PREDICTION OF TECHNOLOGICAL AND ORGANOLEPTIC PROPERTIES OF PORCINE MEAT BY NEAR INFRARED SPECTROSCOPY

Meulemans A.[1], Dotreppe O.[2], Leroy B.[1], Lecocq H.[3], Istasse L.[2] and Clinquart A.[1]
[1]University of Liège, Dept. Food Science (Technology), Faculty of Veterinary Medicine, Belgium.
[2]University of Liège, Nutrition Unit, Faculty of Veterinary Medicine, Belgium.
[3]University of Liège, Robotics and Automation Unit, Faculty of Applied Sciences, Belgium.

Background

The growing interest of consumers in meat quality and the need for the meat industry to satisfy this interest are sufficient justifications to use alternative methods such as the near infrared (NIR) spectroscopy. This faster and non-destructive technique seems to be the most promising amongst the potential techniques. It has been successfully demonstrated in a few applications for pork and beef such as the prediction of technological and organoleptic properties of beef cuts, the determination of fat content and fatty acid composition in beef meat, the tenderness classification of bovine meat (Dotreppe O. *et al*, 2000; Leroy B. *et al*, 2000; Lambotte S. *et al*, 2001); but also the evaluation of porcine fat, the determination of RN-phenotype in pigs, the prediction of water-holding capacity (WHC) and the composition of porcine meat (Irie M., 1999; Brondum J. *et al.*, 2000; Josell A. *et al.*, 2001).

Objectives

The aim of the present study was to evaluate the Fourier Transform NIR spectroscopy as a potential technique for prediction of technological (pH and WHC) and organoleptic (color and tenderness) properties of porcine meat.

Methods

Muscle *Longissimus thoracis* (7-8-9 ribs) was removed from 88 randomly selected pigs at 24 hours *post mortem*. In the laboratory, the samples were cut in two slices. The first one was used to measure the technological and organoleptic parameters by instrumental reference methods and the second was minced (day 1) before spectral acquisition (day 2).

The pH was measured on intact cuts by using an inserting combined pH electrode (Ingold) on a Knick 751 pH-meter. The Labscan II device (Hunterlab) was used to objectively measure CIE L* (brightness), a* and b* (color) parameters. The WHC was estimed by drip loss and cooking loss determinations. Drip loss was assessed as the percentage weight loss after 3 days storage in a plastic bag at 2°C; cooking loss was measured as the percentage weight loss after cooking in an open plastic bag in a waterbath during 60 min at 75°C. Warner-Bratzler peak shear force (WBPSF) was determined with a Lloyd LR5K universal testing machine perpendicular to the muscle fibre direction on ten 1.25 cm diameter cores obtained from heated cuts.

Samples were taken at 24 hours *post mortem* for NIR analysis with the Fourier Transform spectrometer Bomem MB 160D in the 4000 to 12000 cm^{-1} spectral range. The spectral acquisition was performed in reflection mode with the fiber-optic Axiom probe FDR-320. Three spectra were taken in each minced sample and the average spectrum was calculated and used in the data analysis.

The mathematical treatments were performed with the Grams/32 (Galactic) software. A Principal Component Analysis (PCA) was first used to detect outliers : the Mahalanobis distance (*H* statistic) was calculated from principal component analysis scores. A sample with H statistic of 3.0 standardised units from the mean spectrum was defined as a global H outlier and was then eliminated from the calibration set. The mathematical pretreatments such as multiplicative scalter correction (MSC), standard normal variate (SNV), normalisation (norm) or 1^{th} and 2^{th} derivatives were investigated and the best one was selected for each parameter on the basis of the lowest standard error of cross validation (SECV). The predictive models were calculated with the partial least squares (PLS) algorithm and the number of terms determined by cross-validation by using groups of five samples.

Results and discussion

The criteria of model quality expressed by the SECV and the Determination Coefficient of Cross-Validation (R^2cv) are shown in table 1.

The quality of prediction varied amongst parameters : the best models were observed for CIE L* and drip loss while no model was found for WBPSF and cooking loss. Predicted drip loss (%) versus measured drip loss (%) and predicted CIE L* (%) versus measured CIE L* (%) for combined PLSR-models are shown in figures 1 and 2. The high R^2cv which was calculated for the prediction of luminosity could be related to the reflection measurement, which is used in the reference measurement of the color parameters, as previously indicated by Leroy *et al.*(2000) whose reported a R^2cv of 0,82 for the prediction of luminosity in reflection mode on fresh bovine meat cuts.

The drip losses varied from 1.6% to 9.7% (mean=5.7) with a R^2 of 0.53. Pedersen and Engelsen (2001) reported similar findings from 66 samples with a correlation coefficient (*r*) of 0.77 (R^2=0.59) for drip losses ranging from 0.63% to 7.83% and Brondum *et al* (2000) reported a *r* of 0,64 (R^2=0,41) with a mean drip loss of 6.1% on 78 samples. The low SECV and the high variation observed in the present experience for drip loss illustrate the potentiality of thie NIR technique for WHC prediction, which is a parameter of high relevance for the pork industry. The quality of pH prediction was not sufficient. The low quality of the model could be partially explained by the relative narrow variability of the parameter, the lowest and highest values being respectively 5.2 and 5.8.

This study also confirmed poor potentialities of NIR for cooking loss and tenderness prediction as previously reported by Leroy *et al.* (2000) with models obtained on a higher number of samples in bovine meat. It can be precised that, in the present experiment, instrumental reference methods were applied on day one while NIR analysis was realised on day two on homogenized samples.

