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Packaging Strategies for Meat and Meat Products

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Packaging Basics Seminar

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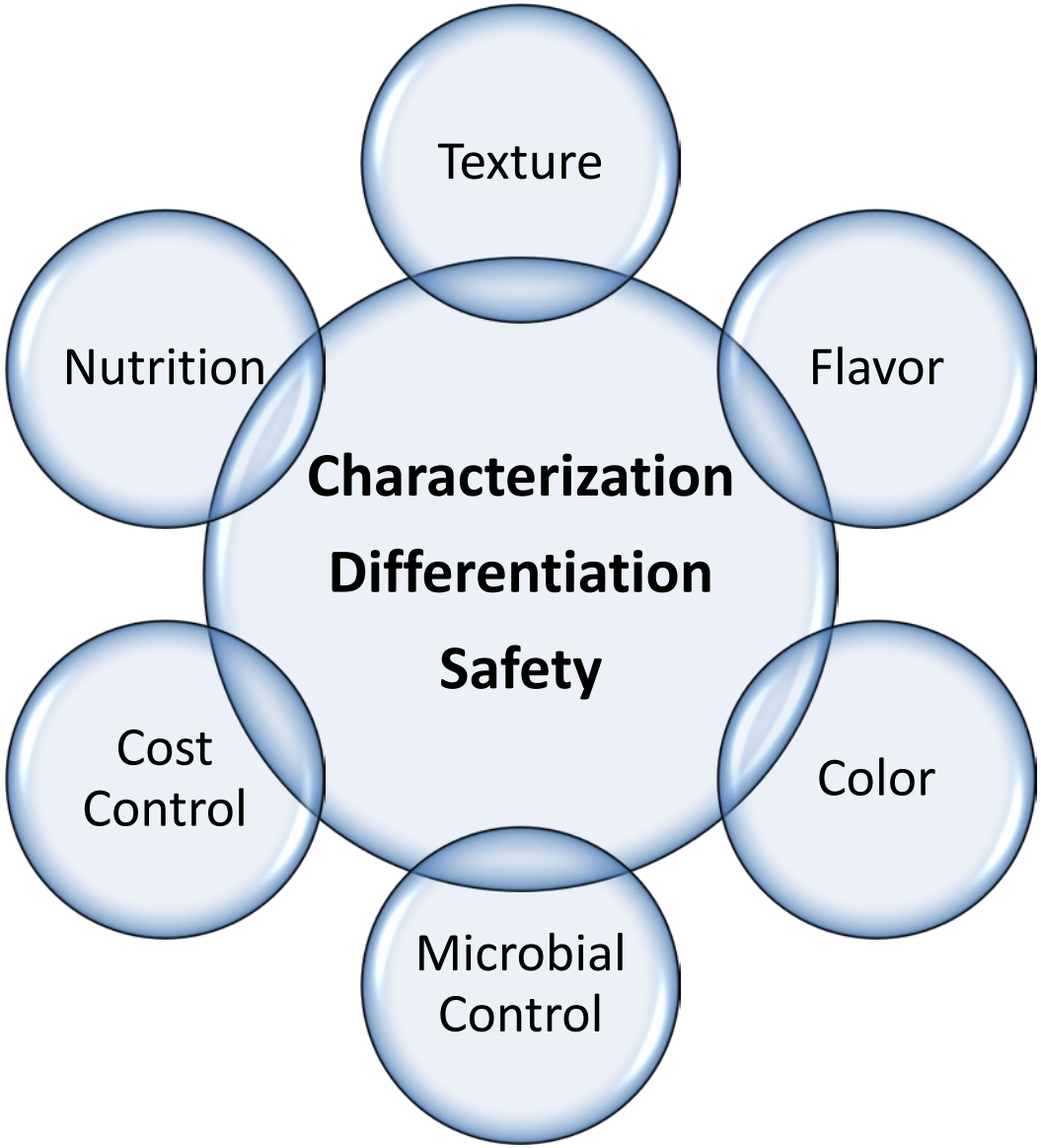
Classes of Attributes in Meat Products

