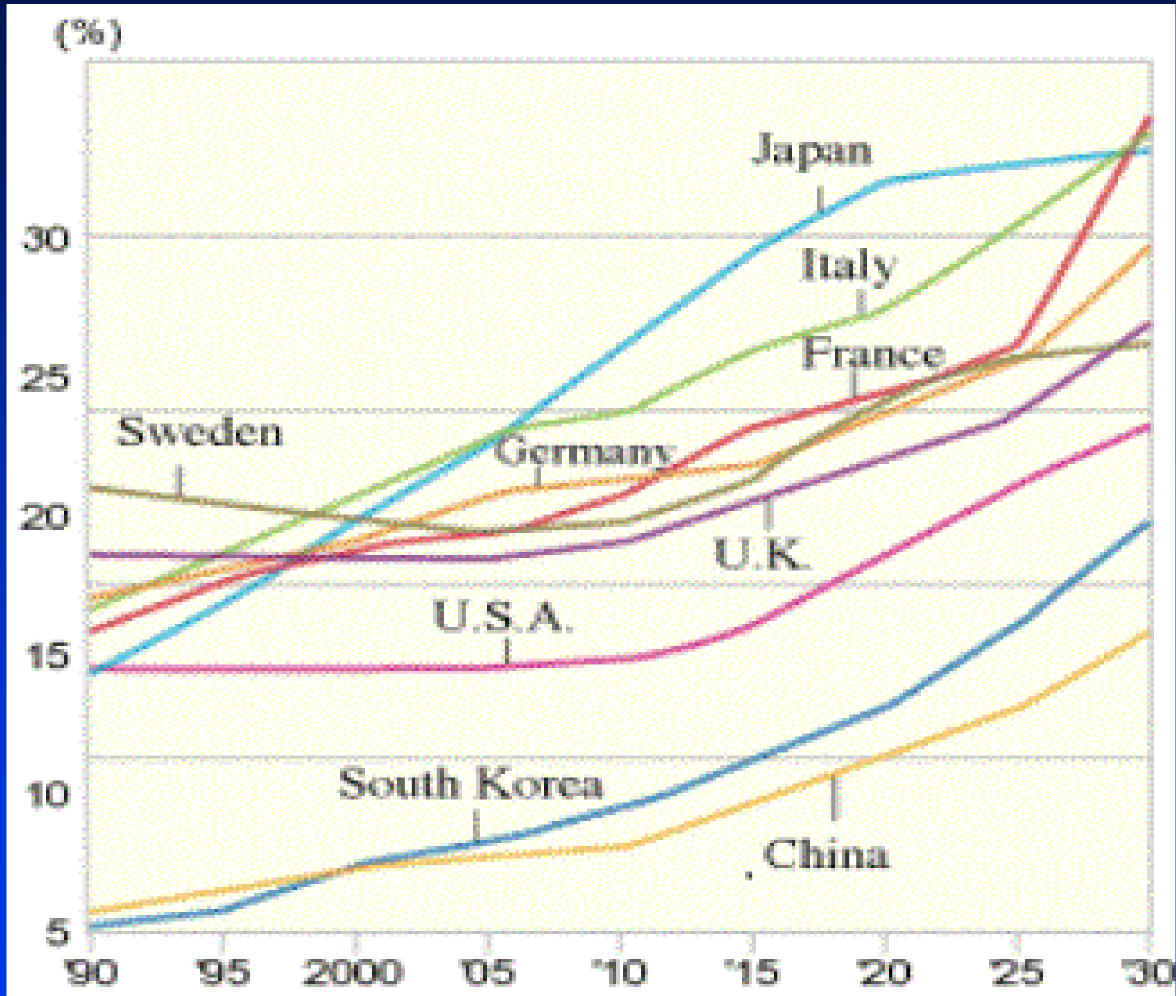


[1]United Nations Populations Division, *World Population Prospects, The 2004 Revision*,

World population growth & aging



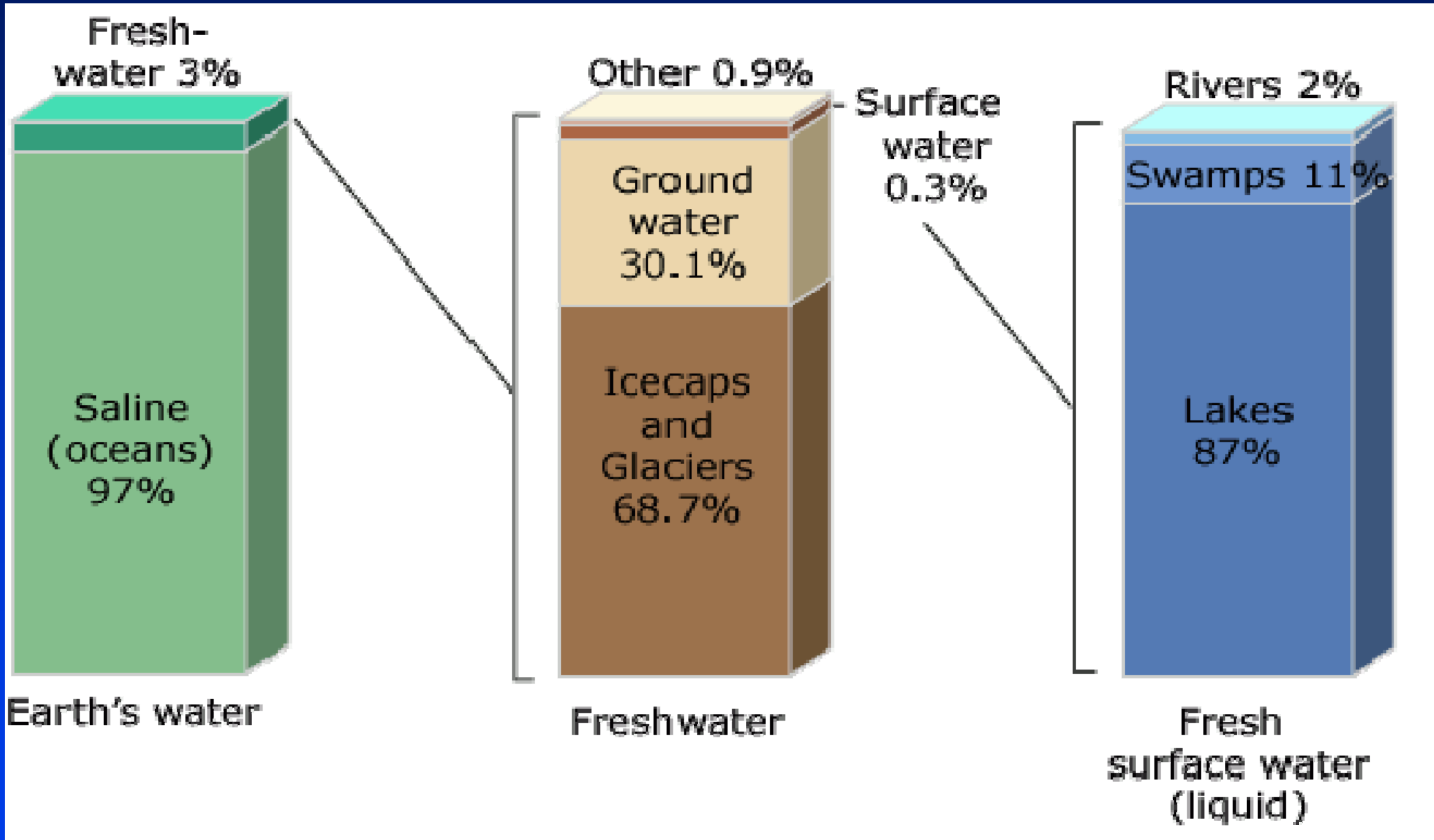
World population growth & aging



Percentage of Population older than 65

(Data from The Australian Network for Universal Housing Design, 2010)

WATER RESOURCES
Distribution of Earth's Water



WATER DEMAND FOR FOOD

The following reference values are applicable to ready-to-eat food :

Approximately 10 lit of water for 1 kcal (4.2 kJ) of meat,
compared to 1 lit of water for 1 kcal of vegetable food.

Accordingly, a global average of about 3,000 lit of water per adult person per day is, therefore, required for foodstuff (Brabeck-Letmathe, 2008)

Numerous parameters, simplifications and various understandings can considerably impact on the estimated amount of virtual water content. Reliability of estimated values published.

FOOD WASTE

FOOD WASTE IN THE FOOD CHAIN

Food waste in Europe

FOOD WASTE IN THE FOOD CHAIN

Agricultural minister's meeting in Brussels - May 19, 2014

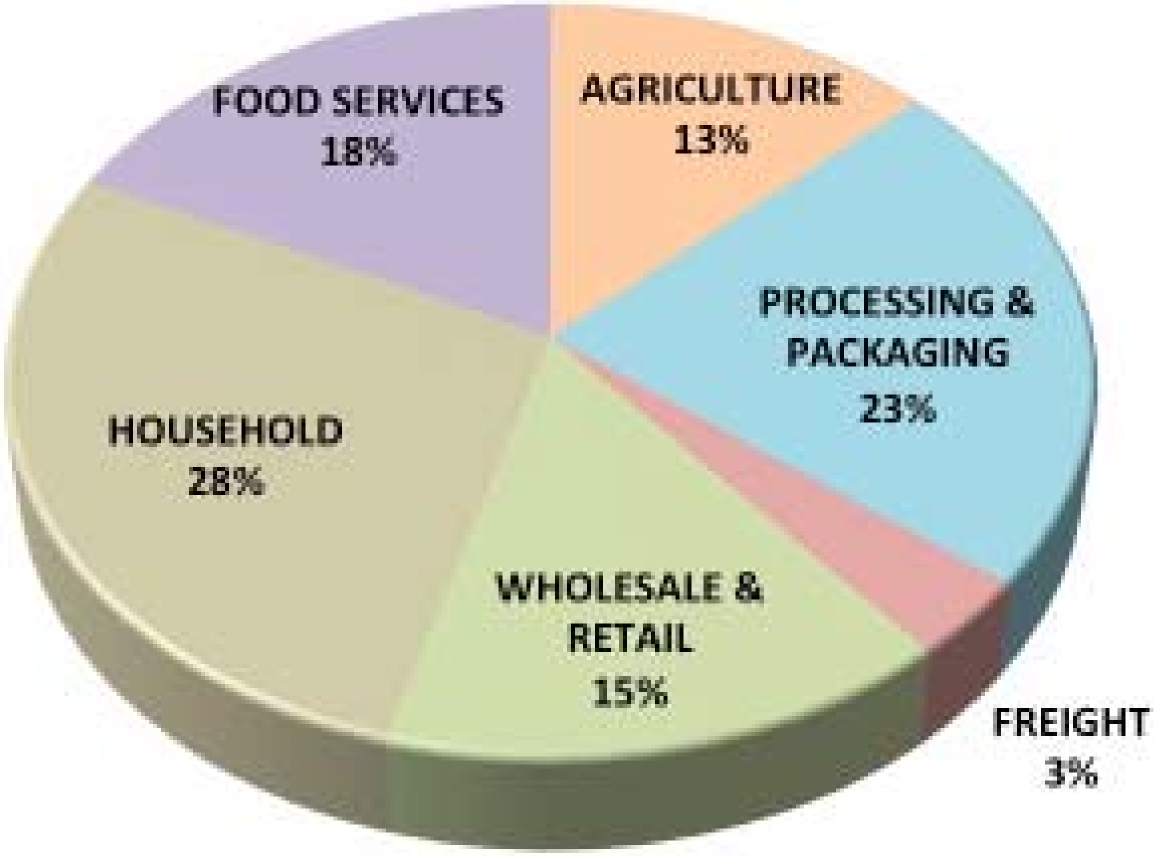
Revise "best before" policy to reduce waste?

Several EU member states urged the European Commission to revise the "best before" date on food labels which, according to them, creates confusion among consumers. According to the European Commission, nearly 90 million tons of food is wasted annually in Europe. Around 40 percent of this amount is partly due to consumer behaviour. As the European Commission explained, there is confusion about many products which have "best before" labelling. Sometimes such products are still fit for consumption after that date, but are still too often thrown away. According to the Commission, this misinterpretation of date marking is considered to have significant impact on food waste in each EU country, reaching around 15 to 20 percent.

Sweden and the Netherlands – supported by the Austrian, Danish, German and Luxembourg delegations – sent a letter to the European Commission asking to consider an extended list of products without this "best before" date.

US National Resources Defence Council Report (NRDC, 2013) also indicated that significant portion of the wastes at the consumer level may be associated with confusion about food labels, specifically a "sell-by" and "use-by" date.

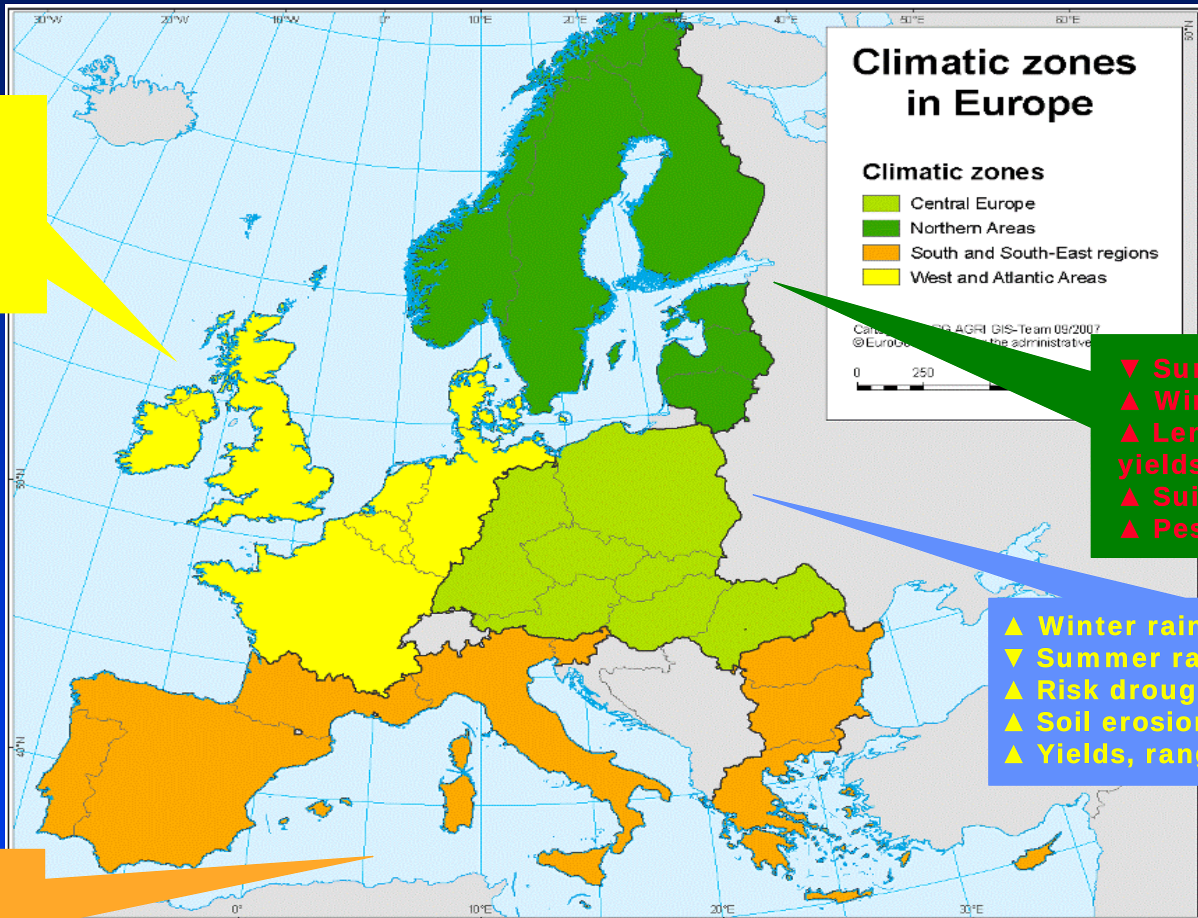
ENERGY CONSUMPTION IN THE FOOD CHAIN



Energy inputs in the US Food System, based on data from the USDA[6]

Climate change – Possible impacts on EU agriculture

▲ Floods risk
▲ Hotter and drier summers
▲ Sea levels
▲ Risk crop pests, diseases
▲ Crop, forage yields
▼ Animal health, welfare



▼ Summer rainfall
▲ Winter storms, floods
▲ Length growing season, yields
▲ Suitable farmland
▲ Pests, diseases risks

▲ Winter rainfall, floods
▼ Summer rainfall
▲ Risk drought, water stress
▲ Soil erosion risk
▲ Yields, range of crops

▼ Water availability
▲ Risk drought, heat spells
▲ Risk soil erosion
▼ Growing season, crop yields
▼ Optimal crop areas

Source: DG Agriculture and Rural Development, based on EEA reports, JRC and MS academic studies.

Your Breakfast Is Under Assault From Climate Change

Time to stock up on Corn Flakes. Oxfam says at least three of the most popular breakfast cereals are expected to increase in price thanks to the effects of climate change

Cereal lovers of the world may want to start stocking up now, because the far-reaching impacts of climate change could cause the price of their favorite breakfast food to climb sharply in the coming years.

Due largely to shifting weather patterns and extreme events like flood and drought, the prices of commodities like corn and rice are projected to double by 2030, according to a report out Tuesday from Oxfam. As a result, some classic breakfast cereals are likely to get more expensive over the next 15 years.

In the United States, Oxfam says, Frosted Flakes could be 20% more expensive by 2030 due to climate change, and 30% more expensive in the U.K. Kix could be up to 24% more expensive in the U.S. while Corn Flakes could be 30% pricier. British Corn Flakes lovers, meanwhile, would have to pay 44% more for a box of the cereal.

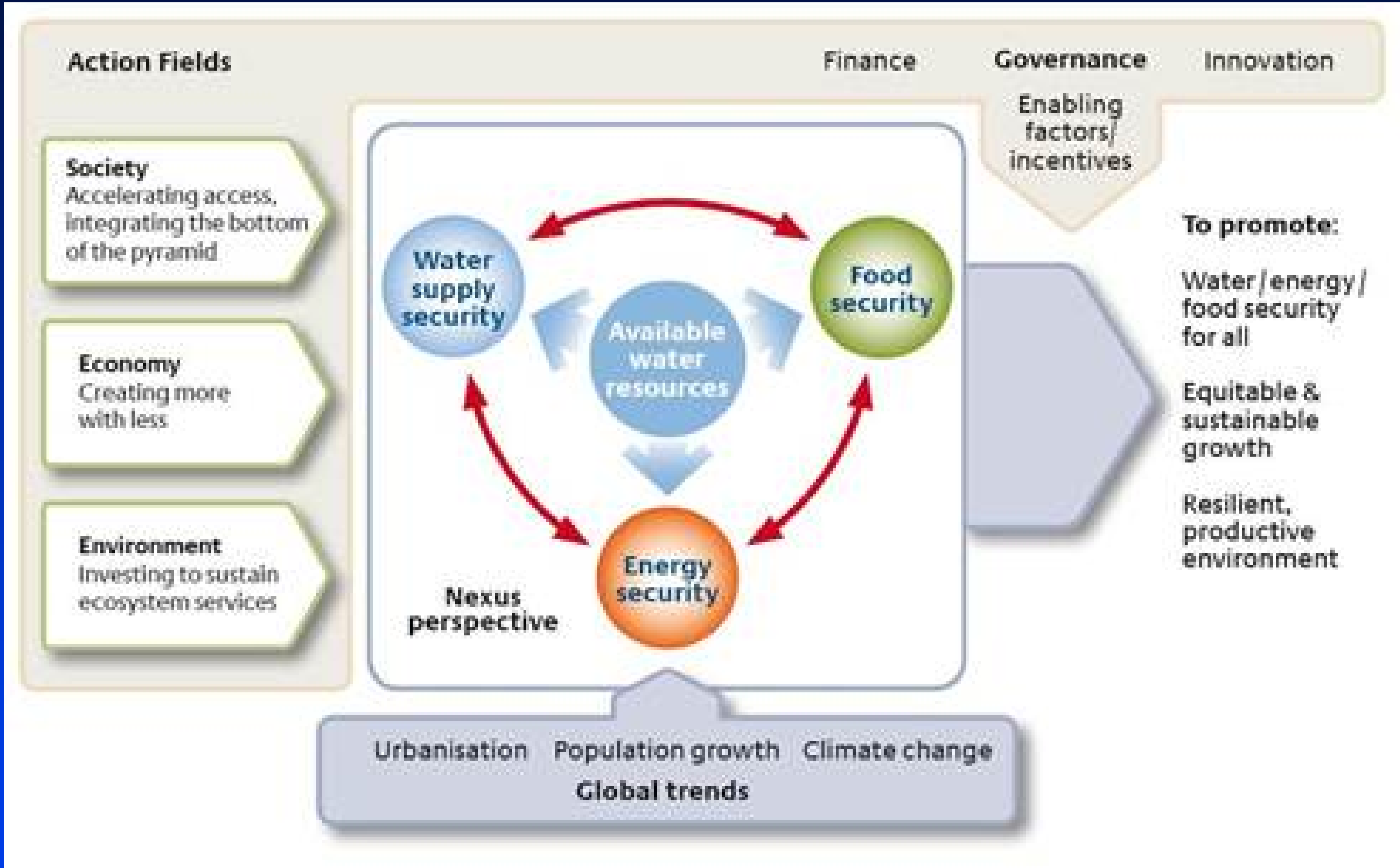
All this talk of the increasing price of sugary breakfast food is beside the point for the people "hit first and worst" by climate change, says Oxfam: the world's poor, for whom the doubling of the price of a staple food like rice would be no small matter.

The Oxfam report is part of the group's "Behind the Brands" campaign, which scrutinizes the world's 10 biggest food corporations on issues from workers' rights to water usage to corporate transparency. The agricultural industry, Oxfam says, is responsible for about a quarter of the world's greenhouse gas emissions. On climate change, the report singles out Kellogg and General Mills as particularly egregious offenders.

"They're two of the worst of the big ten (but) they're not the only bottom dwellers," says Heather Coleman, Oxfam's climate program manager. Coleman says Oxfam wants to see food companies—which are uniquely threatened by climate change among major corporations—pressure governments to act on climate fixes.

The global aid charity is pressing business and trade groups like the U.S. Chamber of Commerce to drop opposition to climate legislation, and invest in sustainable carbon-friendly supply chains from farm to table. "What we're saying is that they're standing on the sidelines. It's time for them to stand up and call on governments to act meaningfully," Coleman said.

General Mills did not respond to a request for comment, but Kellogg told TIME the company is "working on multiple fronts to further reduce our greenhouse gas (GHG) emissions and waste, as well as the energy and water we use. As we do so, we value continued engagement and discussion with Oxfam, and other external stakeholders on the important issues of environmental and social responsibility."


Action Fields
Finance
Governance
Innovation
Enabling factors/ incentives
Society
Accelerating access, integrating the bottom of the pyramid
Economy
Creating more with less
Environment
Investing to sustain ecosystem services
Water supply security
Food security
Available water resources
Energy security
Nexus perspective
To promote:
Water / energy / food security for all
Equitable & sustainable growth
Resilient, productive environment
Urbanisation
Population growth
Climate change
Global trends

Food Science and Engineering

Food Engineering:

Food Engineering is concerned with the design, construction and operation of industrial processes and plants in which intentional and controlled changes in food materials are performed with due consideration to all economic aspects concerned. Parker, 1952

To illustrate the common relationship between basic engineering principles and the fundamentals of food processing. Charm, 1963

The study of the processes that transform raw materials into finished products, or preserves foods so they can be kept for longer periods. Earle, 1966

Food Science and Engineering

Food Engineering:

Food Engineering covers the study, modeling and design of ingredients and foods at all scales using technological innovations and engineering principles in the development, manufacturing, use, understanding and optimization of existing and emerging food processes, food packaging and food materials from food production to digestion and satiation enabling development and design, production, and availability of **sustainable, safe, nutritious, healthy, appealing and affordable supply** of high quality ingredients and foods.

EAFE 2013

INNOVATION CHALLENGES IN FOOD SCIENCE AND ENGINEERING

Among the most significant challenges for the future are the sustainable supply, storage and transport of **energy**, clean **freshwater** and adequate **food** for all mankind at a reasonable cost .

Food science and process engineering is involved in all of these three main challenges directly or indirectly.

INNOVATION CHALLENGES IN FOOD SCIENCE AND ENGINEERING

Besides contributing to sufficient quantity of quality food for a growing world population food science and engineering has to account for today's consumers needs and societal challenges (H&W)

- Consumers demand safe food products of high nutritional value and biofunctional properties, superior sensory attributes, long shelf life and convenience in use, and yet fresh like, minimally processed and with "clean label", sustainably produced in an environmentally and energy efficient way.

These requirements pose extraordinary challenges for the continuous improvement of conventional processes as well as the development of novel products and processes.

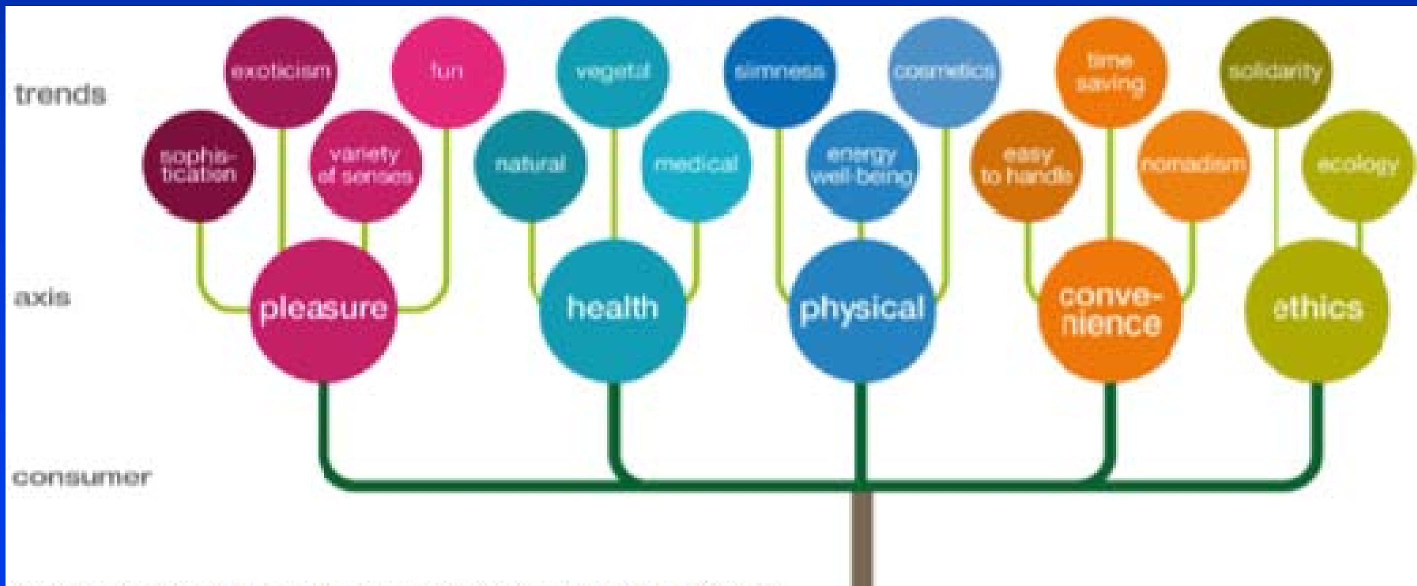
Consumer preferences driving innovation

Drivers of innovation in Europe, 2010-2011 (%)

	2010	2011
Pleasure	52.2	54.5
Health	22.4	19.9
Convenience	16.6	16.8
Physical	6.5	6.1
Ethics	2.3	2.7

Source: XTC World Innovation Panorama 2011; Copyright XTC 2011 (www.worldinnovation.com)

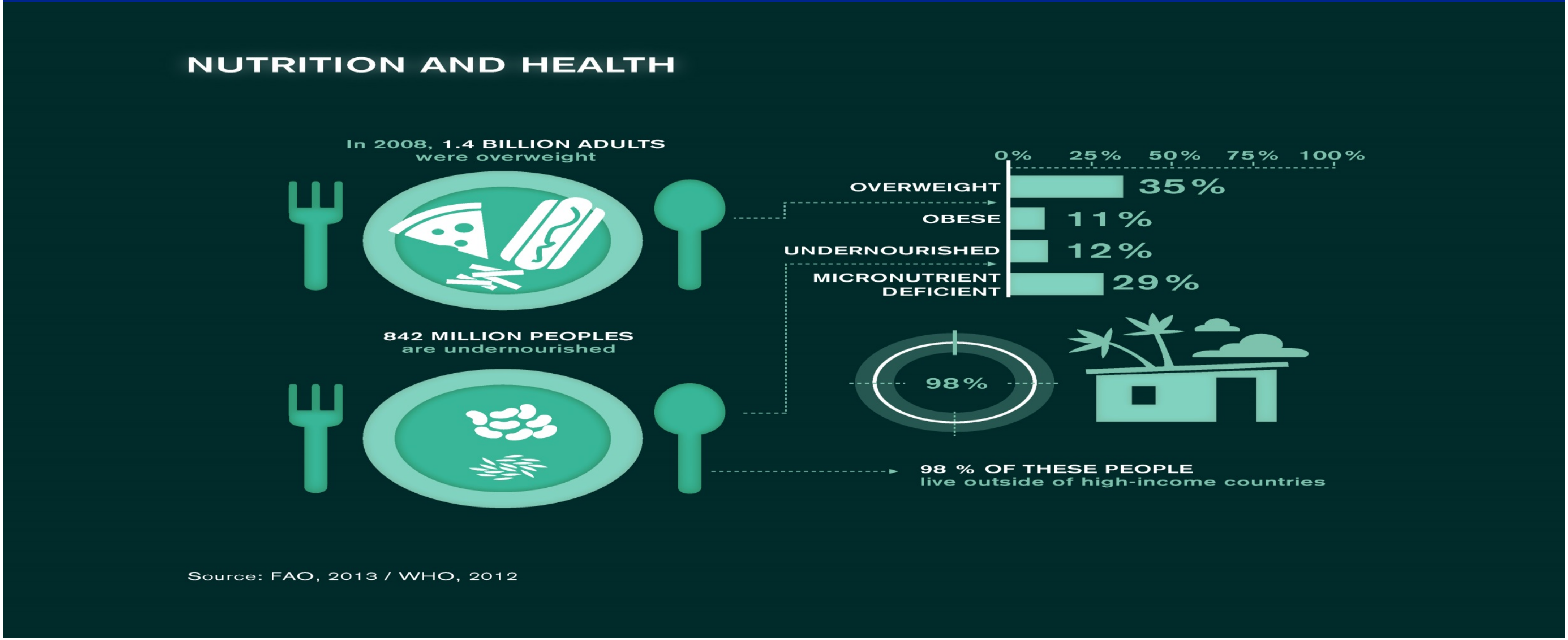
Food innovation trends in Europe



Source: XTC World Innovation Panorama 2011; Copyright XTC 2011 (www.worldinnovation.com)

INNOVATION CHALLENGES IN FOOD SCIENCE AND ENGINEERING

- Problems arising from the consumption of unbalanced food in unhealthy quantities, particularly in highly developed industrialized countries VS malnutrition in low income countries.



