POTENTIAL OF NEAR INFRARED (NIR) SPECTROSCOPY AND DUAL ENERGY X-RAY ABSORPTIOMETRY (DXA) IN PREDICTING PORK BELLY SOFTNESS

Philip O. Soladoye[a,b], Nuria Prieto[b], Óscar López-Campos[b], Jennifer L. Aalhus[b], Bethany Uttaro[b], Jordan Roberts[b], Ivy L. Larsen[b], Phyllis Shand[a], Claude Gariépy[c], Manuel Juárez[b*]

[a]University of Saskatchewan, Saskatoon, SK, S7N 5A8, Canada

[b]Agriculture and Agri-Food Canada, Lacombe, AB, T4L 1W1, Canada

[c]Agriculture and Agri-Food Canada, Saint-Hyacinthe, QC, J2S 8E3, Canada

*Corresponding author email: Manuel.Juarez@agr.gc.ca

I. INTRODUCTION

Belly softness has been identified as a major defect of pork bellies, with negative implications on bacon quality. A number of chemical and physical factors can explain up to 80% of the variation in pork belly softness (Soladoye et al., 2017). Near-infrared (NIR) spectroscopy is a rapid and non-invasive technology that has a wide-range of applications in meat composition and quality evaluation (Prieto et al., 2009), and dual energy X-ray absorptiometry (DXA) has been reported to accurately predict tissue composition of commercial livestock carcasses (Soladoye et al., 2016). The purpose of the present study was to assess the potential of NIR and DXA technologies in predicting pork belly softness when employed individually or in combination.

II. MATERIALS AND METHODS

A total of 198 bellies from a population designed to create variability in carcass and meat quality attributes (Soladoye et al., 2016) were collected and fabricated following Canadian commercial cutting specifications. The subcutaneous and the intermuscular fat layers (lateral cut surface) were scanned using a hand-held fibre optic pro-reflectance probe (1 m long, 3 mm optical window size) attached to a portable LabSpec®4 Standard-Res spectrometer (Analytical Spectral Device, ASD Inc., Boulder, CO, USA). The *latissimus dorsi* muscle was also scanned using a 20-mm ASD fibre-optic high intensity contact probe. Left carcass-side bellies were scanned by DXA (Lunar iDXA Series, GE Medical System, Madison, Wisconsin, USA) equipment in adult full mode. Pork belly softness was assessed using belly-flop angle over an 8.3 cm Ø bar, and subjective score measurements, as described by Soladoye et al. (2017). The population was split randomly to have a calibration (n=132) and validation set (n=66). After mathematical transformations of spectral data, partial least squares regressions (PLSR) were run on transformed and untransformed NIR spectra and DXA values to predict subjective softness and belly-flop angle measurements (SAS V 9.4). T^2 Hotelling statistic was used for factor selection. Only the mathematical transformation and tissue combinations that resulted in the highest R^2 were reported.

III. RESULTS AND DISCUSSION

Fat content, lean content, length, thickness and width of bellies ranged from 22 to 69%, 31 to 78%, 62 to 77 cm, 4 to 9 cm, and 22 to 32 cm, respectively, whereas the proportions of polyunsaturated fatty acids (PUFA), saturated fatty acids (SFA), and iodine values (IV) ranged considerably from 9 to 16%, 32 to 43%, and 53 to 72%, respectively (Soladoye et al., 2017).These traits contributed to high variability in the pork belly softness with subjective softness scores ranging from 1.5 to 5.0 on the 5-point scale. This wide variation in belly characteristics was ideal to evaluate the accuracy of NIR spectroscopy and DXA in predicting pork belly softness.

Using Vis-NIR spectra collected from the three layers of the bellies, the accuracy of the models fit with the calibration set for the subjective softness scores was between 74.5 and 79.7%,and between 72.7 and 99.9% for belly-flop measurements(Table 1). The validation results were lower for lean and subcutaneous fat and the combination of layers, but similar for intermuscular fat. DXA variables predicted 65.2% of subjective softness scores and 43.6% of pork belly-flop angle variation in the validation set. Combining DXA estimates with Vis-NIR spectra reported higher R^2 in the calibration and validation sets.

