Single-kernel vitreousness assessment and optical sorting of durum wheat using NIR spectroscopy and imaging

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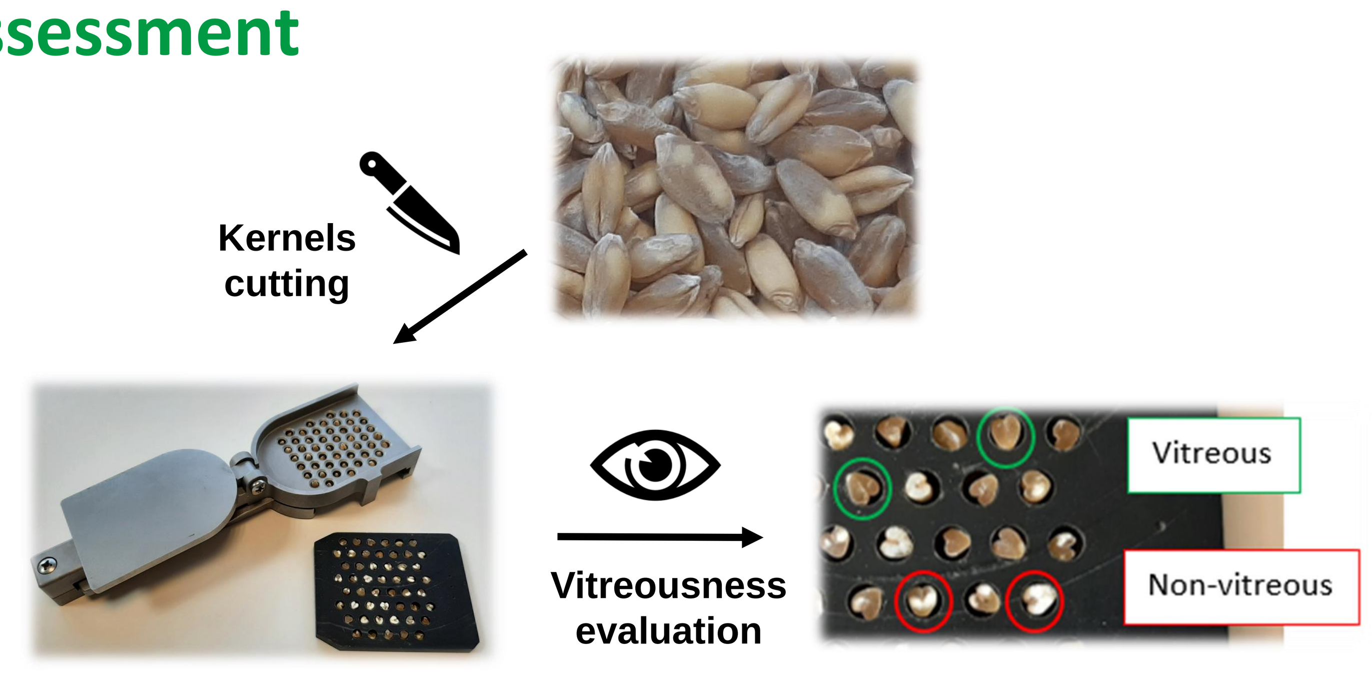
Alternative methods to the conventional durum wheat vitreousness assessment

Kernels vitreousness is a key commercial criterion assessing the technological quality of durum wheat (*Triticum turgidum ssp. durum*) intended for the food industry with a direct impact on semolina yield and pasta processing. The standard method used to grade the vitreousness of a batch relies on the tedious visual inspection of sliced kernels. Near-infrared (NIR) spectroscopy is an analysis technique already routinely used to provide rapidly and accurately various key parameters of wheat grain quality (protein content, moisture…). New prediction models were developed on two benchtop spectrometers, a hyperspectral imager, and a single-kernel analyzer and sorting system with samples from CRA-W trials conducted between 2021 and 2023.

