Near infrared reflectance spectroscopy for the assessment of meat tenderness

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Introduction

Tenderness is frequently rated as one of the most important meat quality factors to the consumer and is, thus, of primary concern to the beef industry. The tenderness problem in many countries has initiated increased interest in developing efficient methods for tenderness assessment, i.e. non-destructive, rapid and sufficiently accurate methods.

Near infrared (NIR) spectroscopic methods are increasingly being used for predicting fat, water and proteins in meat and meat products. Also, other meat quality attributes have been assessed by NIR spectroscopy.[1] NIR has been shown to respond to changes in the state of water in foods and hydrogen bond interactions in foods.[2] As such changes most likely take place during tenderisation and ageing of beef, NIR might give information that relates to the tenderness of the muscles.

Methods and materials

Bovine *M. longissimus dorsi* (loin) samples from 40 carcasses were excised one hour after stunning, chilled at different temperatures and aged for 2, 7 and 14 days at 2–4°C. For NIR analysis, slices of 1.5 cm thickness were cut across the loins—either in the fresh or in the frozen/thawed state. Spectra were recorded in five replicates on each sample in a specially designed cuvette (InfraAlyzer 500, 1100–2500 nm) (Figure 1). Also NIR transmittance was performed in the range 850–1050 nm (Infratec Food and Feed Analyzer 1225).

Tenderness was assessed by sensory and Warner Bratzler shear press (WB) analysis on samples, which were heat-treated in water baths of 70°C for 50 min, cooled and frozen/thawed. Sensory analysis was performed at 20°C by 12 trained assessors (ISO 6564-1985).[3] For calibration and classification studies, principal component regression (PCR) on 90 samples were used, while Mahalanobis distances in PC subspaces (MDC) were also used for three-way classification.[4] The software used was UNSCRAMBLER and SAS.

Figure 1. Sample cup for recording NIR reflectance spectra of intact muscle meat.

Results

Fat contents in the loins ranged from 1 to 11%. The pH, 24 hours after slaughter, in the samples ranged between 5.41-5.73. Sensory tenderness ranged between 2.3–2.8 on a 9-point intensity scale, while WB shear force values were between 29–101 Newton cm^{-2}.

Sensory hardness and tenderness were predicted (PCR) with correlation coefficients in the

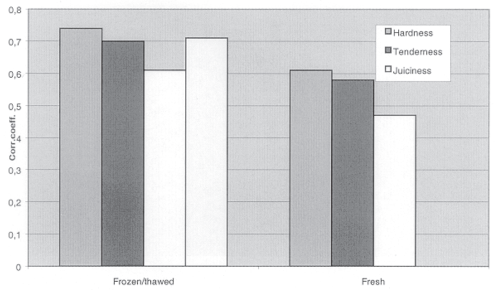

Figure 2. Multivariate correlation coefficients for the NIR prediction of sensory hardness, tenderness and juiciness and WB shear press for fresh and frozen/thawed samples (PCR, full cross-validation, 3–5 PC in models).

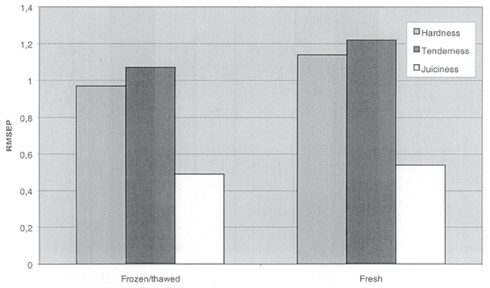

Figure 3. Prediction errors for the NIR prediction of sensory hardness, tenderness and juiciness and WB shear press for fresh and frozen/thawed samples (PCR, full cross-validation, 3–5 PC in models).

range 0.71–0.74 on the frozen/thawed samples (Figure 2). Predictions based on fresh (non-frozen) samples for NIR analysis yielded correlation coefficients about 0.1 lower than those above. The prediction error (*RMSEP*) for sensory tenderness was 1.0–1.2—in sensory intensity units (Figure 3). NIR predicted WB values with similar precision as sensory tenderness. No models were obtained from MSC spectra, which indicated that the predictive information in the NIR spectra was connected to scatter phenomena in the muscles. Increasing the sample area to be measured by NIR reflectance improved the prediction results somewhat (up to 20 recordings per sample). NIR transmittance analysis in the range yielded no prediction models.

Indirect and non-causal correlations between NIR measurements and tenderness might be suspected, i.e. because of high contents of fat and water in meat. However, tenderness values did not correlate well with content of fat, water or protein. Low correlations were observed between tenderness and animal age or sex, carcass weight, sex, drip loss or cooking loss ($r = -0.24$ to $+0.27$). This indicated that the correlations between NIR spectra and tenderness were not primarily based on indirect correlations with these parameters.

A beef manufacturer will usually be more interested in whether the beef is unacceptably tough, acceptable or very tender—than in the exact tenderness value of the meat. In assessment of beef tenderness, classification methods, therefore, seem more relevant than quantitative calibration methods. Classification results of beef tenderness from fresh or frozen/thawed samples were similar. As expected, there were considerable overlaps between neighbouring subgroups. However, for three-way MDC classifications, there were seldom overlaps between extreme groups of tough and tender beef. Average % correct classifications for three-way PCR models were 49–63%. For two-way PCR classifications the corresponding numbers for all samples were 78–81%–and for tender samples 83–87%.

There were significant limitations in the ability of NIR to predict tenderness. A requirement for a reasonably good prediction model was to have a wide range in tenderness in the sample model. The ability of NIR to predict tenderness in tender species like lamb and pork was found to be poor.

The relevance of sensory and WB shear press methods in assesssing tenderness, as perceived by consumers, has often been questioned. Sensory analysis is assumed to be the laboratory method, which is most relevant to consumer acceptance. There is a lack of data in the literature describing the relationship between these methods. A study was done to compare the gradings of 120 randomly chosen consumers at a supermarket with the sensory and WB shear press methods. *M. longissimus dorsi* samples (loins) from eight carcasses of tenderness range 37–101 kg $10^{-1}cm^{-2}$ were used.

Correlations between consumer ratings and the tenderness methods were found to be highly significant ($p < 0.005$). Sensory analysis showed the higher correlation with consumer ratings ($r = 0.96$), while the corresponding correlation WB shear force and consumer rating was a little lower ($r = -0.86$). This also indicates that NIR, as a predictor of consumer tenderness rating, should be relevant.

Acknowledgements

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References

1. K.I. Hildrum, M.R. Ellekjær and T. Isaksson, *Meat Focus International* **April 1995,** 156 (1995).
2. M. Iwamoto and S. Kawano, in *Making light work; Advances in Near Infrared Spectroscopy,* Ed by I Murray and I.A. Cowe. VCH, Weinheim, Germany, p. 367 (1992).
3. K.I. Hildrum, T. Isaksson, T. Næs, B.N.Nilsen, M. Rødbotten and P. Lea , *J. Near Infrared Spectrosc.* **3,** 81 (1995).
4. T. Næs and K.I. Hildrum, *Appl. Spectrosc.* **51,** 350 (1997).