Ensuring the Integrity of the European food chain

Case study for the assessment of Near Infrared Hyperspectral Imaging to determine adulteration of durum wheat

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Overview

Italian industrial pasta must be prepared using exclusively durum wheat - DW (*Triticum durum*). The use of common wheat - CW (*Triticum aestivum*) is forbidden. According to current Italian rules, only a maximum of 3 % of CW is allowed to account for cross-contamination that may occur during common agricultural process. However, mixtures of both wheats can be found due to accidental delivery problems or to fraudulent addition in order to reduce prices.

Introduction

For the time being, all the studies dealing with the detection of CW in DW use macroscopic, microscopic or molecular biology based methods usually performed at laboratory. Efficient methods for the detection of accidental or intentional contamination of CW to DW are required at industry. The current work aims to develop a fast method for the at-line and on-line detection of CW grains in a lot of DW grains based on NIR hyperspectral imaging.

Samples

77 samples of DW and 180 samples of CW were collected in Belgium and Italy in 2014, 2015 and 2016. The aim was to cover enough quality variability of DW at the reception of the Barilla Company as well as a large variability in terms of varieties for CW.

Species	Year	Country	Set name	Nb samples	Nb grains
DW	2014	Italy	DW1	20	320
	2015	Italy	DW2	32	511
	2016	Italy	DW3	25	400
CW	2014	Belgium	CW1	30	480
	2015	Belgium	CW2	35	560
	2016	Italy	CW3	25	400
	2016	Belgium	CW4	48	768
	2016	Belgium	CW5	42	666
Total				257	4,105

Table 1: Set of samples analysed.

Instrumentation

NIR hyperspectral imaging system with a conveyor belt (Burgermetrics) was used. Near spectra (1118-2425 nm) were recorded in reflection mode with 32 scans by pixel (300 µm x 300 µm). Images of 16 grains per sample were recorded.

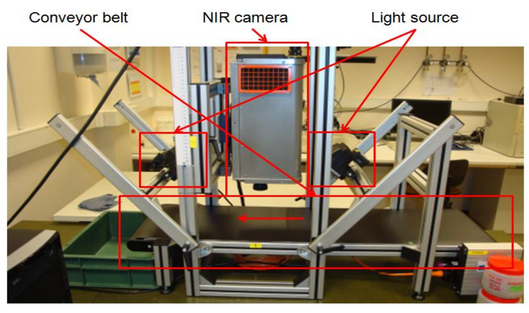


Figure 1: Line-scan NIR hyperspectral imaging system.

Masking / extracting the information

To extract the data from the image, a mask to isolate the grains was built by applying the density-based spatial clustering of applications with noise method (DBSCAN) procedure on each image.

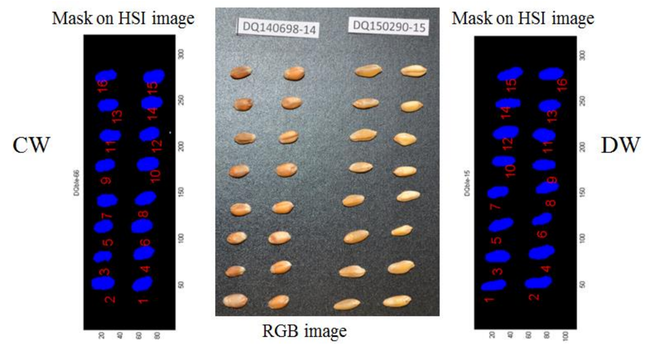
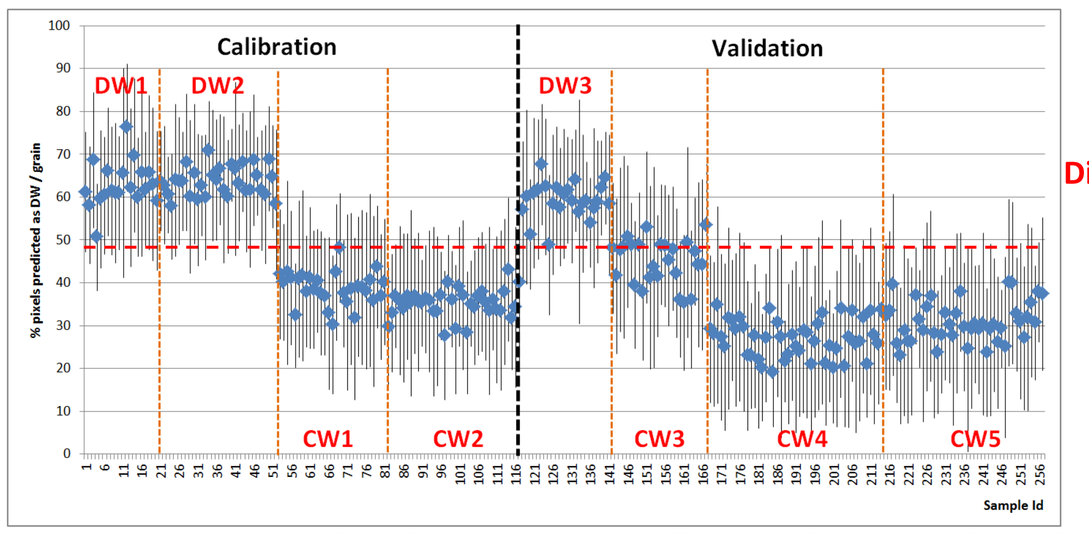


Figure 2: RGB picture and masks applied on images.

