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 allergic reactions, being avoidance the primary management of these allergies. 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) 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 (IRM-M-481kit)
- Aluminum platforms (36 cm² and 95 cm²) (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

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 as 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:
   \[ \mathbf{b}_{IDC} = \mathbf{\Sigma}_{IDC} k (k \mathbf{\Sigma}_{IDC} k^{-1})^{-1} \]
   \( \mathbf{b}_{IDC} \): b coefficients for IDC
   \( \mathbf{\Sigma}_{IDC} \): symmetrical matrices for IDC
   \( K \): Pure spectra of interest (peanut)

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.)

Results

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