Effect of Beef Production Systems on Beef Carcass Merit

Dr. Dwight Loveday
University of Tennessee
Food Science & Technology
Beef Market

Grass + Short Grain Feeding

Grass + Long Grain Feeding

Grass Finished

Grain Finished

Real. Life. Solutions.
Beef Market

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NUTRITION

CATTLE TYPE
Beef Carcass Merit

Cutability Traits:
• Affecting the carcass yield of usable product

Quality Traits:
• Affecting the carcass/cut palatability
  – Flavor
  – Tenderness
  – Juiciness
Beef Carcass Merit

Cutability Traits:

• Affecting the carcass yield of usable product
  – Hot Carcass Wt.
Beef Carcass Merit

*Cutability Traits:*

- Affecting the carcass yield of usable product
  - Hot Carcass Wt.
  - Fat Thickness
    - Between 12\textsuperscript{th} & 13\textsuperscript{th} rib
    - ¾ distance of rib eye muscle
    - 0.20-0.50 in. fat
Beef Carcass Merit

**Cutability Traits:**

- Affecting the carcass yield of usable product
  - Hot Carcass Wt.
  - Fat Thickness
  - Ribeye Area
    - Measure the *longissimus* muscle
Beef Carcass Merit

**Cutability Traits:**

- Affecting the carcass yield of usable product
  - Hot Carcass Wt.
  - Fat Thickness
  - Ribeye Area
    - Measure the *longissimus* muscle
    - Determine size with a grid
    - 11-15 sq. in. (1.6-1.8 sq.in./cwt carcass wt.)
Beef Carcass Merit

**Cutability Traits:**
- Affecting the carcass yield of usable product
  - Hot Carcass Wt.
  - Fat Thickness
  - Ribeye Area
  - %Kidney, Pelvic & Heart Fat
Beef Carcass Merit

**Cutability Traits:**

- Affecting the carcass yield of usable product
  - Hot Carcass Wt.
  - Fat Thickness
  - Ribeye Area
  - %Kidney, Pelvic & Heart Fat
  - Yield Grade
Beef Yield Grades

• A number that represents the percent cutability (major wholesale cuts)
• Yield Grades are numbered 1, 2, 3, 4 & 5
• Factors Used to Determine Beef Yield Grades:
  – Adjusted Fat Thickness
  – Percent Kidney, Pelvic and Heart Fat
  – Rib Eye Area
  – Hot Carcass Weight
• YG= 2.5+ (2.5*Adj. FT) + (.20*%KPH) + (.0038* HCW) - (.32*REA)
# Beef Yield Grades

<table>
<thead>
<tr>
<th>Yield Grade</th>
<th>% Cutability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>52.4 or greater</td>
</tr>
<tr>
<td>2</td>
<td>50.1 - 52.3</td>
</tr>
<tr>
<td>3</td>
<td>47.8 – 50.0</td>
</tr>
<tr>
<td>4</td>
<td>45.5 – 47.7</td>
</tr>
<tr>
<td>5</td>
<td>45.4 or less</td>
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</table>
Carcass and Palatability Traits


• All-forage treatments were compared to grain feeding, (except the 2000 paper by French et al.)

• Animal age appeared to be controlled and where grain feeding lasted 85 days or more
## Carcass Traits: Quantity

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<th>Study</th>
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From Brewer and Calkins, 2003
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From Brewer and Calkins, 2003

HCW tends to be lower for grass fed.
Endpoints can affect weights.
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Grass fed tend to have less internal fat.

