Application of Improved Direct Calibration for Hyperspectral image processing : Detecting peanut traces in wheat flour

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Background

In current **industrial environments** there is an increasing **need** for practical and **in-line detection of foreign materials** in powder food processing lines. This demand is **especially** important regarding to the detection **of highly allergenic products**, such **as peanut**. Peanut are the leading cause of fatalities from food-induced allergenic reactions[2], being avoidance the primary management of these allergies[3]. Adapted detection methods require:

- **High sensitivity**, to detect small traces
- **Robustness** to industrial environments

Objective

Evaluate the feasibility of hyperspectral (HS) imaging and Improved Direct Calibration (IDC[1]) for the detection of peanut traces in wheat flour.

Materials

- Wheat flour (125-100 and 212-160 µm), "Coeur de Blé" from manufacturer MasterChef
- Peanut (500-1000 µm) : obtained from European Commission Institute for Reference Materials and Measurements (IRMM-481kit)
- Aluminum platforms (36 cm^2 and 95 cm^2) (Fig. a.)
- Eleven samples were made: pure peanut, pure wheat flour, samples with known position of peanut on the surface and eight homogeneously mixed samples from 10% to 0.01% by weight.
- HySpex SWIR-320m-e (1000-2500 nm) line-scan push broom camera by *Norsk* Elektro Optikk, Norway

Fig a. Sample preparation

Methods

1. Loadings calculation

Based on:

- **Expert information:** Pure spectra from each product can be used for the loadings calculation, allowing **practical, specific and sensitive** product identification.
- **Experimental information:** "Toxic" information, such us variation around the mean can be removed to improve the **robustness** of the method.

1.1 Spectral pretreatment: SNV and Savitzky-Golay

1.2 Loadings calculation:

$$b_{IDC} = \Sigma_{IDC}\, k'(k\, \Sigma_{IDC}\, k')^{-1}$$

b_{IDC}: b coefficients for IDC[1]
Σ_{IDC}: symmetrical matrices for IDC[1]
K : Pure spectra of interest (peanut)

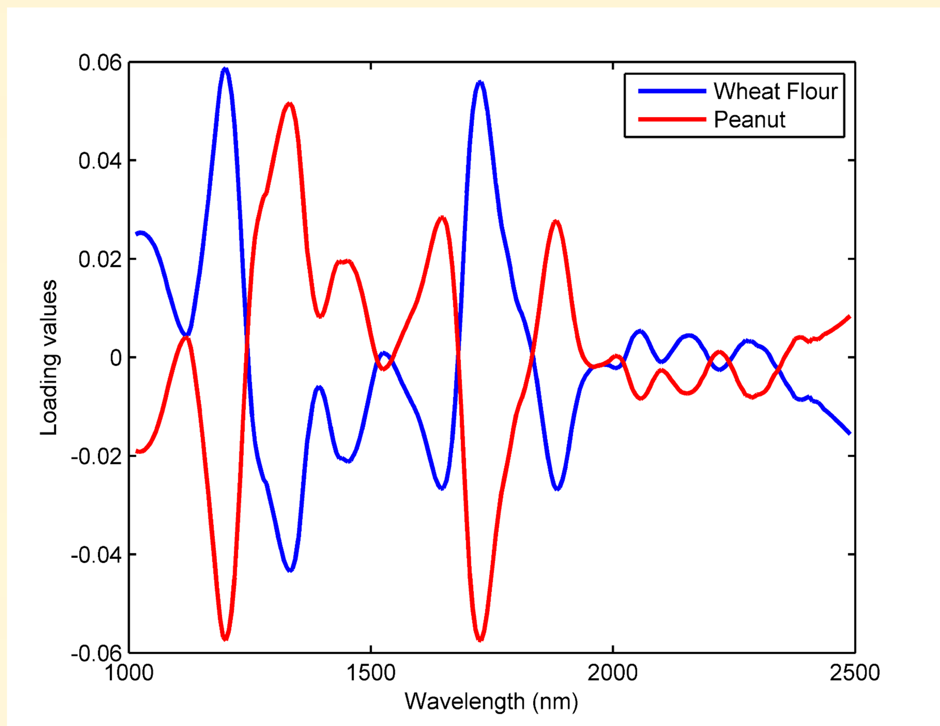

Fig b. IDC loadings (b coefficient)

