TWO HANDHELD SPECTRAL DEVICES CAN DIFFERENTIATE GRASS- AND GRAIN-FED BEEF

R. R. Liddle[1], C. E. O. Coombs[1*], and L. A. González[1],

[1]*Sydney Institute of Agriculture, School of Life and Environmental Sciences, University Of Sydney, Camden, Australia*,

*cassius.coombs@sydney.edu.au

I. OBJECTIVES

Near-infrared reflectance (NIRS) and Raman spectroscopies are frequently used in the determination of meat quality as they are nondestructive and can be used handheld in real time. Both NIRS and Raman have been used previously to differentiate grass-fed meat from grain-fed meat; however, no study has compared both NIRS and Raman scanning both lean and fat tissue of meat. It is hypothesized that NIRS and Raman can accurately classify commercial beef cuts as grass-fed or grain-fed, and in the future these handheld scanners could be used to prevent food fraud and mislabeling, as they provide certification at a quantifiable level as opposed to trusting in the labelling between producers and processors.

II. MATERIALS AND METHODS

A total of 108 beef steaks were purchased, comprising store-labelled grass-fed ($n = 54$) and grain-fed ($n = 54$), with grain-fed beef labelled as 100, 150, and 300 d on feed. Grass-fed samples were sourced from a highly trustworthy supplier with a minimal and highly monitored supply chain. Scans were made using a smartphone-connectable NIRS sensor (900–1,600 nm; NIRvascan, Allied Scientific Pro, Gatineau, Canada) and a portable Raman spectrometer (300–3,200 cm^{-1}; Bravo®, Bruker Optics, Billerica, MA) with the objective of obtaining a complete spectral profile of the lean and fat surfaces of each steak. A mean of 18 scans per sample were made for NIRS on lean and 10 on fat, while a mean of 10 scans were made for Raman on lean and 5 on fat. The NIR spectra were inverse log transformed (log(1/R)). Partial least squares discriminant analysis and linear discriminant analysis models were obtained to classify beef samples as grass- or grain-fed using RStudio, with 75% of the samples assigned to the training data and 25% to the test data. Model fitness was assessed using accuracy, precision, sensitivity, and specificity as metrics, and results are shown for the test data only.

III. RESULTS

When determining correct classification of grass- or grain-fed beef, NIRS was shown to be more accurate and precise than Raman (Table 1). The best model for both lean and fat was a partial least squares discriminant analysis from NIRS (88.5% and 91.7% accuracy, respectively), while the linear discriminant analysis model showed negligible difference (42.3%–46.2% accuracy).

Table 1.
Comparison of NIR and Raman spectroscopy abilities to correctly classify grass- and grain-fed beef using partial least square discriminant analysis (PLSDA) and linear discriminant analysis (LDA).[1]

Model	Sensitivity	Specificity	Precision	Accuracy
NIR Lean PLSDA	0.538	0.077	0.363	0.308
NIR Lean PLSDA Max	0.846	0.923	0.917	0.885
NIR Lean LDA	0.692	0.231	0.474	0.462
NIR Fat PLSDA	1.000	0.636	0.765	0.833
NIR Fat PLSDA Max	1.000	0.818	0.867	0.917
NIR Fat LDA	0.846	0.455	0.647	0.667
Raman Lean PLSDA	0.615	0.154	0.421	0.385
Raman Lean PLSDA Max	0.538	0.923	0.875	0.731
Raman Lean LDA	0.615	0.231	0.444	0.423
Raman Fat PLSDA	1.000	0.000	0.542	0.542
Raman Fat PLSDA Max	0.923	1.000	1.000	0.539
Raman Fat LDA	0.923	0.000	0.522	0.500

- Results shown for the testing or evaluation dataset only.

IV. CONCLUSION

In conclusion, the small, handheld smartphone NIRS sensor showed promise to discriminate between grass- and grain-fed beef compared to Raman, and its portability and ease of use makes it an attractive technology for industry and commercial use.

Keywords: beef meat, near-infrared spectroscopy, prediction models, Raman