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From Brewer and Calkins, 2003

Grass fed tend to have smaller ribeye areas.
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<td>8.6</td>
<td>11.6</td>
<td>1.9</td>
</tr>
</tbody>
</table>

Based on YG, grass fed tend to have higher cutability due to less external fat.
Beef Carcass Merit

**Quality Traits:**

- Affecting the carcass/cut palatability
  - Lean Color
  - Lean Firmness
  - Lean Texture
  - Fat Color
  - Marbling
# Carcass Quality Traits: Lean/Fat Color

<table>
<thead>
<tr>
<th>Trait</th>
<th>Grain-fed</th>
<th>Grass-fed</th>
<th>P Value</th>
</tr>
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<tbody>
<tr>
<td>Ribeye Lightness (L*)</td>
<td>36.7± .7</td>
<td>30.1± .7</td>
<td>0.02</td>
</tr>
<tr>
<td>Ribeye Redness (a*)</td>
<td>23.4± 1.0</td>
<td>24.8± 1.0</td>
<td>0.16</td>
</tr>
<tr>
<td>Fat Lightness (L*)</td>
<td>77.2± 1.1</td>
<td>72.1± 1.1</td>
<td>0.04</td>
</tr>
<tr>
<td>Fat Yellowness (b*)</td>
<td>8.6± .8</td>
<td>10.1± .8</td>
<td>0.04</td>
</tr>
</tbody>
</table>

L* = measure of darkness to lightness (larger value indicates a lighter color)  
 a* = measure of redness (larger value indicates a redder color)  
 b* = measure of yellowness (larger value indicates more yellow color)  
 Carr et. al
Carcass Quality Traits: Lean/Fat Color

• Grass-fed fat tends to more yellow
• Fat color can be variable

Grass-fed

Grain-fed
Carcass Quality Traits: Lean Texture & Firmness

- Grass fed tends to be slightly more coarse textured and slightly softer
Beef Carcass Merit

**Quality Traits:**
- Affecting the carcass/cut palatability
  - Lean Color
  - Lean Firmness
  - Lean Texture
  - Fat Color
  - Marbling

**Palatability Traits:**
- Flavor
- Juiciness
- Tenderness
Tenderness: Warner Bratzler Shear*

*Larger number is less tender
Tenderness: Sensory Panel

*Smaller number is less tender
Tenderness

• Connective tissue effects
  – Amount of connective tissue
  – Heat solubility of connective tissue

• Muscle fiber effects
  – Muscle fiber shortening
  – Ease of muscle fiber fragmentation
Tenderness

• Connective tissue effects
  – Amount of connective tissue
    • Muscle variations
  – Heat solubility of connective tissue
    • Older animals have decreased connective tissue solubility
Tenderness

• Connective tissue effects
  – Amount of connective tissue
    • Muscle variations
      – Animals on lower planes of nutrition have relatively more connective tissue due to smaller muscle fiber size
Tenderness

• Connective tissue effects
  – Heat solubility of connective tissue
    • Older animals have decreased connective tissue solubility
      – Greater days to harvest may result in decreased connective tissue solubility
      – Grass-fed tends to take longer to reach a harvest time
      – 24-30 months appears to be a time where tenderness declines
Tenderness

• Muscle fiber effects
  – Muscle fiber shortening
    • “Cold shortening “ is more common in carcass with less outside fat cover
    • Thinly muscled carcasses chill more quickly
    • Greater chance of “heat ring”
  – Ease of muscle fiber fragmentation
    • Muscle enzyme systems that tenderize muscle are less effective at colder temperatures
Flavor

*Smaller number is less flavorful
Overall Acceptability

*Smaller number is less acceptable

Real. Life. Solutions.
Fescue Flavor

• Sensory descriptions: grassy, milky, oily, sour, livery
• Consumer descriptions: fishy, “nasty”
• Likely due to flavor pre-cursors – fatty acid profiles
• Also, strong aromas when cooking
Flavor, Juiciness & Acceptability

• Most reports favor grain fed beef
• Marbling fat associated with flavor and juiciness
• Forage fed beef has been described as having a bitter, grassy or livery flavor
• Results are variable
• Chemical components of fat and muscle affect ‘beefy’ flavor
Factors Affecting Meat Quality

• Marbling
  • Degrees of Marbling
    o Abundant
    o Moderately Abundant
    o Slightly Abundant
    o Moderate
    o Modest
    o Small
    o Slight
    o Traces
    o Practically Devoid
Marbling Effect on Sensory Experience