- 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



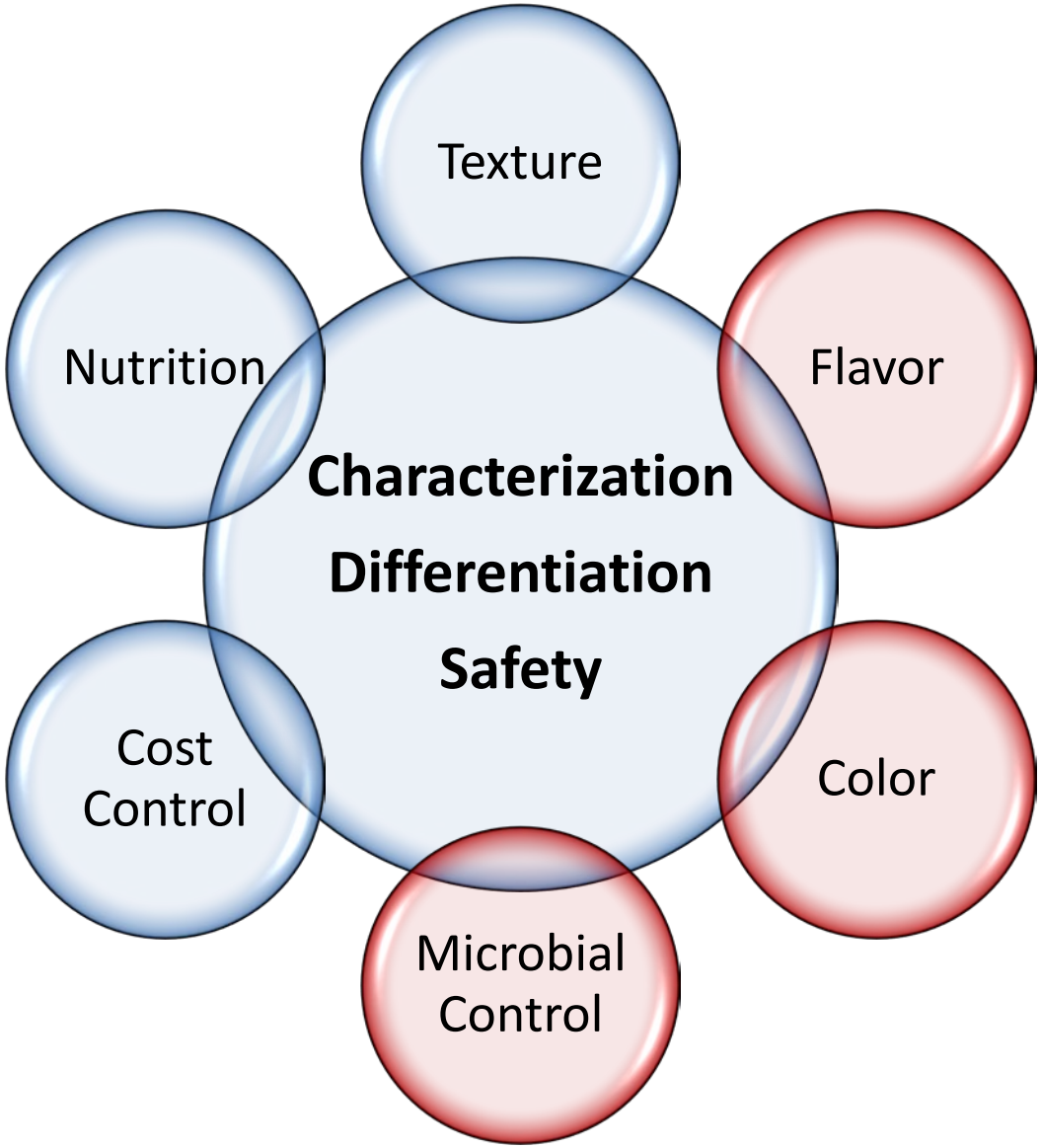
Objectives of Meat Packaging

- 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



Environmental factors that affect quality characteristics

	Color	Flavor	Microbial Control
Oxygen	✓	✓	✓
Light	✓	✓	
Temperature	✓	✓	✓

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

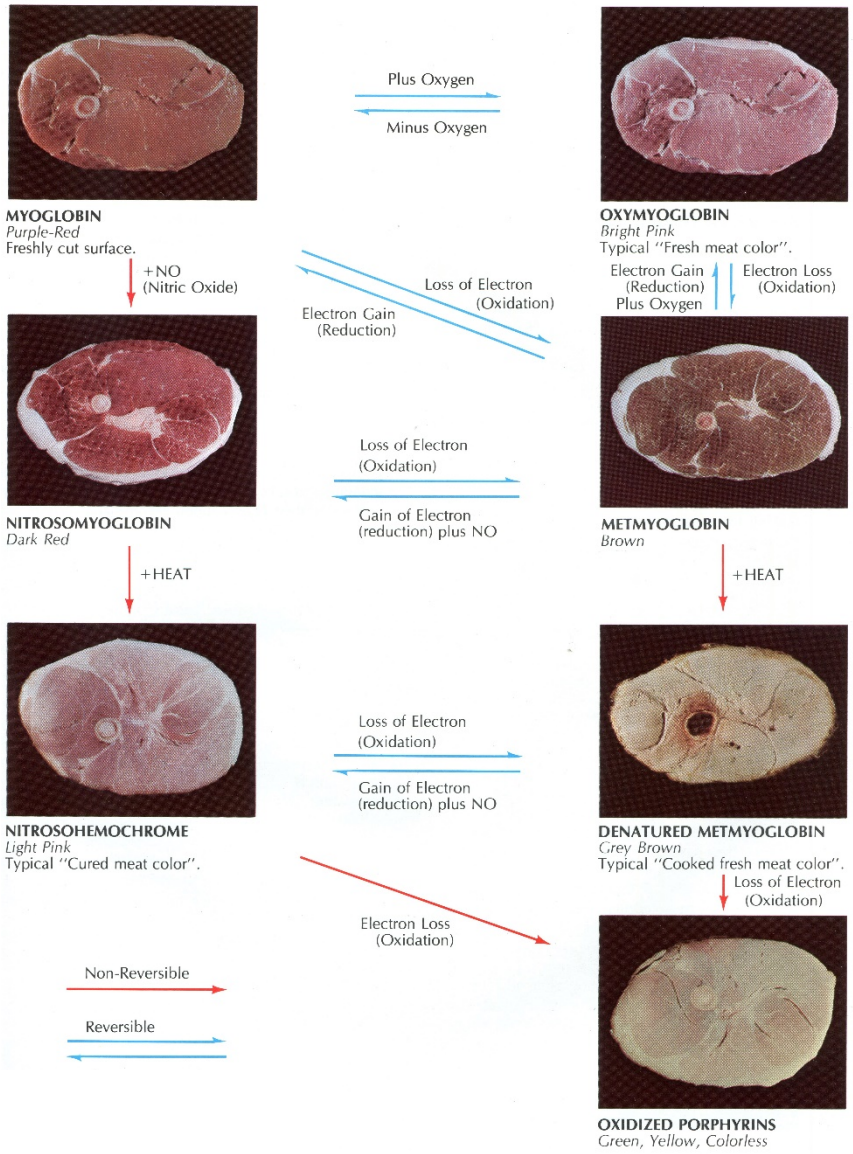
Color

- 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



Source: Rust, R.E., Olson, D.G. 1973. *Meat Curing Principles and Modern Practice*. Kansas City, MO: Koch Supplies, Inc.

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

    → discoloration decreases with increasing O_2 partial pressure
  - Cured meats
    - Pigment oxidation is directly proportional to increasing O_2 tension

    → 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 (H_2S) → sulphmyoglobin
    - Hydrogen peroxide (H_2O_2) → 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 O_2 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 O_2 consumed by meat, resulting in CO_2 production
      - Headspace of good vacuum: <1% O_2, 10–20% CO_2
    - 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 CO_2, O_2 and/or N_2
  - O_2
    - maintains meat pigment in oxymyoglobin state (O_2 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 O_2 and as a filler gas