Innovation drivers in Food
Ethics
Convenience
Health & hunger
Well Being
Pleasure
Sustainability
Climate and environmental protection
EU Commission

Food Science and Engineering **Innovation goals**

Consumer demands (zero risk, user and environmentally friendly, fresh-like taste and flavour, long shelf-life, low cost)

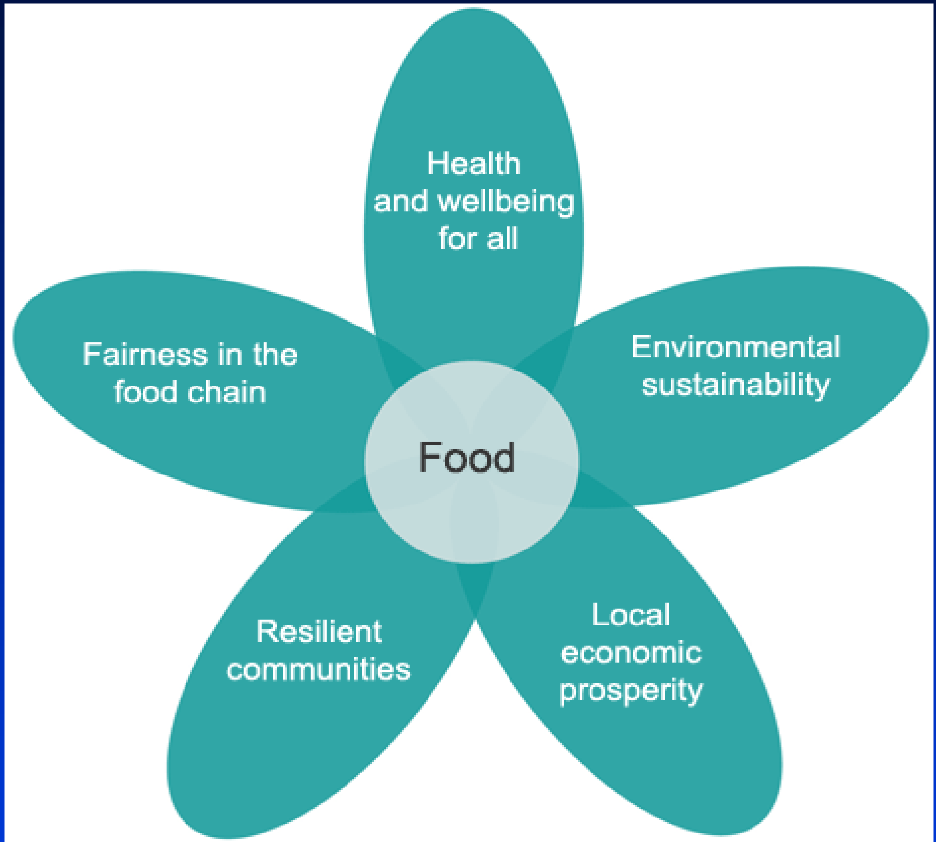
Processes and food products adopting established knowledge combined with modern tools and technologies, measuring devices, nanotechnology and biosciences

COST FEASIBILITY

Water and energy **efficiency**

Sustainability with regards water, energy, raw materials

CHALLENGES FOR FOOD SCIENCE & ENGINEERING



- Feed low-income people in developing and industrialized countries.
- Reconcile the food industry and society.

INNOVATION CHALLENGES IN **FOOD ENGINEERING**

Facing these challenges food engineering research in the following areas may induce substantial improvements and technical innovations (Schubert, 2013)

1. Development of adjusted processes and food products by employing the knowledge established in basic chemical engineering using modern tools such as computer-aided simulation, material sciences, novel measuring devices , nanotechnology… Research in these fields will lead to a better understanding of the relationship between micro- and submicro-structures and functional properties such as bioavailability or bioactivity of food compounds and enable a target product design.

INNOVATION CHALLENGES IN **FOOD ENGINEERING**

2. Improving the process efficiency, saving of energy and water, reduction of waste and environmental pollution to reach high quality food at the lowest cost and improved sustainability

3. Ensure food safety, for example by improving hygienic design, by providing appropriate packaging and by developing and verifying better models to ensure food safety using quantitative microbiology and new mathematical tools to improve microbial risk assessment

4. Improved product quality control by intelligent, computer-aided automation tools, advanced monitoring and control systems and flexible manufacturing of food to manage food processes, conventional and novel, even with complex interacting parameters involved, and get personalized products.

Schubert, 2013

INNOVATION CHALLENGES IN **FOOD ENGINEERING**

Enginomics **focusing on understanding food interactions and inner body processes, H&W**

Inside food & body: Food & Health '*Enginomics*'

Saguy et al., 2013

- **Food (properties, composition, new resources…)**
- **Product engineering (micro- structures-design, material science, packaging…)**
- **Human processing (inner unit operations, gastric, digestibility, targeting, bioavailability...)**

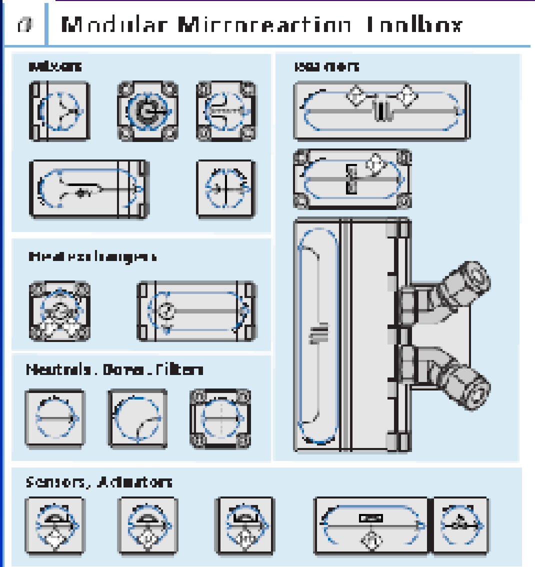
INNOVATION CHALLENGES IN **FOOD ENGINEERING**

Inside food & body: Food & Health ‘*Enginomics*’

- Manufacturing (process optimization, novel processes, waste & water management, environment, compliance, regulations...)
- H&W (medicine, brain, biology, biota, pro- & pre-biotic, nanotechnology, biotechnology...)
- Nutrition (personalization, prevention, satiety…)
- Consumers (safety, acceptability, special needs, emotions, pleasure...)
- Social responsibility (food security, feeding the world, sustainability, ethics, values...)

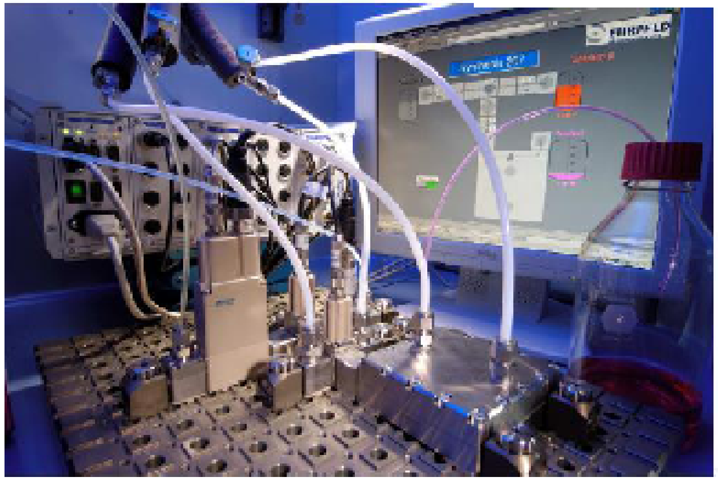
INNOVATION CHALLENGES IN **FOOD ENGINEERING**

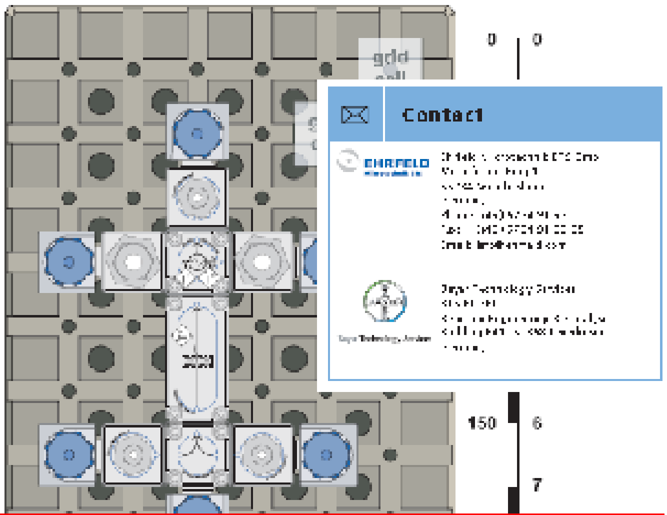
Inside the Body: Micro-processing, modeling, …

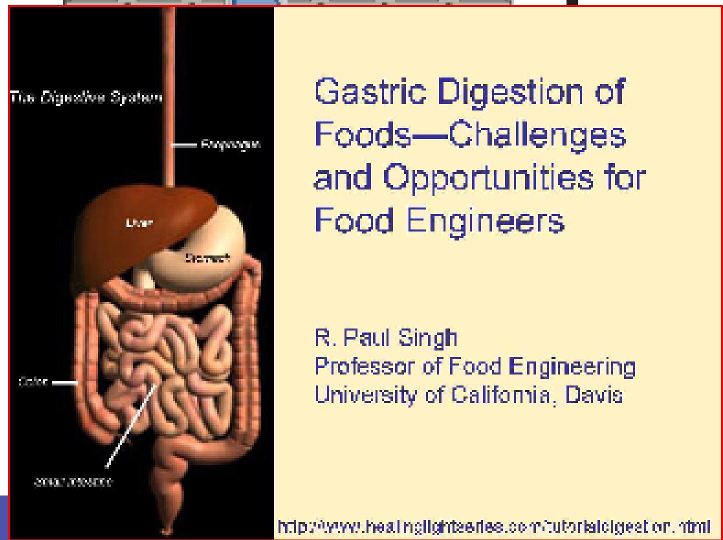


Easy to assemble and to clean!

Modular design!

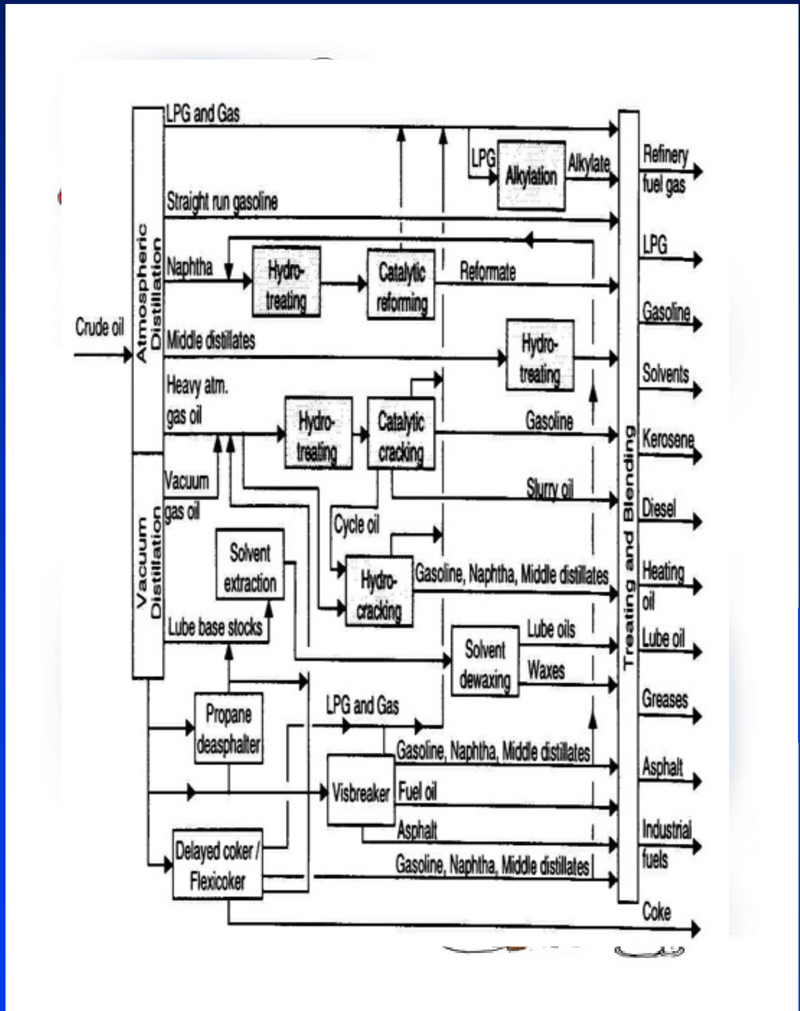


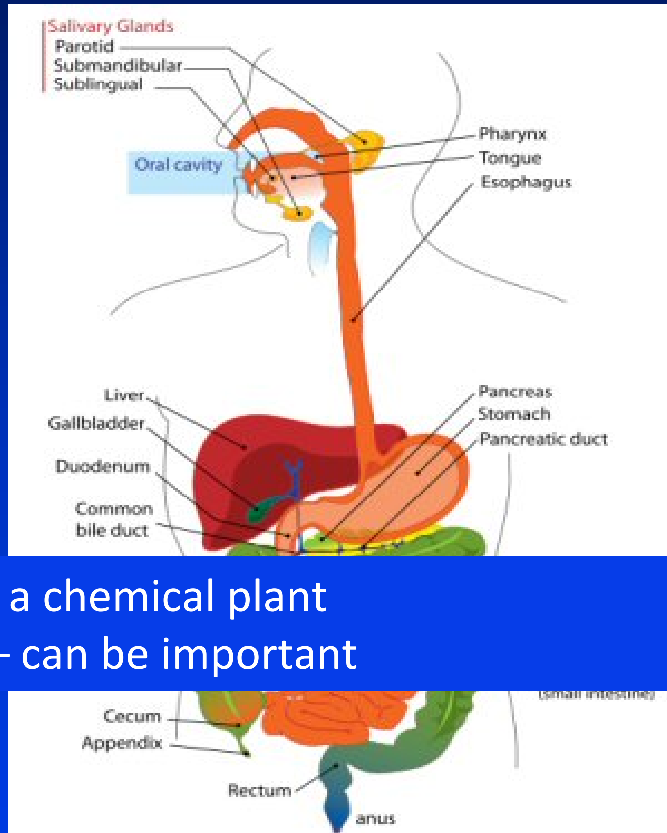




The digestive machine

Digestion involves mixing of food, biological secretions, reactions and absorption of products + disposal of the unusable products

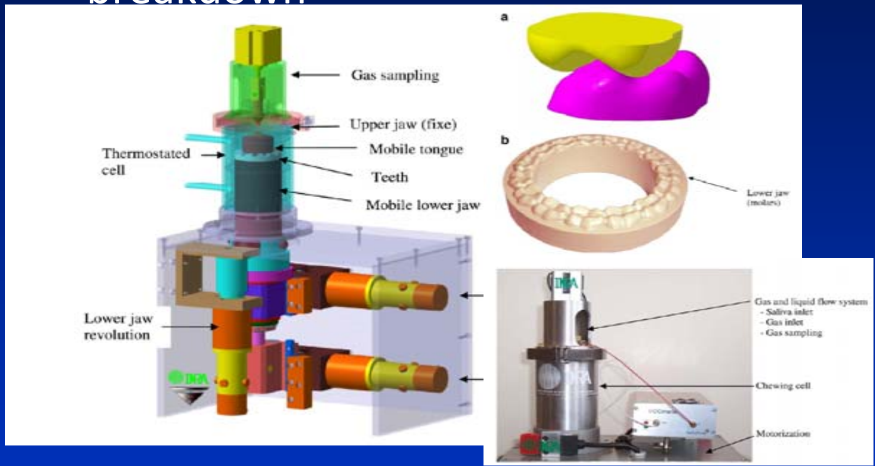




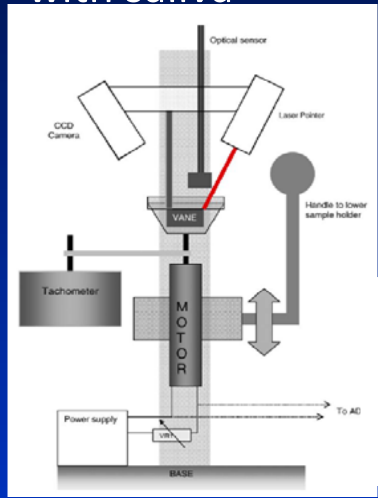
This resembles a chemical plant
Mass transfer – can be important

In-vitro rigs simulating Oral processing

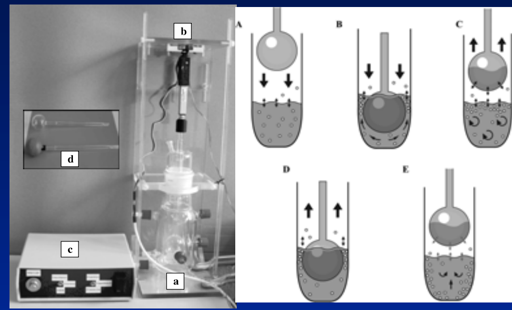
Replicate teeth geometry: Particle breakdown

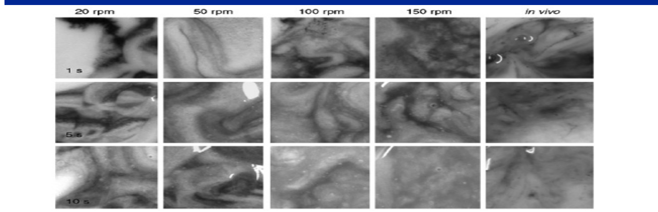


Rheometer: mixing with saliva

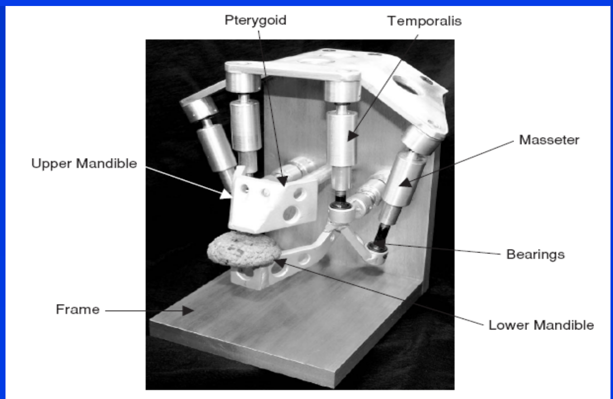


Compression: soft solids

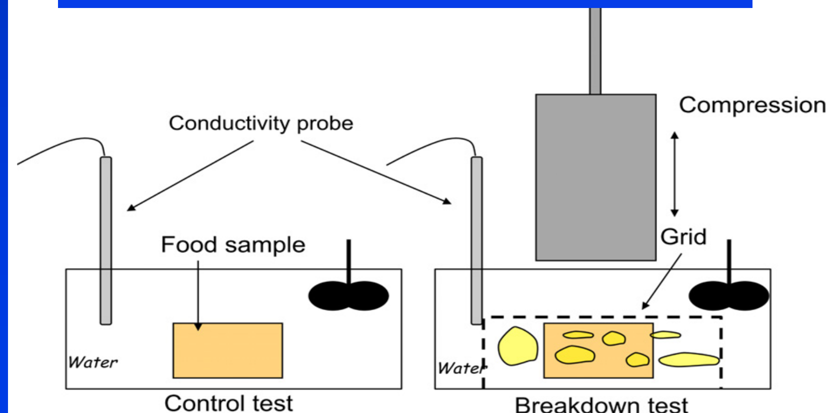




Compression: soft solids (texture)

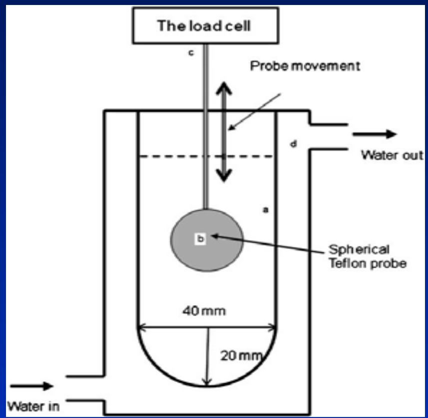


Compression: soft solids (release)

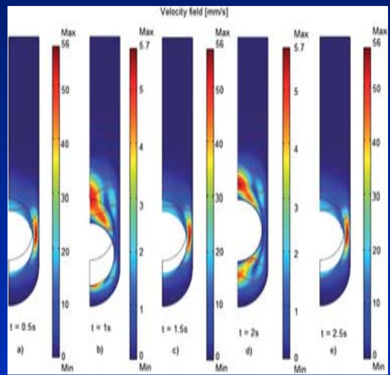


Salles *et al.* 2007 Xu *et al.* 2007 Prinz *et al.*, 2006 de Loubens *et al.* 2007
Mills et al. 2011 Benjamin *et al.* 2012

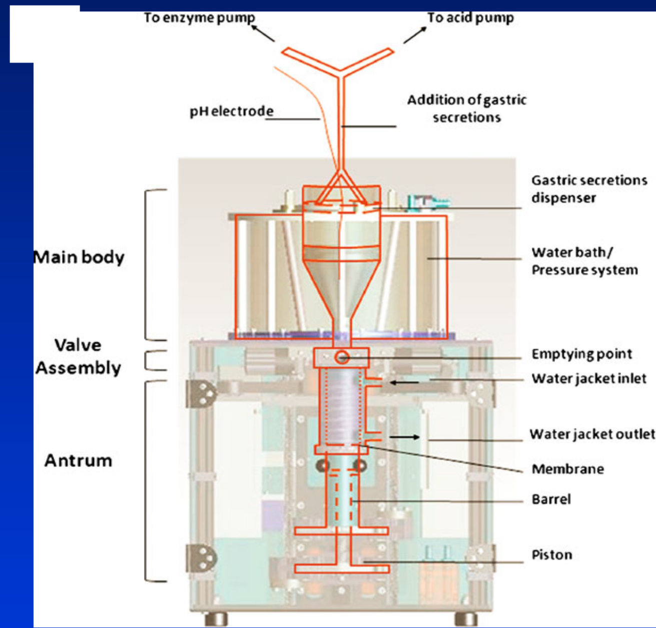
Dynamic Gastric mimicking in-vivo conditions



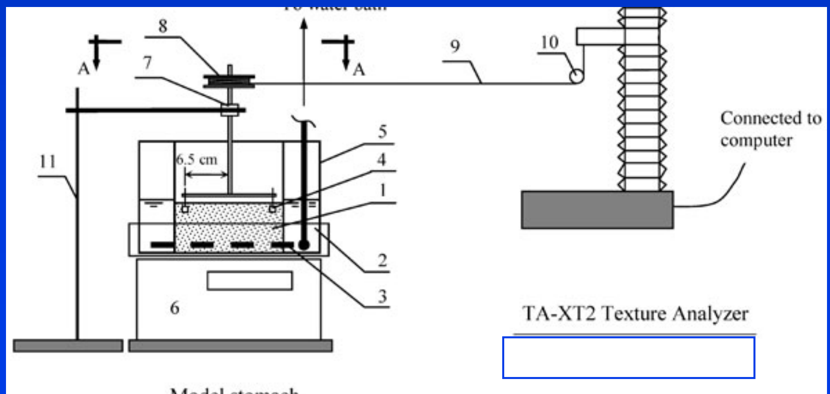
Compression



Complex Wall motion (DGM)



Particle-Particle abrasion



Some mixing (easier to use)

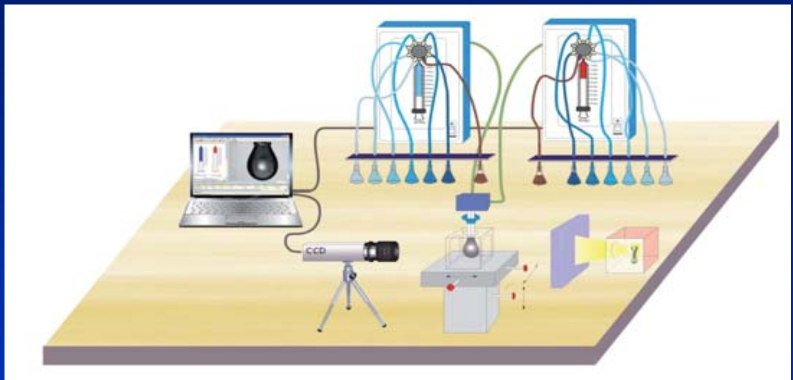
Chen *et al.* 2011

Kong & Singh. 2008

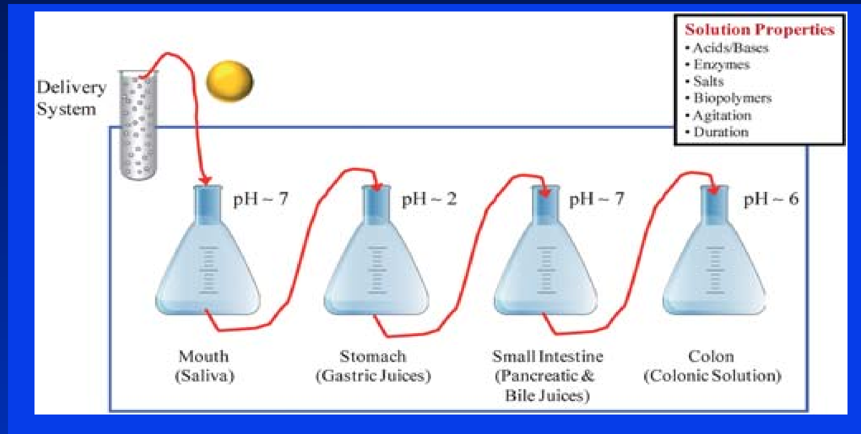
Wickham *et al.* 2012

Integrated digestive system

Octopus: Single droplet

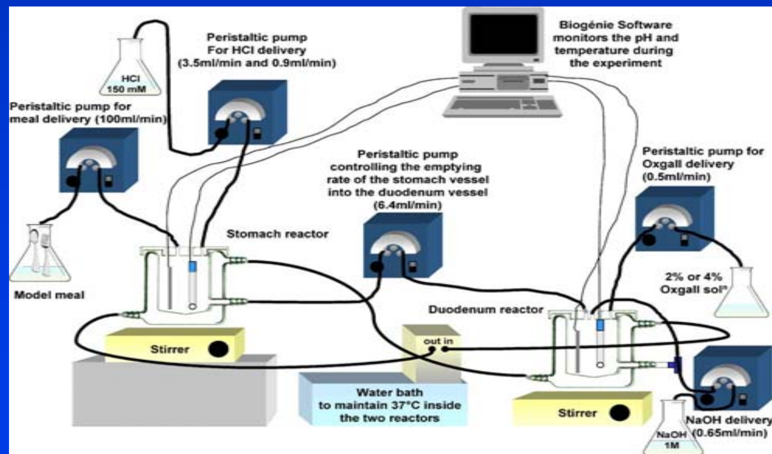


pH-stat



membrane diffusion

gastro-duodenal



Maldonado-Valderrama *et al.*, 2013 Argyri *et al.* 2009 Mainville *et al.* 2005 McClements *et al.* 2010

INNOVATION CHALLENGES IN **FOOD ENGINEERING**

ADVANCES IN ESTABLISHED FOOD PROCESS ENGINEERING

vs

NOVEL PROCESSES

True innovations bring step changes in food process engineering and are rare events.

Generally, innovations in food engineering are mostly renovations or improvements of existing processes, which means taking smaller steps.

Top 10 Most Significant Food Inventions

The Royal Society, U.K.'s national academy of science, ranked the 20 most influential inventions in the history of food and drink. The judging criteria included accessibility, productivity, impact to food quality and health.

The top three spots were filled by relatively modern innovations, while classics like fire and the wheel were absent.

Some items that didn't quite make the top 10 were the microwave oven at No. 19, and eating utensils and the knife at Nos. 16 and 15, respectively. Fermentation was just barely edged out of the top 10, filling the No. 11 slot.

http://www.foodproductdesign.com/galleries/2012/10/image-gallery-food-inventions.aspx?cmpid=TOPFOODEM

Top 10 Most Significant Food Inventions

10 The Plow 

9 Milling/Grinding Machine 

8 Selective Breeding/Strains 

7 Baking 

6 Combine Harvester (Threshing Machine) 

5 Irrigation 

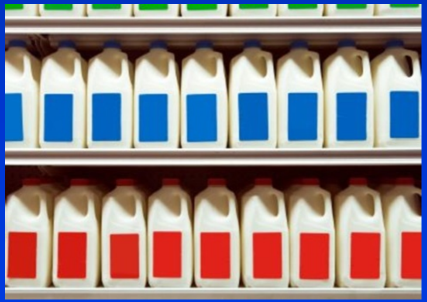
4 The Oven 

Top 10 Most Significant Food Inventions

The bottom of the list was dominated by agriculture-related innovations; the top three slots were dominated by food preservation technologies.

