CONffIDENCE: Contaminants in food and feed: Inexpensive detection for control of exposure

Detection of ergot bodies in cereals by NIRS and hyperspectral NIR imaging

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Introduction

Contamination of cereals with ergot, formed by the fungi *Claviceps purpurea* is well known. For the farmer, the damage caused by ergot is a yield reduction: the ergot replaces the kernels in the grain ears. For the feed/food sector, the presence of ergot in feedingstuffs and agro-food products involves high toxicity risk for animal and human in relation to the alkaloid composition and content in the ergot. The neurotoxic signs comprise feed/food refusal, dizziness but also convulsions. A survey on the presence of undesirable botanic substances in feed, carried out in 2006 inside official control labs from all member states of the European Union, showed a resurgence of the ergot presence in cereals samples. To reduce the risk of poisoning, the European directive 2002/32/EC on undesirable substances in animal feed fixed a limit in the EU of 0.1% for ergot in all feedingstuffs containing unground cereals. The existing microscopy method provides an elegant early warning tool for ergot contamination but is time-consuming. The current work, performed partially in the framework of the CONffIDENCE project (http://www.conffidence.eu), aims to assess by NIRS and hyperspectral NIR imaging the presence of ergot bodies in cereals.

Materiel and methods

Wheat kernels including one ergot body

For this experiment, ergot bodies issue from different sources (Belgium, The Netherlands, Germany and Denmark) and wheat kernels issue from several varieties and Belgian locations have been collected and analyzed with with 2 NIR instruments. The Bruker MPA is a NIR spectrometer active in the 1100-2400 nm range and allows to collect a mean spectrum of a kernels bulk in less than 1 min.

The MatrixNIR™ (Malvern instruments Ltd) is a hyperspectral NIR imaging system active in the 900-1700 nm range and allows to collect the NIR spectra of 10 kernels in 5 minutes. A total of around 3000 spectra from each kernel is obtained. The main characteristics of the NIR camera are described in figure 1. The data treatment was carried out with the PLS toolbox under Matlab 7.5.0 (R2007b).

MatrixNIR™ characteristics
- Wavelength range: 900-1700nm by step of 10 nm
- 1 image = 240 x 320 pixels = 76 800 spectra
- Analysed surface = 76800 pixels = +/- 5cm2
- Time of acquisition = 5 min/image
- 1 kernel = +/- 3000 pixels = 1 mean spectrum

Figure 1: MatrixNIR™ Chemical Imaging System instrument characteristics and Bruker MPA instrument

Results

For this study, a calibration set (25 ergot bodies spectra and 20 wheat kernels spectra) and a validation set (15 ergot bodies spectra and 10 wheat kernels spectra) have been built from the database by selecting, for the validation set, samples from different sources than the calibration set. Figure 2 shows the mean raw spectra for ergot and wheat. The data were preprocessed by the Standard Normal Variate transform followed by 1st derivative Savitzky-Golay treatment (15,2,1). Figure 3 shows the preprocessed spectra. In order to discriminate between ergot bodies and wheat kernels, the Fisher coefficient was used to select the wavelengths where the between-classes variation is higher than the within-classes variation. Figure 4 shows the Fisher coefficient calculated on preprocessed data for the wavelength range of the Bruker MPA. Two wavelengths, 1748 nm and 2126 nm were selected, based on the specific spectral region of the ergot and on the Fisher coefficient value. Figure 5 shows the discrimination between ergot bodies and wheat kernels using in X axis the preprocessed data near 1748 nm and in Y axis the preprocessed data near 2126 nm. The validation samples (empty circles for wheat kernels and squares for ergot bodies) are included or very close to the ellipse corresponding to the 95% confidence limit.

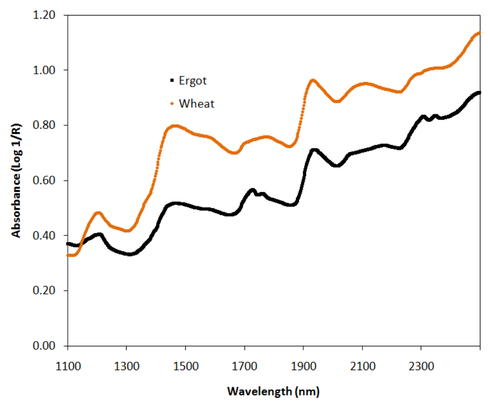

Figure 2: Bruker MPA mean spectra

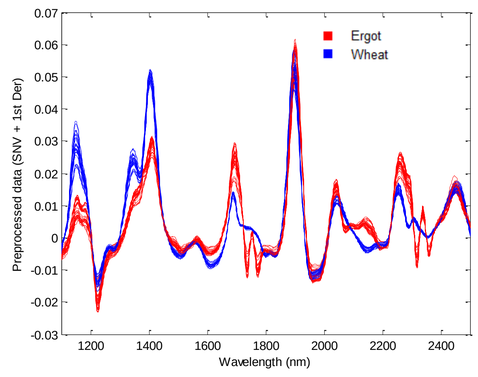

Figure 3: Preprocessed spectra: SNV + Derivative (15.2.1)

