



Quality assessment of protein-rich crops using NIR spectroscopy and hyperspectral imaging



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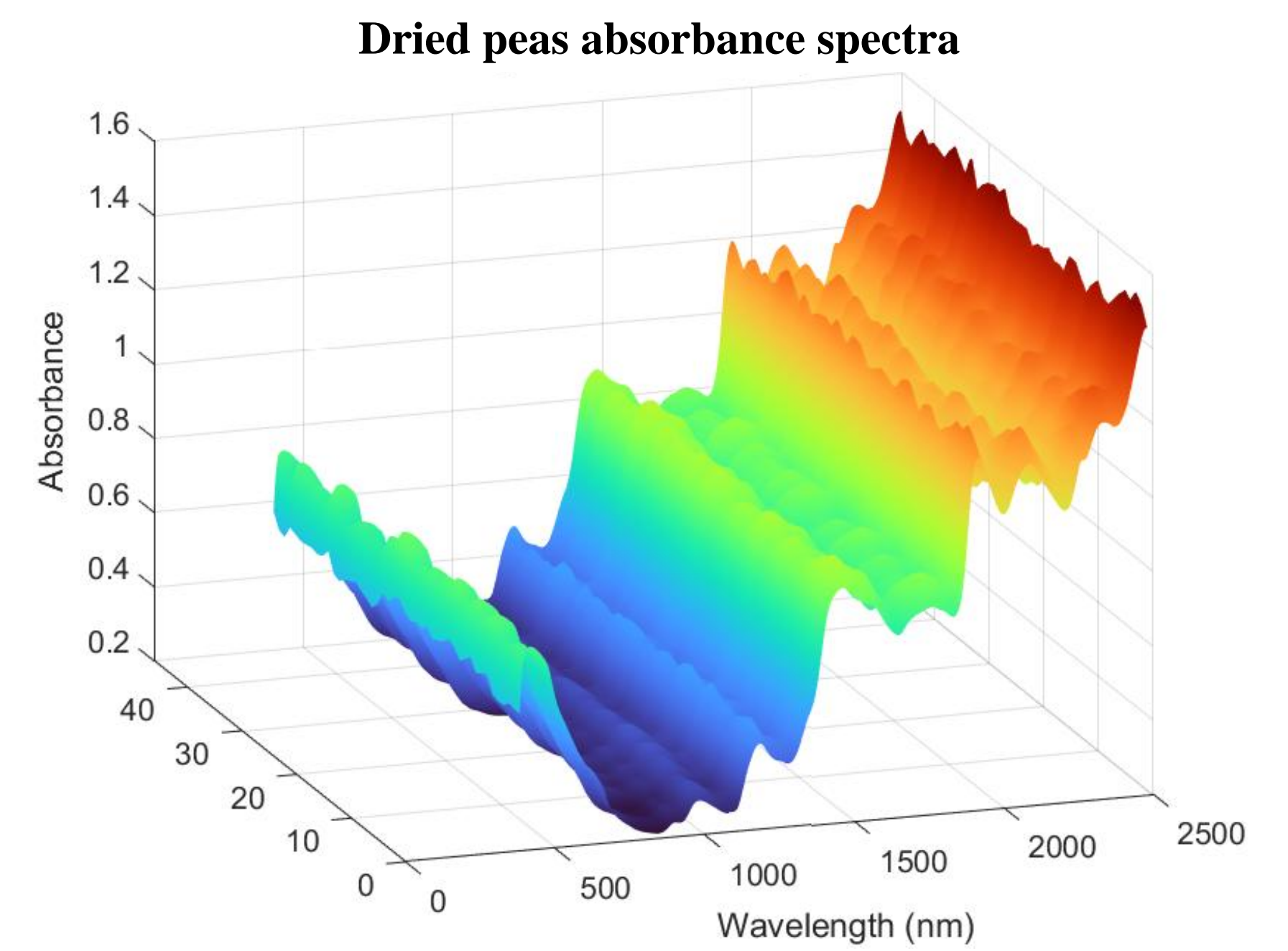
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Near-infrared (NIR) spectroscopy is a commonly used technology to predict the **composition** of agricultural products such as **protein-rich crops** from the measured spectra of infrared light interacting with matter. This method has several advantages compared to conventional wet chemistry:

- **Fast**
- **Cost effective**
- **Environmentally-friendly**
- **User-friendly**
- **Non-destructive**
- **...**

Spectroscopy can be applied at **batch-level** (composition), **kernel-level** (sorting) or **pixel-level** (impurities and contaminants detection) depending on the devices used and the needs.

