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Non-destructive spectrometric technologies to determine meat tenderness and discriminate sheep age group at slaughter (#278)

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Notes

Introduction

The feasibility to predict lamb tenderness has been evaluated previously by several authors using NIR and X-ray based instruments. Dual energy X-ray and NIR spectroscopy can be effectively used as a means of classifying pork bellies according to softness [1]. New multi energy X-ray sensors have also shown the capacity to monitor meat aging during chilling-vacuum packaging of beef samples [2]. The aim of this study was to assess the performance of a multi energy X-ray sensor, and a high performance and a portable low cost NIR system to predict shear-force in lamb samples and to discriminate between age/tenderness groups.

Methods

Samples: Merino-cross lambs were sourced from a commercial sheep flock located in Australia. Half were born in September/October 2016 (n=30), the other half in May/June 2017 (n=30). All were slaughtered in October 2017 as lambs (6 months old) and yearlings (12 months old). After slaughter 2 samples 5 cm long were taken from the *longissimus dorsi* near to the 12/13th rib, aged for 5 days and then frozen. One sample was used to determine shear force and the other was used for scanning using 3 different spectrometric devices.

Spectrometric acquisition systems: High performance NIR device: Spectra were recorded on a Fourier Transform NIR spectrometer model Matrix-F duplex (Bruker Optik GmbH, Germany). NIR reflectance spectra were collected over the 12,000–4000 cm−1 spectral region (830–2500 nm) using an on-contact probe. **Low-cost NIR device:** The SCiO handheld smartphone-based NIR spectrometer (Consumer Physics, Israel) was used. Reflection spectra in a range between 740 nm and 1070 nm were collected. **X-ray multi energy device:** An industrial X-ray prototype system with a multi energy detector (MXV-PACK 4010, Multiscan Technologies, Spain) was used to acquire a spectroscopic image (1000 x 256 pixels) of the sample with each pixel containing an X-ray energy spectra of 128 channels (recording energies from 20 to 160 keV).

Tenderness determination: Shear force was measured using a Lloyd texture analyser (Model LRX, Lloyd Instruments, Hampshire, UK) with a Warner–Bratzler shear blade fitted [3].

Construction and cross-validation of predictive models: All spectra were pre-processed and multivariate calibration models constructed using PLS Toolbox, version 8.1.1 (Eigenvector Research, Inc., Wenatchee, WA, USA). Calibration models were developed by using Partial Least Squares Regression (PLSR) for shear force. Partial Least Squares discriminant analysis (PLS-DA) was used as a linear classification method to predict the category (lambs or yearling at slaughter). Interval variable selection for PLS (iPLS) and PLSDA (iPLSDA) was applied to discard variables that added complexity yet no additional precision to the model, improving the performance of the final model upon validation.

Results

The shear force of lamb and yearling differed (p=0.01) with a mean shear force of 38.45±8.99 N for yearlings and 31.65±7.25 N for lambs.

Table 1 shows performance metrics for iPLSR models to predict lamb tenderness using the three measurement systems. Multi energy X-ray showed no capacity to predict lamb tenderness. In the case of high performance NIR (that acquires from 830 to 2500 nm), the models used specific regions of the spectra and 8 PLS factors to achieve a RMSECV of 5.54 N. In the case of low-cost NIR device (that acquires from 740 to 1070 nm), the models used specific regions of the spectra and 3 PLS factors to achieve a RMSECV of 6.69 N. However, R^2_{cv} were still low in both cases showing values of 0.578 and 0.357 respectively (Figure 1).

The results for the PLS-DA and iPLSDA models for classification of samples according to sheep age at slaughter are shown in Table 2. The lowest error rate was found for the high performance NIR where accuracy of calibration and prediction reached 100% for all the samples when using the most representative interval selection. The highest error was found when using multi energy X-ray (27.5%), suggesting that under current methodology, this technology is not-acceptable for implementation within the food industry. This might partly be due to the variations in thickness found between samples which may cause variation in the attenuation values, producing higher errors. However, low cost NIR devices can discriminate accurately (2.5% error) when using specific spectral intervals).

Conclusion

This study has demonstrated the ability of spectroscopic methods, especially high performance and low-cost NIR, to provide a fast and effective method for classifying meat from lamb and yearling animals at slaughter. It also shows the low potential of these methods for the prediction of the shear force. The potential of studied spectroscopic devices in the prediction of sheep age and shear force needs to be further investigated on a larger number of samples.

Acknowledgements

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References

[1] Soladoye, et al. 2018. Meat Science, 142 1-4 ; [2] Austrich et al. 2017. *ICOMST Proceedings* p. 628; [3] Hopkins et al. 2010. *Animal Production Science*, 50, 382–385.

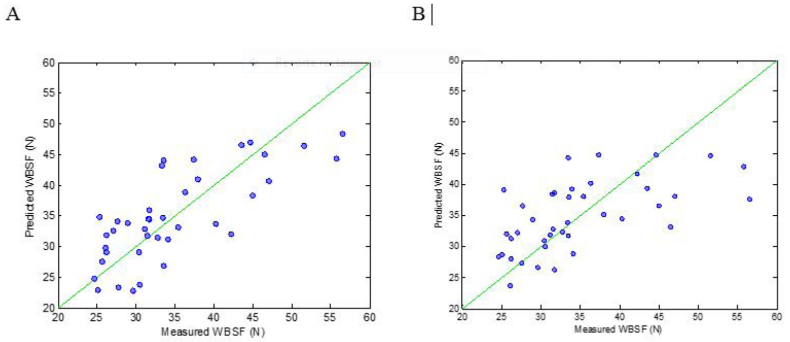

Figure 1 Relationship between the measured and predicted Warner Bratzler shear force (BWSF) using iPLSR models obtained from high performance NIR spectra (A) and low-cost NIR spectra (B).

	Multi energy X-ray		NIR-high performance		NIR-low cost	
PLS-DA						
Calibration	*Actual Lamb*	*Actual Yearling*	*Actual Lamb*	*Actual Yearling*	*Actual Lamb*	*Actual Yearling*
Predicted Lamb	12	4	19	1	18	2
Predicted Yearling	7	17	0	19	1	20
Error rate (%)	27.5%		2.5%		7.6%	
Cross-validation						
Predicted Lamb	12	4	13	2	18	1
Predicted Yearling	7	17	6	18	2	18
Error rate (%)	27.5%		20.5%		7.6%	
iPLSDA						
Calibration	*Actual Lamb*	*Actual yearling*	*Actual Lamb*	*Actual yearling*	*Actual Lamb*	*Actual yearling*
Predicted Lamb	13	2	19	0	19	0
Predicted Yearling	6	19	0	20	0	20
Error rate (%)	20%		0%		0%	
Cross-validation						
Predicted Lamb	11	3	19	0	19	1
Predicted Yearling	8	18	0	20	0	19
Error rate (%)	27.5%		0%		2.5%	

Table 2 Confusion matrix for discrimination of lamb and yearling animals by PLSDA and iPLSDA models.

	Multi energy X-ray	NIR-high performance	NIR-low cost
PLS factors	3	8	3
$RMSE_C$	7.66	1.93	6.19
$R^2{}_C$	0.15	0.947	0.448
$RMSE_{CV}$	9.02	5.54	6.69
$R^2{}_{CV}$	0.005	0.578	0.359

RMSEc, Rc^2: Root mean square error and coefficient of determination of calibration. RMSEcv, R^{2}cv: Root mean square error and coefficient of determination of validation (cross-validation)

Table 1 Performance metrics in iPLSR models for shear force using the three investigated systems.

Notes