Near infrared reflectance spectroscopy: an alternative technology to predict meat quality

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Meat demand and consumption is generally high in most developed countries and is on the rise in emerging nations. Greater control over meat quality and its assessment is now being sought to enable quality control and product diversification. Indeed, in most developed countries where the purchasing power of the population does not limit the consumption of meat, consumers are becoming more willing to pay a price premium for more consistent products along with added quality characteristics, for example, healthier fatty acid profiles. The chemical composition and quality attributes of meat are, however, strongly influenced by pre- (breed, sex, age, diet, weight and environment) and post-harvest factors (cooling rates, aging time, packaging and cooking). Consequently, in order to ensure product consistency, meat products have to be subject to quality control measures. Different techniques including chemical analysis, instrument testing, sensory analysis and screening have been used for quality control purposes. However, these conventional techniques are destructive, time-consuming and as a result are unsuitable for on-line applications. In contrast, near infrared reflectance spectroscopy (NIRS) is a sensitive, fast and non-destructive analytical technique, entailing minimal sample preparation and neither requiring reagents nor producing waste. Moreover, NIRS facilitates the simultaneous assessment of numerous characteristics.

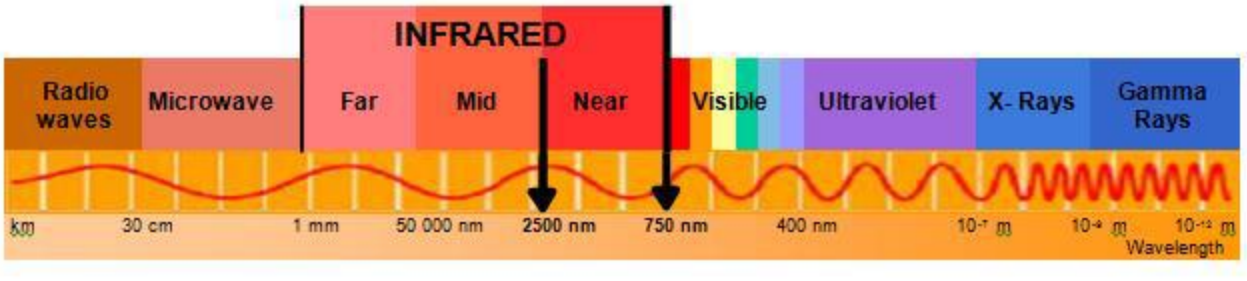

Figure 1. Electromagnetic spectrum

NIR spectroscopy utilizes the spectral range from 750 to 2,500 nm (Figure 1). The process (Figure 2) involves measuring the vibrational response of chemical bonds when illuminated by NIR frequencies. These bonds have unique and characteristic absorption frequencies; hence it is possible to build a characteristic NIR spectrum which can be used to estimate chemical composition and provide information on sample ultrastructure.

