The American Lamb Board focuses on providing a consistent and high quality product to our consumers.

Carcass Quality Research focuses on:

- Flavor
- Palatability and Freshness
- Nutritional benefits
- Culinary Versatility
Quantifying the economic impact of excessively fat lambs in the U.S. lamb processing sector

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OBJECTIVES

1) Collect carcass measurements to estimate quantity and seasonal distribution of carcass characteristics during peak “fat-prone” harvesting periods.

2) Determine fat losses in cutout data and associated plant level economic data.

3) Economic modeling to determine down-stream industry costs.
ImageJ image analysis software can be used to capture ribeye area (REA), 12th rib fat (12RF), and bodywall thickness (BWT) at production speed.
Methods

Carcass Characteristics
- Ribeye Area
- Hot Carcass Weight
- USDA Yield/Quality Grade
- Camera Yield Grade
- Calculated Yield Grade
- Backfat
- Bodywall Thickness
- %BCTRC

Associated Plant Inefficiencies
- Fabrication Floor:
  - Total Trim (lbs.)
- Harvest Floor:
  - Machine Malfunctions
  - Labor inefficiencies
  - Single lot processing time

Plant Economics
- Monte Carlo Model
- Partial Budget comparing income/expenses

Percentage of Boneless Closely Trimmed Retail Cuts (%BCTRC) is an approximation of the amount of edible red meat yield.
## Preliminary Descriptive Statistics

<table>
<thead>
<tr>
<th></th>
<th>Number of Carcasses</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Range</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot Carcass Weight (kg)</td>
<td>7357</td>
<td>23.5</td>
<td>184.5</td>
<td>161</td>
<td>89.45</td>
</tr>
<tr>
<td>USDA Yield Grade</td>
<td>7208</td>
<td>No Grade</td>
<td>5</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Camera Yield Grade</td>
<td>7379</td>
<td>-</td>
<td>8.9</td>
<td>8.9</td>
<td>4.45</td>
</tr>
<tr>
<td>Calculated Yield Grade</td>
<td>7378</td>
<td>0.4</td>
<td>13.45</td>
<td>13.05</td>
<td>3.37</td>
</tr>
<tr>
<td>Ribeye Area (in&lt;sup&gt;2&lt;/sup&gt;)</td>
<td>7379</td>
<td>0.825</td>
<td>5.24</td>
<td>4.41</td>
<td>2.61</td>
</tr>
<tr>
<td>12&lt;sup&gt;th&lt;/sup&gt; Rib Fat (in)</td>
<td>7378</td>
<td>0</td>
<td>1.31</td>
<td>1.31</td>
<td>0.32</td>
</tr>
<tr>
<td>Body Wall Thickness (in)</td>
<td>7379</td>
<td>0.23</td>
<td>2.99</td>
<td>2.76</td>
<td>1.25</td>
</tr>
<tr>
<td>%BCTR</td>
<td>7356</td>
<td>27.26</td>
<td>55.83</td>
<td>28.57</td>
<td>43.69</td>
</tr>
</tbody>
</table>
The Next Steps

◆ Continued carcass data collection (December-April)

◆ Economic modeling

■ Partial Budget

  • Assessing income/cost during peak over-fat lamb season (summer) vs. the spring and fall seasons.

  • Factors may include, but are not limited to:
    - Increased labor costs: more labor for larger carcasses, higher turnover during fat-prone months, overtime
    - Maintenance costs: machinery depreciation, machinery repair/maintenance, cleaning costs
    - Efficiency costs: number of lambs processed, total pounds of sellable red meat, longer processing times on larger carcasses, trucking inefficiencies
    - Cutout: Are the carcasses generating profit based on what lambs are bought for live?
Discovering the capabilities of Rapid Evaporative Ionization Mass Spectrometry (REIMS) as a novel mass spectrometry method to detect off/unacceptable lamb flavors.

Lamb Flavor Phase II - Colorado State University

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Familiarity and Preference

- Research in other countries has demonstrated that consumers differ in their acceptance of various sheep-specific meat flavor notes depending upon past eating experiences (Sanudo et al., 2000; Prescott et al., 2001).
- Consumers who are accustomed to eating lamb or mutton with a particular flavor profile seem to prefer ovine meat products with a familiar flavor (Sanudo et al., 2000; Prescott et al., 2001).
- Consumers who seldom eat lamb or mutton tend to exhibit the greatest aversion to sheep-specific meat flavor notes, sometimes finding even mildly detectable levels of these flavors unacceptable (Prescott et al., 2001; Watkins et al., 20).
- National Lamb Quality Audit (Hoffman, 2016)
- “Eating Satisfaction” most important quality trait for lamb.
- Majority of consumers (71%) are willing to pay a premium for improved “Eating Satisfaction”.
- 68% of consumers who eat lamb want it to be from the US - up from 40% in 2011.
Rapid Evaporative Ionization Mass Spectrometry (REIMS)

