Heat tolerance and tenderness

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Brahman

On the pasture
- Heat tolerant
- Parasite resistance
- Lower maintenance requirements

On the plate
- Variation in tenderness
- Lower marbling
Key questions:

• What features and adaptations make Brahman heat tolerant?  
  ➢ Brahman are resilient

• Is heat tolerance related to meat quality?  
  ➢ Meat – a product of life and death
Heat tolerance

Heat loss or gain with environment

Heat production from metabolism
Heat exchange between the animal and the environment

- Animal surface area : weight
- Temperature gradient, animal vs. air
- Hair coat

Evaporation - sweat

Convection - air

Radiant energy - sun

Evaporation - water from skin & breath

Conduction - ground
Heat loss in Brahman

Evaporation - sweat

Evaporation - water from skin & breath

More sweat glands

Radiant energy - sun

Smooth, slick, light-colored hair

Convection - air

Loose skin

↑ surface area

Conduction - ground
Heat production (metabolic rate)

- Whole body
- Organs differ in metabolic activity & size

- Basal metabolism
- Digestion
- Physical Activity
- Production (growth)
Organ contribution to body metabolism

% of body weight

- Brain: 2%
- Heart: 0.5%
- Kidneys: 0.4%
- Liver: 2.6%
- Digestive system: 20.0%
- Muscle: 40%
- Fat Mass: 21%
- Other: 14%

- Metabolic activity based on total weight
- Metabolic activity on per unit basis
Heat production (metabolic rate) in Brahman

- Lower maintenance requirements
  - Smaller organ size
  - Metabolism on a per unit (cell) basis?

- Basal metabolism
- Digestion
- Physical Activity
- Production (growth)
Heat production (metabolic rate) in Brahman

What do cells use energy for?

- Basal metabolism
- Energy for maintenance
- Protein synthesis
- Ion gradients
- Muscle tone
- Other
What affects energy requirements?

“Uncoupling” processes increase energy demand & metabolic rate

- Protein degradation
- Ion leaks
- Muscle relaxation

Energy for maintenance

- Protein synthesis
- Ion gradients
- Muscle tone
- Other
Protein metabolism

Protein turnover

Protein Synthesis - Protein Degradation = Protein Deposition

- Protein synthesis decreases protein degradation

Limit metabolic rate
Limit heat production

• Heat tolerance?
• Growth rate?
• Meat quality?
Protein degradation contributes to tenderness during meat aging

Evaluating postmortem protein degradation

- Calpain (cuts proteins)
- Calpastatin (inhibitor)
- Calpain : calpastatin
- Breakdown of individual proteins
Increasing Brahman composition

On average, decreases protein degradation and tenderness

- Decreased protein degradation in living animal?

- Hypothesis:
  Slower growing Brahman will have reduced protein synthesis and degradation, resulting in decreased growth rate, low metabolic rate, and greater heat tolerance

  …and tougher beef

Elzo et al., 2012
Heat tolerance, growth, & tenderness in Brahman

Calves born in Dec.-Feb.

Select for high & low growth

Weaning in Aug.

Acclimation & Heat challenge (2 wk)

Oct.

Finishing at BTU in June

Slaughter at UF Meat Lab in Dec.

• Respiration
• Temperature
• Biopsy (pre- and post-)

• Carcass data
• Muscle samples – protein degradation
• Aged steaks for tenderness
Heat challenge

Temperature - rooms

Rectal temperature

Day  $\beta < 0.0001$
Growth  $\beta = 0.70$
Day * Growth  $\beta = 0.25$

Respiration rate (breaths/min)

Day  $\beta < 0.0001$
Growth  $\beta = 0.84$
Day * Growth  $\beta = 0.82$
Meat quality

(n = 16 total)

Quality Grade

Tenderness

Avg shear force = 3.1 kg (2.1 – 3.7 kg)

Sensory rating
Brahman & tenderness

- **Marbling?**
  Not improving sensory tenderness

- **Protein degradation?**
  Improves likelihood for favorable tenderness
Postmortem protein degradation in Brahman

- Calpain activation
  - Slower in Brahman
  - Slower activation ↑ toughness
What affects calpain activation?

Calpastatin (inhibitor)
  • Slower disappearance in tougher steaks
  • Degraded by calpain
  • Greater content?
  • Capacity for inhibition?

- Calcium
- Temperature
- pH

Postmortem metabolism

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<tr>
<th></th>
<th>Tender</th>
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<th>Tough</th>
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# Postmortem metabolism: Conversion of muscle to meat

<table>
<thead>
<tr>
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<th>Living muscle</th>
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<tr>
<td><strong>pH</strong></td>
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<td><strong>Temp.</strong></td>
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<td><strong>Energy</strong></td>
<td>Stable / recoverable</td>
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<td><strong>Intracellular</strong></td>
<td>Calcium tightly controlled</td>
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Postmortem metabolism in Brahman

- More resistant to pH changes
- Improved maintenance of energy status (ATP)
Even in death, Brahman are resilient

A role for mitochondria?
- ATP production
- Calcium sequestration
- Mito-mediated cell death
Mitochondria-mediated (programmed) cell death

- Angus, Brangus, Brahman
- Caspases?

Caspase content – is lower in Brahman

Caspase is not cleaved (activated)

Intact

Calpain gen.

Caspase gen.

Little support for a role for caspase postmortem!
Mitochondria function postmortem

- Does muscle from Angus & Brahman function differently early postmortem?
- Does temperature change functional properties?

- At 1h, mitochondria can work and are coupled (produce ATP)
- Brahman decrease oxygen consumption at higher temperature
Other ways to decrease heat production?

- Limit mitochondrial leak

- Inefficiency (Proton leak)

- Coupled to ATP synthesis

- Protein synthesis
- Ion gradients
- Muscle tone
- Other

Energy for maintenance

Mitochondria
Brahman vs. Angus
Mitochondrial function

• *Longissimus* - 1h postmortem

![Graph showing oxygen consumption and leak across breeds. Bars indicate significant differences between breeds.]
Muscle Na/K ATPase and metabolic rate

- Increasing fiber size is metabolically advantageous (Jimenez et al., 2013)
- Decreasing surface area:volume reduces metabolic cost of maintaining membrane potential

Adapted from Wright et al., Meat Sci., 2018
Conclusions

• Cellular energy metabolism is an important contributor to heat production

• Several possible adaptations that may help reduce heat production in Brahman

• Muscle function in life may be antagonistic to meat quality parameters. Evaluate and balance consequences for pasture vs. plate.
Heat loss in Brahman