MUSCLE STUDY WITH MULTISPECTRAL IMAGE ANALYSIS

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Introduction

A feasibility study of multispectral image analysis (MIA) was undertaken with the aim of relating meat components to sensorial and physical properties. The MIA technique has been used during last decade for the assessment of food products (Novales *et al.*, 1996) especially for the inspection of poultry carcasses in the Visible/NIR range (Park *et al.*, 1996). Contaminations of apples have also been studied using multispectral fluorescence imaging (Kim *et al.*, 2005). In this work we applied MIA to study meat component by targeting myofibres, collagen and lipids which play a major role in meat sensorial quality. In a previous study we established the specific spectral signals of muscle components (Skjervold *et al.*, 2003). This paper describes the multispectral imaging approach we have used in order to characterise muscle slices. A specific bench was built and settled to optimise the UV-Visible image of muscle samples according to specific spectral tissue information. A method of exploiting the resulting multiway image data was developed. It covers the different steps of data analysis *i.e.* from the processing of the raw image signal to statistical analysis of the data. The image segmentation was performed using a multiway method based on multispectral techniques (Novales *et al.*, 1996). This method allowed the capture of information on muscle composition and structure and particularly the distribution and quantification of the connective tissue. The analysis involved segmentation of the connective tissue making it possible to directly identify collagen and lipids, while myofibre information was obtained indirectly. Muscles of six animals were analysed in real conditions to demonstrate the feasibility of the multispectral technique for muscle characterisation.

Materials and Methods

Image analysis was performed on bovine muscles. Frozen *biceps femoris* muscles of six animals were cut into samples of 20 mm thickness. The set of images was produced with an optical bench using a UV sensitive digital camera (Sony XCD-SX900UV) (Figure1). Sample images of 5 cm X 4.5 cm were recorded. They were acquired at different wavelengths in the UV–Visible range. The light source was a 300W maximum power Xenon light used for pure white light or ultra violet light filtered at 320 and 380 nm. Each wavelength corresponded to one channel of the multispectral image.

In order to improve image quality both median and Gaussian low-pass filters were applied. The image segmentation is a chemometric technique based on pixel classification. It was used here to classify the three components of muscle tissue: myofibres, collagen and lipids. The chemometric technique consists of a Matlab toolbox developed by the authors. Image features were extracted from segmented images according to (Abouelkaram *et al.*, 2003). Parameters were selected in order to find the most pertinent ones to use in the prediction models. Data statistical studies, mainly based on multiple linear regression, made it possible to build specific statistical models which relate image features to meat properties.

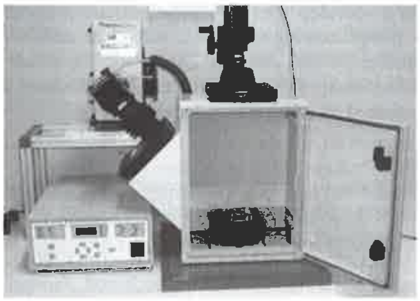


Figure 1: Multispectral imaging bench.

Sensory parameters, including tenderness were assessed on cooked meat by a sensory panel while mechanical tests were performed on raw meat (Maunier-Sifre, 2005).

Results and Discussion

The multispectral imaging technique involves the following steps: image acquisition, image pre-processing, multiway segmentation, image features extraction and statistical analysis (Figure 2). The main default on the raw images was a non uniform lighting. We solved this problem by using a low pass Gaussian filtering (Figure 3). A typical three grey level segmented image resulting from the multiway method is given in Figure 4. It shows the discrimination between myofibrils (in black), collagen (in grey) and lipids (in white) allowing assessment of their quantities and distributions.

On resulting segmented images of muscle of six animals, image features were extracted and related to composition, mechanical and sensory measurements. Because of the low observations number, the predicting models were built with only the most relevant image parameter.

Results in predicting composition and sensory parameters are presented on Figure 5. The R^2 coefficients of the prediction models were satisfactory. However, due to a small number of observations, these results must be confirmed. The highest R^2 were obtained when predicting the proximate composition: collagen (R^2=0.88) and lipids (R^2=0.87). Tenderness gave the lowest R^2 (0.75) while R^2 associated with juiciness was equal to 0.84. Note that collagen and lipids could be assumed as primary parameters as they were visible on the image, whereas sensory characteristics were supposed to be second rank parameters. This can explain the score of tenderness which is also multifactorial.

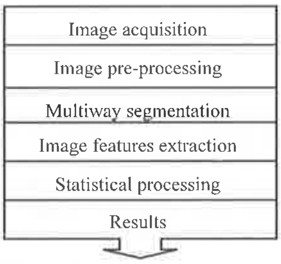
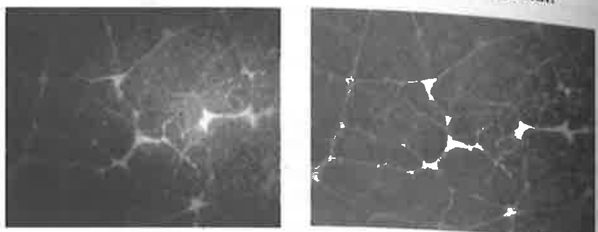


Figure 2: MIA steps.



Raw image

Gaussian filtered image

Figure 3: Image pre-processing.

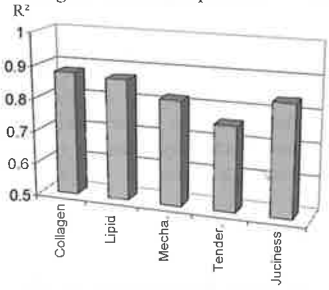


Figure 5: Meat quality prediction results.

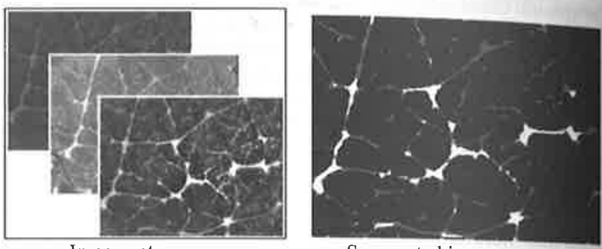


Image set

Segmented image

Figure 4: Multiway segmentation.

Conclusions

This work was focused on the application of a multispectral imaging technique to muscle characterisation. It was needed to develop specific equipment and method. The method covers the different steps of data analysis from the image pre-processing to the data statistical analysis. To complete this study, preliminary experiments were undertaken on muscles of six animals. The results obtained on this small sample population show the potential of MIA in estimating composition and structural organisation and predicting sensory parameters. These promising results have to be confirmed on a larger population.

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