
# New Trends and Challenges in Food Preservation

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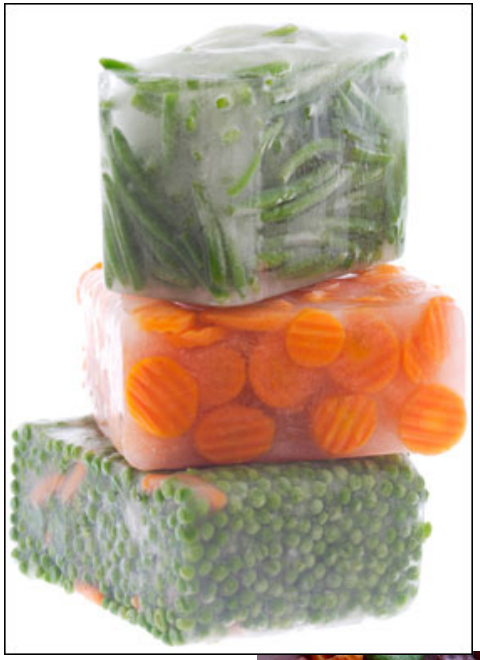
# Why are foods processed ?

to be safe

to be preserved



to be in more convenient forms

to be appelative

# Evolution of the food industry

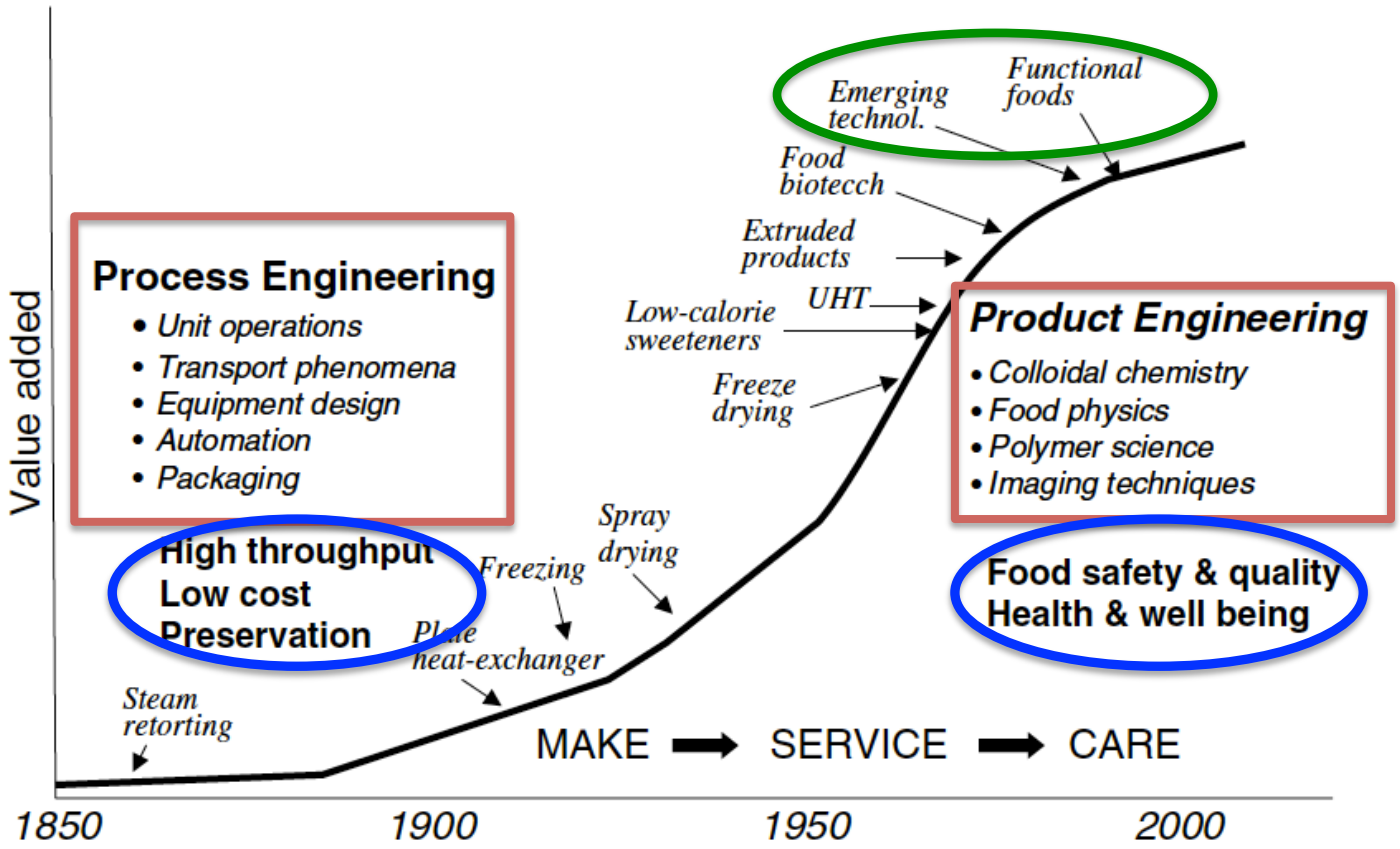
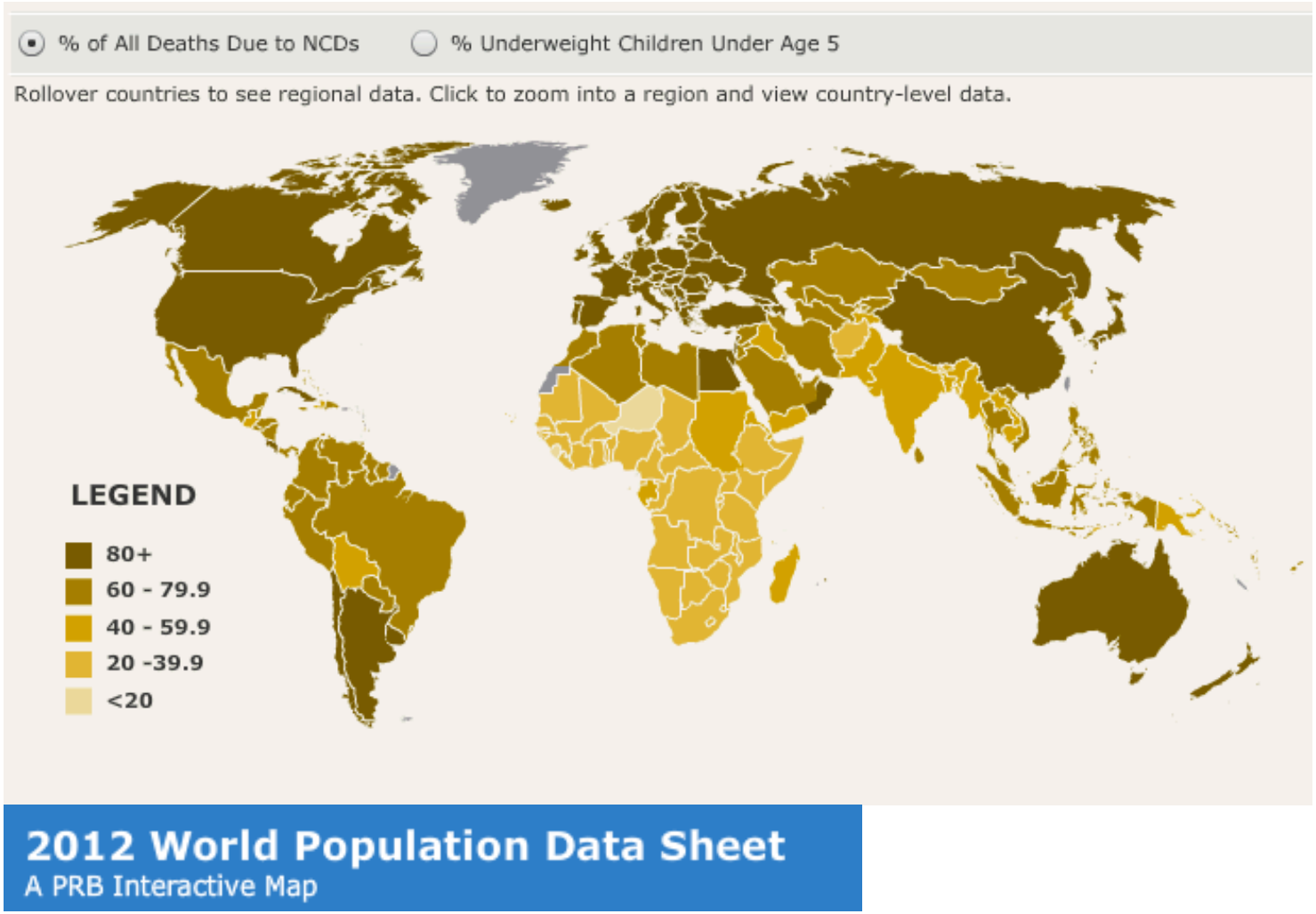