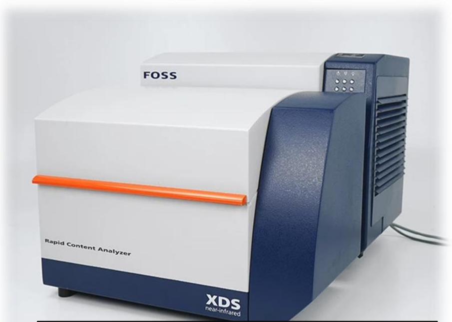


Visual method of reference to measure vitreousness using Pohl's grain cutter.

Near-infrared spectroscopy

Conventional NIR spectroscopy is a reliable method to assess many parameters of post-harvest cereal grain quality. Partial least square (PLS) regression models were developed to predict vitreousness on the XDS with 196 samples in the spectral range from 1100 to 2500 nm and on the NOVA with 141 samples in the spectral range from 900 to 1100 nm. The prediction results obtained in validation reached ratios of performance to deviation (RPD) above 2 for both instruments. The shorter spectral range of NOVA compared with XDS is offset by the difference in sample quantity analyzed critical in vitreousness analysis. This approach provides an approximate assessment of vitreousness but can be used for a prediction combined with other quality parameters.

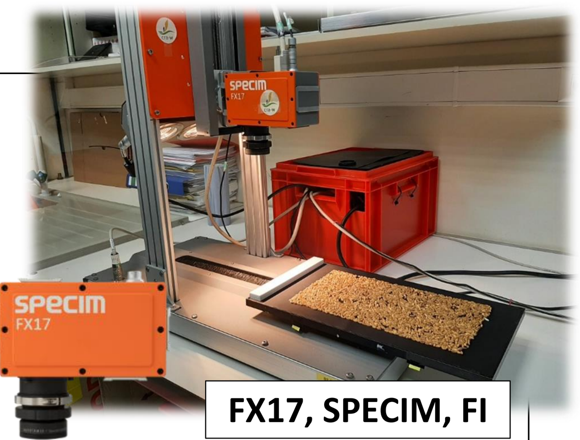
Infratec NOVA, FOSS, DK



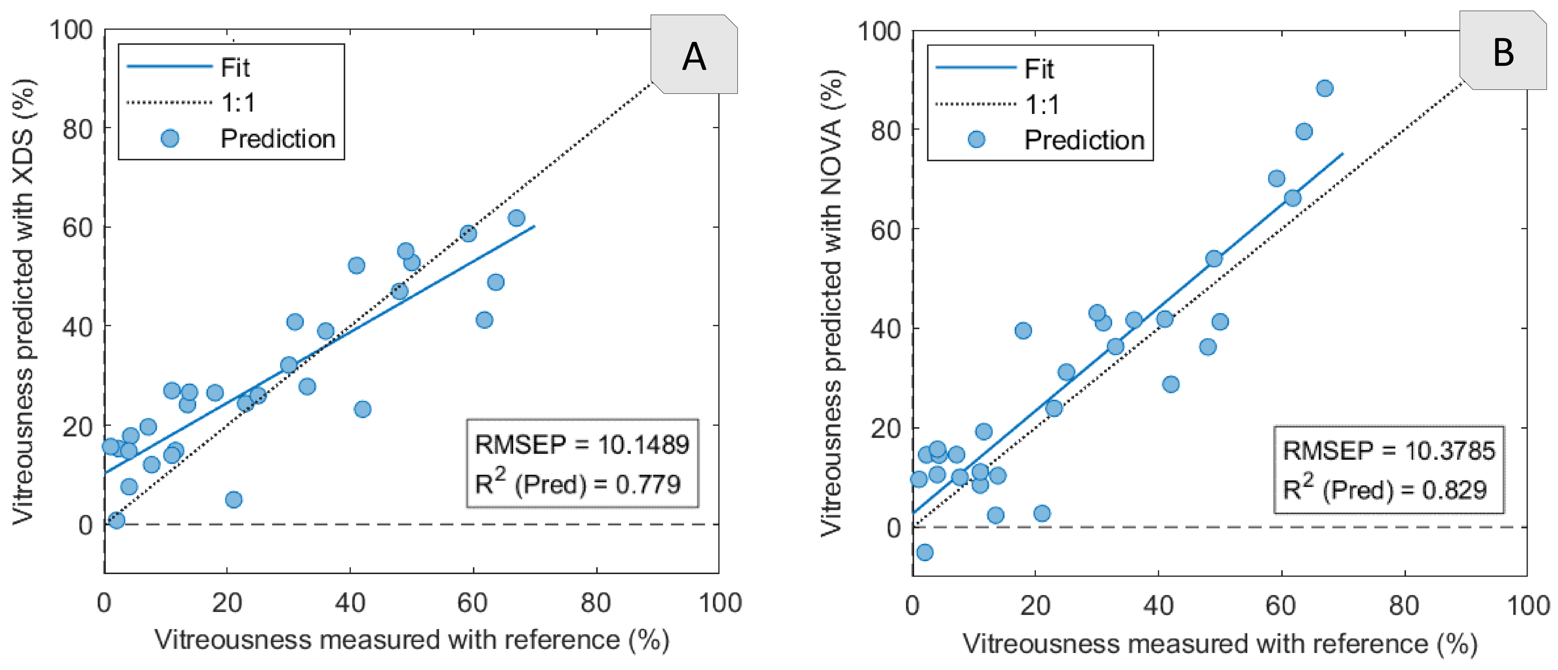
XDS NIR Rapid Content Analyzer, FOSS, DK

