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ESCOLA SUPERIOR DE BIOTECNOLOGIA

15th World Congress of Food Science and Technology

INTEGRATING QUALITY AND SAFETY IN THERMAL AND NON-THERMAL FOOD PROCESSES

Teresa R.S. Brandão[1], Mafalda Quintas[1,2], Cristina L.M. Silva[1]

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August 22-26, 2010
Cape Town, South Africa

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Thermal Processes

... Originally designed to inactivate

spoiling and pathogenic microorganisms

safety

bacteria
yeasts
molds

and **enzymes**

quality

prevent the degradation of the original **organoleptic** and **nutritive** food characteristics

however ...

thermal processes affect negatively quality factors

safety

Pathogenic bacteria

Chemical contaminants

...

quality

Texture

Microstructure

Colour

Vitamin C

...

recently ...

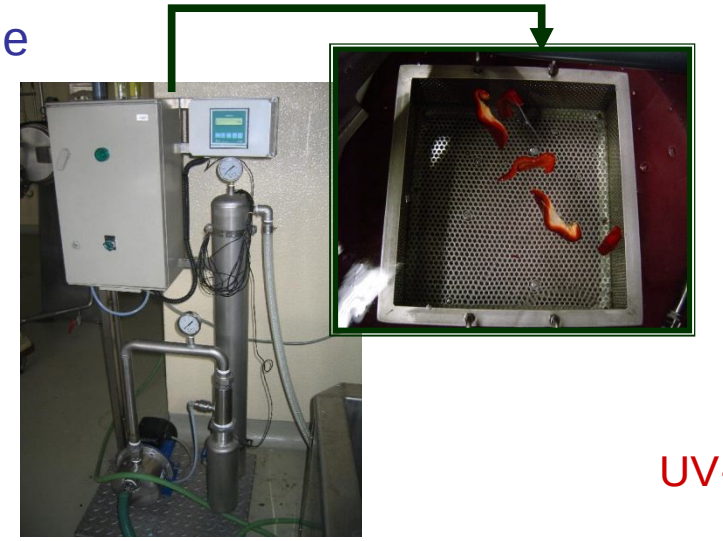
Non-thermal processes have been proposed as technologies able to

- **inactivate spoiling and pathogenic microorganisms & enzymes**

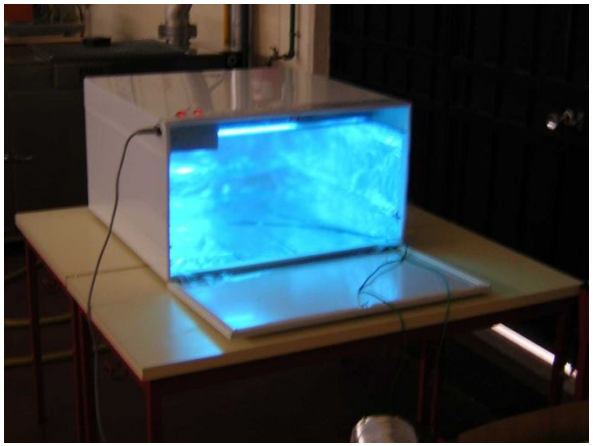
- **while retaining nutritional and sensorial properties**

Examples of Non-Thermal Technologies for food processing

Ozone



UV-C radiation



Ultrasonication /

Thermosonication

Adequate and efficient process design

must take into account…

- type of product
- desired shelf-life
- main sensorial properties
  - to the consumer
  - more “process sensitive”
- main nutritional aspects
- more significant microbial contaminants
- principal spoiling pathways

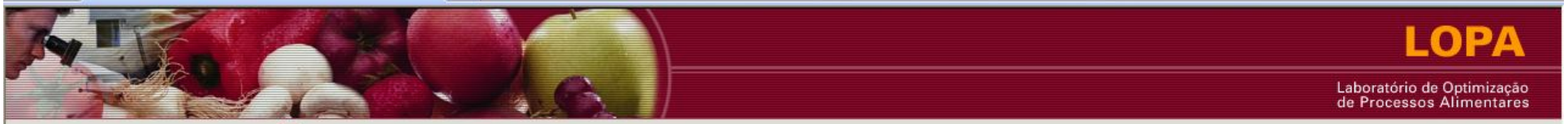
Mathematical modeling is a main allied in collecting data and systematization of information

Today's Presentation

1. The role of mathematical modeling on understanding process induced changes in foods

2. Heat Processing – effect on food quality and safety

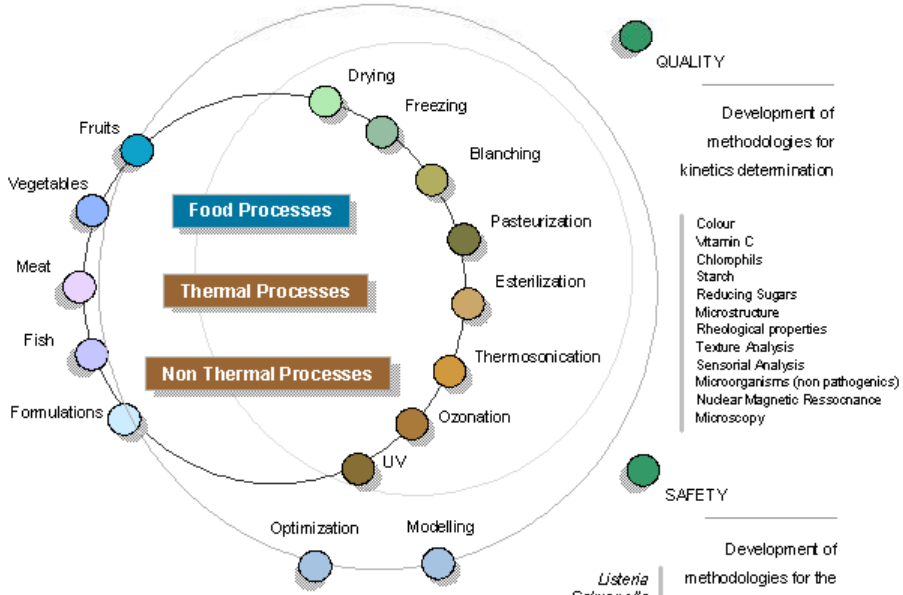
3. Combining Heat and other Non-Thermal Technologies to preserve foods



LOPA

Laboratory for the Optimization of Food Processes

LOPA - Laboratory for the Optimization of Food Proc esses - is a laboratory aiming the research in the food quality and food safety fields, with a strong work on process modelling and optimization.



QUALITY

Development of methodologies for kinetics determination

Colour
Vitamin C
Chlorophils
Starch
Reducing Sugars
Microstructure
Rheological properties
Texture Analysis
Sensorial Analysis
Microorganisms (non pathogenics)
Nuclear Magnetic Ressonance
Microscopy

SAFETY

Development of methodologies for the determination of microbial kinetics

Listeria
Salmonella
E. coli
Pseudomonas

Thermal Processes (e.g. blanching, pasteurization e esterilization, drying and freezing) and **Non-Thermal Processes** (e.g. ozonation, thermosonication and UV) are the food processes on which our research effort lays on. The main research framework is based on horticultural products, although food formulations, meat and fish are emergent food products under our skills.

LOPA - Laboratório de Optimização de Processos Alimentares - Microsoft Internet Explorer provided by SINF

http://www.esb.ucp.pt/LOPA/

LOPA - Laboratório de Optimização de Processos Alim...

LOPA

Laboratório de Optimização de Processos Alimentares

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- Research team
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- Publications
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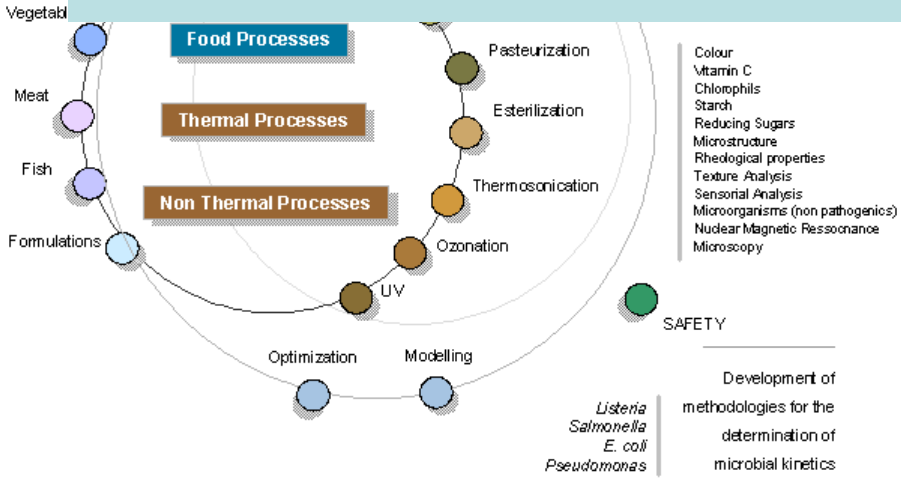

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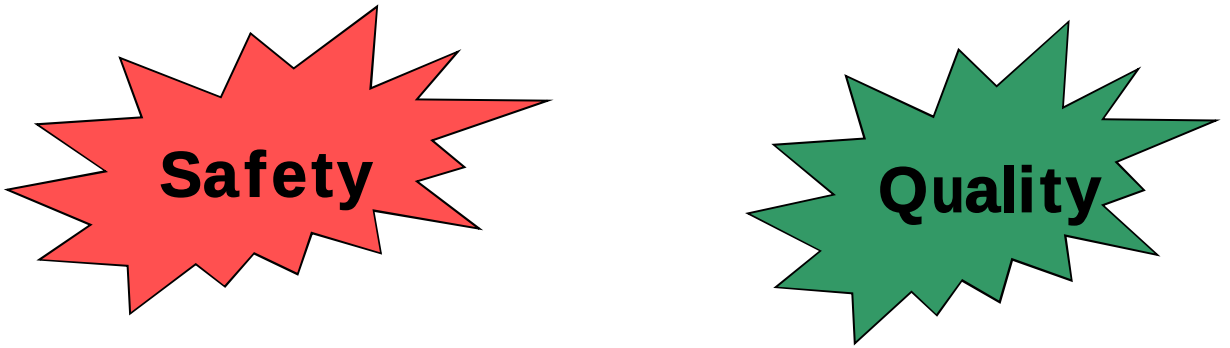
1. The role of mathematical modeling on understanding process induced changes in foods

