Packaging technology and preservation of foods

Fátima Poças
Biotechnology Faculty
Universidade Católica Portuguesa 2017
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 vitamins (exudate)
Frozen food

- Packaging requirements
  - Reduced head-space
  - Allow for volume expansion
  - 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
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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
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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
  - Commercial 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
In-pack thermal processed foods (Canned food)

- Packaging requirements
  - Prevent recontamination
    - Hermetic
    - Double seam
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Aseptic packaging

- Heat treatment of food and packaging separately
- 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
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 = \( \varphi \) (initial contamination, pack and shape, treatment efficiency)

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
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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 collapse
  - Others: argon
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
    – $\beta = \frac{PCO_2}{PO_2}$
    – Change with temperature
  – Format and volume
  – Integrity
  – Optical properties
  – Mechanical resistance
MAP – Recommended atmospheres

<table>
<thead>
<tr>
<th>Product</th>
<th>T °C</th>
<th>O₂ %</th>
<th>CO₂ %</th>
<th>N₂ %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red meat</td>
<td>-1 a 2</td>
<td>70</td>
<td>30</td>
<td>-</td>
</tr>
<tr>
<td>White meat</td>
<td>-1 a 2</td>
<td>-</td>
<td>30</td>
<td>70</td>
</tr>
<tr>
<td>Fish (low fat)</td>
<td>-1 a 2</td>
<td>30</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td>Fish (high fat)</td>
<td>-1 a 2</td>
<td>-</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>Pasta</td>
<td>0 a 5</td>
<td>-</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Baked</td>
<td>Amb</td>
<td>-</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Cheese (hard)</td>
<td>0 a 5</td>
<td>-</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>Cheese (soft)</td>
<td>0 a 5</td>
<td>-</td>
<td>30</td>
<td>70</td>
</tr>
<tr>
<td>Dried</td>
<td>Amb</td>
<td>-</td>
<td>-</td>
<td>100</td>
</tr>
</tbody>
</table>
MAP – Recommended atmospheres

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

Comparision of heating mechanism in conventional and microwave oven

**CONVENTIONAL**
- Heating Element
- Furnace
- Insulation

**MICROWAVE**
- Microwave Port
- Microwave Cavity
- Insulation

Energy transfer
- External heating source
- Heat Flow: outside to inside
- Material independent
- Energy losses

Energy conversion
- Internal heating
- Inside to outside
- Material dependent
- 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
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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

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

Bull et al, 2010

Mensitieri et al 2013
Conclusion

• Packaging requirements
  – changes considerably with the technology used to preserve the food
  – It should be considered together in the food process design