Packaging Strategies for Meat and Meat Products

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Classes of Attributes in Meat Products

• Characterizing Attributes
  – Those that make a product what it is
  – Often dictated by a standard of identity or other legal definition

• Differentiation
  – Those that make a product different unique
  – Provides variety and choice

• Safety
  – Those that ensure product is safe to consume
Meat Product Attributes in Relation to Quality Characteristics

Characterization

Differentiation

Safety

Texture

Flavor

Color

Microbial Control

Cost Control

Nutrition
Objectives of Meat Packaging

• Containment
  – Enable apportionment
  – Facilitate storage, transportation, handling

• Protection
  – Protect food from the external environment
    • Microorganisms, water, oxygen, light, external objects, other contaminants

• Convenience and Ease-of-Use
  – Reclosability, reheatability, portability
Objectives of Meat Packaging, cont.

• Communication
  – Key product information
    • Name, name qualifiers, ingredients, nutrition facts, handling/cooking/heating instructions
  – Marketing
    • Branding, image, claims, advertising, couponing
Meat Product Attributes in Relation to Quality Characteristics

Characterization
Differentiation
Safety

- Texture
- Flavor
- Color
- Microbial Control
- Cost Control
- Nutrition
Environmental factors that affect quality characteristics

<table>
<thead>
<tr>
<th></th>
<th>Color</th>
<th>Flavor</th>
<th>Microbial Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Light</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
The “Perfect” Package

• From a quality perspective the “perfect” package keeps light and oxygen out
• However, this is not always practical due to the nature of the meat market
  – Visual inspection by the consumer is a key element of the purchase decision in the meat case
  – Product must be visible and attractive
• Therefore, the perfect package solution is a compromise
Microbial Control

• Basic Meat Microbiology
  – Fresh Meats
    • Microflora affected by pre- and post-slaughter factors
    • Microflora dominated by gram-negative bacteria
    • Spoilage flora
      – Predominantly *Pseudomonas, Aeromonas, Enterobacter, Acinetobacter, Moraxella, Lactobacillus* and other lactic acid bacteria, *Brochothrix*
        – *Pseudomonas* can cause putrid and other off-odors
    • Pathogenic flora
      – *Campylobacter, Clostridium spp., Escherichia coli, Aeromonas, Salmonella, Shigella spp., Listeria monocytogenes, Yersinia enterocolitica*
Microbial Control

• Basic Meat Microbiology
  — Cured Meats
    • Microflora dominated by gram-positive bacteria
    • Spoilage flora
      — Predominantly lactic acid bacteria, *Brochothrix*
      — May cause off-odors/flavors (sweet/sour), greening
    • Pathogenic flora
      — Mostly concerned with *Listeria monocytogenes*, *Staphylococcus aureus*, *Clostridium* spp.
Microbial Control

• Control Strategies
  – Fresh Meats
    • Initial microbial counts should be as low as possible
    • Temperature must be as close to 0°C as possible
    • Anoxic packaging conditions inhibit *Pseudomonas*, but
      not *Lactobacillus*
      – Oxygen permeability of film and MAP atmosphere are
        important
      – *Lactobacillus* grows more slowly and is associated with
        sour off-odors and off-flavors, not putrid
      – Vacuum-packaged meat can be stored for >12 weeks at
        0°C
Microbial Control

• Control Strategies
  – Cured Meats
    • Must minimize post-lethality contamination
    • Temperature must be as close to 0°C as possible
    • Anoxic packaging conditions are most effective
      – Oxygen permeability of film and MAP atmosphere are important
Color

• Due to meat pigment *myoglobin*
  – O$_2$ storage and transport protein
  – Concentration varies by:
    • Species
      – Beef > Lamb > Pork > Turkey > Chicken
    • Muscle Type
      – Higher in movement muscles
    • Animal Age (within same species)
      – Bull/Cow > Steer/Heifer > Calf > Veal
      – Hens > Broilers > Chicks
  
• Not well-correlated with eating quality, but still demanded by consumers
Color Deterioration

• Affected primarily by
  – Oxygen
  – Light
  – Microbial growth
Meat Color Chemistry

Color Deterioration

• Effects of Oxygen
  — Fresh meats
    • Pigment oxidation is highest at around oxygen tension of 4–6 mmHg and lower below and above this level
      — Lower at $O_2$ tension below and above this level
      $\rightarrow$ discoloration decreases with increasing $O_2$ partial pressure
  — Cured meats
    • Pigment oxidation is directly proportional to increasing $O_2$ tension
      $\rightarrow$ discoloration increases with increasing $O_2$ pressure
Color Deterioration
Color Deterioration

• Effects of Oxygen
  – Control Strategies
    • Package under high $O_2$ or anoxic conditions
    • Avoid low oxygen tensions
    • Because high $O_2$ promotes spoilage bacteria, low $O_2$ MAP is a good option
    • $CO_2$ effective at controlling Gram-negative, aerobic, psychotropic bacteria (e.g., *Pseudomonas*); less effective against LAB
      – Increasing effectiveness up to about 20%
  – Cured meats
    • Anoxic packaging (vacuum, low-oxygen MAP) protects cured meat pigment
Color Deterioration

