Quantitation of lamb content in mixtures with raw minced beef using visible, near and mid infrared spectroscopy

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Introduction

Partial substitution of a high value meat with one of lower value or quality is an adulteration and may be an economic fraud. While speciation is obvious when meat is examined in large pieces, after mincing it becomes difficult without time-consuming analytical procedures. Visible and infrared spectroscopic procedures are rapid and non-destructive and both have shown promise in feasibility studies for meat speciation.[1,2] The objective in this study was to investigate the use of combined spectral regions for the quantification of mixtures of lamb and beef.

Materials and methods

Beef (n = 32; *m. semimembranosus*) and lamb (n = 33; *m. longissimus dorsi*) samples were purchased from local retail outlets over a period of ten weeks in 1997. Single species samples were minced using a model R301 ultra (Robot Coupe SA, Vincennes, France) for 15 s each. Mixed meat samples (33 of each) of 5% lamb : 95% beef, 10% lamb : 90% beef and 20% lamb : 80% beef (w/w) were produced by weighing samples of cubed beef and lamb, placing both in the blender and mincing for 20 s. Minced samples were placed in covered plastic containers and stored at 4°C. Combined visible and near infrared (NIR) spectra were collected, in reflectance mode, using an NIRSystems model 6500 instrument (NIRSystems Inc., Silver Spring, MD, USA) over the wavelength range 400–2500 nm at 2 nm intervals. Mid infrared (MIR) spectra were recorded over the range 800–2000 cm^{-1} (12,500–5000 nm; resolution 8cm^{-1}) on an Infinity Series Fourier-transform spectrophotometer (ATI Mattson, WI 53717, USA) using an attenuated total reflectance (ATR) sample accessory. Data analysis (PLS–1) was by The Unscrambler software (V.6.1; CAMO A/S, Trondheim, Norway) using raw and derivatised spectral data. In the case of merged spectral data sets involving MIR spectra, reflectance values were normalised to unit variance.

Results and discussion

NIR and mid-IR spectra for the collection of meat samples (beef, lamb and lamb-in-beef mixtures) are shown in Figures 1 and 2, respectively. The main compositional differences between beef and lamb relate to fat content (~ 2% w/w for lean beef and ~ 4% w/w for lean mutton)[3] and composition, especially with regard to C14:0, C16:0, C18:0 and C18:1 lipids. Myoglobin is the basic pigment in fresh meat and varies in content with species. Protein, fat and water are detected by NIR principally at the

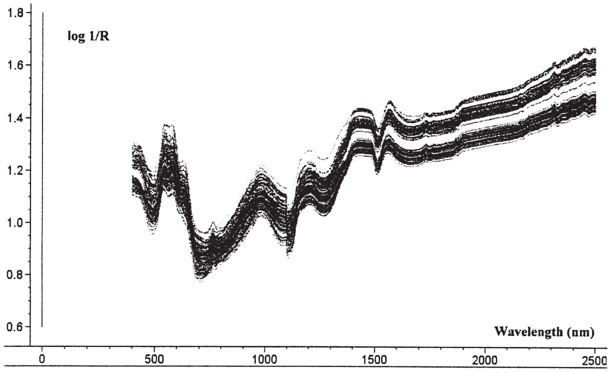

Figure 1. Visible-NIR spectra of beef, lamb and beef + lamb mixtures in reflectance mode.

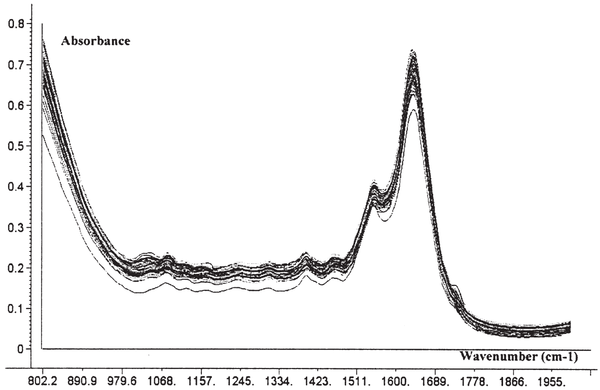

Figure 2. Fingerprint mid IR ATR spectra of beef, lamb and beef + lamb mixtures.