- New technique allowing for characterization of biological tissues
- Provides molecular fingerprint
  - Real-time analysis (seconds)
  - No sample preparation
  - Hand-held sampling device
- Histological-based tissue identification with 90-98% accuracy (Balog et al., 2013) in well defined treatment groups

Source: Balog et al. (2016)
Factor Scores from Trained Sensory Attributes Colored for a 3-Level Sensory Classification

Factor Scores from Trained Sensory Attributes Colored for a 2-Level Sensory Classification
Least squares means of carcass traits among sheep age classifications.\(^1\)

<table>
<thead>
<tr>
<th>Treatment Group</th>
<th>n</th>
<th>Hot Carcass Weight (kg)</th>
<th>Adj. 12(^{th}) Rib Fat Thickness (cm)</th>
<th>Body Wall Thickness (cm)</th>
<th>Ribeye Area (cm(^2))</th>
<th>Marbling(^2) at 12(^{th}) Rib</th>
<th>Calculated Yield Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age(^1)</td>
<td></td>
<td>(P&lt;0.0001)</td>
<td>(P&lt;0.0001)</td>
<td>(P&lt;0.0001)</td>
<td>(P&lt;0.0001)</td>
<td>(P&lt;0.0001)</td>
<td>(P&lt;0.0001)</td>
</tr>
<tr>
<td>Lamb</td>
<td>50</td>
<td>31.3(^b)</td>
<td>0.64(^b)</td>
<td>2.13(^b)</td>
<td>17.15(^b)</td>
<td>457.6(^b)</td>
<td>2.9(^a)</td>
</tr>
<tr>
<td>Yearling</td>
<td>50</td>
<td>40.5(^c)</td>
<td>0.88(^c)</td>
<td>2.64(^c)</td>
<td>18.82(^c)</td>
<td>518.0(^c)</td>
<td>3.9(^b)</td>
</tr>
<tr>
<td>Mutton</td>
<td>50</td>
<td>27.5(^a)</td>
<td>0.22(^a)</td>
<td>1.03(^a)</td>
<td>13.16(^a)</td>
<td>303.1(^a)</td>
<td>1.3(^c)</td>
</tr>
<tr>
<td>SEM(^2)</td>
<td></td>
<td>1.33</td>
<td>0.05</td>
<td>0.11</td>
<td>0.51</td>
<td>20.1</td>
<td>0.21</td>
</tr>
</tbody>
</table>

\(^{a-c}\)Least square means in the same column without a common superscript differ \((P < 0.05)\) due to treatment.

\(^1\)Age group defined as: Lamb = 0 Permanent Incisors, Yearling = 2 Permanent Incisors, Mutton = >2 Permanent Incisors.

\(^2\)Marbling score: 300=Slight\(^00\), 400=Small\(^00\), 500=Modest\(^00\).

\(^3\)Standard error of the least squares means.
Prediction of a 2-level Sensory Classification using Partial Least Squares-Linear Discriminant Analysis on Molecular Profiles of lean of sheep legs.

<table>
<thead>
<tr>
<th>Predicted Class</th>
<th>Positive</th>
<th>Neutral</th>
<th>Total</th>
<th>Sensitivity</th>
<th>Precision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>13</td>
<td>5</td>
<td>18</td>
<td>72.2%</td>
<td>68.4%</td>
</tr>
<tr>
<td>Negative</td>
<td>6</td>
<td>5</td>
<td>11</td>
<td>45.5%</td>
<td>50.0%</td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>10</td>
<td>29</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Overall Prediction Accuracy 62.1%
Balanced Prediction Accuracy 58.9%
No. of PLS Components 2
Conclusions

- Multiple models were evaluated for prediction accuracy.
- Lamb Flavor ID was not statistically different between lamb, yearling and mutton carcasses.
- Mutton-like and green/hay-like off-flavor intensities are driving ‘negative’ sensory classifications among both 3-level and 2-level sensory groups.
- ‘Negative’ cluster for 3-level sensory classification were all lambs with numerically higher ratings of mutton-like off-flavor.
- Higher balanced prediction accuracies were observed from 3-age classifications (Lamb, Yearling, and Mutton), 4-age classifications (USDA Graded Lamb, Ungraded-Lamb, Yearling, and Mutton) and production background (Grain-finished or Grass-finished) models.
Industry Implications

- Use of REIMS is a unique platform to capture high resolution metabolic profiles faster and without lengthy sample preparation compared to other analytical approaches.
- REIMS is able to provide metabolite information in real-time, indicating high potential for its use in harvest facilities at production speed.
- Annotation and identification of specific compounds among metabolic data could improve understanding of flavor profiles that are being influenced by specific sheep flavor attributes.
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