Probability of a Positive Sensory Experience

Source: Emerson et al, 2011
<table>
<thead>
<tr>
<th>Marbling</th>
<th>Flavor</th>
<th>Tenderness</th>
<th>Overall Palatability</th>
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</thead>
<tbody>
<tr>
<td>Prime</td>
<td>1 in 43</td>
<td>1 in 36</td>
<td>1 in 26</td>
</tr>
<tr>
<td>Up 2/3 Choice</td>
<td>1 in 39</td>
<td>1 in 22</td>
<td>1 in 19</td>
</tr>
<tr>
<td>Low Choice</td>
<td>1 in 12</td>
<td>1 in 12</td>
<td>1 in 7</td>
</tr>
<tr>
<td>Select</td>
<td>1 in 8</td>
<td>1 in 12</td>
<td>1 in 5</td>
</tr>
<tr>
<td>Standard</td>
<td>1 in 3</td>
<td>1 in 2</td>
<td>1 in 2</td>
</tr>
</tbody>
</table>

*Odds of "Undesirable"

Source: Smith et al., 1984
## Fat Content of Quality Grades

<table>
<thead>
<tr>
<th>Percentage Intramuscular Fat</th>
<th>USDA Quality Grade</th>
<th>Degree of Marbling</th>
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</thead>
<tbody>
<tr>
<td>11% and Above</td>
<td>Prime+</td>
<td>Abundant 00-100</td>
</tr>
<tr>
<td>9.5% - 11%</td>
<td>Prime°</td>
<td>Moderately Abundant 00-100</td>
</tr>
<tr>
<td>8% - 9.5%</td>
<td>Prime-</td>
<td>Slightly Abundant 00-100</td>
</tr>
<tr>
<td>7% - 8%</td>
<td>Choice+</td>
<td>Moderate 00-100</td>
</tr>
<tr>
<td>5% - 6%</td>
<td>Choice°</td>
<td>Modest 00-100</td>
</tr>
<tr>
<td>4% - 5%</td>
<td>Choice-</td>
<td>Small 00-100</td>
</tr>
<tr>
<td>3.5% - 4%</td>
<td>Select+</td>
<td>Slight 50-100</td>
</tr>
<tr>
<td>3% - 3.5%</td>
<td>Select-</td>
<td>Slight 00-50</td>
</tr>
<tr>
<td>2.5% - 3%</td>
<td>Standard+</td>
<td>Traces</td>
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<td>2.5% and Below</td>
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4 year old grass-fed Wagyu; brought $100/lb
Flavor, Juiciness & Acceptability

• Most reports favor grain fed beef
• Marbling fat associated with flavor and juiciness
• Forage fed beef has been described as having a bitter, grassy or livery flavor
• Chemical components of fat and muscle
Factors Affecting Palatability

- Genetics – marbling, tenderness
- Maturity – older carcass maturity (~24+ months) less tender
- Grass/forage – not all grasses the same
- Post-mortem handling – prevent cold shortening
- Cookery – leaner meats prepared differently
Cooking Lean Meat

• Because the meat has less fat, use a little cooking oil for frying or grilling
• Marinade in oil and/or acid (improve tenderness)
• Sear the beef over a high heat on a grill or stovetop skillet to seal in its juices, then proceed with a lower temperature to finish grilling, frying, or roasting
• Require about a third less cooking time than conventional beef
• Best prepared rare or medium-rare
• Remove the meat from the heat source when it is about 10 degrees from your goal temperature

• Very lean ground beef, consider making additions compensate for the lack of fat; Ex. diced up peppers or caramelized onions to add moisture.
• Leaner burgers will also require about a third less cooking time
• Never use a fork to turn your beef . . . precious juices will be lost; use tongs
• Do not use the microwave for defrosting or cooking
Nutritional Claims

• Red meat is nutrient dense
• Important source of:
  – Essential amino acids
  – Vitamins A, B\textsubscript{6}, B\textsubscript{12}, D and E
  – Minerals iron, zinc and selenium
• Fats source of energy and absorption of fat-soluble vitamins A, D, E, and K
Nutritional Claims

