Evaluating Rapid Evaporative Ionization Mass Spectrometry (REIMS) as a Novel, Real Time Method for Measuring and Predicting Beef Flavor, Tenderness, and Nutritional Value


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Evaluating Rapid Evaporative Ionization Mass Spectrometry (REIMS) as a Novel, Real Time Method for Measuring and Predicting Beef Flavor, Tenderness, and Nutritional Value: Project Summary

Background

Preliminary data suggest that Rapid Evaporative Ionization Mass Spectrometry (REIMS) has considerable promise for measuring volatile organic compounds, fatty acids, and other metabolic products that serve as indicators of beef flavor, tenderness, and healthfulness instantaneously. REIMS is a relatively new technology that is emerging in many areas of science, including in human medicine and biological sciences. REIMS-based tissue analysis generally takes only a few seconds and can provide histological tissue identification with 90–98% correct classification performance (Balog et al., 2013). Using time-of-flight (TOF) mass spectrometry, REIMS profiling provides in situ, real-time molecularly-resolved information by ionizing biological samples in real-time without any sample preparation.

Objectives

The objectives of this study were to 1) Evaluate the ability of REIMS to predict beef quality traits in real time, including beef flavor and tenderness performance, from a sample derived at the time of grading, 2) Identify the accuracy of REIMS for quantifying volatile organic compounds and fatty acid profiles of beef by comparing it to established Gas Chromatography Mass Spectrometry (GC/MS) methods for quantifying the same compounds, 3) Evaluate the ability of REIMS to accurately characterize the fatty acid profile of beef in real time, in order to obtain an instantaneous measure of healthfulness of beef resulting from a single animal, and 4) Compare REIMS results from an early postmortem beef sample to a matching aged beef sample.

Methods

The samples utilized in this study were from a previous study in which sensory evaluations, shear force measurements, and REIMS output were already collected on 14-day aged samples; therefore, no additional samples needed to be purchased for this study. The beef samples were very diverse in quality level, production background, and breed type. By obtaining additional measures of meat composition from a paired sample with only 4 days of postmortem age, using established and proven benchtop methods, REIMS was validated as a real time tool for characterizing meat flavor, tenderness, and healthfulness at the time of grading. In order to achieve this, 4-day aged samples were analyzed for volatile organic compounds (VOCs) known to contribute to beef flavor, a full fatty acid profile, including both polar and neutral fatty acids, and free amino acids, and these data were compared to both 4-day aged and 14-day aged REIMS data.

Important Findings

Analysis of compositional elements of meat (amino acids, fatty acids, and volatile organic compounds) using GC/MS methods showed differences between targeted classification groups of beef. Spectra collected from REIMS on 4-d and 14-d samples showed that correlations and relationships exist between these compositional elements and the specific masses of compounds identified using REIMS. This work has demonstrated the ability of REIMS to correlate with “gold standard” methods for determining the amino acid and fatty acid composition of beef, which can be expanded to assess nutritional value in real time. Furthermore, the predictive ability of 14-d REIMS and GC/MS methods suggest the possibility of compound identification and quantification of REIMS in real time. Methods and operating procedures for spectra collection from a 4-d REIMS sample appeared to produce error in predictive ability. However, the relationship of 14-d REIMS and GC/MS indicates that properly collected 4-d REIMS spectra will more appropriately identify, and potentially quantify compositional elements of beef. There is significant work to be done for the development of REIMS procedures to most appropriately assess beef samples; however, there is significant promise for the application of REIMS for beef quality differentiation.
Industry Impact

A validated platform that has the capability to analyze beef samples in situ, real-time and accurately classify flavor performance and tenderness classification could be a real asset to the beef industry. With further development, the REIMS technology can be packaged to operate in a processing environment to segregate beef into meaningful quality and health classifications and ultimately improve the marketability and demand for beef. This technology and the information that it produces may be utilized to augment the USDA grading system to more accurately classify beef and validate marketing claims. Additionally, with instantaneous quantification of fatty acids in beef, a true health profile for beef can be determined in real time. At minimum, the results of this study will generate novel information for compounds of beef reflective of sensory attributes over an expanded mass range compared to the well-established GC-MS methodologies.

Figures

Tables

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<th>Predicted Class</th>
<th>Actual Class</th>
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1Number of samples falling into each respective classification category after prediction.
2Models were built using 80% of the original data and tested using the remaining 20%.

References