Near-infrared hyperspectral imaging

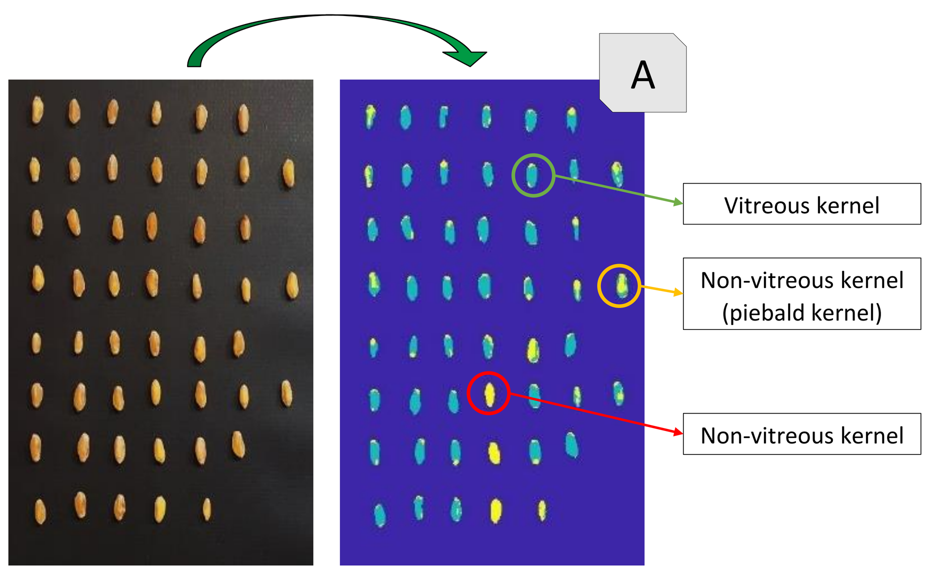
NIR hyperspectral imaging provides a high spatial and spectral resolution which enables the characterization of parameters unevenly distributed in a sample. Two analysis approaches and sample displays were evaluated: at kernel-level and in bulk. The assessment at kernel-level enabled a classification with a sensitivity of 73.5 % and a specificity of 92.4 % for non-vitreous kernels from the analysis of 81 samples in replicate. Errors in predictions mostly concerns piebald kernels (partially non-vitreous). Bulk analysis results were expressed by the ratio of pixels predicted as non-vitreous on the total number of kernel pixels. This approach offers a better batch representativeness because it takes larger samples into account than at kernel-level but correlation with the reference values is challenging due to variations in the presence of piebald kernels between batches.



