The potential of hyperspectral imaging for the measurement of meat quality

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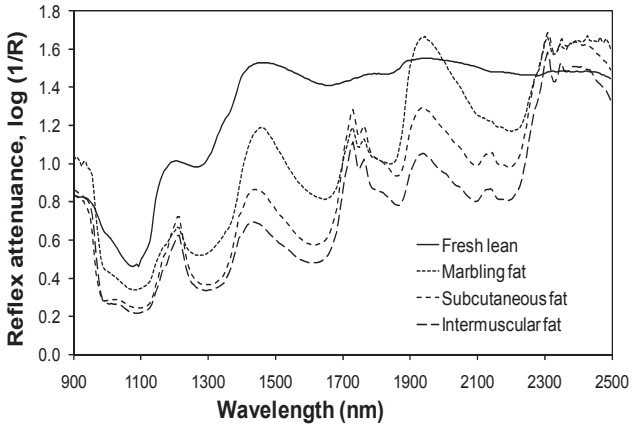
Introduction The application of near infrared spectroscopy to predict meat tenderness has been recently reviewed by Prieto *et al.*, 2009. To obtain representative sampling, NIR equipment suitable for measurement of relatively large areas of the muscle is required. Marbling fat within the muscle is not equally distributed and thus sampling different areas of the muscle can result in different spectra depending on the amount of marbling fat in the sampled area. Hyperspectral imaging instead provides the potential to identify and measure spectra for specific regions of interest. Applications to several food quality applications are reviewed by Gowen *et al.*, 2007. For beef, NIR hyperspectral imaging has the potential to identify independent spectra relating to subcutaneous fat, marbling fat and lean. The aim of this study was to identify and characterise the spectra from different regions in the beef foreib joint and within the longissimus dorsi (LD) muscle between marbling fat and areas of lean devoid of visible marbling.

Materials and methods A random selection of 150 foreribs were obtained 2 days post slaughter from a commercial abattoir and transported to the laboratory. A slice approximately 25 mm thick was removed from the caudal surface of the forerib and an image of the exposed surface taken within 2 minutes of cutting. Images were taken using an instrument described by Millar *et al.*, 2008, incorporating a SWIR spectral camera (Specim, Oulu, Finland) with a cooled 14 bit HgCdTe detector and N25E spectrograph. The system was configured to image a 200mm line spanning the full width of the joint with a spatial resolution of 320 pixels, and 256 spectral bands with a wavelength range of 900-2500nm. The sample was moved on a motorised stage and scans were taken at a rate of 50 lines/s to acquire an image of the whole cut surface in a total scan time of 9s. After scanning the freshly cut surface, the meat was allowed to bloom at 4^{o}C for at least 1 hour and scanned again.
Further scans were made to assess the contribution of several factors. The effect of blooming was assessed by scanning selected samples at a larger number of time intervals up to 1 hour. To assess the depth of the sample surface contributing to the measurements, scans were made for thinly sliced samples of lean beef and subcutaneaous adipose tissue presented against white and black backgrounds. Scans were also undertaken samples containing clearly identifiable regions of connective tissue to characterise the corresponding connective tissue spectra.

Results Figure 1 shows examples of reflection spectra for several tissues. The mean spectrum is shown for a freshly cut lean region of the longissimus dorsi. Further measurements of the same sample at times of up to 1 hour (not shown) showed no strong changes in the NIR spectrum as the sample bloomed, despite clear visible changes in colour. This may be due to the measured spectral range being outside the visible region, however, Moss *et al* (2010) noted changes due to blooming in the NIR region. Spectra are also shown for examples of subcutaneous, intermuscular and marbling fat for a single freshly cut sample. All types of fat are clearly distinguishable from lean tissue facilitating automated classification of the lean and fat regions of each image and determination of representative spectra for each component. In samples where the area of marbling fat was small, the spectra obtained in these regions were intermediate between those of lean and fat. This was partly due to the resolution of 0.6mm used, such that pixels in regions of thin marbling may contain both lean and fat, and also due to the penetration depth of the NIR radiation. As can be seen from Figure 1, the absorbance was greater at longer wavelengths. Tests for samples of known thickness showed measurable penetration to a depth of about 10mm at 1100nm, but minimal penetration beyond 2-3mm for wavelengths greater than about 1500nm.

Figure 1 Reflection spectra for lean and fat tissue



Conclusion The results show that hyperspectral NIR imaging has the potential to discriminate between lean and fat tissue. Further work is required to identify how the ability to discriminate between tissues (eg marbling fat & lean) can be developed for prediction models for meat quality.

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