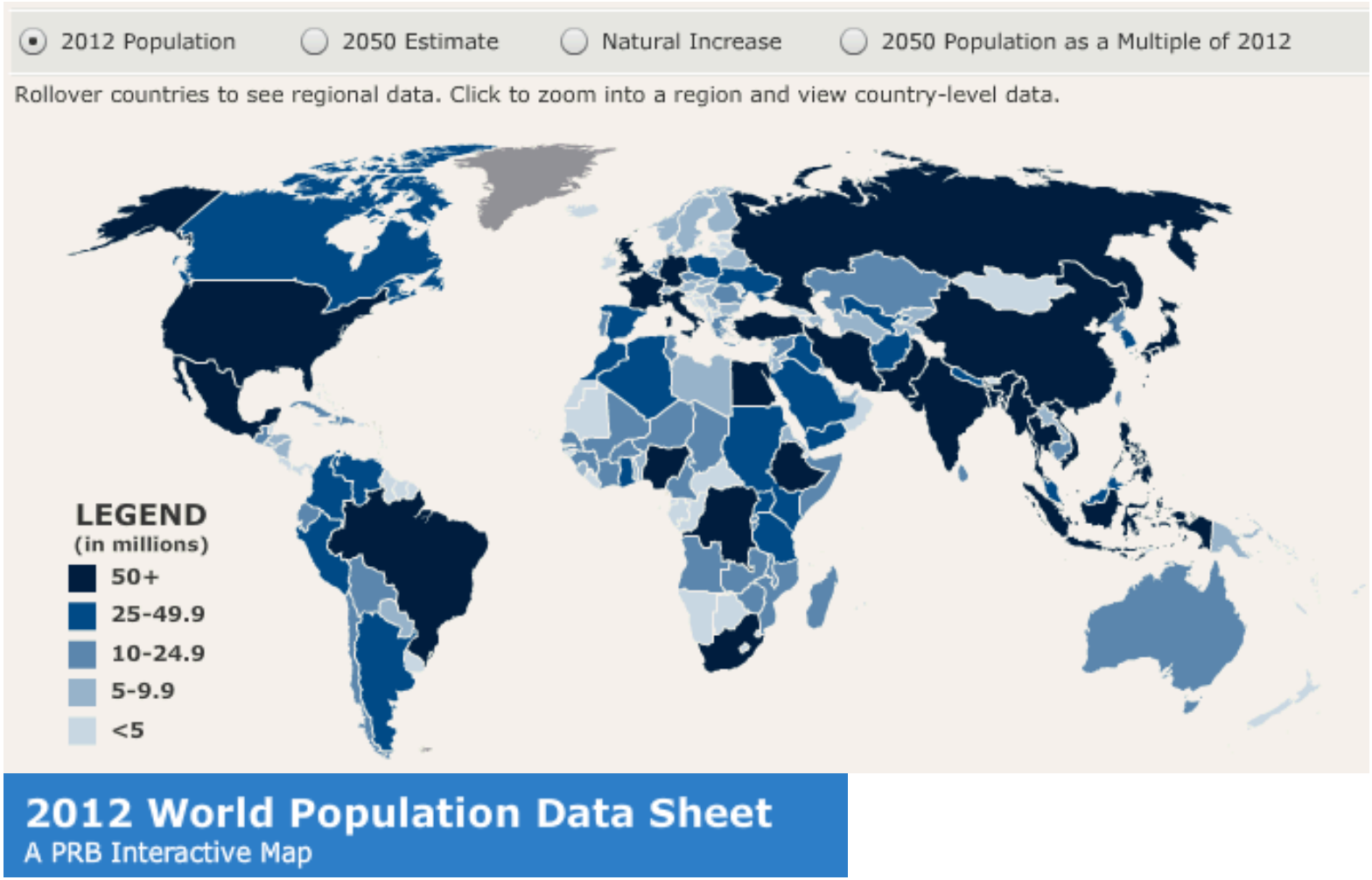

**Figure 1.** Evolution of the food industry in terms of value added to products and shift in emphasis from process engineering to product engineering. This transition has implied a change in concepts and techniques that support each approach.

[1]Aguilera J. (2006). J. Sci. Food & Agric. 86(8): 1147-55.