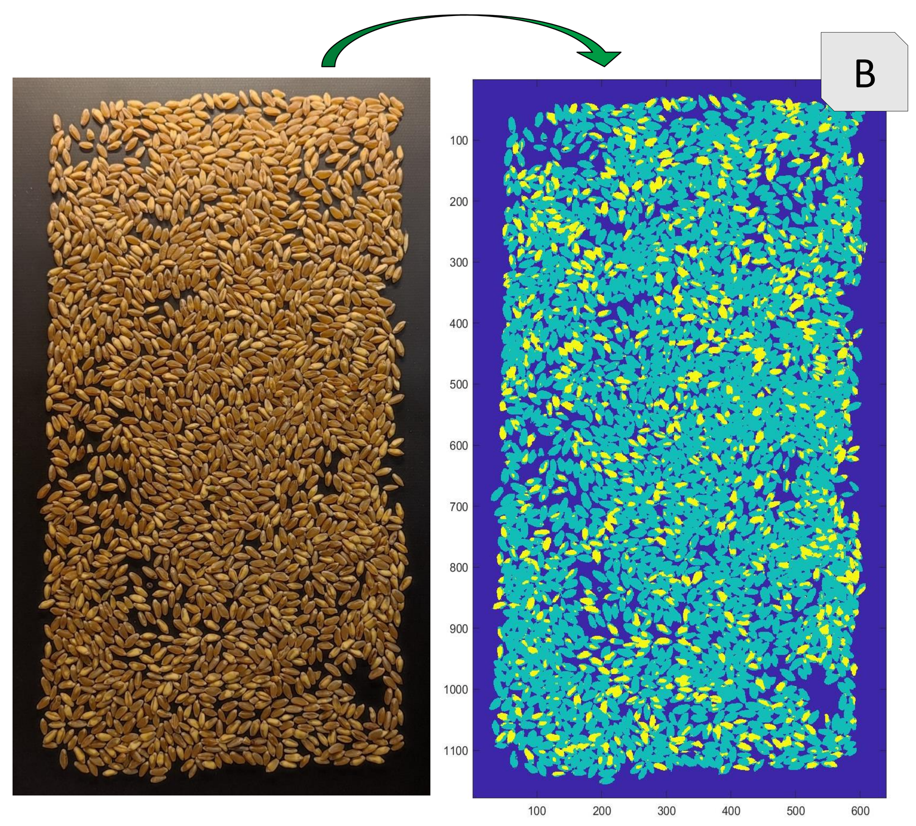
FX17, SPECIM, FI



Durum wheat samples vitreousness prediction plot of a validation set in relation to the reference value from mean spectra acquired with the XDS (A) and NOVA (B).