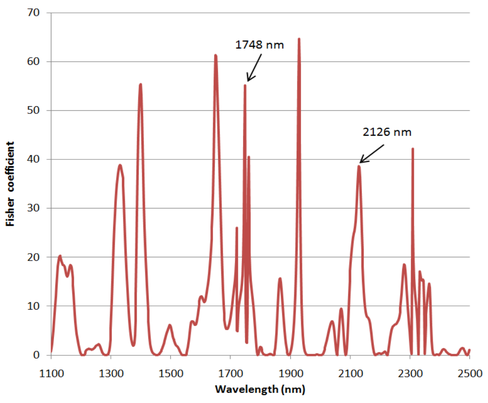

Figure 4: Bruker MPA: Fisher coefficient calculated from preprocessed spectra

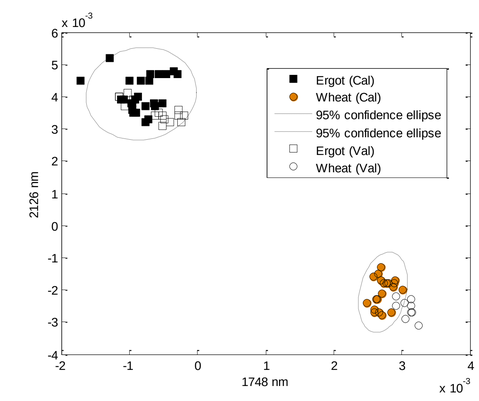

Figure 5: Bruker MPA: Discrimination Ergot/Wheat based on 2 wavelengths (1748nm/ 2126 nm)

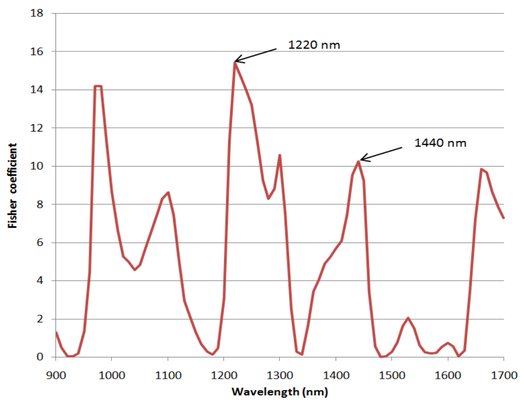

Figure 6: MatrixNIR™: Fisher coefficient calculated from preprocessed spectra

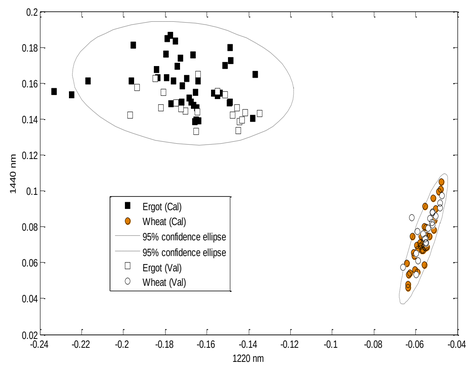

Figure 7: MatrixNIR™: Discrimination Ergot/Wheat based on 2 wavelengths (1220 nm/ 1440 nm)

A similar study was carried out on the hyperspectral NIR imaging system, using the same samples. Figure 6 shows the Fisher coefficient calculated on preprocessed data for the wavelength range of the NIR camera. Two wavelengths, 1220 nm and 1440 nm were selected. Figure 7 shows the discrimination between ergot bodies and wheat kernels using in X axis the preprocessed data near 1220 nm and in Y axis the preprocessed data near 1440 nm. The validation samples (empty circles for wheat kernels and square for ergot bodies) are clearly included inside the ellipse corresponding to the 95% confidence limit.

Conclusion

This study showed the potential of NIRS and hyperspectral NIR imaging to discriminate the ergot bodies from wheat kernels. Additional developments on hyperspectral NIR imaging will be undertaken for the quantification of ergot bodies in the samples.

References

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