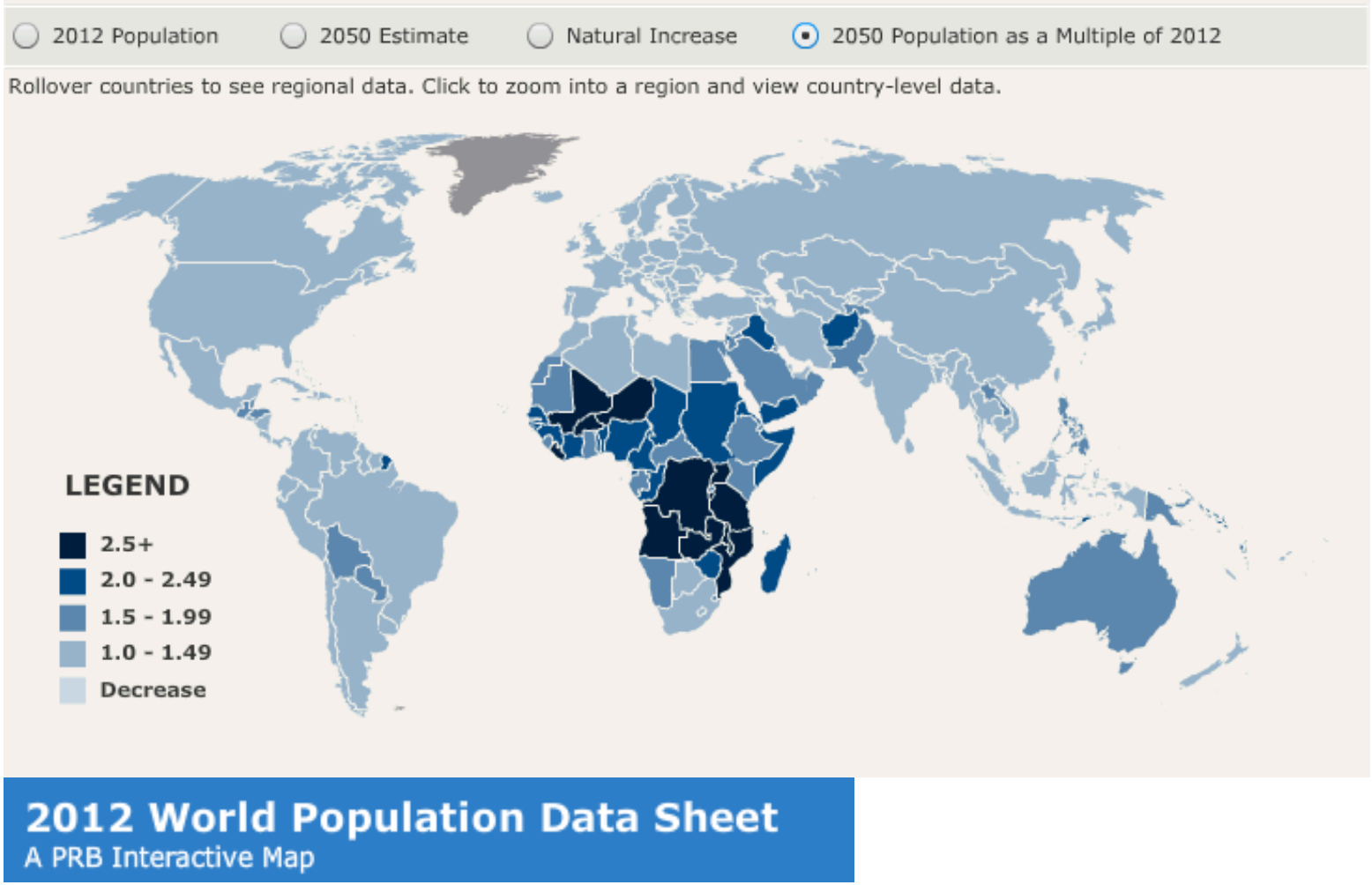
# World population ageing



# World population growth



# World population growth



# Environment, Food Security & Sustainability

- **Environment:**
  - **Water scarcity & management (withdrawal could exceed natural renewal by 60%, by 2030)**
  - **Farmland diminishing**
  - **Energy sustainable supply, storage, transport, renewable & alternative resources**
- **Food security: safe, nutritious food ➔ feed the world (1.3 Bn suffer chronic hunger vs. obesity)**
- **Sustainability, green technologies, processes for less developed regions, waste management.**

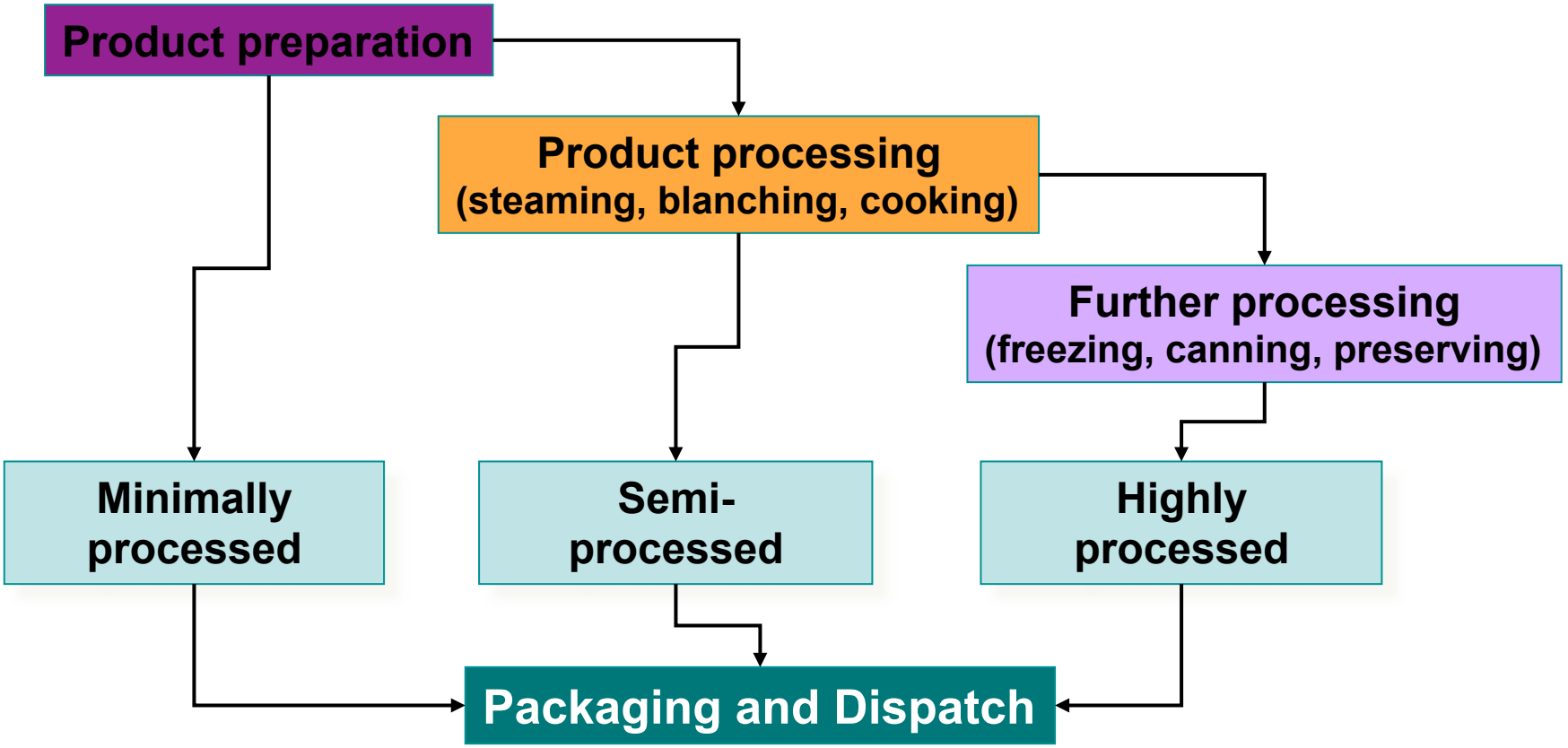
Sam Saguy 2012, 17th Workshop: Italian PhD Res. On FST & Biotechnology

# Consumers Requests

- ✓ Fresh like, convenient, healthy

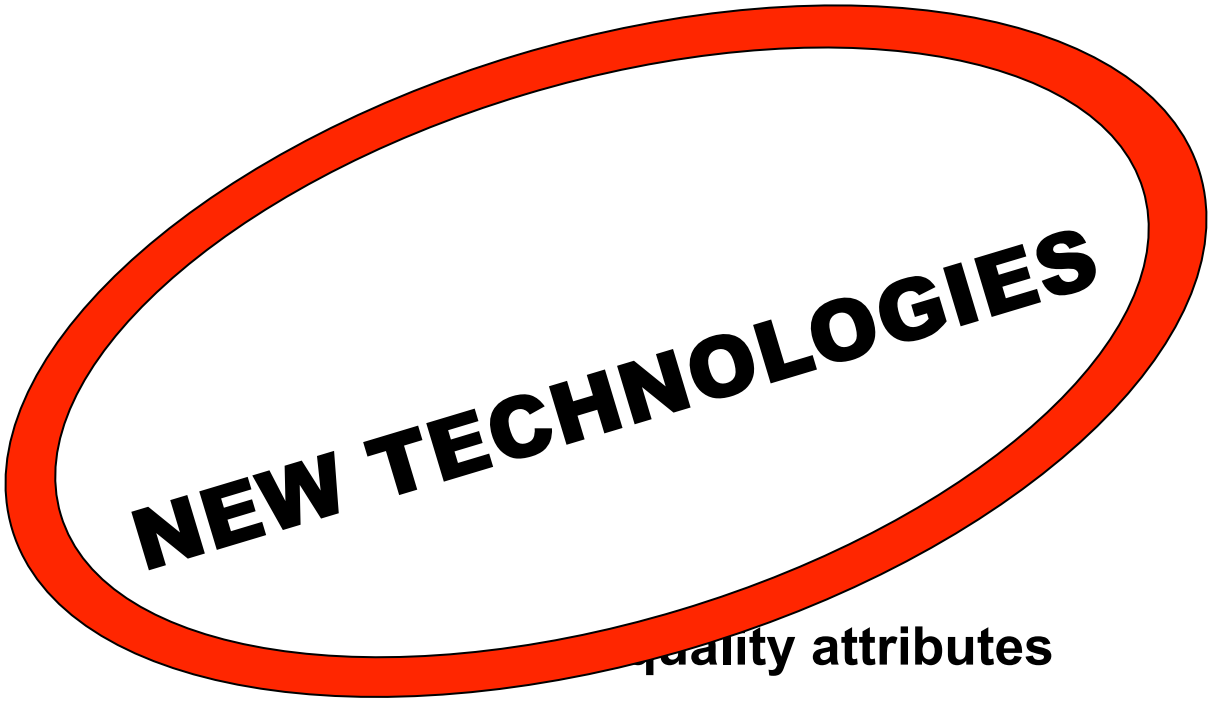
- ✓ Environmental care

# Role of non-thermal processes



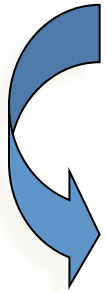
# Role of non-thermal processes

**The problem is… Heating!**



# Role of non-thermal processes

**NON-THERMAL TECHNOLOGIES**



**little loss of:**
- **colour**
- **flavour**
- **texture**
- **nutrients**

**…but still retaining the desired shelf-life and safety!**

# Non-Thermal processes

| | |
|---|---|
| **Pulsed Electric Fields** | **Exposure of food to an intense electric field by means of controlled pulses of high voltage** |
| **Ohmic Heating** | **Generation of heat inside the food as a consequence of Joule effect** |
| **Radio Frequency** | **Exposure of food to electromagnetic waves in the radio-frequency range** |
| **Microwave** | **Exposure of food to controlled microwaves** |
| **High Pressure** | **Short-time exposure to extremely high pressure (up to 5000 bar)** |