2. Loadings application on HS images

2.1 HS images pretreatment: SNV and SAVGOL

2.2 Application of the b coefficients to obtain score images (Fig. d.)

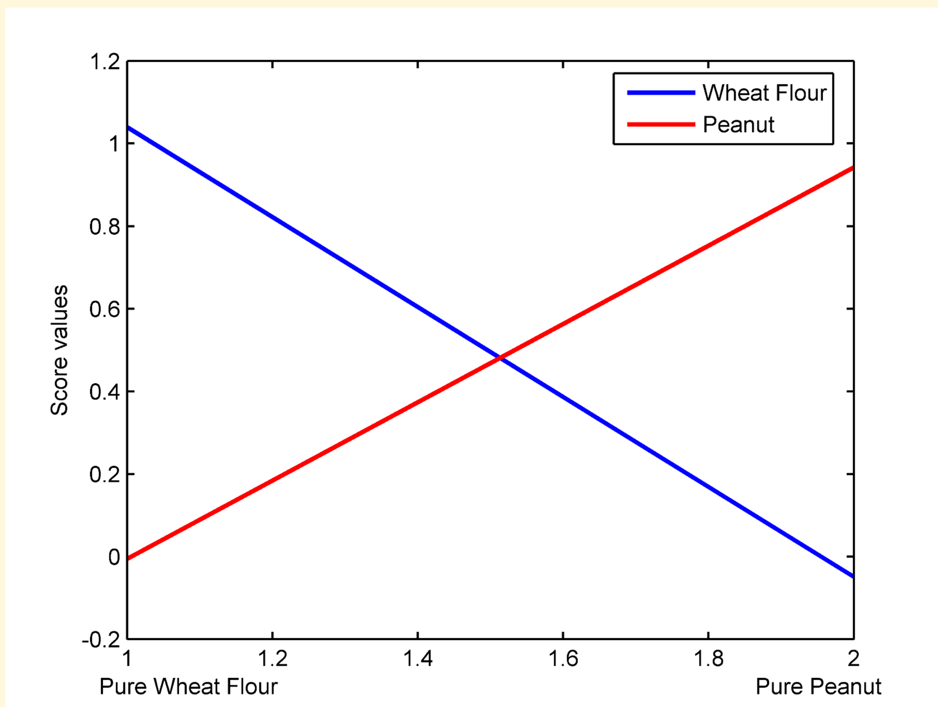

Fig c. Score validation for pure

3. Image segmentation

3.1 Score images were segmented into flour and peanut pixels according to a reference image histogram.

Results

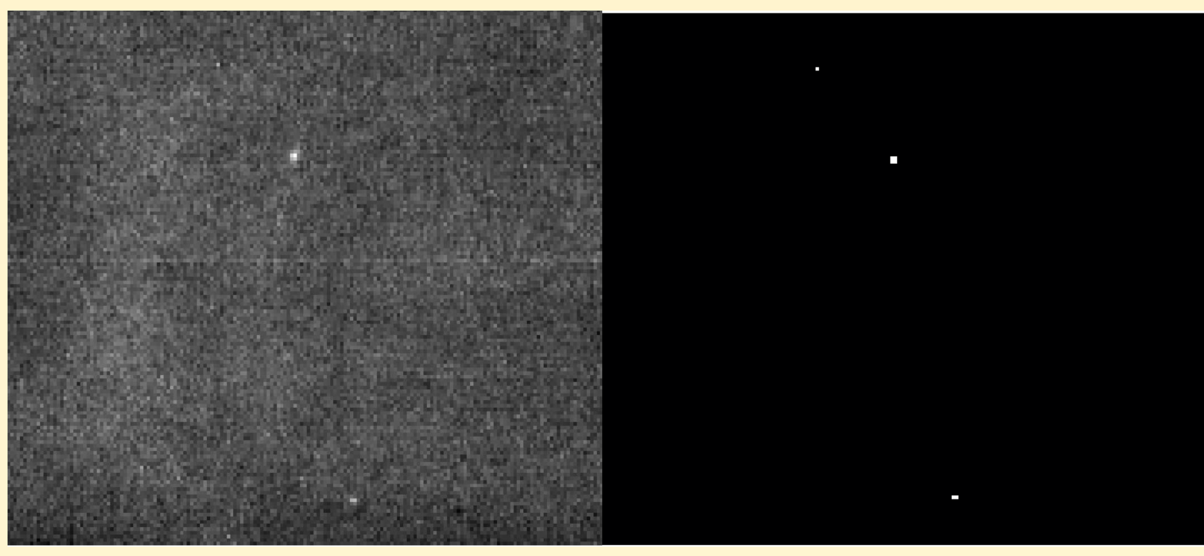

Fig d. Scores image **Fig e. Class image**

- Classification images provided clear detection of peanut traces in wheat flour Fig.(e).
- Minimum level of peanut traces detected with present experimental setup was 0.01 % by weight.

Conclusions

- NIR Hyperspectral imaging (1000-2500 nm) combined with IDC allowed the detection of peanut traces down to adulteration percentages 0.01%.
- Contrary to PLSR , IDC does not require a calibration set, but uses both expert and experimental information and suitable for quantification of an interest compound in complex matrices.
- The obtained results shows the feasibility of using HSI systems for the detection of peanut traces in conjunction with chemical procedures, such as RT-PCR and ELISA.

References

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