Effect of Hydrodynamic Pressure Processing (HDP) and Aging on the Tenderness and Protein Characteristics of Pork Loins

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Background Information

- Tenderness, juiciness, and fresh meat color are primary factors determining meat quality and consumer satisfaction
- Postharvest technologies that improve these characteristics and decrease product variability would enhance product value and desirability

Hydrodynamic Pressure Processing (HDP)

Expose meat to a supersonic-hydrodynamic shock wave pressure front in liquid media. Shock wave is generated using a small amount of high energy explosives.

- HDP causes instantaneous and sustained improvements (10-55%) in tenderness
  
  *(Solomon et al., 1997, 1998, 2002)*

- HDP decreases the variability in tenderness along length of strip loins
  
  *(Spanier et al., 2000)*

*(Berry et al., 1997)*
Hydrodynamic Pressure Processing (HDP)

Mechanism of tenderization???

- Disruption of the myofibrillar structure
  
  (Zuckerman and Solomon, 1998)

- Disruption of endomysial connective tissue
  
  (Zuckerman et al., 1999)

Direct protein modification:
- Redistribution of protein in myofibrillar and sarcoplasmic fractions with differential centrifugation
  
  (Spanier and Romanowski, 2000)

- Alteration in protein solubility with HDP treatment
  
  (Bowker et al., 2007)

Alteration of postmortem enzymatic proteolysis??

Graph:
- X-axis: Days Postmortem
- Y-axis: Toughness
- Three curves: Control, HDP, HDP-treated
Objective

- Determine the effects of HDP and aging on the quality parameters of pork loins
- Determine the effects of HDP on aging-related muscle protein changes
Materials and Methods

• **Samples:**
  Market wt. barrows (n=16)
  Removed loins from pork carcasses at 24 h postmortem
  Boneless loins frozen at 24 h postmortem and thawed 48 h prior to treatment on day 0

• **Study Design:**
  Randomized block design with each loin serving as a block
  Processed 4 loins on 4 different experimental days

• **Treatments:**
  HDP samples: vacuum-packaged, heat shrunk, 2 samples per HDP shot
  Control samples: vacuum-packaged, heat shrunk, no HDP treatment
  Aging: 0 day (sampled on day of HDP treatment)
  7 day (sampled after 7 days of aging at 4°C in vacuum-package)
Materials and Methods

Meat quality parameters:

Tenderness: 2.5 cm thick chop, grilled to 71°C, Warner-Bratzler Shear force (kgf) on Universal Intron Testing Machine (AMSA, 1995), measured cooking yield

Water-holding capacity:

1. Drip loss % (gravitational) at 1, 4, and 7 days at 4°C (Honikel 1998)
2. Centrifugal force % water lost, 2400×g for 20 min at 4°C (Boles and Shand, 2001)

Color: Minolta CR200 colorimeter (L*a*b*), 30 min bloom
pH: duplicate 2 g samples in 10 mL deionized water (Solomon 1987)

Protein parameters:

Whole muscle protein extracts: 2% SDS-10 mM sodium phosphate buffer (Huff-Lonergan et al., 1996)
SDS-PAGE on extracts: 15% Tris-HCl gels, 60 μg/lane, Coomassie stain, Kodak Gel Imager
Protein solubility: sarcoplasmic, myofibrillar, and total protein solubility (Schilling et al., 2002)

Statistical Analysis:

SAS Proc Mixed
Fixed effects = treatment (control, HDP) and age (0, 7 days)
Random effects = pork loin
Repeated measures within loin
PDIFF option at p<0.05 to compare treatment lsmeans
Meat Quality

% improvement with aging

Control 14%

HDP 24%

Warner-Bratzler Shear Force (kgf)

Day 0

Day 7

Aging

abc p<0.05

Control  HDP

4.82  4.54

4.15  3.47

abc
Meat Quality

Cumulative Drip Loss (%)

Days

* p<0.05

Control

HDP
## Meat Quality

<table>
<thead>
<tr>
<th>Trait</th>
<th>Day 0 Control</th>
<th>Day 0 HDP</th>
<th>Day 7 Control</th>
<th>Day 7 HDP</th>
<th>S.E.M.</th>
<th>Trt</th>
<th>Aging</th>
<th>Trt*Aging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centrifugal drip % loss</td>
<td>31.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>33.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>27.2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>25.7&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.5</td>
<td>NS</td>
<td>&lt;0.0001</td>
<td>0.0014</td>
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<tr>
<td>Cooking Yield %</td>
<td>76.6</td>
<td>75.6</td>
<td>76.8</td>
<td>77.2</td>
<td>0.5</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
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<tr>
<td>pH</td>
<td>5.3</td>
<td>5.3</td>
<td>5.3</td>
<td>5.3</td>
<td>0.04</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

<sup>abcd</sup> p<0.05  

NS = not significant
# Meat Quality

<table>
<thead>
<tr>
<th>Trait</th>
<th>Day 0</th>
<th>Day 7</th>
<th>S.E.M.</th>
<th>P-level of significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td>HDP</td>
<td>Control</td>
<td>HDP</td>
</tr>
<tr>
<td><strong>L</strong>*</td>
<td>50.2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>50.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>52.6&lt;sup&gt;a&lt;/sup&gt;</td>
<td>54.3&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td><strong>a</strong>*</td>
<td>7.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.6&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>5.9&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>6.0&lt;sup&gt;c&lt;/sup&gt;</td>
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<tr>
<td><strong>b</strong>*</td>
<td>2.7&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.6&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>3.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.0&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>abc</sup> p<0.05  

**NS**=not significant
Whole Muscle Protein Extract Profile

Control | HDP
---------|---------
0       | 0       | 7       | 7

- Myosin: 95 kDa, 135 kDa
- Actin: 38 kDa, 60 kDa
- Mb: 30-32 kDa

WBSF (kgf): 5.0, 4.5, 4.6, 3.4

- Aging effect: 135, 30-32 kDa increases, 95, 38 kDa decreases
- HDP effect: 60 kDa increases
- HDP*Aging interaction: 30-32 kDa
Summary and Conclusions

- **Meat Quality:**
  HDP enhanced aging related tenderization and had minimal effects on water-holding capacity and color in pork loins

- **Protein characteristics:**
  HDP caused slight alterations to the electrophoretic profile of muscle proteins and myofibrillar protein solubility

- Data suggests that HDP enhances aging tenderization in pork loins primarily through the physical disruption of the muscle ultrastructure