High temperature processing – general aspects

Paola Pittia

University of Teramo, Faculty of Bioscience and Technology for Food Agriculture and Environment

Teramo (Italy)

ppittia@unite.it

Outline

In this module the following topics will be briefly presented:

- Why high temperature treatments in foods ?
- Role of high temperature on degradative reactions in foods
- High temperature tecnologies applied to foods and applications
    - Blanching
    - Pasteurisation
    - sterilisation

Learning Outcomes

Trainer will improve his/her knowledge on

- the stabilisation of foods by using heat treatments
- Importance of the process parameters to obtain quality and stability of foods

Heat treatments in foods

Heat processes in food

- **Vapour/ water**
  - Extrusion
  - Evaporation
  - Cooking
  - Blanching
  - Pasteurisation
  - Sterilisation
- **AIR**
  - Drying
  - Roasting
  - Cooking
- **OIL**
  - Cooking
  - Frying
- **Radiation energy**
  - Microwave cooking/pasteurisation
  - Infrared cooking

Overview of processes applied to foods based on the use of heat

Why heat treatments in food processing?

Desired effects	Processes/applications
Enzyme inactivation **Microbial death**	**Microbial and enzymatic stabilisation** Cooking, *blanching* Pasteurisation and sterilisation Drying/concentration
Chemical reactions	**Modification of qualitative properties** Cooking Roasting
Phase transitions/ separation	**Sepation/isolation of food components** Distillation (ethanol, volatile compounds) Drying (water removal)

Thermal stabilization processes

Aims

1. Desired

- **Shelf-life:** prolongation
- **Safety:** Sanification effect
    - ❖ Reduction of the number of microorganisms of public health concern
    - ❖ Creation of an environment to suppress the growth of spoilage microorganisms
    - ❖ Degradation toxic chemical compounds

2. Others desired

- **Quality attributes:** modifications of sensory quality (eg. colour and aroma of baked products)
- **Nutritional value:** increased digeribility, biodisponibility

Thermal stabilization processes

Undesired, side-effects

Intense treatments can cause

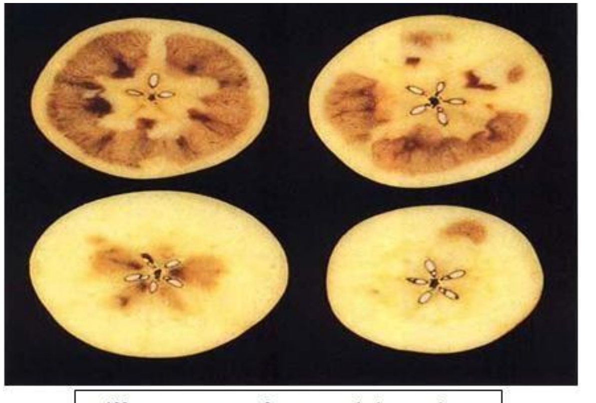
- **Sensory quality properties:** significant changes (aroma, colour, texture)
- **nutritional and health value**: decrease due to degradation thermolable compounds

Heat effect on enzymes

Enzymes: molecules of protein origin, able to catalyze and favor, according to their specificity, reactions in the systems in which they are found.
In foods:
Endogenous enzymes (naturally present in food)
Exogenous enzymes (generally of microbial origin)

The activity of endogenous or exogenous enzymes (from microorganisms) can cause undesirable changes in the qualitative characteristics of foods

<u>Examples:</u>
Polyphenoxidase: browning
Peroxidases: off-flavour, lipid oxidation
Pectinases: softening

