INVESTIGATING THE USE OF VISIBLE AND NEAR INFRARED SPECTROSCOPY TO PREDICT SENSORY AND TEXTURE ATTRIBUTES OF BEEF *LTL*

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Abstract –While textural and sensory information of beef products is critical, the analyses of these traits are time consuming and destructive. Visible-Near Infrared Spectroscopy (VisNIRS) offers a rapid, non-destructive technique with the potential to predict sensory and Warner-Bratzler Shear Force (WBSF) values of beef steaks. The aim of this study was to calibrate a chemometric model to predict beef *M. longissimus thoracis et lumborum* (*LTL*) sensory and WBSF values using VisNIRS. Spectra were collected on the cut surface of *LTL* steaks (n= 61) at 48 h and 49 h *post-mortem*. *LTL* steaks were cooked and analysed by a trained beef sensory panel as well as undergoing WBSF analysis. R^2 prediction values of 0.56 for sensory tenderness, 0.21 for sensory juiciness and 0.56 for WBSF were obtained.

Key Words – Chemometrics, Eating quality, Tenderness, WBSF

I. INTRODUCTION

Eating satisfaction, sensory characteristics and nutritional content are key factors that influence consumers in regard to purchasing fresh meat [1] [2]. Measurement of beef texture using WBSF and trained sensory panelists is time consuming, expensive and destructive [3]. VisNIRS has been proposed as a method of analyzing beef quality traits, with advantages such as rapid measurements, simple preparation of sample and non-destructive analysis [3] [4].Therefore, this study aimed to investigate the use of VisNIR spectroscopy as a tool to determine WBSF, sensory tenderness and sensory juiciness values in beef *LTL*.

II. MATERIALS AND METHODS

Crossbred beef bulls and steers (16±4 month old, n= 61) finished under controlled feeding and environmental conditions were slaughtered in 10 batches in a commercial plant by electrical stunning followed by exsanguination. Twelve steaks with a thickness of 2.54cm were removed from the *LTL* at 48 h *post-mortem* (PM), vacuum packaged, aged for 14 days at 4°C then frozen at -20°C. The 4th and 5th steak on each loin were selected for WBSF and sensory analysis, respectively. VisNIRS measurements were recorded on the cut surface of the remaining *LTL* muscle immediately and after 1h blooming (48 h and 49 h PM). ASD Labspec 5000 (ASD Inc., Boulder Colorado, USA) VisNIR spectrometer fitted with a high-intensity contact probe with a 10 mm spot size was used to collect spectra between 350-2500 nm with 1 nm intervals, using the Indico Pro program (ASD Inc.). Spectra were collected in triplicate, for each given scan 20 spectra were collected consecutively and averaged to reduce the noise effect, then saved in reflectance mode - log (1/*R*) and exported as JCAMP to The Unscrambler X version 10.3 (CAMO ASA, Oslo, Norway) for further chemometric analysis. WBSF analysis was conducted according to AMSA (1995) guidelines using the Instron 4464 Universal testing machine (Instron Ltd., Buckinghamshire, UK), with a load cell of 500 N and a cross head speed of 50 mm/min. Sensory analysis followed a modified version of the American Meat Science Association Research Guidelines for Cookery, Sensory Evaluation and Instrumental Tenderness Measurements of Meat (2nd Edition, Version 1, March 2015). Samples were cooked on a grill to an internal temperature of 70ºC then served to a 12 member trained sensory panel to assess tenderness and juiciness, on a 0-100 line scale.

III. RESULTS AND DISCUSSION

Ranges, means, standard deviations (SD) and coefficients of variation (CV) of three beef eating quality traits are presented in Table 1.

