PREDICTION OF MEAT TENDERNESS BY NEAR INFRARED SPECTROSCOPY

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SUMMARY

The use of near infrared (NIR) spectroscopy in the prediction of sensory hardness, tenderness and juiciness of bovine **M. Longissimus dorsi** muscles was studied. Principal component predictions (PCR) between NIR measurements on frozen and thawed samples and sensory variables of 120 samples (40 animals x 3 ageing times) yielded multivariate correlation coefficients of cross validation of 0.71, 0.67 and 0.59 for hardness, tenderness and juiciness, respectively. The corresponding correlation coefficients of NIR measurements of fresh (non-frozen) samples were approximately 0.1 lower for all sensory variables.

When separate regressions were made between NIR measurements and sensory values for samples with different ageing times, much lower correlations were obtained for the day 2 samples than for those aged for 7 and 14 days. By making separate calibration models for conditioned (15 °C; 26 h) and electrically stimulated/rapidly chilled samples, the former yielded multivariate correlation coefficients of 0.76, 0.67 and 0.66 for sensory hardness, tenderness and juiciness, respectively. The corresponding correlation coefficients for the electrically stimulated sample model were lower. Predicting shear press values from NIR measurements on the 120 frozen and thawed samples gave a correlation coefficient on the same level as for the corresponding correlation of sensory hardness with NIR measurements.

Introduction

There are numerous reports on methods for measurement of meat tenderness (Lepetit and Culioli, 1994). However, most methods are destructive and time consuming or they use predictors which are not highly correlated to the actual tenderness. There is therefore a considerable need to find efficient non-destructive methods for assessing meat tenderness.

Near infrared spectroscopy has so far mainly been used in the analysis of chemical composition of foods (Osborne and Fearn, 1986). In the last years applications of NIR for prediction of functional properties and quality variables in foods have emerged. The ability of NIR to reveal changes in the state of water and hydrogen bond interactions in foods has been observed (Iwamoto and Kawano, 1992). Since such changes evidently occur during tenderization and ageing of meat, we have studied changes in NIR absorbtions of beef during ageing. Furthermore, we have made a feasibility study in using NIR in predicting sensory variables of beef during the same process.

Materials and methods

M. longissimus dorsi muscles from 40 animals of the Norwegian Red Cattle breed, 7 cows and 33 young bulls, were used to span a wide sample space. The carcass weights ranged from 244 to 417 kg.

Ten of the animals were subjected to low voltage electrical stimulation (80 V, 14 Hz, 32 sec, approx. 10 min post mortem), and the loin muscles were removed 45 min after stunning. These muscles were subjected to chilling at 4 °C for 26 hours after slaughtering. The loins from the remaining 30 animals, which were not subjected to electrical stimulation, were also excised after 45 min, and then conditioned at 15 °C for 26 hours to avoid cold shortening. After 26 hours samples for NIR, sensory and texture (WB shear press) analyses were taken from all muscles, both electrically stimulated and conditioned. The remaining parts of the loins were aged at 4 °C, and samples for repeated analyses were removed after 7 and 14 days of ageing.

NIR reflectance (InfraAlyzer 500, Bran & Luebbe Gmbh, Norderstedt, Germany) was measured both on fresh samples and on samples that had been frozen and thawed. Samples for sensory and texture analysis were heat treated at 70 °C for 50 min (60 samples) or 75 min (60 samples) and kept frozen at -40 ° C until the time of analysis. After thawing all analyses were performed at 20 °C. The sensory profiling was performed by a 12 member trained panel assessing hardness (first bite), tenderness (chewing process) and juiciness of all samples.

The data analysis was performed in the software package UNSCRAMBLER (Version 5.5, Camo AS, Trondheim, Norway). The linear principal component regression (PCR) modelling method was used in predicting sensory and textural properties from NIR spectra. Full cross validation was used to validate the regressions models. The predictive accuracy of the regression models was given by RMSEP (root mean square error of prediction) (Martens and Næs, 1989).