Conclusions

From this study, it can be concluded that NIR spectroscopy shows good potentiality for prediction of several color and water holding capacity parameters. The quality of the models could be improved by using a larger number of samples or, alternatively, by choosing samples with larger variability, or possibly by performing reference analysis and NIR analysis on the same day. Since the spectra were obtained on minced meat, these results have to be confirmed when applying the technique on intact meat in the laboratory or on the slaughterline.

Pertinent literature

Brondum J., Munk L., Henckel P., Karlsson A., Tornberg E., Engelsen S.B., 2000. Prediction of water-holding capacity and composition of porcine meat by comparative spectroscopy. *Meat Science*, **55**, 177-185.

Dotreppe O., Lambotte S., Leroy B., Clinquart A., Lecocq H. and Istasse L., 2000. The use of near infrared spectroscopy to determine fat content and fatty acid composition in beef meat. *Proceeding of the 46th International Congress of Meat Science and Technology*, Argentina, Vol. I: 376-377.

Irie M., 1999. Evaluation of Porcine Fat with Fiber-Optic Spectroscopy. *Journal of Animal Science*, **77**, 2680-2683.

Josell A., Borggaard C., Andersen J.R., 2001. Determination of RN phenotype in pigs early post-mortem using visual and near-infrared spectroscopy. *Proceeding of the 47th International Congress of Meat Science and Technology*, Krakow, Vol. I: 208-209.

Lambotte S., Leroy B., Dotreppe O., Lecocq H., Istasse L. and Clinquart A., 2001. Application of NIR spectroscopy for tenderness classification of bovine meat. *Proceeding of the 47th International Congress of Meat Science and Technology*, Krakow, Vol II: 306-307.

Leroy B., Lambotte S., Dotreppe O., Lecocq H., Istasse L. and Clinquart A, 2000. Prediction of technological and organoleptic properties of beef cuts by near infrared spectroscopy, *Proceeding of the 46th International Congress of Meat Science and Technology*, Argentina, Vol. II: 610-611.

Pedersen D.K. and Engelsen B., 2001, Early prediction of the quality of porcine meat by FT-IR spectroscopy. *Proceeding of the 47th International Congress of Meat Science and Technology*, Krakow, Vol. I: 204-205.

A cknowledements

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Table 1: Accuracy and precision of models from fresh meat in reflection mode – Mean; SD (Standard Deviation); SECV; R²cv.

Items	n	Min	Max	Mean	S.D.	Math.*	Optimal factors°	SECV	R²cv
pH	88	5.2	5.8	5.4	0.1	0,0,5 none	1	0.09	0.14
CIE L* (%)	80	47.8	66.4	55.1	4.9	0,0,5 norm	1	2.81	0.66
CIE a*	83	2.9	9.7	6.4	1.5	0,0,5 none	6	1.19	0.40
CIE b*	88	11.5	19.3	15.6	1.6	0,0,5 norm	5	1.30	0.38
Drip loss (%)	82	1.6	9.7	5.4	2.0	0,0,5 none	3	1.37	0.53
Cooking loss (%)		no model							
WBPSF (N)		no model							

*best mathematical treatment of the spectra : derivative, gap, smoothing segment, and pretreatment (MSC, SNV, norm or none); °number of PLS terms in the model.

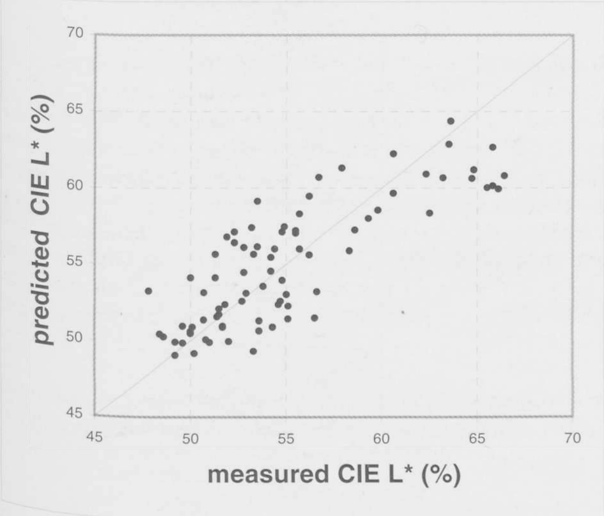

Fig 1: Predicted *vs* measured CIE L* parameter for a PLSR model of FT-NIR spectra of 80 pig meat cuts (R²cv=0.66; SECV=2.81).

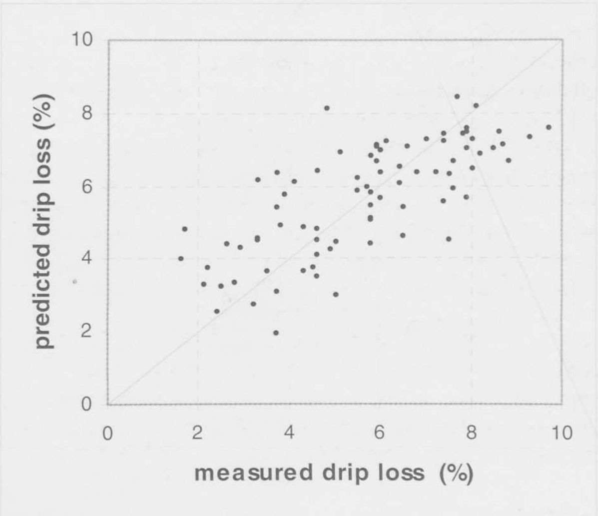

Fig 2: Predicted *vs* measured drip loss for a PLSR model of FT-NIR spectra of 82 pig meat cuts (R²cv=0.53; SECV=1.37).