Mathematical models



$$y = f(x, q) + e$$

process time

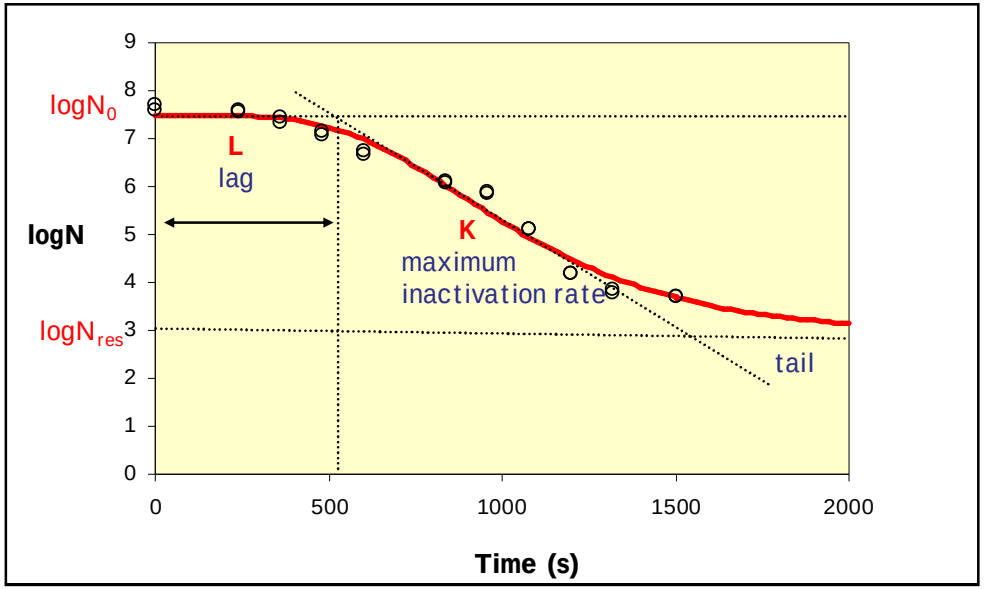
kinetic parameters

1. The role of mathematical modeling on understanding process induced changes in foods

One example of modeling …

Safety

microbial thermal inactivation in which the kinetic parameters of the model assumed are directly related to specific features …



N – microbial counts
N_0 – initial microbial counts

Gompertz-inspired model

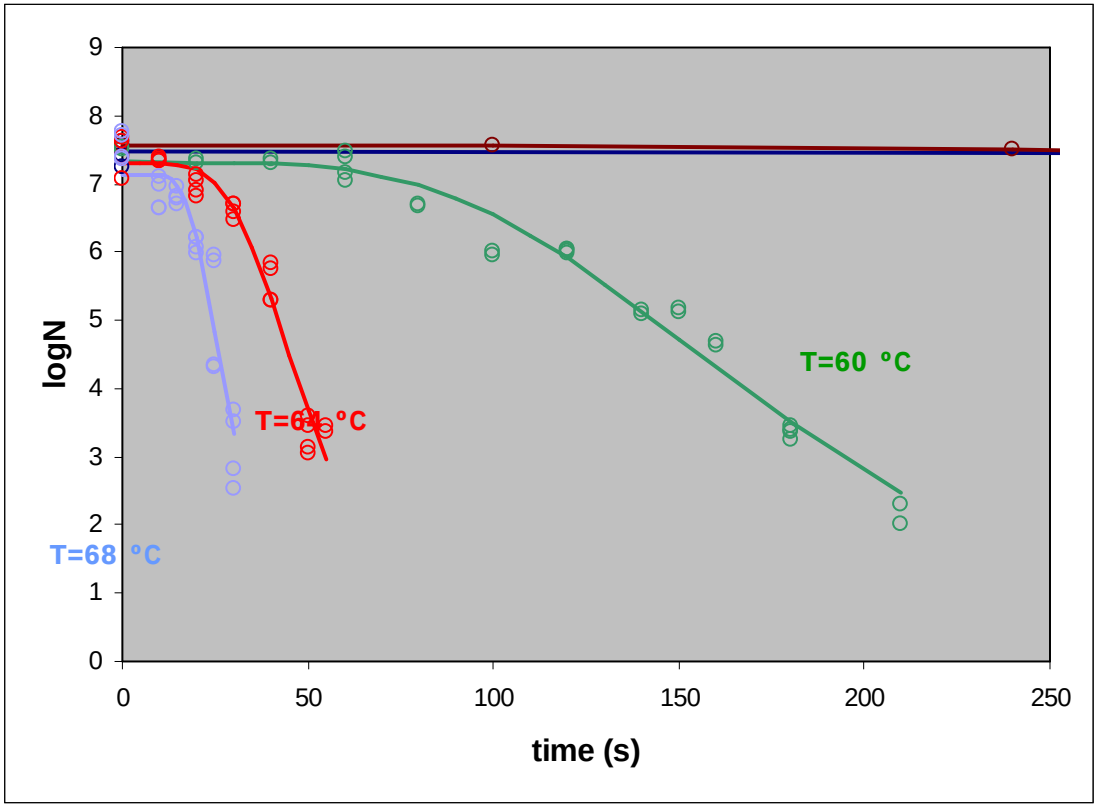
$$\log N = \log N_0 - \log\left(\frac{N_0}{N_{res}}\right)\exp\left(-\exp\left(\frac{k\,e}{\log\left(\frac{N_0}{N_{res}}\right)}(L - t) + 1\right)\right)$$

kinetic parameters

1. The role of mathematical modeling on understanding process induced changes in foods

One example of modeling …

Safety



Data of *L.monocytogenes* Scott A at 52,56,60,64,68°C

(24 hours incubation at 5°C in half cream) **Casadei et al. (1998)**

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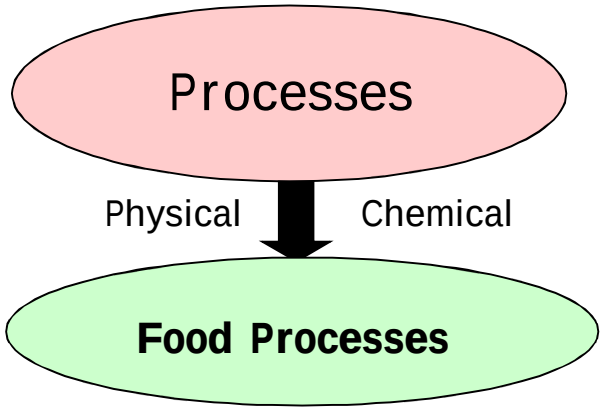
1. The role of mathematical modeling on understanding process induced changes in foods

Transport Phenomena
- heat
- mass
- *momentum*

Reaction kinetics

Properties



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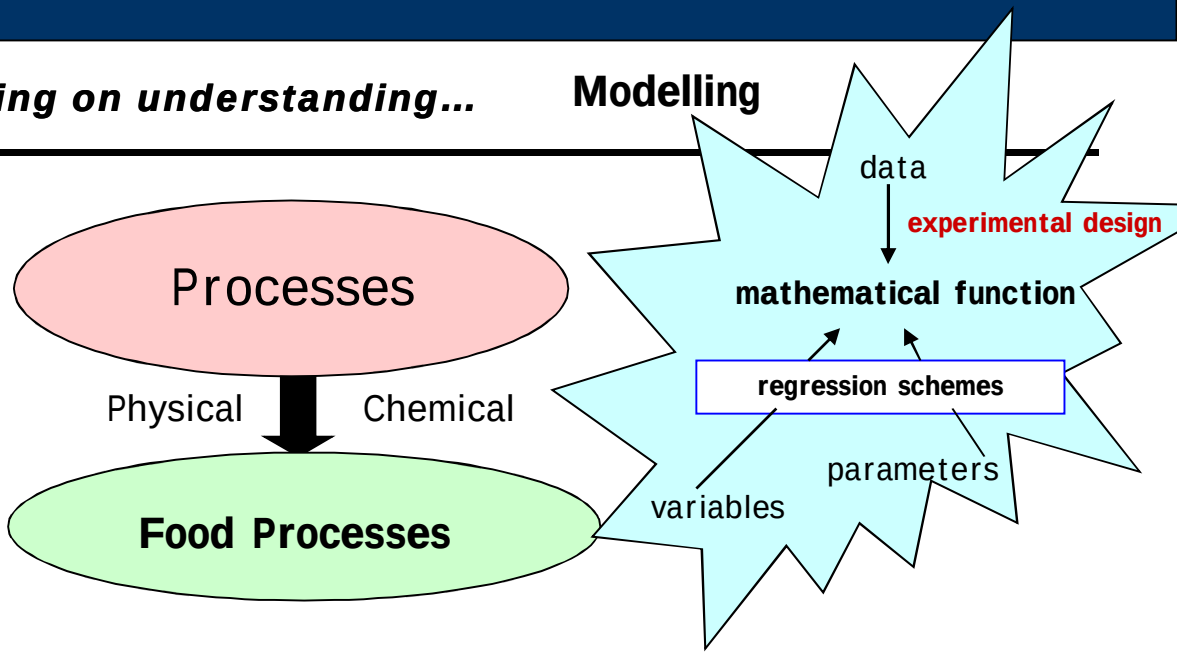

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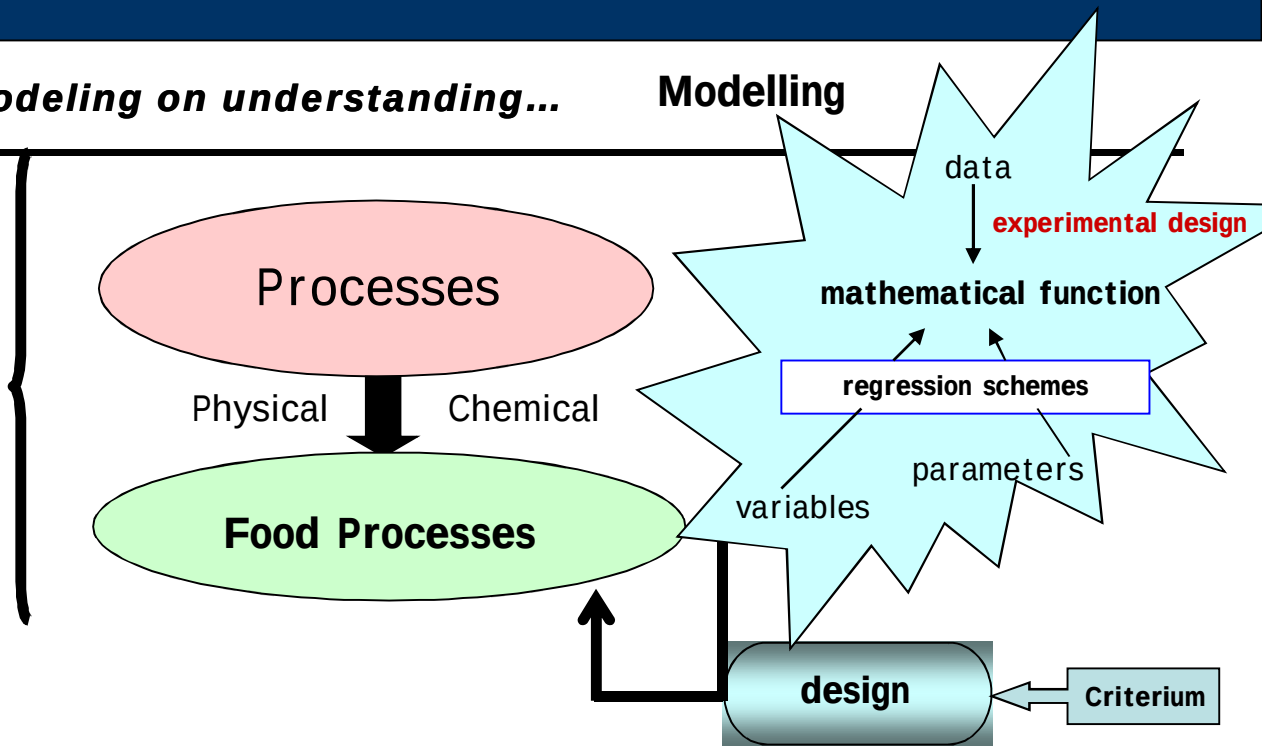