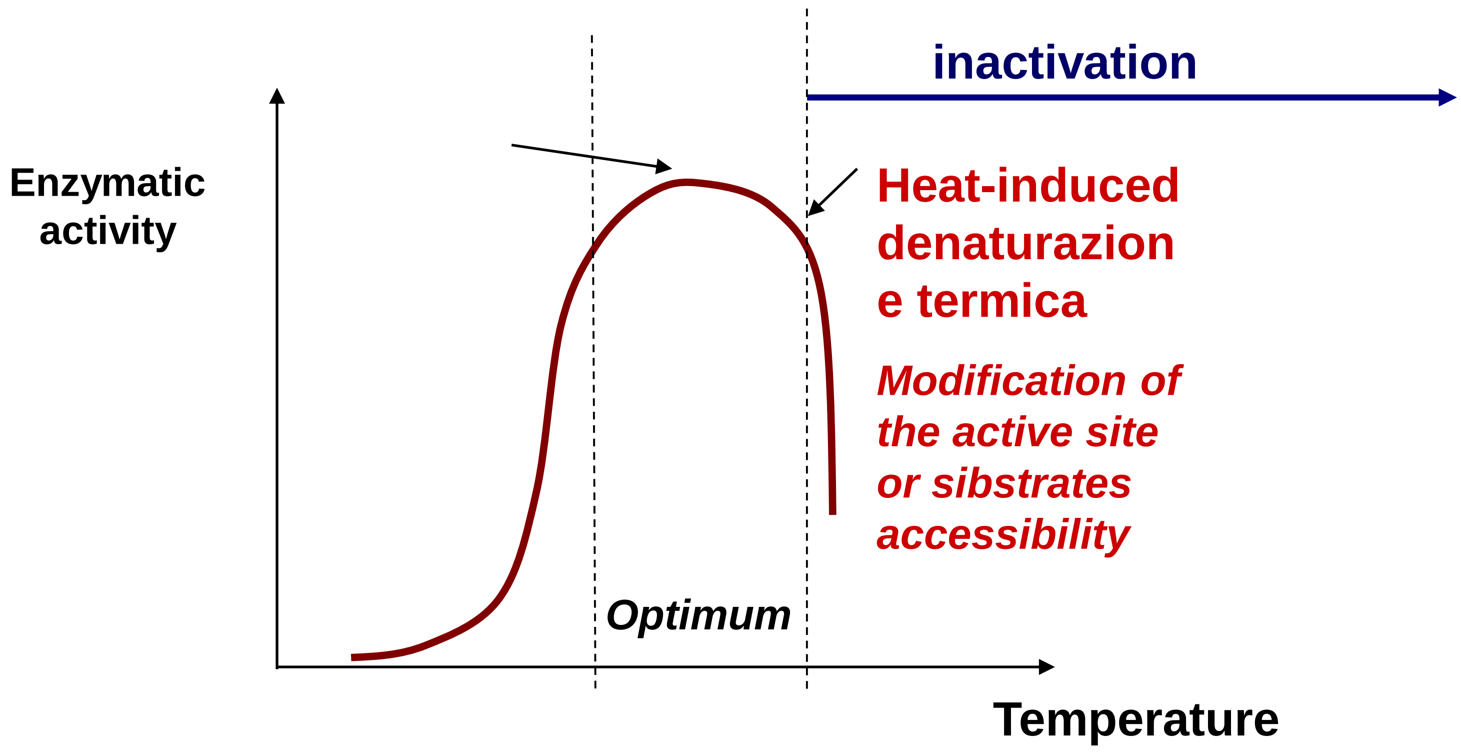


Different stages of enzymatic browning

Heat effect on enzymes

Each enzyme has an optimal range of temperature (min-max) and:

- below the minimum temperature: activity is significantly slowed down
- above the maximum: the proteic moiety can be denaturated and heat can alter its ability to catalyse chemical reactions