# Non-Thermal processes

| | |
|---|---|
| **Super Critical $CO_2$** | **Contact of food with $CO_2$ at supercritical pressure** |
| **Ozone** | **Exposure of food to ozone** |
| **Ultrasonication** | **Exposure of foods to ultrasounds (US)**<br>**US + mild temperatures (T) → thermosonication**<br>**US + pressure (P) → manosonication**<br>**US + T + P → manothermosonication** |
| **UV-C** | **Exposure of food to controlled pulses of UV rays** |

# Ozone, Ultrasonication & UV-C

| | |
|---|---|
| **Ozone** | **Exposure of food to ozone** |
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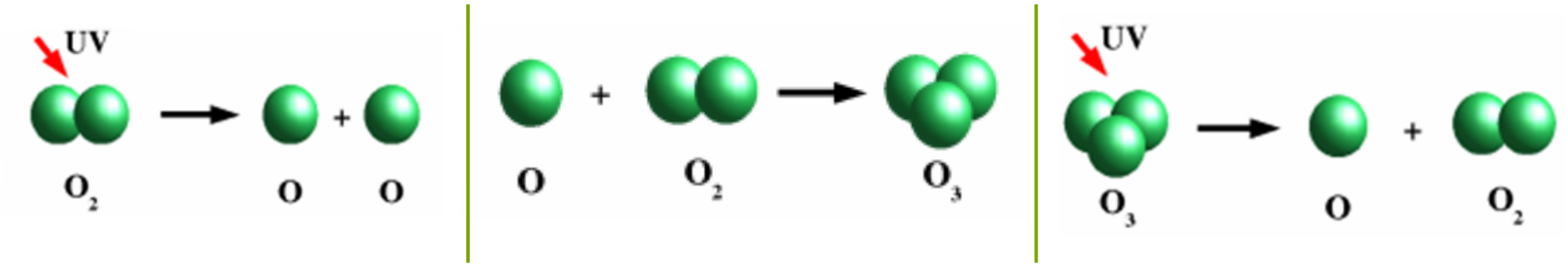
# OZONE

- Gas formed by 3 oxygen atoms
- Highly instable
- In nature it is formed by the action of sun UV light (185 nm)



# OZONE

-**Commercially**:

**Ozone generated by Electrical Discharge**

# OZONE

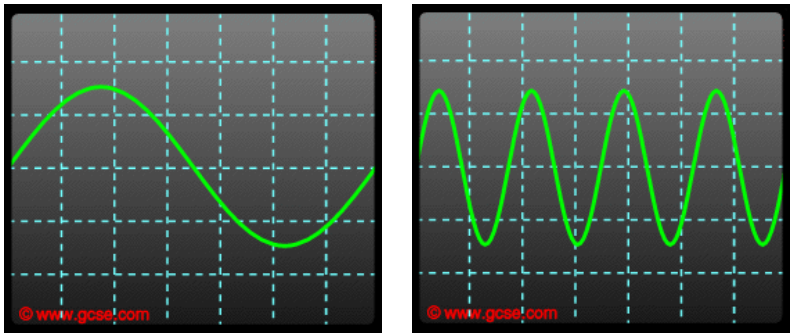
- Powerful antimicrobial agent → strong oxidant
- Lethal or inhibitory effect on microorganisms due to its reaction with:
  - intracellular enzymes
  - nucleic material
  - membrane components → destruction of coating of spores and viral capsules

# ULTRASOUNDS

- **Vibrations similar to sound waves**

- **Very high frequencies: 18 kHz – 500 MHz → greater than upper limit of human hearing!**

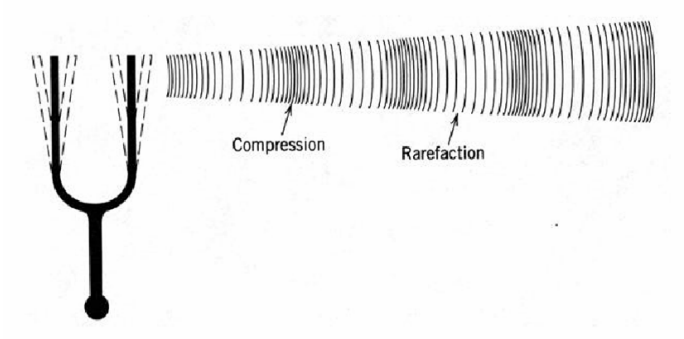
- **Some animals, such as dogs, dolphins, and bats, have an upper limit that is greater than that of the human ear and thus can hear ultrasound.**