• Effects of Light
  – Some inconsistencies in the literature
  – Generally, more light means less shelf-life
Color Deterioration

• Effects of Light
  – Discoloration affected by:
    • **Heat**
      – Increases discoloration, so avoid hot light sources
    • **Intensity**
      – Too high – increased discoloration
      – Too low – inadequately illuminated product
    • **Wavelength**
      – Wavelengths near the red end of the spectrum (>550 nm) are protective
      – Ultraviolet (UV) wavelengths promote discoloration and should be avoided
      – As a rule, seek light sources with high emissions in the red end of the spectrum and low emissions in the blue
Color Deterioration

• Effects of Microbial Growth
  – Microbial metabolic products react with meat pigments to produce undesirable discoloration
    • Hydrogen sulfide (H₂S) → sulphmyoglobin
    • Hydrogen peroxide (H₂O₂) → yellow/green pigments
Flavor Deterioration

• Primarily centered around Lipid Oxidation
  – Results in rancidity, off-odors, off-flavors, discoloration, texture deterioration
  – Believed to be initiated by oxidation of highly-unsaturated membrane phospholipids
  – Hydroperoxides (primary oxidation products)
    • Break down into hydrocarbons, ketones, aldehydes, alcohols

• Fresh meats
  – Over-wrapped trays allow odor volatiles to escape
  – In MAP, odor volatiles are retained and could be detected by consumers upon opening
  – High O₂ atmospheres can induce lipid oxidation
Flavor Deterioration

• Cooked meats (uncured)
  – Lipid oxidation still proceeds due to residual $O_2$
  – Warmed-over Flavor (WOF)

• Cured meats
  – Knowledge base still evolving
  – Cured meat flavor is believed to be due to the antioxidative properties of nitrite
    • Fewer total volatiles in cured meats vs. uncured
    • Higher carbonyls in volatile fraction of uncured meats
  – Flavor deterioration generally related to loss of flavor over time.
Flavor Deterioration

• General Control Strategy
  – Exclude oxygen!
Meat Packaging Technologies

• Vacuum Packaging
• Controlled/Modified Atmosphere Packaging (MAP)
Meat Packaging Technologies

• Vacuum Packaging
  – Fresh Meats
    • Residual O₂ consumed by meat, resulting in CO₂ production
      – Headspace of good vacuum: <1% O₂, 10–20% CO₂
    • Restricts *Pseudomonas*, favors *Lactobacillus* and *B. thermosphacta*, which are slower growers and less offensive spoilers
    • Extends refrigerated shelf-life by weeks
    • Not always suitable for retail display meat (due to formation of purplish deoxymyoglobin)
  – Cured Meats
    • High vacuum is highly desirable
Meat Packaging Technologies

• Controlled/Modified Atmosphere Packaging (MAP)
  – Typically a mixture of CO₂, O₂ and/or N₂
  – O₂
    • maintains meat pigment in oxymyoglobin state (O₂ tension > 240mmHg)
    • Accelerates lipid oxidation and microbial growth
  – Carbon dioxide
    • Inhibits microbial growth up to ≈25%
      – Effectiveness increases with decreasing temperature
    • Nitrogen
      – Inert gas: used to displace O₂ and as a filler gas
Meat Packaging Technologies

• Controlled/Modified Atmosphere Packaging (MAP)
  – Fresh Meats
    • High O₂ MAP
      – Typical gas mixture: 60–80% O₂, 20–40% CO₂
      – Oxidative conditions encourage lipid oxidation and color degradation, so shelf-life is short
      – More suitable for retail display
    • Low O₂ MAP
      – Typically >65% CO₂ with balance as N₂
      – Due to purple color, more suitable for centralized packing
  – Cured Meats
    • Achieving low residual O₂ is key
    • Typical gas mixture: 70% N₂, 30% CO₂
## Meat Packaging Technologies

### Common Packaging Systems

<table>
<thead>
<tr>
<th></th>
<th>Atmosphere</th>
<th>Fresh Meats</th>
<th>Processed Meats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Store wrap</td>
<td>Air</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Case-ready pack</td>
<td>Air/MAP</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Formed pouch</td>
<td>Vacuum/MAP</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Heat shrink</td>
<td>Vacuum</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Thermoforming trays</td>
<td>Vacuum</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Skin pack</td>
<td>Vacuum</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Formed trays</td>
<td>MAP</td>
<td>✓</td>
<td>✓</td>
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</tbody>
</table>
Technically Effective Meat Package

Specific Product

Packaging Material
- Gas transmission
- Light filtering
- Strength/thickness

Storage, Distribution, Display Conditions
- Temperature
- Lighting

Package Atmosphere
- Low/high O2
- Vacuum
- MAP (gas composition)