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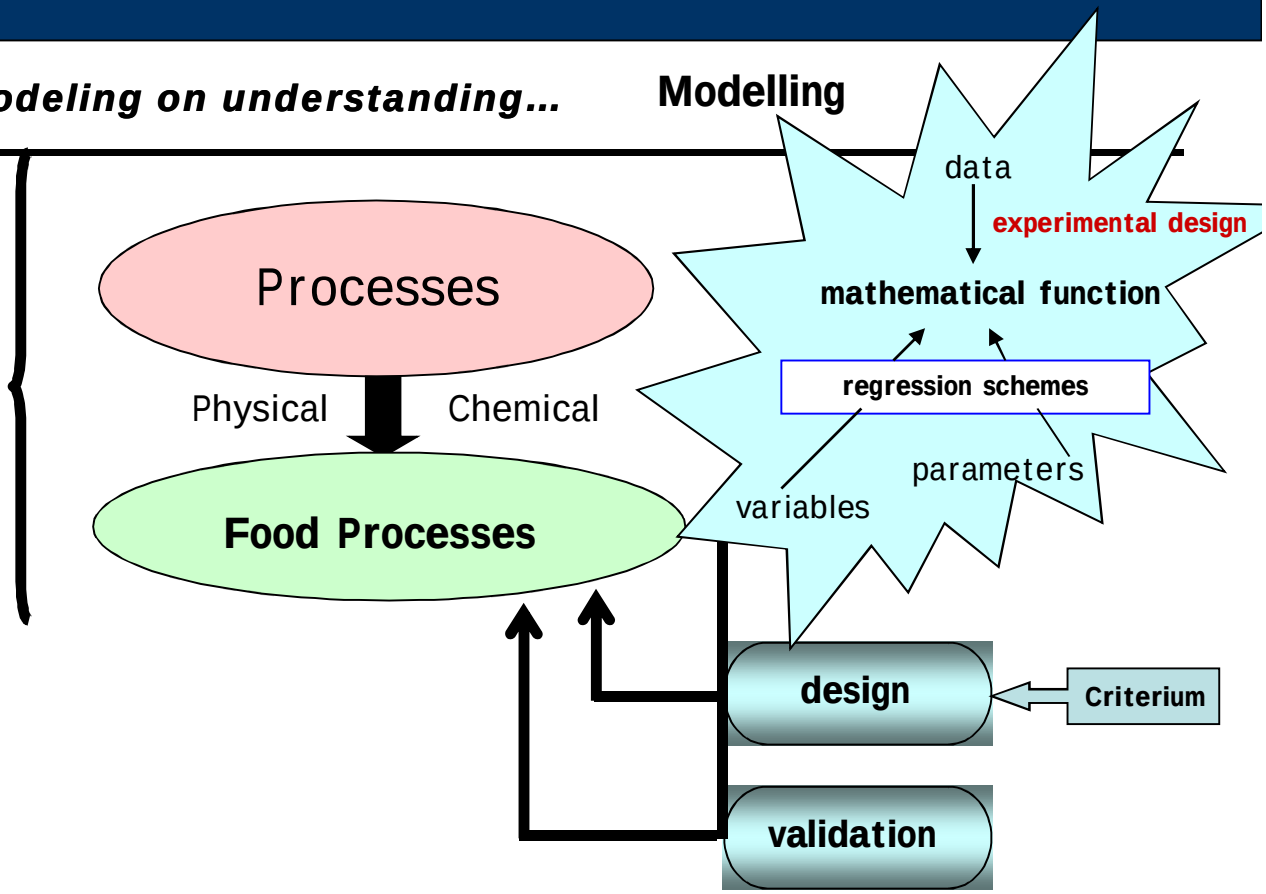

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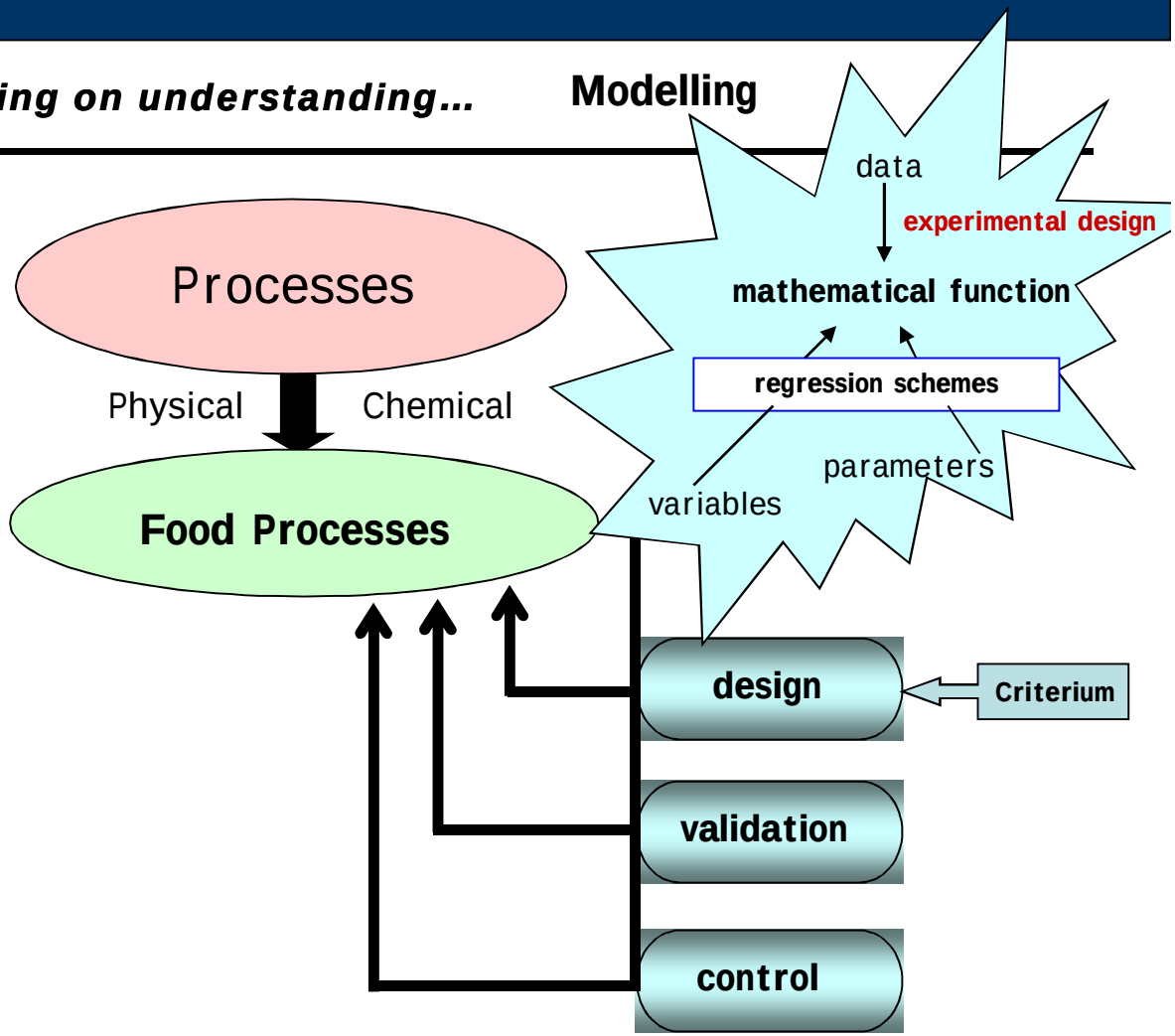

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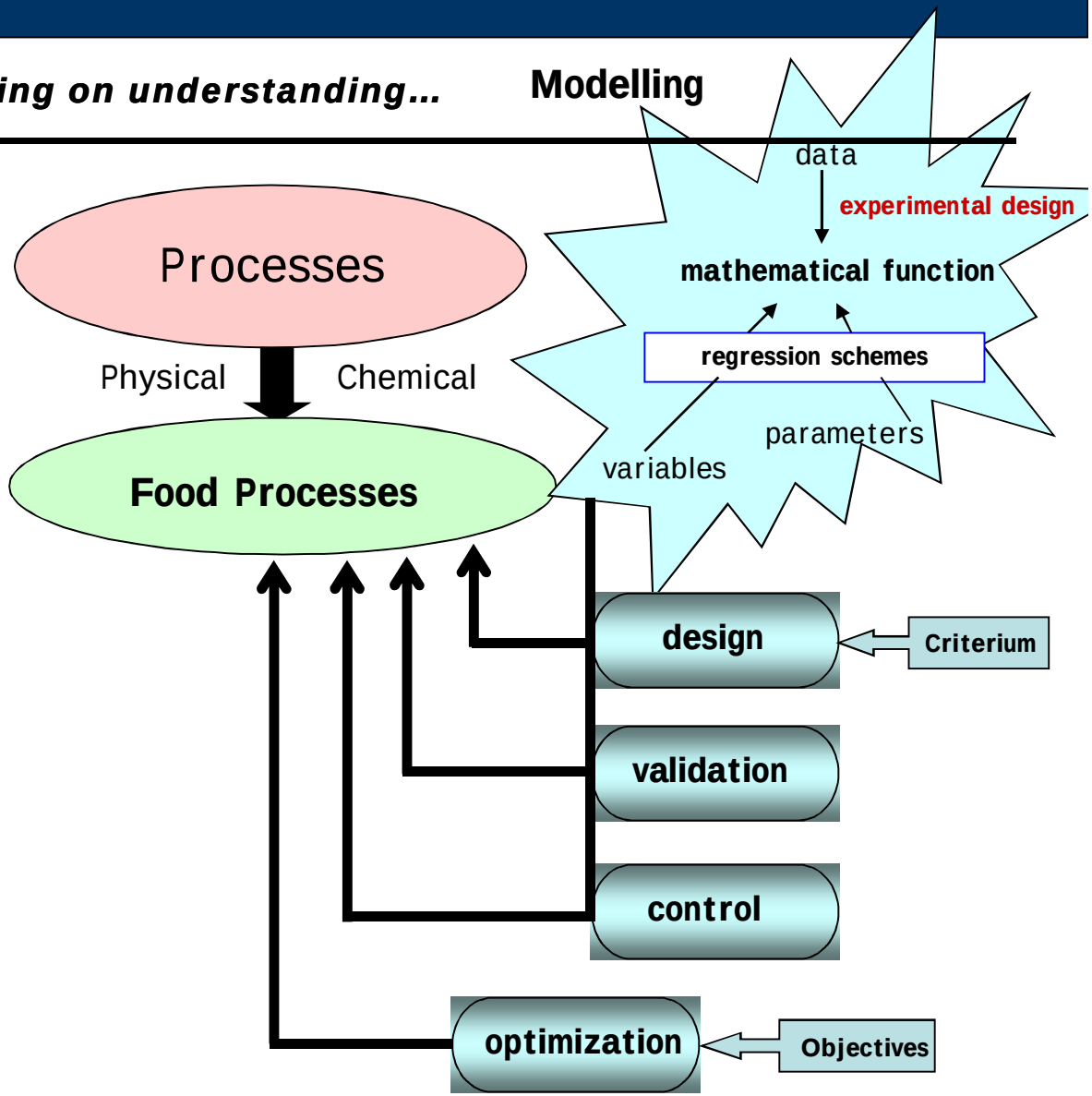

