Managing Tenderness, Flavor, and Shelf Life

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Meat Quality

• Fresh meat must first look good, then meet visual expectations by tasting good
• Color and texture affect visual preference
• Tenderness, juiciness, flavor and aroma affect taste preference
PALATABILITY
Meat Palatability

- For meat scientists, cooked meat palatability is determined by the combined effects of tenderness, juiciness, and flavor.
  - Generally, tenderness and flavor are considered the most critical variables.
  - Numerous pre- and post-mortem factors influence each variable.
  - Tenderness is the most widely researched palatability factor
Meat Tenderness

- Meat components that contribute to tenderness
  - Connective tissue
  - Muscle fibers
  - Adipose tissue
Meat Tenderness

• Connective Tissue
  - Affected by age, muscle location, and gender
  - Amount of collagen
    • Becomes more complex and abundant as animal matures
Meat Tenderness

• Muscle Fibers
  - Rigor mortis
Meat Tenderness

• Adipose Tissue
  - Adipose tissue may provide lubrication in the mouth during chewing, reduce bulk density or both
  - Adipose tissue likely provides some protection from overcooking
  - Research does not directly correlate tenderness and marbling
    • Approximately 10% of the variation in tenderness is associated with marbling.
    • “Halo effect”: Consumers rate highly marbled beef more tender
Proximate composition of raw beef strip steaks from various fat levels and quality treatments

<table>
<thead>
<tr>
<th>Quality treatment</th>
<th>Fat, %</th>
<th>Moisture, %</th>
<th>Protein, %</th>
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<tbody>
<tr>
<td>Australian Wagyu</td>
<td>26.64a</td>
<td>54.16e</td>
<td>17.37f</td>
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<td>American Wagyu</td>
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<tr>
<td>Prime</td>
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<tr>
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<td>66.81c</td>
<td>22.51c</td>
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<td>Low Choice</td>
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<td>23.21b</td>
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<tr>
<td>Grass-finished</td>
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<td>22.55c</td>
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<tr>
<td>Select, Holstein</td>
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<td>71.73a</td>
<td>23.20b</td>
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<td>Select</td>
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<td>71.36a</td>
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<tr>
<td>Standard</td>
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<td>24.10a</td>
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<tr>
<td>SEM</td>
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*Corbin et al., Meat Science 100 (2015) 24-31*
## Consumer ratings of the palatability traits of grilled beef strip loin steaks of varying fat levels and quality treatments

<table>
<thead>
<tr>
<th>Quality treatment</th>
<th>Tenderness</th>
<th>Juiciness</th>
<th>Flavor liking</th>
<th>Overall liking</th>
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<tbody>
<tr>
<td>Australian Wagyu</td>
<td>79.34a</td>
<td>85.00a</td>
<td>68.20ab</td>
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<tr>
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<td>81.60a</td>
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<tr>
<td>Top Choice, Holstein</td>
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<td>63.25c</td>
<td>61.54c</td>
<td>62.67b</td>
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Corbin et al., Meat Science 100 (2015) 24-31
Pearson correlation coefficients among consumer sensory scores and proximate composition of beef strip steaks from varying fat levels and quality treatments

<table>
<thead>
<tr>
<th>Trait</th>
<th>Overall liking</th>
<th>Tenderness</th>
<th>Juiciness</th>
<th>Flavor</th>
<th>% fat</th>
<th>% moisture</th>
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<td>Tenderness</td>
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<tr>
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<td>0.93*</td>
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<tr>
<td>Flavor</td>
<td>0.96*</td>
<td>0.88*</td>
<td>0.87*</td>
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<tr>
<td>% fat</td>
<td>0.79*</td>
<td>0.81*</td>
<td>0.88*</td>
<td>0.74*</td>
<td></td>
<td></td>
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<tr>
<td>% moisture</td>
<td>− 0.80*</td>
<td>− 0.81*</td>
<td>− 0.89*</td>
<td>− 0.76*</td>
<td>− 0.99*</td>
<td></td>
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<tr>
<td>% protein</td>
<td>− 0.72*</td>
<td>− 0.76*</td>
<td>− 0.85*</td>
<td>− 0.67*</td>
<td>− 0.95*</td>
<td>0.92*</td>
</tr>
</tbody>
</table>

*Corbin et al., Meat Science 100 (2015) 24-31*
Meat Flavor

- Meat flavor is a combination of taste (detected on the tongue) and aroma (detected in the nasal-pharyngeal region) as perceived by consumers.