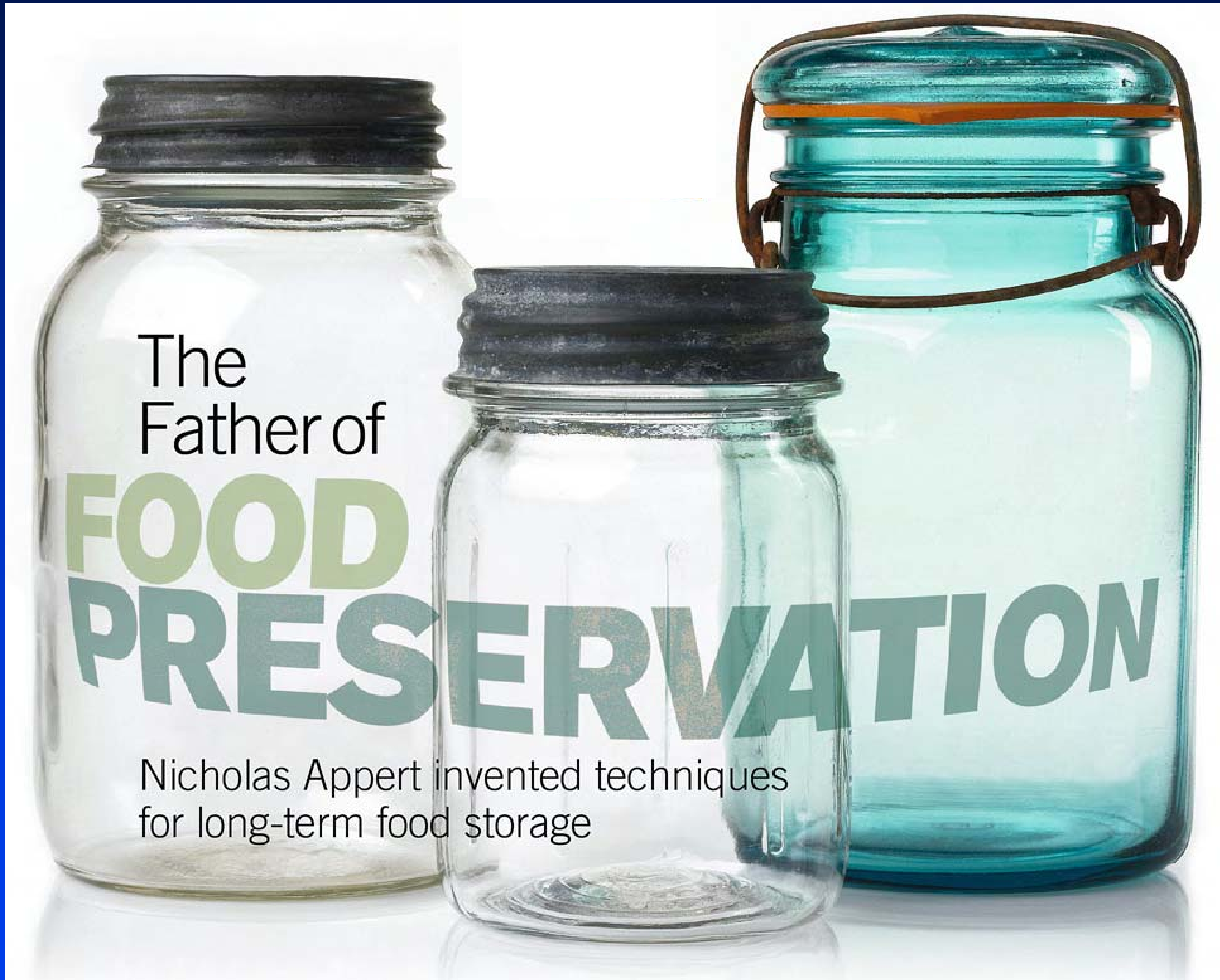
3 Canning

2 Pasteurization/Sterilization



1 Refrigeration

Nicolas François Appert (1749-1841)



Nicolas François Appert (1749-1841)

In 1804 his methods had been perfected and his samples tested by the Marine Prefect at Brest who reported to the Board of Health in Paris: “The broth in the bottles was good, the broth included with boiled beef in a special vessel good also but weak. The beef itself was very edible. The beans and green peas prepared both with and without meat have all the freshness and agreeable flavour of freshly picked vegetables.”

Food Quality, February/March, 2011.

Peter Durand

Peter Durand's Metal Can led to a food safety staple (1810)

Food Quality, April/May, 2012

Louis Pasteur (1822-1895)

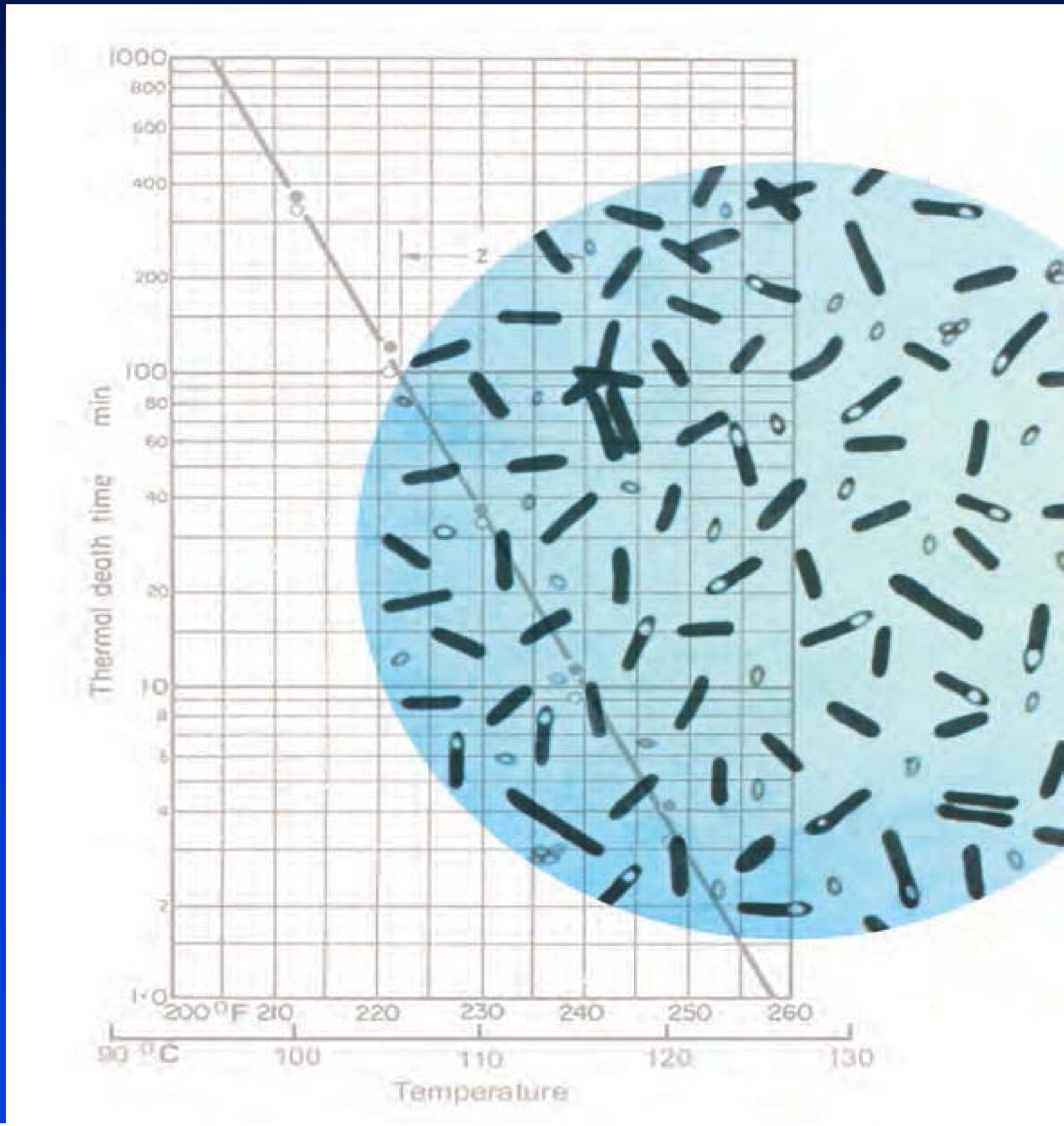
Louis Pasteur, a key figure in food safety, found that microorganisms were the cause of spoilage in milk and other products such as wine and beer.

Food Quality, April/May, 2011

In 1867 he won the Grand Prize of the Exposition Universelle for what became known as pasteurization, his method of preserving wine by heating it, after publishing a book on the subject the year before.

Later, in 1894, Samuel Cate Prescott and William Lyman Underwood recognized that surviving microorganisms were the cause of spoilage in canned food.

Charles Olin Ball (1893-1970)



Charles Olin Ball (1893-1970)

To Kanichi Hayakawa
with compliments and appreciation
Mar. 27, 1961. C. Olin Ball

Vol. 7. Part 1 OCTOBER, 1923 Number 37

BULLETIN
OF THE
NATIONAL RESEARCH COUNCIL

THERMAL PROCESS TIME FOR CANNED FOOD

By
CHARLES OLIN BALL
Research Laboratory, National Canners Association
Washington, D. C.

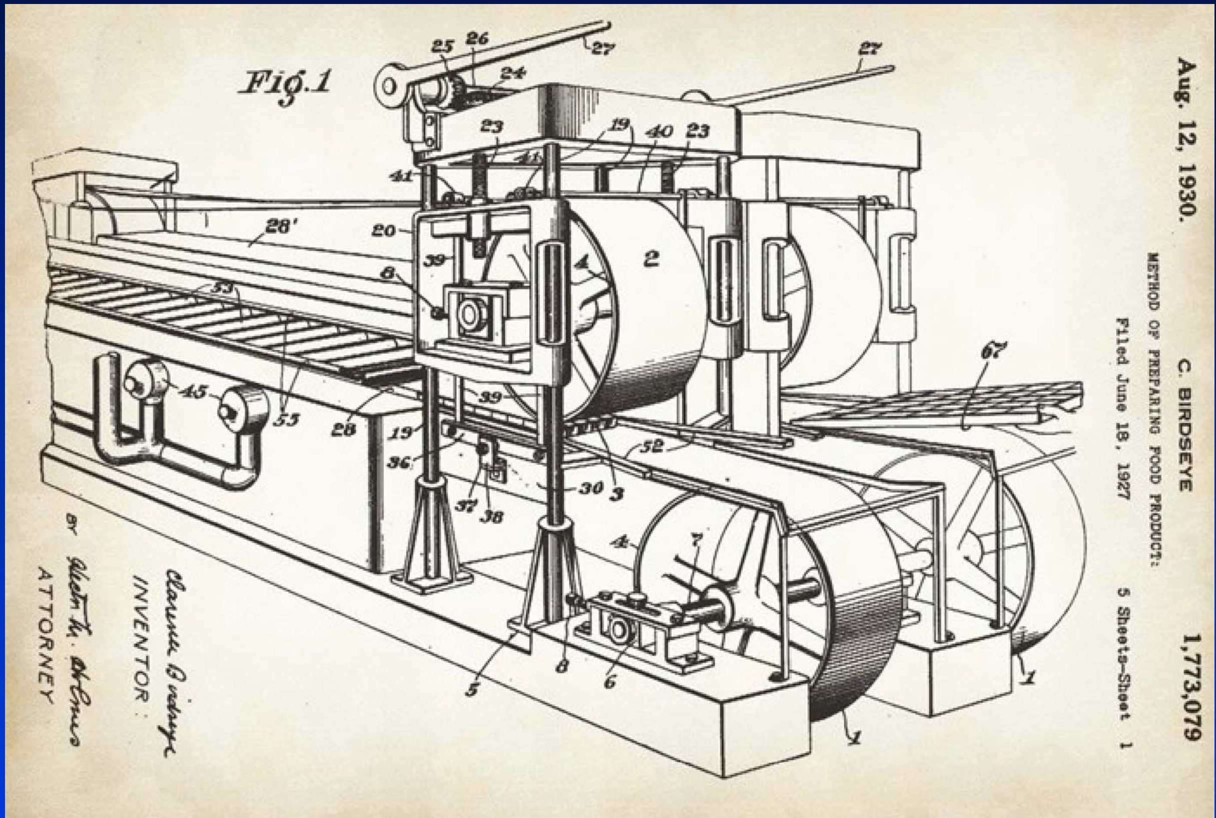
PUBLISHED BY THE NATIONAL RESEARCH COUNCIL
OF
THE NATIONAL ACADEMY OF SCIENCES
WASHINGTON, D. C.
1923

A pioneer in Thermal Death-Time calculations, C. Olin Ball used mathematical formulae to determine how much heat and time are needed to kill bacteria and keep food safe (1920, 1923).

The formulae for thermal death time, which became an FDA standard for calculating thermal processes, is still in use today.

Food Quality, June/July, 2011

Clarence Birdseye (1886-1956)



Patent #1,773,079 issued to Clarence Birdseye for the production of quick-frozen fish.

While Birdseye's name is typically synonymous with frozen food. What was unique was his method, which involved freezing food extremely rapidly and putting into packages pressed between refrigerated metal plates.

Food Quality, February/March, 2012

Technological MILESTONES

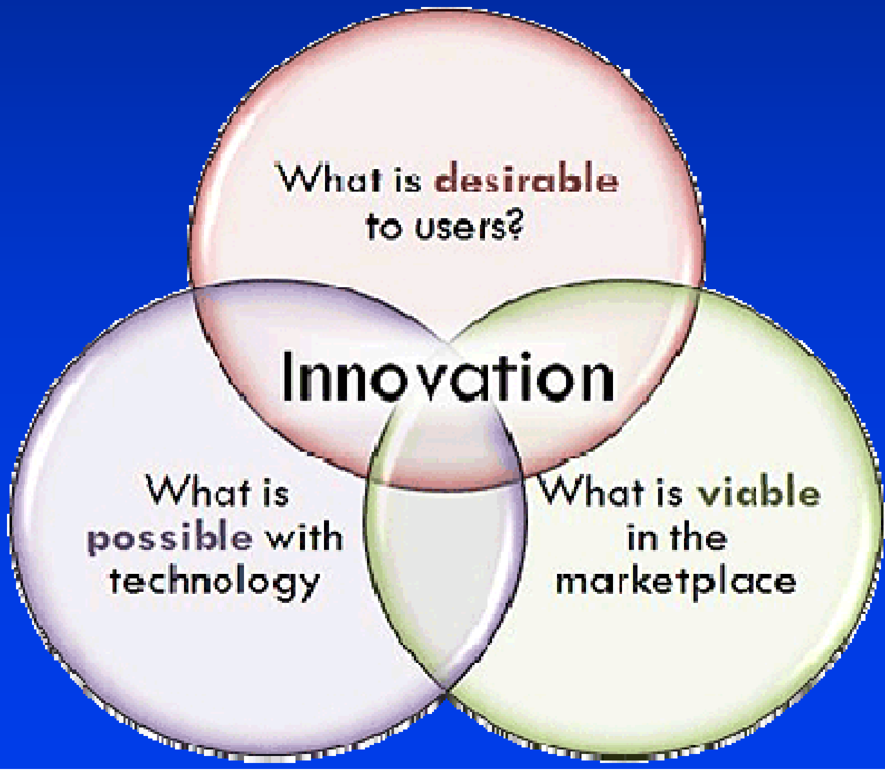
- 1800s: Nicholas Appert demonstrated thermal processing of foods
- 1896: Von Linde invented and developed the mechanical refrigeration
- 1900s: Vacuum packaging was invented to prolong food shelf-life
- 1920s: Birdseye established the basis of the modern frozen food industries
- 1940s: The advent of automated processes to concentrate, freeze, and dehydrate foods enabled a greater variety of foods to be mass-produced and packaged for shipment overseas
- 1950s: Controlled-atmosphere packaging using plastic increased the shelf life of fresh foods.

Technological MILESTONES

- 1960s. The first commercial-scale plant began producing freeze-dried foods and coffee.
- 1970s   Advances in aseptic processing allowed shorter heating times for sealed food containers
- 1980s. Modified-atmosphere packaging used widely.
- 1990s. The U.S. Food and Drug Administration (www.fda.gov) first approved the use of irradiation to control harmful bacteria in fresh and frozen poultry and meats. High-pressure processing was also commercially applied first to fresh packaged foods to kill microorganisms that cause spoilage without altering flavor, texture, or appearance.

Innovation

"Innovation is the process of making changes, large and small, radical and incremental, to products, processes, and services that results in the introduction of something new for the organization that adds value to customers and contributes to the knowledge store of the organization."



INNOVATION CHALLENGES IN **FOOD ENGINEERING**

ADVANCES IN ESTABLISHED FOOD PROCESS ENGINEERING

VS

NOVEL PROCESSES

True innovations bring step changes in food process engineering and are rare events. Innovations in food engineering are mostly renovations or improvements of existing processes, which means taking smaller steps.

Applying sound engineering and science is a key element for a successful innovation

Paradigms:
Thermal *vs* Non-thermal Processes

- Traditional Canning
- Aseptic Processing
- Ohmic Heating
- Microwave Heating

- High Pressure Processing
- Ultraviolet Irradiation
- Pulsed Electric Fields
- Ultrasound
- Cool Plasma
- Irradiation
- Pulsed Light

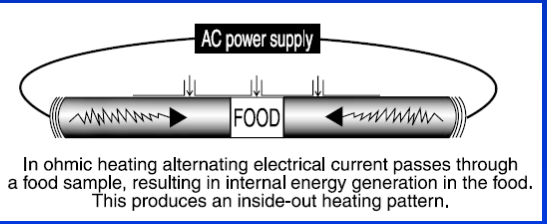
Thermal Processes

Safety *vs* Quality

- Traditional Canning
  Size depended product quality

- Aseptic Processing
  Heat processing before packing

- Ohmic Heating
  Liquid/particulate processing



- Microwave Heating
  Volumetric heating (fast heating)

Ohmic Heating

The following areas of research need to be addressed before implementing ohmic heating as a preservation method:

- Develop a more complete body of knowledge about the combined influence of temperature and electric fields on the destruction kinetics of key pathogenic microorganisms.
- Develop the knowledge base to assess the impact of deviations for specific designs of ohmic heaters. This would include improved models for ohmic processes.
- Develop methods for monitoring temperatures within individual solids.

http://www.fda.gov/Food/FoodScienceResearch/SafePracticesforFoodProcesses/ucm101246.htm

Microwave Heating

Research needs have been identified in the following areas:

- Effects of food formulation on heating patterns.
- Effects of equipment design factors, including frequency (for example, 915 MHz is proposed instead of the commonly used 2450 MHz for better uniformity of heating).
- Development of variable frequency ovens (although currently more expensive for food applications) for improved uniformity of heating.
- Understanding factors affecting heating patterns, including qualitative changes occurring with frequency changes.
- Monitoring and real-time adjusting for process deviations in microwave and radio frequency processing.

http://www.fda.gov/Food/FoodScienceResearch/SafePracticesforFoodProcesses/ucm100250.htm

Thermal Processes

Multi Component Optimization

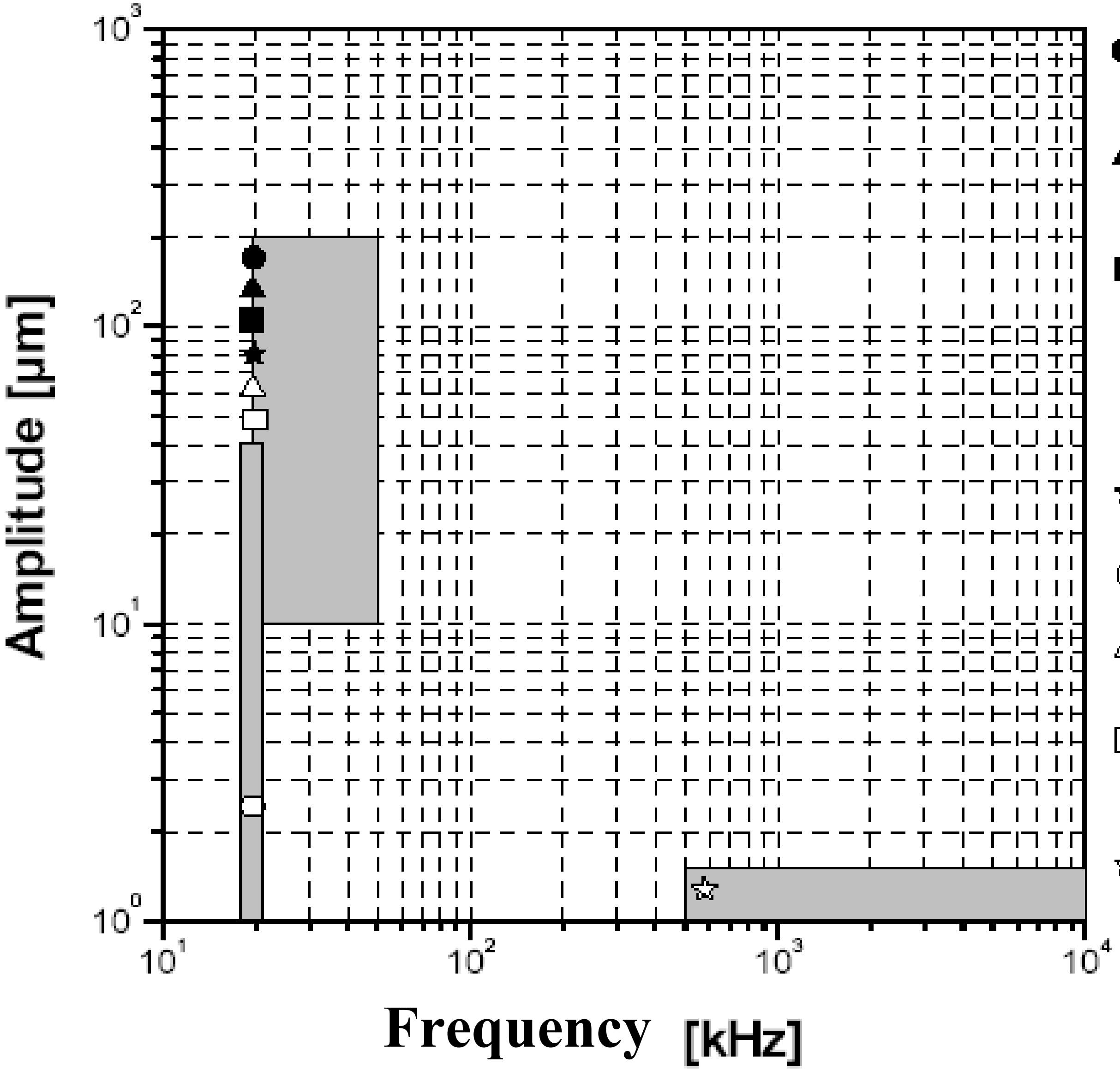
- Nutritional parameters (vitamins, antioxidant agents…)
- Textural characteristics (integrity, cohesiveness, crispiness…)
- Color
- Organoleptic parameters (flavor, aroma…)
- Enzymes (remaining activity detrimental or beneficial)

- Energy requirements
- Water reduction
- Waste reduction
- Cost reduction

NON-THERMAL PROCESS TECHNOLOGIES FOR FOODS

- ULTRASOUND
- DENSE PHASE CARBON DIOXIDE
- IRRADIATION
- UV
- COLD PLASMA
- PULSED ELECTRIC FIELDS
- HIGH HYDROSTATIC PRESSURE

Ultrasound in Food Processing



Inactivation of Microorganisms and Enzymes
Cell Disintegration

Homgenization
Emulsification
Dissolution

Filtration
Extraction
Drying
Degassing
(Re-)Hydration
Crystallization

Tenderization

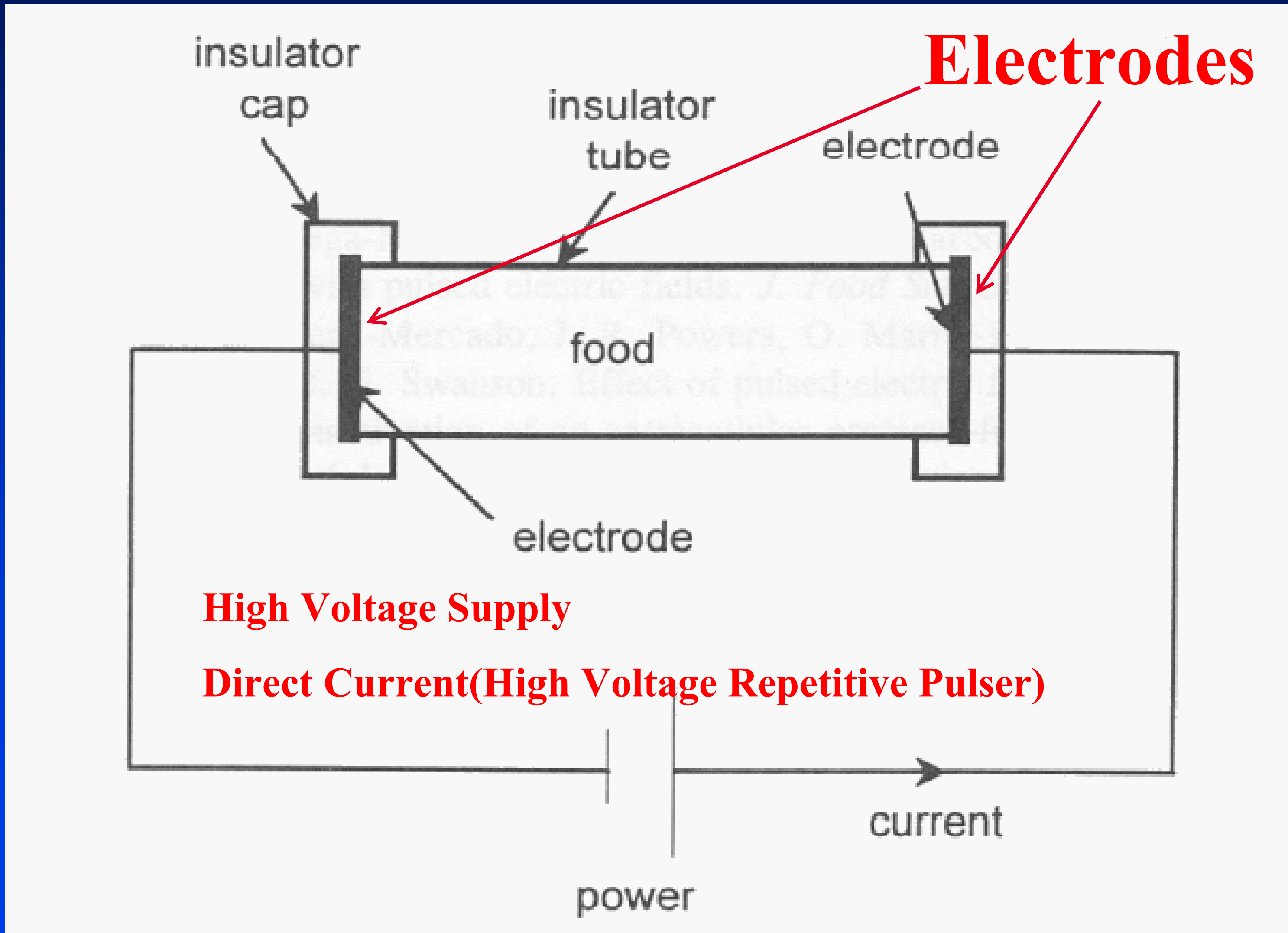
Stimulation of Living Cells

Welding (Packages)
Improvement of Heat Transfer

Cleaning
Sifting
Cutting

Process Control
Non-destructive Testing

Pulsed Electric Fields Processing of Foods



Pulsed Electric Fields Processing of Foods

PEF pasteurizes by two major processes:

1. ***Stretching bacteria to its disruption (electro-polation) by strong electrical fields***

2. Bi-Polar pulsing enhances a break-up of a membrane

PEF is used to enhance a cold extraction of up to 80% for juices, proteins, nutrients, vitamins and natural colors *from :*

-- roots,

-- fruits,

-- vegetables,

-- grass and leafs ,

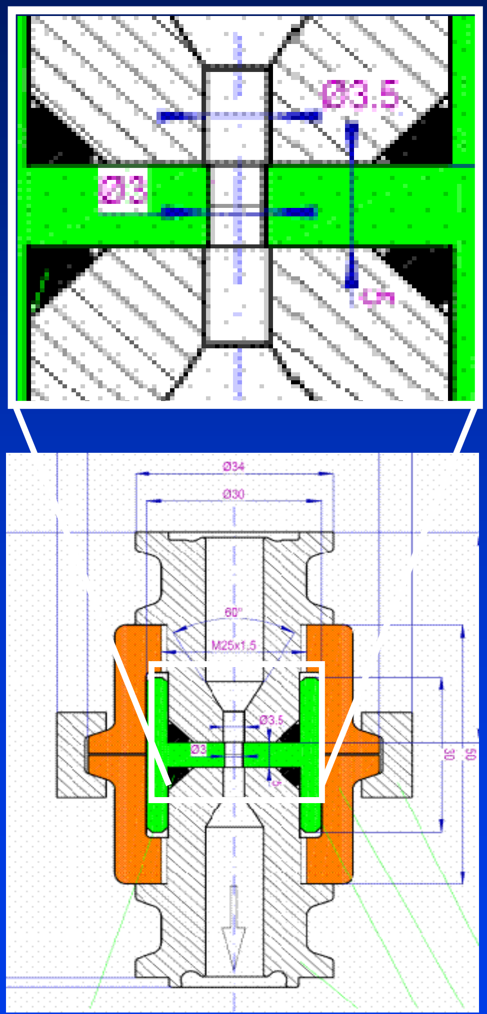
-- protein rich original products.

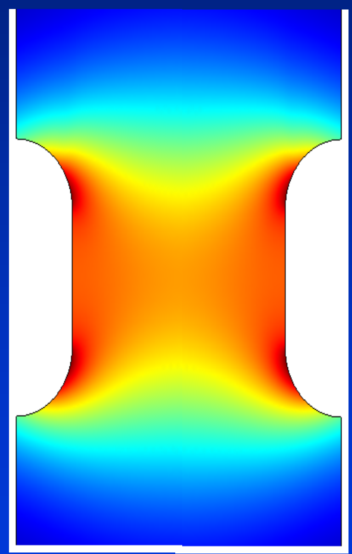
ADVANTAGES:

- works uniformly on an entire treated liquid (or jell, mash) flow,
- *has no wearing parts*,*
- keeps the product temperature almost unchanged**,
- *has no dependence on optical properties,*
- does not degrade nutrient properties of a treated media,
- *does not produce harmful or any by-products,*
- cost-effective because uses the latest advances in pulsed power technology,
- *can be integrated into production lines,*
- No labeling in contrast to “radiation and heat” sterilization.

