CATÓLICA
UNIVERSIDADE CATÓLICA PORTUGUESA | PORTO
Escola Superior de Biotecnologia

Packaging technology and preservation of foods

Fátima Poças
Biotechnology Faculty
Universidade Católica Portuguesa 2017




European FooD-STA WEBINAR

ISEKI Food Association

Agenda

- Packaging systems for different food processing technologies:
  - Frozen foods
  - Dry and dried foods
  - In-pack thermal processed foods
  - Aseptic processed foods
  - Modified atmosphere packaging
  - Microwavable foods
  - High pressure processed foods

Frozen foods

- Main causes of degradation
  - Dehydration
  - Oxidation
  - Changes in colour and texture
  - Loss of vitamines (exudate)

Frozen food

- Packaging requirements
  - Reduced head-space
  - Allow for volume expantion
  - Moisture barrier
  - Light and oxygen barrier
  - Mechanical resistance (tearing and perfuration)
  - Compatibility with application :
    - Not to stick to food
    - Fat and water impermeable
    - Use in oven or boiling

Types of packaging for frozen foods

- Flexible packaging as primary packaging
  - LDPE bags
  - (modified) PP bags
  - Multilayer plastic/metalised bags

- Folding carton as secondary or primary packaging
  - With a non printed inner bag

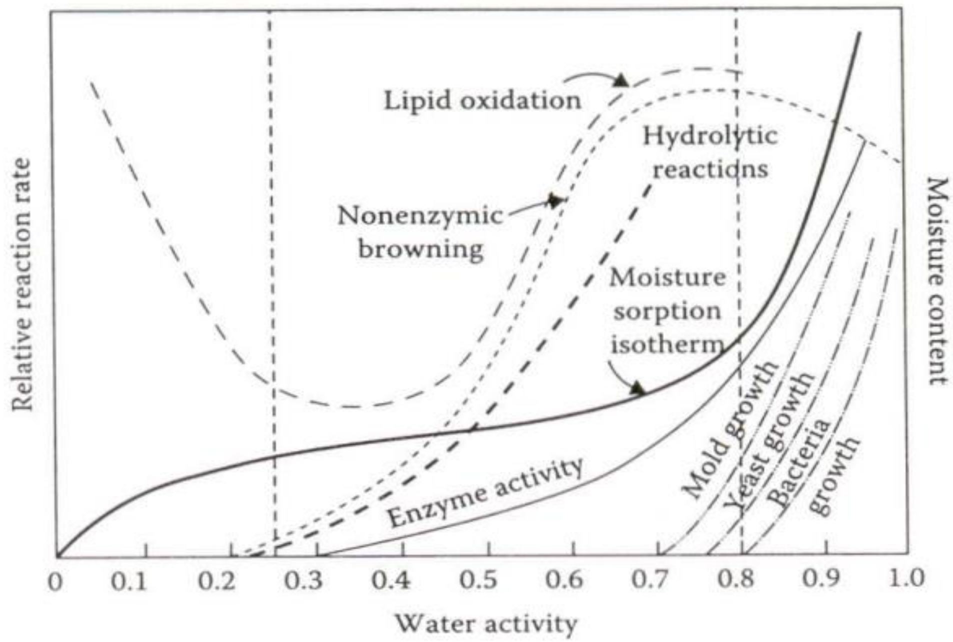
- Folding carton as primary packaging
  - Carton coated with PE

Agenda

- Packaging systems for different food processing technologies:
  - √ – Frozen foods
  - Dry and dried foods
  - In-pack thermal processed foods
  - Aseptic processed foods
  - Modified atmosphere packaging
  - Microwavable foods
  - High pressure processed foods

Dry and dried foods

- Main causes of degradation
  - Increase in moisture
  - Change in texture
  - Microbial development
  - Fat oxidation



