TRANSFERABILITY OF PREDICTION EQUATIONS BETWEEN NIR INSTRUMENTS FOR PREDICTING INTRAMUSCULAR FAT AND MOISTURE IN HOMOGENISED BEEF *M. LONGISSIMUS THORACIS*

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I. INTRODUCTION

Visible-Near-Infrared (NIR) spectroscopy has been used for decades as a research tool for objective measurement of beef quality [1,2]. No two NIR instruments are exactly the same, and instrument manufacturers improve the technology over time (e.g. increased resolution, higher signal-to-noise ratios etc.). One potential barrier to the industrial uptake of NIR technology for real-time measurement of meat quality is the perceived risk of a total reliance on the same instrument being readily available for future scanning requirements. Little is known about the transferability of prediction equations between instruments for meat quality applications, and the potential impacts of using a new instrument with different calibrations. The aim of this research was to investigate how NIR prediction equations developed on spectral data collected using an ASD Labspec 5000, 350-2500nm purchased in 2009 (OLD NIR) could be applied to spectral data collected on an ASD Labspec 4, 350-2500nm, purchased in 2017 (NEW NIR) to predict the IMF% of homogenised beef *M. longissimus thoracis*.

II. MATERIALS AND METHODS

894 *M. longissimus thoracis* (LT) samples were collected at 24 hours post mortem from beef carcasses processed between January 2016 and September 2017 as part of the Firstlight Wagyu progeny test programme. 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 (40mm long x 30mm wide x 15mm thick) 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.

After tempering the samples at in a -5°C freezer for 12 hours, the soft-frozen sample was diced into ~15mm cubes then homogenised using a Philips hand mixer with an enclosed blender attachment before NIR scanning. Three replicate scans were collected with OLD NIR (fitted with a bespoke reflectance probe [3]) and one scan was taken with NEW NIR fitted with an ASD High-Intensity contact probe. Homogenised samples were frozen after NIR scanning. A subset of 102 samples with marble scores ranging from 2 to 8 (average scores assessed by a panel of judges) against the Japanese Beef Marbling Standards system were selected for intramuscular fat and moisture content analysis. Intramuscular fat and moisture content analysis was undertaken on 3.5-4g of homogenous wet meat sample dried in an oven at 102°C for 18 hours followed by soxhlet extraction (AOAC 960.39). 15 of the samples were analysed as duplicates for repeatability analysis. The weight of water (Moisture%) and fat (IMF%) in each sample were expressed as a percentage of the wet meat sample weight.

Calibration models (Partial Least Squares Regression, PLSR) were fitted to spectra from the OLD NIR based on 66% data (calibration set), with validation performed on the remaining 33% of data (validation set).

A transfer model was then fitted to transfer spectra from OLD to NEW NIR. Spectra from samples with no available IMF% or Moisture% data (n = 444 samples) were used to fit a transfer model using direct standardization (DS) based on Tikhonov regularization (ridge regression). The optimal regularization

parameter (α=0.03) was determined by cross-validation. The calibration transferred model was then applied to spectra from the NEW NIR from samples with known IMF% (n=34) and Moisture% (n=33).

RESULTS AND DISCUSSION

The use of homogeneous meat samples to assess calibration transfer minimises sampling error due to probe placement on the sample. Measurements of intramuscular fat content ranged from 2.3 to 23.1%. The repeatability of the Soxhlet assay was estimated to be ± 0.53% (based on 15 replicate samples in the trial). Measurements of moisture content ranged from 57.8 to 74.0%. The repeatability of the moisture assay was estimated to be ± 0.67% (based on 15 replicate samples). The maximum possible IMF% model R^2 (before any NIR measurements are made) is therefore 0.987 and the maximum possible Moisture% model R^2 (before any NIR measurements are made) is therefore 0.964.

The model fitted on spectra from the OLD NIR and applied to spectra collected in the NEW NIR with no calibration transfer provides a R^2 = 0.85 for IMF% and R^2 = 0.42 for Moisture% and slope/intercept between predicted and expected significantly different from 1 and 0, respectively (IMF%: slope=1.20±0.09; intercept = -2.13±0.82, Moisture%: slope=0.91 ± 0.19; intercept = 6.7 ± 13). The performance of calibration transfer is summarised in Table 1. The direct standardization based on Tikhonov regularization has similar performance to the OLD NIR model based on a single spectra (validation R^2=0.81, RMSE=2.01% for IMF% and validation R^2=0.61, RMSE=1.99% for Moisture%) and three spectra (validation R^2=0.88, RMSE=1.58% for IMF% and validation R^2=0.73, RMSE=1.66% for Moisture%).

Table 1. Model performance of the calibration transferred model of IMF% (IMF) expressed as % crude fat and moisture% based on NEW NIR spectra (homogenised samples).

	Calibration			Calibration set Variation				Validation			Validation Set Variation			
Attribute	N	R^2	RMSE	Min	Max	Mean	SD	N	R^2	RMSE	Min	Max	Mean	SD
IMF%	68	0.78	2.28	2.7	21.0	7.5	3.9	34	0.88	1.51	2.3	19.6	7.9	4.5
Moisture%	69	0.79	1.71	59.2	74.0	69.6	3.3	33	0.61	2.13	60.1	73.9	69.4	3.2

CONCLUSION

Calibration equations transfer well between the ASD Labspec 5000 and the ASD Labspec 4 instruments for predicting IMF% and Moisture% in homogenised beef *M. longissimus thoracis*. For this approach to calibration transfer, a common set of samples where spectral data is available for both instruments is required. Transferability of calibrations between data collected on different instruments from the same manufacturer should not be seen as a major barrier to implementation of NIR technology for measurement of meat quality.

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REFERENCES

1. Smith D.R., Smith N.B. and Muir P.D. (1995). Near Infrared reflectance analysis of intramuscular fat in beef. Proceedings of the New Zealand Society of Animal Production 55: 124-126
2. Reis M.M. and Rosenvold K. (2014). Prediction of meat attributes from intact muscle using near-infrared spectroscopy. Encyclopedia of Meat Sciences (Second Edition). M. Dikeman and C. Devine. Oxford, Academic Press: 70-77.
3. Craigie C.R. Fowler S., Knight M., Stuart A., Hopkins D., and Reis M.M. (2015). Spectral Imaging Techniques for predicting meat quality – an Australasian perspective. Farm Animal Imaging A Summary Report Edinburgh 2015. C Maltin, C Craigie and L Bunger. Published by SRUC: 75-79.