Pulsed Electric Fields Processing of Foods

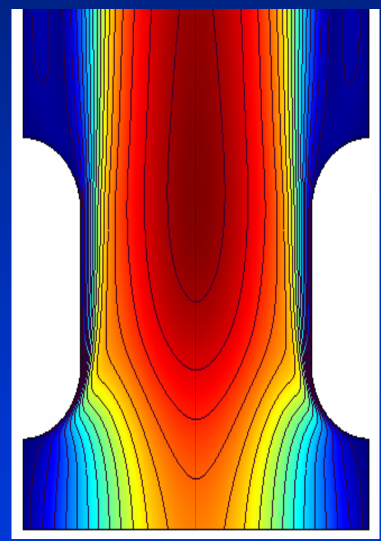
Production based on mathematical models for process optimization





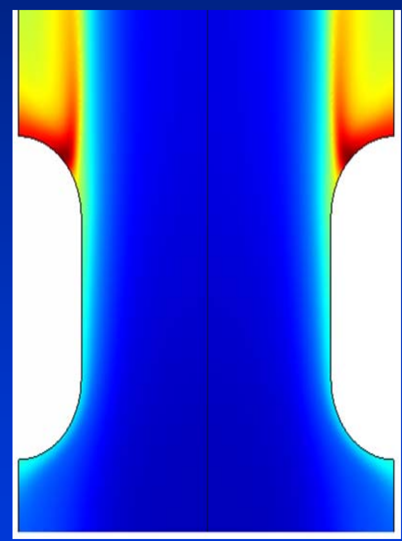
Electric Field

20 – 40 kV/cm



Flow Pattern

2 – 60 cm/s



Temperature Field

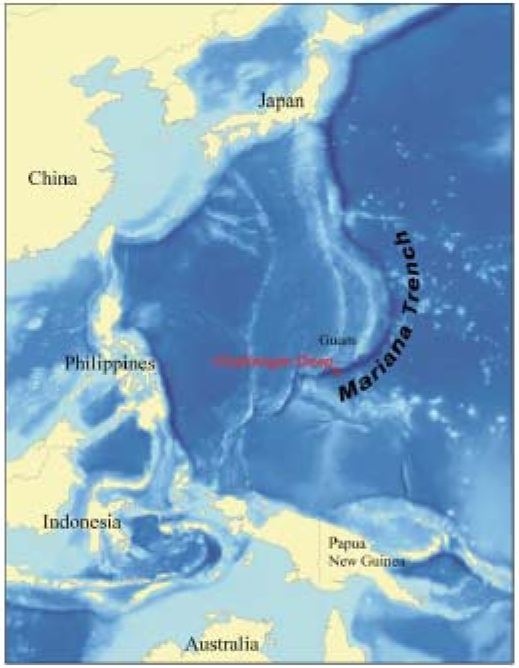
40-84°C

NON-THERMAL PROCESS TECHNOLOGIES FOR FOODS

- ULTRASOUND
- DENSE PHASE CARBON DIOXIDE
- IRRADIATION
- UV
- COLD PLASMA
- PULSED ELECTRIC FIELDS
- HIGH HYDROSTATIC PRESSURE

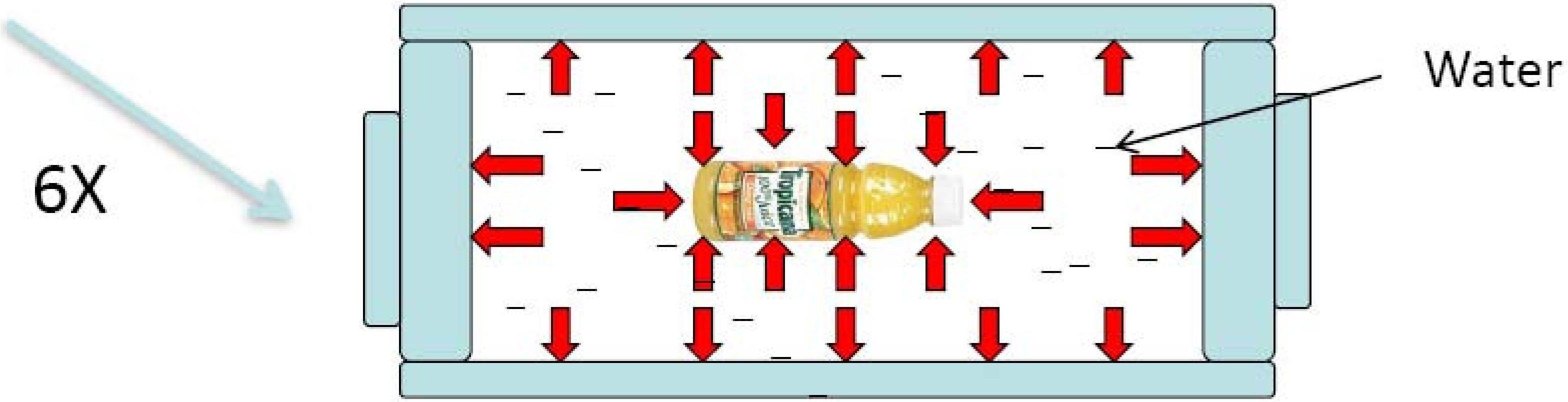
High Hydrostatic Pressure processing

High pressure processing offers an extra processing variable influencing (bio) chemical, physical and microbiological changes of biological materials and allows unique approaches in precision processing for the creation of targeted new and improved functional properties of foods and food ingredients

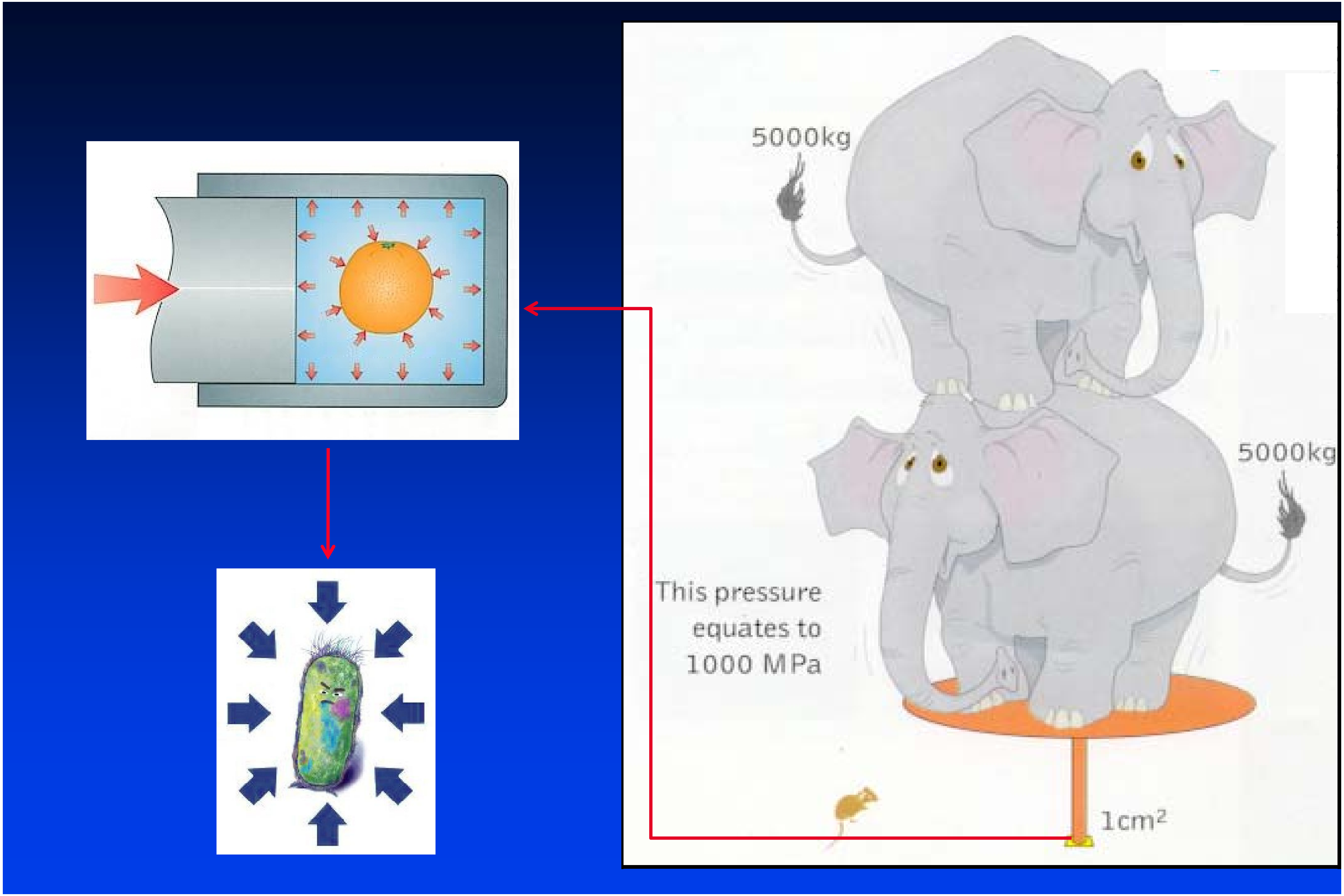


Mariana Trench

- deepest part of the world's oceans
- 11.03 km deep
-Water column pressure at the bottom
– 108.6 Mpa (15,750 psi)
- **1000 times atmospheric pressure**



HPP – 6000 times atmospheric pressure


5000kg
5000kg
This pressure
equates to
1000 MPa
1cm²

Advantages of HHP

1. Inactivation of microorganisms and enzymes wile minimally affecting nutrients, biofunctional components and organoleptic attributes (texture, flavor, aroma).

2. Low energy

3. Does not favor side formation of chemical components e.g. free radicals

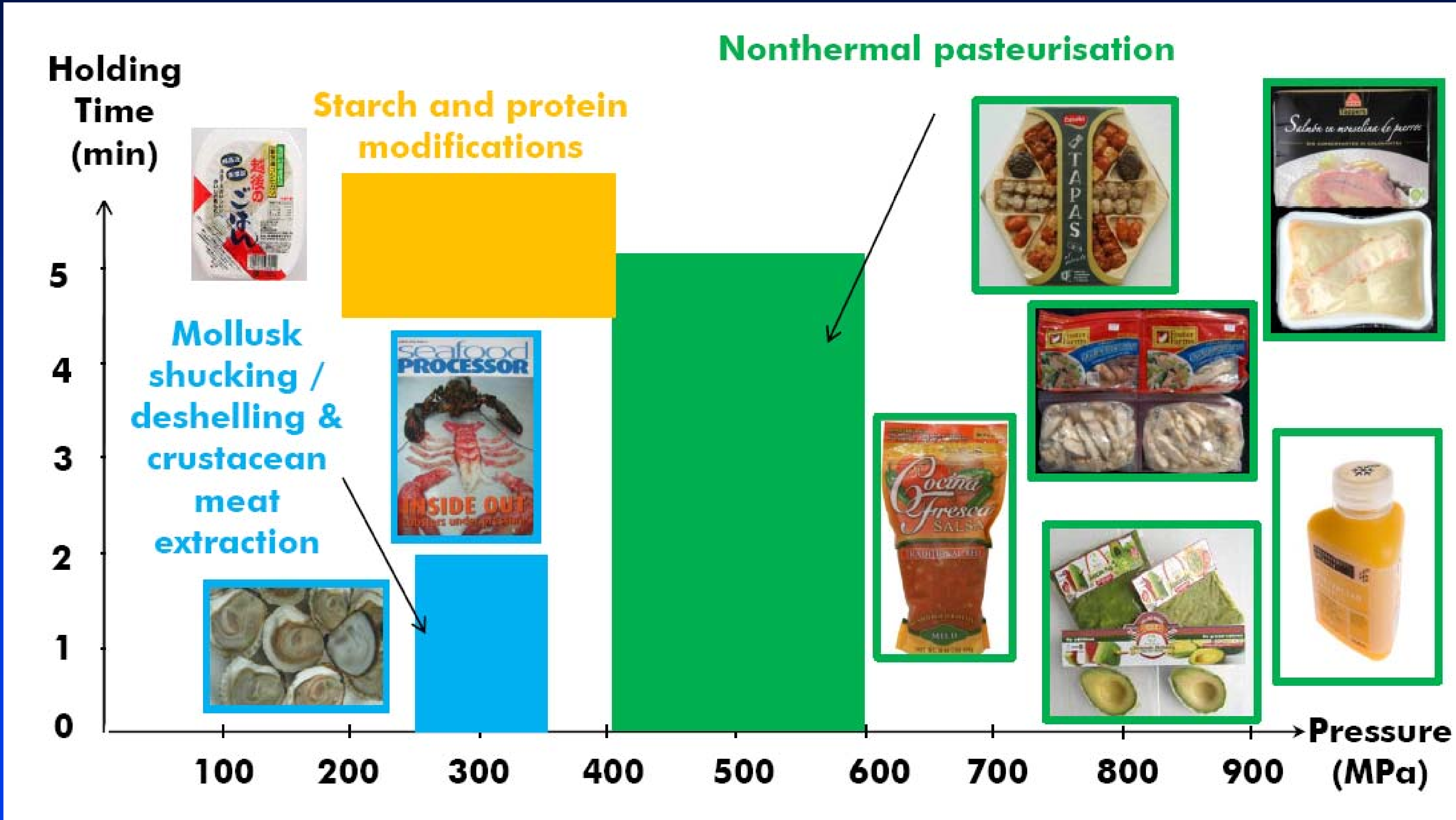
4. Instantaneous and homogeneous transfer of pressure, not affected by volume and geometry, shape of processed food

Hydrostatic Pressure

Air filled foods are compressed by hydrostatic pressure.

Water dense foods are not deformed by hydrostatic pressure.

Process Conditions for the Application of HHP for…



High Pressure Processing (HPP) is an innovative although industrially mature technology that is consolidating its position as the most natural alternative for processing of a wide range of food products.

Meat products – Shelf life extension

Avocado Products – Shelf-life extension

Ready To Eat Meals – Shelf-life extension

Seafood products – Shelf life extension & Yield increase

Juices – Shelf-life extension

Fruit products – Shelf-life extension

Dips and salsas – Shelf-life extension

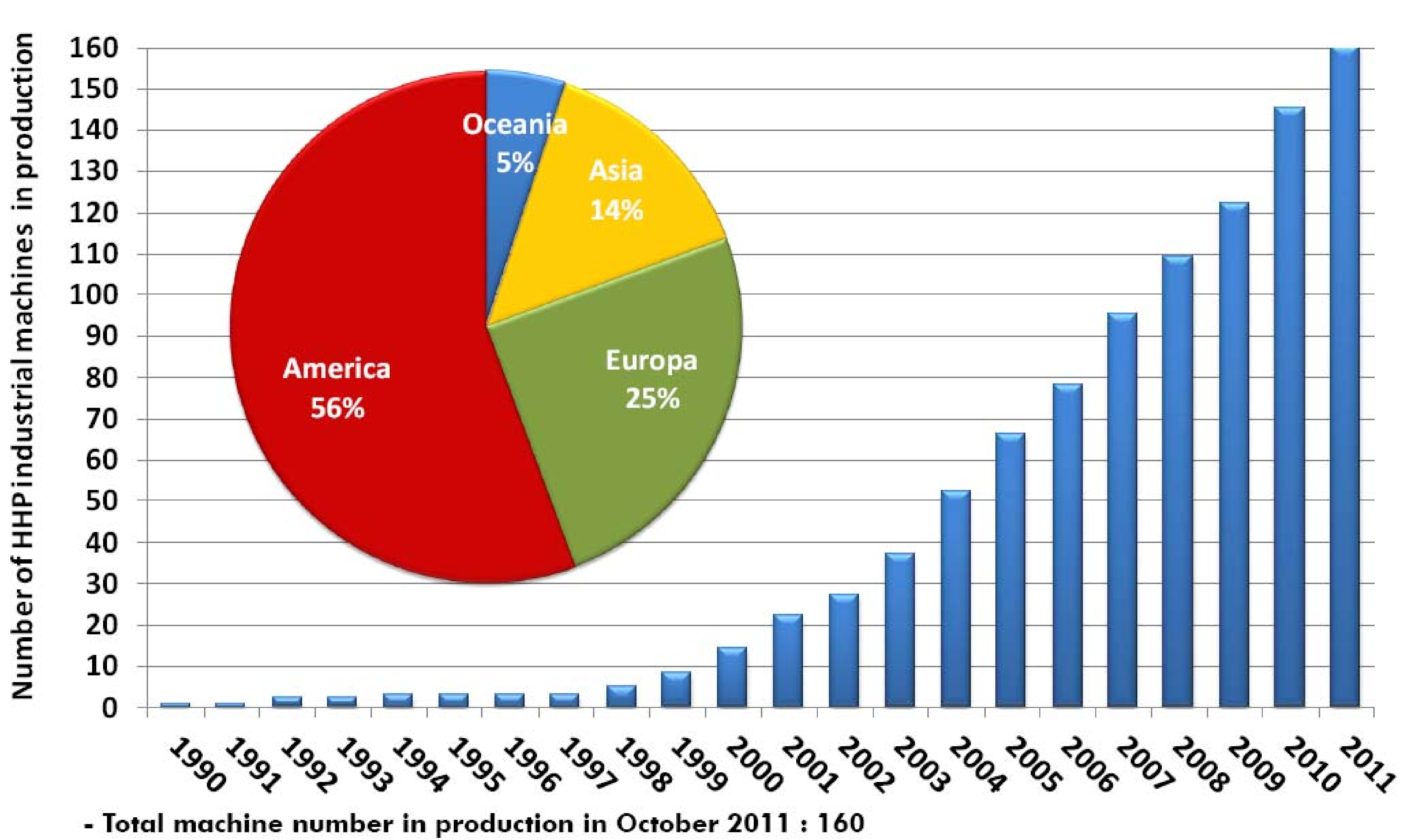
Wet salads and sandwich fillings – Shelf-life extension

Dairy – Shelf-life extension & Novel products

The meat industry has historically been one of the main drivers for HP technology.

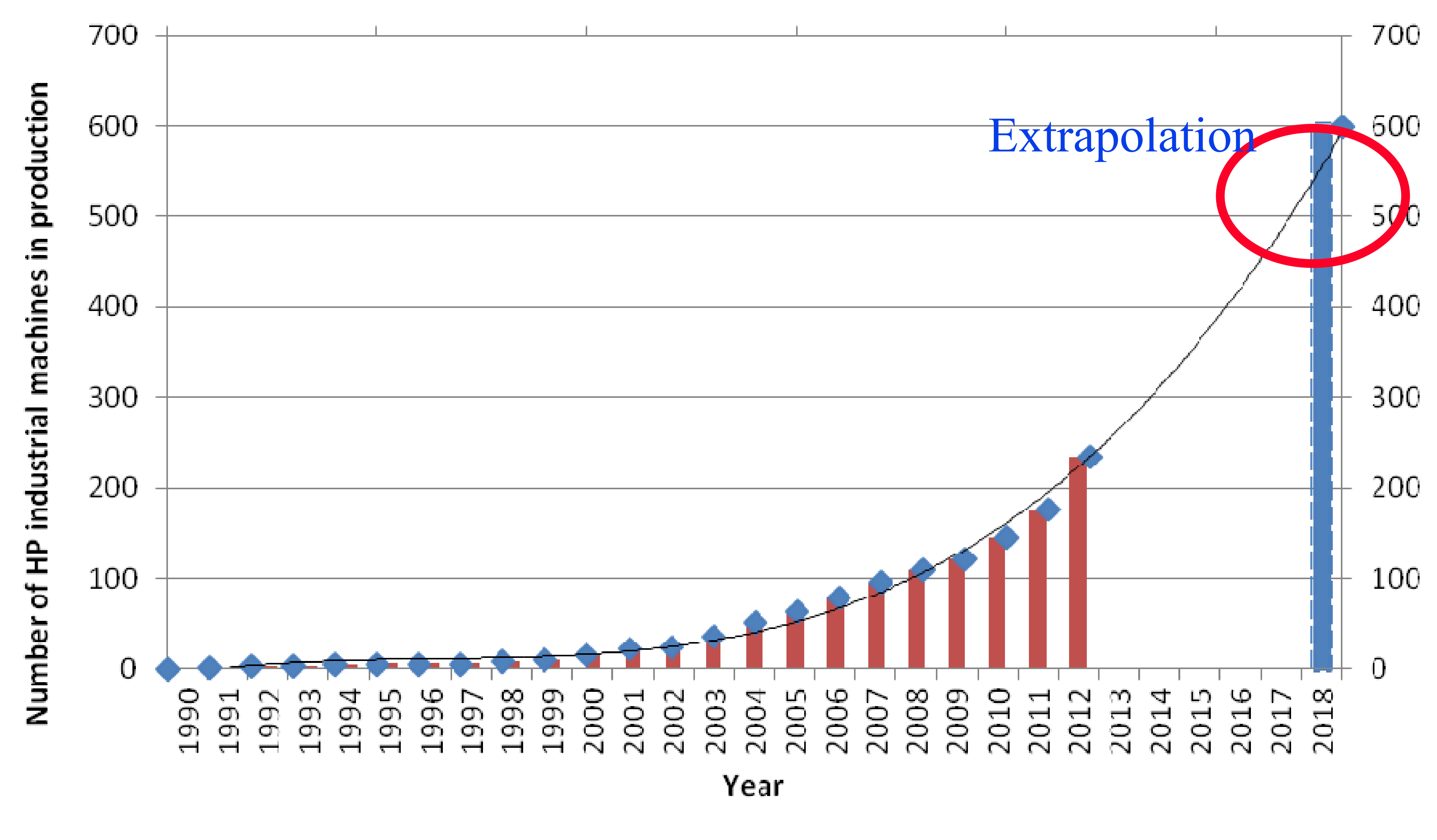
Application and Industrialization of Food Engineering Innovation

HHP Units installed worldwide



Application and Industrialization of Food Engineering Innovation

HHP Units installed worldwide



Cost analysis: a parameter for food product design for a Food engineer

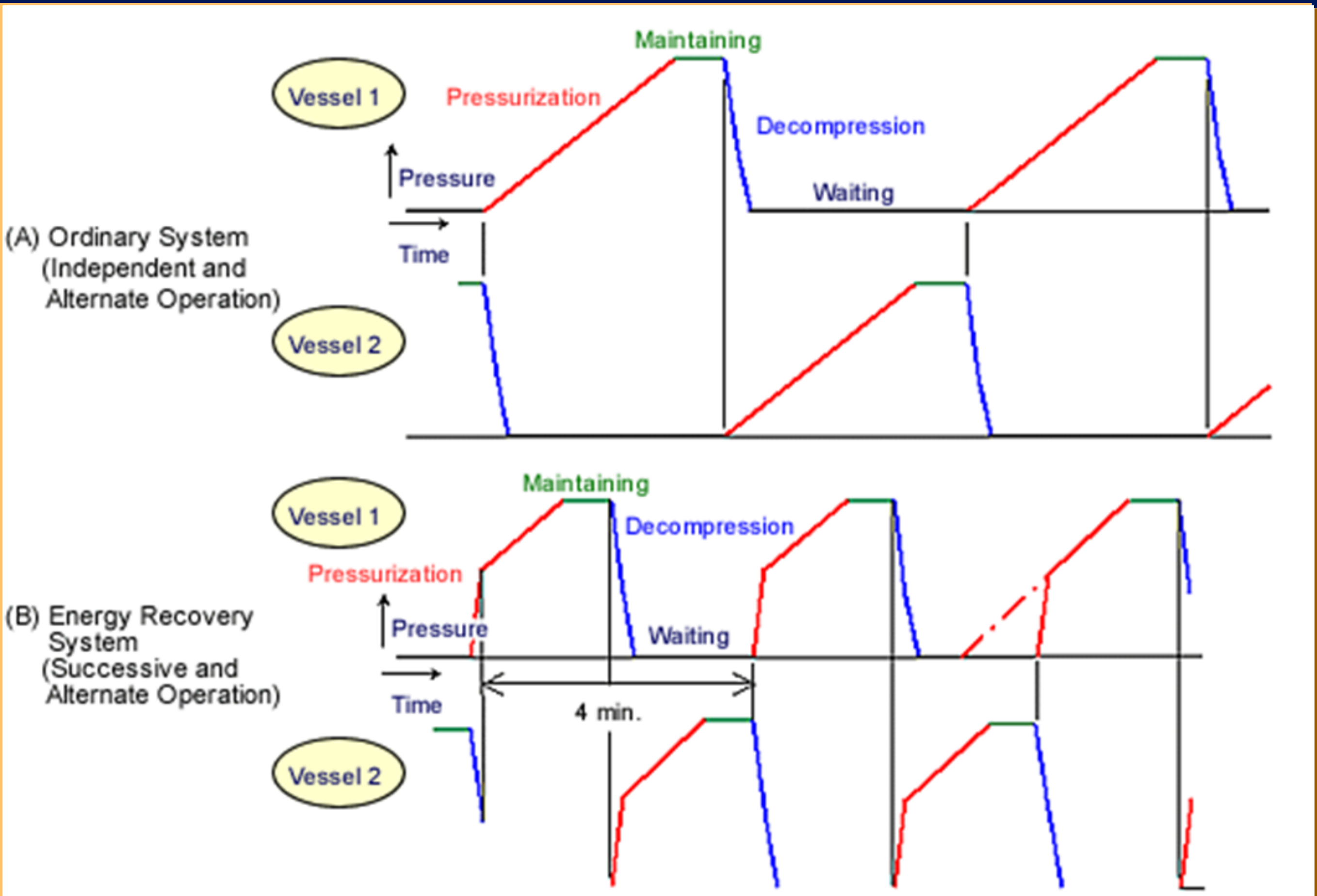
Table : Processing cost for cold pasteurization and pressure assisted thermal sterilization versus type of use and equipment size

		Cold pasteurization			Pressure assisted thermal sterilization		
Processing temperature	ºC / (ºF)	5 (41)			90 (194)		
Type of use		Moderate		Intensive	Moderate		Intensive
Vessel volume	liters	55	300	300	55	300	300
Hourly production	lbs	582	3175		582	3175	
	Kg	264	1440		264	1440	
Yearly production	Mlbs	1.2	6.4	19.1	1.2	6.4	19.1
	tons	528	2880	8640	528	2880	8640
Labour & Energy							
Operator(s)	/ shift	1	3	3	1,5	4	4
Maintenance people number	/ shift	0.1	0.3	0.3	0.15	0.4	0.4
Energy consumption	kWh/hour	17	90	90	37	190	190
Processing cost							
Depreciation charge	US$ / lbs	0.125	0.063	0.021	0.209	0.105	0.035
Wear parts	US$ / lbs	0.028	0.017	0.027	0.037	0.020	0.034
Labour	US$ / lbs	0.039	0.022	0.022	0.059	0.029	0.029
Energy	US$ / lbs	0.002	0.002	0.002	0.003	0.003	0.003
Total	**US$ / lbs**	**0,194**	**0,103**	**0,071**	**0,308**	**0,157**	**0,101**

Legend:
- Moderate use: 2000 hours / year (one shift of 10 hours during 200 days / year)
- Intensive use: 6000 hours / year (2 shift of 20 hours during 300 days / year)

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

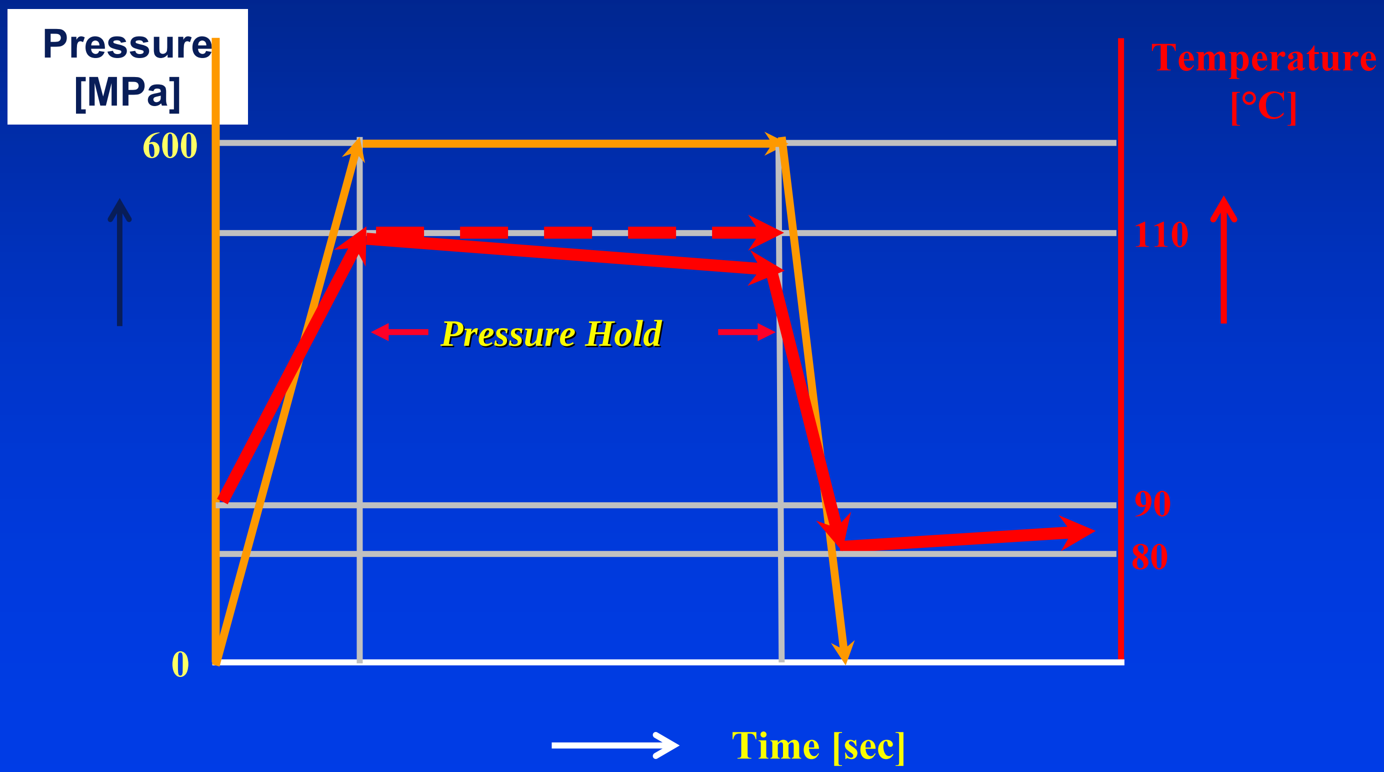
High Hydrostatic Pressure processing_Energy savings