INTEGRATING QUALITY AND SAFETY IN THERMAL AND NON-THERMAL FOOD PROCESSES

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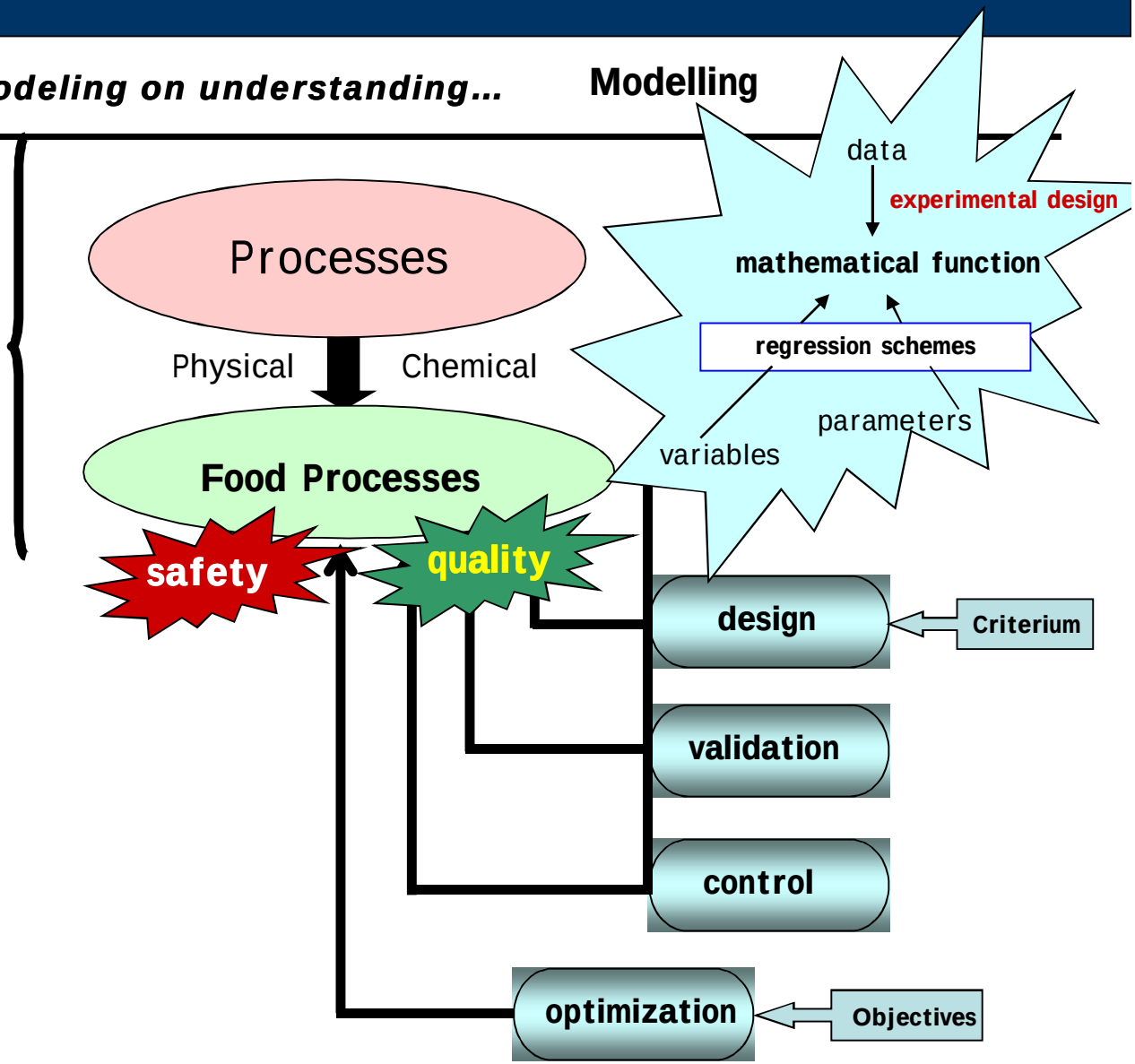


Today's Presentation

1. The role of mathematical modeling on understanding process induced changes in foods

2. **Heat Processing – effect on food quality and safety**

3. Combining Heat and other Non-Thermal Technologies to preserve foods

Blanching

In spite of the benefits of blanching, such as prolonging storage life by the inactivation of enzymes responsible for quality degradation and reducing the number of bacteria and other contaminants, it also leads to excessive loss of weight, alterations in colour, softening of the tissue and loss of nutrients through their diffusion into the water

… particularly important in **VEGETABLES**

2. Heat Processing – effect on food quality and safety

Blanching

Quality

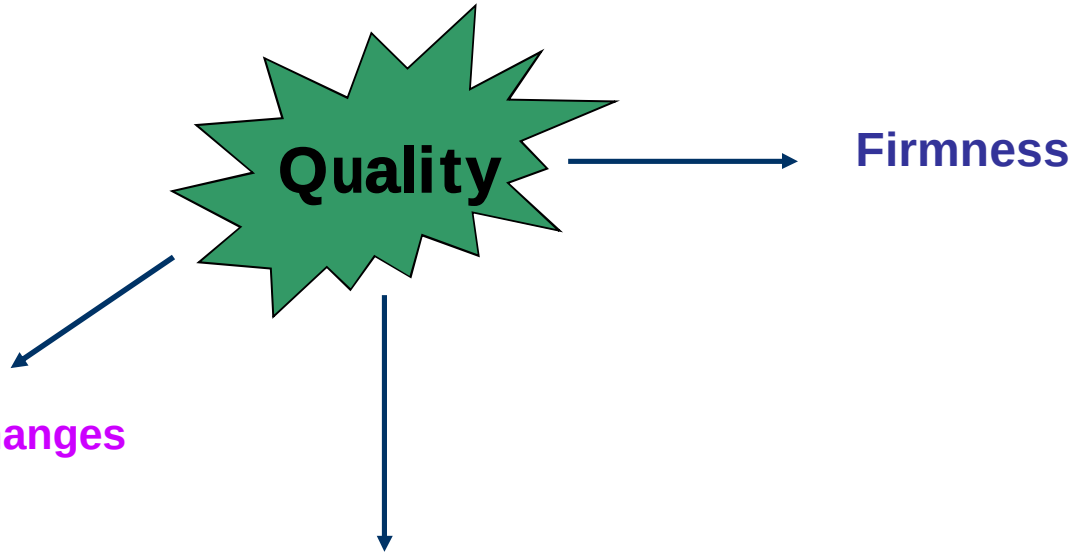
pumpkin

Cucurbita maxima L.

broccoli

Brassica oleracea L.

2. Heat Processing – effect on food quality and safety

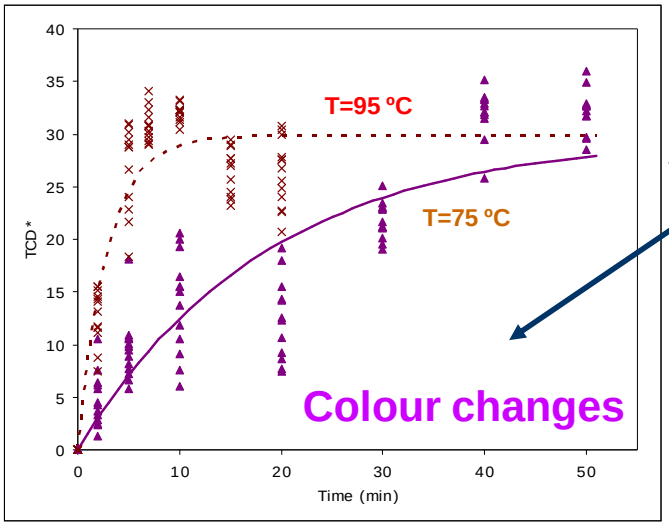


pumpkin

Cucurbita maxima L.

2. Heat Processing – effect on food quality and safety

Total Colour Difference, Hunter (L,a,b) scale, colourimeter (CR-300, Minolta)



Colour changes

Quality

Firmness

Peroxidase

pumpkin

Cucurbita maxima L.

2. Heat Processing – effect on food quality and safety

Fractional conversion model

$$\frac{TCD - TCD_{eq}}{TCD_0 - TCD_{eq}} = e^{-kt}$$

k(T) → Arrhenius

Quality

Firmness

Peroxidase

pumpkin

Cucurbita maxima L.

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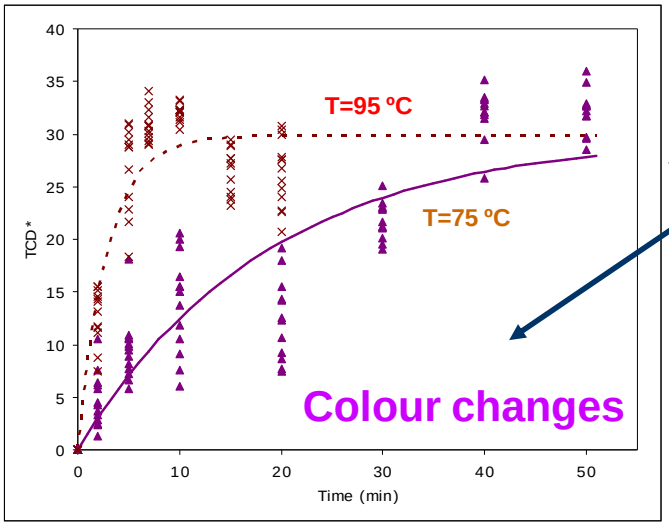
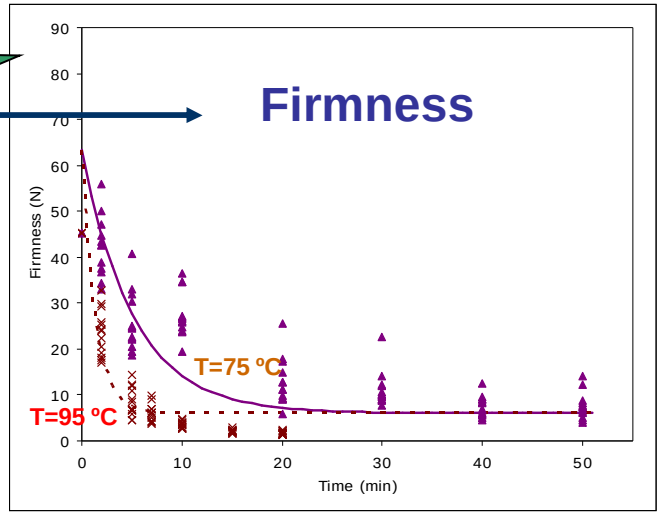
2. Heat Processing – effect on food quality and safety



Quality

Texture Analyser (Stable Micro-System Ltd, Godalming, UK)
single puncture measurement,10 mm depth of penetration, velocity of 1.0 mm s^{-1}

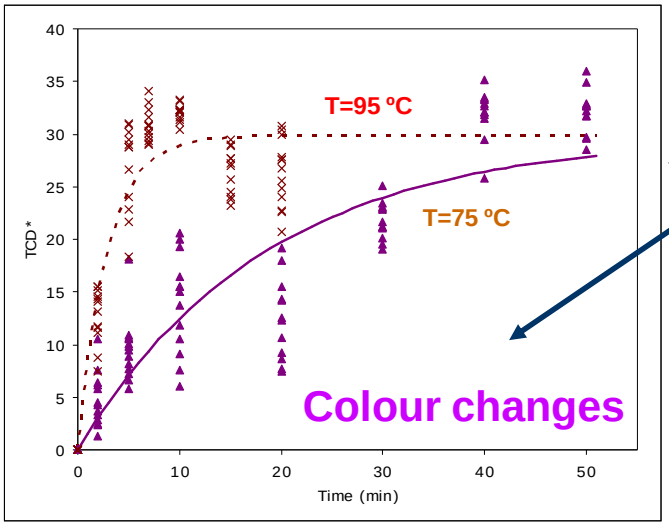


pumpkin

Cucurbita maxima L.