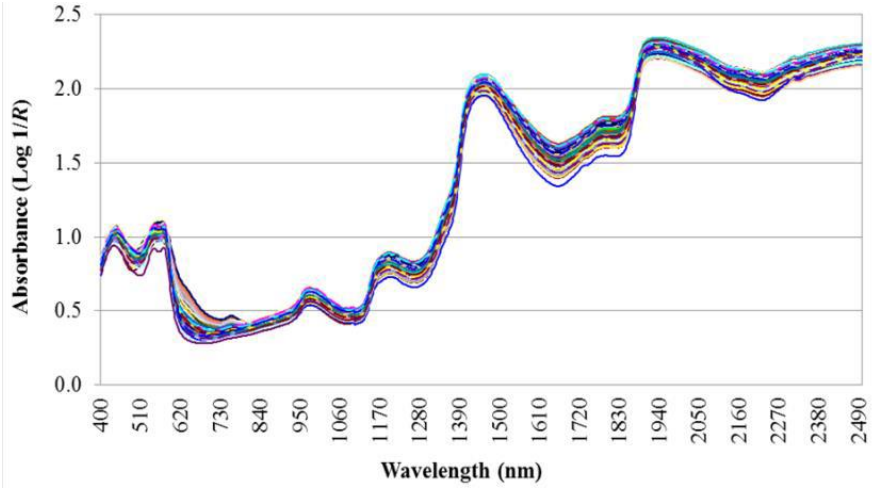

Figure 2. NIR spectra from beef samples

NIR spectroscopy has been successfully applied to estimate the amount of major constituents (moisture, fat and protein) of meat and meat products. In fact, these NIRS procedures have been approved by the international committee for validating analytical procedures (AOAC) and are currently being used in industry. Beyond this, NIRS can also be used to help categorize meat, for example beef that is fresh or frozen and thawed, meat from different species, meat from animals fed different diets as well as detection of hamburger adulteration.

Recent Alberta Meat and Livestock Agency (ALMA) funded studies carried out at the Lacombe Research Centre (AAFC) using beef have shown the potential of NIRS to predict the proportion of fatty acids with important human health-related benefits such as omega-3, rumenic (c9,t11-CLA) and vaccenic (t11-18:1) acids. Further investigation into NIRS potential is now underway in a joint study between the University of Alberta and the Lacombe Research Centre with funding from the Alberta Crop Industry Development Fund Ltd. (ACIDF). This research is testing an on-line NIRS fibre-optic probe (Figure 3) which, despite the challenging operational environment at abattoirs such as fluctuations in temperature and humidity, could significantly improve the ability of NIRS to monitor and control meat processing via remote on-line detection. Additionally, the use on-line of a fibre-optic probe enables measurements to be made simply by placing the probe on the sample itself. With no previous sample treatment required, the on-line probe may thus provide rapid simultaneous prediction of various meat quality criteria on-line in a commercial environment.

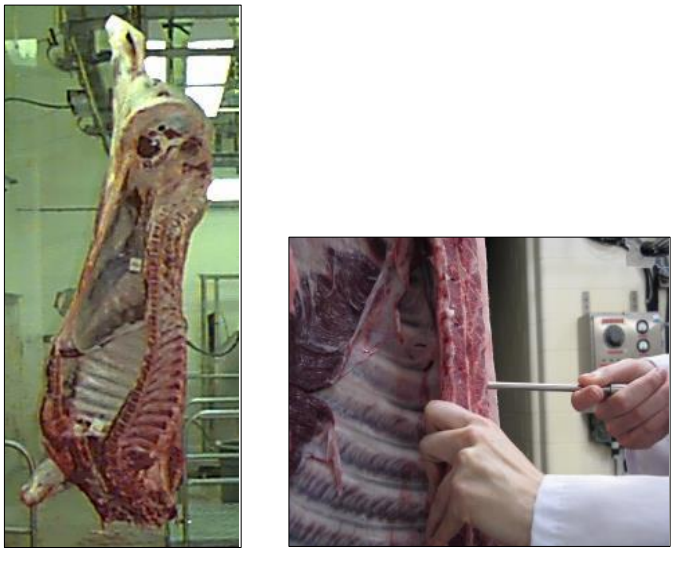

Figure 3. Using on-line NIRS fibre-optic probe on beef carcass

When using NIR spectroscopy it must, however, be remembered that it is a predictive and not a direct measure, and a wide range together with a homogeneous spread along the range of reference values is required to maximise the prediction power of NIRS. NIR spectroscopy requires calibration using a reference method (i.e. typically chemical analysis) that uses a set of calibration samples representative of all sample types to be encountered in industry. 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. Although the cost per sample when using NIRS is low, the price of an analytical (i.e. multiwavelength) NIR instrument is about $60,000, which may be daunting to food processors and producers. Recent efforts have, therefore, been placed on trying to identify wavelengths at which NIRS measurements are closely associated with meat quality characteristics. 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 (i.e. similar to instruments now available for measuring moisture, fat and protein). Moreover, the use of portable fibre-optic probes makes the application of NIRS at commercial level more feasible.

As greater emphasis is being placed on meat quality and composition, and more rapid and accurate methods are being required to meet these demands, the use of NIRS seems to be a perfect fit. Consequently, it is anticipated NIRS will become more widely accepted for use in many meat industry applications in the near future as robust calibrations are developed using large representative sample sets and models become available for commercial applications.