P-07-34

Objective determination of marbling levels in beef using hyperspectral imaging (#633)

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Introduction

The aim of the present study was to evaluate hyperspectral imaging (HSI) to estimate fat content and distribution on the surface, i.e. fat marbling, on packed fresh beef cuts.

From a consumer's point of view, quality of beef mostly refer to the eating experience, i.e. eating quality, and they are willing to pay more for beef which is guaranteed a positive eating experience. As the demand of meat of high eating quality increases, a need for cost-effective and fast ways to evaluate and predict also increases.

Fat marbling is positively influencing eating quality attributes flavour, juiciness and tenderness, as well as to sensory attributes of meat; flavour intensity increases with marbling levels. A steak with a high amount of finely distributed fat streaks will be considered to be of superior quality.

Since the demand for high quality meat with high fat marbling increases, and as todays marbling grading is done subjectively, there is a need to develop objective and automatic non-destructive techniques. Different types of imaging systems used for detecting marbling have been developed and tested, and the results indicate that imaging systems are powerful tools for predicting beef quality attributes In this study we have investigated HSI.

Methods

120 sirloin cuts (LD) were provided from and individually vacuum packed by the slaughter company (Nyhlén & Hugosons, Luleå, Sweden); sampled to provide a wide variation in fat marbling, and kept at approx. 4°C before measurement.

The cuts were analysed using a ViaSpec Hyperspectral imaging system, with a motor driven transmission stage, a focus grid and a white reference (Middleton Spectral Vision, Middleton) with a push broom Specim short-wave infrared (SWIR) camera; 15 mm f/2.1 lens (SWIR spectral camera, SPECIM, Finland). The acquired images consisted of 288 spectral bands; range: 935-2457 nm, spectral resolution of 12 nm, spatial resolution of 0.42 mm, controlled by the Breeze software (Breeze, Prediktera AB, Umeå). Samples were illuminated by halogen light source. All the images were made comparable in terms of spectral response (9). Ev. effects of plastic package material and to compare fat content and distribution from the surface area on both sides of the sample, 20 samples were randomly chosen and scanned both with and without plastic, and on both sides.

The hyperspectral image data were analysed using a principal component analysis (PCA) implemented in the Breeze software (Prediktera, Umeå, Sweden). For building the quantification model, and to quantify the percentage of fat and its distribution on the surface of the beef samples, a partial least square regression (PLS-R) model was used. For the classification of pixels into classes of either fat, protein, background or plastic, a partial least squares-discriminant analysis (PLS-DA) was used.

Results

The results from the image analysis indicate HSI is suitable for predicting the amount and distribution of fat in beef samples, with a high accuracy. A high correlation between fat content and higher marbling grade was found; however, but a low correlation between the visually marbling grading and objectively measured fat content was found. The classification, as shown in Tab. 1 showed correct classification with high accuracy for the four constituents. The PLS model used for quantifying the constituents showed a high R^2=0.94, indicating a good model performance.

Table 1 Classification matrix for the HSI classification model. The matrix shows a classification accuracy of 100%.

Classes	Total	Background	Plastic	Protein	Fat
Background	1604	1604 (100%)	0 (0%)	0 (0%)	0 (0%)
Plastic	946	0 (0%)	946 (100%)	0 (0%)	0 (0%)
Protein	1586	0 (0%)	0 (0%)	1586 (100%)	0 (0%)
Fat	912	0 (0%)	0 (0%)	0 (0%)	912 (100%)
#Predicted	5048 (100%)				
Correctly	5048 (100%)				
Incorrectly	0 (0%)				

Conclusion

HSI showed high potential for predicting meat constituents based on chemical composition and its spectral information. Using PLS-DA model is was possible to separate fat and protein pixels with an accuracy of 0.96 for fat and 0.95 for protein. Moreover, the HSI based quantification model was successful in accurately predicting the amount and distribution of fat in the beef samples. Scanning the beef with plastic did not affect the results. Average fat and fat distribution was not consistent for both sides of the sample, resulting in a 0.53 coefficient of determination for fat content and 0.43 for distribution. In order to increase accuracy, larger fat lumps should be excluded. In this study, correlation was found between higher marbling grade and increased fat content. However, there are some biases between the subjective

Notes

evaluation of marbling grades and the objectively predicted fat content. This is probably caused by differences in the two methods. Despite the differences between the objective and subjective analysis, HSI should be further investigated since it shows promising results to identify the amount of intra muscular fat in beef. It should be concluded that the higher accuracy for the HSI based models are caused by the more complex spectral information in HS-images.

Notes