Meat Packaging Technologies

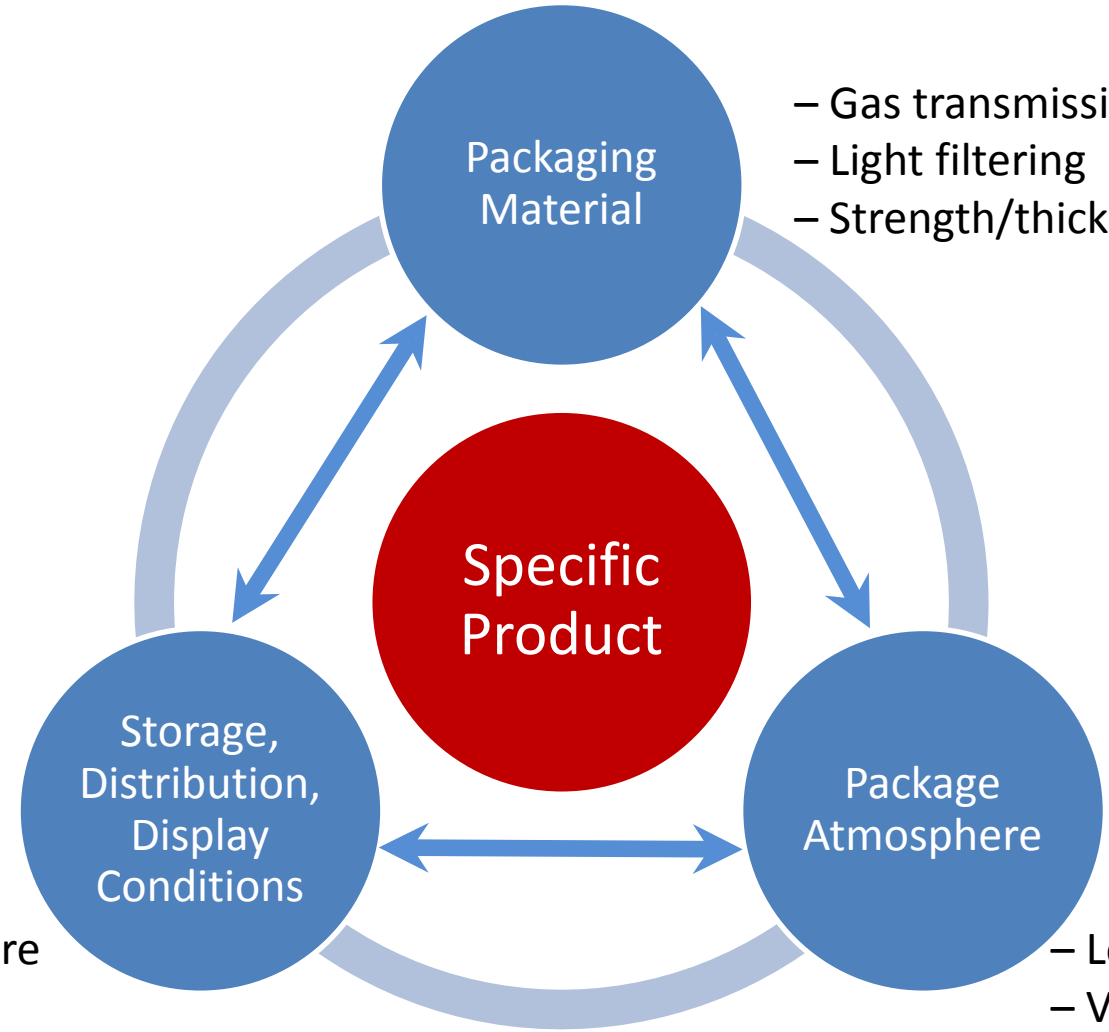
- Controlled/Modified Atmosphere Packaging (MAP)
  - Fresh Meats
    - High O_2 MAP
      - Typical gas mixture: 60–80% O_2, 20–40% CO_2
      - Oxidative conditions encourage lipid oxidation and color degradation, so shelf-life is short
      - More suitable for retail display
    - Low O_2 MAP
      - Typically >65% CO_2 with balance as N_2
      - Due to purple color, more suitable for centralized packing
  - Cured Meats
    - Achieving low residual O_2 is key
    - Typical gas mixture: 70% N_2, 30% CO_2

Meat Packaging Technologies

Common Packaging Systems

	Atmosphere	Fresh Meats	Processed Meats
Store wrap	Air	✓	
Case-ready pack	Air/MAP	✓	
Formed pouch	Vacuum/MAP	✓	✓
Heat shrink	Vacuum	✓	✓
Thermoforming trays	Vacuum	✓	✓
Skin pack	Vacuum	✓	✓
Formed trays	MAP	✓	✓

Technically Effective Meat Package



– Gas transmission
– Light filtering
– Strength/thickness

– Temperature
– Lighting

– Low/high O2
– Vacuum
– MAP
(gas composition)