THE USE OF NEAR INFRARED REFLECTANCE SPECTROSCOPY (NIRS) TO PREDICT BOVINE MARONESA BREED MEAT TENDERNESS

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Introduction

NIRS has the potential to predict different attributes of meat quality quickly and accurately. It allows rapid and frequent measurements, the sample preparation is fast and simple, is suitable for on-line use and for simultaneous determinations of different attributes (Prevolnik *et al.*, 2004).

Since tenderness is the single most important quality parameter of consumer importance (Rødbtten *et al.*, 2000, Leroy *et al.*, 2003), in the context of the application of NIRS to predict the quality of fresh meat, most attention has been focused on the prediction of this parameter (Geensink *et al*, 2003). Tenderness can be assessed as a measurement of meat mechanical resistance (Warner-Bratzler Shear Force, WBSF) which is a destructive and time-consuming method (Rødbtten *et al.*, 2000).

The aim of this study was to examine the accuracy of visible/NIR spectroscopy for the prediction beef quality characteristics such as pH post-mortem, WBSF and sarcomere length using the *longissimus thoracis* et *lumborum* muscle of young Maronesa bulls.

Materials and Methods

Young Maronesa bulls (n=30) aged between 9 and 11 months and with live weights ranging from 90 to 150 kg were slaughtered and selected according to the ultimate pH (pH measured at 24 h post-mortem) in the muscle *longissimus thoracis* et *lumborum*, to obtain an high range of pH values. This muscle was excised 24 hours post-mortem between the 8th rib and 2nd lumbar vertebra and divided into four parts. The first one was used for the laboratory procedures performed during the first day *post mortem* and the three remaining pieces were vacuum packed and aged at 4ºC for 3, 7 and 14 days. At the end of each period, one slice (2.5 cm thick) was vacuum packaged and stored (–80ºC) for NIRS analysis. Other slices for WBSF and other one for sarcomere length (SL) measurements were taken.

pH was measured directly in the muscle at 3 hours (pH_3) and 24 hours (pH_{24}) post-mortem. SL analyses were performed at day 7 *post mortem*; 4 g of meat was minced and homogenised at low speed (8000 rpm) in a chilled 0.25 M sucrose solution using an Ultra Turrax T25 mixer (Cross *et al.*, 1980-81). The length of 10 consecutive sarcomeres was measured (15 groups of 10 sarcomeres for each sample) using a phase microscope (40x objective). WBSF was measured (meat cooked at 70ºC at the core) on 10 sub-samples of 1 cm^2 cross-section with fibres perpendicular to the direction of the blade attached to a Stevens QTS 25 texturometer (Silva *et al.*, 1999).

Prior to NIRS measurements, meat samples were thawed in a fridge for 24 hours, stored in a plastic bag and left at least one hour at ambient temperature. Each sample was trimmed to eliminate connective tissue, two pieces of intact meat of 35 mm diameter were cut parallel to the longitudinal orientation of the muscle fibres (Cozzolino and Murray, 2004) and put inside 35 mm diameter quartz cuvettes with aluminium foil backing and scanned in order to obtain a mean spectrum per sample.

Diffuse reflectance spectra were collected at 2 nm intervals from 400 to 2498 nm using a NIRSystems 6500 scanning spectrophotometer (FOSS NIRSystems, Silver Spring, MD, USA).

Calibration development and validation were performed using WinISI II version 1.02 (Infrasoft International, Port Matilda, PA, USA). Spectral data pre-treatments such as standard normal variate and detrending (SNV-D), multiplicative scatter correction (MSC) and first or second order derivatives were applied. Partial least squares regression (PLSR) with mathematical treatment (2, 12, 2, 2) was used. The accuracy of prediction is given by the standard error of cross validation (SE_{CV}).

Results and Discussion

Measurements of the parameters (Table 1) showed a wide range of variability as a consequence of the aging of meat and the different ultimate pH values of the samples. With regard to the mean pH values, as a consequence of the acidification during post-mortem aging process pH_{24} was slightly lower than pH_3.

Table 1: Range, mean, standard deviation (SD) and coefficient of variation (CV) of beef parameters.

Parameter	n	Mean	Range	SD	CV(%)
pH_3	26	6.64	6.17 – 6.95	0.203	3.06
pH_{24}	27	6.03	5.59 – 6.67	0.330	5.47
SL (μm)	99	1.710	1.51 – 1.84	0.083	4.85
WBSF (kg/cm)	112	10.44	3.85 – 19.88	3.889	37.26

n: number of samples

WBSF showed a mean value of 10.44 kg/cm^2 with a coefficient of variation equal to 37.26%. This variation is due mainly to aging and ultimate pH but the effect of sarcomere length may not be excluded.

Table 2: Prediction of beef parameters by near infrared reflectance spectroscopy.

Parameter	n	SEC	R^2	SE_{CV}	1-VR	RPD
pH_3	26	0.183	0.186	0.210	-0.054	0.97
pH_{24}	27	0.059	0.968	0.104	0.906	3.17
SL (μm)	107	1.87	0.608	2.05	0.532	0.04
WBSF (kg/cm)	112	2.30	0.650	2.67	0.532	1.46

n: number of samples, SEC: standard error of calibration; R^2: coefficient of determination for calibration; SE_{CV}: standard error of cross validation; 1-VR: coefficient of determination for validation; RPD; ratio performance deviation calculated as SD/SE_{CV}.

Currently, limited published information about the ability of NIRS to predict meat quality parameters is available. However, in the present study, absorbance data of meat samples aged during 24 hours showed good correlations with pH_{24} parameter. Therefore, this parameter could be accurately predict by NIRS (Table 2, R^2=0.97 and RPD=3.17). The good repeatability of the reference method in the present study could have contributed partially to the successful predictions of pH_{24} obtained by NIRS (SEL_{pH24}=0.102).
The prediction results for WBSF (R^2=0.650, RPD=1.46) shouldn't be ignored. These statistics are in agreement with that described by Rødbotten *et al.* (2000) showing R^2 values of 0.68.

Conclusions

It must be pointed out that although the beef samples studied in this work arose from a small number animals and samples, some conclusions can be drawn.
The results suggest that VIS/NIRS instruments may predict pH_{24} and have potential to provide information about WBSF.

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