- Meat contains a multitude of “precursor” compounds (i.e. protein, lipid, carbohydrates, vitamins, minerals, etc.).

- During cooking, chemical changes alter these precursors, causing the formation and release of volatile compounds with known flavor profiles.

- The amount, availability, and reactivity of precursor compounds in raw beef influences the development of cooked flavor volatiles.
Meat Flavor

There are several factors, which have known influences on flavor, including:

- Species
- Cookery
- Diet (Grain-fed vs. Grass-fed; others diets)
- Maturity
- Intramuscular fat
- Muscle source
- Post-mortem aging
- pH
- Fatty acid composition
Managing Palatability

Pre-harvest

• Genetics
• Castration of intact males
• Age/Maturity
• Feeding of quality, balanced, high energy diets
• Feeding to fat end-points
  - Marbling is the last fat deposited
Managing Palatability

Post-harvest (tenderness)

• Prevent/decrease sarcomere shortening
  - Electrical stimulation; fat cover; stretching
• Disrupt the muscle fibers
  - Aging/Conditioning
  - Exogenous enzymes
  - Mechanical severance/Blade tenderization
Managing Palatability

Post-harvest (tenderness)

- Disrupt the connective tissue
  - Exogenous enzymes
  - Mechanical severance/Blade tenderization
  - Moist heat cookery – braise, stew, pot roast
  - Cooler aging
SHELF LIFE
Shelf Life

• It is difficult to make a definitive determination of when the shelf life of meat has ended
• The usual characterization is the point it becomes unfit for human consumption or spoiled
• Spoilage is often equated with decomposition and putrefaction resulting from microorganisms
Shelf Life

• Shelf life for a specific cut is influenced by:
  - Microbial contamination
  - Microbial activity
  - Muscle
    • Lipid and/or protein oxidation
    • Discoloration
  - Endogenous hydrolytic enzymes
Shelf Life

- Spoilage bacteria cause objectionable odors, flavor and discoloration
- Called “spoilage” bacteria because their growth and metabolic products lead to objectionable appearance and odor
- Subtle changes, however, may appear in color, odor, flavor, tenderness and processing properties
Shelf Life

• Aerobic spoilage by bacteria and yeasts usually results in slime formation, undesirable odors and flavors (taint), and color changes
  - Because of production of oxidizing compounds by bacteria, changes in meat color are also observed

• Anaerobic and microaerophilic spoilage occurs in vacuum packaged products, sealed containers or deep inside whole muscle cuts
  - Usually described as taint, sour or putrefaction
Managing Shelf Life

- Managing spoilage bacteria in fresh meat
  - Sanitation
  - Refrigeration
  - Atmosphere
    - Packaging

- Managing lipid oxidation and discoloration is more difficult
  - Refrigeration and atmosphere
Lipids in Meat

• Lipids in meat are classified in three ways:
  - Triglycerides (Neutral lipids)
  - Phospholipids (Polar lipids)
  - Sterols (cholesterol)
• Triglycerides are associated with fat depots (subcutaneous, intermuscular, intramuscular)
• Phospholipids and sterols are associated with the membranes of animal cells
Lipid Oxidation

- Shelf life deterioration occurs because of lipid oxidation and muscle pigment oxidation.
  - Lipid oxidation rate and extent is primarily affected by PUFA content of tissue
- Unsaturated fatty acids undergo auto-oxidation by a free radical mechanism
  - Adversely affects meat color and texture
Lipid Oxidation