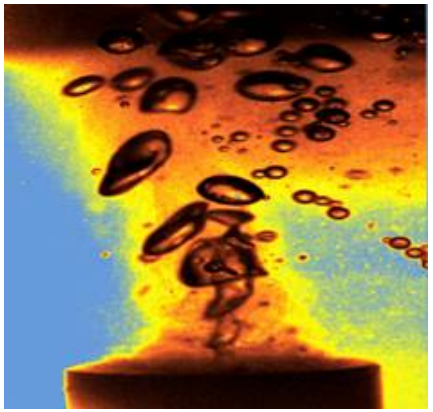


# ULTRASOUNDS

- **In a biological medium: production of compression and expansion cycles**

  **→ CAVITATION phenomenon**

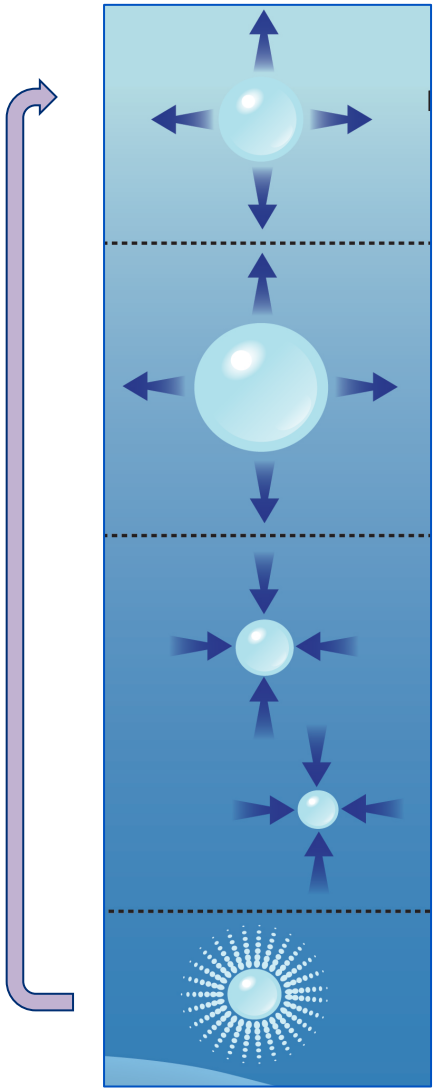


# ULTRASOUNDS

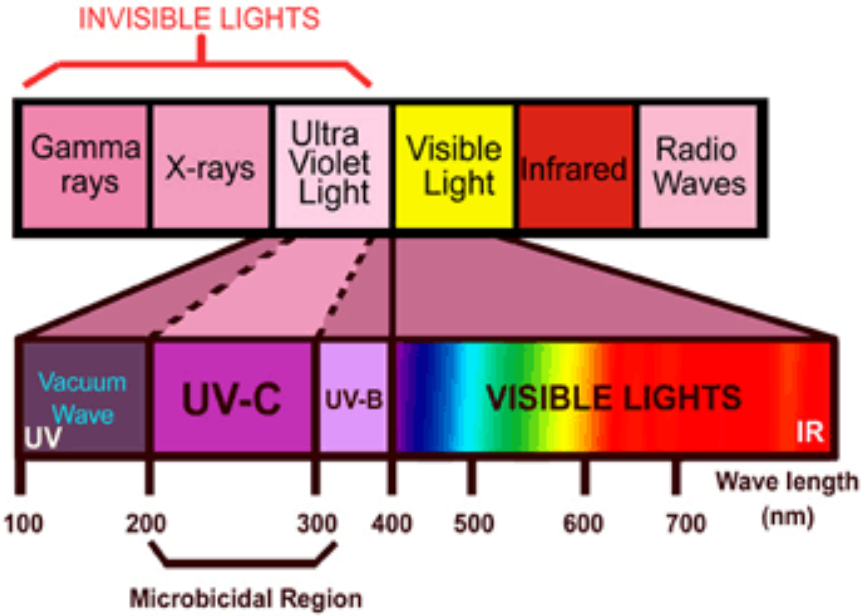
- **The implosion of gas bubbles → high temperature and high pressure spots**

  **→ Cell disruption → cellular death**



# ULTRAVIOLET RADIATION

- **Ultraviolet light in the non-ionizing region of the electromagnetic spectrum, between X-rays (200 nm) and visible light (400 nm)**



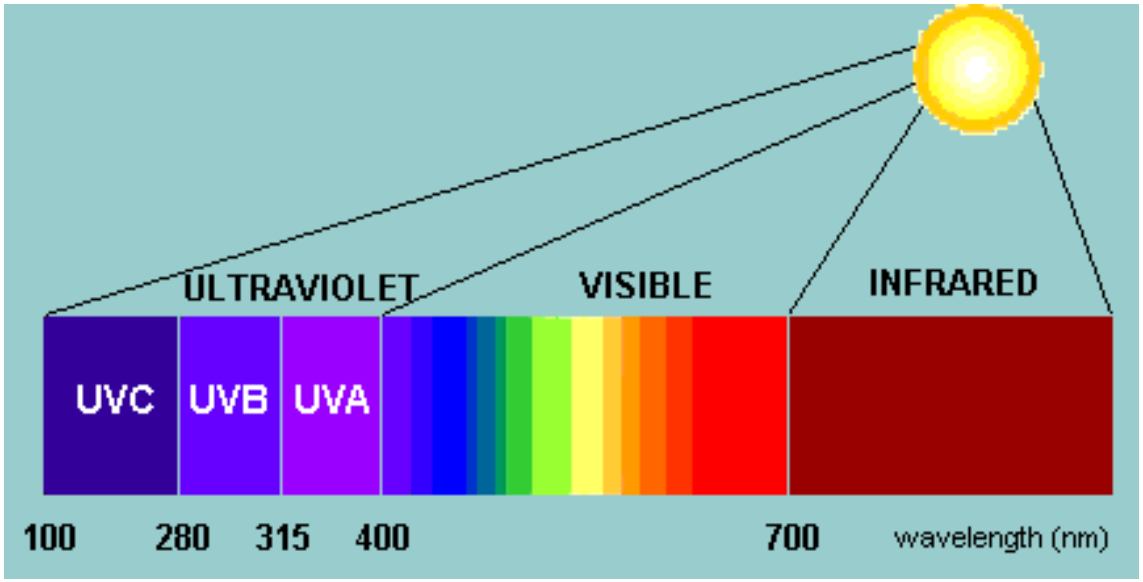
# ULTRAVIOLET RADIATION

**UV light can be divided into three regions:**

**- UVA: 320-400 nm – therapeutic effects (dermatological);**

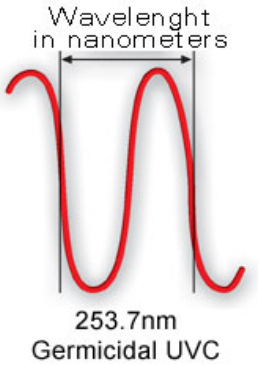
**- UVB: 280-320 nm – sun burn and plant damage**

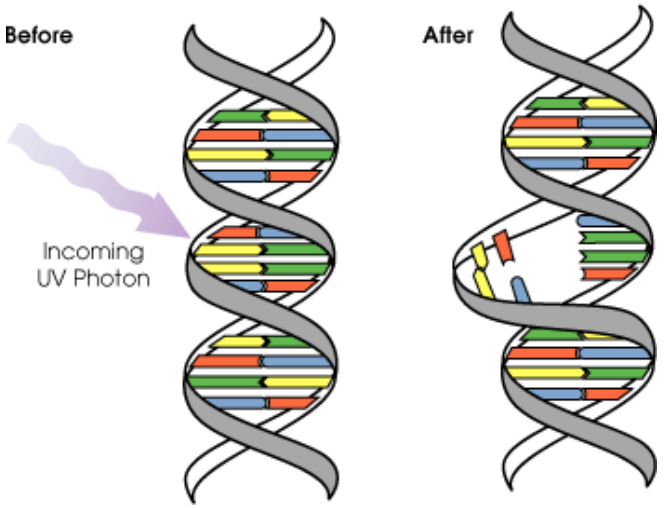
**- UVC: 100-280 nm – dangerous to life – maximum lethal effect at 254 nm**



# ULTRAVIOLET RADIATION - UVC

**Lethal effect (254 nm) due to its destroying action on DNA chains → decreasing or inactivation of vital functions of cells**