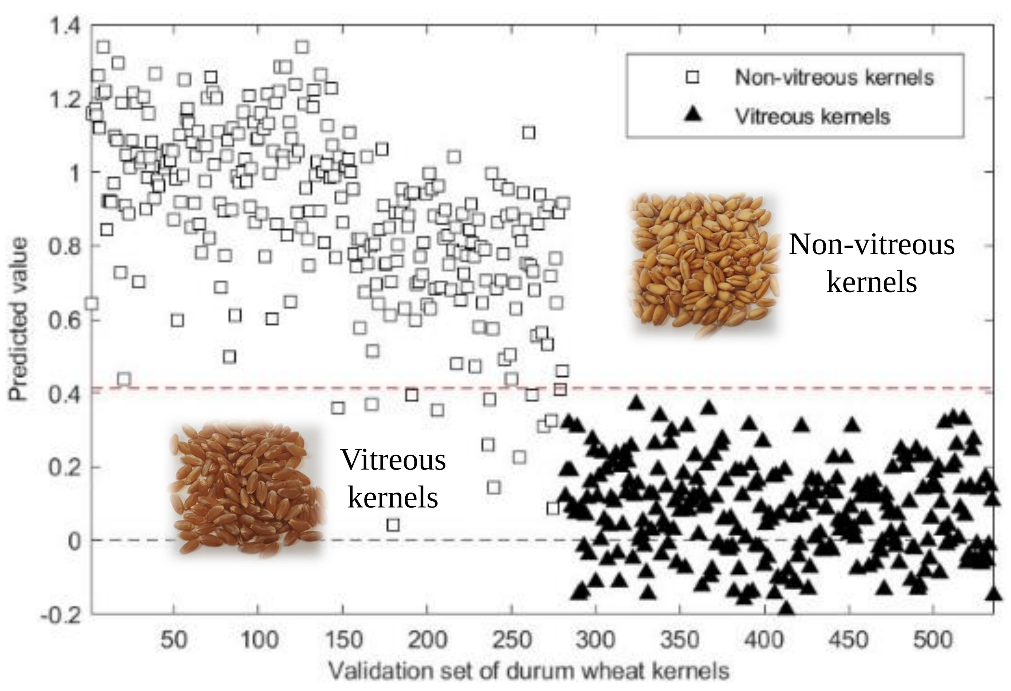
Durum wheat kernels measurement with NIR HSI FX17 of a sample at kernel-level (A) and in bulk (B) illustrated by the RGB image (left) and the vitreousness prediction image (right).



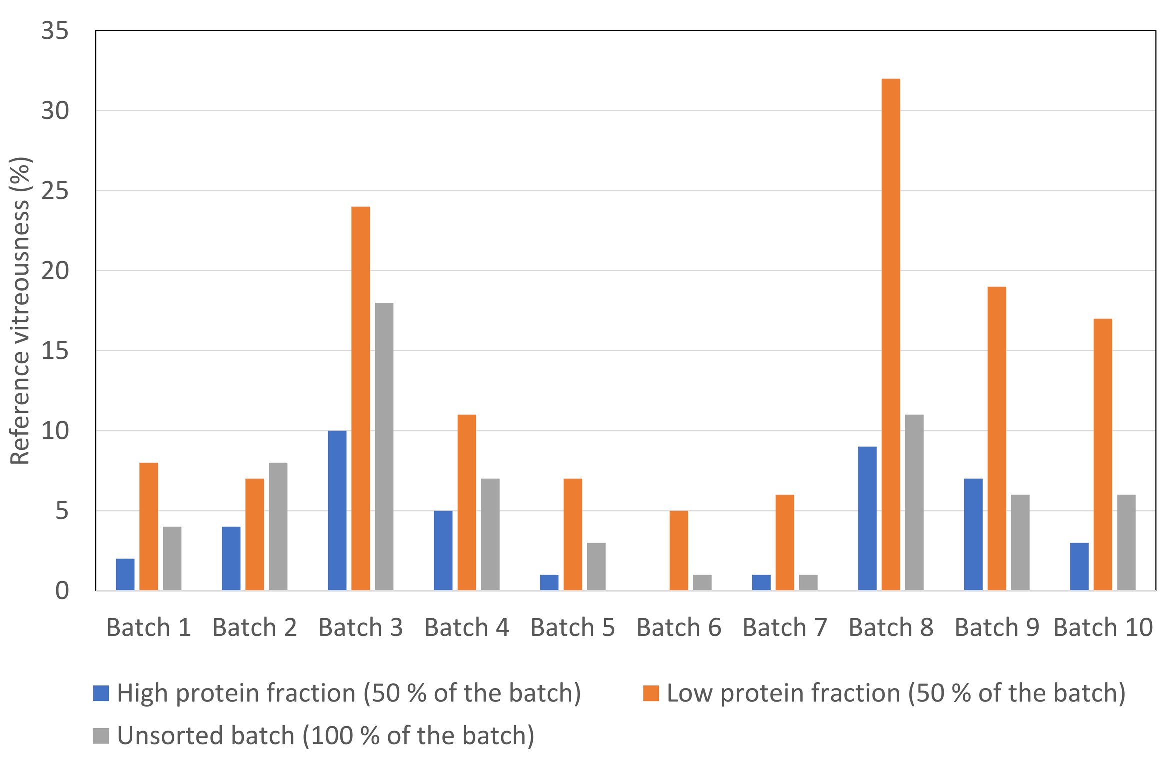
Optical sorting : an effective way to add value

