Predicting meat quality:
the application of NIR spectroscopy

by N. Prieto, D. R. Ross and R. Roehe

Over the past three decades, Near Infrared Reflectance (NIR) spectroscopy has been shown to be one of the most efficient and accurate tools for predicting various meat quality criteria. NIR spectroscopy is a suitable alternative to other analytical procedures since it is a rapid and non-destructive method, entailing minimal sample preparation. The technique does not require reagents nor does it produce waste and it can be easily integrated into the production process.

Meat demand and consumption is generally high in most developed countries. As a very heterogeneous product, chemical composition and sensory attributes are strongly influenced by pre-slaughter factors (individual breed, sex, age, weight and environment) and post-mortem factors (maturation time, temperature conditions). Variability in the quality of meat available has shown to be a concern in consumer preference studies. Indeed, it has been noted that in most developed countries where the purchasing power of the population does not limit the consumption of meat, some consumers are willing to pay a price premium a more dependable product along with certain additional quality characteristics, such as tenderness.

Nowadays, meat is increasingly consumed as part ready-to-eat, convenience products such as hamburgers and sausages. In the processed meat sector, premium quality material can be adulterated by the inclusion of inferior grades, which carries with it a number of legal sanctions. Consequently, consumers need assurance that they have received the precise quality of meat they have paid for.

In order to keep quality standards high, meat products must be subject to control procedures. Different techniques including chemical procedures, instrument testing, sensory analysis and screening have been used to provide reliable information. However, these

techniques are destructive, time-consuming and consequently unsuitable for on-line applications. In contrast to conventional methods employed to determine meat quality, near infrared reflectance spectroscopy is a sensitive, fast and non-destructive analytical technique, entailing minimal sample preparation. NIR facilitates the simultaneous assessment of numerous meat characteristics.

NIR spectroscopy utilises the spectral range, 750 to 2,500 nm [Figure 1]. The process [Figure 2] involves measuring the response of the molecular bonds O-H, C-H and N-H, when subjected to vibrational energy changes during irradiation by NIR frequencies. These hydrogen bonds have unique and characteristic absorption frequencies relatively free of bias from internal and external sources; hence it is possible to build a characteristic spectrum that behaves as a fingerprint for a particular sample. In a scanned sample, the NIR composite spectrum data provides information about chemical constituents as well as tissue ultra-structure.

The applications of NIR

NIR spectroscopy has been successfully applied to the quantitative determination of the major constituents (moisture, fat and protein) of meat and meat products [1]. In fact, the near infrared procedure has been approved by the international commitee for validating analytical procedures (AOAC) [2] as applied to the commercial analysis of moisture, fat and protein in meat and meat products. In addition, discrimination between frozen and unfrozen beef [3], beef and kangaroo meat [4], as well as adult steers and young cattle ground meat samples [5] is possible using NIR.

However, studies established in order to exploit NIR's ability to predict technological (instrumental texture and water holding capacity) and sensory (tenderness, juiciness and flavour) parameters in meat and meat products show less reliable results [6,7]. The association between NIR measurements and technological and sensory attributes emerges from either the chemical (e.g. water, lipid and protein content) or physical or structural (e.g. muscle fibre characteristics) properties of the meat. It should be noted that NIR spectroscopy is a secondary method, so that its true precision depends on the reference method used for calibration. E.g. instrumental texture or the subjectivity of the assessors when scoring the sensory attributes (in albeit scientifically-constructed consumer taste panels). Therefore, the reference method must be chosen carefully according to the particular needs of each study. As a secondary procedure, NIR requires calibration by reference to a primary method which uses a calibration set of typical specimens representative of all future samples. This means that all the variables one is likely to encounter in future samples must be represented in the calibration set. Otherwise, NIR spectroscopy findings will not be wholly accurate.

NIR spectroscopy allows the simultaneous assessment of numerous meat properties.

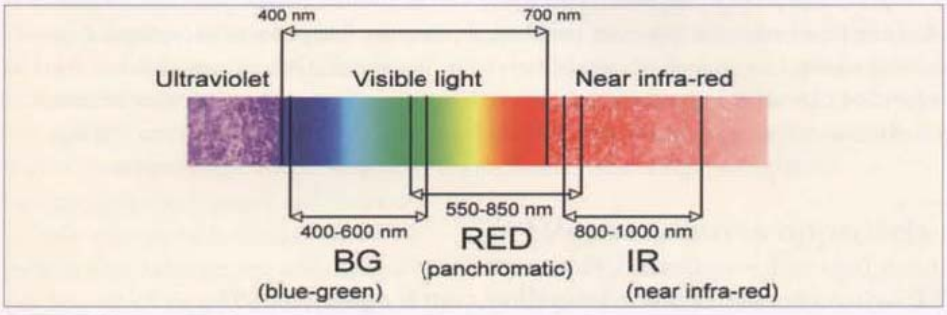

Figure 1. Electromagnetic spectrum.

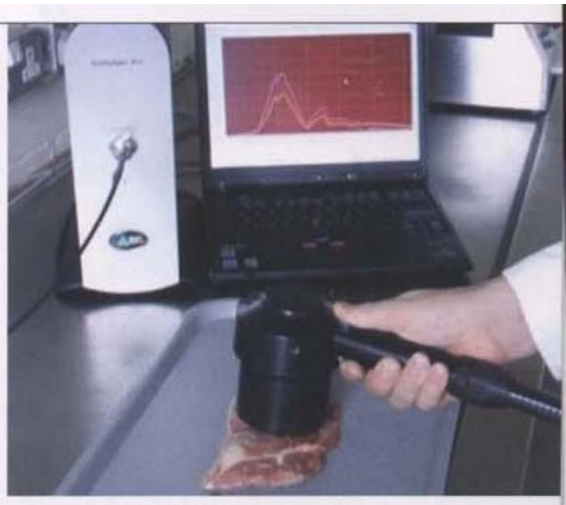

Figure 2. NIR spectra collection on meat.

Improving workability

Although the individual analytical cost of using NIR is low, the price of a suitable NIR instrument is over £30,000. This means that the technique may not be viewed as attractive to food processors and producers. In addition, the technique needs to be tested and calibrated in research trials. Recently, meat researchers and analysts have been trying to identify wavelengths at which NIR measurements are closely associated with various characteristics of meat quality. By isolating the critical wavelengths, it should be possible to obtain more robust calibrations, and so develop simple and low-cost instruments employing only these specific wavelengths. Furthermore, the use of fibre-optic probes may significantly improve the ability of NIR to monitor and control meat processing via remote on-line detection. For example, Brøndum *et al.* [8] and Hoving-Bolink *et al.* [9] used a fibre-optic probe on intact carcasses to estimate meat quality attributes. Despite the challenging operational environment at abattoirs and slaughterhouses with, for example, fluctuations in temperature and humidity, fibre-optic probes significantly improved the ability of NIR to monitor and control these processes. This demonstrates that NIR is a suitable technique to simultaneously predict

various meat quality criteria, on-line, at processing speeds, taking place in a commercial environment.

In conclusion, it is anticipated that NIR spectroscopy will become more widely accepted in many meat industry applications as more attention is given to reducing errors in reference methods, more robust calibrations are developed by using larger sample data sets (with wide ranges and variation in the reference values) and the transfer of calibration models is enabled for commercial applications.

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The authors

Dr. Prieto, Researcher,
D. Ross, Research Engineer,
Prof. Roehe, Principal Researcher,
Sustainable Livestock Systems Group
Scottish Agricultural College Research Division, West Mains Road,
Edinburgh EH9 3JG, UK.
Email: etcnpb00@estudiantes.unileon.es

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