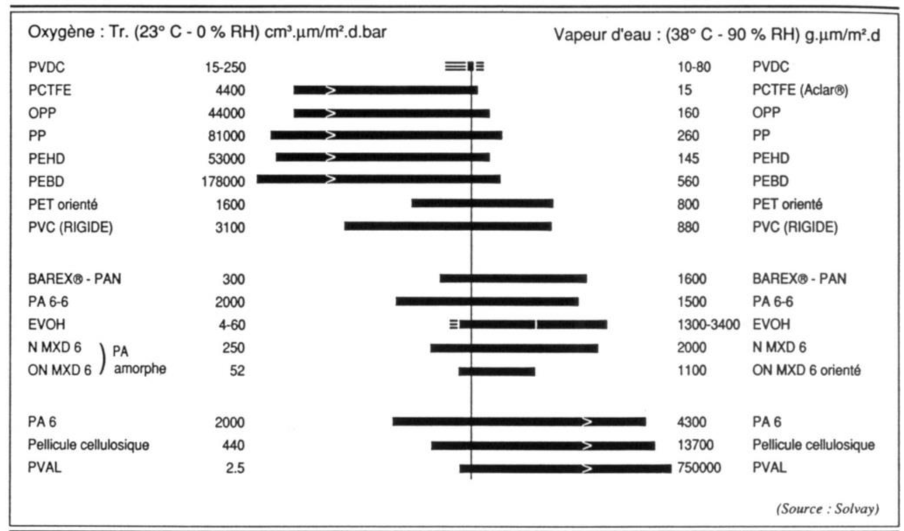
Dry and dried foods

- Packaging requirements
  - Moisture barrier
  - Light and oxygen barrier (fat products)
  - Low oxygen residual content (fat products)
    - Vacuum
    - Inert atmosphere
    - Absorbers
  - Closure between uses

Types of packaging for dry and dried foods

- High barrier to moisture
  - LDPE, OPP
  - OPP metalised
- High barrier to oxygen
  - Multilayer with EVOH
  - Multilayer with Al foil
- Barrier to light
  - Multilayer with Al foil
  - Systems with a folding carton

Figure 3.7 : *Tableau global de la perméabilité O_2 et H_2O de 16 polymères pour un film de 1 micron d'épaisseur*



Agenda

- Packaging systems for different food processing technologies:
  - √ – Frozen foods
  - √ – Dry and dried foods
  - – In-pack thermal processed foods
  - – Aseptic processed foods
  - – Modified atmosphere packaging
  - – Microwavable foods
  - – High pressure processed foods

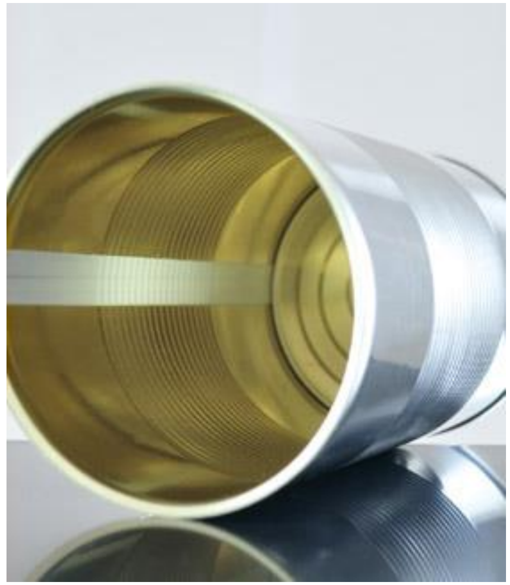
In-pack thermal processed foods (Canned food)

- Typically metal cans
- Other materials such as glass, multilayer composite materials

- Main principles:
  - Heat processing of filled closed can
  - Specified process temperature and time
    - Inactivate/kill microorganisms
    - Inactivate enzymes
  - Comercial stability, long shelf-life at room temperature storage

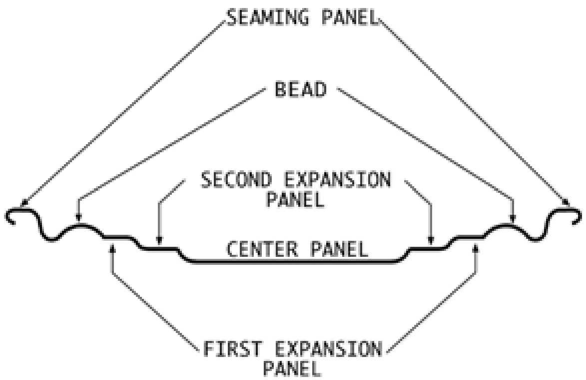
In-pack thermal processed foods (Canned food)

- Packaging requirements
  - Heat conduction
    - Geometry
    - Size
  - Heat resistance
    - Metals: tin-plate, aluminium
    - Internal coating
      - Epoxi-phenolic
      - Polyester



In-pack thermal processed foods (Canned food)