Muscle and air temperatures were monitored continuously during ageing, and pH in the muscles was recorded at intervals. The contents of water, fat, protein and collagen of the samples were analyzed by NIR transmittance analysis and standard methods. Further details about the experimental conditions and analytical methods are given in Hildrum *et al*, 1994.

Results and discussion

The pH after 24 hours in the loins ranged from 5.41 to 5.73 and the fat contents from 1-12 %, as analyzed on slices taken across the muscles. The drip losses after 14 days of ageing were in the range 0.1-0.7 %.

As expected the average sensory hardness values decreased steadily during ageing, while the average sensory tenderness values increased (Fig.1). Sensory juiciness did not change markedly during ageing. WB shear press values showed a decrease parallell to the changes in hardness and tenderness, in average from 67.5 Nn (Newton) at 2 days to 49.3 Nn at 14 days after slaughtering. The univariate correlation coefficient between hardness and shear press values of all 120 samples was 0.84. There were wide variations in sensory hardness and tenderness values between the 40 carcasses, as well as in shear press values. These variations decreased during ageing of the muscles, but still remained large after 14 days of ageing.

Predicting sensory variables from NIR analysis of 120 frozen and thawed samples yielded multivariate correlation coefficients of 0.71, 0.67 and 0.59 for hardness, tenderness and juiciness, respectively (Fig.2). Optimum predictions were obtained with 4 principal components in the model. The expected errors in future predicted values (RMSEP), were 1.00, 1.08 and 0.54 in sensory units, for hardness, tenderness and juiciness, respectively. The corresponding correlations using NIR on fresh samples were lower for all sensory variables (Fig.2).

Performing separate regressions between NIR measurements (frozen/ thawed samples) and sensory hardness and tenderness for samples aged for 2, 7 and 14 days, resulted in much lower correlations for the day 2 samples than for the other days (Fig.3). The corresponding correlation for juiciness improved with the time of ageing.

By making separate calibration models for conditioned (15 °C; 26 h) and electrically stimulated/rapidly chilled samples, the former yielded multivariate correlation coefficients of 0.76, 0.67 and 0.66 for sensory hardness, tenderness and juiciness, respectively (Fig.4). A comparison with with Fig.2 shows clear improvements in correlation coefficients compared to the all sample model. The corresponding correlation coefficients for the electrically stimulated sample model were lower. One reason is probably a larger variation in sensory properties in the electrically stimulated and cooled samples than in the conditioned samples. The separate models for conditioned and electriacally stimulated/chilled samples indicate that early post mortem treatments have important influences on the results of the calibration models.

Predicting shear press values from NIR of 120 frozen and thawed samples gave a similar correlation coefficient (r=0.71) to those predicting sensory hardness (RMSEP=10.8 Nn). The optimum model required 5 principal components.

The predictive information in the NIR spectra does not seem to be connected to specific chemical moieties in the samples, but rather to scatter phenomena occurring during ageing of meat. Specificly multiplicative scatter seems to play an important role in this picture.

It is presently not clear whether the information in the NIR spectra that relates to tenderness is sufficient, both qualitatively and quantitatively, for a practical, meat tenderness prediction method. To reach a conclusion at this point, a larger number of samples from different animals, breeds and treatments must be included in the studies. Furthermore, the chemical and physical basis for these relationships needs to be clearified.

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Captions to figures

Fig.1 Average sensory values of **M.Longissimus dorsi** muscles during ageing (40 animals).

Fig.2 PCR predictions of sensory variables from NIR analysis of the muscles.

Fig.3 Separate regressions between NIR measurements (frozen/thawed samples) and sensory variables of samples aged for 2, 7 and 14 days.

Fig.4 Separate regressions between NIR measurements (frozen/thawed samples) and sensory variables that had been either conditioned or electrically stimulated and chilled.