Tenderness Evaluation in Poultry Meat

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Per Capita Consumption of Poultry

DOUBLED in 30 years

Chicken
Turkey

%
U.S. Poultry Industry: Market Segments

% of Production

- Whole
- Parts
- Further Processed

Consumer Appeal

Convenience
Versatility
Healthy
Economical
Consumer Purchasing Habits

- Other
- Bone-in Breast
- Wing
- Thigh
- Drumstick
- Leg
- Whole
- Boneless, Skinless Breast

% of Respondents

* Heavy chicken consumers purchase at higher rates.

National Chicken Council, 2003
Market Demand and Production

- Increased production of boneless breast meat
- Shorter aging periods
- Need for quality control to ensure tender product
Factors Affecting Poultry Meat Tenderness
Factors Affecting Poultry Meat Tenderness

- Bird and Environment
  - Age
  - Sex
  - Strain
  - Stresses (nutritional/environmental)

- Various, conflicting reports

- Little research on the “bird of today”

Guhne, 1970; Simpson and Goodwin, 1984; Lyon and Wilson, 1986; Smith and Fletcher, 1988; Poole et al., 1999; Sams, 2002
Tenderness of Commercial Strains (6 & 7 wk)
Deboned at 2 and 4 h Postmortem

Neither tough nor tender

*Significant of debone hour, age, and strain

Mehaffey et al., 2004
Factors Affecting Poultry Meat Tenderness

- PROCESSING CONDITIONS
  - Deboning
  - Chilling
  - Interactions with rigor development

- Cooking Methods
  - Effect on juiciness

Stewart et al., 1984; Lyon and Wilson, 1986; Dawson et al., 1987
Factors Affecting Poultry Meat Tenderness – Intrinsic Factors

- Myofibrillar component
- Connective Tissue component
- Juiciness
Tenderness: Myofibrillar Component

Factors affecting contractile state:

- Early deboning shortens sarcomeres
Tenderness of Broiler Breast Meat Deboned at Various Times

Razor Blade Total Energy (N.mm)

- Very Tender
- Moderately Tender
- Slightly Tender
- Neither Tough nor Tender
- Slightly Tough

Time Postmortem (hours)
Tenderness: Myofibrillar Component

- Age 4-6+h prior to deboning
  - BUT, higher production costs
- Shortened aging periods decrease tenderness
  - Help streamline process
Techniques to Improve Tenderness of Early Harvested Breast Meat

- ELECTRICAL STIMULATION
- Wing restraint or tensioning
- Post-chill flattening
- Extending chilling
- MARINATION
- Combination of techniques
Tenderness: Connective Tissue

- Not a major influence in young broilers, problem in spent fowl
- Heat stable crosslinks form as animal ages
- High tensile strength
Tenderness: Juiciness

- Associated with texture; lubrication effect
- Cooking high heat, low moisture environments results in drier, less juicy product
- Consumers perceive less juicy meat as tougher

Lawrie, 1974; Lyon and Wilson, 1986; Lyon and Lyon, 1990
Methods to Measure Texture

- Tenderness
  - Allo-Kramer
  - Warner-Bratzler
  - Razor Blade
  - TPA
  - Sarcomere Length
  - Sensory – Descriptive/Consumer
Warner-Bratzler Shear

- Single blade triangle cut (TA-7)
- 1 sample / fillet (width/height 19mm)
- Cross head speed: 500 mm/min (8.33 mm/s)
- Maximum Force (Kg)

DeMan et al., 1979; Lyon and Lyon, 1990; Lyon and Dickens, 1993; Lyon et al., 1997
**Allo-Kramer Shear**

- 10 blade shear cell
- Cross head speed: 500 mm/min (~8.33 mm/s)
- Sample size (40 x 20 x 7 mm)
- 2 samples/fillet
- Maximum Force (Kg/g)

Kramer *et al.*, 1951; Sams, 1990; Lyon and Lyon, 1990
Razor Blade Shear Device

- 8.9 mm width razor blade
- Cross head speed: 10 mm/s
- Intact Fillet
- Multiple shears/fillet
- Maximum Force (N)
- Total Energy (N.mm)

Cavitt et al., 2001, 2004
Instrumental Shear

- Typical location
- Can vary slightly
Texture Profile Analysis

- Instrumental method that emulates conditions that food is subjected to in mouth
- Similar results to WB and AK
- Maximum force
- Not best tool for sole use in predicting whole muscle meat tenderness

Szczesniak, 1963
Sarcomere Length

- Laser diffraction method
- Measure of contractile state
- Highly correlated with tenderness

Locker, 1960; Cross et al., 1981; Sams et al., 1990
Descriptive Sensory Analysis

- 6 member trained meat descriptive sensory panel
- 15 cm linear reference scale
- Sample size: 3-4, 0.5 inch cubed
  - First Bite/Chew
    - initial hardness
  - Chewdown Characteristics (after 10-12 chews)
    - chewdown hardness

Meilgaard et al., 1999
Consumer Sensory Analysis

- Consumers
- 9 point Hedonic and Intensity scale
- 5 point Just-About-Right scale
- Sample size: 3-4, 0.5 inch cubed
  - Overall Acceptance (Texture and Tenderness)
  - Intensity of Tenderness
  - JAR (Tenderness and Juiciness)

- Can be expensive, time consuming
Consumer Ballot: Hedonic and Intensity

2. Considering only TENDERNESS, which of the statements below best describes your impression of this product?

Check ( ) your response

<table>
<thead>
<tr>
<th>Dislike Extremely</th>
<th>Dislike Very Much</th>
<th>Dislike Moderately</th>
<th>Dislike Slightly</th>
<th>Neither Like</th>
<th>Like Slightly</th>
<th>Like Moderately</th>
<th>Like Very Much</th>
<th>Like Extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

Explain your choice

1

3. Concentrating on the INTENSITY OF TENDERNESS (the way it feels in your mouth), which of the statements below best describes your impression of intensity of tenderness of this product?