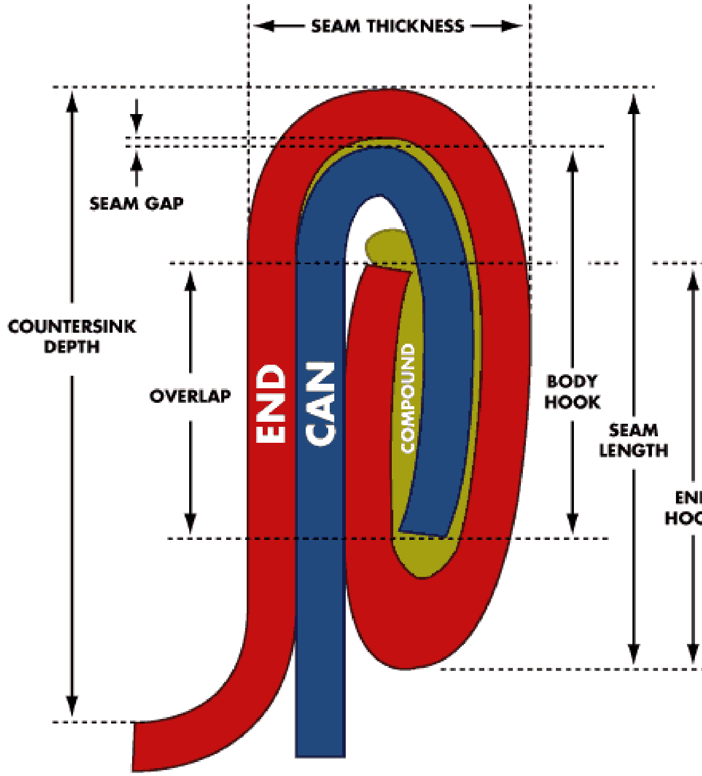
- Packaging requirements
  - Mechanical resistance during heat treatment
    - Internal pressure, volume expansion
    - Vacuum up on cooling



CATÓLICA
UNIVERSIDADE CATÓLICA PORTUGUESA | PORTO
Escola Superior de Biotecnologia

In-pack thermal processed foods (Canned food)

- Packaging requirements
  - Prevent recontamination
    - Hermetic
    - Double seam

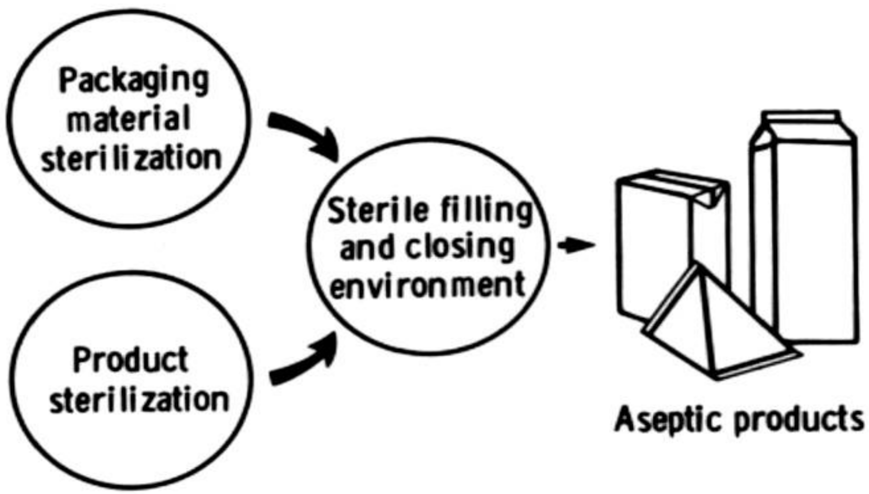


Agenda

- Packaging systems for different food processing technologies:
  - √ – Frozen foods
  - √ – Dry and dried foods
  - √ – In-pack thermal processed foods
  - – Aseptic processed foods
  - – Modified atmosphere packaging
  - – Microwavable foods
  - – High pressure processed foods

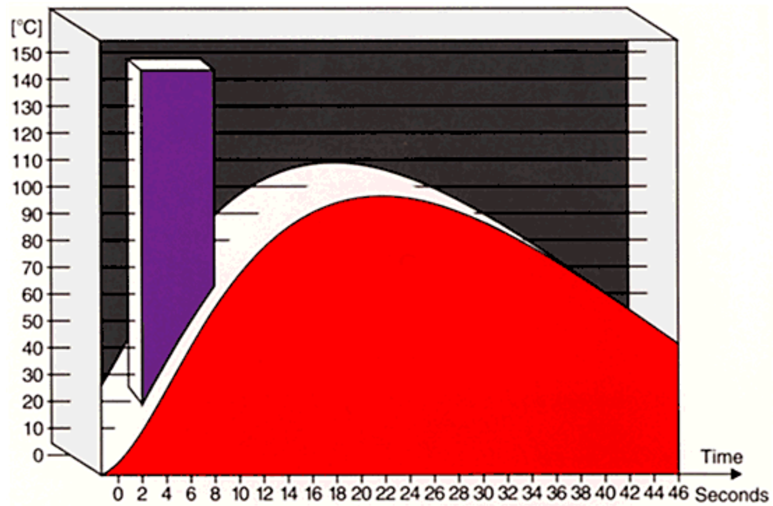
Aseptic packaging

- Heat treatment of food and packaging separatedely
- Filling and closing under aseptic conditions
- Result: absence of viable microorganisms under normal non-refrigerated conditions



