Project Summary

Prediction of Beef Tenderness from Spectral Reflectance

Principal Investigator: J. Brad Morgan, Ph.D.
Oklahoma State University

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Background

Tenderness has been shown to be the most important factor affecting consumer satisfaction for beef. The most commonly used method to predict beef tenderness is USDA quality grading, but that system is not completely accurate as it only reflects a compilation of traits that are indicators of tenderness.

During recent years, the beef industry has examined instrument grading for its potential to improve objectivity of palatability and cutability predictions. Employing technology has shown promise in increasing the ability to more accurately sort carcasses into quality groups.

Researchers have developed several instrument grading systems, but widespread commercial adoption has still not occurred.

In order for a tenderness prediction system to be accepted in a commercial setting, it must meet the following guidelines:

- Machine must be accurate and repeatedly classify carcasses into tenderness groups (tender, intermediate, tough)
- Must be a rapid, non-destructive method for on-line evaluation
- Should be a direct measure of tenderness at the consumer level

Researchers at Oklahoma State University developed a spectrometric grading instrument that meets these criteria in a laboratory setting. The objective of this project was to evaluate the system in a packing plant environment by 1) developing a portable system to collect near-infrared spectral reflectance values from fresh meat at three days postmortem and 2) developing chemometric models to relate spectral reflectance to 14-day shear force tenderness measurements.

Methodology

During the first phase of the project, 292 carcasses were selected at the USDA grading stand, approximately 48 hours postmortem. The following factors were collected for each carcass:

- Preliminary yield grade
- Adjusted fat thickness
- Ribeye area
- Kidney, pelvic and heart fat percentage (KPH)
- Lean maturity
- Skeletal maturity
- Marbling score
- Quality grade as determined by USDA personnel

After the carcasses were fabricated, individual ribeye rolls were collected and sent to the Oklahoma State University Food and Agricultural Products Research Center for analysis.

At approximately 72 hours postmortem, a one-inch steak was cut from each ribeye roll and allowed to bloom for thirty minutes. Color (L*a*b*) values and pH were collected for each sample. Sample was then spectrally scanned in a laboratory setting. Steaks were individually vacuum-packaged and allowed to age for an additional 11 days. Slice shear force values were collected for each sample and statistical models were developed to predict tenderness based on the spectral reflectance readings.

During the second phase of the project, 476 carcasses from two commercial plants were selected for the project. Spectral scanning of each carcass was performed in-plant. Carcass grade data was collected, and similar to Phase I, ribeye rolls were individually identified, collected during fabrication, vacuum-packaged and transferred to Oklahoma State University.

At 72 hours postmortem, a steak was cut from each ribeye roll. Following blooming, pH and Hunter color (L*a*b*) values were obtained from the steak surfaces. After the baseline data collection, steaks were allowed to age an additional 11 days, after which slice shear force values were collected for 277 samples. From this information, statistical models were developed to predict tenderness based on the spectral reflectance readings.

In the third, and final phase of the project, 199 ribeye steaks collected during Phase II were sent to the U.S. Meat Animal Research Center (MARC) for third-party validation via sliced shear force measurements. Each steak was assigned a predicted tenderness classification based on the scan information obtained in the packing plant.

The ribeyes collected for all three phases of the project represented a typical USDA quality grade distribution—approximately 80 percent USDA Select and Low Choice.

The evaluation of system performance was consistent with past research that assessed other instrument grading systems. The models were evaluated on the basis of progressive certification of steak sample “tenderness” in 10 percent increments.

Samples were sorted on the basis of predicted values from the spectral reflectance system, and the 10 percent that had the lowest predicted values were classified into a “certified tender” group and the remaining into a “not certified tender” group. The slice shear force values were compared to the tenderness predictions from the spectral reflectance system as a means of validating the predictions. When there was a significant difference between the “certified tender” and the “not certified tender” based on the values from the observed slice shear force, the researchers concluded that the spectral reflectance system had successfully sorted the “tender” from the “tough” samples at that certification level. Any samples that were tough (≥ 25 kilograms) based on the slice shear force, but were predicted to be “certified tender” based on the spectral reflectance system were considered to be errors. A 100 percent certification level meant that the spectral reflectance system had successfully classified as “tough” all samples with 14-day postmortem aging slice shear values greater than 25 kilograms.

Findings
In both phases of the investigation, slice shear force values exceeding 25 kilograms were greater for the Select quality samples—nine percent—versus only 3.4 percent and 5.9 percent tough samples from Choice carcasses in Phases I and II, respectively.

There was substantial variation in tenderness for the entire population, with a range in slice shear force from 9.87 to 39.87. In fact, 12 ribeye samples had slice shear force values that exceeded 28 kilograms in toughness.

In the initial phases of the project, 39 of the 568 carcass samples were categorized as tough (≥ 25 kilogram slice shear force at 14 days of postmortem aging). This reflects a 6.8 percent error in certification at the 100 percent level. A very high percentage of the samples were correctly classified as tender when the population was categorized into expected certification levels. Of the 39 tough samples, 20 (3.7 percent error rate) were correctly placed in the 90 percent certification level. Another 10 tough samples were placed in the 80 percent certification level. (2.0 percent error rate).

Fifty-seven samples were spectrally predicted to be the most tender. The mean slice shear value for this group was 14.90 kilograms and no tough samples occurred in this set. In other words, the spectral reflectance accurately predicted the steaks' tenderness and did not erroneously group a tough steak into the "certified tender" group. The overall mean for the samples predicted as "toughest" was 24 kilogram with 20 of the 39 tough samples being correctly placed in this category.

Regardless of percentage certified, the difference in mean longissimus slice shear force value between "certified tender" and "not certified" was significant ($P < 0.05$) for spectral analysis. Removing the toughest 10 percent improved the mean slice shear force of the group more than 6.5 kilograms. In other words, when predicted tough samples were removed from the population, improvements were made in the "certified tender" population.

Utilizing the 60 percent certified as tender as a sorting tool for eliminating tough carcasses, improved slice shear force values in excess of 4.0 kilograms. In fact, an improvement in excess of 32 percent was observed in the slice shear force values between the extreme 10 percent certified (14.80 kilograms) and not certified (21.56 kilograms) categories.

Implications
One of the biggest hurdles to the adoption of instrument grading at the commercial level has been the degree of inaccurate predictions that are produced by many of the current systems available. Based on this project, the spectral reflectance predictions appeared to offer more consistent readings.

Segmenting carcasses based on their projected slice shear force value as estimated by spectral readings appears to be an effective tool for sorting carcasses into relative quality groups, especially carcasses from lower quality grades. The ability to more accurately sort carcasses for tenderness can be hugely beneficial in marketing programs that promise consumers tender beef on a consistent basis.

For more information contact:
National Cattlemen's Beef Association
9110 East Nichols Avenue
Centennial, Colorado 80112-3450
(303) 694-0305