Hyperspectral imaging for rapid screening of quality parameters in granular food commodities

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I. Introduction

Hyperspectral imaging (HSI) in food science has been widely applied during the past few years due to its enormous advantages for on-line quality control, *i.e.* reduced analysis time and non-destructive nature [1]. The aim of this work was to explore the potential of HSI for characterising whole wheat kernels and green coffee beans. Several properties were tested, including total protein content and estimation of the potential α-amylase activity for wheat. Both parameters are relevant for the food industry as they influence the quality of baked product, and both are key aspects of milling wheat specifications.

II. Materials and Methods

Measurements were made for single kernel NIR spectra obtained using a pushbroom HSI system in the NIR range (1000-2500 nm), with a HgCdTe detector and a resolution of 320 x 256 pixels.

A calibration for wheat protein was successfully developed using PLS regression against reference Dumas combustion measurements of >2100 single kernels from >180 wheat samples.

α-Amylase activity in wheat and flour is commonly assessed using the Hagberg Falling Number (HFN) measurement [2]. A calibration was developed using Partial Least Squares (PLS) regression for single kernel spectra of ~30 grains per batch, against reference HFN measurements for the bulk wheats. An alternative approach used PLS discriminant analysis to classify grains into high (>250s) and low (<250s) HFN classes, with satisfactory classification accuracy.

The potential of HSI was also explored to analyse whole green coffee beans. Samples were taken from different geographical origins and pre-processing (dry- and wet-processed), selecting mainly Arabica samples.

Unsupervised classification methods were applied to test the classification among Arabica and Robusta samples, taken on a single coffee bean basis. Also, the measurement of selected component compounds was assessed by using appropriate reference methods based on liquid extraction and quantification using liquid-chromatography and mass-spectrometry (LC/MS) [3].

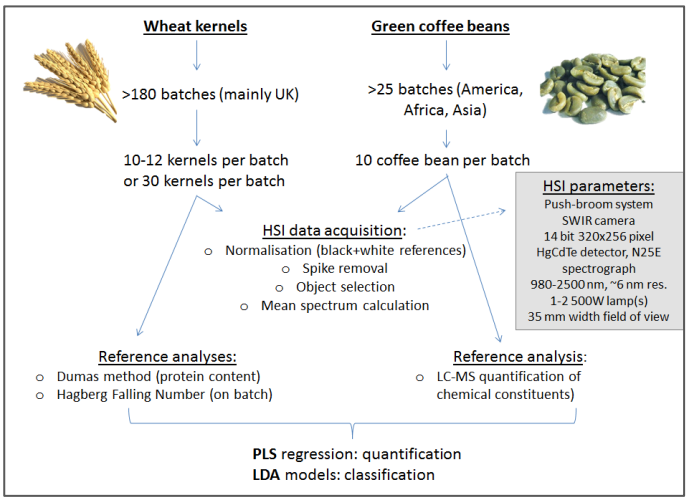

Fig. 1. Representation of the experimental plan for the present communication, regarding the application of HSI for the study of quality parameters in two commodities, i.e. wheat and coffee beans.

III. Results and Analysis

Wheat.

The PLS model based on HSI and reference protein measurement resulted in satisfactory prediction of protein content in intact kernels, with R^2>0.8 and RMSEV<0.9%. While normal NIR instrumentations present better calibration performance and lower prediction error, there are several advantages associated to the use of HSI at an industrial level, or for screening wheat during breeding programmes.