Aseptic packaging

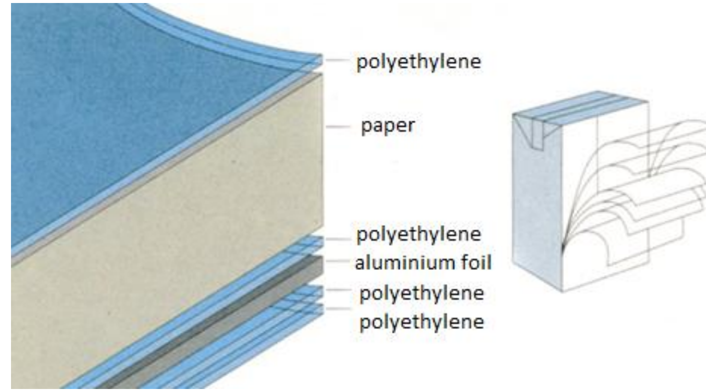
- Advantages
  - Ultra High Temperature treatment
  - Use of packaging materials that do not need to be resistant to high temperatures



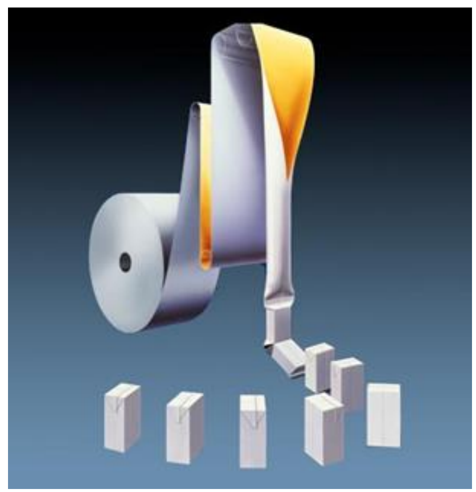
Quick heating and cooling of the product preserve its quality and taste.

Aseptic packaging

- Requirements
  - Suitable for sterilization
  - Hermetic – good seals
  - Gas, aroma and light barrier



- Multilayer multimaterial
- Systems
  - form-fill-seal
  - Pre-formed packs



Aseptic packaging

- Packaging sterilization
  - Vapor
  - Hot air
  - Heat energy from processing
  - Radiation UV, IV, γ
  - Hydrogen peroxide

- Sterilization degree= φ (initial contamination, pack and shape, treatment efficieny)

Combination of techniques

Aseptic systems – Liquid cartons

- *Tetra Pak*

Tetra Brik
Tetra Classic
Tetra Evero
Tetra Fino
Tetra Gemina
Tetra Wedge
Tetra Prisma

Aseptic systems – Liquid cartons

- Combibloc

Combifit
Combibloc
Combidome

Agenda

- Packaging systems for different food processing technologies:
  - √ – Frozen foods
  - √ – Dry and dried foods
  - √ – In-pack thermal processed foods
  - √ – Aseptic processed foods
  - – Modified atmosphere packaging
  - – Microwavable foods
  - – High pressure processed foods

Modified atmosphere packaging - MAP

- Use of composition different from normal air (O_2 and CO_2), in combination with refrigeration
- Composition of normal air: N_2 79 %, O_2 21 %, CO_2 0.04 %, gases inerts e water vapor

