VARIABILITY IN NEAR INFRA-RED SPECTRA OF FRESH AND FROZEN-THAWED BOVINE CARCASS TISSUES

Jyoti P. Mishra[1], Alessandro Ferragina[1], Stephen Hegarty[2], and Ruth M. Hamill[1*]

[1]Food Quality and Sensory Science Department, Teagasc, Ashtown, Dublin 15, Ireland

[2]Centre for Advanced Photonics and Process Analysis, Munster Technological University, Bishopstown Campus, Cork, Ireland

*Corresponding author email: ruth.hamill@teagasc.ie

I. INTRODUCTION

While several studies have demonstrated potential for infra-red spectral classification of different muscles within the carcass (Aït-Kaddour et al., 2017), spectroscopic classification of other tissues in the bovine carcass is less well-studied. Furthermore, the application of spectroscopy for authentication of fresh versus frozen-thawed meat especially in valuable cuts such as striploin has been investigated with a view to elaboration of spectral regions that permit classification of meat as fresh or frozen-thawed (Barbin et al., 2013), but this has not yet been investigated for other carcass tissues. The current work has the objective to record near infra-red spectral variability in a range of tissue types (bone, cartilage, marrow, fat, muscle, ligaments and tendons) and two preservation states (fresh and frozen-thawed). Principal component analysis will be applied to examine the variability in spectral profiles in relation to tissue type under fresh and frozen-thawed conditions.

II. MATERIALS AND METHODS

Between three and ten replicate samples from each of thirteen tissues, within eight tissue categories from the bovine dressed carcass were collected from a standard beef processing line including cartilage, bone (head and body), ligament, tendon, marrow, fat and muscle. The samples are achilles tendon (n=4), atlas bone (n=4), cervical cs marrow (n=3), femur head (n=4), femur body (n=4), flank muscle (n=10), neck muscle (n=10), paddywack (n=4), rib (n=4), rib cartilage (n=7), rump fat (n=4), scapula cartilage (n=7), sternum cs marrow (n=4)). All the tissues were cleaned manually and kept in labelled bags. A Vis-NIR instrument (Labspec®, wavelength range: 350-2500 nm) was used for collecting the spectra. Three spectra were captured for each of 138 samples for a total of 414 spectra. The spectral data were collected on 1) fresh sample (kept in chill at 1°C approximately 24h following deboning 2) thawed sample (frozen for one week and thawed overnight in a chill at 4 °C). Data analysis were carried out in R. Before averaging the three replicates, the spectra were first visually edited to remove the noisy bands at the tails and detect outlier spectra. Standard Normal Variate and Detrend (SNVD) was applied before data analysis. PCA analysis was done on the pre-processed data to explore discrimination in between the samples based on tissue type, tissue category and preservation state (fresh versus freeze-thawed).

III. RESULTS AND DISCUSSION

PCA analysis permitted visualisation of variability within and among tissue categories/types and preservation state (fresh and frozen-thawed). The PCA score plots for the first three PCs are shown in Figure 1. PC1-3 accounted for 36.6%, 31.5% and 13.6% respectively. The score plot with Figure 1a) shows the discrimination of tissues based on tissue type and category. PC1 and PC2 clearly separate bone marrow from other tissues. PC3 separates fat (rump fat) from other tissues. Overall clustering patterns reflect tissue composition e.g. tendons and ligament cluster close together. When the 95% confidence ellipse for a tissue type cluster does not overlap the ellipse of a different tissue

type, this represents significant discrimination between tissue types. Discrimination between tissues within the same category (e.g. flank muscle versus neck muscle, rib cartilage and scapula cartilage) based on spectra was also observed. Regarding fresh versus frozen-thawed, no obvious structure according to this criterion was represented in the first three PCs for the tissues studies. This is reflected in the large and overlapping 95% confidence ellipses in Figure 1b, suggesting the major sources of variability in the data did not distinguish fresh from frozen-thawed samples.

