In-plant, non-invasive spectral imaging for the prediction of lamb meat quality attributes

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Abstract

Muscle foods such as meat are a perishable, nutritious, relatively expensive food commodity, a great source of human nutrition and are a large part of the New Zealand economy, as well as overseas. Currently, New Zealand's meat producing companies measure meat quality attributes by using a different technology for every trait, with no overarching way to combine them, with many of the technologies requiring collection and destruction of the product. There is a desire by the meat industry to find a single way to measure and compare meat quality parameters in a single process or technology. The development of an in-line (within the normal production line of an abattoir or meat processor), real time, non-destructive quality control system could help define multiple meat traits in a way that can guarantee the product in terms of composition, safety and consistency. These guarantees not only help the producer to ask a higher premium for their product, but also give assurances to the consumer that they are getting exactly what they are expecting and paying for.

This thesis focussed on determining whether the spectral imaging technologies of near infrared and hyperspectral imaging, and relevant pre-processing and modelling techniques were suitable for use in an in-plant situation for the prediction of lamb meat quality attributes.

Data was collected on 2511 lambs from 10 separate kills. The lambs were slaughtered through three abattoirs owned by Alliance Group Limited with near infrared and hyperspectral imaging of intact *M. Longissimus thoracis et lumborum* muscle surface collected at 24 hours *post-mortem.* Traditional meat quality measurements were also collected; tenderness using a MIRINZ tenderometer, CIELab colour using a CR-400 colour meter, ultimate pH using an Eutech Cyberscan pH 300 meter, marbling using subjective scoring by trained personnel and intramuscular fat content using gas chromatography – flame ionisation detector. The resulting data were split and used to generate calibration and validation data sets. The calibration data was used together with the spectral data that was processed using a variety of chemometric techniques including partial least squares, variable selection and neural networks to generate predictive models. The accuracy of the predictive models was then tested using the validation data set.

This work found that not all meat quality traits were able to be predicted accurately and certain techniques worked better for differing traits. The best predictive models for ultimate pH using the near infrared and hyperspectral data achieved R^2 values (a measure of goodness of fit) from the validation data sets of 0.63 and 0.48 respectively. For near infrared the best predictive models were achieved using partial least squares with pre-processing (standard normal variate, orthogonal signal correction and mean centring) applied, while for hyperspectral imaging neural networks provided the best model using a decay of 0.00004 and a node size of 2. The best predictive models for intramuscular fat using the near infrared and hyperspectral data achieved R^2 values from the validation data sets of 0.56 and 0.75 respectively. For near infrared this was achieved using partial least squares with pre-processing (normalisation, multiplicative scatter correction and mean centring) applied, while for hyperspectral imaging neural networks provided the best model using a decay of 0.0009 and a node size of 4. This performance of these two traits in particular, shows that that the prediction abilities are of a quality that future work on implementing these into an in-line system at a pilot scale should be considered.

Overall, the use of novel modelling techniques such as neural networks showed potential to increase the predictive abilities of the resulting models, over more traditional modelling techniques. Additionally, it was demonstrated that the number of predictors needed to create a calibration model could be reduced, increasing the speed of analysis with only minimal loss in the accuracy of the resulting model.

Results obtained during this study suggest that the calibration models are not abattoir dependent and the transfer of one calibration model to multiple abattoirs could decrease the costs and allow for faster development and implementation of an in-line, in-plant system.

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Figures, tables and equations