Table 1: Prediction of pork belly softness measures using NIR spectroscopy and DXA technology

Measures	Softness measurement	#Factors	Data transformation[a]	R^2 Calibration	RMSECV[b]	R^2 Validation	RMSEP[c]
Lean	Subjective	7	SG1st	0.745	0.475	0.436	0.656
	Objective	7	SNV-D SG2nd	0.727	14.76	0.506	17.99
Intermuscular Fat	Subjective	5	SG1st	0.762	0.451	0.724	0.449
	Objective	2	SNV-D SG2nd	0.760	13.23	0.611	15.87
Subcutaneous Fat	Subjective	2	SNV-D SG2nd	0.769	0.436	0.653	0.510
	Objective	2	SNV-D SG2nd	0.811	11.77	0.686	14.25
Lean+SC Fat	Subjective	2	SNV-D SG2nd	0.797	0.407	0.663	0.496
	Objective	9	SG2nd	0.999	0.970	0.715	13.71
DXA	Subjective	7	SG1st	0.745	0.475	0.436	0.656
	Objective	7	SNV-D SG2nd	0.727	14.76	0.506	17.99
DXA+NIR Lean	Subjective	5	SG1st	0.762	0.451	0.724	0.449
	Objective	2	SNV-D SG2nd	0.760	13.23	0.611	15.87
DXA+NIR Lean+SC fat	Subjective	2	SNV-D SG2nd	0.769	0.436	0.653	0.510
	Objective	2	SNV-D SG2nd	0.811	11.77	0.686	14.25

[a]SG1st: Savitzky-Golay smoothing plus first-order derivative; SG2nd: Savitzky-Golay smoothing plus second-order derivative; SNVD-SG2nd: standard normal variate and detrend and Savitzky-Golay smoothing plus second-order derivative.

[b]RMSECV: root mean square error of cross-validation.

[c]RMSEP: root mean square error of prediction.

Pork belly softness is influenced by both chemical and physical factors. The prediction accuracies observed from Vis-NIR spectra or DXA models would likely not be suitable for reliable predictions of softness measures. However, the accuracies for some models would likely be sufficient to classify bellies according to extremes in softness. This classification approach has been shown for many meat quality traits in previous studies (Juárez et al., 2017). NIR spectroscopy captures vital information about the chemical constituents and tissue ultra-structure in any scanned sample (Prieto et al., 2009). NIR spectroscopy prediction of pork belly softness could be partly associated with the level of fatty acid unsaturation. Other pork belly attributes that may have their basis rooted in the tissue molecular bonds or chemical structures may influence pork belly softness, and likely contributed to overall prediction accuracies observed in this study.

IV. CONCLUSION

NIR spectroscopy and DXA scans could be used as a mean of classifying pork bellies according to softness to facilitate export merchandizing. Combining Vis-NIR spectra from boththe lean and the subcutaneous fat belly layers would improve the accuracy of pork belly softness classification.

ACKNOWLEDGEMENTS

Canada's Swine Innovation Pork provided funding and the Canadian Centre for Swine Improvement provided support.

REFERENCES

1. Soladoye, O., Uttaro, B., Zawadski, S., Dugan, M., Gariépy, C., Aalhus, J., Shand, P. & Juárez, M. (2017). Compositional and dimensional factors influencing pork belly firmness. Meat Science 129:54-61.
2. Prieto, N., Ross, D. W., Navajas, E. A., Nute, G. R., Richardson, R. I., Hyslop, J. J., Simm, G., Roehe, R. (2009). On-line application of visible and near infrared reflectance spectroscopy to predict chemical–physical and sensory characteristics of beef quality. Meat Science, 83(1), 96-103.
3. Soladoye, O.P., Campos, Ó.L., Aalhus, J.L., Gariépy, C., Shand, P., & Juárez, M. (2016). Accuracy of dual energy X-ray absorptiometry (DXA) in assessing carcass composition from different pig populations. Meat Science, 121, 310-316.
4. Juárez, M., Horcada, A., Prieto, N., Roberts, J.C., Dugan, M.E.R., López-Campos, O., & Aalhus, J.L. (2017). Guaranteeing Canadian lamb meat quality using near infrared spectroscopy on intact rack. Canadian Journal of Animal Science. doi: 10.1139/CJAS-2017-0106.