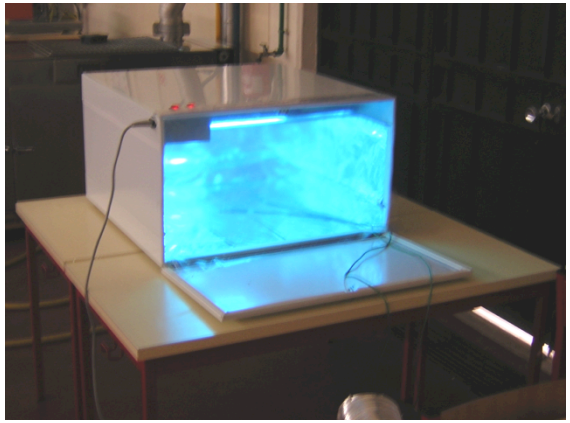



## Ozone


## Ultrasounds



## UV-C

# Products

Strawberry

Red bell pepper

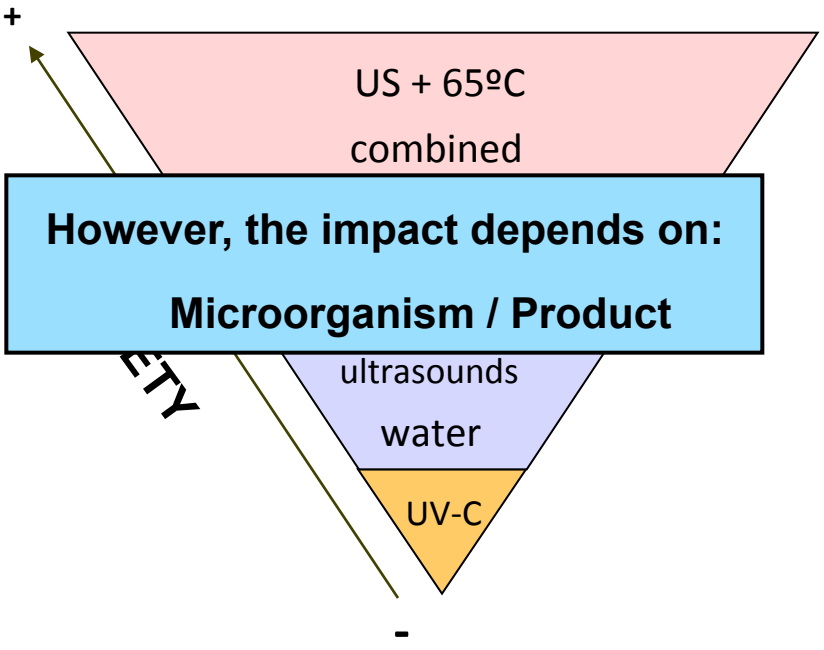
Watercress

Brocoli

Courgette / squash

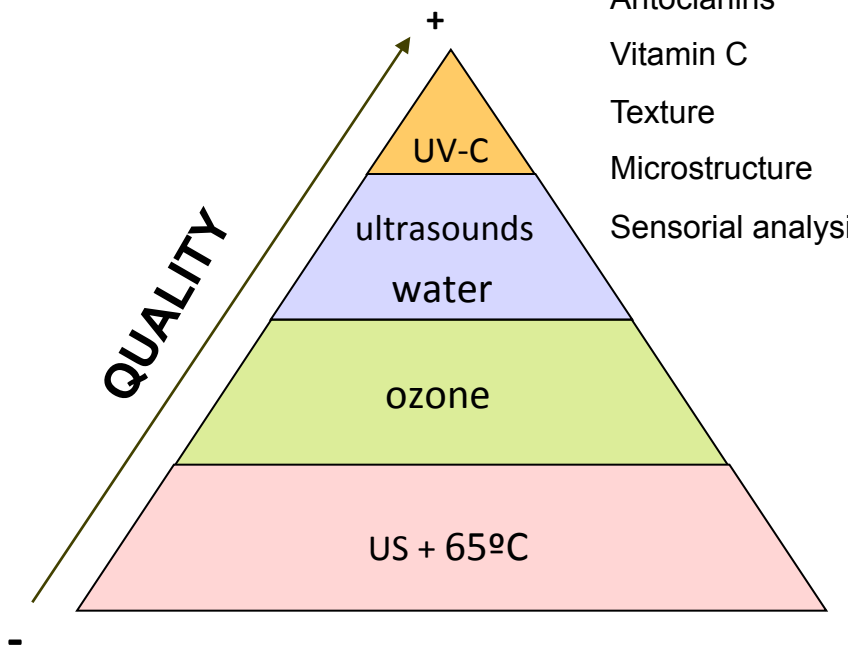
pumpkin

# SAFETY

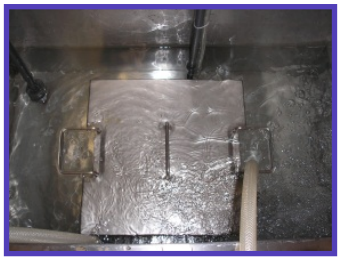



# QUALITY

Colour
pH
Antocianins
Vitamin C
Texture
Microstructure
Sensorial analysis




**Compromise: safety + quality**

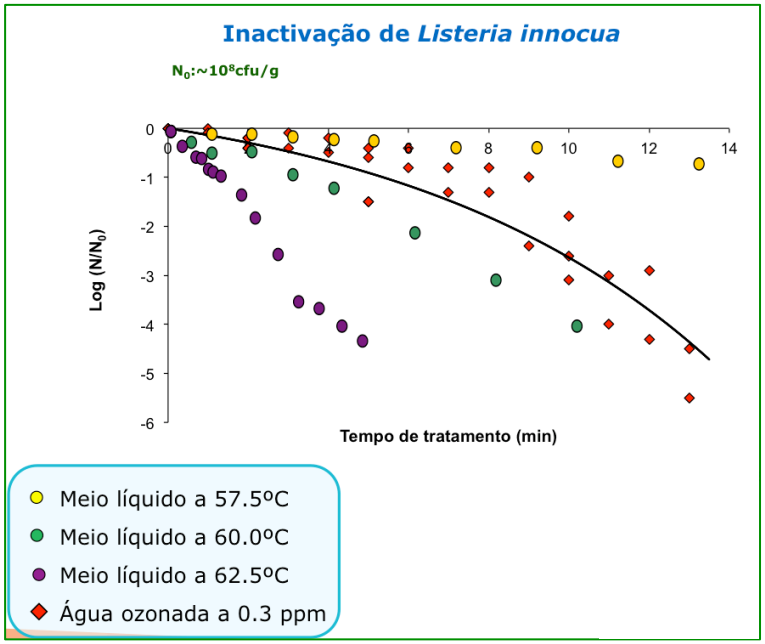


15 minutes

Ozonation

Inumeration

**Weibull model**

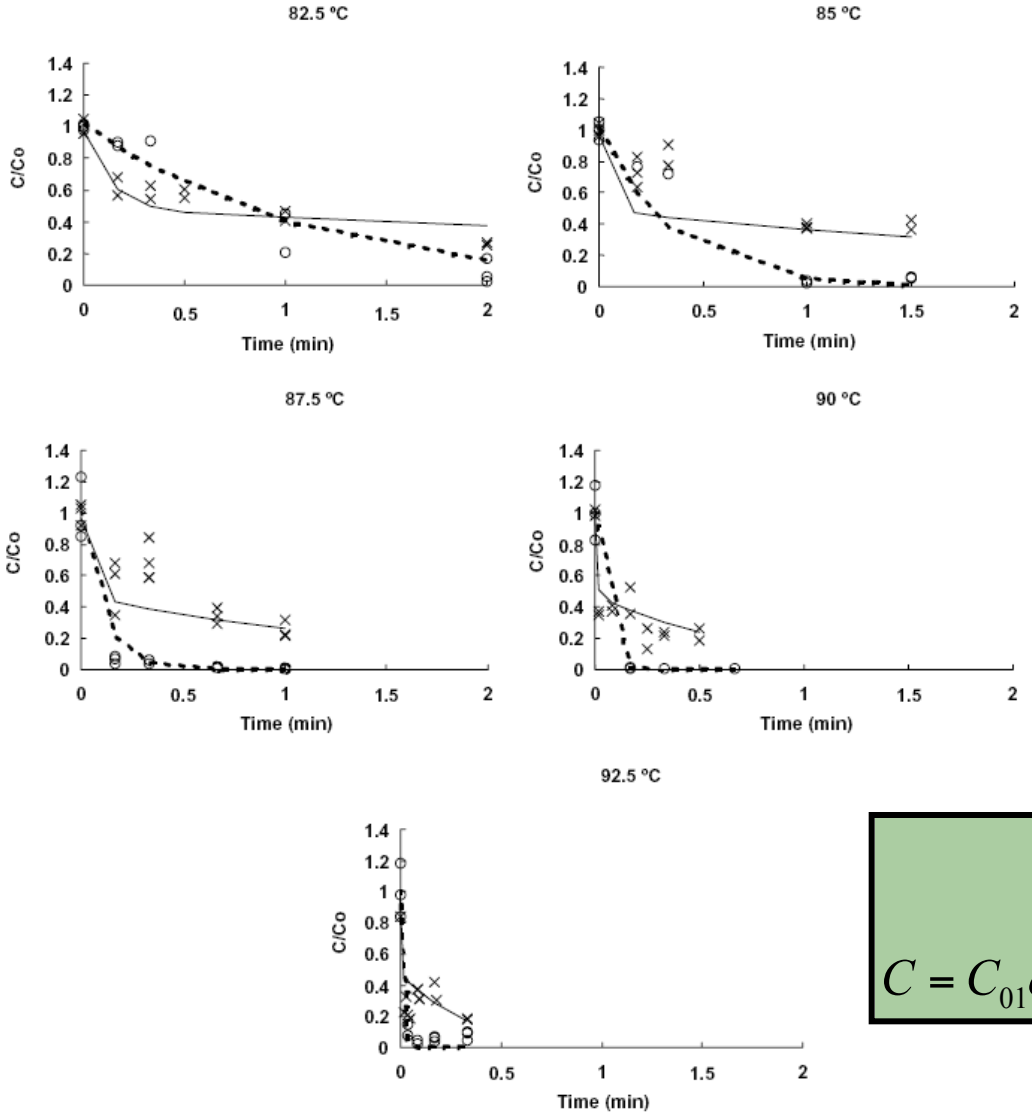


# Case Study

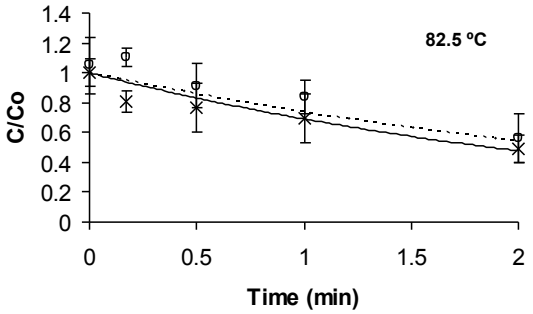
**Effect on Peroxidase ….**

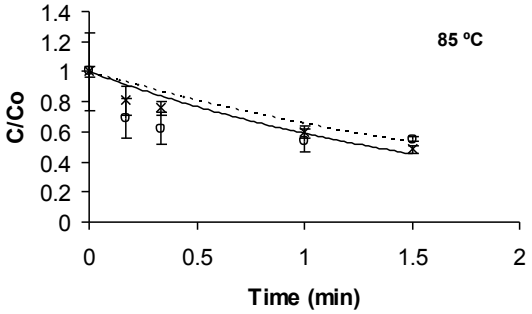
