Exploring factors that contribute to beef tenderness

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Meat

A product of life and death

Color

Texture

Marbling

Tenderness

Juiciness

Flavor
Tenderness – key factors

- Postmortem protein degradation
- Connective tissue
- Marbling
Muscle – built for life

- A machine
- Shapes & sizes
- Build, maintain, & repair
- Adapt
<table>
<thead>
<tr>
<th>System</th>
<th>Living muscle</th>
<th>Dying muscle/meat</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td></td>
<td></td>
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<tr>
<td>Temp.</td>
<td></td>
<td></td>
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<tr>
<td>Energy</td>
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</tbody>
</table>
Living muscle - growth and maintenance

Synthesis and degradation of muscle proteins

- Different tools
- Energetically demanding
Protein degradation in muscle after death

• One tool – calpain

• Contributes to tenderness
Protein degradation – muscle & meat

Calpain activity is regulated
- Calcium dependent
- Calpastatin – inhibitor
- Postmortem events
How do we evaluate postmortem protein degradation?

- Calpain
- Calpastatin
- Calpain : calpastatin
- Breakdown of individual proteins
Protein degradation explains some variation in tenderness

- Muscle
- Breed/type

“No neck hump exceeding 2 inches (safeguards against cattle with more variability in tenderness)”
Understanding tenderness in *Bos taurus* and *Bos indicus*

<table>
<thead>
<tr>
<th>Breed Group</th>
<th>Fraction*</th>
<th>Angus</th>
<th>Brahman</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Angus</td>
<td>0.80-1.00</td>
<td>0.00-0.20</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>0.60-0.79</td>
<td>0.21-0.40</td>
</tr>
<tr>
<td>3</td>
<td>Brangus</td>
<td>0.625</td>
<td>0.375</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>0.40-0.59</td>
<td>0.41-0.60</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>0.20-0.39</td>
<td>0.61-0.80</td>
</tr>
<tr>
<td>6</td>
<td>Brahman</td>
<td>0.00-0.19</td>
<td>0.81-1.00</td>
</tr>
</tbody>
</table>

*Cattle represent a continuous spectrum of Angus-Brahman genetic variation*
Objective tenderness

Warner–Bratzler Shear Force

Tough

Tender

Elzo et al., 2012
Wright et al., submitted
Protein degradation

1.5 h  24 h  14 d

Intact

Angus

Fraction degraded

Brahman, %

0.00  0.20  0.40  0.60  0.80  1.00

0  20  40  60  80  100

24 h

14 d
Protein degradation & tenderness

Protein degradation

Very tender

Moderately tough

0.0 0.20 0.40 0.60 0.80 1.00

0.0 0.20 0.40 0.60 0.80 1.00

7.0 6.0 5.0 4.0 3.0 2.0 1.0 0.0

Protein degradation
Calpastatin

Degraded during postmortem period, aging

Calpastatin remaining at 24h

Brahman, %

Angus
The Calpain System

Inactive

Intermediate

‘Activated’

1.5 h 24 h 14 d

Angus
Increasing Brahman composition

- On average, decreases tenderness
- ↓ calpain activation
- ↑ intact calpastatin

How can we increase protein degradation & improve tenderness?
Will this affect muscle growth or other traits?
Increasing calpastatin in muscle

- Growth & remodeling?
- Metabolism?
- Heat tolerance?
Muscle fiber characteristics

- Contraction

Endurance
Type 1

Strength / power
Type 2a
Type 2x
Determining contractile fiber type

Type 1
Type 2a
Type 2x
Muscle fiber cross-sectional area (CSA)

CSA of Type IIx Fibers

Is calpastatin higher in certain fibers?
Muscle fiber characteristics

- Contraction
- Metabolism
  How the cell produces energy

Endurance
Type 1

Strength / power
Type 2a
Type 2x

Oxidative

Glycolytic
Oxidative enzyme activity
Shifting muscle metabolic properties

Mitochondria

• Energy production
• Efficiency
• Calcium regulation
• Trigger cell death

Endurance

Strength
Postmortem changes in pH

- Related to energy depletion
- Delay calpain activity?

![Graph showing pH changes over time for Angus and Brahman breeds.](image-url)
Shifting muscle metabolic properties

What else might be different?

Endurance

Oxidative

Glycolytic

Strength / power
Development of tenderness

- Complex trait
- Muscle properties
- Postmortem events
- Regulation
- Relationship to other important muscle & animal traits
Acknowledgements

Thanks to

- Dr. Chad Carr
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- UF IFAS
Effect of marbling on probability of a positive rating

Emerson et al., 2012
Bos indicus and tenderness

• “No neck hump exceeding 2 inches (safeguards against cattle with more variability in tenderness)”
• 80 / 85 programs
Tenderness – key factors

• Connective tissue
Tenderness – key factors

- Connective tissue – cut location

![Tenderloin vs. Mock tender](image)

![Bar chart](chart)

<table>
<thead>
<tr>
<th>Conn. Tissue</th>
<th>Tenderloin</th>
<th>Mock tender</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.7</td>
<td>9</td>
</tr>
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</table>
Tenderness – key factors

• Connective tissue – old vs young animals
  ◦ “hardbone”
Tenderness – key factors

- Connective tissue
- Marbling
Tenderness – key factors

- Connective tissue
- Marbling
- Postmortem protein degradation
Living muscle $\rightarrow$ Meat

- pH 7.2 $\rightarrow$ 5.6
- Temperature 101°F $\rightarrow$ < 40°F

- An ‘open’ system $\rightarrow$ closed system
  - Oxygen delivery eliminated
  - Waste removal accumulates