Mini NIR spectrophotometer for predicting intramuscular fat in beef: A comparison with high resolution NIR spectrophotometers

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I. INTRODUCTION

Intramuscular fat (IMF) is of significant importance in beef because of its contribution to eating quality traits, such as juiciness, aroma and tenderness [1]. Near-Infrared (NIR) spectroscopy is an extensively researched technology with regard to meat composition and quality analysis [2]. Recent developments in micro-fabrication and miniaturization of optical systems have allowed the creation of "palm-sized" spectrophotometers which are compact, mobile and can be carried in a pocket. In the current study, a "palm-sized" mini NIR spectrophotometer has been compared to three other high resolution NIR systems for predicting IMF in beef combined with Chemometrics.

II. MATERIALS AND METHODS

A total of 112 samples of *M. longissimus thoracis* (LT) were collected at 24 hours post mortem from beef carcasses. A 30mm thick steak was excised from the 12th rib and transported chilled to the AgResearch Ruakura meat science laboratory for further processing and sample preparation. A sample of LT (40 x 30 x 15 mm) devoid of subcutaneous fat and connective tissue, from the ventral part of the muscle excised was frozen at -30°C in a zip-lock bag for subsequent NIR and intramuscular fat analysis. Frozen beef samples were thawed and subjected to spectroscopic analysis while packed in zip lock plastic bags. NIR reflectance spectra were collected using mini NIR (DLP NIRscan Nano EVM, Texas Instruments Inc., Texas, USA) and three other high resolution spectrophotometers viz. Lab spec 5000, Lab spec 4 Hi-Res and Trek (ASD Inc., Colorado, USA). Mini NIR works in the wavelength range of 900-1700 nm with an optical resolution of 10 nm while the other three spectrophotometers work in a wavelength range of 350-2500 nm with higher resolutions. For NIR analysis, the sample window of mini NIR was placed over the sample surface and the spectra were recorded at 3 different locations, for the other spectrophotometers a spectrum per single sample location was collected.

Soxhlet method (AOAC 960.39) was used for determining fat content (AOAC method 960.39) of the samples. All analyses were performed in triplicate. A subset of frozen beef samples (n=46) were subjected to accelerated solvent extraction (ASE) using hexane iso-propanol as solvent. The wavelength range of 900-1700 nm was chosen in order to compare mini NIR with other spectrophotometers. Multiplicative scattering correction (MSC) was used for pre-processing. Partial least squares regression (PLSR) was used for calibration of fat content by Soxhlet. Cross validation with 20 splits was used to assess performance of the model. Data analysis was performed using Unscrambler X (The Unscarambler, Version 10.2, Camo, Oslo, Norway).

III. RESULTS AND DISCUSSION

Fat content by Soxhlet was compared to ASE, Fig.1 (a), to provide a point of reference for the evaluation of mini NIR against the other instruments and showed a R^2 of 0.96.

Fig. 1 (b) and (c) shows the regression coefficients for the mini NIR and Labspec 5000 models with major contribution from C-H first stretching peak at 1200 nm, associated with the fat content [3]. Both mini NIR and Labspec 5000 showed similar regression coefficients. Mini NIR model showed similar performance to the other instruments as illustrated in Table 1.

IV. CONCLUSION

The performance of the mini NIR was comparable to others high resolution NIR spectrophotometers for prediction of IMF content in beef, suggesting that it could be used as screening tool for detection of high and low levels of fat content in beef samples.

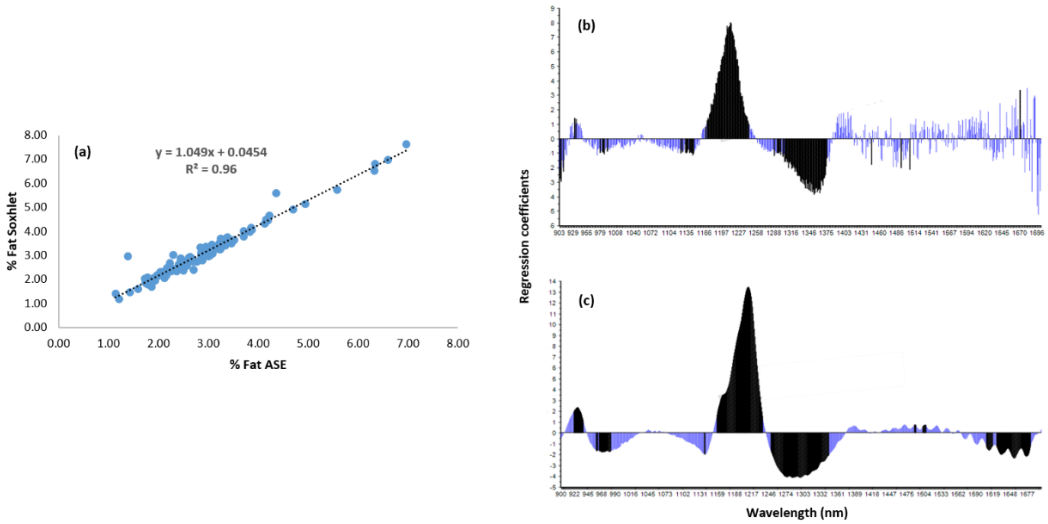

Fig. 1. Relationship between Soxhlet and ASE methods for fat analysis in beef; (a) Regression coefficients plots: (b) Mini NIR and (c) Labspec 5000.

Table 1. Comparison of PLSR models for predicting the IMF in beef using 4 different spectrophotometers.

Spectrophotometer model	Calibration			Cross-validation	
	LV	R_c^2	RMSEC	R_{cv}^2	RMSECV
Mini NIR	5	0.75	2.10	0.67	2.46
Labspec 5000	4	0.76	2.07	0.70	2.32
Labspec 4	10	0.83	1.74	0.70	2.31
Trek	5	0.62	2.69	0.54	2.98

Coefficients of determination (R^2) and root mean square errors for calibration (R_c^2, RMSEC) and cross validation (R_{cv}^2, RMSECV).

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