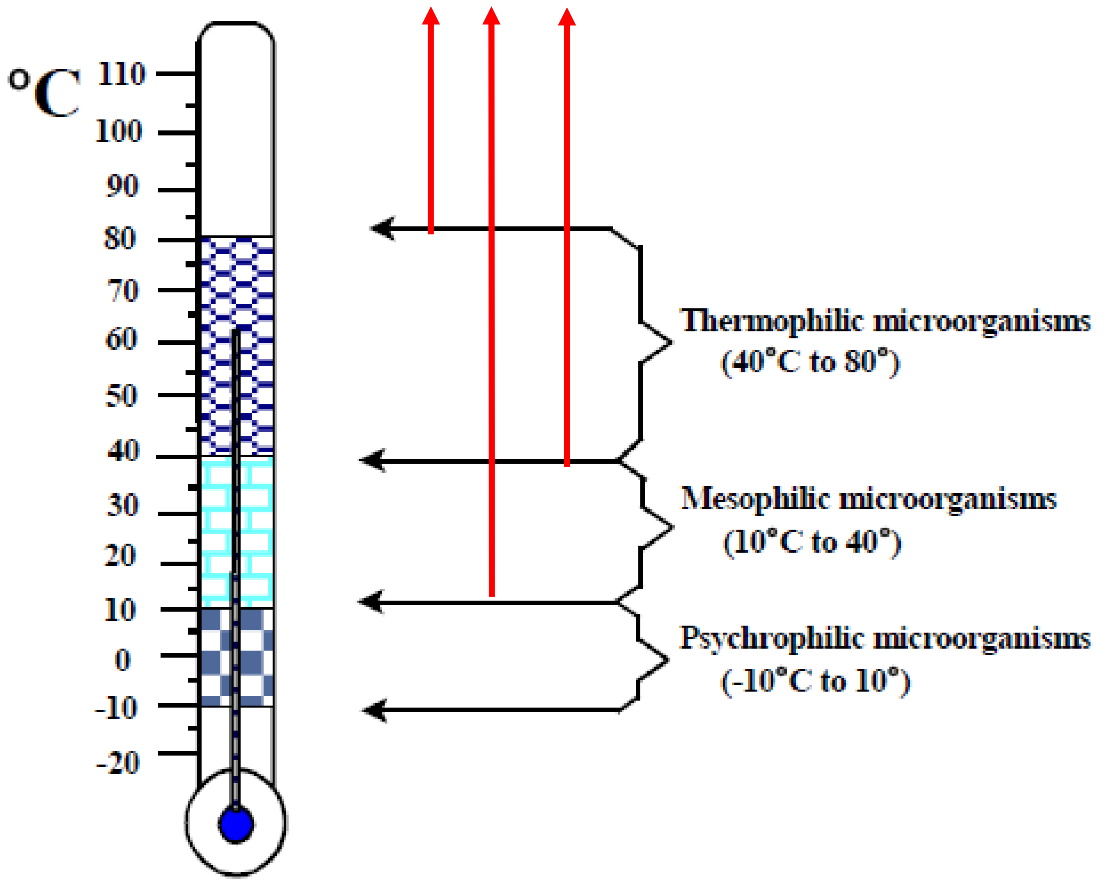


Heat effect on micro-organism

Microorganisms (vegetative, spores, moulds, yeasts): each microorganism has an optimal range of temperature (min-max) of growth and toxins production (only toxinogenetic microorganisms), and:

- below the minimum temperature: activity is significantly reduced
- above the maximum: the cell is progressively damaged and cause the cell death

Heat effect on micro-organism



Optimum temperature range for microorganisms.

Above the maximum temperature of the optimal temperature range, microbial cells are progressively damaged and this cause death

Heat effect on micro-organism

Each microorganism has a specific thermoresitance that is described by two parameters:

D_T = time (min) needed at a specific temperature T to determine the death of one log (= 90%) of a microbial population

z: range of temperature that determines the cariation of 10 times of the D_T

Each heat treatment is set as a combination of time and temperature to determine a certain degree of microbial inactivation.

The thermal conditions are different depending on the target microorganisms, food type, heat treatment processing conditions.

Heat treatments for food stabilization

Heat treatments:

- **blanching**
- **pasteurisation**
- **sterilisation**

<u>Heat transfer medium</u>:

- Direct (air)
- Indirect (heat exchangers, vapour or water)
- Microwaves
- Ohmic heating

Blanching

Heat treatment carried out at relatively low temperatures and short time (70-105°C) as pre-treatment of vegetables that have to be subjected to following stabilisation processes (drying, freezing, sterilisation.

Carried out by immersion in hot water, by tunnels with water vapour or microwaves

MAIN OBIECTIVE:

- enzymatic inactivation

Each vegetable has specific target enzymes that need to be inactivated to obtain the stability and avoid quality changes during processing and storage.

Thus, depending on the target enzyme and its thermostability, blanching is carried out at process conditions

Mild impact on other quality attributes

Pasteurisation

Mild heat treatment carried out at T $\leq$ 100°C aimed to kill pathogenic microorganisms and vegetative cells of degradative microrganisms with low thermoresistance.