Check ( ) your response

<table>
<thead>
<tr>
<th>Extremely Tough</th>
<th>Very Tough</th>
<th>Moderately Tough</th>
<th>Slightly Tough</th>
<th>Neither tender nor Tough</th>
<th>Slightly Tender</th>
<th>Moderately Tender</th>
<th>Very Tender</th>
<th>Extremely Tender</th>
</tr>
</thead>
<tbody>
<tr>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

Explain your choice
4. Concentrating on the TENDERNESS of this product, which of the statements below best describes your impression of this product?

Check ( ) your response

<table>
<thead>
<tr>
<th>Much Too Tough</th>
<th>Too Tough</th>
<th>Just About Right</th>
<th>Somewhat Too Tender</th>
<th>Much Too Tender</th>
</tr>
</thead>
<tbody>
<tr>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
</tr>
</tbody>
</table>

Explain your choice

5. Concentrating on the JUICINESS of this product, which of the statements below best describes your impression of this product?

Check ( ) your response

<table>
<thead>
<tr>
<th>Much Too Dry</th>
<th>Too Dry</th>
<th>Just About Right</th>
<th>Somewhat Too Juicy</th>
<th>Much Too Juicy</th>
</tr>
</thead>
<tbody>
<tr>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
<td>⬜</td>
</tr>
</tbody>
</table>
Relationships among Evaluation Methods
Allo-Kramer Shear vs. Razor Blade Shear

Cavitt et al., 2001
## Correlations between Sensory and Instrumental Texture Measurements

<table>
<thead>
<tr>
<th></th>
<th>Sarcomere Length</th>
<th>AK Shear Value</th>
<th>Max. Force</th>
<th>Total Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Initial hardness</strong></td>
<td>-0.93</td>
<td>0.82</td>
<td>0.86</td>
<td><strong>0.92</strong></td>
</tr>
<tr>
<td><strong>Chewdown hardness</strong></td>
<td>-0.91</td>
<td>0.81</td>
<td>0.85</td>
<td><strong>0.90</strong></td>
</tr>
<tr>
<td><strong>Sarcomere Length</strong></td>
<td><strong>--</strong></td>
<td><strong>-0.91</strong></td>
<td><strong>-0.85</strong></td>
<td><strong>-0.94</strong></td>
</tr>
</tbody>
</table>

(P < 0.05)
Instrumental and Sensory Measurements of Tenderness

Cavitt et al., 2004b
JAR Distribution for Meat Deboned 0.25 h through 24 h Postmortem

Cavitt et al., 2004b
Regression Model for RBE against Intensity of Tenderness

\[ y = -0.0549x + 13.631 \]

\[ R^2 = 0.9048 \]

Regression Model for WBF against Intensity of Tenderness

\[ y = -0.5058x + 9.2399 \]

\[ R^2 = 0.9668 \]

Regression Model for AKSV against Intensity of Tenderness

\[ y = -0.5029x + 9.818 \]

\[ R^2 = 0.9122 \]

Cavitt et al., 2004b
## Equivalency Scales for Instrumental Measurements

<table>
<thead>
<tr>
<th>Intensity of Tenderness</th>
<th>Razor Blade Force (N)</th>
<th>Razor Blade Energy (N*mm)</th>
<th>Allo-Kramer Shear Value (kgf/g)</th>
<th>Warner Bratzler Shear Force (kgf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely Tough</td>
<td>18.00</td>
<td>221.97</td>
<td>16.70</td>
<td>15.98</td>
</tr>
<tr>
<td>Very Tough</td>
<td>16.69</td>
<td>205.48</td>
<td>14.89</td>
<td>14.08</td>
</tr>
<tr>
<td>Moderately Tough</td>
<td>15.38</td>
<td>188.99</td>
<td>13.07</td>
<td>12.17</td>
</tr>
<tr>
<td>Slightly Tough</td>
<td>14.07</td>
<td>172.49</td>
<td>11.26</td>
<td>10.26</td>
</tr>
<tr>
<td>Neither Tough nor Tender</td>
<td>12.77</td>
<td>156.00</td>
<td>9.44</td>
<td>8.36</td>
</tr>
<tr>
<td>Slightly Tender</td>
<td>11.46</td>
<td>139.51</td>
<td>7.63</td>
<td>6.45</td>
</tr>
<tr>
<td>Moderately Tender</td>
<td>10.15</td>
<td>123.01</td>
<td>5.82</td>
<td>4.54</td>
</tr>
<tr>
<td>Very Tender</td>
<td>8.84</td>
<td>106.52</td>
<td>4.00</td>
<td>2.64</td>
</tr>
<tr>
<td>Extremely Tender</td>
<td>7.54</td>
<td>90.03</td>
<td>2.19</td>
<td>0.73</td>
</tr>
</tbody>
</table>

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Cavitt et al., 2004b
Razor Blade test provides advantages over other methods for evaluating tenderness in cooked broiler breast fillets

- Requires no sample cutting
- Not excessively destructive
- Cost efficient
- Similar or greater precision for predicting tenderness
Cost Estimates for Analyzing Tenderness Using Razor Blade Method

*Calculation based on $11.00/h x est. time to complete samples. Instron (AK or WB Analysis) = 30 smp/h  Texture Analyzer (Razor Blade Shear) = 60 smp/h

Cavitt, 2003
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   • USDA
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