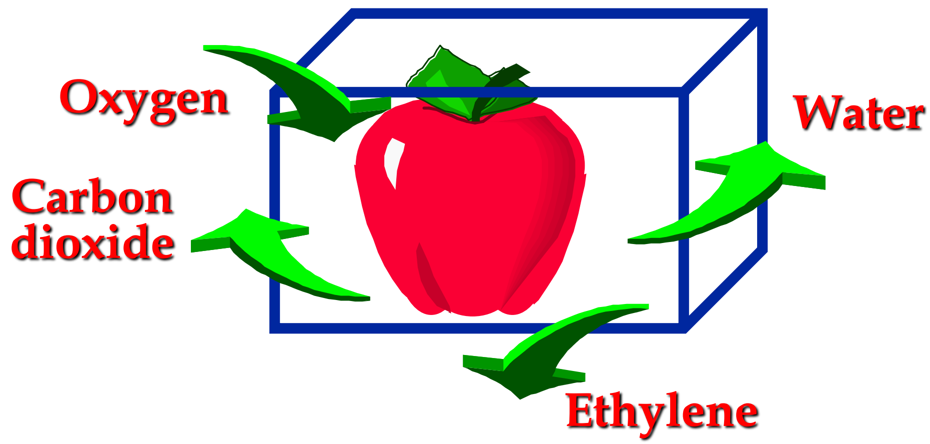
- Applications
  - Meat and fish
  - Pasta and baking products
  - Cheese
  - Dry products
  - Vegetables and fruits

MAP

- Gases used
  - Oxygen
    - Oxidation and growth of micro aerobic
    - Red colour if fresh meat
    - Respiration of fruits and vegetables
    - Avoid anaerobic growth
  - Carbon dioxide
    - Avoid growth of aerobic bacteria and moulds
    - Absorption by food (fat): excess can yield bad taste, exudation, and packaging collapse
  - Nitrogen
    - Inert; balance and avoid colapse
  - Others: argon

MAP

- Critical parameters
  - Initial quality and product nature
    - Non-respiring: water activity, fat content, etc.
    - Respiring: Specie, type and maturation grade
  - Optimization of mixture composition
  - Control of temperature
  - Equipment efficiency
  - Packaging characteristics



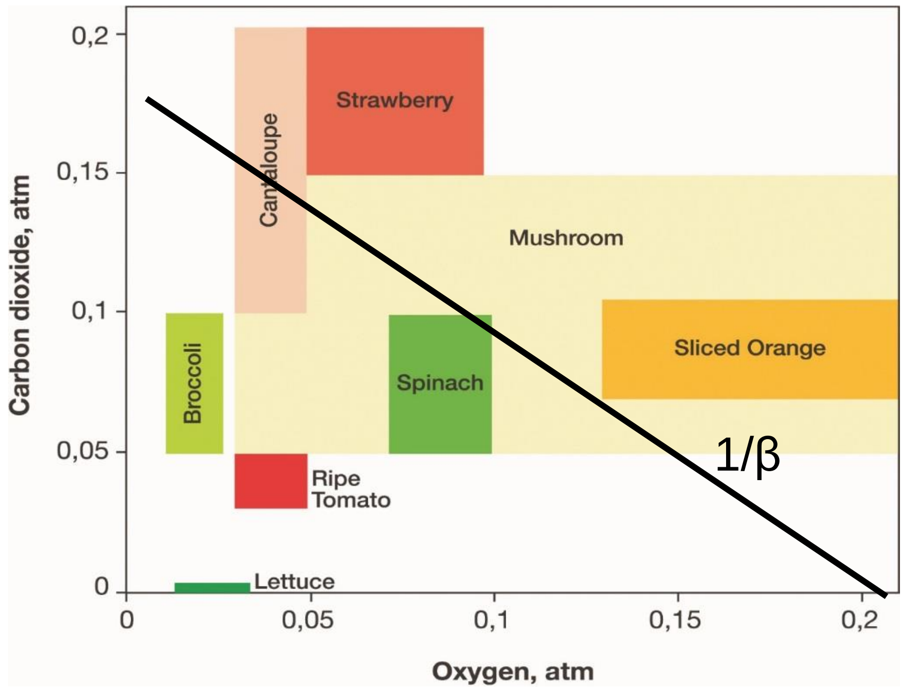
MAP

- Packaging characteristics
  - Barrier properties
    - Oxygen
    - Carbon dioxide
    - Water vapor
    - ß = PCO_2/PO_2
    - Change with temperature
  - Format and volume
  - Integrity
  - Optical properties
  - Mechanical resistance

MAP – Recommended atmospheres

Product	T ºC	O_2 %	CO_2 %	N_2 %
Red meat	-1 a 2	70	30	-
White meat	-1 a 2	-	30	70
Fish (low fat)	-1 a 2	30	40	30
Fish (high fat)	-1 a 2	-	40	60
Pasta	0 a 5	-	50	50
Baked	Amb	-	50	50
Cheese (hard)	0 a 5	-	100	-
Cheese (soft)	0 a 5	-	30	70
Dried	Amb	-	-	100

