# MEAT MUSCLE IDENTIFICATION USING VISIBLE AND NEAR INFRARED REFLECTANCE SPECTROSCOPY

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## Background

The determination of food authenticity and the detection of adulteration are major issues in the food industry, and are attracting and increasing amount of attention (Monin, 1998). With meat and meat products major authenticity issues concern the substitution of high value raw materials with cheaper materials such as less costly cuts, mechanically recovered meat, offal, blood, water, eggs, gluten or other proteins of animal or vegetable origin (Monin, 1998). Therefore analytical methods have focused on the identification of meat species in raw, cooked and processed products. Meat specication has been addressed by inmunological (Jones and Patterson 1986) and enzymatic procedures (Smith, 1991). These methods are cheap and have the ability to detect wide range and low levels of adulteration. However, spectroscopic methods are attractive options due to the speed of analysis and minimal sample preparation. Near Infrared Reflectance Spectroscopy (NIRS) was originally developed to provide a rapid measurement of the composition of grains and oilseeds (Osborne et al. 1993). Most of the established methods have involved the development of NIRS calibrations for the quantitative prediction of composition in meat. This was a rational strategy to pursue during the initial stages of its application, given the type of equipment available, the state of development of the emerging discipline of chemometrics and the overwhelming commercial interest in solving such problems (Downey, 1996). One of the advantages of NIRS technology is not only to assess chemical structures through the analysis of the molecular bonds in the near infrared spectrum, but also to build an optical model characteristic of the sample which behaves like the "finger print" of the sample. This opens the possibility of using spectra to determine complex attributes of organic structures, which are related to molecular chromophores, organoleptic scores and sensory characteristics. These same optical properties may also provide a means of characterising complex features of quality, structure, texture, and stability to oxidation and subsequent shelf life. Routine assessment of meat composition using such optical devices is now widely in use in the oilseed, milk and cereal industry for quality purposes (Osborne et al, 1993). At present there is little information on how NIRS can sense the quality of the muscle "as meat" and few reports were found in the literature in relation to the use of NIRS for species identification in meat.

## Objectives

The aim of this work was to study the reliability and accuracy of near infrared reflectance spectroscopy for identification and authentication of raw meat species such as pork, chicken, lamb and beef without depend on chemical information.

## Methods

One hundred (n: 100) beef muscle samples (*longissimus dorsi*); one hundred and forty (n: 140) lamb muscle samples (*longissimus dorsi, infraspinatus, supraspinatus, rectus femoris, semitendinosus* and *semimembranosus*), forty-eight (n: 48) chicken muscle samples (breast and thigh) and forty-four pork samples (n: 44) (*longissimus dorsi*) were analysed. Samples were kept frozen in a commercial freezer (- 4 $^0$C) until NIRS analysis were done. About 100 to 200 g of muscle was thawing at room temperature (20 – 22 $^0$C) and homogenised during one to two minutes with a Philips multiprocessor blender (RI - 3142, Brazil). The blender cup was washed first with hot water, followed by cold water and towel dried between samples. Minced thawed samples were flattened, then sub-samples were taken randomly for further chemical analysis. Samples were scanned minced in reflectance mode (400 – 2500 nm) in a scanning monochromator NIRS 6500 (NIRSystems, Silver Spring, MD, USA) using a circular cup (50 mm diameter, 10 mm depth) (Part number IH – 0307, NIRSystems, USA) sealed with disposal paper back. Spectral data collected were recorded as the logarithm of reciprocal of reflectance [log (1/R)] with two nm interval. Spectral data were collected without rotating samples. Two pairs of lead sulphide detectors collected the reflectance spectra and referenced to corresponding readings from a ceramic disk. The spectrum of each muscle sample was the average of 32 successive scans (16-32-16 sequence). Spectral data collection and manipulation were performed using NIRS 2 software, version 3.01, from Infrasoft International (ISI, Port Matilda, PA, USA). Spectra were exported from the ISI software as NSAS file for chemometric analysis. Principal Component Analysis (PCA) and dummy partial least square regression (PLS) analysis were performed using The Unscrambler (CAMO, Norway). Discriminant analysis was performed using the dummy regression technique as described elsewhere by other authors (Osborne et al., 1993, Ding et al. 1999).

## Results and Discussion

Figure 1 plotted the first three PCA used for discriminate between the raw meat species. The score - plots showed clusters of data related with the different meat species. This confirms the assumption that different spectral attributes between samples were associated with characteristics of the muscles depending on the species. Moisture, pigments and fat could explain the discrimination between the two groups of feeding systems. PC1 explains 68 per cent of the total variance in the samples and weight plot strongly showed an invert of the mean spectrum. The highest loadings on PC1 were found around 580 nm, 980 nm, 1200 nm, 1439 nm and at 1918 nm respectively. These spectral regions are characteristic of water absorption (980 nm, 1200 nm, 1400 nm, 1918 nm - OH overtones) (Osborne et al., 1993) and related with moisture content of the beef muscles. PC2 explains 19 per cent while PC3 explains 8 per cent of the total variance respectively. In this work, the highest loading on PC2 were found around 570 nm, 1412 nm, 1632 and 1860 nm respectively. These spectral regions are characteristics for the respiratory meat pigments at 570 nm and water at 1412 nm respectively. Some authors reported that absorbance shoulders between 450 and 510 nm correspond to light absorption by muscle pigments (Swatland, 1995). Absorption between 1600 – 1850 nm was related to the type of fat present in the sample (Osborne et al., 1993; Downey et al 2000). Spectral bonds in the region at 1638 nm and between 2200 nm to 2300 nm were related to unsaturated = C – H and C = C groups which suggests that differences in polyunsaturated fatty acids may also contribute for further muscle classification (Downey et al., 2000). The region between 500 - 600 nm have great effect in the discrimination as seen by the highest loadings on the three PC's.

## Conclusions

The presence o meat contamination with other species can be detected through VIS/NIRS spectroscopy. Multivariate classification methods like discriminant analysis or dummy regression using PLS can be used to classify different muscle species. The process of comminuting the sample can lead to selective loss of moisture and fat in the mincing process.

## References

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## Data

Figure 1. Discrimination between muscle species.

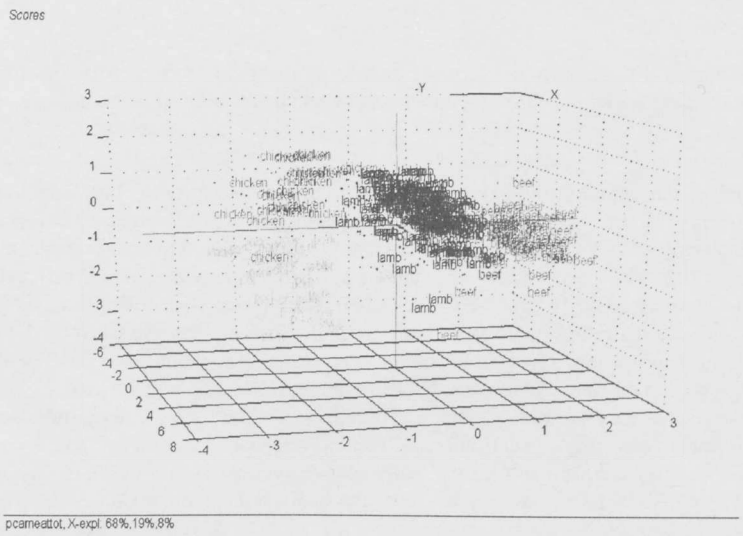


Figure 2. PC loadings used for the meat sample discrimination