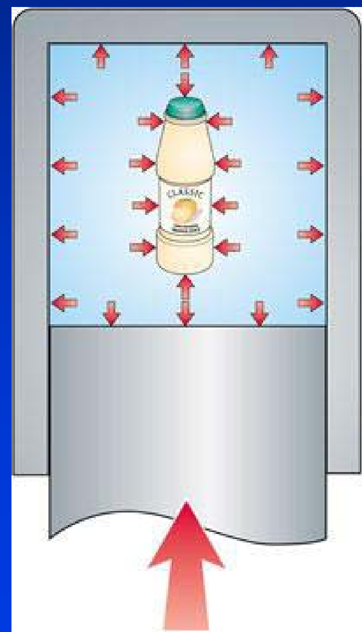
High Hydrostatic Pressure processing

Parameters to be considered for the product design by a food engineer:

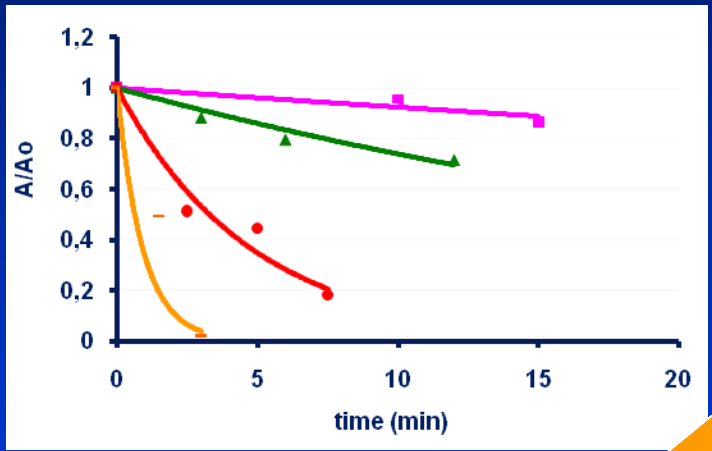
Pressure-Temperature-Time



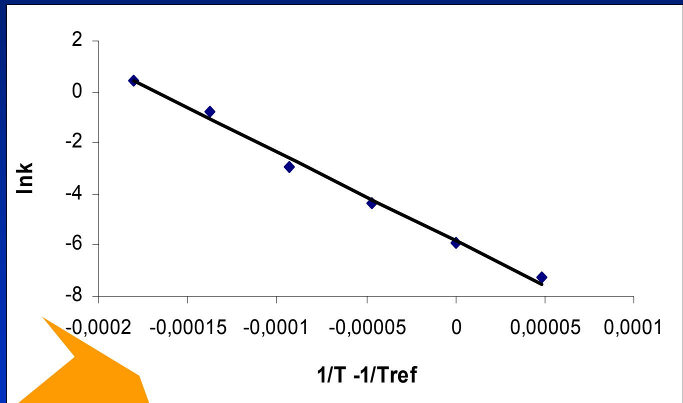
Principle of Iso-Staticity



Mathematical description

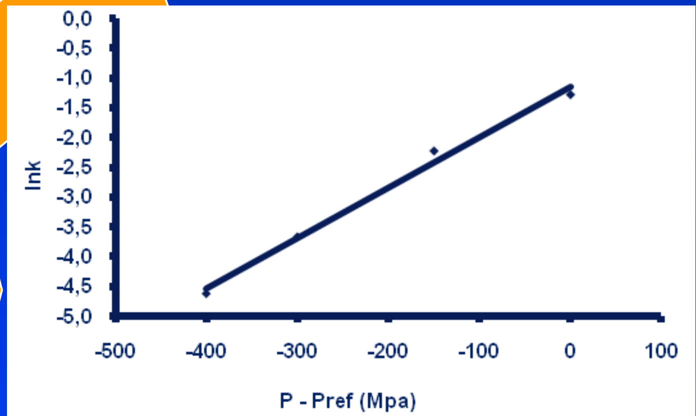


$$A/A_o = \exp(-k \cdot t)$$



Arrhenius equation

$$k = k_{T_{ref}} \cdot \exp\left[-\frac{E_a}{R}\left(\frac{1}{T} - \frac{1}{T_{ref}}\right)\right]$$



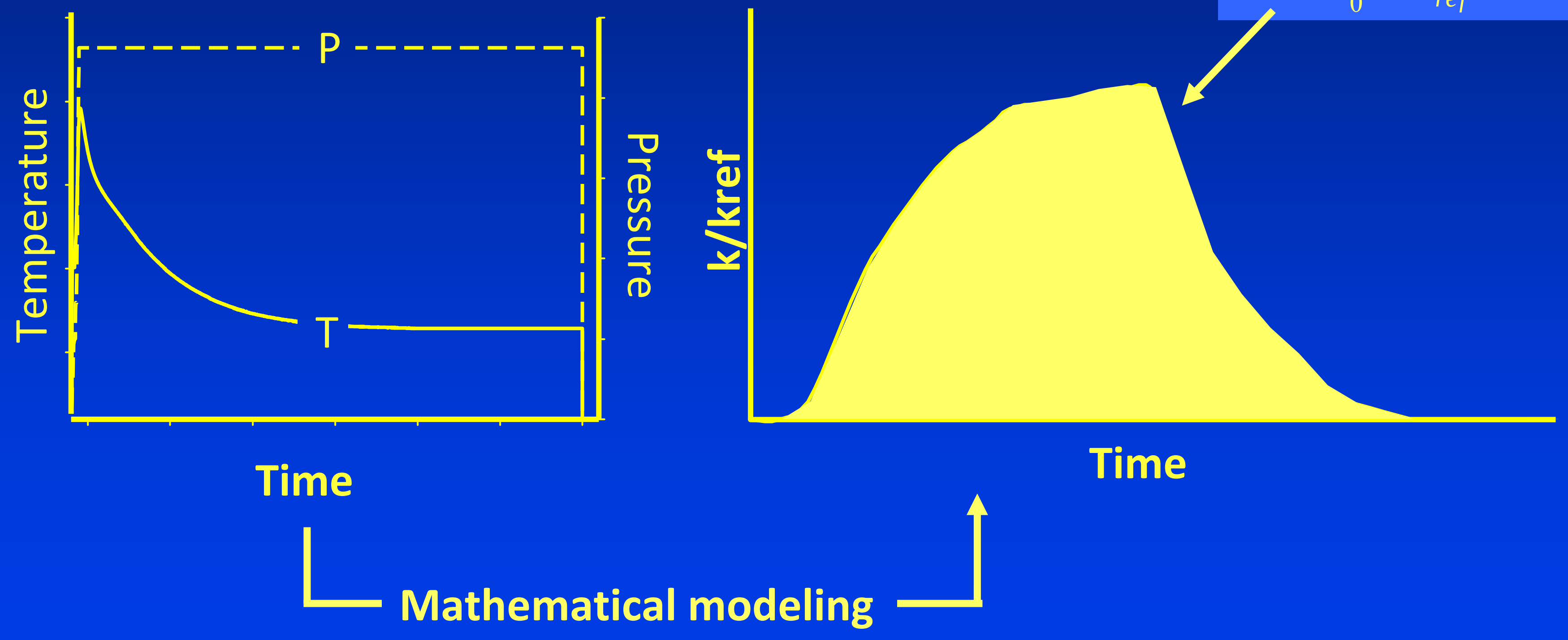
Eyring equation

$$k = k_{P_{ref}} \cdot \exp\left[-\frac{V_a(T)}{R} \cdot \frac{(P - P_{ref})}{T}\right]$$

Evaluation and control of HP processes

Estimation of the F-value at HP processes

$$F_{ref} = \int_0^t \frac{k(T,P)}{k_{ref}} \cdot dt$$

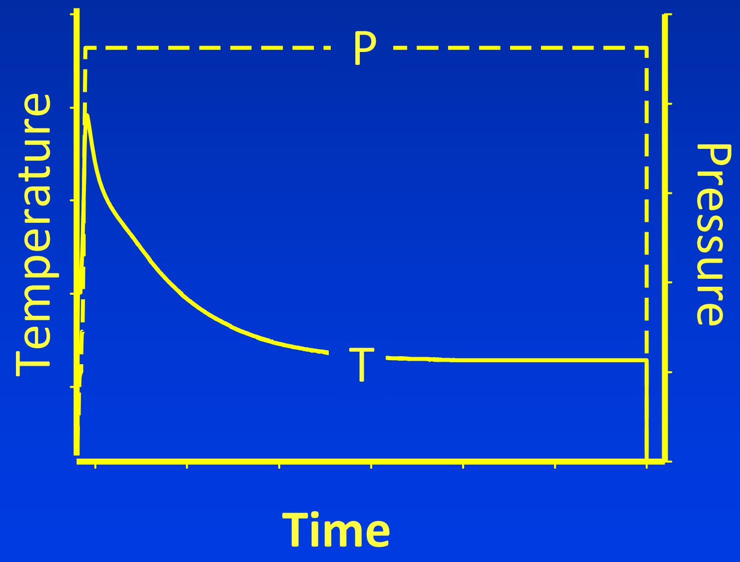


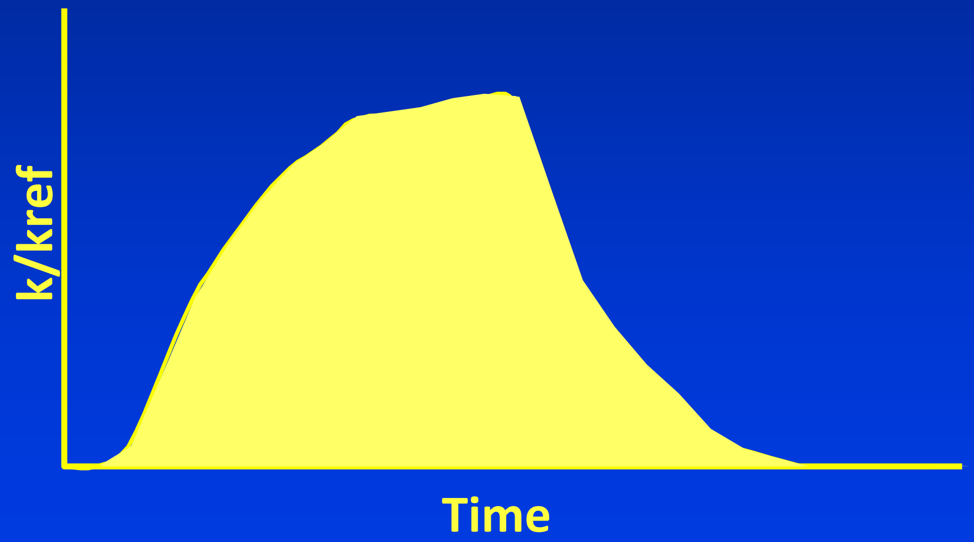
Evaluation and control of HP processes

Estimation of the F-value of HP processes

$$k(T,P) = k_{ref_{P,T}} \cdot \exp\left(-\frac{E_{a,P_{ref}} + B\cdot\left(P_{process} - P_{ref}\right)}{R} \cdot \left(\frac{1}{T_{eff}} - \frac{1}{T_{ref}}\right) - \frac{V_{a,T_{ref}} + A\cdot\left(T_{eff} - T_{ref}\right)}{RT_{eff}} \cdot \left(P_{process} - P_{ref}\right)\right)$$

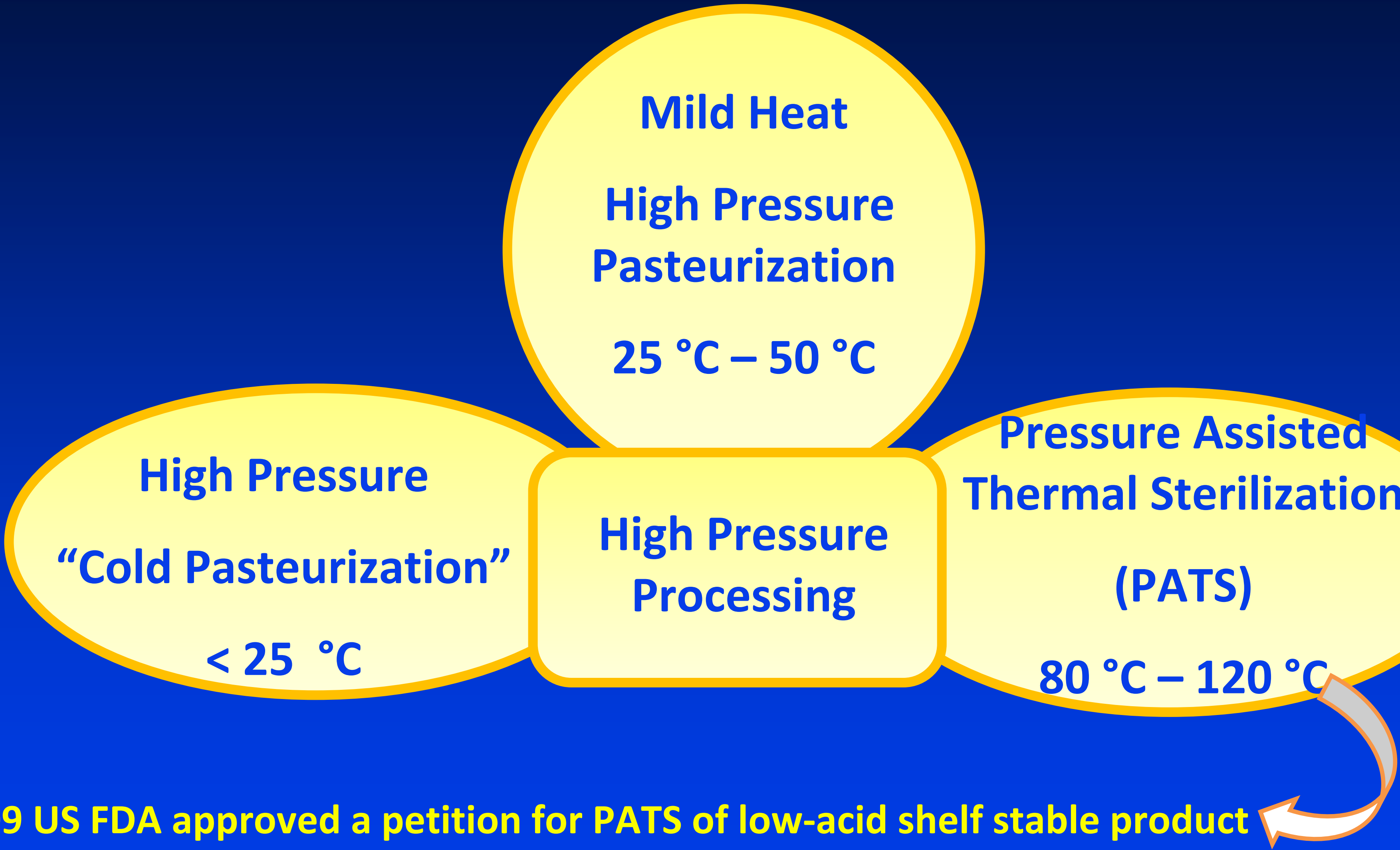
$$\frac{A}{A_0} = \exp\left\{ -\left(k_{ref_{P,T}} \cdot \exp\left(-\frac{E_{a,P_{ref}} + B\cdot\left(P_{process} - P_{ref}\right)}{R} \cdot \left(\frac{1}{T_{eff}} - \frac{1}{T_{ref}}\right) - \frac{V_{a,T_{ref}} + A\cdot\left(T_{eff} - T_{ref}\right)}{RT_{eff}} \cdot \left(P_{process} - P_{ref}\right)\right)\right) \cdot t_{process} \right\}$$





Mathematical modeling

Combined Pressure Temperature Process

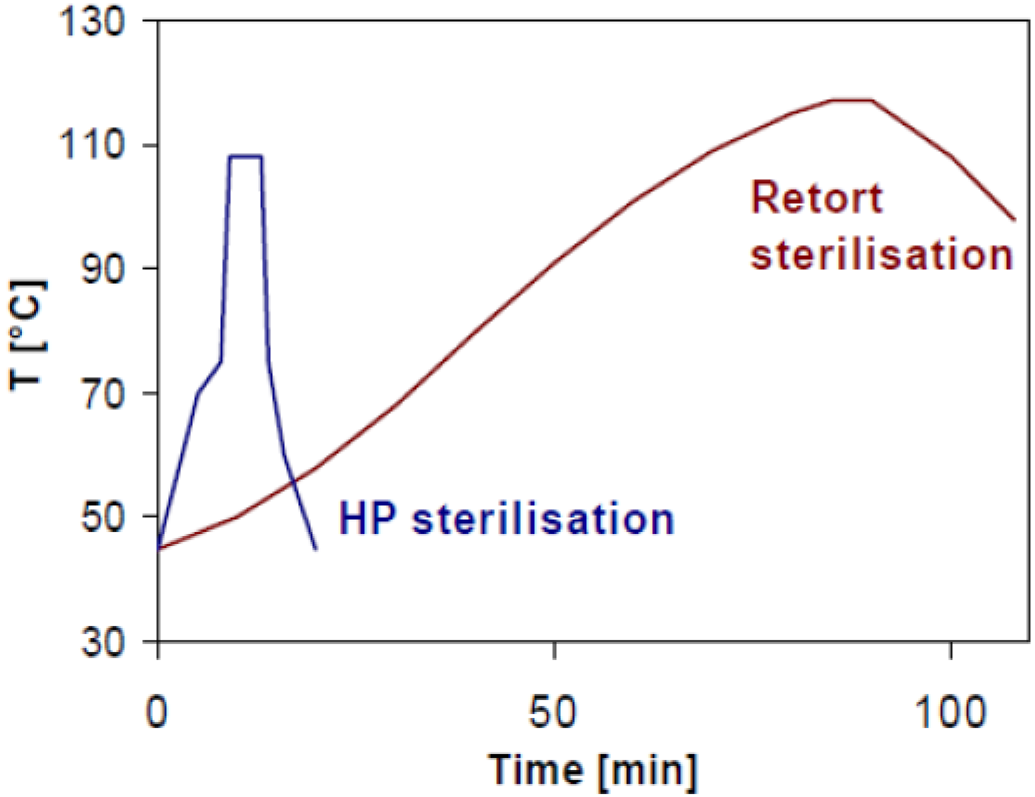


High Pressure Sterilisation (HPS)

THE UNIVERSITY OF QUEENSLAND AUSTRALIA

Principle of PATS/HPS

- Start HPP processing at an elevated temperature – 70-90° C
- Use heat generated by applying pressure for uniform rapid increase of temperature, and vice versa cooling at pressure decrease
- Spores inactivated by combination of P and T
- Maximum temperature is 5 - 10 ° C lower than normal sterilisation temperature
- Lower heat input compared to retort => higher quality



HP

✓ **Food in pack cold pasteurization -Shelf-life increase**

✓ **Decrease cheese maturation time**

✓ **Develop new dairy products with reduced fat and total solids**

✓ **Reduce orange juice bitterness**

✓ **Cold extraction_ Olive oil yield increase from olives**

High Pressure Processing Research in NTUA

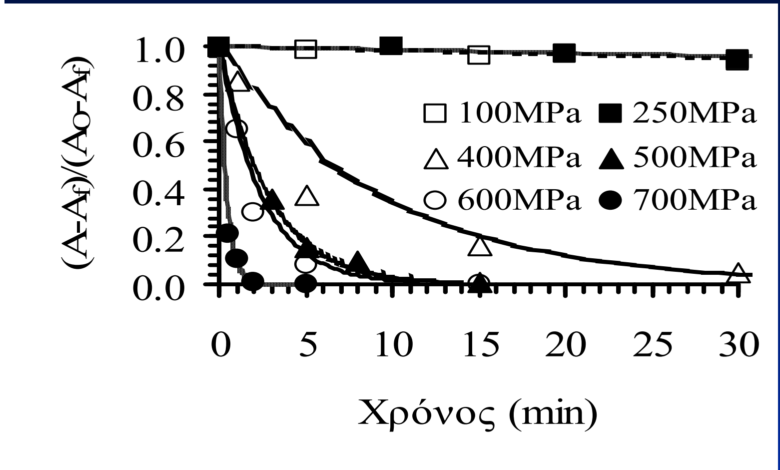
-Enzymes inactivation

-Microorganisms inactivation

-Selection of HP optimal process conditions

Food Pressure Unit FPU 1.01, Resato International BV,Roden,Holland

Inactivation of fruits PMe



Orange Navel: 30°C

ELSEVIER
Journal of Food Engineering 62 (2004) 291–298
JOURNAL OF FOOD ENGINEERING
www.elsevier.com/locate/jfoodeng

Inactivation kinetics of pectin methylesterase of greek Navel orange juice as a function of high hydrostatic pressure and temperature process conditions

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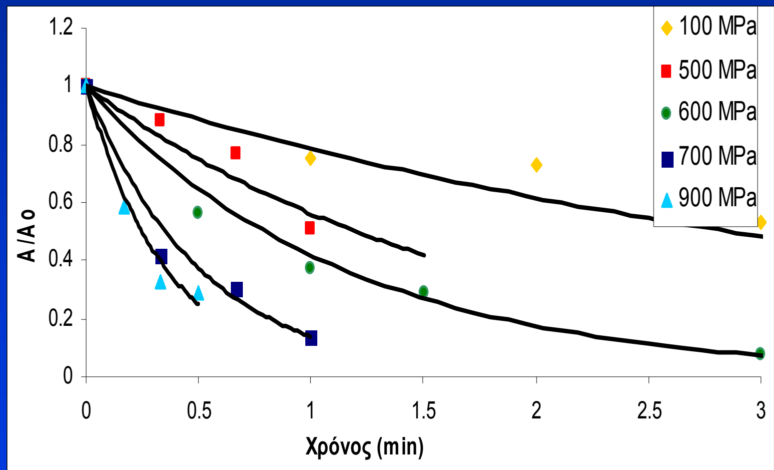
Received 7 January 2003; accepted 22 June 2003

Peach Everts: 70°C

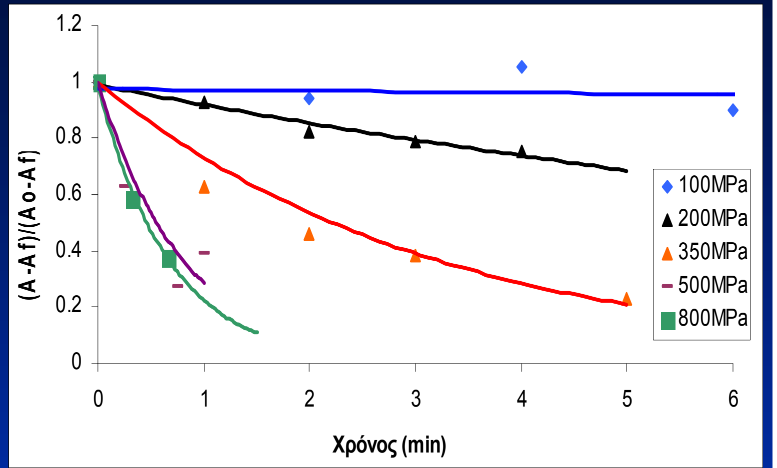


Food Bioprocess Technol (2010) 3:699–706
DOI 10.1007/s11947-008-0132-4

ORIGINAL PAPER

Inactivation Kinetics of Peach Pulp Pectin Methylesterase as a Function of High Hydrostatic Pressure and Temperature Process Conditions

Sofia S. Boulekou · George J. Katsaros · Petros S. Taoukis



Orange Valencia: 30°C

International Journal of Food Science & Technology
International Journal of Food Science and Technology 2010, 45, 1119–1129

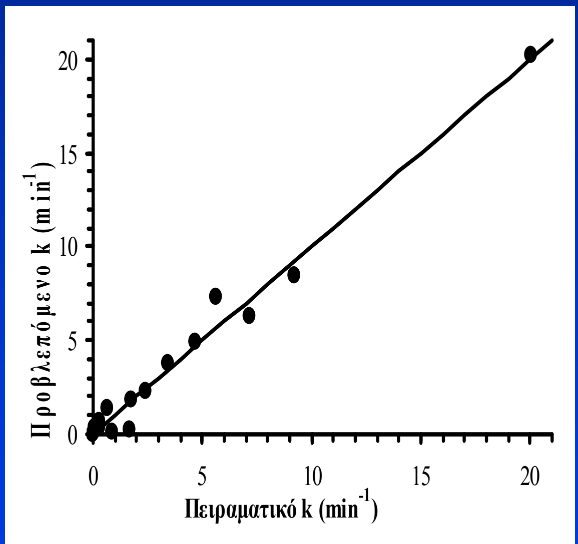
Original article

Kinetic study of high pressure microbial and enzyme inactivation and selection of pasteurisation conditions for Valencia Orange Juice

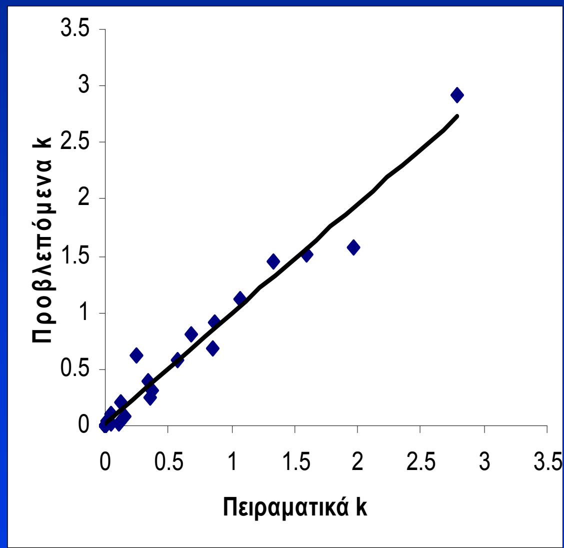
George I. Katsaros, Maria Tsevdou, Theodora Panagiotou & Petros S. Taoukis*

Effect of pressure and temperature on the inactivation rate constant

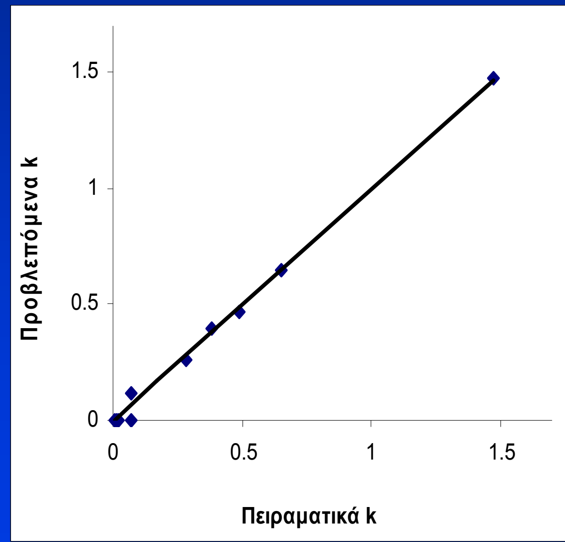
$$k = k_{ref_{P,T}} \cdot \exp\left\{ -\frac{E_{a_P}}{R} \cdot \exp\left[-B \cdot (P - P_{ref})\right] \cdot \left(\frac{1}{T} - \frac{1}{T_{ref}}\right) - \frac{A \cdot (T - T_{ref}) + V_{a_T}}{R} \cdot \frac{(P - P_{ref})}{T} \right\}$$



Orange Navel



Peach Everts



Orange Valencia

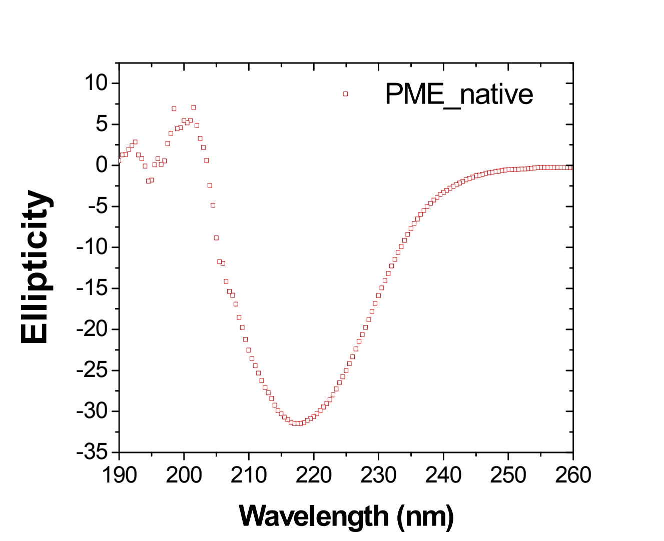
Effect of pressure and temperature on the inactivation rate constant

Same enzyme from different source and variety behaves different when HP processed:

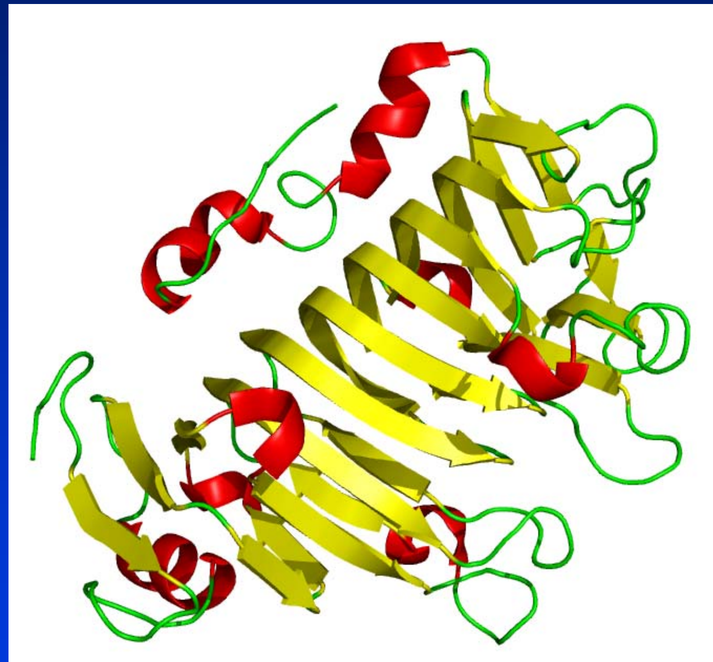
different inactivation kinetics

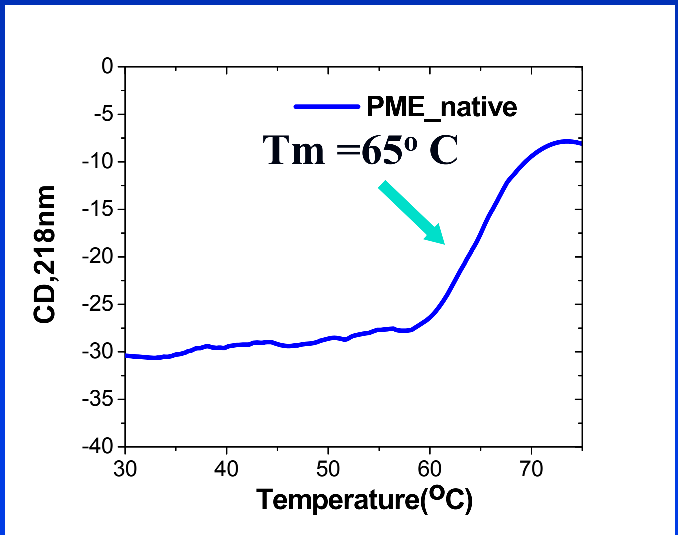
Necessary Knowledge for a Food Engineer to optimally design the process