- Breakdown of lipid hydroperoxides produces aldehydes, ketones and carboxylic acids
  - Negatively affect odor and flavor
Muscle Pigment Oxidation

- Lipid and muscle pigment oxidation are closely related
- Muscle pigment oxidation negatively affects meat color
- Oxidation of the iron in the heme moiety of myoglobin causes an undesirable change in meat color
- Some muscles discolor less rapidly than others because of increases in metmyoglobin reducing activity (MRA)
Managing Shelf Life

• Managing lipid oxidation and discoloration
  - Refrigeration
  - Atmosphere (limit exposure to oxygen)
  - Time

• Industry does a good job of managing palatability and shelf life of traditional cuts
  - The time used postmortem to maximize palatability is not limited by shelf life

• Alternative cuts
Consumer sensory & precursor compound evaluation of three beef muscles from three USDA quality grades aged for two wet-aging periods on beef flavor acceptability

Caroline Kirby, M.S.
Texas Tech University

This project was funded, in part, by The Beef Checkoff
Objective

The influence of USDA beef quality grade, muscle source, and wet-aging period on:

- Consumer Sensory Evaluation
- Raw Chemical Analysis:
  - Proximate Composition: Total fat, moisture, ash, protein, and pH
  - Lipid oxidation by-products
  - Fatty acid composition:
- Cooked Chemical Analysis:
  - Proximate Composition: Total fat, moisture, ash, protein
  - Lipid oxidation by-products
  - Fatty acid composition
  - Volatile Compound Analysis

Funded by The Beef Checkoff
MATERIALS & METHODS
Materials & Methods

• Carcasses of “A” maturity were selected to represent USDA beef quality grades:
  - USDA Prime (PR; Slightly Abundant\(^0\) or greater)
  - USDA Low Choice (LC; Small\(^0\) to Small\(^1\)
  - USDA Standard (ST; Traces\(^9\) or lower)

• Subprimals (muscles) evaluated:
  • Top sirloin butt (IMPS, #184B) – Gluteus medius
  • Bottom round (IMPS, #171B) – Biceps femoris
  • Chuck roll (IMPS, #116A) – Serratus ventralis

• Subprimals were vacuum packaged and wet-aged for 21 or 42 d postmortem at 2 to 4°C in the absence of light
Materials & Methods

After each aging period

- Coarse and fine grind
- Chub packages and frozen (-20 °C)
- Portioned into 1.9-cm thick patties
- Patties were thawed for 12-24h at 2-4 °C
- Non-stick griddle pans over open gas burners - preheated to 246 °C
- Cooked to an internal temperature of 72 °C
Materials & Methods

• 108 consumers – Lubbock, TX

• Ballot traits:
  - Flavor Liking
  - Overall Liking
  - Flavor Acceptability
  - Overall Acceptability
  - Quality Levels
    - Quality Level 1: Unsatisfactory
    - Quality Level 2: Good everyday quality
    - Quality Level 3: Better than everyday quality
    - Quality Level 4: Premium quality

Funded by The Beef Checkoff
Materials & Methods

- Raw and cooked proximate composition percentages (AOAC, 2005)
  • Total Intramuscular Lipid Analysis (modified methods of Folch, Lees, & Stanley, 1957)
  • Protein, Moisture, Ash Analysis
- pH Analysis (Luqué et al. 2011)
- Raw and cooked lipid oxidation by-products (modifications of Buege & Aust (1978) described by Martin et al. 2014)
  • Thiobarbituric acid reactive substances (TBARS)
    – mg malonaldehyde/kg of meat
Materials & Methods

- Volatile Compound GC-MS Analysis (Chail, 2015; Hunt et al. 2016)
  - 3.00 g (+/- 0.02 g) cores were weighed and internal standard
  - Equilibration, Extraction (SPME fiber), and Separation/Detection
  - ng volatile compound/g of meat