Peroxidase

2. Heat Processing – effect on food quality and safety



Quality

Firmness

Fractional conversion model

$$\frac{Firmness - Firmness_{eq}}{Firmness_0 - Firmness_{eq}} = e^{-kt}$$

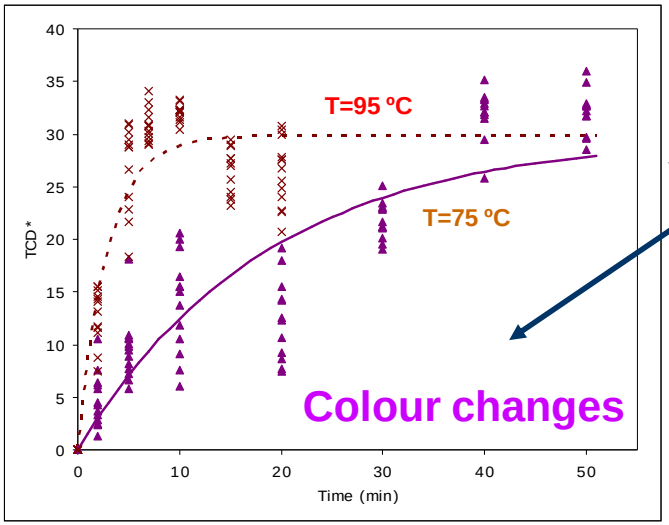
k(T) → Arrhenius

pumpkin

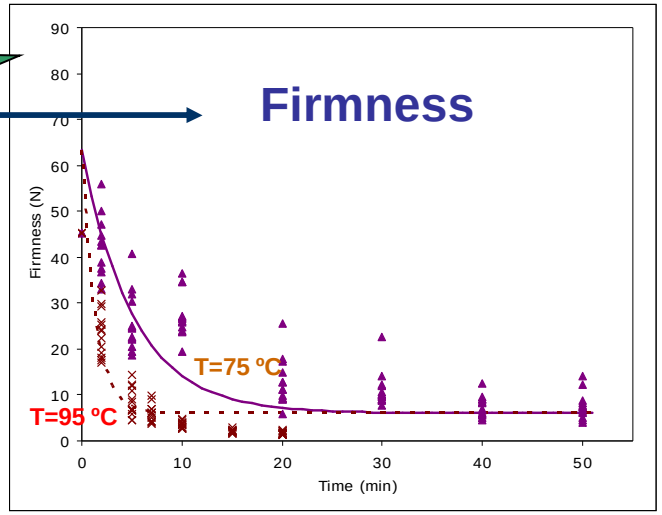
Cucurbita maxima L.

Peroxidase

2. Heat Processing – effect on food quality and safety

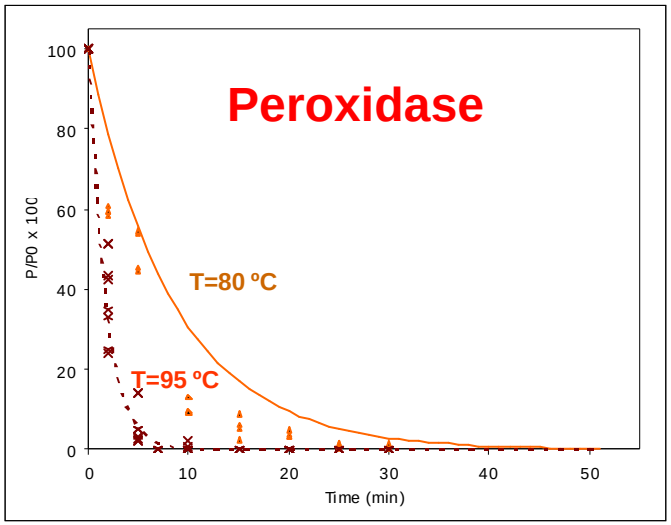


Quality



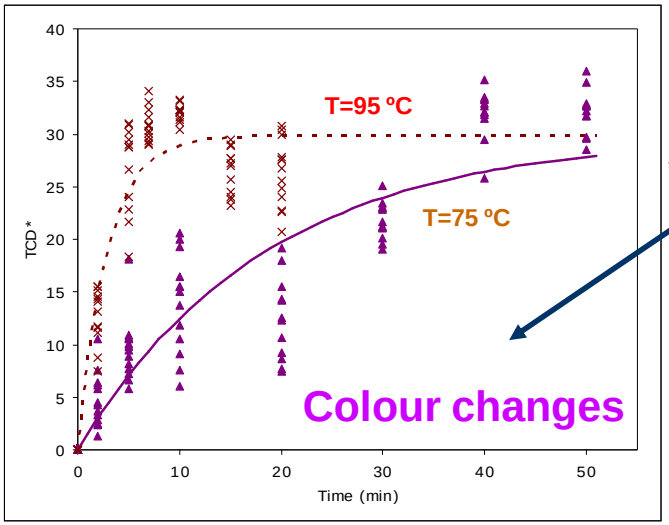
pumpkin

Cucurbita maxima L.



Spectrophotometry (Unicom Ltd, Cambridge, UK)

2. Heat Processing – effect on food quality and safety



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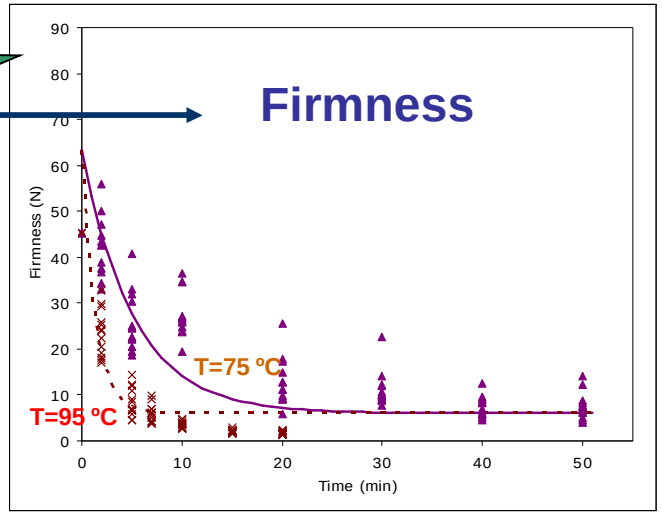


pumpkin

Cucurbita maxima L.

Peroxidase

First order kinetics

$$\frac{P}{P_0} = e^{-kt}$$

k(T) → Arrhenius

2. Heat Processing – effect on food quality and safety

Modelling the kinetics of **peroxidase** inactivation and **colour** and **texture** changes of pumpkin during blanching, allow convenient design of thermal processes

⇩

Stabilisation of enzymatic deterioration

Minimisation of quality losses

pumpkin

Cucurbita maxima L.

Blanching conditions	5.8 min at 90 ºC and 3.9 min at 95 ºC

… are recommended to decrease 90% of peroxidase activity, ensuring a good retention of colour. Unavoidably, texture is greatly affected (~ 14% is retained).

2. Heat Processing – effect on food quality and safety

Blanching

Quality

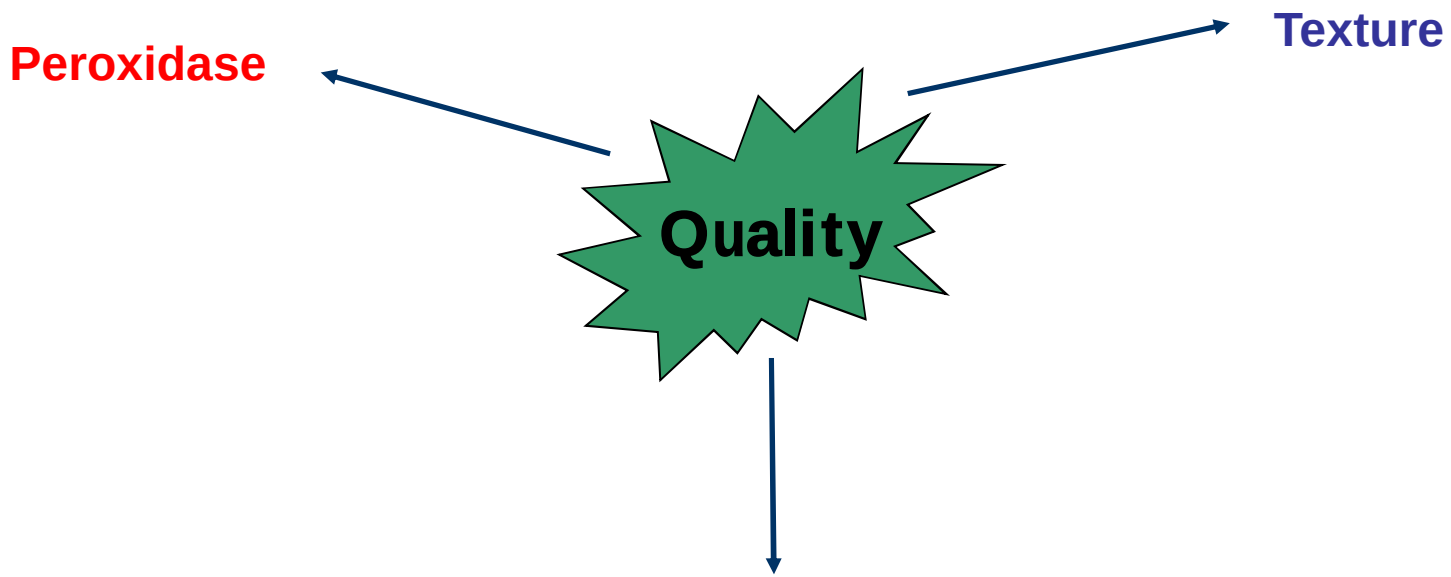
pumpkin

Cucurbita maxima L.

broccoli

Brassica oleracea L.