Circular Dichroism Experiments

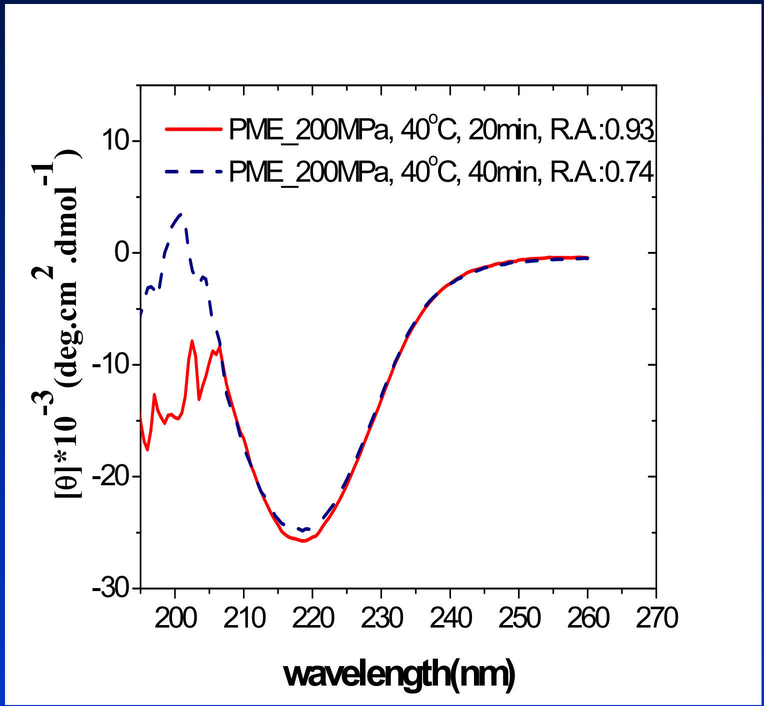


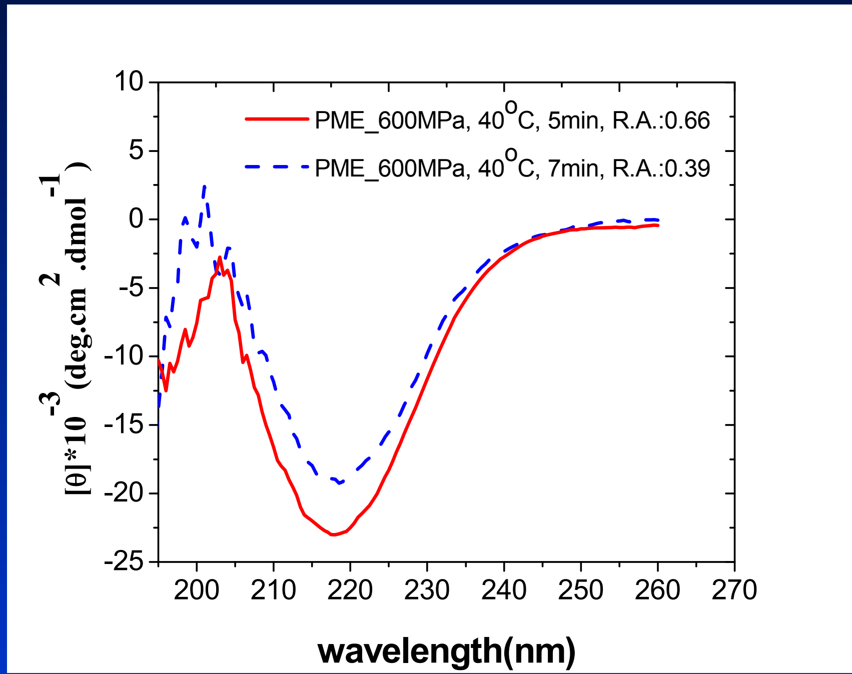
	205-260 nm
Helix	25.2 %
Antiparallel	10.0 %
Parallel	11.9 %
Beta-Turn	18.1 %
Rndm. Coil	40.1 %
Total Sum	105.3 %





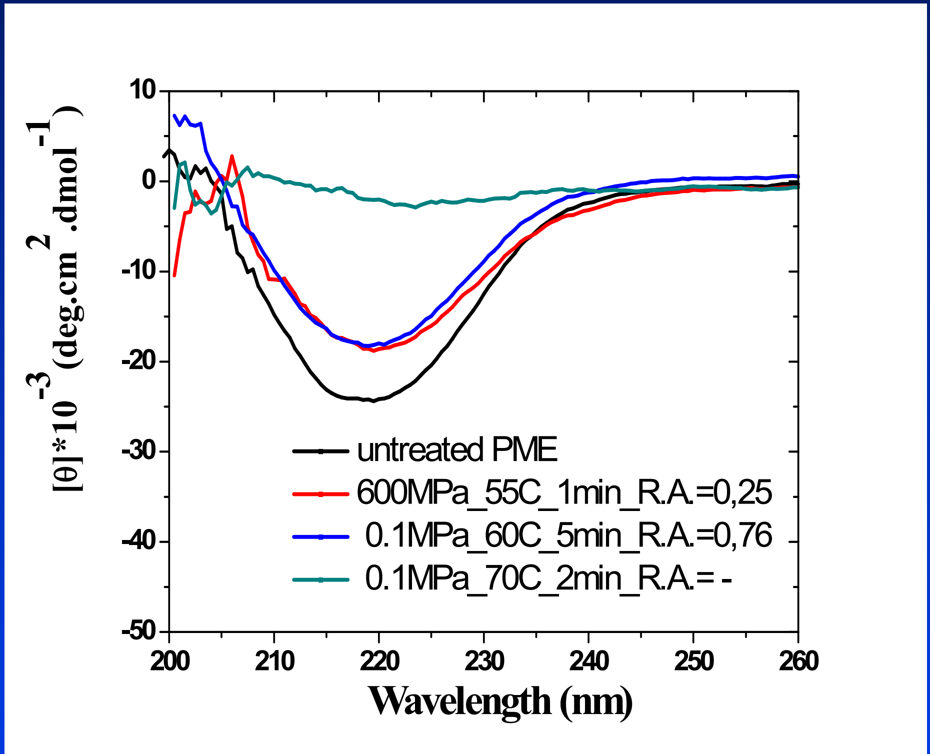
Circular Dichroism Experiments





treatment duration increase (P,T=ct) ⇒ slight change of PME secondary structure

EFFECT OF PRESSURE AND TEMPERATURE ON VALENCIA ORANGE PME SECONDARY STRUCTURE

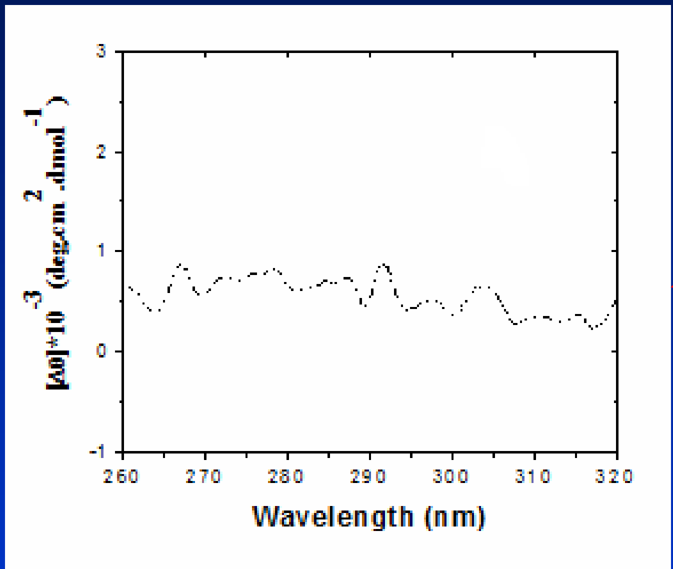


The structural changes of pressure-treated PME differ when compared to the corresponding changes of thermal (significantly lower ellipticity values) treated enzyme

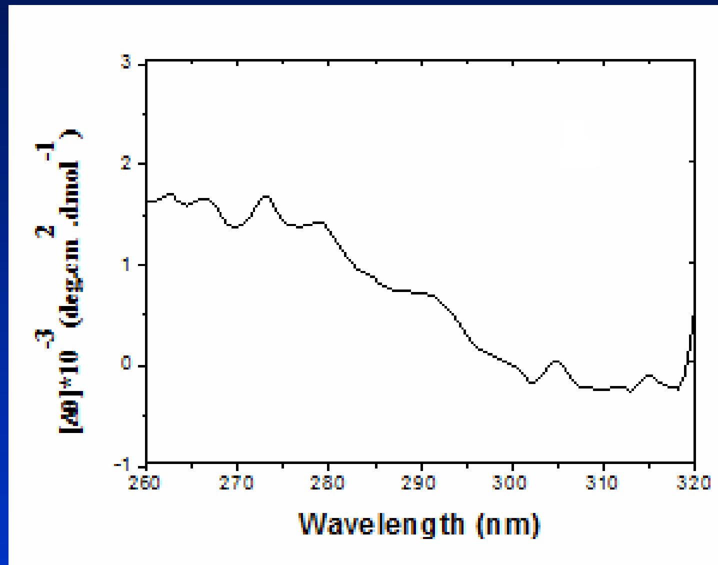
Pressure denaturation corresponds to the incorporation of water into the protein, whereas heat denaturation corresponds to the transfer of non-polar groups into water

EFFECT OF PRESSURE ON VALENCIA ORANGE PME TERTIARY STRUCTURE

200MPa - 30°C - $A_{t=10\ min}/A_{o} = 0.97$

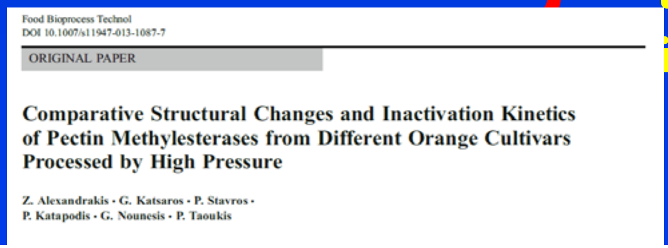


600MPa - 30°C - $A_{t=10\ min}/A_{o} = 0.80$



- The conformational change of the tertiary structure was accompanied by a corresponding loss of enzyme activity
- Effect of HP on tertiary structure is higher than on secondary structure

The weakest non covalent interactions between amino acid residues (tertiary structure) are first destabilized after HP processing and then replaced by protein-water interactions.



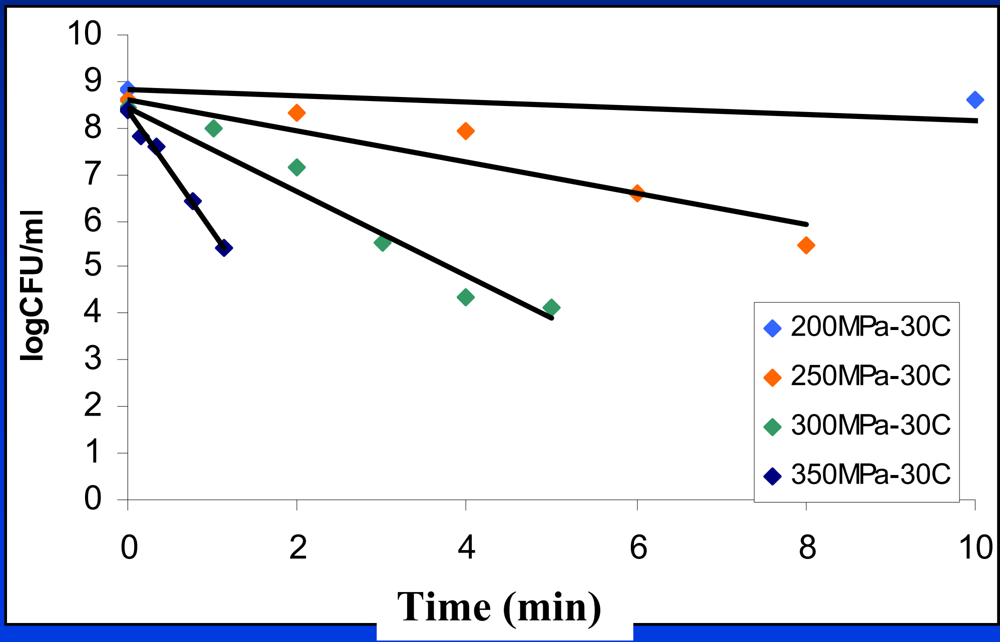
Food Bioprocess Technol
DOI 10.1007/s11947-013-1087-7

ORIGINAL PAPER

Comparative Structural Changes and Inactivation Kinetics of Pectin Methylesterases from Different Orange Cultivars Processed by High Pressure

Z. Alexandrakis · G. Katsaros · P. Stavros · P. Katapodis · G. Nounesis · P. Taoukis

Effect of HP on orange juice lactic acid bacteria

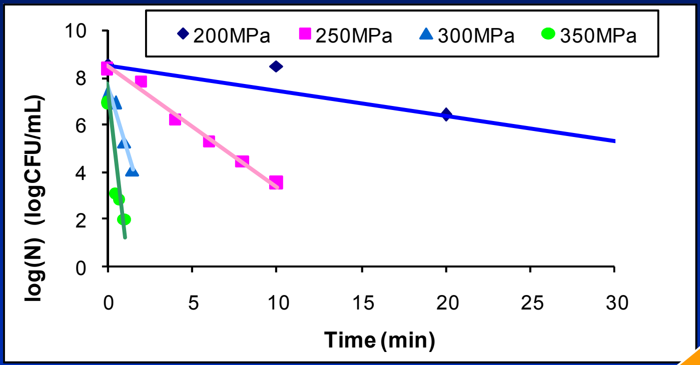


Lactobacillus plantarum

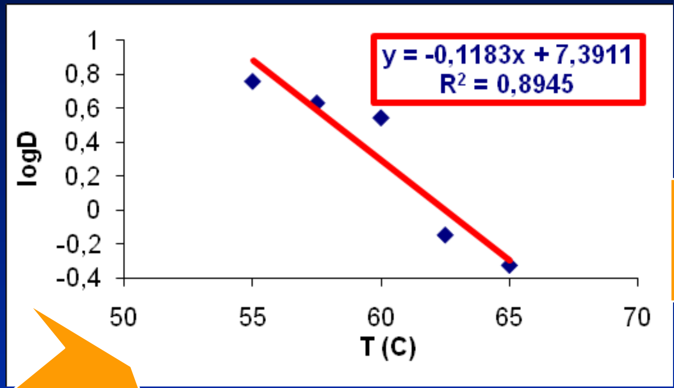
D (min)

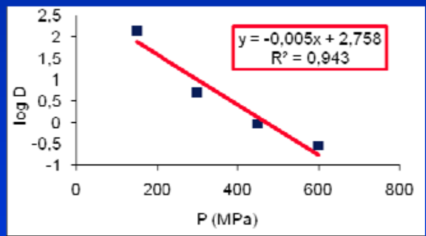
Process Conditions	25°C	30°C	35°C	40°C
200MPa	17,82	12,9 0	14,73	10,3 1
250MPa	8,65	3,00	2,30	2,51
300MPa	1,97	1,11	0,71	0,32
350MPa	0,25	0,32	0,29	0,17

Mathematical description of the inactivation



$$\log(N/N_0) = -D \cdot t$$





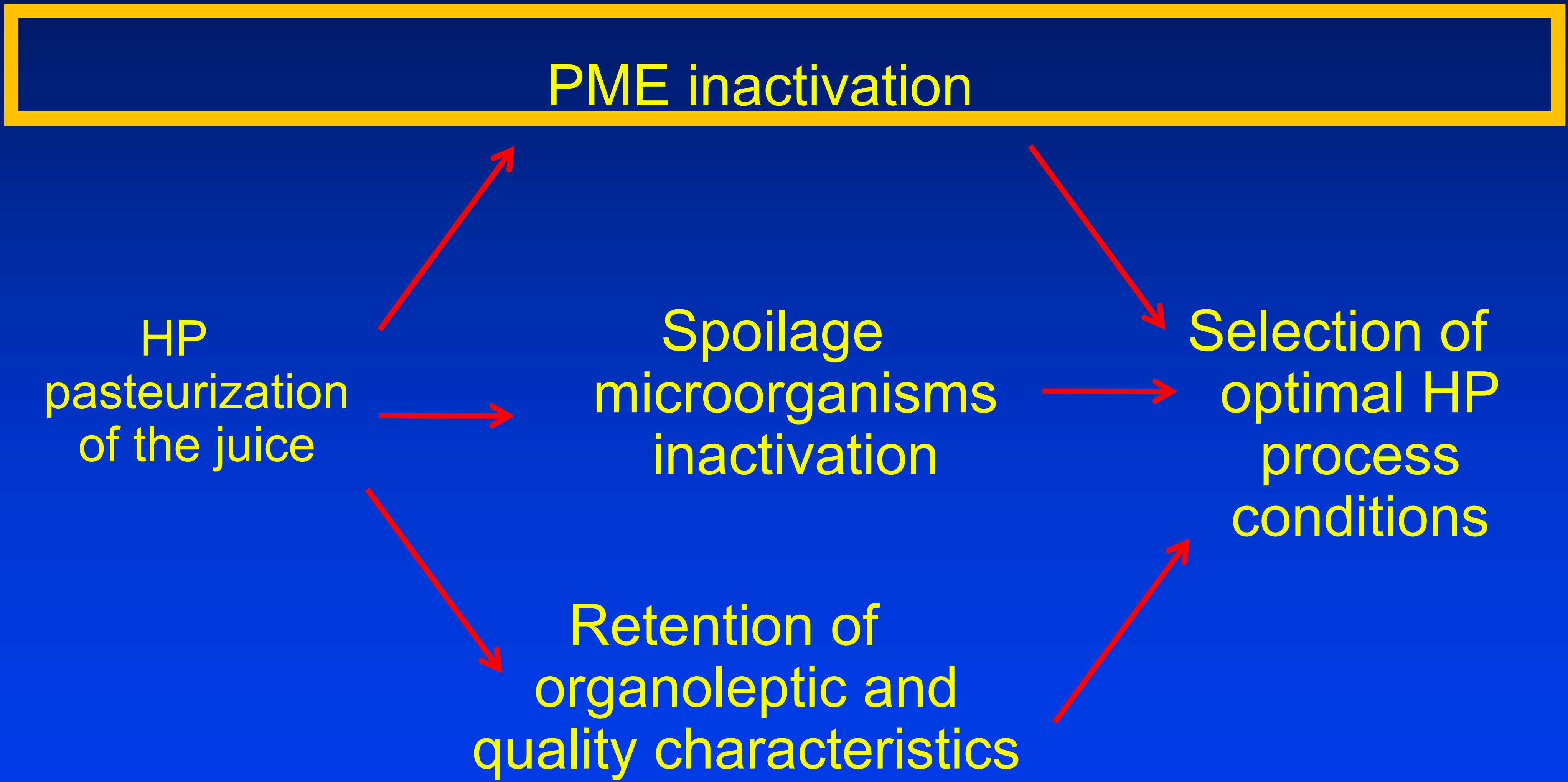
$$Z_T = \frac{T_{ref} - T}{\log\left(\frac{D}{D_{ref}}\right)}$$

+

$$Z_P = \frac{P_{ref} - P}{\log\left(\frac{D}{D_{ref}}\right)}$$

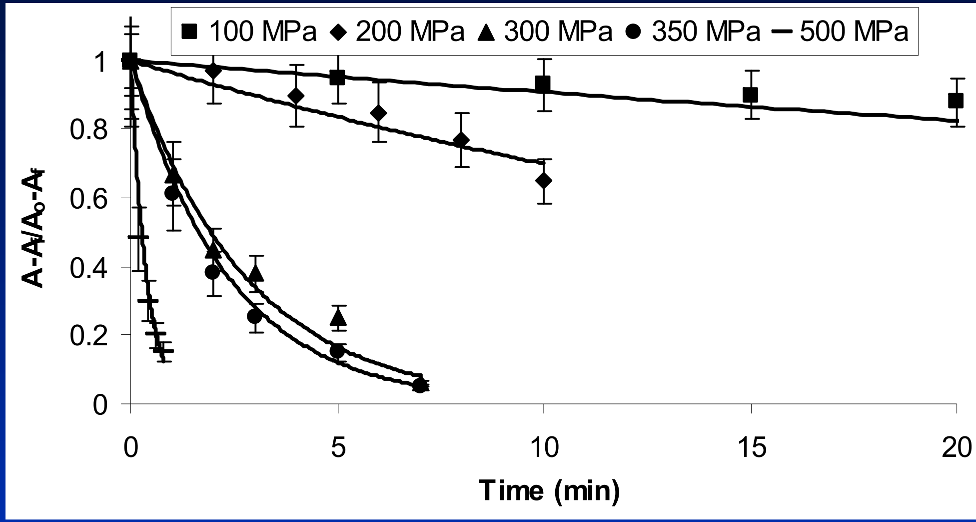
$$D = D_o \cdot \left(\exp\left\{ -\frac{2,303 \cdot T \cdot T_{ref}}{Z_T} \cdot \exp\left[-A\left(P - P_{ref}\right)\right] \cdot \left(\frac{1}{T} - \frac{1}{T_{ref}}\right) + \frac{\left(\frac{2,303 \cdot R \cdot T}{Z_P}\right)}{R} \cdot \frac{\left(P - P_{ref}\right)}{T} \right\} \right)^{-1}$$

HP Pasteurization of Valencia orange juice

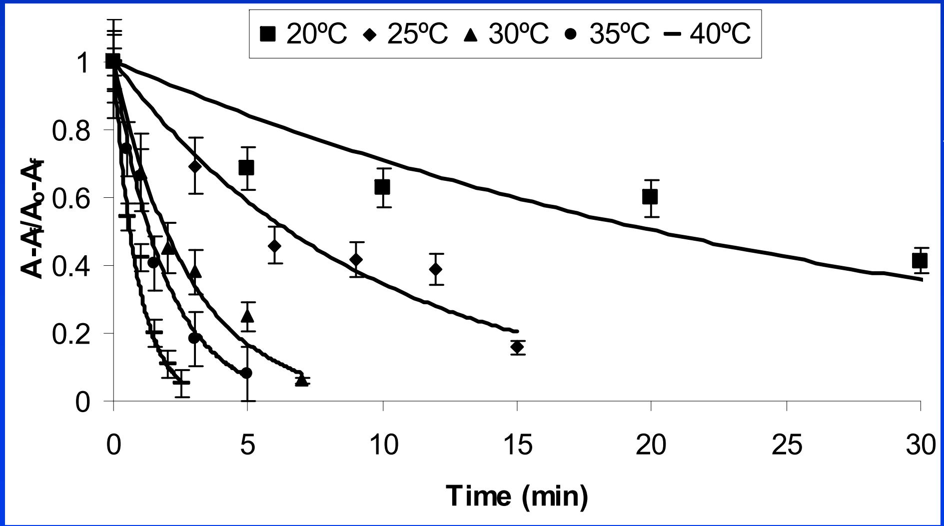


HP Pasteurization of Valencia orange juice

Valencia PME inactivation during HP processing at 100 to 500 MPa, at 30ºC



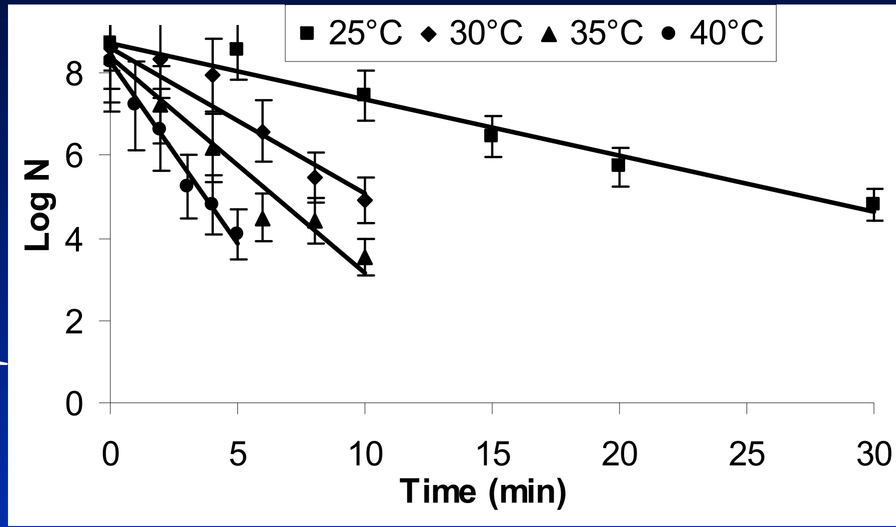
PME inactivation



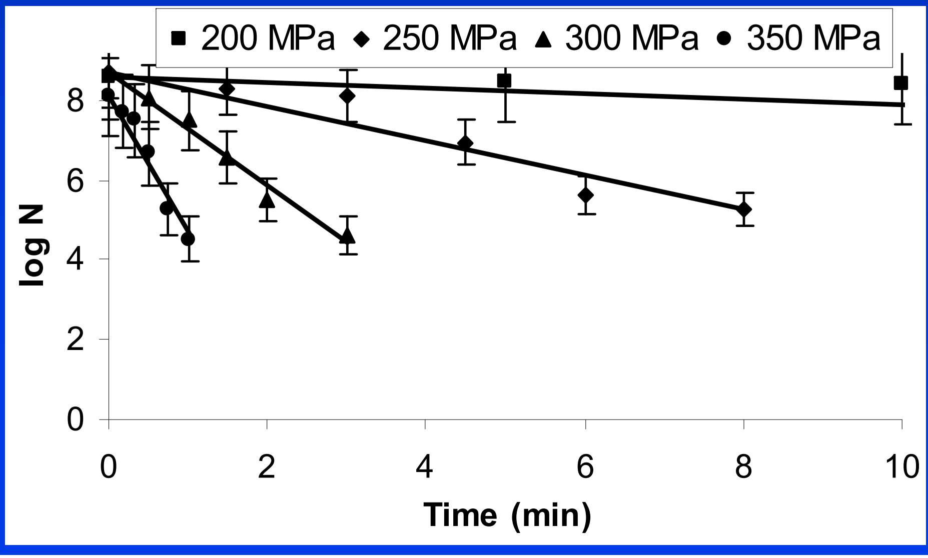
Valencia PME inactivation during HP processing at 300 MPa combined with temperatures in the range of 20-40 °C

HP Pasteurization of Valencia orange juice

L. brevis inactivation during HP processing at 250 MPa combined with temperatures in the range of 25-40 °C



LAB inactivation



L. plantarum inactivation during HP processing at 200 to 350 MPa at 35ºC and 200-350 MPa

HP Pasteurization of Valencia orange juice

PME inactivation

$$k = k_o \cdot \exp\left\{ -\frac{E_{ao}}{R} \cdot \exp\left[-B\left(P - P_{ref}\right)\right] \cdot \left(\frac{1}{T} - \frac{1}{T_{ref}}\right) - \frac{A \cdot \left(T - T_{ref}\right) + V_{ao}}{R} \cdot \frac{\left(P - P_{ref}\right)}{T} \right\}$$

LAB inactivation

$$D = D_o \cdot \left(\exp\left\{ -\frac{2,303 \cdot T \cdot T_{ref}}{Z_T} \cdot \exp\left[-A\left(P - P_{ref}\right)\right] \cdot \left(\frac{1}{T} - \frac{1}{T_{ref}}\right) + \frac{\left(\dfrac{2,303 \cdot R \cdot T}{Z_P}\right)}{R} \cdot \frac{\left(P - P_{ref}\right)}{T} \right\} \right)^{-1}$$

How a Food engineer should think and work:

Valencia orange juice HP pasteurization_CASE STUDY

PME inactivation:

