On-line application of visible and near infrared reflectance spectroscopy to predict physical and sensory characteristics of beef quality

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Introduction Visible and near infrared reflectance spectroscopy (Vis-NIR) has been widely used by the industry research-base for large-scale meat quality evaluation to predict the chemical composition of meat quickly and accurately. Meat tenderness is measured by means of slow and destructive methods (e.g. Warner-Bratzler shear force). Similarly, sensory analysis, using trained panellists, requires large meat samples and is a complex, expensive and time-consuming technique. Nevertheless, these characteristics are important criteria that affect consumers' evaluation of beef quality. Vis-NIR technique provides information about the molecular bonds (chemical constituents) and tissue ultra-structure in a scanned sample and thus can indirectly predict physical or sensory parameters of meat samples. Applications of Vis-NIR spectroscopy in an abattoir for prediction of physical and sensory characteristics have been less developed than in other fields. Therefore, the aim of this study was to test the on-line Vis-NIR spectroscopy for the prediction of beef quality characteristics such as colour, instrumental texture, water holding capacity (WHC) and sensory traits, by direct application of a fibre-optic probe to the *M. longissimus thoracis* with no prior sample treatment.

Materials and methods Cross-bred steers and heifers (n = 194; sired by either Aberdeen Angus or Limousin bulls) were used in this three-year study. The animals were slaughtered in 11 batches from autumn 2006 until spring 2008 at an average carcass weight and age at slaughter of 335 (SD = 30.3) kg and 584 (SD = 26.2) days, respectively. Vis-NIR measurements were taken from the left side carcass *M. longissimus thoracis* (13th rib region) at 48 h *post mortem* (pm), by means of a NIR spectrophotometer (Qualityspec Pro, ASD Inc., Boulders, Colorado) provided with a sampling fibre-optic probe. Meat samples were scanned at every 1 nm over the Vis-NIR spectral range (350 to 1,800 nm). The absorbance data, stored as log (1/*R*), were subjected to multiplicative scatter correction and/or derivatives. Calibrations were performed using partial least squares regression. Full cross-validation was applied and the best equation was selected on the basis of minimising the standard error of cross-validation (SE_{CV}). Meat colour (CIE L*a*b*) was measured at the same position and time as Vis-NIR measurements. Sensory characteristics (texture, juiciness, beef flavour, abnormal flavour and overall liking) were assessed on 1-8 scale by a trained taste panel on meat samples (joint section including 11-12th ribs) aged for 14 days. The *M. longissimus lumborum* was used to determine the WHC and the instrumental texture. Meat aged for 14 days was weighed, cooked in a clam shell grill to a tissue centre temperature of 71 ºC and reweighed to calculate cooking loss (WHC). The slice shear force (SSF) test was performed on hot cooked meat (at 3 and 14 days pm) according to Shackelford *et al*. (1999); a single meat sample of 50 mm by 10 mm was cut orthogonal to muscle fibre orientation. Samples of 10 days aged meat were cooked in a water bath until a tissue centre temperature of 78 ºC and 10 replicate blocks (20 x 10 x 10 mm) were cut parallel to the fibre direction and sheared across the fibres with a Volodkevitch jaw.

Results Vis-NIR calibrations, tested by cross-validation, showed high predictability for L*, a* and b* (R^2 = 0.863, 0.861 and 0.907; SE_{CV} = 0.965, 0.949 and 0.692; respectively; Table 1). The accuracy of Vis-NIR to estimate WHC and instrumental texture ranged from R^2 = 0.31 to 0.54, suggesting moderate prediction ability for these traits. The Vis-NIR equations to predict sensory characteristics resulted in R^2 in the range from 0.21 (juiciness) to 0.59 (flavour).The correlations of Vis-NIR measurements and several meat quality traits ranged from 0.46 to 0.95.

Table 1 Ranges, means, standard deviations and prediction statistics of physical and sensory characteristics of beef samples

	Range	Mean	SD	R^2	SE_{CV}
L*/a*/b* colour	31-54/17-29/3-15	38/24/8	2.8/2.1/1.8	0.86/0.86/0.91	0.96/0.95/0.69
Volod./SSF3/SSF14 (N)	17-98/89-386/61-273	48/193/125	13.9/69.8/34.6	0.37/0.54/0.31	12.70/59.45/28.49
Cooking loss (%)	16-30	24	2.7	0.35	2.35
Texture/Juiciness	3.0-6.7/3.8-5.9	4.8/4.8	0.70/0.43	0.28/0.21	0.60/0.41
Flavour/Abnormal flav.	2.6-5.7/2.0-4.0	4.3/2.9	0.56/0.41	0.59/0.22	0.42/0.37
Overall liking	3.1-5.7	4.3	0.44	0.25	0.38

Conclusions The results of this research support the use of on-line Vis-NIR spectroscopy for the estimation of beef colour, a parameter closely associated with freshness, ripeness or desirability, factors which are often a primary consideration for consumers when making purchasing decisions. Considering that the Vis-NIR measurements were taken at different locations and at an earlier time *post mortem* compared to those used for sensory characteristics, WHC and instrumental texture, the correlations obtained indicate that Vis-NIR could be used in the abattoir as an early predictor for meat eating quality on-line. Under practical conditions, much more variation in meat quality is expected than for these experimental animals and so these correlations may be at the lower end of those possible for predicting meat eating quality.

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References

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