Improving Tenderness with Further Processing

Wesley N. Osburn
Associate Professor
Texas A&M University
Objectives

- Factors influencing tenderness
- Three major functional properties of raw materials
- Overview of processing technologies that enhance product tenderness
- Reciprocation
  - Improving current technologies
  - Identifying new technologies
Tender Muscle Fiber

- Few interfiber connections per unit of surface area
- Few heat-stable collagen crosslinks (Low residual strength after cooking)
- Few crossbridges
- Degraded contractile proteins
- Long sarcomeres
Many interfiber connections per unit of surface area

Tough Muscle Fiber

Many heat-stable collagen crosslinks (High residual strength after cooking)

Many crossbridges

Many protein interactions (Dehydration & packing)

Short sarcomeres
How to Make Meat More Tender

- Cause the sarcomeres to be longer
- Disrupt the integrity of the myofibrils
- Disrupt the integrity of the connective tissue

  BBQ 101- Meat Tenderness – Jeff Savell, TAMU
Three major functional properties of raw materials

- Water holding capacity
  - Ingredients, mechanical treatments
- Protein solubilization and extraction
  - Ingredients, mechanical treatments
- Protein gelation
  - Myofibrillar and connective tissue
  - Cookery methods
- Functional properties can be optimized to enhance product tenderness
Current Technologies

- Mechanical Tenderization
  - Blade, grinding, flaking, chopping

- Marination/Injection
  - Ingredients
    - Salt, phosphates, starches, etc.
    - Bind added water/fat
    - Organic acids, plant enzymes

- Cookery Methods
- High Pressure Processing
Make sarcomeres longer

- Electrical stimulation
- Adequate subcutaneous fat covering
  - Prior to further processing
Disrupt Myofibrils – Mechanical

- Blade tenderization, macerator, grinder, chopper, flaker
  - Disrupts the structural integrity of myofibrils, muscle fibers, etc. along with connective tissues (collagen, reticulin, elastin)
Disrupt Myofibrils –
Endogenous/Exogenous Enzymes

- Postmortem proteolysis
  - Calpain system
    - Injection of CaCl₂
- Tropical plant enzymes — Heat activated
  - Papain (papaya); bromelin (pineapple); ficin (fig)
    - Marination/injection
- Adolph’s Meat Tenderizer®
  - Sprinkle on or use as a marinade
- Must control temperature/time to target desired tenderness
  - “Mushy” texture
Disrupt Connective Tissue – Exogenous Enzymes

- Marination with salt and vinegar (acetic acid)
  - Water solution with 2% NaCl plus acetic acid
Identifying muscle and processing combinations suitable for use as beef for fajitas

- Four different treatments—control, papain, blade tenderization, and papain + blade tenderization
- Brine mixture (pH 7.2) 10% w/w
  - 6.5% salt, 3.5% sodium tripolyphosphate, (5000 ppm/0.5% in-going), 89.97% water, and 0.033% papain (Liquipanol T-100)
- Trained and consumer panelists scored papain samples higher for most sensory traits
- Consumers were willing to purchase
  - M. latissimus and M. serratus ventralis (beef plate muscles) treated with papain + blade tenderization and papain, respectively
- Alternative muscles for the beef fajita market.
Factors Affecting Protein Extraction and Solubilization

- Ingredients
  - Salt (NaCl)
  - Alkaline Phosphates
- Protein Extraction Temperature and Duration
- Mechanical Action
- Vacuumization
  - Bind fat and added water
Muscle Fibers TEM Photo

Untreated

Phosphate and Salt Treated
Interactions of Salt and pH as Related to Meat Water Holding Capacity

Meat System pH

Meat System Water Holding Capacity, %

- Adjusted pH
- 2% Salt and Adjusted pH

61st Reciprocal Meat Conference
Cooking Yield as Related to Boneless Ham Tumbling Duration

![Graph showing the relationship between cooking yield and tumbling duration.](image)

