Conversion of Muscle to Meat

ANSC 4400/5400

Homeostasis

- Defined as maintaining systems of the body for life to maintain a balanced internal environment
- Many postmortem changes are a direct result of homeostasis
- Why is homeostasis important?
Stunning

- Render animals unconscious
- Methods
  - Electrical, Concussion, CO2
- Exceptions
  - Kosher and Halal
  - Kosher consists of animals with split hooves and chew their cud.
    “Do not wish to consume blood”

Exsanguination

- 50% of all blood left in animal
- Extend length of time from stun to stick:
  - In muscle = blood splash
  - In fat = fiery fat (ecchymiosis)
Remaining steps to convert to a carcass

- Remove feet, head, tail, hide, etc.
- Evisceration
- Weigh, Wash, and Chill

Process of Rigor

- Latin for stiffness of death
- Occurs soon after death and is characterized by stiffness and extensibility of muscles
Process of Rigor

• Circulatory system is no longer in existence
  – Muscles loses communication with external environment

• In muscles energy metabolism is shifted from aerobic to anaerobic
  – What happens as a result of loss of circulatory system and aerobic metabolism?

Process of Rigor

• 4 Steps of Rigor
  – Delay
    • “Onset of Rigor” – aerobic metabolism, ATP is present, muscle can relax
  – Onset
    • Rise in curve, muscles getting more stiff, creatine phosphate is being used
  – Completion
    • Out of CP and glycogen, almost all muscle is in form of Actomyosin – forming permanent cross-bridges (100% of all possible ones are formed)
  – Resolution
Process of Rigor

ISOMETRIC TENSION OF MUSCLE

Resolution of Rigor
Rigor Completion
Rigor Onset

TIME POSTMORTEM

Figure 5.3. Isometric tension development in muscle during phases of rigor mortis.

Muscle pH
Muscle Extensibility

ATP
Creatine Phosphate
Time to Onset of Rigor

<table>
<thead>
<tr>
<th>Species</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef</td>
<td>6–12</td>
</tr>
<tr>
<td>Lamb</td>
<td>6–12</td>
</tr>
<tr>
<td>Pork</td>
<td>1/4–3</td>
</tr>
<tr>
<td>Turkey</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>Chicken</td>
<td>&lt; 1/2</td>
</tr>
<tr>
<td>Fish</td>
<td>&lt; 1</td>
</tr>
</tbody>
</table>

End Result

- Accumulation of Lactic Acid
  - Why?
- Normal pH = 5.6
- Too high = 6.8
- Too low = 5.2
Loss of Protective Mechanisms

- No longer have the #1 temp control method
  - Results in rise in postmortem muscle temp
  - Heat generated by ongoing metabolism causes a rise soon after bleeding
  - Temp will eventually begin to decline

Temp Rise Caused BY:

- Size and location of the muscle
- Amount of fat covering the muscle
- Ambient temp in slaughter area
- Length of slaughter operation
- Temp in chill cooler
Factors affecting postmortem changes and meat quality

- Stress – physiological changes such as heart rate, respiration, body temp, and blood pressure occur during the exposure of the animal to adverse conditions

Stress and Muscle Characteristics

1. Blood Splash
   - Rupture of capillaries, because blood pressure skyrockets
   - Most common in what specie of red meat?
   - Found in lean or fat
Stress and Muscle Characteristics

2. Callused eye
   Caused by trauma to LD
   Improper use of pour-on products
   Nerve damage causes muscle fibers to die
   Connective tissue and fat deposit in damaged area

3. Highly stress susceptible
   - Physical appearance – extreme musculature, anxious behavior, muscle tremors, etc.
   - Muscle appearance – Pale, Soft, Exudative (PSE)
     - Short term stress
     - Lactic acid buildup
     - Severe pH drop
     - Decreased ability to hold water
     - Most often in loin and ham muscles
     - Price dock
Stress and Muscle Characteristics