Table 1. Ranges, means and standard deviations of WBSF-D14, tenderness and juiciness scores on all beef samples (n = 61)

Attribute	Range	Mean	SD	CV
WBSF-D14 (N)	22.05 -96.77	40.95	12.69	30.99
Sensory-Tenderness	27.1 – 69.2	47.67	10.47	21.96
Sensory-Juiciness	17.5 – 54.35	35.47	9.18	25.88

WBSF-D14 had the largest range and variability within the dataset when compared to sensory tenderness and juiciness scores, in agreement with previous research by Prieto et al [5]. Reasonably high coefficients of determination (R^2) for WBSF-D14 (0.56) and sensory tenderness (0.56) were obtained (Table 2), indicating a reasonable prediction ability for VisNIR spectroscopy. It is noteworthy that the best prediction models for these two traits were obtained from the same spectral measurement time point (48 h PM) albeit at different wavelengths and using different Partial Least Square (PLS) terms (WBSF-D14; 8th term, 450-2300 nm and sensory tenderness; 7th term, 1100-2300 nm, respectively). Coefficients of determination for the prediction of these two traits reduced after the muscle was left to bloom for 1 h , even when using exactly the same samples (i.e. n= 51 or 52), indicating that oxygenation of the meat may hinder VisNIR prediction. The wavelength range that produced the highest prediction R^2 for WBSF was 450-2300 nm, which includes most of the visible (350-779 nm) and all of the whole near infrared spectrum (1100-2300 nm). In contrast, the wavelength range that produced the highest prediction R^2 for sensory tenderness (1100-2300 nm) was solely situated within the near infrared spectrum. R^2 values for sensory juiciness were lower than the texture traits (R^2 of 0.14 and 0.21 at 48 h and 49 h PM respectively) and these models had the lowest ratio performance deviations. However, these models had fewer terms than those for tenderness and WBSF-14 (48 h and 49 h models both had 3 terms). In contrast to the other models, the sensory juiciness model prediction was slightly improved after 1 h blooming. The best model for juiciness was found to be in the full VisNIR spectral wavelength range of 350-2500 nm. When spectra were trimmed of noise to 450-2300 nm the efficacy of the model decreased.

Table 2. Prediction of WBSF-D14, tenderness and juiciness scores on beef samples using VisNIRS measurements

Variable	PM Time	Math treatment	*n*	Outliers	*p*	R^2	SEC	SE_{cv}	RPD	Wavelength (nm)
WBSF-D14	48 h	Log (1/*R*)	61	0	8	0.56	8.44	11.68	1.09	450 - 2300
	49 h	Log (1/*R*)	51	4	4	0.35	8.66	10.0	1.269	1100 - 2300
Sensory - Tenderness	48 h	Log (1/*R*)	60	1	7	0.56	6.76	8.48	1.23	1100 - 2300
	49 h	Log (1/*R*)	52	3	5	0.45	7.44	9.33	1.12	350 - 2500
Sensory - Juiciness	48 h	Log (1/*R*)	61	0	3	0.14	8.53	9.11	1.01	450 - 2300
	49 h	Log (1/*R*)	55	0	3	0.21	7.89	8.59	1.07	350 - 2500

n, number of samples: VisNIRS was not performed on a number of samples at 49h PM at the first sample collection; *p*,number of PLS terms utilized in the calibration equation; R^2, coefficient of determination of calibration; SEC, standard error of calibration; SE_{cv}, standard error of cross-validation; RPD, ratio performance deviation calculated as SD/ $SE_{cv.}$

IV. CONCLUSION

The results of this experiment indicate that VisNIRS has potential to predict WBSF and sensory tenderness values, however further refinement may be required to improve the prediction of juiciness.

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REFERENCES

[1] Grunert, Klaus G., Bredahl, Lone, Brunso, Karen, 2004. Consumer perception of meat quality and imperfections for product development in the meat sector – A Review. Meat Science. 66, 259-272

[2] De Marchi, M., Penasa, M., Cecchinato, A., Bittante, G., 2013. The relevance of different near-infrared technologies and sample treatments for predicting meat quality traits in commercial beef cuts, Meat Science. 93, 329-335

[3] Prevolnic, M., Candek-Potakar, M., Skorjanc, D., 2004. Ability of NIR spectroscopy to predict meat chemical composition and quality – A Review. Czech Journal of Animal Science. 49, 500-510

[4] Prieto, N., Roehe, R., Lavin, P., Batten, G., Andres, S., 2009. Application of near infrared reflectance spectroscopy to predict meat and meat products quality – A Review. Meat Science. 83, 175-186

[5] Ripoll, G., Alberti, P., Panea, B., Olleta, J. L., Sanudo, C., 2008. Near-Infrared reflectance spectroscopy for predicting chemical, instrumental and sensory quality of beef. Meat Science. 80, 697-702