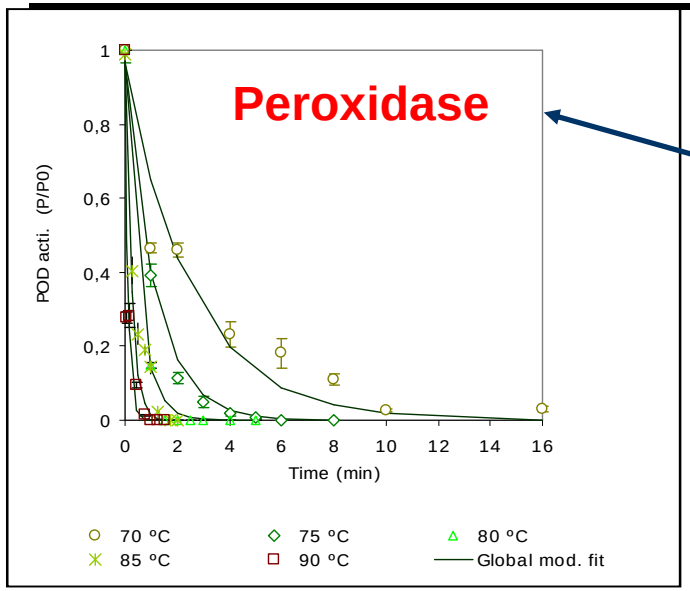
2. Heat Processing – effect on food quality and safety



broccoli

Brassica oleracea L.

2. Heat Processing – effect on food quality and safety



Spectrophotometry (Unicom Ltd, Cambridge, UK)

Quality

Texture

Phenolic content

broccoli

Brassica oleracea L.

2. Heat Processing – effect on food quality and safety

Peroxidase

First order kinetics

$$\frac{P}{P_0} = e^{-kt}$$

k(T) → Arrhenius

Quality

Texture

Phenolic content

broccoli

Brassica oleracea L.

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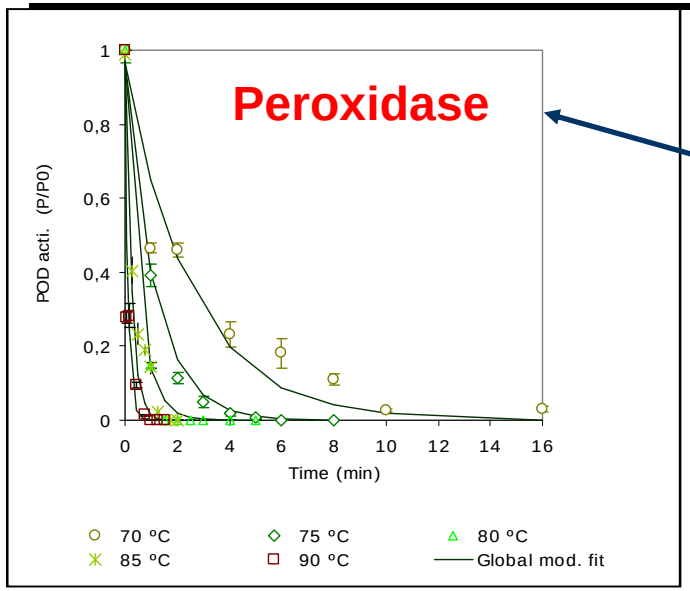
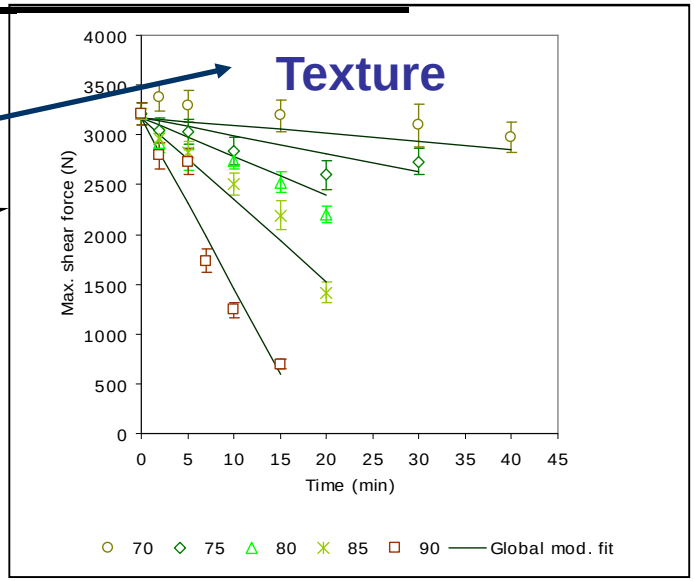
2. Heat Processing – effect on food quality and safety



Quality



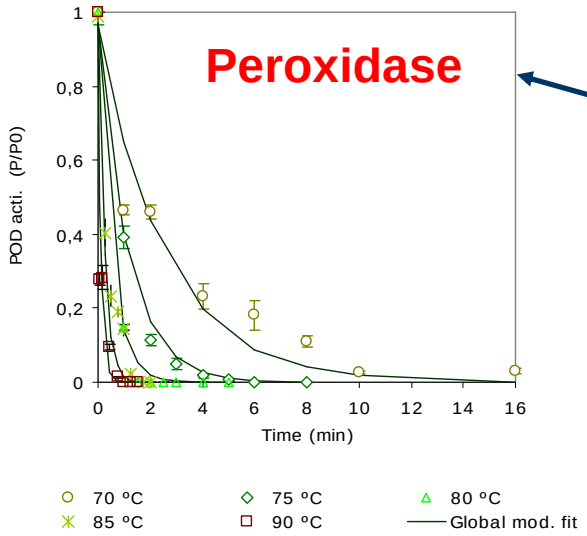
Texture Analyser (Stable Micro-System Ltd, Godalming, UK)
maximum shear force , test speed 8 mm s^{-1} , full-scale load 500 N

Phenolic content

broccoli

Brassica oleracea L.

2. Heat Processing – effect on food quality and safety



Quality

Texture

Zero order kinetics

$$Maxshearforce = (Maxshearforce)_0 - kt$$

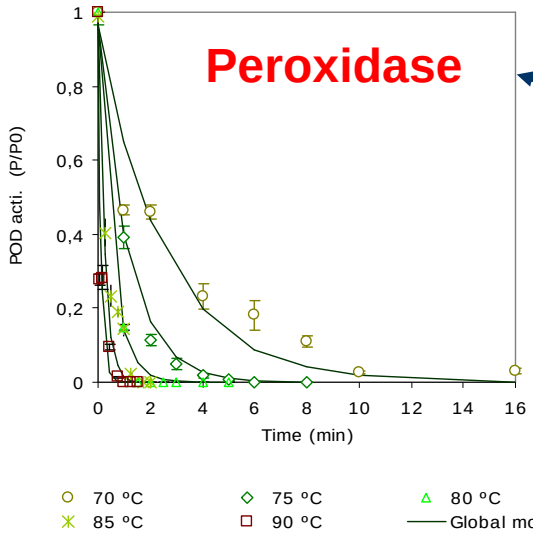
k(T) → Arrhenius

Phenolic content

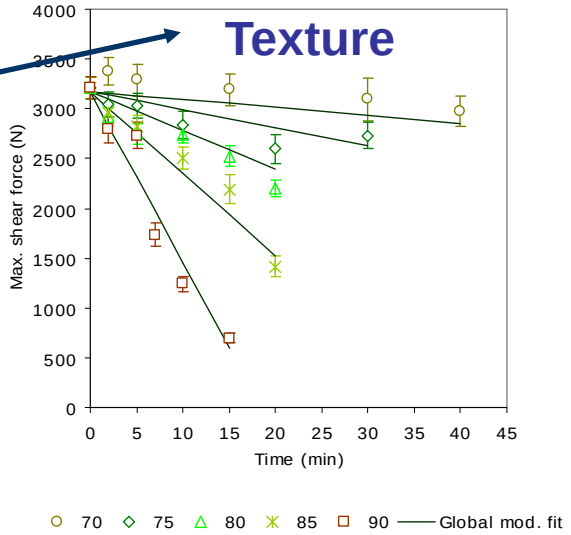
broccoli

Brassica oleracea L.

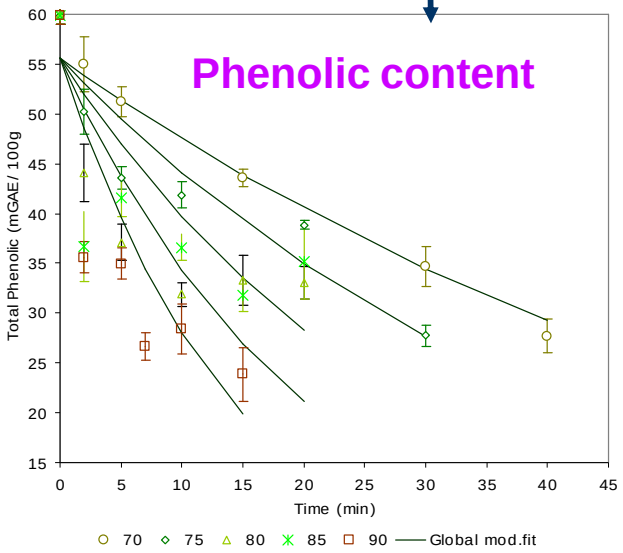
2. Heat Processing – effect on food quality and safety



Quality



Spectrophotometry
(Unicom Ltd, Cambridge, UK)



broccoli

Brassica oleracea L.

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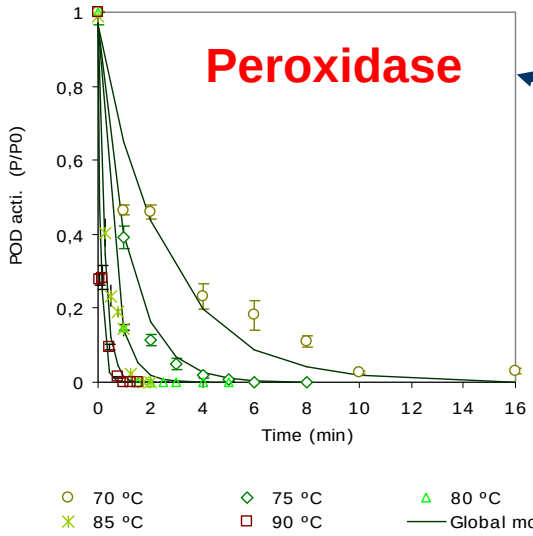
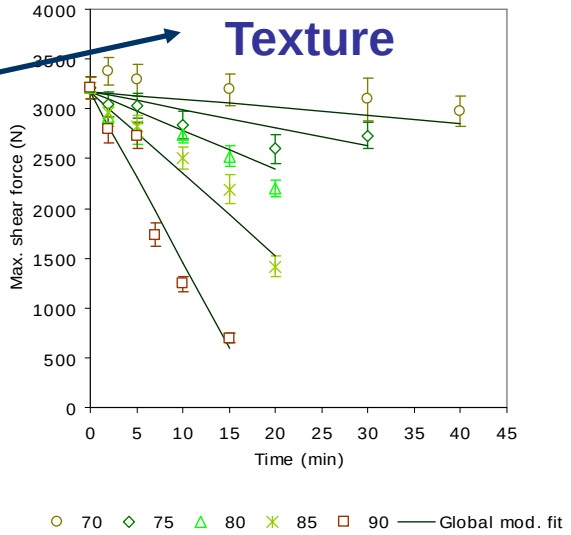
2. Heat Processing – effect on food quality and safety

Quality

Peroxidase



Texture



Phenolic content

First order kinetics

$$P = P_0 e^{-kt}$$

k(T) → Arrhenius

broccoli

Brassica oleracea L.

2. Heat Processing – effect on food quality and safety

Modelling the kinetics of **peroxidase** inactivation and **phenolic content** and **texture** changes of broccoli during blanching, allow convenient design of thermal processes

⇩

Stabilisation of enzymatic deterioration

Minimisation of quality losses

broccoli

Brassica oleracea L.