Courtesy Mac Orcutt, Solae
Blended lipid solutions as a functional ingredient to enhance the nutritional value of ground beef
A. Lowder, S.B. Smith and W.N. Osburn – Funded by NCBA

- A beef pattie containing 4 and 14% of a 57/43 beef tallow and high oleic safflower oil added to 6% fat beef trim had lower shear force values compared to a 10 and 20% beef pattie control
  - Addition and type of fat

10% fat pattie (6% fat) with 4% added BT/HOSO blend
Protein Transitions During Heating

Myofibrillar Gelation

<table>
<thead>
<tr>
<th>°C</th>
<th>°F</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>(122)</td>
<td>Actin-myosin complex dissociates</td>
</tr>
<tr>
<td>50-55</td>
<td>(122°-131°)</td>
<td>Transition point from raw to cooked</td>
</tr>
<tr>
<td>&gt;55</td>
<td>(131°)</td>
<td>Increased hardness, firmer texture</td>
</tr>
<tr>
<td>65-70</td>
<td>(149°-158°)</td>
<td>Hardening increases; loss of WHC</td>
</tr>
</tbody>
</table>

Dry heat cookery – targeted internal product temperature
Protein Transitions During Heating

Collagen Gelation

<table>
<thead>
<tr>
<th>°C</th>
<th>°F</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>104</td>
<td>Minimum toughness of myofibrillar proteins and maximum toughness of connective tissues</td>
</tr>
<tr>
<td>60</td>
<td>140</td>
<td>Collagen shrinks</td>
</tr>
<tr>
<td>70</td>
<td>158</td>
<td>Myofibrillar proteins shrink; collagen begins to solubilize</td>
</tr>
<tr>
<td>74</td>
<td>165</td>
<td>Maximum hardening of the myofibrillar proteins</td>
</tr>
<tr>
<td>75-80</td>
<td>166-176</td>
<td>Collagen melts - gelatinization</td>
</tr>
<tr>
<td>23-33</td>
<td>73-91</td>
<td>Cooling the collagen causes gelatin formation</td>
</tr>
<tr>
<td>45-50</td>
<td>113-122</td>
<td>Heating remelts the gelatin</td>
</tr>
</tbody>
</table>

Moist heat cookery – Dry bulb/wet bulb - % relative humidity
Benefits of Marination

- Tenderness – (water, salt, phosphate)
- Juiciness – (water, salt, phosphate)
- Color (External application of seasonings)
- Flavor
- Marination cannot completely reverse the effects of poor raw material quality
What is Marination?

- Ingredient delivery process.
  - 3 basic elements:
    - Substrate
    - Marinade
    - Process treatment
  - “Marinated” is a USDA regulated label claim
Marinade

A “pickling” or “savory” solution used to preserve, season and/or tenderize meat
- May also be a suspension or emulsion
- Water or oil based.
- Contains functional ingredients

Primary
- Affect water binding or textural properties
- Condition meat proteins to bind water (ionic strength and pH)
- Tenderize meat

Secondary
- Affect the appearance, flavor, texture and odor
Primary Ingredients

- Primary
  - Water
  - Salt
  - Phosphates
  - Organic acids and their salts
  - Enzymes
  - Hydrocolloids, protein isolates, starches
Vacuum tumbled poultry breasts
Injected poultry breasts

Marinade Distribution in Boneless, Skinless Breast Fillets.
Single needle injection.
12.5% average pickup; 10.9% retained prior to freezing.
To improve tenderness through further processing…

- Must understand raw material functionality
  - Myofibrillar “heavy”
  - Connective tissue “heavy”
- Select and apply right methods to enhance tenderness
And if all else fails........
Blow it up!!!!!!

- **Hydrodyne™**
  - Placing meat in a water-filled chamber and setting off explosion that destroys Z-lines
  - High pressure (100 Mpa) - short time (2 to 4 min)
How can we improve current technologies
What new technologies are being developed?