**Synergetic effect of**

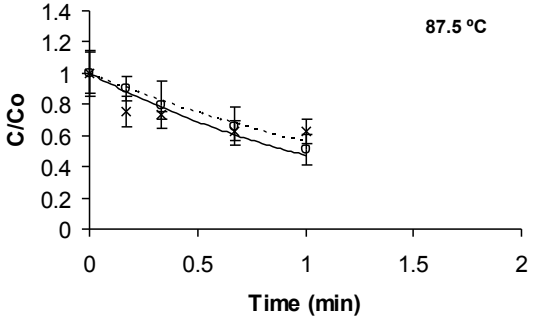
**Temperature and ultrasonication**

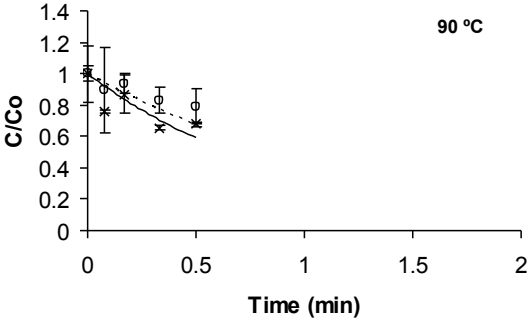


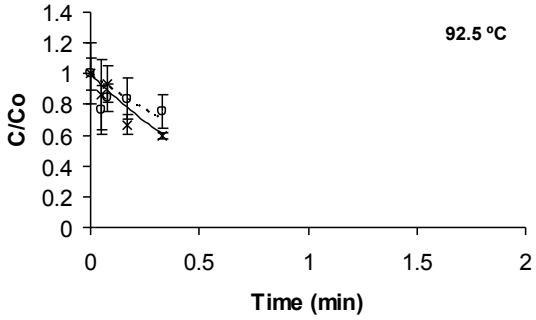

$$C = C_{01}e^{\left[-k_{1ref}e^{\left(\left(-\frac{Ea_1}{R}\right)\left(\frac{1}{T}-\frac{1}{T_{ref}}\right)\right)}t\right]} + C_{02}e^{\left[-k_{2ref}e^{\left(\left(-\frac{Ea_2}{R}\right)\left(\frac{1}{T}-\frac{1}{T_{ref}}\right)\right)}t\right]}$$



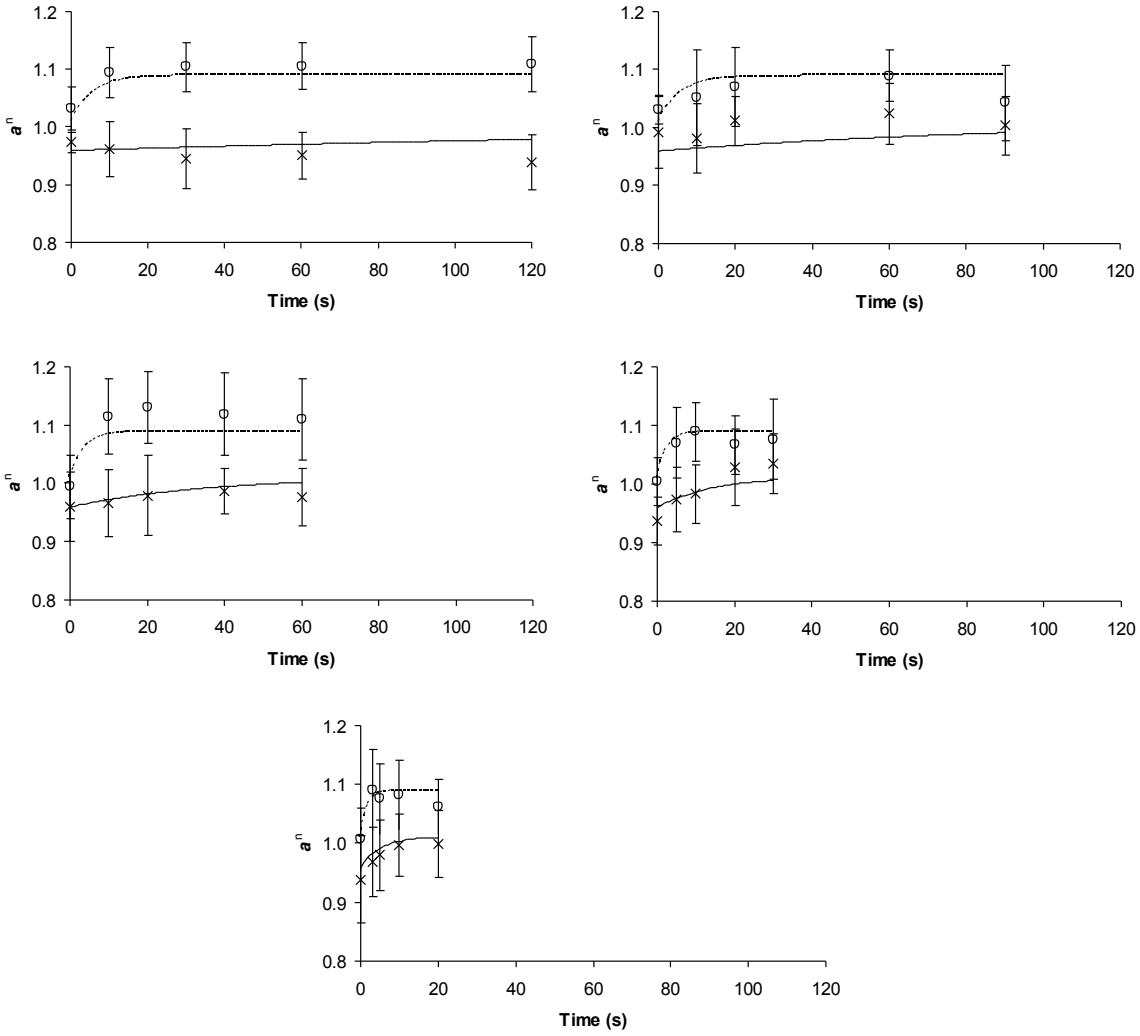




## Vitamina C

$$\frac{C}{C_0} = e^{\left\{-k_{\text{ref}} e^{\left[-\frac{E_a}{R}\left(\frac{1}{T}-\frac{1}{T_{\text{ref}}}\right)\right]} t\right\}}$$