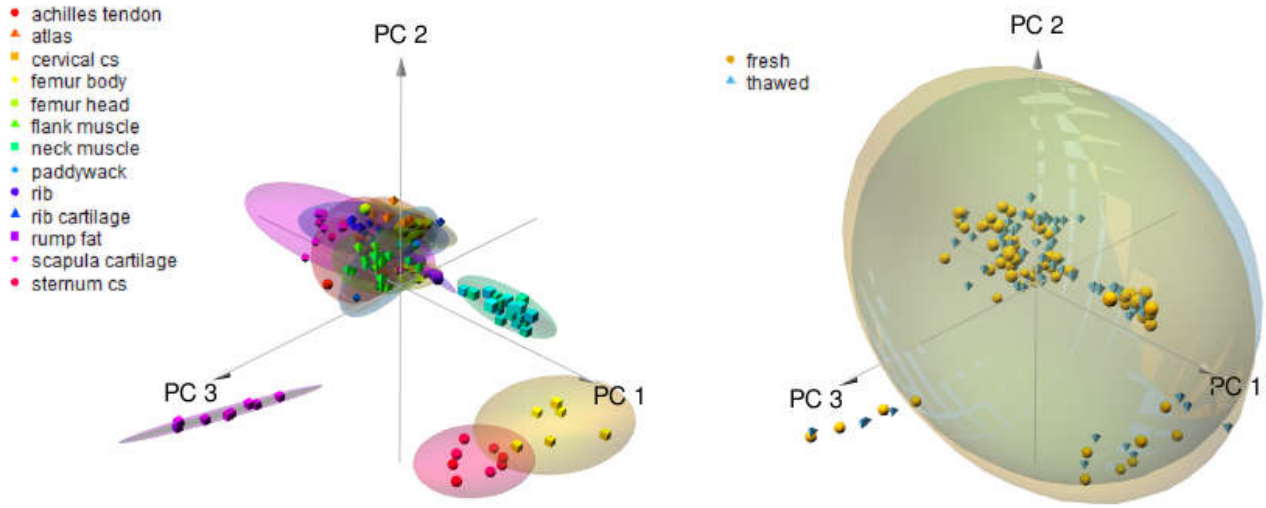

Figure 1: PCA score plot of first 3 PCs with 95% confidence ellipses based on a) tissue type b) fresh and frozen-thawed

IV. CONCLUSION

The PCA analysis of near infrared spectral data recorded on a range of carcass component tissues showed clustering of the tissue samples based on tissue category (e.g. bone, muscle, fat, cartilage etc.) and tissue types within category (e.g. rib cartilage versus scapula cartilage), whereas the analysis did not markedly distinguish preservation state, i.e. whether the sample was fresh or frozen-thawed. It will be of interest to examine additional freeze-thaw steps to investigate whether spectral profiles in the studied tissues are altered over a larger number of freeze thaw cycles.

ACKNOWLEDGEMENTS

This work was supported by Meat Technology Ireland (MTI) a co-funded Industry/Enterprise Project (TC 2016 002) and a Teagasc Walsh Scholarship Award (WS 2021039) to Jyoti P. Mishra. We acknowledge the facilitation of Eugene Vesey, Teagasc and staff at Liffey Meats, Ballyjamesduff, Co. Cavan.

REFERENCES

1. Aït-Kaddour, A., Jacquot, S., Micol, D., & Listrat, A. (2017). Discrimination of beef muscle based on visible-near infrared multi-spectral features: Textural and spectral analysis. International Journal of Food Properties, 20(6), 1391–1403.
2. Barbin, D. F., Sun, D. W., & Su, C. (2013). NIR hyperspectral imaging as non-destructive evaluation tool for the recognition of fresh and frozen-thawed porcine longissimus dorsi muscles. Innovative Food Science and Emerging Technologies, 18, 226–236.