Data treatment and Results

A first step involved the construction of libraries from images for each class of species (DW and CW). To discriminate DW from CW, two approaches were studied. The first approach was based on NIR spectral profile and the second on 8 morphological criteria (area, perimeter, circularity, maxFeret, minFeret, aspect ratio, roundness and solidity). In all cases, the Chemometric tool Partial Least Squares Discriminant Analysis (PLS-DA) was used as classification method. Models were developed with samples collected in 2014 (DW1, CW1) and 2015 (DW2, CW2) and were validated with samples collected in 2016 (DW3, CW4, CW5). The models were applied either to all the individual pixels in all the images to be predicted or on the 8 morphological criteria. The results are presented at the grain level based on the individual approaches or by combining both approaches.

NIR spectral profile approach



Discrimination threshold DW/CW

Figure 3: Percentage of pixels predicted as DW (◆: mean by image +/- 2 SD) after applying NIR data model on the 257 images of 16 grains.

Morphological criteria approach

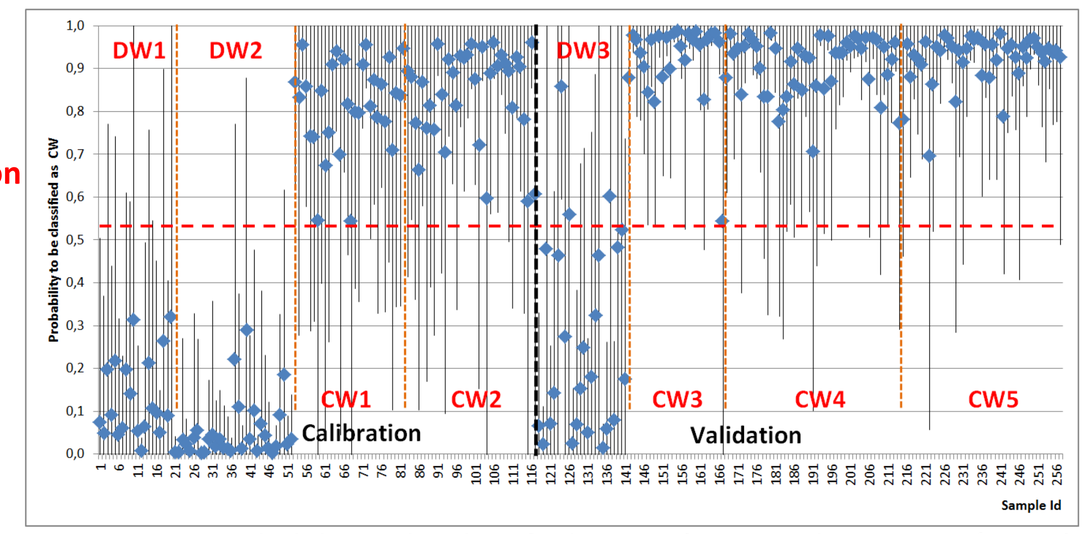


Figure 4: Probability to be classified as CW (◆: mean by image +/- 2 SD) after applying morphological criteria model on the 257 samples of 16 grains.

Data fusion – NIR and morphological criteria combination

The data fusion consists on combining the predicted value obtained by each approach individually and to calculate a new indicator. A grain is classified as CW if both approaches lead to a classification as CW. In the other cases, the grain is classified as DW. Table 2 shows the number and the percentage of CW and DW grains rightly classified according to the number of criteria used.

on 4,105 grains	DW (1,231 grains)		CW (2,874 grains)	
	Nb	%	Nb	%
1 criterion	*1 right criteria*		*0 right criteria*	
NIR spectral profile C2 (16 grains)	1,156	93.9	2,618	91.1
Morphological criteria C1 (16 grains)	1,084	88.1	2,712	94.4
2 criteria	*1 or 2 right criteria*		*0 right criteria*	
C1+C2	1,216	98.8	2,471	86.0

Table 2: Discrimination results between DW and CW grains according to 1 or 2 criteria.

Conclusion

The study shows the potential of NIR hyperspectral imaging combined with chemometrics to propose solutions for sorting grains and for detection of adulteration at the entrance of the production chain.

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