- Fatty acid composition of raw and cooked samples (Hunt et al. 2016; Legako, Brooks et al. 2015)
  - Extraction of total lipids
  - Fractionation of total lipids (Juaneda & Rocquelin, 1985) into:
    - Neutral lipid fraction
    - Polar lipid fraction
  - Derivatization of fatty acids into fatty acid methyl esters for GC-FID analysis
    - Neutral lipids (Li & Watkins, 2001)
    - Polar lipids (Maxwell & Marmer, 1983)
  - Linolelaidic (18:2\textsuperscript{Δ9,12} trans) methyl ester – internal standard
  - Fatty acid percentages (%) – g fatty acid/100 g dry matter
Materials & Methods

- PROC GLIMMIX procedure of SAS (SAS version 9.3, SAS Institute, Inc., Cary, NC) was employed for three-way analysis of fixed effects
  - Fixed effects: USDA beef quality grade, muscle source, and wet-aging period
  - Random variable: Carcass ID
- Least square means of each raw and cooked analysis were separated using the PDIFF function of SAS to determine significance of fixed effects
  - P < 0.05 – significant
  - P < 0.10 – tendency
- Principal Component Analysis (PCA) was conducted on the MUS X AGE interaction between consumer sensory scores, then correlated with volatile compounds, raw and cooked fatty acids, and proximate composition

Funded by The Beef Checkoff
RESULTS & DISCUSSION
### Significant Results

<table>
<thead>
<tr>
<th></th>
<th>Raw Proximate</th>
<th></th>
<th>Cooked Proximate</th>
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<tbody>
<tr>
<td></td>
<td>Total Fat</td>
<td>Moisture</td>
<td>Protein</td>
<td>Ash</td>
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<td><strong>QG</strong></td>
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<tr>
<td><strong>MUS</strong></td>
<td>&lt;0.0001*</td>
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*Significant results at the 0.05 level.

*Funded by The Beef Checkoff*
## Significant Results

<table>
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<tr>
<th></th>
<th>Flavor Liking</th>
<th>Overall Liking</th>
<th>Flavor Acceptability (%)</th>
<th>Overall Acceptability (%)</th>
<th>Quality Level 1</th>
<th>Quality Level 2</th>
<th>Quality Level 3</th>
<th>Quality Level 4</th>
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**Funded by The Beef Checkoff**
Principal component analysis of the interaction between muscle source (BF = *Biceps femoris*; GM = *Gluteus medius*, SV = *Serratus ventralis*) and wet-aging period (21 or 42d) on consumers sensory rankings, volatile compounds collected from the headspace of **grilled ground beef patties** and lipid oxidation by-products (TBARS; mg malonaldehyde/kg meat) (n = 108).

Funded by The Beef Checkoff
Principal component analysis of the interaction of muscle source (BF = Biceps femoris; GM = Gluteus medius, SV = Serratus ventralis) and wet-aging period (21 or 42d) on consumers sensory rankings, proximate composition, lipid oxidation by-products (TBARS; mg malonaldehyde/kg meat), and fatty acids within the neutral lipid fraction of grilled ground beef patties (n = 108).
Principal component analysis of the interaction of muscle source (BF = Biceps femoris; GM = Gluteus medius, SV = Serratus ventralis) and wet-aging period (21 or 42d) on consumers sensory rankings, proximate composition, lipid oxidation by-products (TBARS; mg malonaldehyde/kg meat), and fatty acids within the polar lipid fraction of grilled ground beef patties (n = 108).

Funded by The Beef Checkoff
Conclusions

• Quality grade (marbling) was not an indicator of palatability in the muscles evaluated
  • Muscle and Age influenced consumer evaluations
• Extended aging to improve tenderness was detrimental in muscles susceptible to oxidation
• Traditional approaches to manage palatability and shelf life need to be evaluated for efficacy in alternative cuts