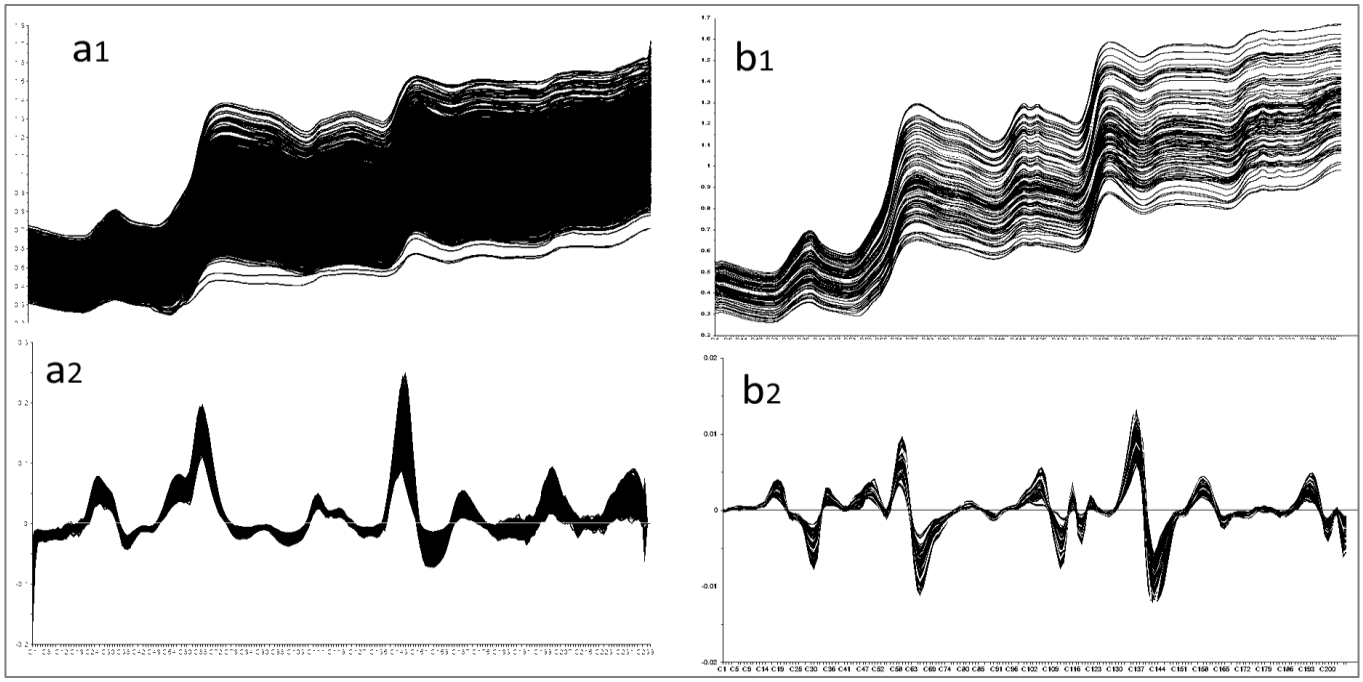

Fig. 2. Typical NR absorbance spectra of: a_1) intact wheat kernels, b_1) green coffee beans; same spectra after first derivative calculation (a_2 and b_2). Data were obtained at single kernel/bean level (mean spectra within the object).

HFN prediction was carried out on batches: due to the low amount of enzyme and the fact that it is inactive in whole wheat kernels, the direct prediction of potential amylase activity is complicated. However, a LDA classification model was successfully developed to discriminate between wheats with acceptable and unacceptably low HFN values.

Coffee.

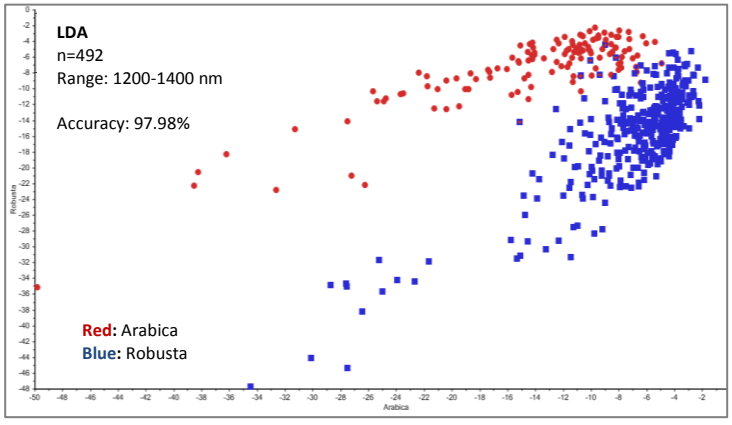

Fig. 3. Linear Discriminant Analysis (LDA) for green coffee beans Arabica/Robusta discrimination, based on HSI in the NIR region. Beans were scanned both on the ventral and dorsal side. Accuracy: 98.0%

A discrimination between Arabica and Robusta coffee beans based on individual analysis of green beans by hyperspectral imaging was effectively performed by Linear Discriminant Analysis (LDA), which led to very good discrimination ability, i.e. ~98%.
Chemical properties of green coffee beans were also studied, using the LC/MS method for their quantification and PLS models to assess whether it is possible to calibrate for chemical constituents directly in whole green coffee beans.

I. Conclusions

The use of HSI for the non-destructive study of granular food commodities has been shown to demonstrate potential for the food industry, as well as for scientific purposes to better investigate the spatial distribution of a particular chemical compound or group of compounds within a single grain. Several approaches have been applied for data analysis, e.g. using PLS regression for quantification purposes or LDA for object classification based on internal chemical properties.

References

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