Residual activity <10% of initial activity

HP pasteurization of the juice

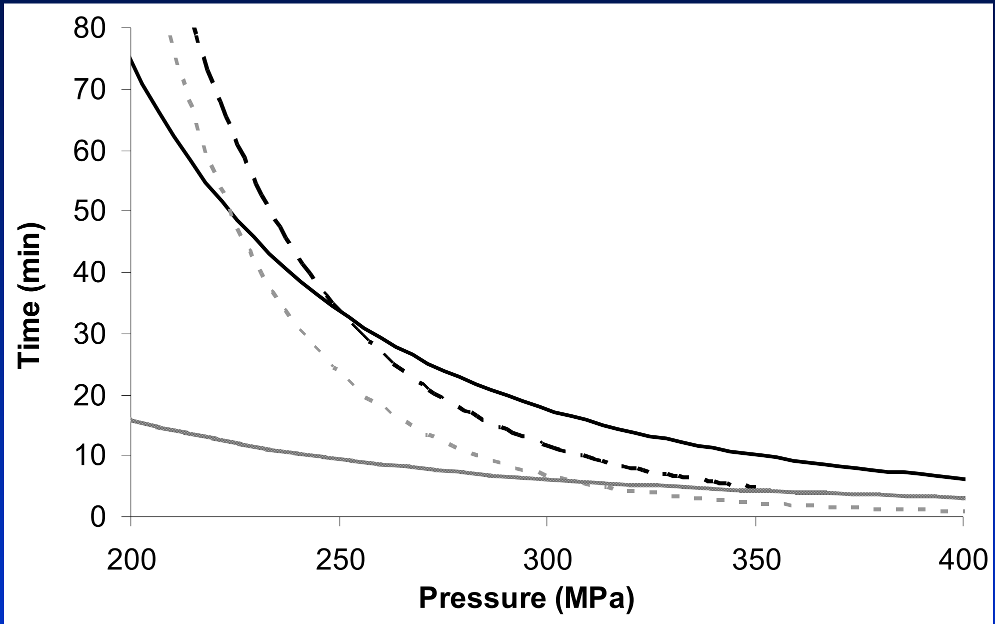
As mild as possible processing

Selection of optimal HP process conditions

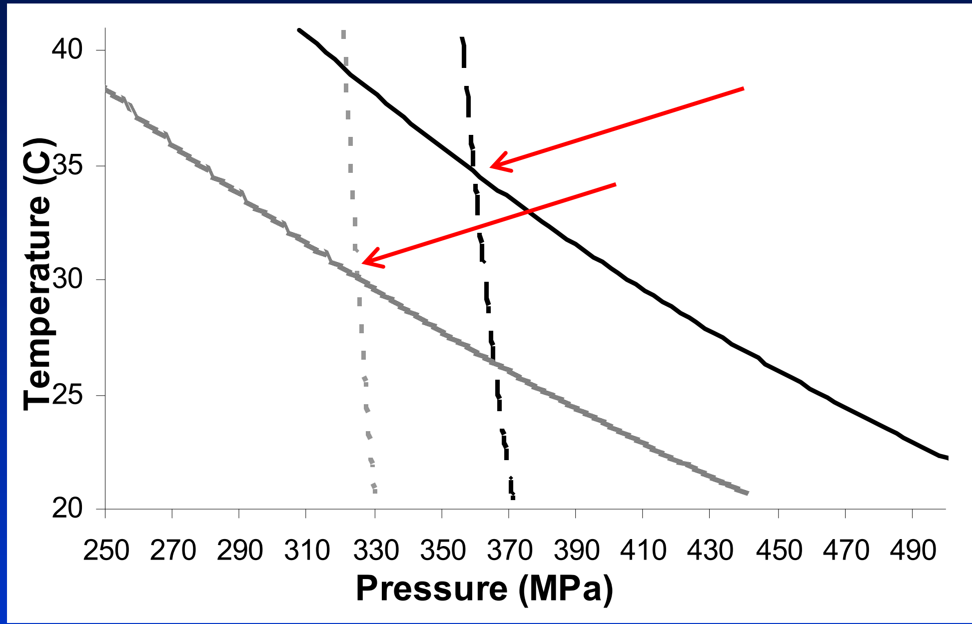
LAB inactivation:

7D reduction of viable initial cells

Selection of optimal HP process conditions for Valencia orange juice



Required processing time for the inactivation of PME and LAB as a function of pressure at 25ºC and 30ºC. Dashed lines represent a 7D LAB reduction and solid lines represent 90% PME inactivation. Black lines show processing at 25ºC, grey lines show processing at 30ºC



Microbial (LAB) and enzymatic (PME) iso-reduction plots for achieving a 7 microbial log reduction and 90% PME inactivation after processing for 2 and 5 min. Dashed lines represent a 7D LAB destruction and solid lines represent 90% PME inactivation. Black lines show processing for 2 min, while grey lines show processing for 5 min

International Journal of
Food Science & Technology
International Journal of Food Science and Technology 2010, 45, 1119–1129

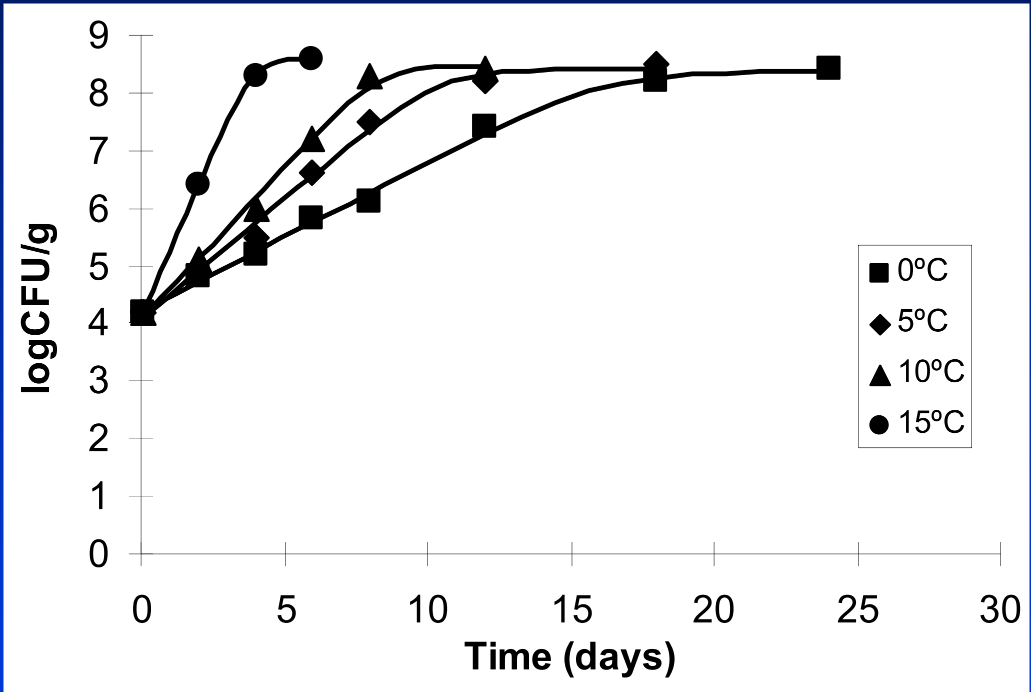
Original article

Kinetic study of high pressure microbial and enzyme inactivation and selection of pasteurisation conditions for Valencia Orange Juice

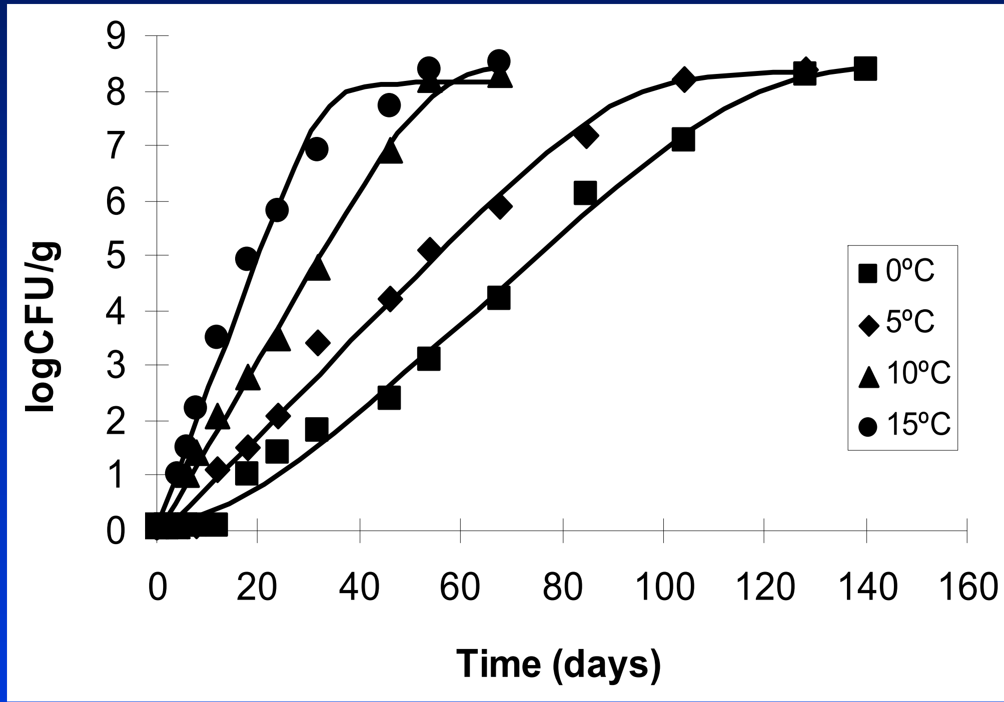
George I. Katsaros, Maria Tsevdou, Theodora Panagiotou & Petros S. Taoukis*

IN-PACK PASTEURIZATION OF RTE Meat products USING HP TECHNOLOGY

Effect of HP processing of Lactic acid bacteria growth of sliced cooked hams



Lactic acid bacteria growth for non-HP treated samples



Lactic acid bacteria growth for HP (600MPa-5min) treated samples

Effect of HP processing on sliced cooked hams shelf-life

Storage temperature (°C)	Shelf-life for untreated samples (days)	Shelf-life for HP treated samples (days)
0	9	105
5	6	82
10	5	46
15	3	30

Application of HP technology-Status in Greece

<u>Packed meat products leader companies use HP technology in Greece</u>

The new FreshPress label assures consumers of "ultimate food protection". It also refers them to a web site where they can see an Avure HPP system at work in an Ifantis production facility.

CEO said:*"…Every day we try to be innovative to differentiate ourselves and our products. This technology matches perfectly with our philosophy…"*

CRETA FARMS

"…Creta Farms ensures pasteurization of the final product by applying high hydrostatic pressure for a short time in a water tank:

The process ensures 100% safety in a natural way.

It preserves the product's nutritional elements and taste down to the last slice. Guaranteed freshness for up to 10 days from opening the package…"

-Novel dairy products_plant proteolytic enzymes

-Cheese maturation time decrease

-Yoghurt production without solid fortification

-Orange juice bitterness decrease

-Olive Oil yield increase

NON - PASTEURIZATION STUDIES

Novel dairy products using plant origin milk clotting enzymes_Excessive proteolysis control by HP

Journal of Food Engineering 94 (2009) 40–45

Contents lists available at ScienceDirect

Journal of Food Engineering

journal homepage: www.elsevier.com/locate/jfoodeng

Modeling the effect of temperature and high hydrostatic pressure on the proteolytic activity of kiwi fruit juice

G.I. Katsaros, P. Katapodis, P.S. Taoukis *

Journal of Food Engineering 91 (2009) 42–48

Contents lists available at ScienceDirect

Journal of Food Engineering

journal homepage: www.elsevier.com/locate/jfoodeng

High hydrostatic pressure inactivation kinetics of the plant proteases ficin and papain

G.I. Katsaros, P. Katapodis, P.S. Taoukis *

FOOD ENGINEERING_Development of an innovative process and a novel dairy product using HP technology and proteolytic enzymes

Actinidin

Milk coagulation →
Hardness increase

Application of HP technology to control proteolysis

Homogenized pasteurized milk


Innovative Food Science and Emerging Technologies 11 (2010) 47–51

Contents lists available at ScienceDirect

Innovative Food Science and Emerging Technologies

journal homepage: www.elsevier.com/locate/ifset

Production of novel dairy products using actinidin and high pressure as enzyme activity regulator

George I. Katsaros, George Tavantzis, Petros S. Taoukis *

Decrease of ripening time in brine cheeses by HP activation of intra-cellular aminopeptidases of starter cultures

JFS E: Food Engineering and Physical Properties

Kinetic Study of the Combined Effect of High Hydrostatic Pressure and Temperature on the Activity of *Lactobacillus delbrueckii* ssp. *bulgaricus* Aminopeptidases

G.I. KATSAROS, M.N. GIANNOGLOU, AND P.S. TAOUKIS

Vol. 74, Nr. 5, 2009—JOURNAL OF FOOD SCIENCE E219

ACTIVATION OF ENZYMES USING HP

Proteolytic enzymes from starter cultures

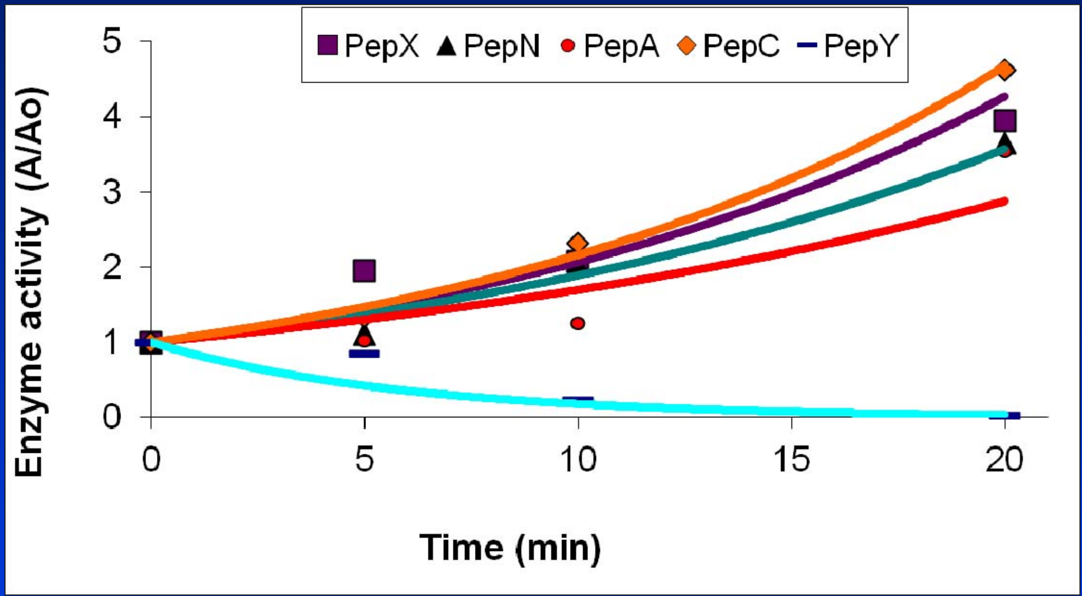
- Cell membrane peptidases
- Intracellular aminopeptidases
- Glycolytic enzymes

Their activity results in specific flavour and texture of cheeses

+

Their activity is correlated to the necessary time for cheese maturation

Selection of HP process conditions based on the higher rate activation of *L. bulgaricus* aminopeptidases



200MPa - 20°C

At low pressures (100-300 MPa) and temperature (20ºC) an increase of aminopeptidases activity was observed, while at more intense pressure or/and temperature process conditions the aminopeptidases were inactivated

APPLICATION OF HP TECHNOLOGY AS AN INNOVATIVE STEP IN CHEESE PRODUCTION

Milk

↓

Pasteurization

↓ Cooling

Addition of rennin and HP treated starter culture

↓ + $CaCl_2$

Milk clotting

Whey drainage ↓

Salting

↓

Ripening

(Moisture <56% and $4.4 < pH < 4.6$)

HP processing may be applied to starter culture exactly before cheese production

↓

Additional cost for HP processing during cheese production:

~0,08 €/kg cheese

New yoghurt dairy products

-No solids fortification

-Superior quality characteristics_texture properties

Innovative Food Science and Emerging Technologies 17 (2013) 144–152

Contents lists available at SciVerse ScienceDirect

Innovative Food Science and Emerging Technologies

journal homepage: www.elsevier.com/locate/ifset

Transglutaminase treatment of thermally and high pressure processed milk: Effects on the properties and storage stability of set yoghurt

Maria S. Tsevdou, Evangelia G. Eleftheriou, Petros S. Taoukis *

Food Chemistry 138 (2013) 2159–2167

Contents lists available at SciVerse ScienceDirect

Food Chemistry

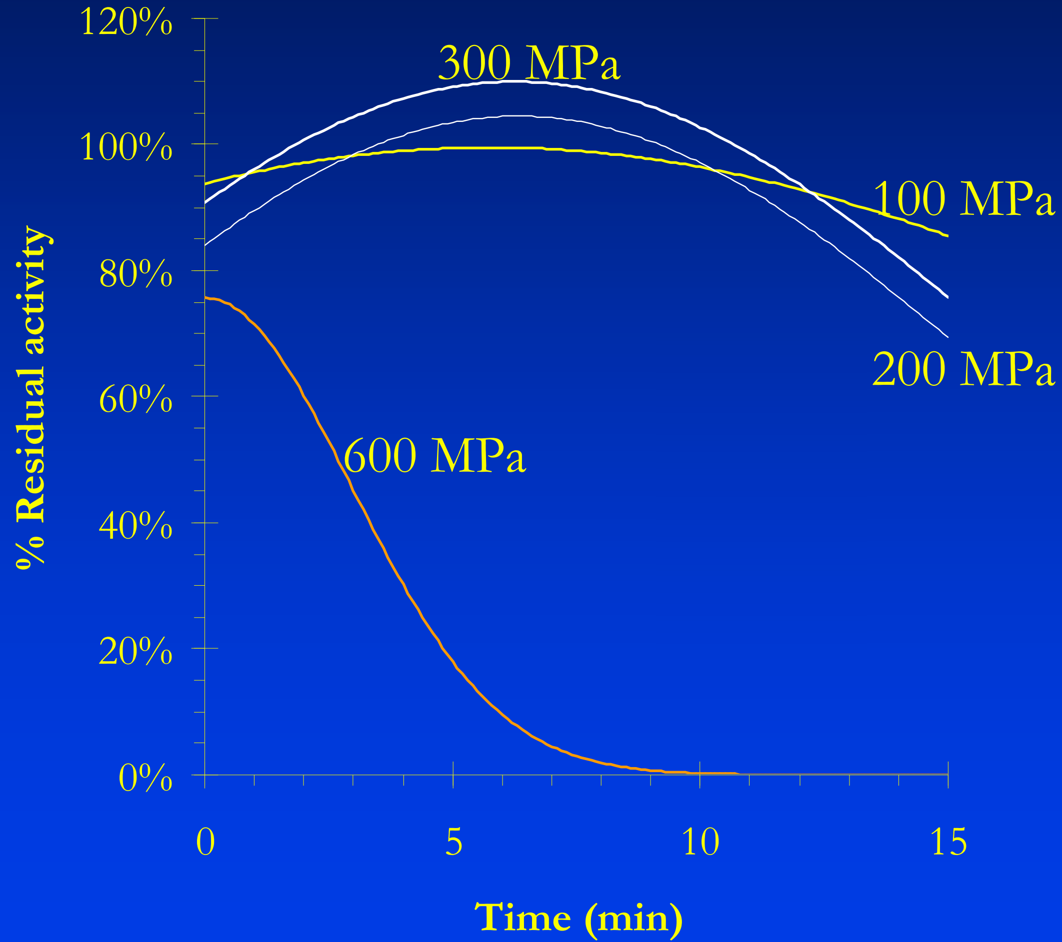
journal homepage: www.elsevier.com/locate/foodchem

Monitoring the effect of high pressure and transglutaminase treatment of milk on the evolution of flavour compounds during lactic acid fermentation using PTR-ToF-MS

Maria Tsevdou [a], Christos Soukoulis [b,1], Luca Cappellin [b], Flavia Gasperi [b], Petros S. Taoukis [a,*], Franco Biasioli [b]

Orange Juice bitterness decrease

Effect of HP on LGTase remaining activity



Virgin olive oil yield increase using HP treated olive fruits

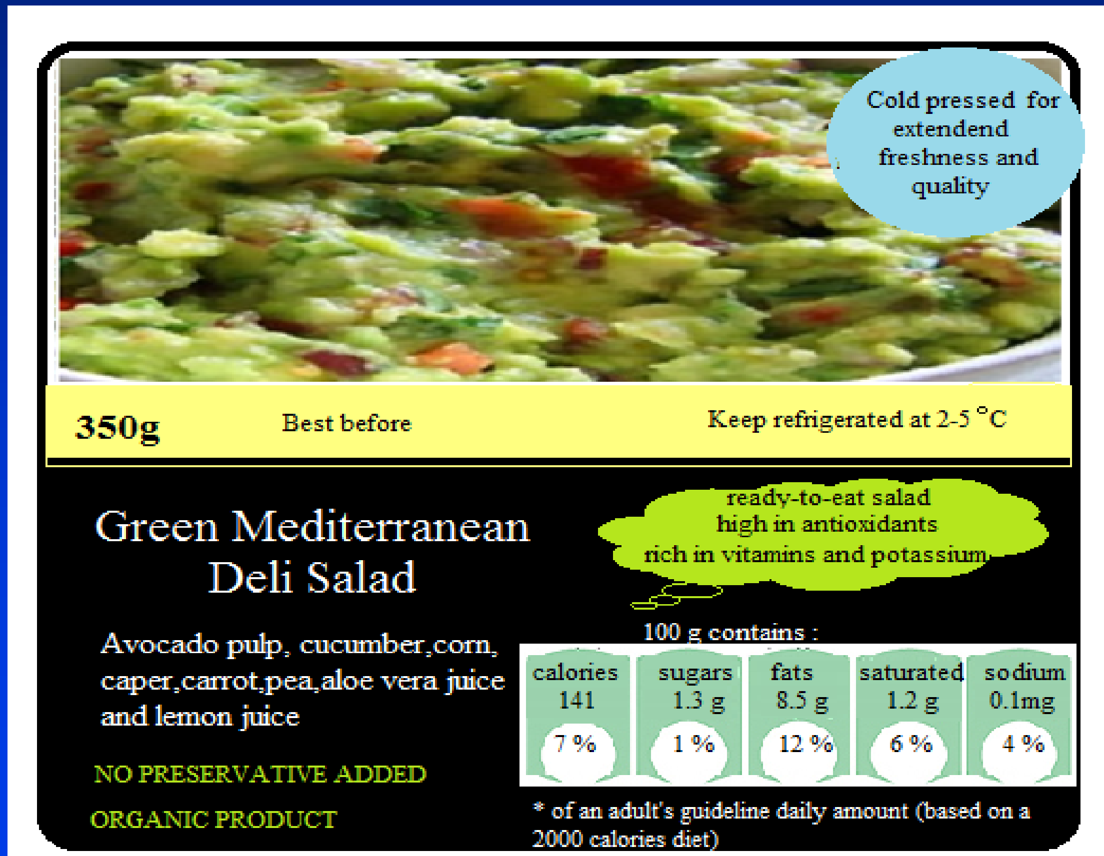
ΣΕΒΤ

ÉCOTROPHÉLIA ΕΛΛΑΔΑ

EUROPE INNOVA
Eco-Innovation
EcoTroFood

"Green Mediterranean Deli Salad"

Storage temperature (C)	Shelf-life (days)
0	72
5	45
10	20
15	7



<u>RESEARCH TRENDS</u>

<u>IN FOOD SCIENCE & ENGINEERING</u>

ICEF11
11th International Congress on Engineering and Food

1100 papers

- **Oral** 415
- **Posters** 685

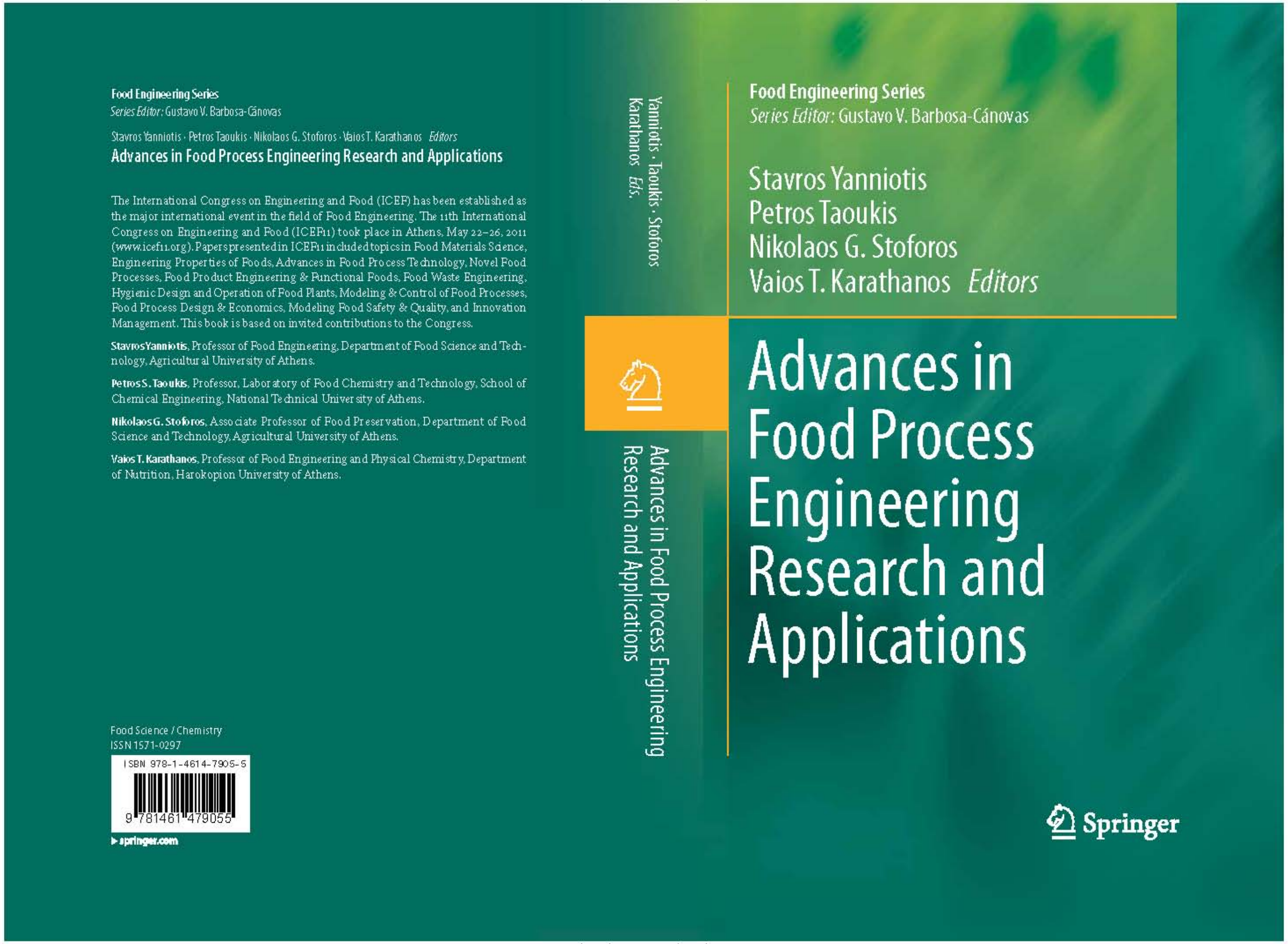
200 Papers

Food Processing

- Advances in Food Process Technology
- Novel Food Processes
- Modeling & Control of Food Processes

PAPERS PRESENTED AT ICEF11 PER TOPIC

Food Materials Science (FMS)	308
Engineering Properties of Foods (EPF)	117
Modeling and Control of Food Processes (MCF)	119
Novel Food Processes (NFP)	122
Modeling Food Safety and Quality (MFS)	106
Advances in Food Process Technology (AFT)	119
Food Product Engineering and Functional Foods (FPE)	145
Hygenic Design and Operation of Food Plants (HDO)	18
Food Waste Engineering (FEW)	19
Innovation Management and Sustainability (INM)	13



Food Engineering Series
Series Editor: Gustavo V. Barbosa-Cánovas

Stavros Yanniotis · Petros Taoukis · Nikolaos G. Stoforos · Vaios T. Karathanos *Editors*

Advances in Food Process Engineering Research and Applications

The International Congress on Engineering and Food (ICEF) has been established as the major international event in the field of Food Engineering. The 11th International Congress on Engineering and Food (ICEF11) took place in Athens, May 22–26, 2011 (www.icef11.org). Papers presented in ICEF11 included topics in Food Materials Science, Engineering Properties of Foods, Advances in Food Process Technology, Novel Food Processes, Food Product Engineering & Functional Foods, Food Waste Engineering, Hygienic Design and Operation of Food Plants, Modeling & Control of Food Processes, Food Process Design & Economics, Modeling Food Safety & Quality, and Innovation Management. This book is based on invited contributions to the Congress.

Stavros Yanniotis, Professor of Food Engineering, Department of Food Science and Technology, Agricultural University of Athens.

Petros S. Taoukis, Professor, Laboratory of Food Chemistry and Technology, School of Chemical Engineering, National Technical University of Athens.

Nikolaos G. Stoforos, Associate Professor of Food Preservation, Department of Food Science and Technology, Agricultural University of Athens.

Vaios T. Karathanos, Professor of Food Engineering and Physical Chemistry, Department of Nutrition, Harokopion University of Athens.

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ISSN 1571-0297
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9 781461 479055
springer.com

Yanniotis · Taoukis · Stoforos
Karathanos *Eds.*

Advances in Food Process Engineering
Research and Applications

Food Engineering Series
Series Editor: Gustavo V. Barbosa-Cánovas

Stavros Yanniotis
Petros Taoukis
Nikolaos G. Stoforos
Vaios T. Karathanos *Editors*

Advances in Food Process Engineering Research and Applications

Springer

Scientific research vs Industrial Innovation

THE COMPETITIVENESS OF THE FOOD INDUSTRY DEPENDS ON INNOVATION

The European market of food products will be more and more affected by the changes in society (demographics, ageing), by the changes of the nutritional habits and by the way of life.