Blanching conditions

6.5 min at 70 ºC
and
0.4 min at 90 ºC

… are recommended to decrease 90% of peroxidase activity. Texture was the most temperature sensitive parameter. Thus, attention should be given to texture against other quality parameters for optimizing thermal processes of broccoli.

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2. Heat Processing – effect on food quality and safety

Blanching

Safety

red bell pepper

Capsicum annuum, L.

parsley

Petroselinum crispum

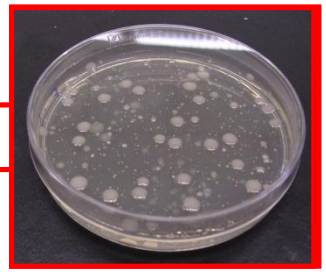
2. Heat Processing – effect on food quality and safety

Safety

red bell pepper

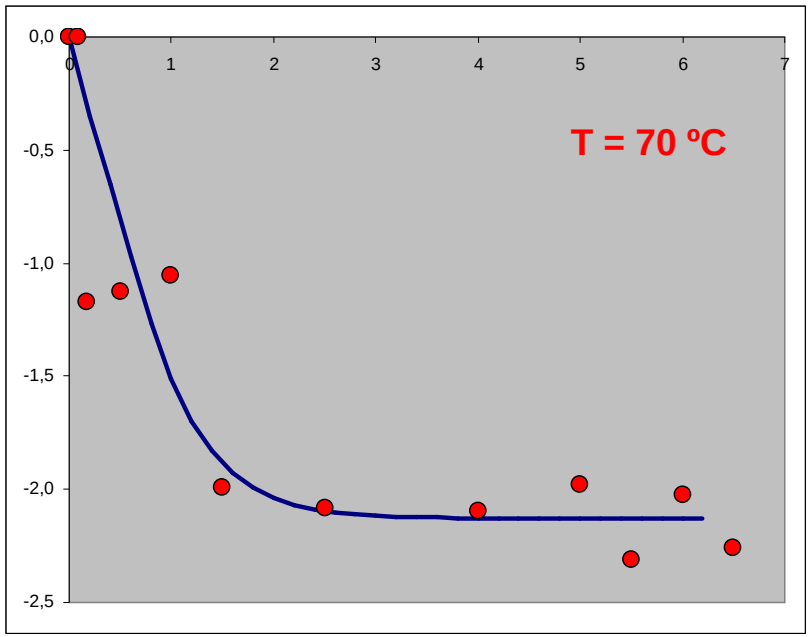
Capsicum annuum, L.

total mesophiles



PCA

autoctone flora



Initial counts: $N_0 \sim 10^7$ CFU / mg

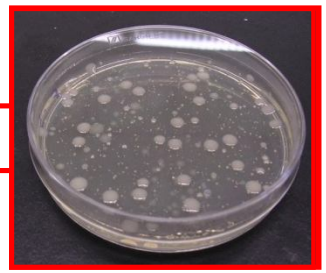
2. Heat Processing – effect on food quality and safety

Safety

red bell pepper

Capsicum annuum, L.

total mesophiles



PCA

autoctone flora

$\log(N/N_0)$

Gompertz-inspired model

$$\log\left(\frac{N}{N_0}\right) = \log\left(\frac{N_{res}}{N_0}\right)\exp\left(-\exp\left(-\frac{k\,e}{\log\left(\frac{N_{res}}{N_0}\right)}(L-t)+1\right)\right)$$

time (min)

Initial counts: $N_0 \sim 10^7$ CFU / mg

2. Heat Processing – effect on food quality and safety

Safety

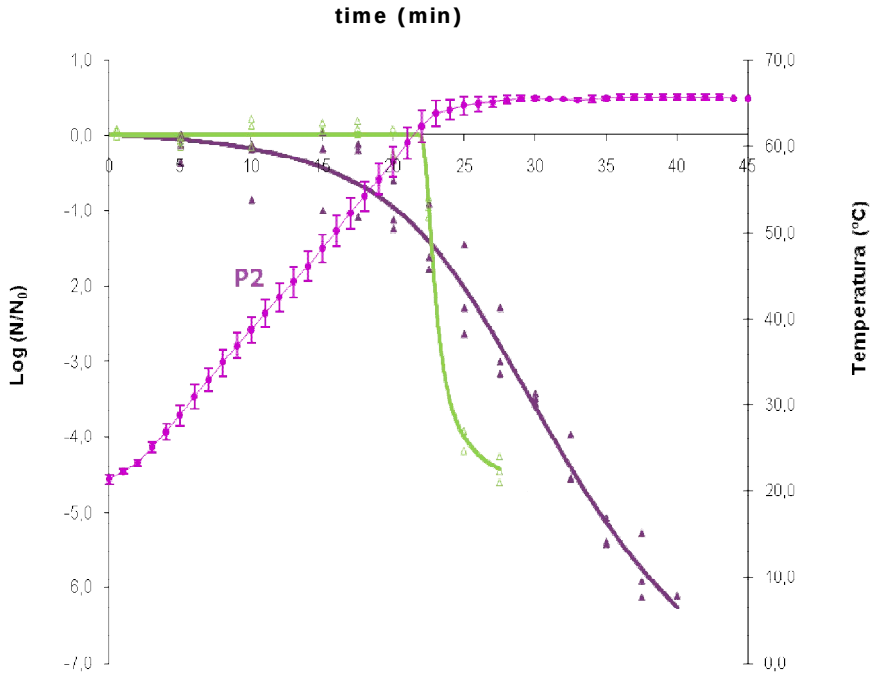
parsley

Petroselinum crispum

Palcam Agar

Listeria innocua

artificially innocuated



Initial counts: $N_0 \sim 10^7$ CFU / mg

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2. Heat Processing – effect on food quality and safety

Safety

parsley

Petroselinum crispum

Gompertz-inspired model

$$\left(\log\frac{N}{N_0}\right)_{non-isot} = \int_0^t \left[-k(T)\,e \exp\left(-\frac{k(T)e}{\log\left(\frac{N_{res}}{N_0}\right)}(L(T)-t')+1 \right) \exp\left(-\exp\left(-\frac{k(T)\,e}{\log\left(\frac{N_{res}}{N_0}\right)}(L(T)-t')+1 \right) \right) \right] dt'$$

Initial counts: $N_0 \sim 10^7$ CFU / mg

Palcam Agar

Listeria innocua

artificially innocuated

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2. Heat Processing – effect on food quality and safety

Modelling the kinetics of microbial inactivation including the effect of relevant variables (temperature, pH and water activity) allow convenient design of thermal processes

Today's Presentation

1. The role of mathematical modeling on understanding process induced changes in foods

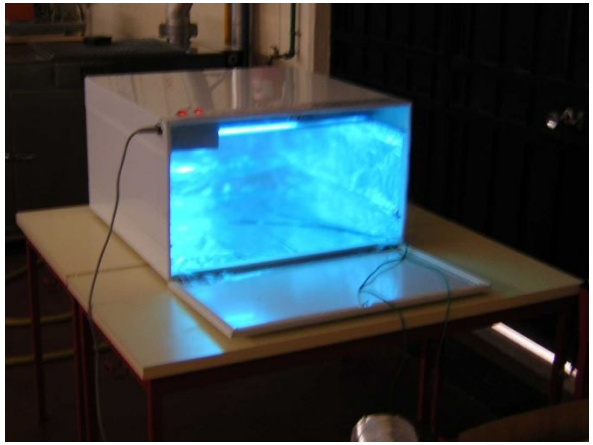
2. Heat Processing – effect on food quality and safety

3. **Combining Heat and other Non-Thermal Technologies to preserve foods**

3. Combining Heat and other Non-Thermal Technologies to preserve foods

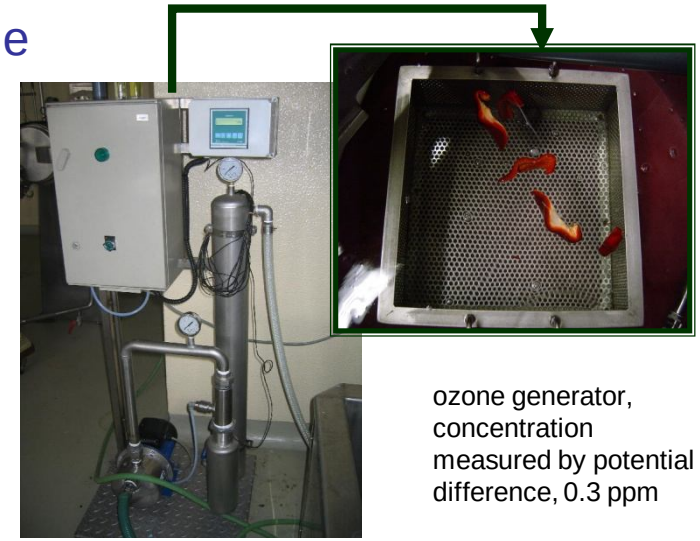
Non-Thermal Technologies for food processing

UV-C radiation



UV-C chamber (University of Algarve), 4 germicidal UV lamps (TUV G30T8, 16 W, Philips, peak emission at 254 nm), average intensity 12.36 W/m^2

Ozone



ozone generator, concentration measured by potential difference, 0.3 ppm

Ultrasonication /

Thermosonication

ultrasound equipment (Bandelin Sonorex RK 100H) operating at 32 kHz

3. Combining Heat and other Non-Thermal Technologies to preserve foods

Thermosonication

watercress

Nasturtium officinale

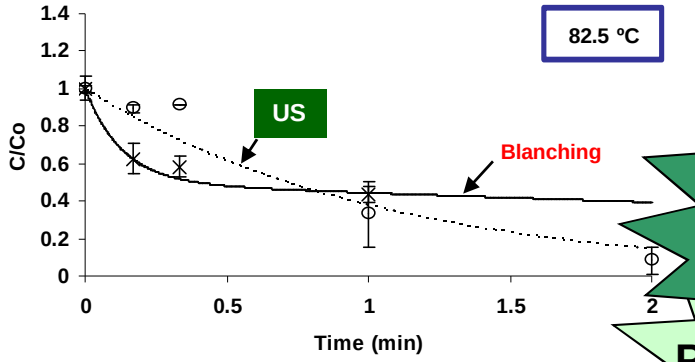
Quality

Vitamin C

Colour changes

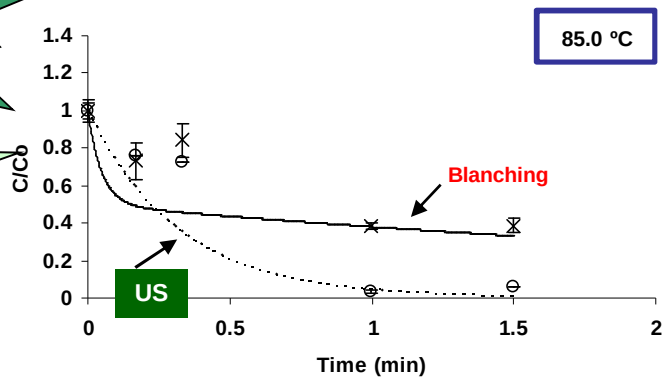
Peroxidase

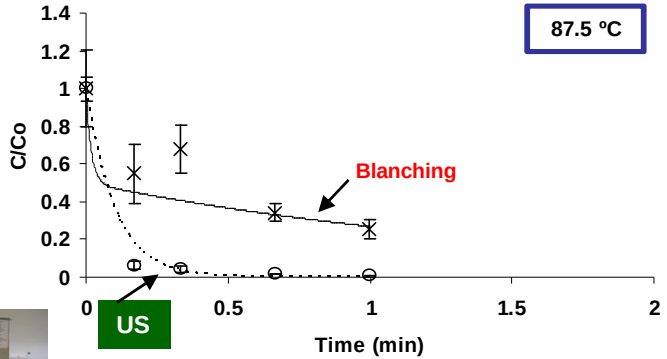
3. Combining Heat and other Non-Thermal Technologies to preserve foods