MAP – Recommended atmospheres



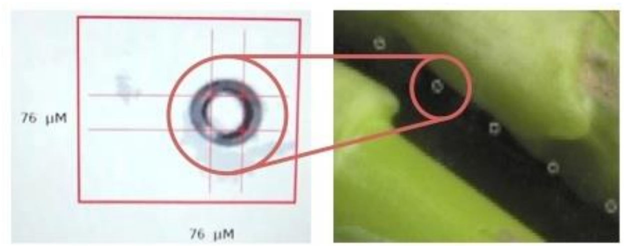
$$C_{CD}(\infty) \approx C_{CD}^{air} + \frac{1}{\beta}\left[C_{Ox}^{air} - C_{Ox}(\infty)\right]$$

MAP - Exemples of packaging

- Meat and fish
  - Tray EPS/EVOH/LDPE with lids PET/PVDC/LDPE
  - Trays HDPE or PP with bag PET/PVDC/LDPE ou PA/PVDC/LDPE

MAP - Examples Bags and trays

- Films.
  - Polyethylene (PE)
  - Polypropylene (PP)
  - Mixture PE-EVA
  - Resin K (Styrene-Butadiene Copolymers)
- Combination: copolymers, laminates, coextruded
- Microperforated and microporous films
- Boxes with perforations
- Films responding to temperature change

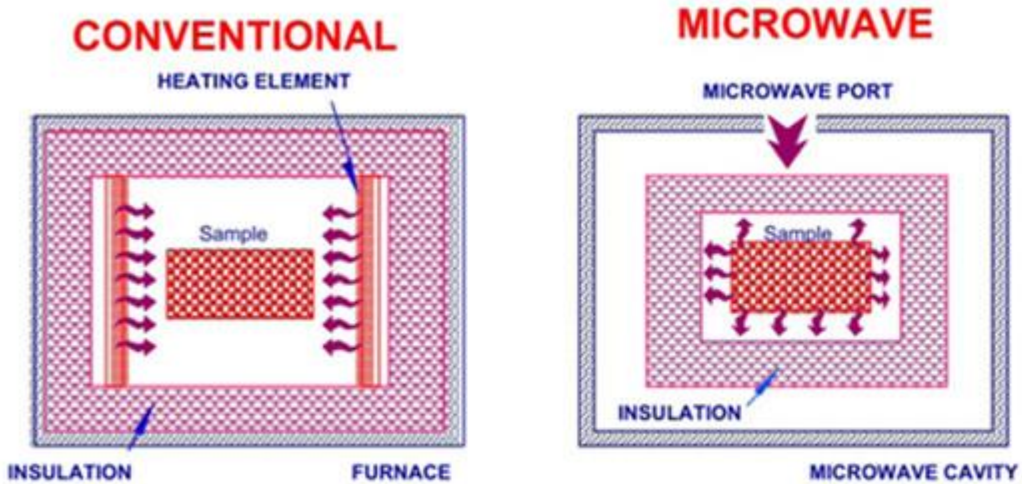


Agenda

- Packaging systems for different food processing technologies:
  - √ – Frozen foods
  - √ – Dry and dried foods
  - √ – In-pack thermal processed foods
  - √ – Aseptic processed foods
  - √ – Modified atmosphere packaging
  - – Microwavable foods
  - – High pressure processed foods

Packaging for microwave

Comparision of heating mechanism in conventional and microwave oven



CONVENTIONAL	MICROWAVE
Energy transfer	Energy conversion
External heating source	Internal heating
Heat Flow: outside to inside	Inside to outside
Material independent	Material dependent
Energy losses	Highly efficient

Packaging for microwave

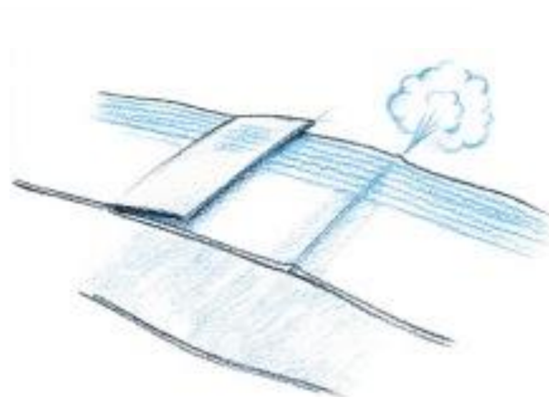
- Should consider
  - Thermal performance of product and packaging
  - Shape and size of packaging
  - Type of material
- Temperature
  - Amount of energy absorbed
  - Mass, composition, shape and thickness of foods
  - Thermal properties (conductivity and heat capacity)
  - Initial temperature
  - Shaking, covering, apply intermittent treatment

