On-line detection and quantification of ergot bodies in cereals by near infrared hyperspectral imaging

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Introduction

Contamination of cereals with ergot (*Claviceps purpurea)* is well known. For the farmer, the damage caused by ergot is a yield reduction. For the feed and food sectors, the presence of ergot involves high toxicity risk for animal and human due to its content in alkaloids. To reduce the risk of poisoning, the European directive 2002/32/EC on undesirable substances in animal feed fixed a limit of 0.1% for ergot in all feedingstuffs containing unground cereals. The regulation EEC No 689/92 restricted to 0.05% the concentration of ergot bodies in cereals for humans. The current work, performed in the framework of the CON*ff*IDENCE project (http://www.conffidence.eu), aims to detect and quantify on-line by NIR hyperspectral imaging, the presence of ergot bodies in cereals.

Material and methods

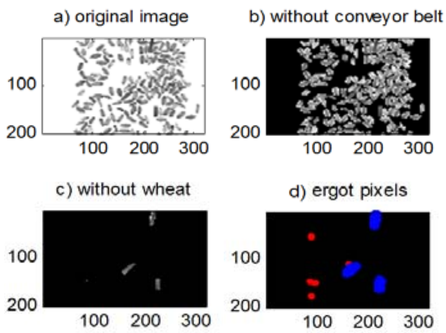
Figure 1: Image acquisition of cereals kernels using a line scan hyperspectral imaging system instrument.

Seven samples of wheat contaminated with 0.01% to 1% (100 to 10 000 ppm) of ergot were prepared and measured using a NIR hyperspectral line scan system combined with a conveyor belt (BurgerMetrics) (Figure 1). All images consisted of lines of 320 pixels that were acquired at 209 wavelength channels (1100-2400 nm with a step of +/-6 nm). Discrimination models were built based on specific spectral libraries. Partial Least Squares Discriminant Analysis (PLSDA) (Figure2) and Support Vector Machines (SVM) (Figure 3) were used as classification methods for the construction of these models. They were applied to all the individual pixels in the images of the adulterated wheat samples in order to isolate and quantify the number of pixels detected as ergot. The tests using SVM were compiled in a program developed by CRA-W in Matlab v7.0 and the PLSDA model was built using the HyperSee software (BurgerMetrics).

RGB picture

e)

SVM results



PLSDA results

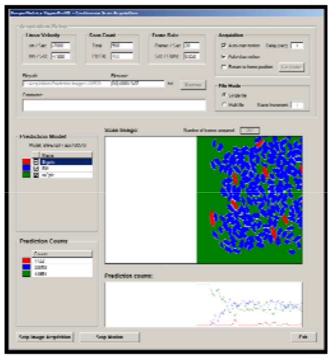


Figure 2: Ergot prediction in wheat using the SVM model displaying a) the hyperspectral image, b) the image a after removing the pixels detected as spectra belonging to the conveyor belt, c) the image b after removing the pixels detected as spectra belonging to wheat, d) the image c after applying the density-based clustering method (DBScan): red pixels are erroneous pixels detected as ergot, blue clusters are set of pixels detected as ergot body, e) RGB picture.

Figure 3: Image from HyperSee software showing the analytical parameters used and the results of the PLSDA on-line prediction for a wheat sample on the conveyor belt. Wheat grains are in blue, ergot bodies in red and background in green. The number of pixels counted for each class of the model is also provided.

Results

The results showed a correlation higher than 0.99 between the predicted and the reference values using PLSDA and SVM models. For a wheat sample containing a level of contamination of ergot as low as 0.01 %, it has been possible to detect enough pixels of ergot to conclude that the sample was contaminated. Moreover, no false positives were obtained when dealing with non contaminated samples (0% ergot samples).

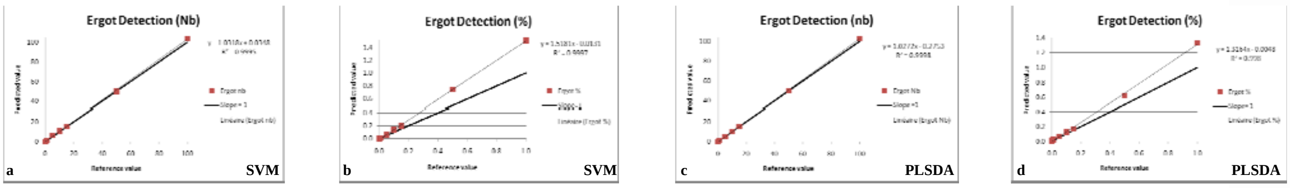


Figure 4: Results of ergot bodies detection in wheat expressed in ergot number (a,c) or in ergot % (b,d), using SVM (a,b) or PLSDA (c,d) models

Conclusion

This study demonstrated that NIR hyperspectral imaging can be used to detect and quantify, in cereals, contaminants like ergot sclerotia. PLS-DA and SVM give good results. Chemometric tools and NIR hyperspectral imaging data could be used by the control laboratories to assess on-line the presence and the quantity of ergot bodies in cereals. In the future, SVM could be useful when dealing with mixtures of contaminants.

References

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