Predict and determine pork quality with near infrared spectroscopy

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Introduction

Drip loss percentage, colour of the meat (Minolta L*) and pH ultimate (pHu) are important pork quality characteristics and correlate with the sensory appreciation of pork by consumers.[1,2] Drip loss percentage is the exudation of intra- and extra-cellular fluid from the meat. Drip loss percentage, Minolta L* and pHu also affect the amount of saleable meat and processing yields of further processed products.[3] Methods used to estimate pork quality are time-consuming and often cumbersome.[4] Literature shows that the non-invasive method near infrared (NIR) spectroscopy is a useful method to measure pork meat quality, however, a representative sampling method is very important.[5-10] Previous reports have shown promising results for the prediction of drip loss percentage using NIR spectroscopy, with correlations (R^2) ranging from 0.55 to 0.56.[10,11] These authors concluded that improved and dedicated methods are needed before NIR spectroscopy can be introduced on process lines.

The objective of this study was to compare NIR spectroscopic prediction of pork quality (pHu, drip loss percentage and Minolta L*) from intact pork loin samples measured under both laboratory and pork processing plant conditions. The hypothesis was that NIR spectroscopic prediction equations can be used to predict pork quality measured at pork processing plants.

Materials and Methods

The laboratory dataset contained 131 *Longissimus dorsi* samples which were randomly collected from a commercial Dutch pork production plant, during two processing days. Samples were taken 24 h post-mortem from the *Longissimus dorsi* at the shoulder side. A rectangular sample of 6 × 5 cm and approximately 2 cm thick was taken to allow the samples to fit into the ¼-rectangular samples cup. The reference parameters, i.e. colour of the meat (Minolta L*, Chroma Meter CR-400, Konica Minolta Sensing, Europe b.v., United Kindom.) and pHu (MPI pH-Meter, Meat Probes, Inc, Topeka, Kansas USA) were measured in duplicate. Laboratory NIR spectra (4000 to 2500 cm^{-1} and 35 scans) were recorded using a FOSS 6500 (Foss NIRSystems, Silver Springs, MD, USA). The samples were kept at room temperature (20°C) for approximately 20 mins before placing in the ¼-rectangular cups to avoid condensation at the quartz glass surface.

The processing plants dataset contained the results from a total of 685 *Longissimus dorsi* samples which were collected from randomly chosen pigs at four Dutch pork processing plants (A, B, C, and D) during one processing day at each plant. The number of samples varied from 158 to 192 per production plant. A slice of approximately 2 cm thick was taken from the middle of the *Longissimus dorsi* at the shoulder side. A NIR spectrum was recorded from the fresh cut surface directly after the slice was sampled in the cold room (~ 4°C) of the production plants. Spectra were measured with a Bruker Matrix-FE (Bruker Optics GmbH, Ettlingen, Germany) using a contact free probe (Q-412 Bruker Optics GmbH, Ettlingen, Germany) with an integrated light source. Reflectance was measured from 4000 to 12 000 cm^{-1} and 32 scans were averaged per sample. The chosen wavelength resolution was 16 cm^{-1}. Settings were chosen to be close to the maximum scanning time for practical application; the total scan time was 10 seconds per sample.

In both studies after NIR spectral measurements samples were used to determine drip loss percentage (4°C and 48 h in consumer retail trays). Drip loss percentage was expressed as weight loss percentage during 48 h. Drip loss percentage, Minolta L* and pHu were used as the reference parameters for the NIR spectral data. Chemometric data treatments were performed with OPUS 6.5 software (Bruker Optics GmbH, Ettlingen, Germany) for both studies. Modified partial least squares regressions were used. Test set validation was performed whereby 30% of the samples were selectively chosen by the software for the test set in the laboratory study and 50% of the samples for the processing plant study, before a calibration was performed. Prediction equations were evaluated by means of R^2 and the root mean square error of prediction (RMSEP). A combination of the highest R^2 with the lowest RMSEP was regarded as the most suitable equation.

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Pretreatmens such as 1st or 2nd derivative with smoothing, vector normalisation, constant offset elimination and no spectral data pre-processing were evaluated.

Results and Discussion

In the laboratory study, data pretreatments were used for the development of prediction equations (Table 1). First derivative was used for drip loss percentage and Minolta L*, and second derivative was used for pHu. The used number of factors for the prediction equations varied between 4 and 8. The chemometric prediction equations showed root mean square error of prediction (RMSEP) values greater than root mean square error of estimation (RMSEE) values.

Table 1. Results for the best prediction equations calculated for drip loss percentage, Minolta L* and pH ultimate under laboratory conditions and using a split dataset of 92 samples for calibration and validation.

	Calibration				Validation			
Parameter	n	R^2*	RMSEE*	RPD*	n	R^2*	RMSEP*	RPD*
Minolta L*	92	0.76	2.1	2.0	39	0.74	2.3	2.0
pH ultimate	92	0.39	0.2	1.3	39	0.36	0.2	1.3
Drip loss %	90	0.80	0.6	2.2	38	0.73	0.8	1.9

*Correlation coefficient (R^2), root mean square error of estimation (RMSEE) and prediction (RMSEP) and residual prediction deviation (RPD).

Table 2. Results for the best prediction equations for drip loss percentage calculated from spectra recorded in cold room conditions at 4 pork processing plants and using split datasets for calibration and validation.

	Calibration				Validation			
Location	*n*	*R^2**	*RMSEE**	*RPD**	*n*	*R^2**	*RMSEP**	*RPD**
A	174	0.76	0.89	2.05	86	0.76	0.81	2.05
B	182	0.66	0.80	1.71	90	0.54	0.73	1.49
C	156	0.63	0.94	1.64	78	0.62	0.89	1.63
D	180	0.69	1.06	1.78	75	0.60	1.12	1.61
Combined	665	0.58	1.11	1.54	329	0.59	1.02	1.56

*Correlation coefficient (R^2), root mean square error of estimation (RMSEE) and prediction (RMSEP) and residual prediction deviation (RPD).

NIR spectroscopy could be used for screening of Minolta L* and drip loss percentage in laboratory conditions. The R^2 and residual prediction deviation (RPD) for pHu were less than 0.70 and 2.0 respectively, which indicates that the prediction equation was less reliable and unlikely to be used for sorting with NIR spectroscopy on commercially slaughtered pigs. In the processing plant study, the validation R^2 for drip loss percentage ranged from 0.54 to 0.76 between different production locations (Table 2). No data pretreatments were used for drip loss percentages. The chosen prediction equations for drip loss percentage showed a RMSEP of 0.73–1.12. The number of factors, which was needed to develop prediction equations, varied between 3 and 9. Comparable results were found in other studies.[6,7,12,13]

Conclusion

Prediction equations for drip loss percentage varied between different pork processing plants. The differences in R^2, RMSEP and RPD of these prediction equations might be explained by the difference in variation of the reference parameters per plant. The best prediction equation for drip loss percentage in the pork processing plant study was developed from plant A data. The developed prediction equation from plant A was comparable with the results from the prediction equation for drip loss percentage in the laboratory study. NIR spectroscopy measurements can be performed under cold room conditions at pork processing plants and are therefore applicable for practical applications to predict drip loss percentage.

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