Packaging for microwave

- Shape and size
  - Regular, avoid sharp corners
  - Round and ovals instead of squared
  - Bottom concave for lower thickness of food at the centre
  - Use of lids to increase temperature uniformisation
- Type of material
  - Microwave transparent
  - Thermal resistance
  - Product preservation

Packaging for microwave

- Exemples
  - Trays in board coated with PET and other plastics
  - Glass
  - Plastic: PP, CPET

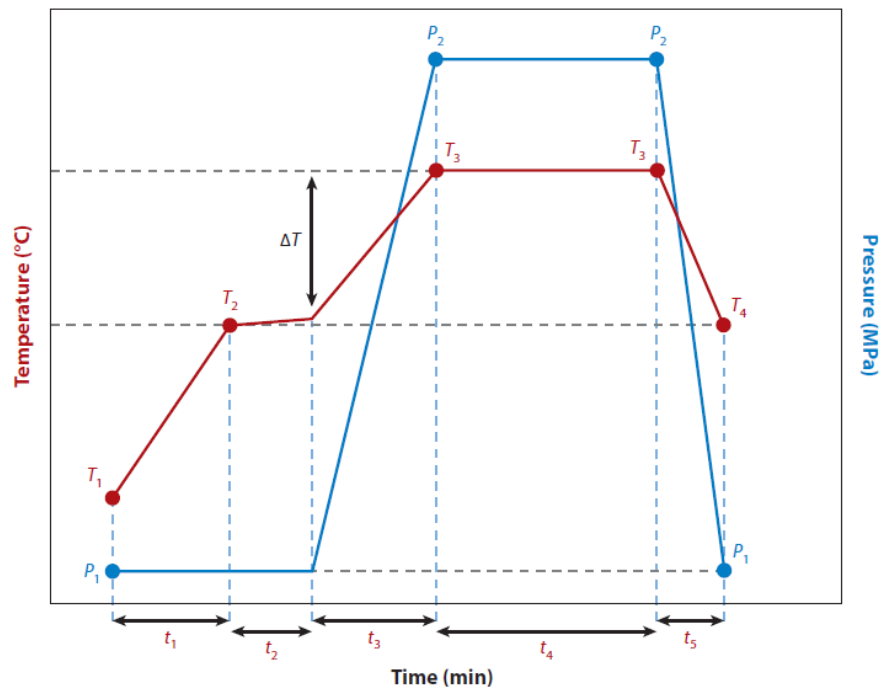


Agenda

- Packaging systems for different food processing technologies:
  - √ – Frozen foods
  - √ – Dry and dried foods
  - √ – In-pack thermal processed foods
  - √ – Aseptic processed foods
  - √ – Modified atmosphere packaging
  - √ – Microwavable foods
  - – High pressure processed foods

High pressure processed foods

- HPP (also known as high hydrostatic pressure processing and ultrahigh pressure processing)
- involves the use of pressures in the range of 100–800 MPa, with or without the application of heat, for inactivating a variety of pathogenic and spoilage vegetative bacteria, yeasts, molds, viruses, and spores to ensure microbiologically safe foods.
- It can be combined with thermal treatment



High pressure processed foods

Table 1 Unique advantages and limitations of high pressure food processing

Description	Advantage	Limitations
Hydrostatic pressure	Rapid, quasi-instantaneous uniform distribution throughout the sample	Batch or semicontinuous operation
Thermal distribution	Minimal or reduced thermal exposure Instant temperature increase and subsequent cooling upon depressurization	Preheating step for pressure-assisted thermal processing (PATP) Thermal nonuniformity during PATP
Physical compression	Suitable for high moisture–content foods	Not suitable for products containing dissimilar compressibility materials such as marshmallows
Product handling	Suitable for both liquid and pumpable foods	Throughput limited due to batch operation
Process time	Independent of product shape and size	
Functionality	Opportunity for novel product formulation Distinct products through pressure effects such as protein denaturation, carbohydrate gelatinization, and fat crystallization	
Reaction rate	Within some pressure-thermal boundary conditions, pressure accelerates microbial inactivation	Variable efficacy in enzyme inactivation; pressure alone cannot inactivate bacterial spores
Consumer acceptance	Consumer acceptance as a physical process	Higher processing costs and batch operations are barriers for commodity product processing

High pressure processed foods

- Packaging requirements (Important parameters to consider)
  - Volume and geometry (productivity aspects, not treatment)
  - Composition (polymer type, film thickness, and sealing and barrier properties)
  - At least one interface of the package should be flexible enough to transmit pressure.