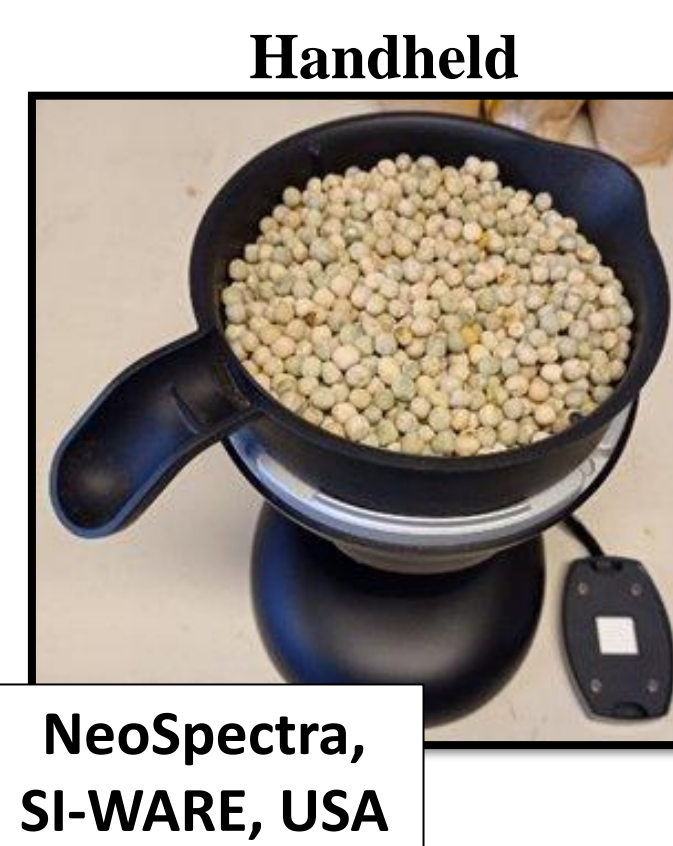
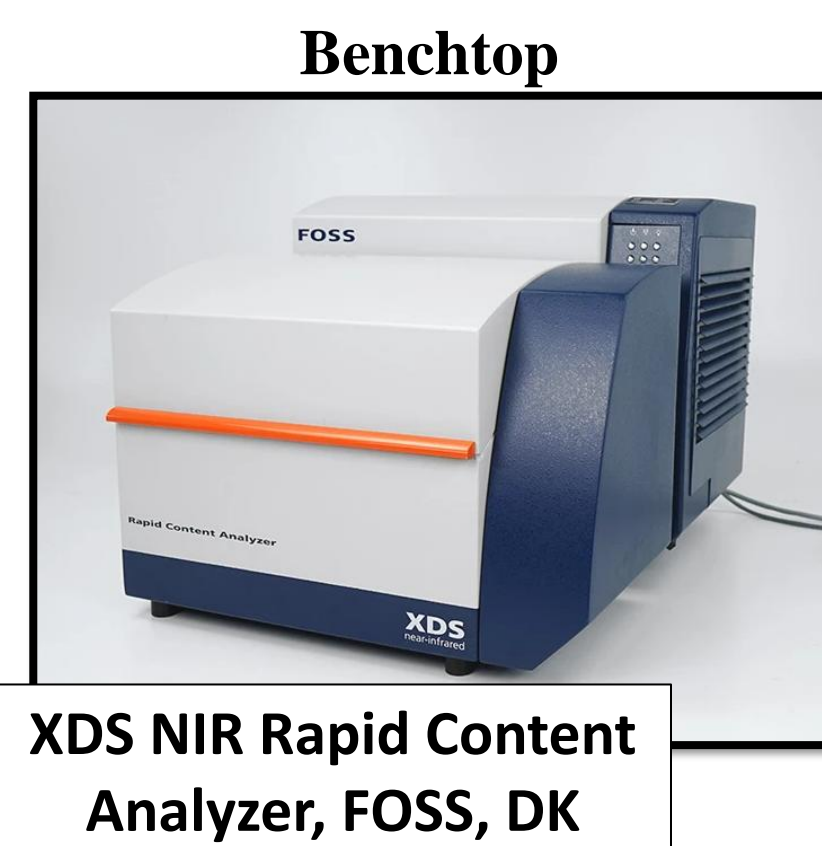


NIR spectroscopy: an efficient prediction tool

Benchtop or handheld **spectrometers** are used to predict various **composition** parameters such as:

- ✓ Protein
- ✓ Moisture
- ✓ Fat
- ✓ Fiber
- ✓ Starch
- ✓ Ash
- ✓ ...