For the process conditions applied pasteurisation determines also the inactivation of alterative enzymes

MAIN OBIECTIVE:

- **To kill pathogenic microorgamisms (= food saftey)**
- **enzymatic inactivation**

Limited impact on other quality attributes (nutritional, sensory)

Pasteurisation

Depending on the pH of the food, pasteurisation could lead to obtain

-if **<u>food pH< 4.5</u>** after pasteurisation the product is a preserve (i.e. a product shelf stable at environmental temperature). At this pH only thermolable, non pathogenic and no-sporigens microrganisms could grow and pasteurisation can cause their thermal death.

- if **<u>food pH > 4.5</u>**, after pasteurisation the product is not shelf-stable and for stability purposes additional actions are needed (refrigeration). In foods at pH> 4.5 pathogenic, thermoresistant microoranisms grow and they are not killed by the mild heat treatment

Pasteurisation

Lower pH of growth	Microorgamism
5 4.6 4.5	**Sporigens/thermophilic** **Bacillus, *Salmonella*** ***Cl. Botulinum***
4.2 3.9 1.5	***Cl. butirricum, E. coli*** **No sporigens** **Lattobacilli**

PATHOGENIC

High thermorestance (need heat treatments T > 100°C)

PATHOGENS low thermoresistance (need heat treatments T< 100°C)

Sterilisation

Intense heat treatment carried out at T > 100°C aimed to kill all microorganisms (vegetative cells and spores) also those with high thermoresistance.

For the process conditions applied sterilisation determines also the inactivation of alterative enzymes

MAIN OBIECTIVE:

- **To kill pathogenic microorgamisms (= food safety)**
- **enzymatic inactivation**

Main negative impact on other quality attributes (nutritional, sensory)

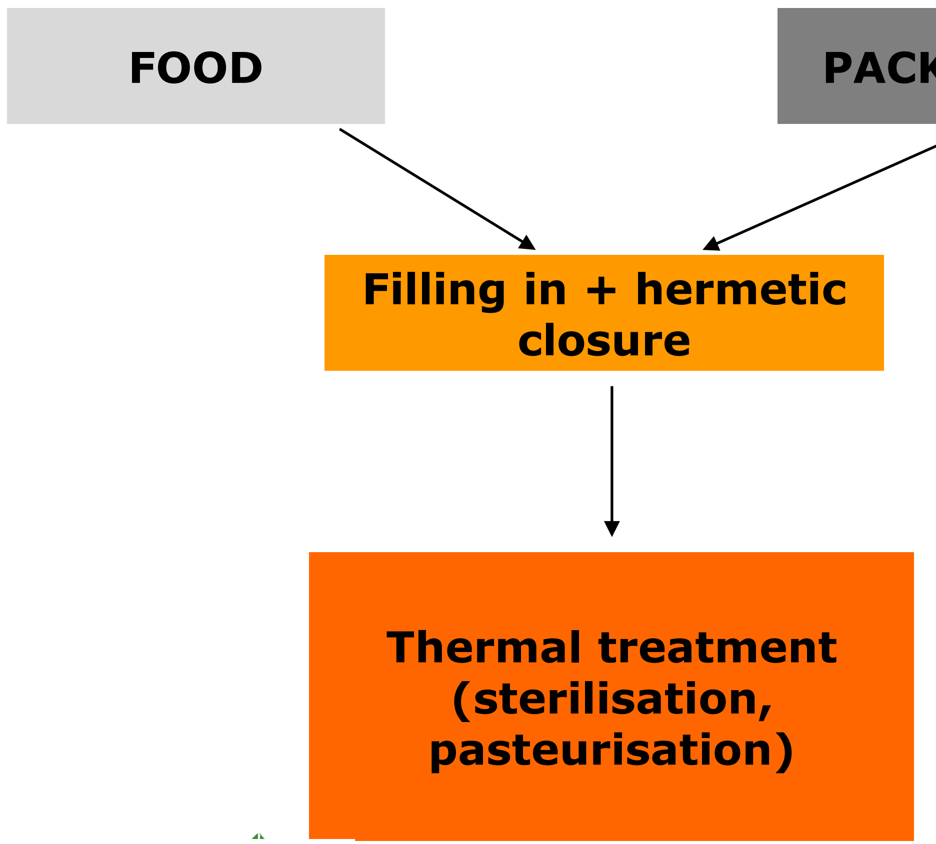
Thermal processing

- On the product after packaging (conventional)