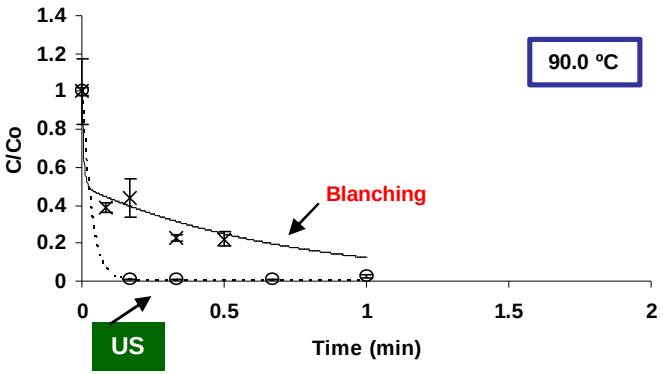


Quality

Peroxidase







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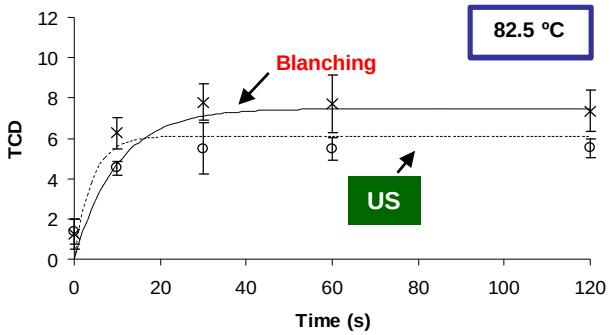
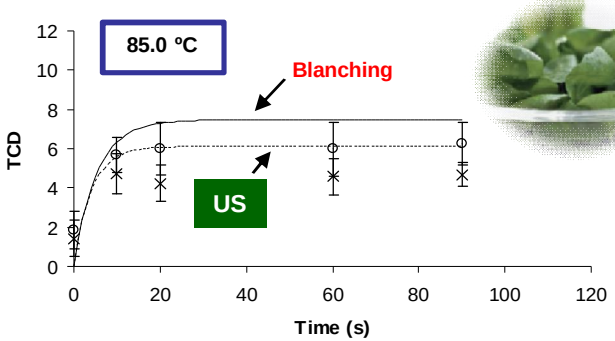
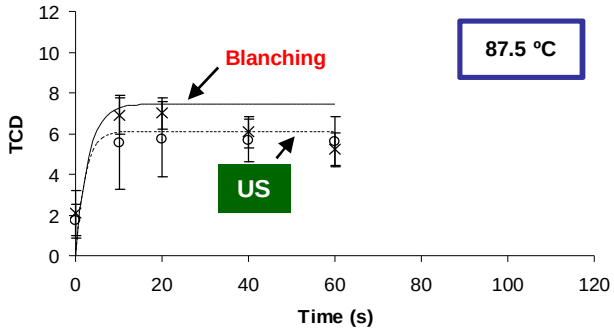
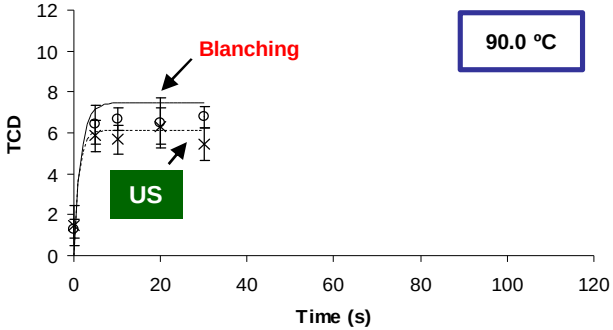
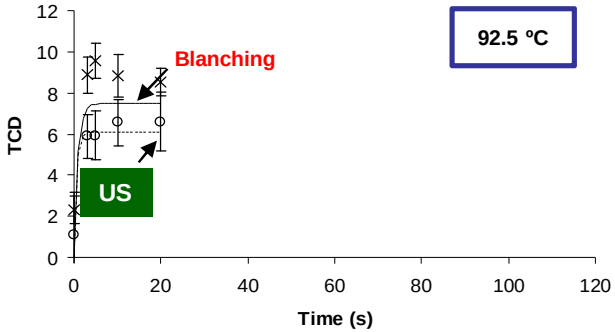
3. Combining Heat and other Non-Thermal Technologies to preserve foods











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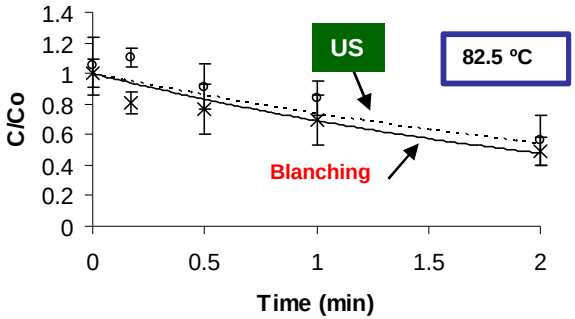
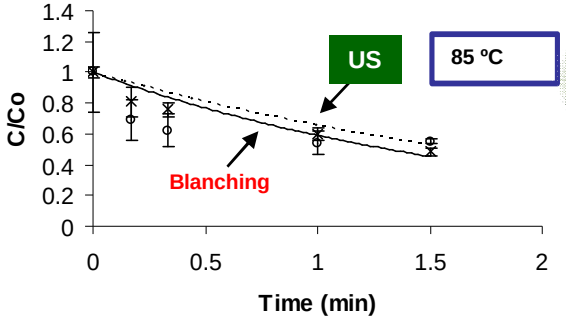
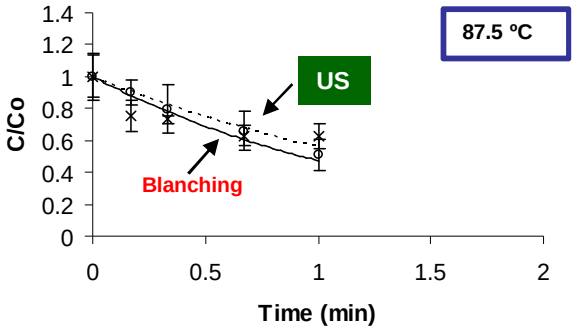
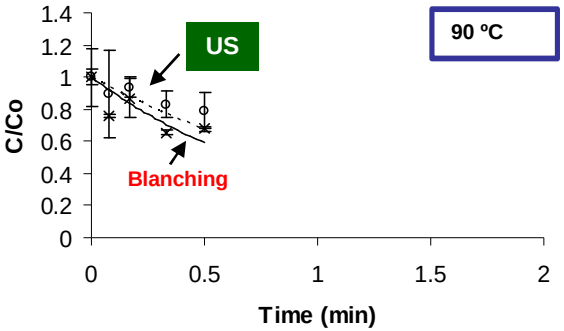
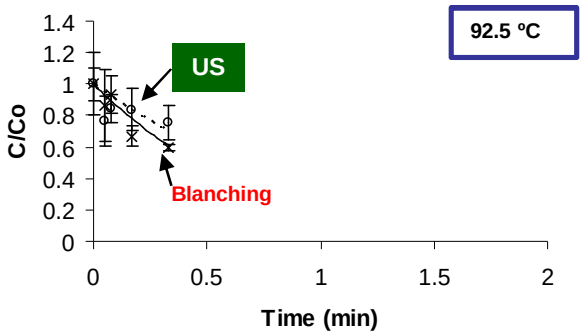
3. Combining Heat and other Non-Thermal Technologies to preserve foods











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3. Combining Heat and other Non-Thermal Technologies to preserve foods

Thermosonication

Peroxidase

Temperatures above 85 ºC and for the same blanching times led to higher enzyme inactivation when compared to heat blanching processes

Colour

Reaction rates of watercress colour changes due to heat and thermosonication blanchings were not significantly different

Vitamin C

Results showed no significant differences between heat and thermosonication treatments. The treatment will allow good vitamin C retention

3. Combining Heat and other Non-Thermal Technologies to preserve foods

Thermosonication

Quality

The thermosonication treatments can be a good alternative to the traditional heat blanching processes, since higher quality products are attained

3. Combining Heat and other Non-Thermal Technologies to preserve foods

Safety

watercress

Nasturtium officinale

red bell pepper

Capsicum annuum, L.

strawberries

Fragaria ananassa

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3. Combining Heat and other Non-Thermal Technologies to preserve foods

Safety

red bell pepper

Listeria innocua

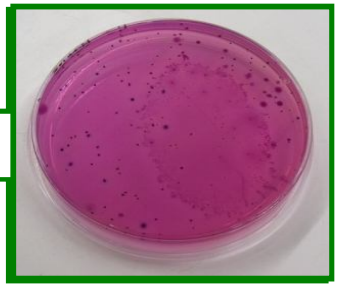
(artificially inoculated)

Palcam Agar

watercress

Total coliforms

(autoctone flora)

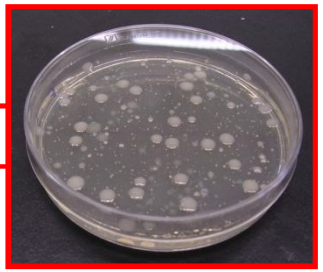


VRBA

strawberries

Total mesophiles

(autoctone flora)



PCA

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3. Combining Heat and other Non-Thermal Technologies to preserve foods

Treatment time = 2 min

5 replicates

Initial counts: ~ 10^7 CFU / mg

Listeria innocua

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3. Combining Heat and other Non-Thermal Technologies to preserve foods

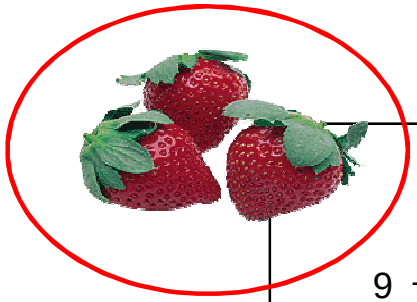
Treatment time = 2 min

5 replicates

Initial counts: ~ 10^8 CFU / mg

Total coliforms

3. Combining Heat and other Non-Thermal Technologies to preserve foods



Treatment time = 2 min

5 replicates

Initial counts: ~ 10^7 CFU / mg

Total mesophiles

3. Combining Heat and other Non-Thermal Technologies to preserve foods

Thermosonication

Ozone in aqueous solution

UV-C radiation



Safety

- Thermosonication is a promising technique
- Ozonated water-washings are equivalent to simple water-washings
- UV-C radiation is not efficient

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Thank you

inrb Instituto Nacional de Recursos Biológicos, I. P.

CBQF - INTERFACE A^4

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