High pressure processed foods

- Headspace air, oxygen in particular, should be reduced:
  - Dissolved oxygen becomes more reactive at high pressure
  - Air has different compressibility properties than water and more effort is needed to compress the air (vacuum)

High pressure processed foods

- Resistance to the treatment
  - Physical changes in the structure of the polymers
  - Maintain barrier properties after treatment
  - Effect on migration on packaging components

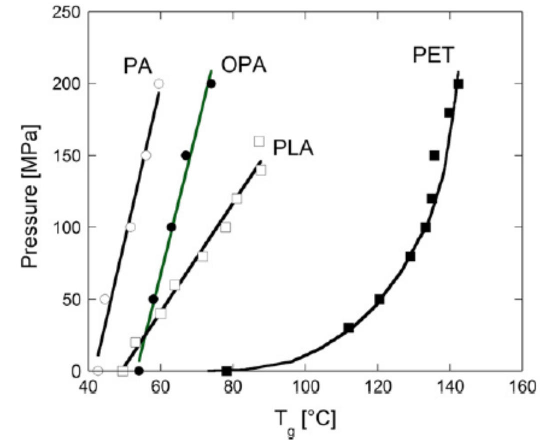


Fig. 2. Dependence of T_g of PA, OPA, PLA and PET on pressure as detected from high pressure dilatometric experiments.

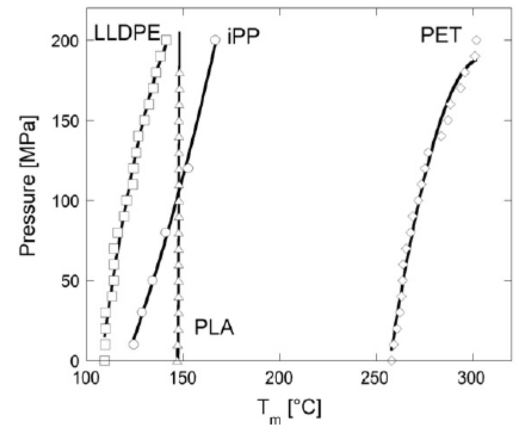


Fig. 4. Dependence of T_m of LLDPE, iPP, PLA and PET on pressure as detected from high pressure dilatometric experiments.

Mensitieri et al 2013

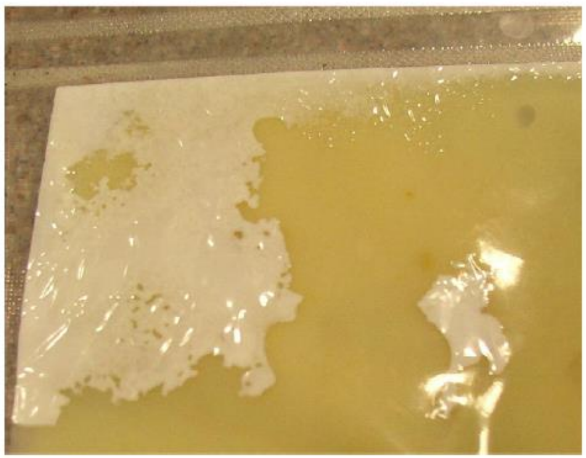


Fig. 2. Large delamination areas on PET–AlOx 12 μm/ON 15 μm/CPP 80 μm pouch after HPT processing.

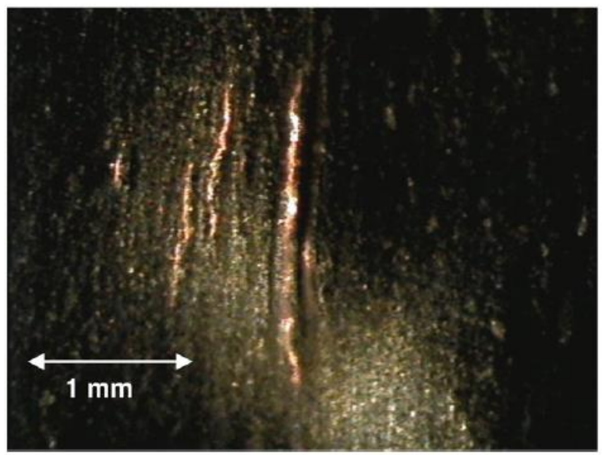


Fig. 3. Photomicrograph of a flex crack in the foil of PET 12 μm/Al foil 7 μm/CPP 70 μm film after HPT processing.

Bull et al, 2010

Conclusion

- Packaging requirements
  - changes considerably with the technolgy used to preserve the food
  - It should be considered together in the food process design