Predicting Aged Beef Tenderness with a Hyperspectral Imaging System

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Summary
A hyperspectral imaging apparatus was developed to predict, at 2-day postmortem, the 14 day aged tenderness of beef. USDA Choice and Select grade longissimus steaks (n = 314) from between the 12th and 13th ribs were scanned at 2 days postmortem, vacuum packaged, aged to 14 days, and frozen. For tenderness determination, steaks were thawed overnight, scanned, cooked in an impingement oven, and slice shear force values were obtained. The model predicted three tenderness categories (tender, intermediate, tough) with 77.1% accuracy, and two tenderness categories (acceptable, tough) with 93.7% accuracy. This hyperspectral imaging system was effective in predicting 14-day aged beef tenderness from scans of 2-day aged beef.

Procedure

Hyperspectral imaging apparatus
A hyperspectral imaging apparatus (Figure 1) was constructed by integrating an InGaAs digital video camera and a spectrograph. The spectrograph has a spectral range of 900-1700 nm. Complete system specifications are described in 2007 Nebraska Beef Report, pp. 97-99.

Data Collection
USDA Choice and Select grade longissimus steaks from between the 12th and 13th ribs at 2 day postmortem were cut to 1-inch thickness and scanned by the imaging system. Prior to the first scan, and periodically throughout data collection, a reference measure was obtained by measuring a 100% and 0% reflectance plate. Steaks were placed on a Teflon-coated plate mounted on a linear slide that utilized a stepper motor for movement. The steak was then scanned by the camera to obtain a three-dimensional data cube (reflectance by two-dimensional position). Images were obtained at wavelength intervals of 2 nm. After imaging, 2 day aged steaks were vacuum packaged, aged to 14 days and frozen. Steaks were later thawed overnight, scanned and cooked immediately on an impingement oven to an internal temperature of 157-162°F. Slice shear force (SSF) values were obtained by an Instron Texture Analyzer.

Statistical Analysis
From each image, a region-of-interest (ROI) was selected corresponding to the approximate shear...
sorting two categories (acceptable from tough), this system correctly classified 287 out of 298 consumer acceptable steaks (96.3%). This yields an overall accuracy of 93.7% for sorting acceptable from tough. Table 1 shows the classification of steaks by the hyperspectral imaging system vs. the actual SSF categories of those steaks.

### Table 1. Hyperspectral tenderness prediction vs. actual shear force tenderness.

<table>
<thead>
<tr>
<th>Actual Categories</th>
<th>Predicted Categories</th>
<th>Tendera</th>
<th>Intermediateb</th>
<th>Toughc</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tender</td>
<td>200</td>
<td>47</td>
<td>9</td>
<td>256</td>
<td></td>
</tr>
<tr>
<td>Intermediate</td>
<td>8</td>
<td>32</td>
<td>2</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>Tough</td>
<td>3</td>
<td>3</td>
<td>10</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>211</td>
<td>82</td>
<td>21</td>
<td>314</td>
<td></td>
</tr>
</tbody>
</table>

a ≤ 46.0 lb SSF.  
b 46.1-57.1 SSF.  
c ≤ 57.32 lb SSF.

Implications

This hyperspectral imaging system was effective at predicting 14 day tenderness of beef longissimus steaks from 2-day postmortem scans. Implementation of a noninvasive tenderness prediction system may result in “guaranteed tender” premiums for beef products that may benefit producers and the industry as a whole.

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