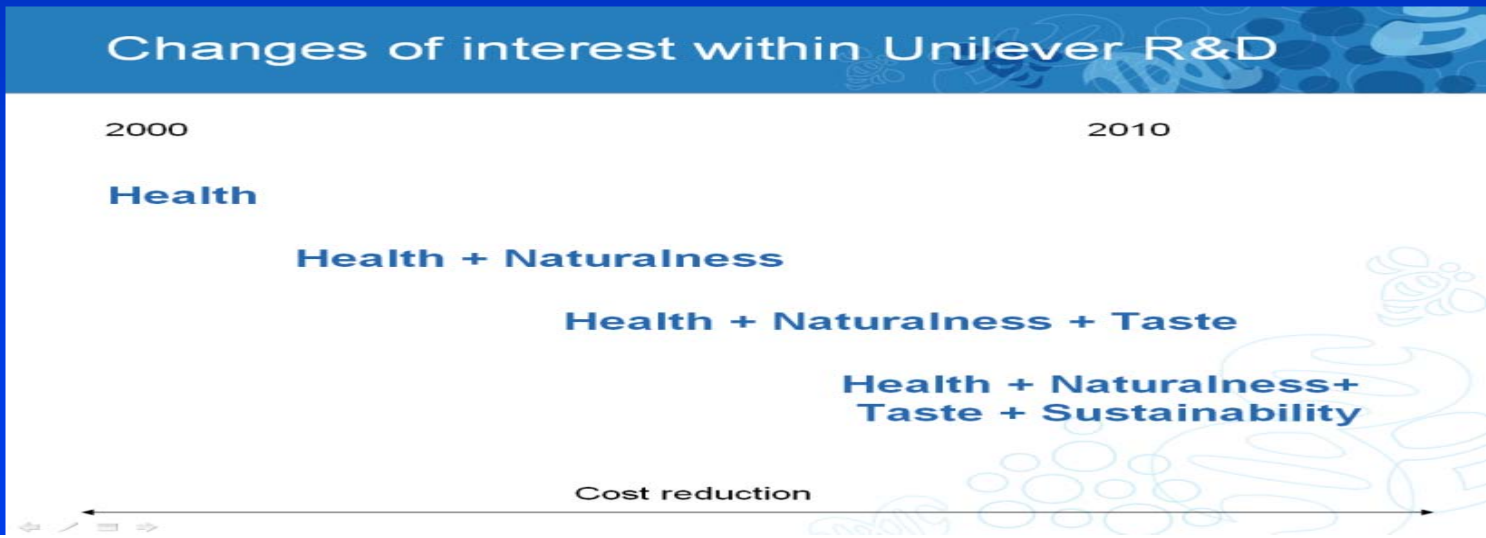
R&D in industry focuses in **MEETING CONSUMERS' NEEDS** supplying products adapted to the various nutritional needs, considering as well the different ways of consumption that enable the consumer to make responsible choices and to follow a diet suitable to his/her lifestyle and the physical activity performed.

Consumers themselves are more and more in a position to recognize the real value of what they are buying, from the choice of the primary products, the technological features, to the attention given to the correct employ of natural resources, to logistics and packaging,from the point of view of the concept of global quality.

INNOVATION DRIVERS FOR THE **FOOD INDUSTRY**

Among the topics of innovation in the food sector, an important part is driven by the main consumer trends:

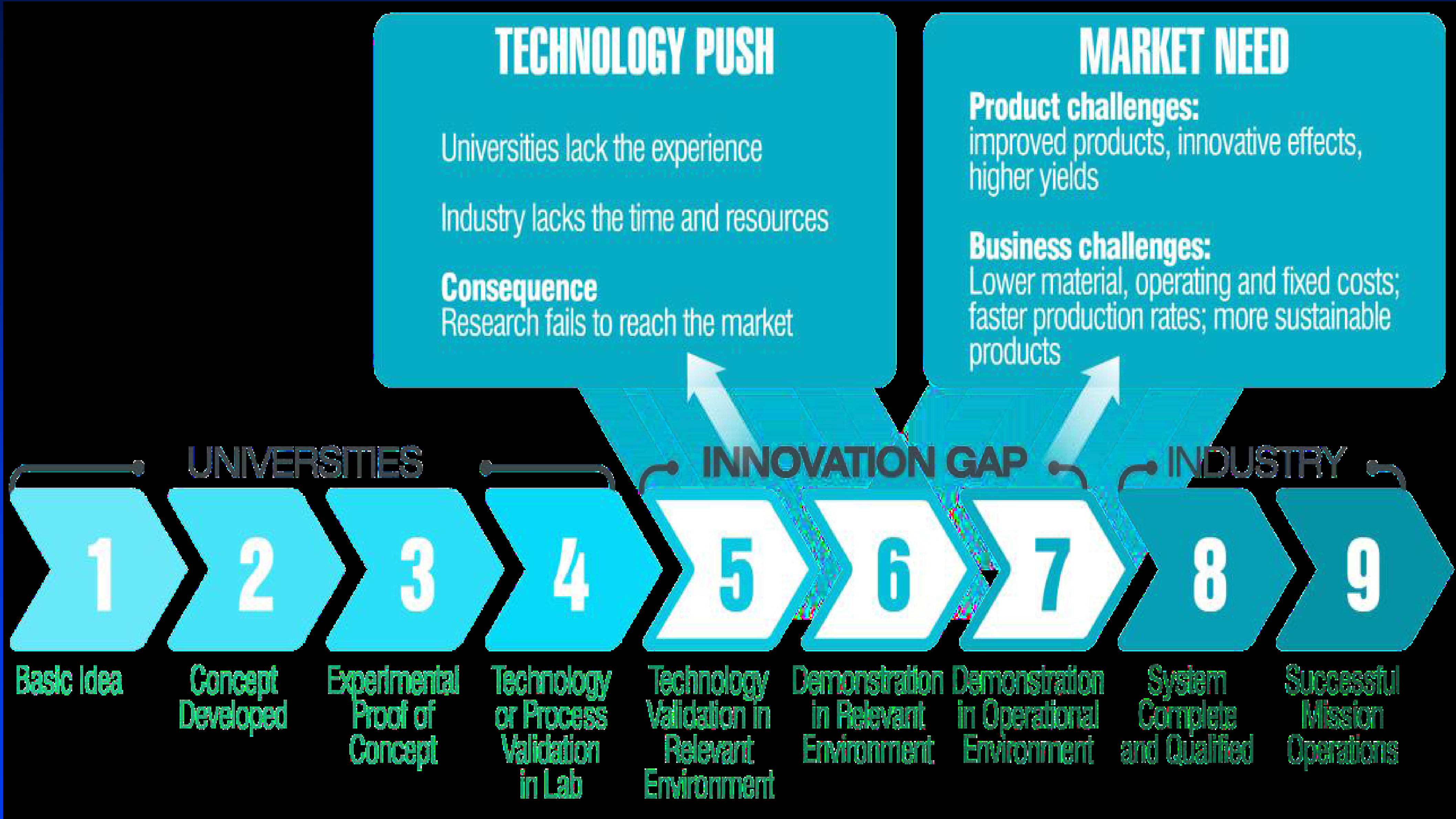
NATURAL & FRESHNESS OF PRODUCTS, TEXTURE, COLOUR, TASTE & FLAVOUR, RECIPES & THEIR REFORMULATIONS, PORTIONING & PRESENTATION WITH THE INTEGRATED SERVICE, NUTRITIONAL & HEALTH VALUES ,FUNCTIONALITY, OPPORTUNITY & PLACE OF CONSUMPTION.



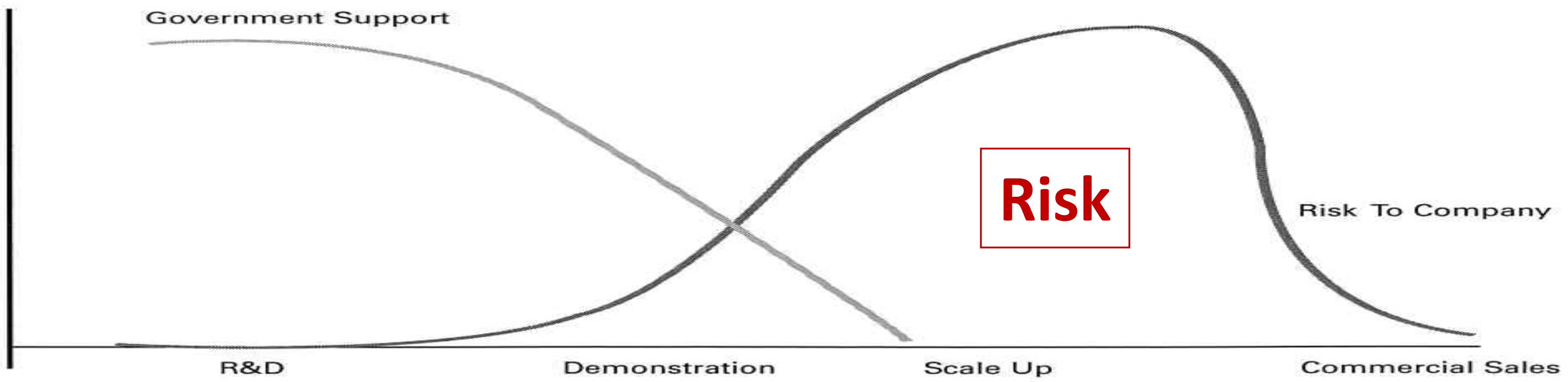
MAIN CHALLENGES FOR INNOVATION OF FOOD BUSINESSES

- Access to innovative ideas
- Converting of research results into practical solutions
- Reduction of the risks of investment of company resources into innovation
  - reduction of failure rate of innovation projects (technical management, business support) during the process
  - reduction of barriers: legal, administrative
  - protection of confidential information/knowledge, on which innovative products, processes, services, systems, market solutions are based
- Financing innovation

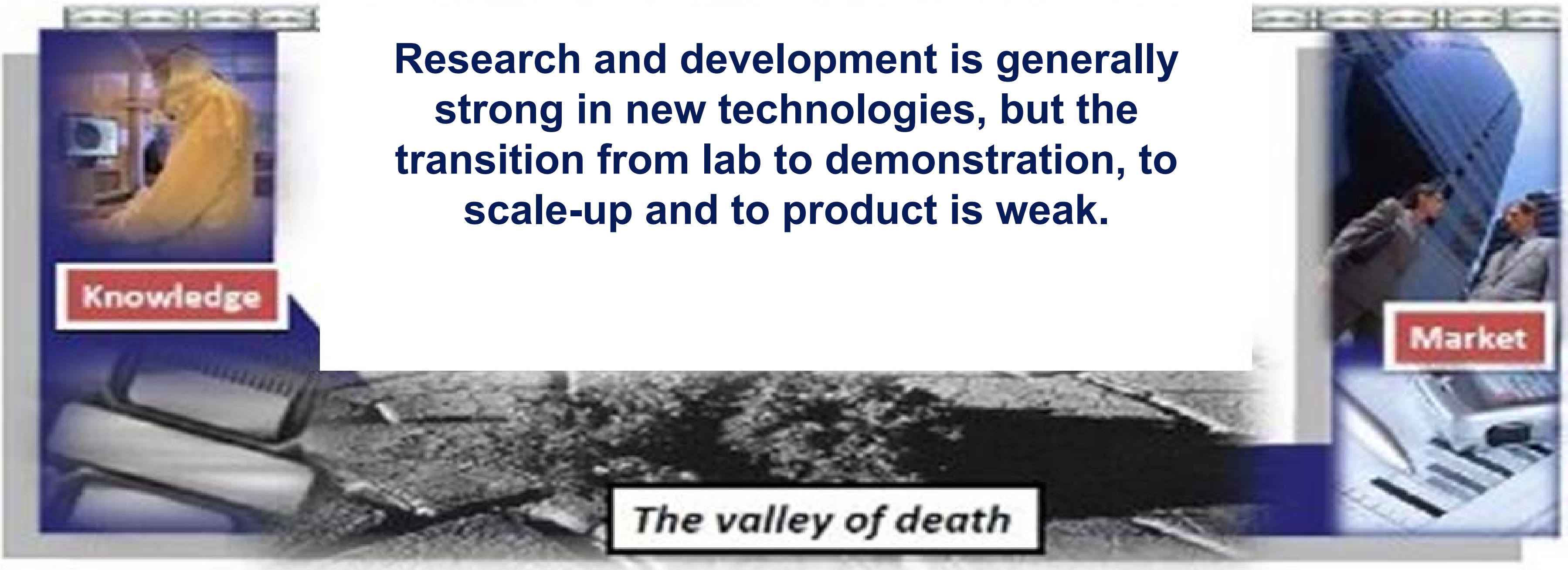
Technology Readiness Levels (TRLs) and the "Innovation Gap"



The valley of death: a global problem



Research and development is generally strong in new technologies, but the transition from lab to demonstration, to scale-up and to product is weak.



European Technology Platform
Food for Life

National Food Platforms

- Increase **R&D strategy;**
- Coordinate **research in Europe and prevent duplication;**
- Promote **SME participation, specific programmes and networks;**
- Focus, **align and collaborate transnationally between stakeholders;**
- Increase **multidisciplinary / cross-sector education and;**
- Optimise **knowledge capture and dissemination of knowledge between Member States and towards SMEs.**

MEMBERS

- **Food Industry (leading role)**
  - **Food Research Community**
  - **Consumers' organisations**
  - **National Public Bodies**
  - **Farmers representatives**
  - **Retailers representatives**
  - **Financial institutions**

36 NTPs

NTPs

GOALS

- DRIVE FOOD **INNOVATION.**
- PROMOTE A BETTER **COORDINATION** OF EU FOOD & NUTRITION RESEARCH ACTIVITY.
- MOBILISE A **CRITICAL MASS** OF NATIONAL & EU PUBLIC & PRIVATE RESOURCES.
- ENHANCE **COMMUNICATION, TRAINING** & **TECHNOLOGY TRANSFER.**
- INVOLVE SMEs IN **INNOVATION PATHS**

HORIZON 2020: 3 priorities

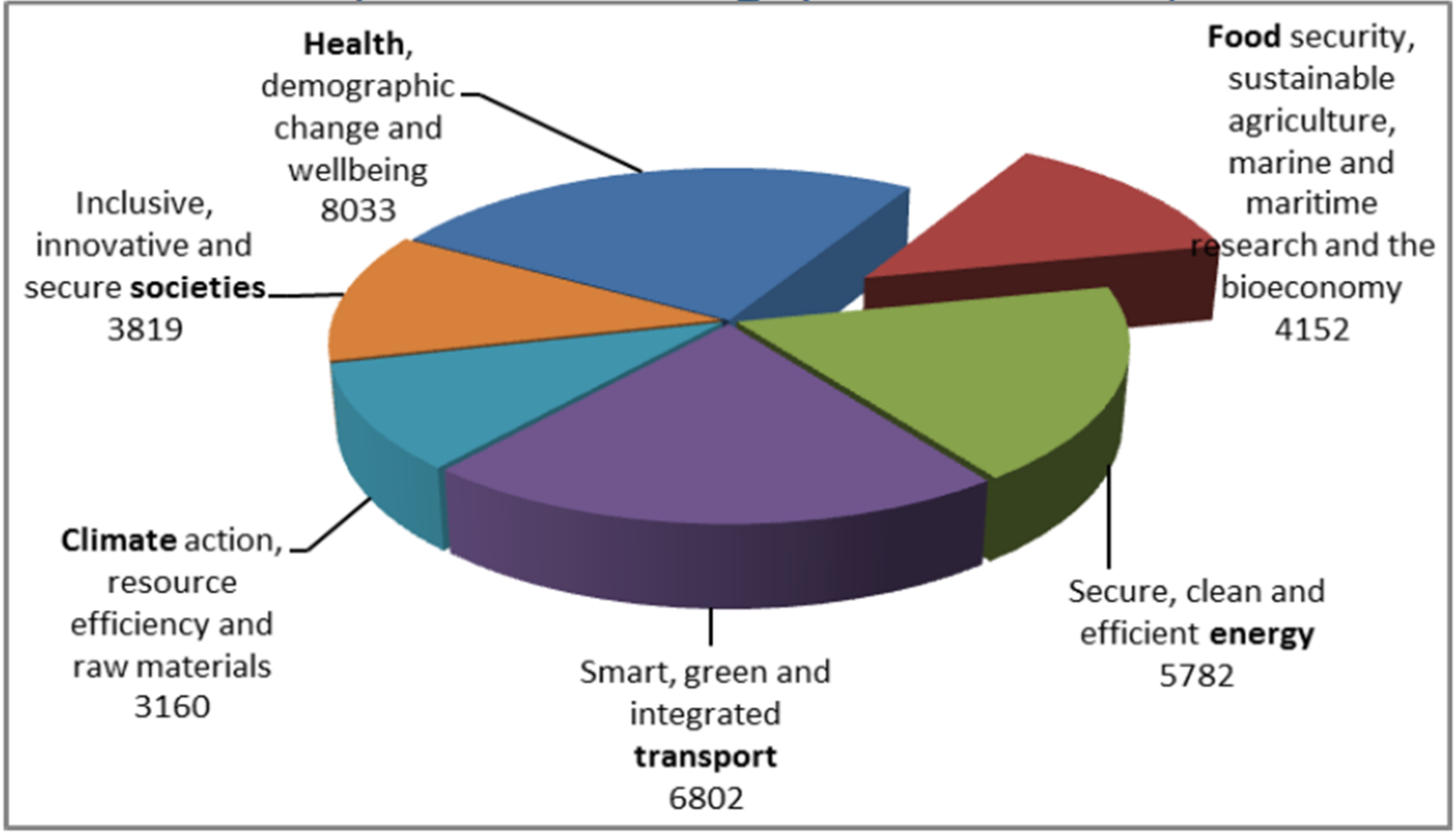
1. Excellent science

2. Industrial leadership

3. Societal challenges

1. Health, demographic change and wellbeing
2. Food security, sustainable agriculture and forestry, marine and maritime and inland water research and the bioeconomy 3.851 billion euros 2014-2020
3. Secure, clean and efficient energy
4. Smart, green and integrated transport
5. Climate action, resource efficiency and raw materials
6. Inclusive, innovative and reflective societies
7. Secure societies

Proposed funding (million euro, 2014-2020)



Work Programme *2014*
Funding for calls

- Societal Challenges Pillar: ~ € 2.8 billion

1. Health, demographic change and wellbeing **(2 calls)** € 600 million
2. **Food Security, Sustainable Agriculture and Forestry, Marine and Maritime and Inland Water Research and the Bioeconomy (3 calls) *€ 300 million***
3. Secure, clean and efficient energy **(4 calls)** € 600 million
4. Smart, green and integrated transport **(3 calls)** € 540 million
5. Climate action, environment, resource efficiency and raw materials **(3 calls)** € 300 million
6. Europe in a changing world – inclusive, innovative and reflective societies **(5 calls)** € 112 million
7. Secure Societies **(4 calls)** € 200 million

- In addition
  - Spreading Excellence and Widening Participation **(3 calls)** € 50 million
  - Science with and for Society **(4 calls)** € 45 million

SC2, WP 2014-2015: 3 calls

Sustainable Food Security

- Sustainable food production systems
- Safe food and healthy diets and sustainable consumption
- Global drivers of food security

Blue Growth: unlocking the potential of Seas and Oceans

- Sustainably exploiting the diversity of marine life
- New offshore challenges
- Ocean observation technologies/systems
- Horizontal aspects, socio-economic sciences, engagement with society,…

Innovative, Sustainable and Inclusive Bioeconomy

- Sustainable agriculture and forestry
- Sustainable and competitive bio-based industries
- Cross-cutting actions covering all the activities

Sustainable Food Security (call 2014-2015)

SFS Call (248,5 million EUR)

Sustainable food production systems: 11 topics
(9 RIAs + 1 CSA + 1 SME instrument)

Safe food, healthy diets and sustainable consumption: 6 topics
(4 RIAs + 1 CSA + 1 IA)

Global drivers of Food security: 3 topics
(3 RIAs)

SC2: Sustainable Food Security Call

Examples of topics:

1. Sustainable food production systems

- SFS-1-2014/2015: Sustainable terrestrial livestock production
- SFS-2-2014/2015: Sustainable crop production
- SFS-8-2014/2015: Resource-efficient eco-innovative food production and processing
- SFS-9-2014: Towards a gradual elimination of discards in European fisheries

2. Safe food and healthy diets and sustainable consumption

- SFS-12-2014: Assessing the health risks of combined human exposure to multiple food-related toxic substances
- SFS-13-2015: Biological contamination of crops and the food chain
- SFS-14-2014/2015: Authentication of food products
- SFS-15-2014: Proteins of the future
- SFS-16-2015: Tackling malnutrition in the elderly
- SFS-17-2014: Innovative solutions for sustainable novel food processing

3. Global drivers of food security

- SFS-19-2014: Sustainable food and nutrition security through evidence based EU agro-food policies

SFS-17-2014: Innovative solutions for sustainable novel food processing

First Draft version:

…Throughout the last decades, much research on innovative food processing technologies has been carried out, such as **high hydrostatic pressure (HHP), ultrasound, pulse electric field (PEF), and advanced heating by microwave, ohmic heating, and radio frequency waves**. These technologies are expected to combat pathogens, reduce spoilage and waste, reduce the need for chemical preservatives, and improve the functionality of foods. However, market failures and barriers have hindered the uptake of promising research and innovation results in novel food processing from finding applications in the market. **One of the means to support sustainable food security is first market replication of innovative solutions in sustainable novel food processing technologies….**

Final version:

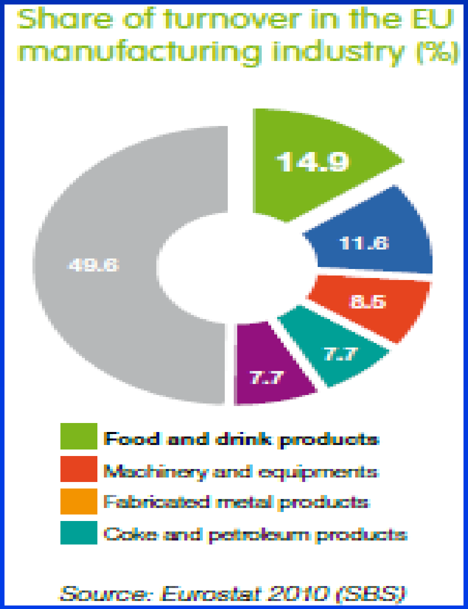
…Over recent decades, much research on innovative food processing technologies has been carried out with a view to combating pathogens, reducing spoilage and waste, optimising process efficiency, reducing the need for chemical preservatives, improving the functionality of foods, and improving the nutritional and sensorial properties of food responding to the demands of the different consumer niches and markets, also in terms of affordability. However, risks associated with scaling-up have often impeded real-scale demonstration of the viability of innovative solutions, and market failures and barriers have hindered the uptake of promising research and innovation results in novel food processing by industry and in the market. One way of supporting sustainable food security is through demonstration and first application in the market of eco-innovative solutions in sustainable novel food processing. …

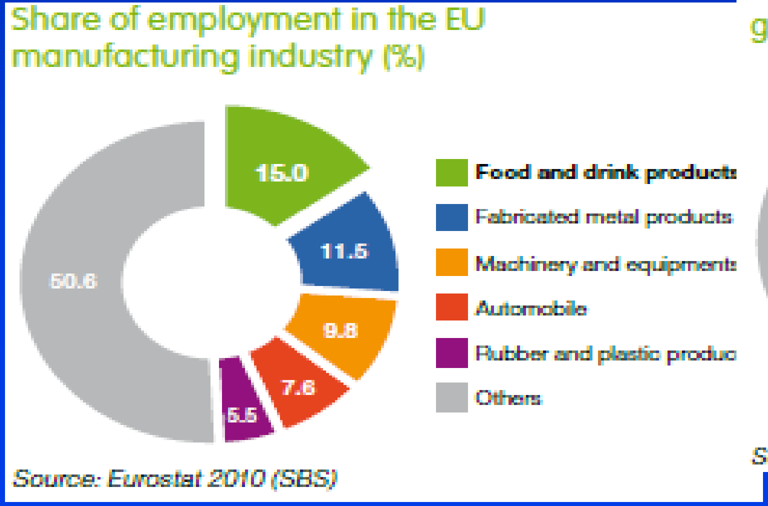
Expected impact:

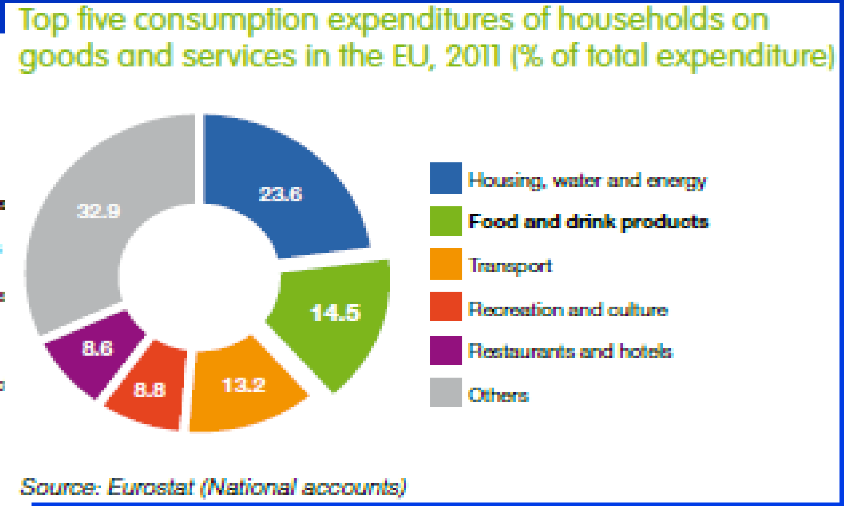
- **Wider and faster deployment of innovative solutions for sustainable novel food processing resulting from greater user acceptance, higher visibility of innovative solutions and the creation of scalable markets**.
- Improved competitiveness as well as opportunities for growth, diversification and job creation for the EU food (equipment) sector in general and SMEs in particular

Economic dimension

- *The food chain (including agriculture, distribution and consumer services) has a turnover of >3 billion, generates added value of EUR 751 billion**= 6% of the EU27's GDP (2008)****
- *48 million people employed > 20% **of EU27 workforce***
- ***The** largest manufacturing sector by turnover, added-value and employment*
- *Private expenditure on food and beverages**= 14,5 % of EU household consumption expenditure***







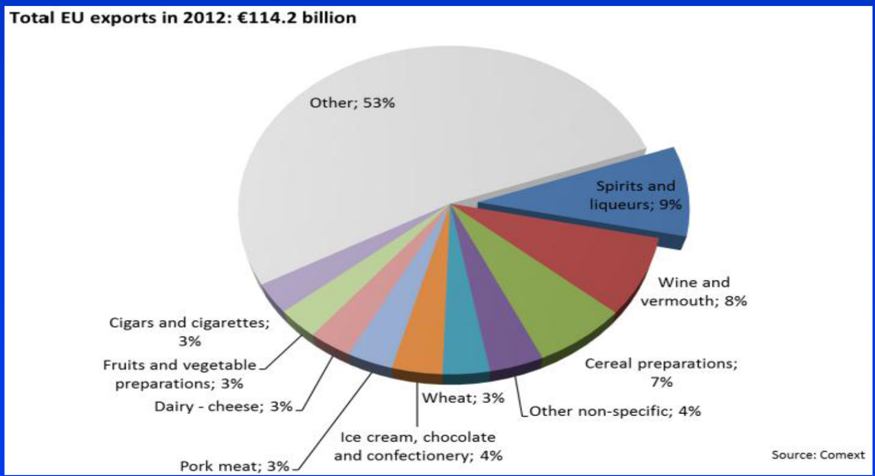
Trade

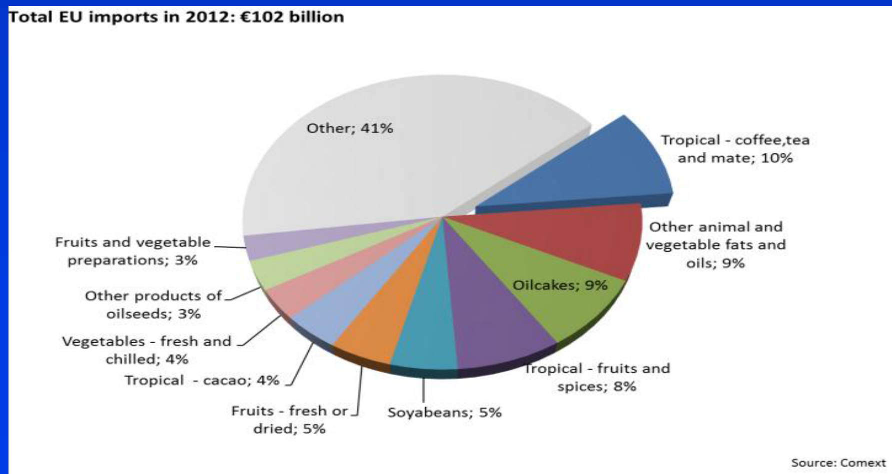
- *Intra-EU trade **accounts for about** 20 % of the EU's food and beverage production **has risen by** 72 % over the last decade*

- *EU is the world's largest importer and 2nd largest exporter of food and drinks after the US**:***
  Total annual EXP=EUR 114 billion, Total annual IMP=EUR 102 billion. Fish exports (EUR18,6 billion and imports (EUR 31,5 billion) are excluded

- **EU specializes in the export of final high value-added products** accounting for two thirds of total and **imports fish products, commodities** (coffee and soya bean oilcakes, soya beans, palm oil for **feeding stuffs**) and **fruits and vegetables**

- **Trade composition** (finished high value exports vs. commodity imports) and the current **trade surplus**, underscore the **EU's relative competitive advantage in food manufacturing**





SUMMARY- CONCLUSIONS

Applying sound engineering and science is a key element for a successful innovation

Research and innovations in the field of food process engineering will have to consider **food security**, i.e., access to sufficient, safe, and nutritious food for all people at all times.

Sustainability will have to be the common denominator in all efforts.

SUMMARY- CONCLUSIONS

In order to remain competitive and successful, the food industry needs continuous innovation in products and process, which demand ongoing research and development. Besides R&D in industry, research in academia and institutions is necessary, not only to broaden the basic knowledge and to create new ideas and results, but also to train, qualify and supervise students and young and open-minded researchers. Young food scientists and engineers in collaboration with natural scientists, i.e., chemists, biologists and physicists, will become the driving force for the future of food science and process engineering. Interdisciplinarity will be key in solving the new society problems.

Excellent education of adequate young people is a major challenge for the future of food research and innovation in an ever-changing world with fast growing knowledge in science and technology.

The ISEKI-Food Association (IFA) is an independent European non-profit organisation, founded in 2005 under Austrian law. IFA was established to ensure the sustainability of the ISEKI_Food network.

Source: www.iseki-food.net/


3rd International ISEKI_Food Conference
ISEKI_Food 2014
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Food Science and Technology Excellence
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"Food Science and Technology research and innovations delivering sustainable solutions to the global economy and society"

- From basic research in Food Science and Engineering to sustainable process and product development
- Novel processes for optimized conventional foods and optimization of classic processes for new products
- Energy, water and waste reduction in the food chain from theory to the consumer
- Food chemistry and material science for enhanced nutrition, health and pleasure
- New research and tools for efficient and sustainable risk and food safety management
- Advances in food structure and functionality: Research and application from the nano to the macro scale.
- Food science and process engineering research applications contributing to food security and water conservation
- Food quality from the perspective of science, the food industry and the society. Current and future challenges.

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Thank you for your attention!

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