A sorting machine based on reflection NIR analysis (900-1700 nm), the QSorter Explorer, was tested to improve the quality of durum wheat batches. This system allows for the measurement of individual kernels and their classification into a low and a high fraction of fixed proportions. A partial least square discriminant analysis (PLS-DA) model was developed to distinguish between vitreous and non-vitreous kernels. It provided promising results for batch sorting, with a classification error of 2.6 % on a validation set. Additionally, a PLS regression model to predict kernels protein content was developed with 140 samples and applied to divide batches into two equal fractions grouping together kernels with low and high protein contents. While vitreousness is primarily associated with protein content, it can also be influenced by the crop year, climatic conditions and varietal sensitivity. Therefore, both classifications methods based on either vitreousness or protein content proved to be complementary to improve the quality of a batch.

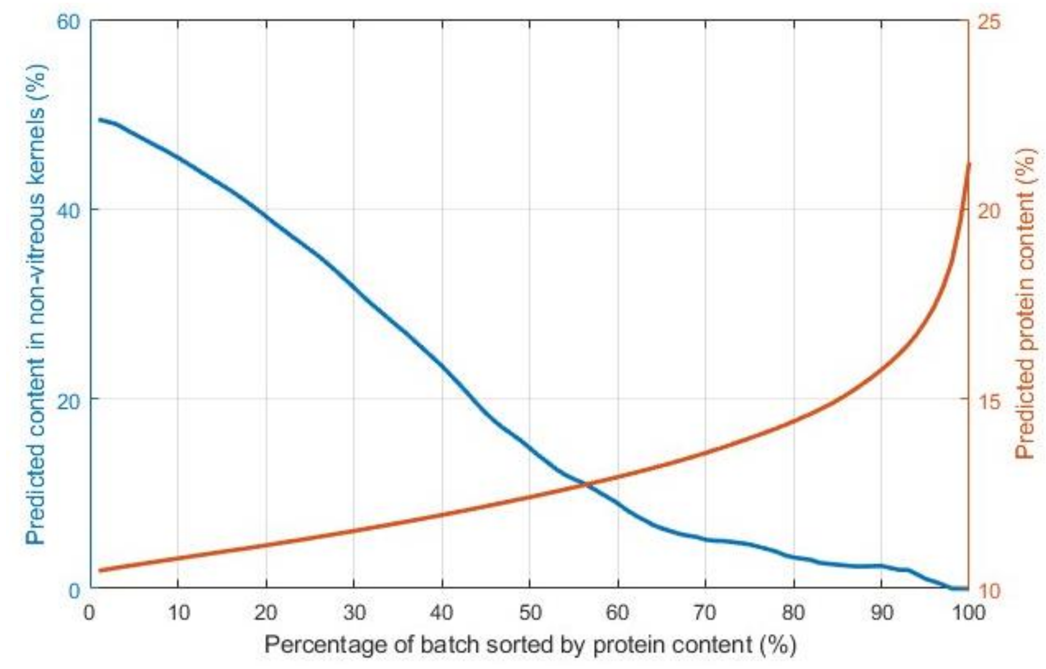
QSorter EXPLORER 2.0, QualySense AG, CH



Durum wheat kernels classification performances of the vitreousness PLS-DA model developed at kernel-level with the QSorter single-kernel analyzer obtained on a validation set.



Vitreousness of fractions sorted at 50 % of the batch based on protein content compared to the unsorted batch.



Evolution of the average vitreousness and protein content in the high fraction at different sorting proportions of a batch (0 to 100 %).

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