• Saturated fat
  – Animal fats contribute approximately 60% of the SFA in the American diet
  – Not all saturated fats are alike
  – Generally raise the blood cholesterol level and “bad” cholesterol levels
    • Lauric acid
    • Myristic acid
    • Palmitic acid
  – Beef’s saturated fat is stearic acid which is neutral effect on blood cholesterol
  – Approximately 30% beef’s FA is oleic acid which is a monounsaturated FA with cholesterol lowering effect
Nutritional Claims

• Saturated fat
  – Grass fed:
    • Lower in total fat
    • Lower in myristic, lauric and palmitic FA
    • Similar in oleic FA to grain fed
    • Less likely to raise serum cholesterol
    • Lower monounsaturated FA (MUFA)
Nutritional Claims

- **Cholesterol**
  - Does not differ in grain- or grass-fed beef

Cholesterol content of 3 oz serving of cooked beef:

- Grain-fed = 64.17 mg
- Grass-fed = 65.29 mg

*(Duckett and Paven, 2007)*
Nutritional Claims

• Omega-6 and Omega-3 Fatty Acids

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<tr>
<th>Item</th>
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<th>Grass-fed</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Omega-6</td>
<td>3.71</td>
<td>3.77</td>
</tr>
<tr>
<td>% Omega-3</td>
<td>0.79</td>
<td>2.32</td>
</tr>
</tbody>
</table>

Duckett et. al (2009)

Grass fed results in a more ideal Omega-6/ Omega-3

Based on Recommended Daily Intake, a person would have to eat 4 ½ pounds of cooked grass-fed steak per day to get the minimum daily allowance of omega-3 fatty acids. (J. Comerford)
Nutritional Claims

- Beef a poor source of Omega-3 fatty acids
- To meet daily adequate intake recommendations (1.6 g/d) of Omega-3 fatty acids, you would need to eat 14 pounds of grain-fed beef or 12 pounds of grass-fed beef each day
- (Belk 2008)
Nutritional Claims

• Conjugated Linoleic Acid

CLA Content of **RAW** Beef
Grain-fed = 0.36% of total fat
Grass-fed = 0.78% of total fat
Nutritional Claims

• Conjugated Linoleic Acid
  CLA Content of *RAW* Beef
  Grain-fed = 0.36 % of total fat
  Grass-fed = 0.78% of total fat

CLA Content of *Cooked* Beef
  Grain-fed = 0.016 % of total fat
  Grass-fed = 0.017 % of total fat
Nutritional Claims

• **Vitamin E: Alpha Tocopherol**
  – Effective fat-soluble vitamin as an antioxidant
  – RDA is 15 mg/d for humans
  – Content in grain-fed steers is 2.0 micrograms/g
  – Content in grass-fed steers is 6.0 micrograms/g
    (Daley et al., 2007)

• 3X more in grass fed

• A person would have to eat 156 pounds of grass-fed beef to get the minimum RDA
  (J. Comerford)
Nutritional Claims

• **Pro-Vitamin A: Beta Carotene**
  – RDA is 1200 micrograms per day
  – Content in grain fed steers was reported as 0.05 micrograms/g
  – Content in grass-feed steers was reported as 0.06 micrograms/g (Descalzo et al.)

• Some reports had up to 7X more in grass fed

• To reach RDA from grass-fed meat, a person would have to eat 4 ½ pounds of meat per day. (J. Comerford)
Food Safety

*E. coli* O157 In Feces Of Cattle From Different Production Systems At Slaughter  

<table>
<thead>
<tr>
<th></th>
<th>Feedlot Cattle</th>
<th>Grass-Fed Cattle (Pasture)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E. Coli O157 (prevalence)</td>
<td>15%</td>
<td>10%</td>
</tr>
<tr>
<td>E. coliO157 (number)</td>
<td>&lt;10 to $10^5$</td>
<td>&lt;10 to $10^5$</td>
</tr>
</tbody>
</table>

Conclusion: The prevalence & number of *E. coli* O157 in the feces of cattle at slaughter was not affected by the production system.
Summary: Grass finished beef tends to be:

- Lighter weight
- Less muscle development
- More mature
- Leaner carcass
- Less marbling
- Tend to be less tender
- Less (different) flavor

- May or may not be “healthier” depending on your definition
- No different on *E. coli* 0157 shedding
Questions