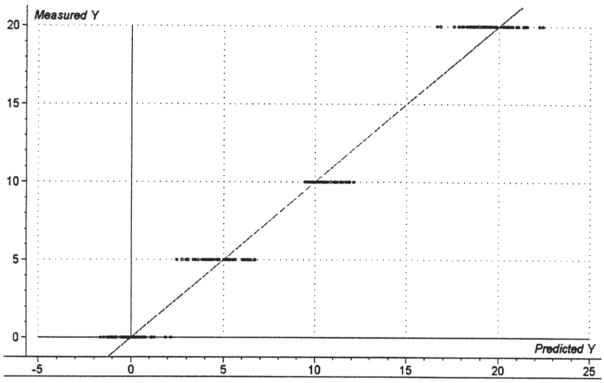

Figure 3. Prediction of lamb content by visible-NIR-mid-IR spectra (*SEP* = 1.05; 0–20% lamb-in-beef; 2nd derivative pre-treatment).

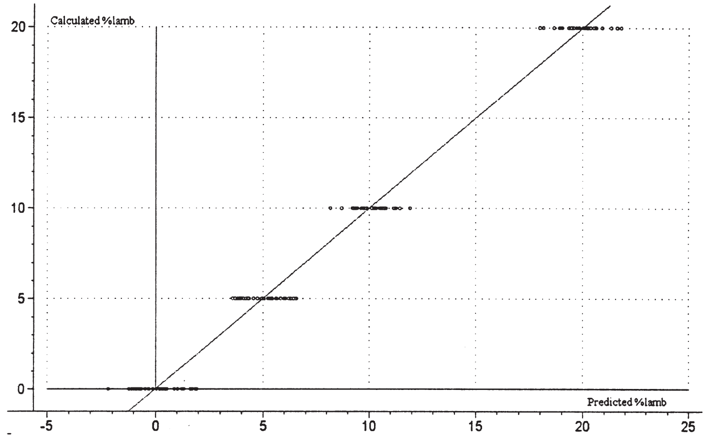

Figure 4. Prediction of lamb content by combined NIR + mid-IR (*SEP* = 0.91%; 0–20% lamb-in-beef; 2nd derivative pre-treatment.

bands for: water (964, 1440 and 1960 nm), protein (908, 1018, 1510, 1980, 2050 and 2180 nm) and fat (928, 1037, 2310 nm). In the mid infrared, bands at 1650 cm^{-1} (water), 1740 cm^{-1} (fat) and protein (1650 and 1550 cm^{-1}) have been reported.[2]

The most accurate predictive models were generated by combined wavelength ranges (Figures 3 and 4). Lamb content was predicted with a standard error of prediction equal to 4.1% (0–100% range) using visible-NIR-mid-IR data and 0.91% (0–20% range) using NIR-mid-IR spectra. Combined

Table 1. Best prediction of % lamb in lamb : beef mixtures in a variety of wavelength ranges.

	Prediction statistics for % lamb						
	Data treatment	Complete sample selection			Collection without 100% lamb samples		
		n	*SEP*	*R*	*n*	*SEP*	*R*
400–2498 nm	1st derivative	6	9.4	0.97	17	1.4	0.98
400 –750 nm	1st derivative	5	11.4	0.95	18	2.4	0.94
1100–2498 nm	1st derivative	9	8.1	0.98	14	1.1	0.99
800–2000 cm^{-1}	2nd derivative	11	9.8	0.97	12	1.9	0.97
400–2498 nm + 800–2000 cm^{-1}	2nd derivative	7	4.1	0.99	7	1.05	0.99
400–750 nm + 800–2000 cm^{-1}	2nd derivative	5	7.9	0.98	4	3.3	0.90
1100–2498 nm + 800–2000 cm^{-1}	2nd derivative	7	5.5	0.99	8	0.91	0.99

n: number of PLS loadings; *SEP*: standard error of prediction using full cross-validation; *R:* correlation coefficient wavelength models involved fewer PLS loadings than the other spectral ranges, suggesting better stability and ease of transferability.

Conclusions

This non-destructive and rapid analytical approach may have the required accuracy and ease-of-use for application by manufacturers and regulatory authorities.

Acknowledgements

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