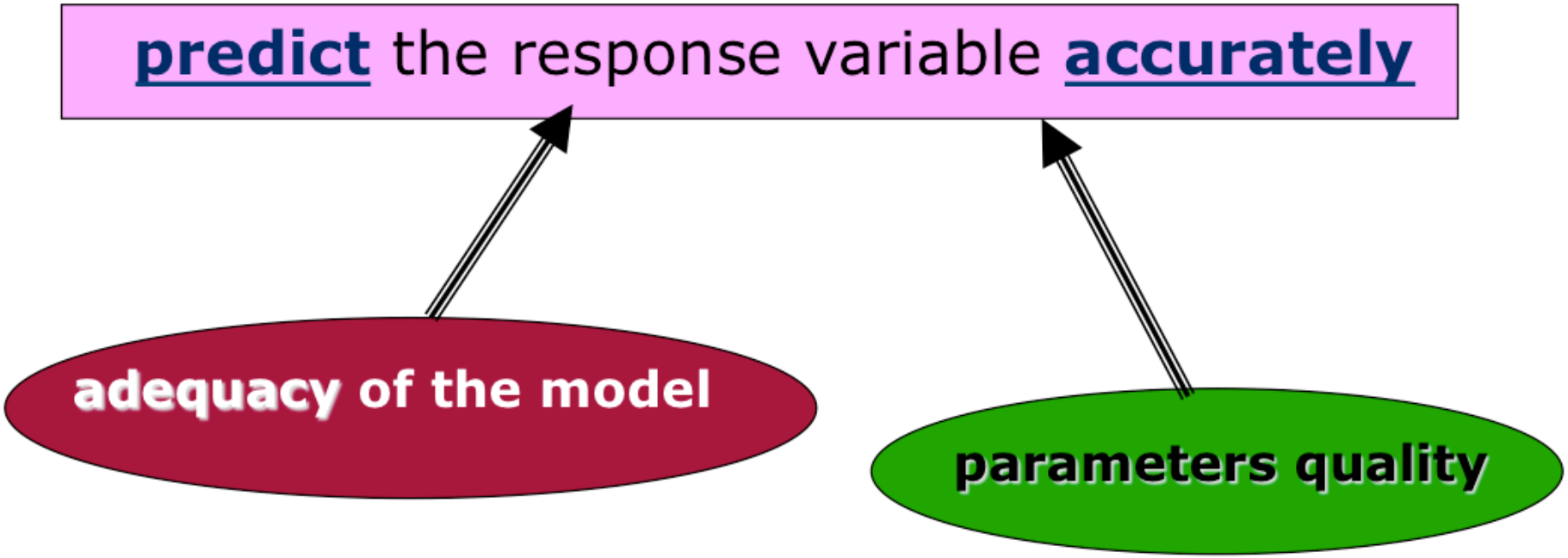



## Colour a*

$$\frac{C - C_e}{C_0 - C_e} = e^{\left\{-k_{ref} e^{\left[-\frac{E_a}{R}\left(\frac{1}{T} - \frac{1}{T_{ref}}\right)\right]} t\right\}}$$

# Role of Mathematical Modelling

## Models should:



# The complexity of dynamic conditions

**Laboratory research**


**Industrial scale**

# The complexity of dynamic conditions

**Laboratory research**

- Studies are often carried out at constant temperatures

**Industrial scale**

- Time-varying temperature conditions are common

**transfer of results is compromised**

**isothermal**

**non-isothermal**

# Horizon 2020

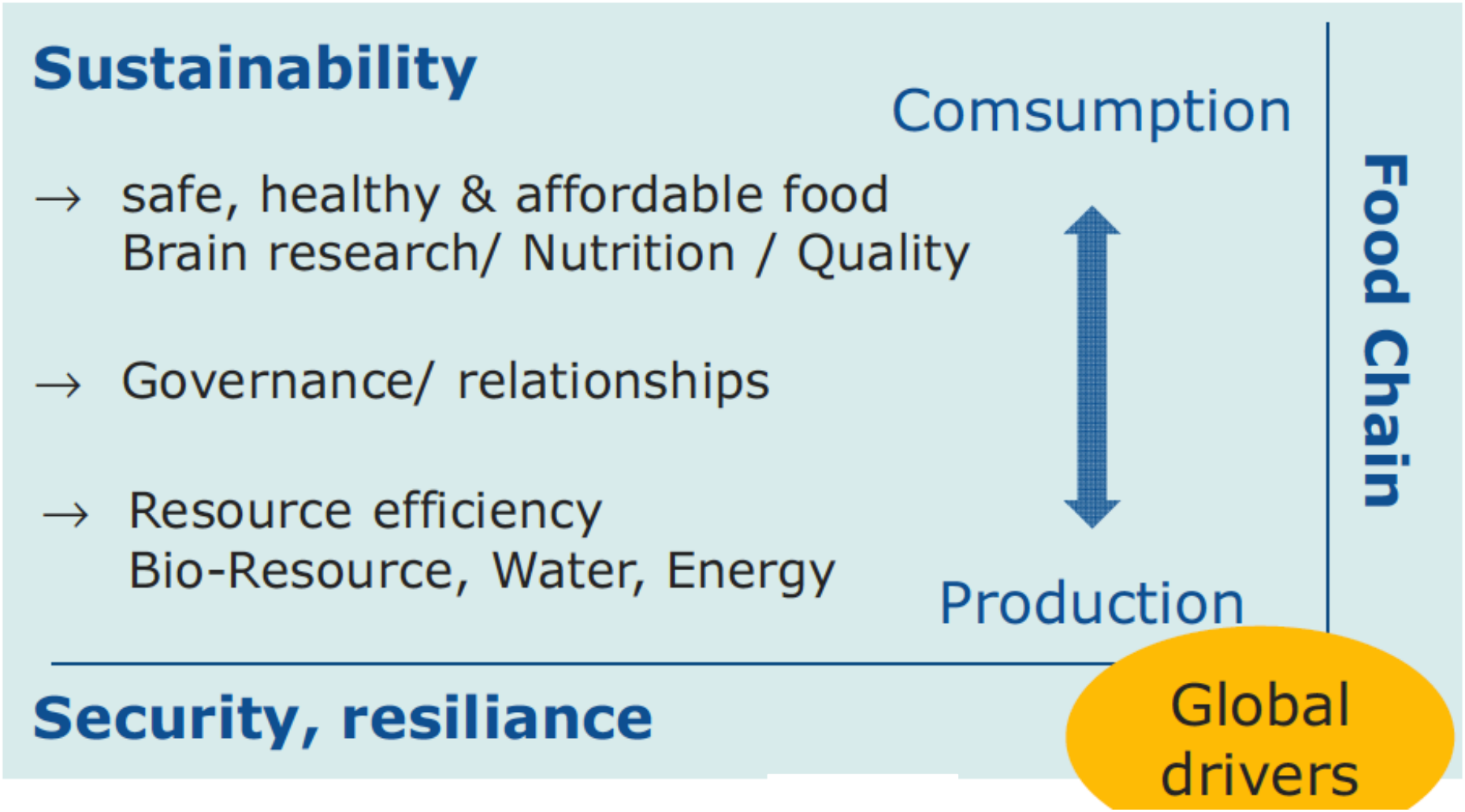
- **Consumers**, societal, industrial & health aspects
- **Nutrition**, diet-related diseases & disorders
- Innovative food & feed **processing**
- Improved **quality & safety** of food, beverage & feed
- **Environmental impacts** & total **food chain** concept

# Horizon 2020

**Currently faced with:**

- Demographic changes (↑ world population, aging)
- ↑ food-related health problems
- ↑ environmental pressures
- ~ competitiveness & resilience of agri-food systems

# Horizon 2020



# Challenges

- ✓ Europe's strategic 2020 goal is for EU to become smart and sustainable economy.
- ✓ Smarter technologies have to be developed, with the objective to substitute fossil by renewable sources.
- ✓ The actual ageing population, life style diseases, pathologies linked to nutrition and poverty present large challenges for food processing and preservation, and industries require **advanced knowledge** not only on preservation methods, but also nutrition, food safety issues, consumer and behavioural science, information technology as well as management of the food chain.


Thank you