NIR Hyperspectral imaging analysis of individual kernels : a tool helping to detect contamination/fraud in cereals

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Introduction

In the food and feed sectors, the Near Infrared (NIR) technology is nowadays considered as an essential analytical tool that greatly contribute to enhance the quality and safety of agricultural products. Moreover, it has been implemented with success at different stages of the production chains, allowing performing a larger number of analysis by unit of time, saving, then money. The NIR technology is actually used for quality control of raw materials and end products, for the detection of undesirable products and for the detection of presence of fraud in the food/feed chains.

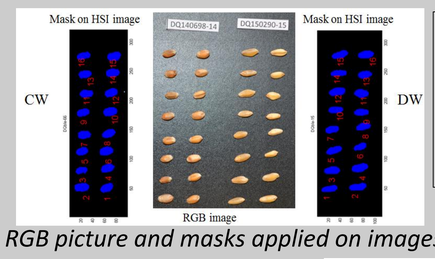
Objectives

To meet the quality product specifications required by the world grain markets and by the agro-food industries, the NIR technology has been adapted for the analysis at the kernel level. In this way, NIR hyperspectral imaging has been developed in order to detect contamination and fraud in cereals. To illustrate the kernel by kernel analysis, four case-studies have been selected.

Study cases

An authentication issue: the detection of common wheat kernels in durum wheat

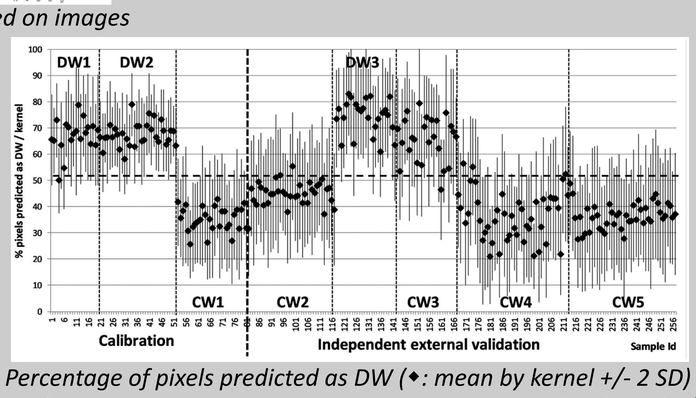
Quantifying the degree of adulteration in order to lower the undesirable kernels in the cereals supply



RGB picture and masks applied on images

Pasta production:
use of durum wheat (DW)
Italian legislation:
3% common wheat allowed (CW)

➢ On the full set of 4112 kernels, 94.8 % of kernels were correctly classified by combining morphological criteria and NIR spectral profile.



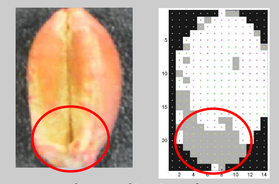
Percentage of pixels predicted as DW (◆: mean by kernel +/- 2 SD) after applying NIR data model to the 257 images of 16 kernels

Vermeulen *et al.* (2018). Discrimination between durum and common wheat kernels using near infrared hyperspectral imaging. J. Cereal Sci. 84 74-82

An homogeneity issue: the assessment of the cereals seeds coating

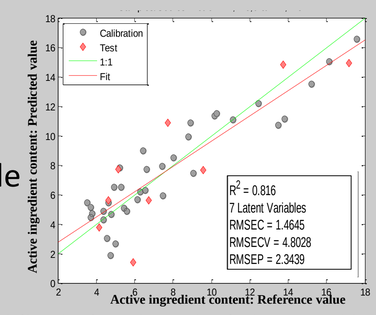
Controlling the quality of cereal seed treatment in order to lower the risk of diseases damage or toxicity in cereals production

Seed coating:
potential fraud / toxicity risk
Cereal seed coating assessment:
no rapid method



RGB picture and predictive hyperspectral image of a wheat seed showing the treated area in white and the non-treated area in grey

➢ For some lots, the active ingredient content in more than 75 % of the seeds was higher than the acceptable 30% around the target dose.



		% Target dose					% Seeds		
Sample	n	Mean	SD	Min	Max	CV	<30%	>30%	± 30%
Ultra performance liquid chromatography									
Wheat									
20	24	86,6	30,3	35,8	159	37,6	33	4	37
51	24	239,7	147,5	143,7	795,7	61,5	0	100	100
Barley									
74	24	49,6	30,5	23,1	149,2	61,6	83	4	87
75	24	55,2	27,5	22	107,2	50,0	71	0	71
NIR hyperspectral imaging									
Wheat									
20	24	93,6	26,3	40,7	165,6	28,1	12	8	21
51	24	187,3	35,7	115,2	269,4	19,0	0	96	96
Barley									
74	24	44,5	22,1	8,5	103,5	49,6	87	0	87
75	24	49,5	25	17,1	93,7	50,4	79	0	79

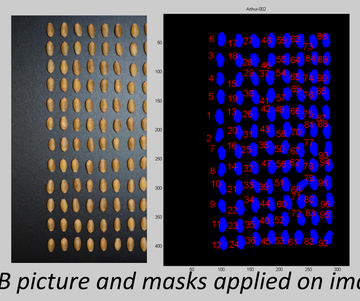
PLS model (barley) and results (wheat and barley) showing the classification of the treated single seeds in 2 groups: underdosing (<30%) and overdose (>30%) using NIR-HIS in comparison to UPLC

Vermeulen *et al.* (2017). Assessment of pesticide coating on cereal seeds by near infrared hyperspectral imaging. J. Spectral Imaging, 6: (a1), 1-7.