Glass

Metallic cans

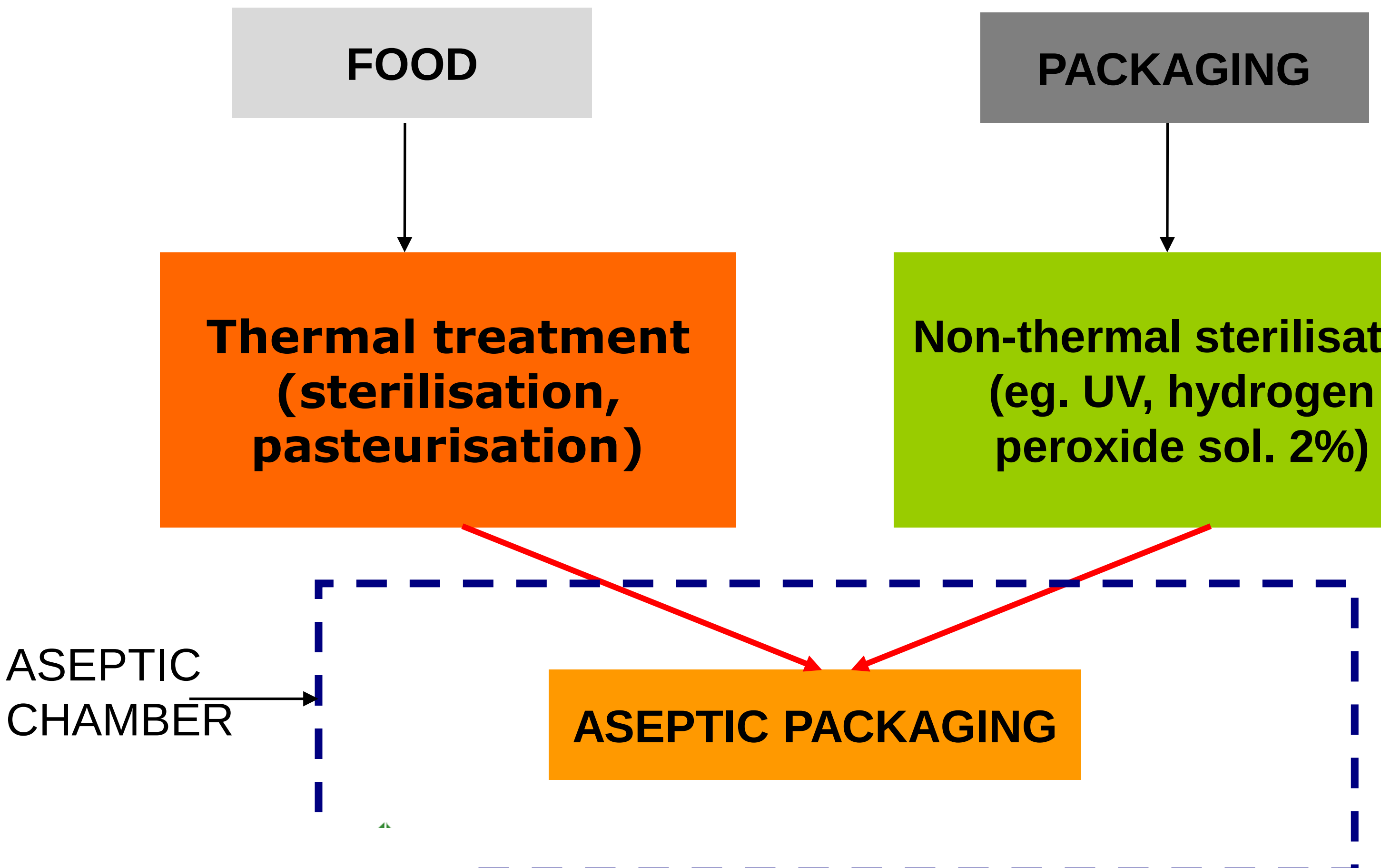
Thermoresistant plastics



*: Packaging must be thermoresistant

Thermal processing

- On the product prior to packaging (e.g. HTST and UHT processes). In this case, it is coupled with an aseptic packaging



References

- Sing R.P, Eldman D. Introduction to Food Engineering. 5th Edition Academic Press, 2013
- Fellows P.J. Food Processing Technology. 4th Edition. Woodhead Publishing Series in Food Science, Technology and Nutrition 2016.