• PSE cont…
  – Commonly seen in pork
  – Rapid pH decline at high muscle temps, resulting in pale color, loss of WHC
  – Reduced juiciness, increased cooking losses
  – Solution:
    • Rest animals prior to slaughter to replenish glycogen reserves and to remove lactic acid from the muscle

Stress and Muscle Characteristics

• Muscle appearance = Dark, Firm, Dry
  – Long term stress
  – Little glycogen
  – Little pH drop
  – Increased ability to hold water
  – Increased microbial growth
  – Dark cutters
    • 3% of all carcasses
    • Price dock
Stress and Muscle Characteristics

- DFD cont…
  - Glycogen is depleted, but muscle temp and homeostatic conditions are met
  - Fatigue, exercise, fasting, excitement, fighting
  - Results in reduced glycogen reserves at slaughter time, and thus less lactic acid is produced
  - Dark color, firm texture, excellent water binding capabilities
Water Holding Capacity

- The ability of meat to retain its water during application of forces
- 3 forms
  - Bound
    - Inner most layer of water
    - Associated with a protein
    - Remains bound even during mechanical processes
  - Immobilized
    - Middle layer, less organized, released depending on the amount of force exerted
  - Free
    - Outer most layer, held by weak capillary forces

Water Holding Capacity

- Net charge effect – responsible for 1/3 of water loss
  - pH drop, reaching the isoelectric point (pI) of about 5.1
  - The + and - groups are attracted to each other
  - The influence of pH is called the NET CHARGE EFFECT
    - DFD has better WHC because of its high pH being far from the pI
    - PSE has a low WHC because of its low pH being close to the pI
    - Higher pH’s have greater net charges on proteins and a greater % of bound and immobilized water
Water Holding Capacity

- Steric effects – responsible for 2/3 of the water loss
  - ADP and proteins interact with actomyosin resulting in tight network
  - Ca and Mg combine with and neutralize two negatively charged reactive groups
  - This pulls the protein chains closer together and prevents the reactive groups still available from binding water
  - The lack of space for water molecules within the protein structure is called THE STERIC EFFECT
Postmortem Effects

- Temperature
  - Thaw rigor – a severe type of rigor that develops when muscle that has been frozen prerigor is thawed
    - Calcium leaves SR and TC in large amounts
    - Severe toughening and release of juices
    - 80% shortening of unrestrained muscles from original length
Postmortem Effects

• Cold Shortening – shortening at temps above freezing, but below room temp
  – Rapid release of Ca from damaged SR
  – Severe contraction = toughening
  – Seen in animals with little fat cover – muscle chills to fast

• Heat Shortening – shortening at temps above room temp
  – Rapid depletion of ATP
  – Results in rapid onset of rigor

Postmortem Effects

• Heat ring – found in carcasses with less fat cover
  – Outer ring of ribeye muscle gets cold too quickly, has slower glycolytic rate, slower pH decline, and a longer time until rigor develops
  – Results in an undesirable ring around the muscle that is darker in color, coarser in texture, and softer in firmness
  – Slower chilling and ES prevent this formation
Technologies to Improve Quality

• Cooler aging
  – Enzyme activity degrades proteins at Z-line
  – Longer aged, more tender the muscle is
  – Does not degrade connective tissue

• Hot boning
  – Occurs before pH drops, so with a high pH has better WHC
  – Without skeletal restraint, muscles shorten and become tough if allowed to go through rigor and not ground
  – Whole-hog sausage
Technologies to Improve Quality

• Delayed Chilling
  – Hold carcasses at room temp for 2 to 4 hours after dressing
  – Glycolytic rate is faster at the higher temps, ATP is depleted, and cold shortening is prevented. Aging is accelerated
  – Potential problems?

Technologies to Improve Quality

• Electrical Stimulation (ES)
  – Acceleration of pH decline
  – Muscle goes into rigor faster
  – Benefits
    • Prevent cold shortening
    • Accelerates proteolytic activity
    • Physically disrupts muscle fibers
    • Makes tough carcasses more tender, but not tender carcasses more tender
    • Brightens red muscle – possible improvement in quality grade