NIR Hyperspectral imaging system

A sorting issue: the quantification of the protein content

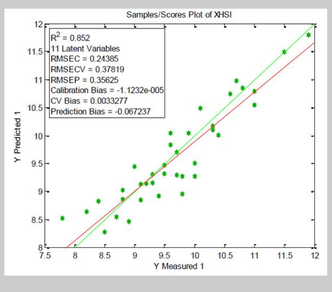
Analysing a cereals sample at kernel level in order to lower the sorting scale based on the quality parameters



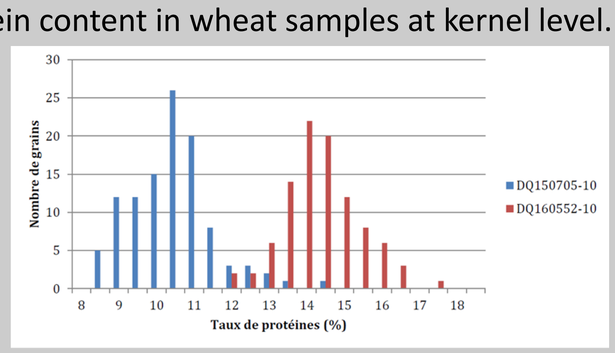
RGB picture and masks applied on images

Feed:
low protein content
Food (bread, pastery, …) :
high protein content

➢ The study has shown a large variability of protein content in wheat samples at kernel level.



PLS model validation performance



Distribution of protein content predicted at kernel level for 2 wheat varieties with low and high protein content

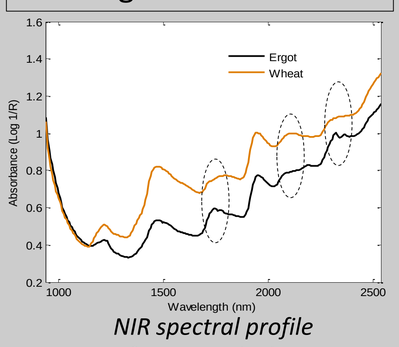
Dijon Arthur (2017). Évaluation de différents instruments de spectroscopie proche infrarouge pour la prédiction de la teneur en protéines de céréales analysées en graine à graine. Huy, HEC- ISIa, 108

A sampling issue: the ergot detection in cereals

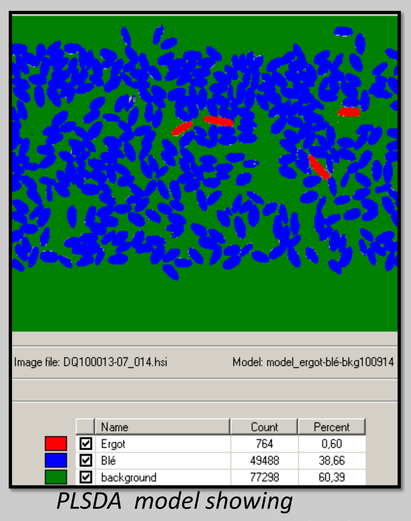
Scanning a sample portion as small as possible in order to lower the limit of the contaminant detection of NIRS technique

Ergot (claviceps purpurea)

EU limit: 0.05 % of ergots in cereals for human
Toxicity risk due to high alkaloid content

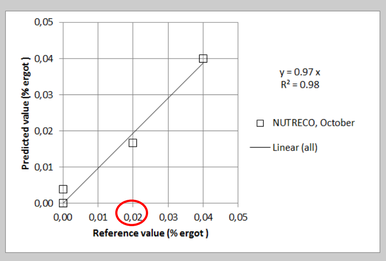


NIR spectral profile of ergot and wheat



PLSDA model showing the detection of ergot (red)

➢The validation on blind samples with an ergot concentration of 0.02 % has shown that the method could identify and quantify ergot contamination.



Validation results on real samples

Vermeulen *et al.* (2013). Validation and transferability study of a method based on near-infrared hyperspectral imaging for the detection and quantification of ergot bodies in cereals. Anal. Bioanal. Chem., 405: (24), 7765-7772.

Expected outcomes

These studies using NIR Hyperspectral imaging have proved that by combining spectral and spatial information, it is possible to tackle challenges facing the cereal industry.

Acknowledgments

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