PREDICTION OF BOVINE MEAT TENDERNESS USING IMAGE ANALYSIS TECHNIQUE

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Introduction

Tenderness is the most important meat quality attribute for consumers. Many studies have identified the muscle components which are responsible of tenderness while its inconstancy is still unexplained (Hedrick *et al.*, 1994). The muscle connective tissue plays a major role in meat tenderness and presents important variations in its constituent content and in its spatial organisation. It is mainly composed of collagen, whose content and distribution has an important effect on the background toughness of meat. Tools of meat quality prediction based on image analysis have been studied by several authors. Connective tissue information was obtained using image analysis to predict collagen content (Abouelkaram *et al.*, 2003). Lu *et al.*, (1998) have used colour and marbling image features in models of tenderness prediction which were found to be limited. Li *et al.*, (1999) used the same features and added image texture characteristics in their models to obtain R^2 values up to 0.70 for predicting beef tenderness.

The goal of our study was to develop prediction tools of meat tenderness using image analysis techniques. Our results show that tenderness is significantly related to connective tissue characteristics. Indeed we extracted from images of bovine muscle parameters related to connective tissue which were used in models of tenderness prediction.

Materials and Methods

Animals: the assays were performed on samples of semitendinosus (ST) muscle of young bulls from four French breeds: Aubrac (n=17), Charolaise (n=19), Limousine (n=18) and Salers (n=19). The animals were 15, 19 and 24 months old. The experimental design was described in Jurie et al. (2005).

Sensory analysis: sensorial qualities (tenderness, juiciness, flavour intensity) after 14 days of ageing were determined by experimented (QUERY; do you mean experienced?) panellists as described in Drandsfield et al. (2003).

Imaging material and method: Imaging bench is build with a black and white CCD video camera (Sony MACC77) remote-controlled by a PC, an UV and a polarised white lighting (Figure 1).

The images, of which size was 530 x 521 pixels, were processed following a threshold method for the objects extraction. A segmentation algorithm was used to obtain areas of the objects identified as belonging to the connective tissue network. A classification of these objects according their size allowed obtaining the image parameters used to characterise the meat samples.

The kept parameters hold the information of connective tissue organisation in term of size distribution of the connective network constituents (perimysium). The parameters were extracted from meat sample images acquired with white (20 variables) and UV (20 variables) lightings. The tenderness factor was analysed with data issued from a combination of the two types of variables (n=40).

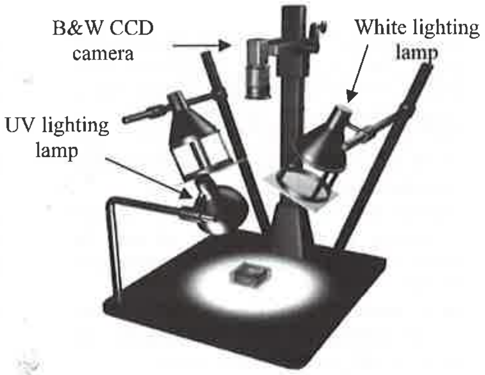

Figure 1: Imaging bench.

Statistical analysis: The whole data was analyzed using the SAS software. The prediction models of the tenderness, built with the image parameters, were determined by an approach based on multiple linear regressions (MLR). A step of parameter selection was performed in order to keep the most relevant variables for the MLR. The final model retained for tenderness prediction is determined according to a maximization criterion of R^2 ($p<0.05$).

Results and Discussion

In this study we compared the various results of statistical analysis carried out on the tenderness. This factor was explained according to the age of the animals.

The best results of regression were obtained by the combination of the two types of parameters. Table 1 gives the R^2 obtained by using the first six variables which maximize the R^2. The choice of the number of parameters was based on a cross validation criterion (Leave one out) in order to stop introducing additional variables in the regression model. Figure 2 gives charts of the values estimated by the models of regression according to the measured values, for the samples of the three animal ages.

Table 1: Coefficients of determination of the regression models for the three ages.

Results obtained with the combined parameters		
	R^2 (%)	R^2 (%)
Age (month)	Model	Validation
15	83.58	69.97
19	87.70	76.74
24	76.08	58.10

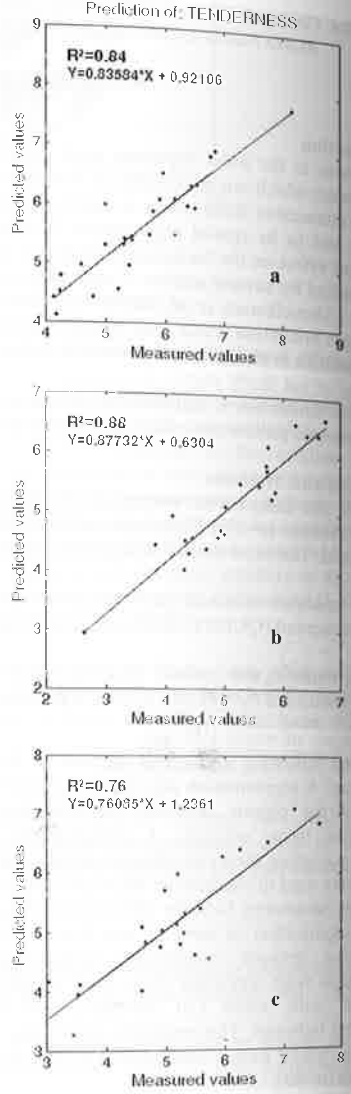

Figure 2: Predicted vs. measured values of tenderness of young bulls' meat. Curve 'a' corresponds to animals which were 15, 'b' 19 and 'c' 24 months old.

Conclusions

Results presented here show that a good estimate of the tenderness was achieved using these models. The image parameters which were used in these models give information on the distribution of the connective tissue. They depend partially on the method used for segmenting the images. Obviously these models can be improved by optimizing classification of object sizes and image segmentation method.

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