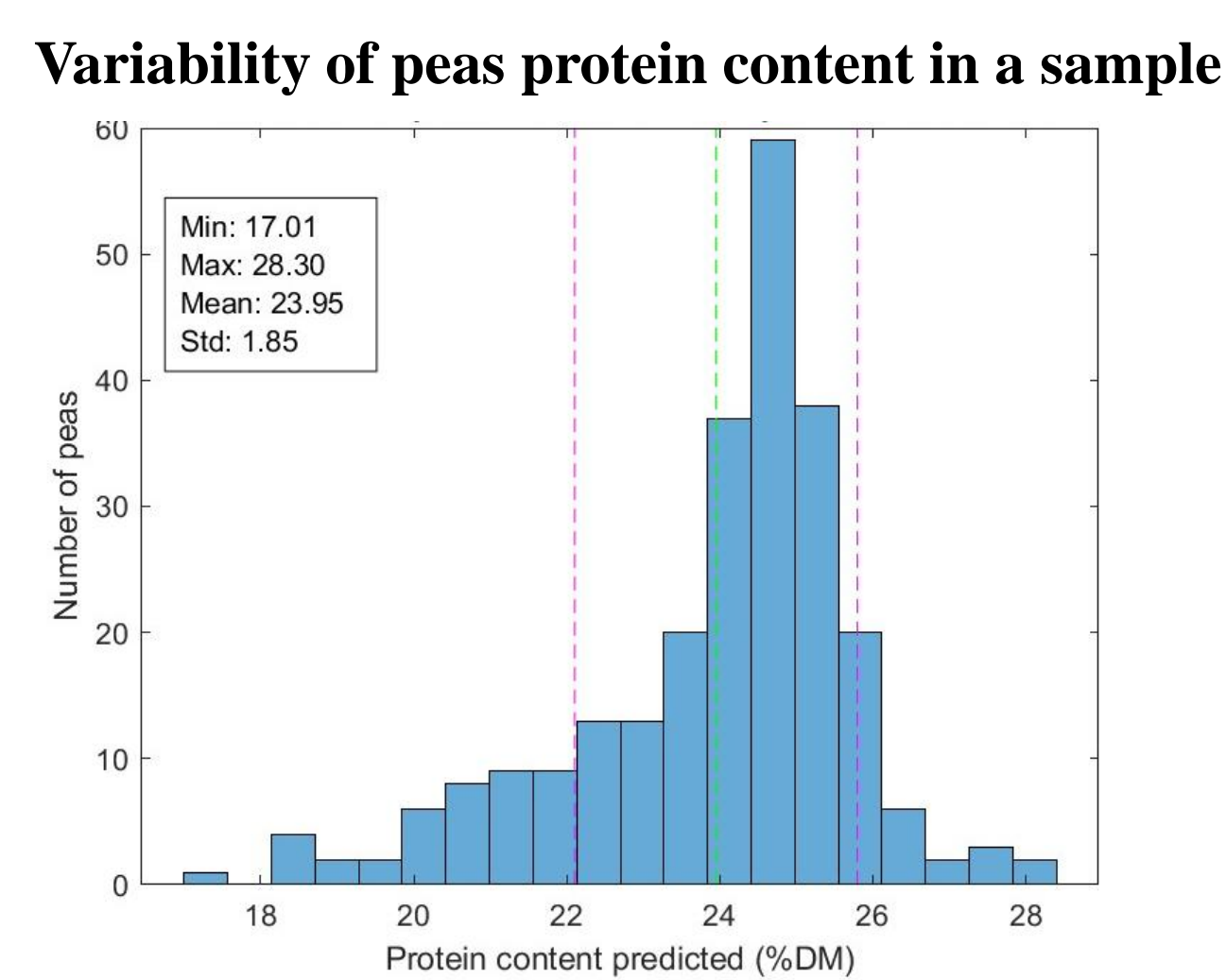
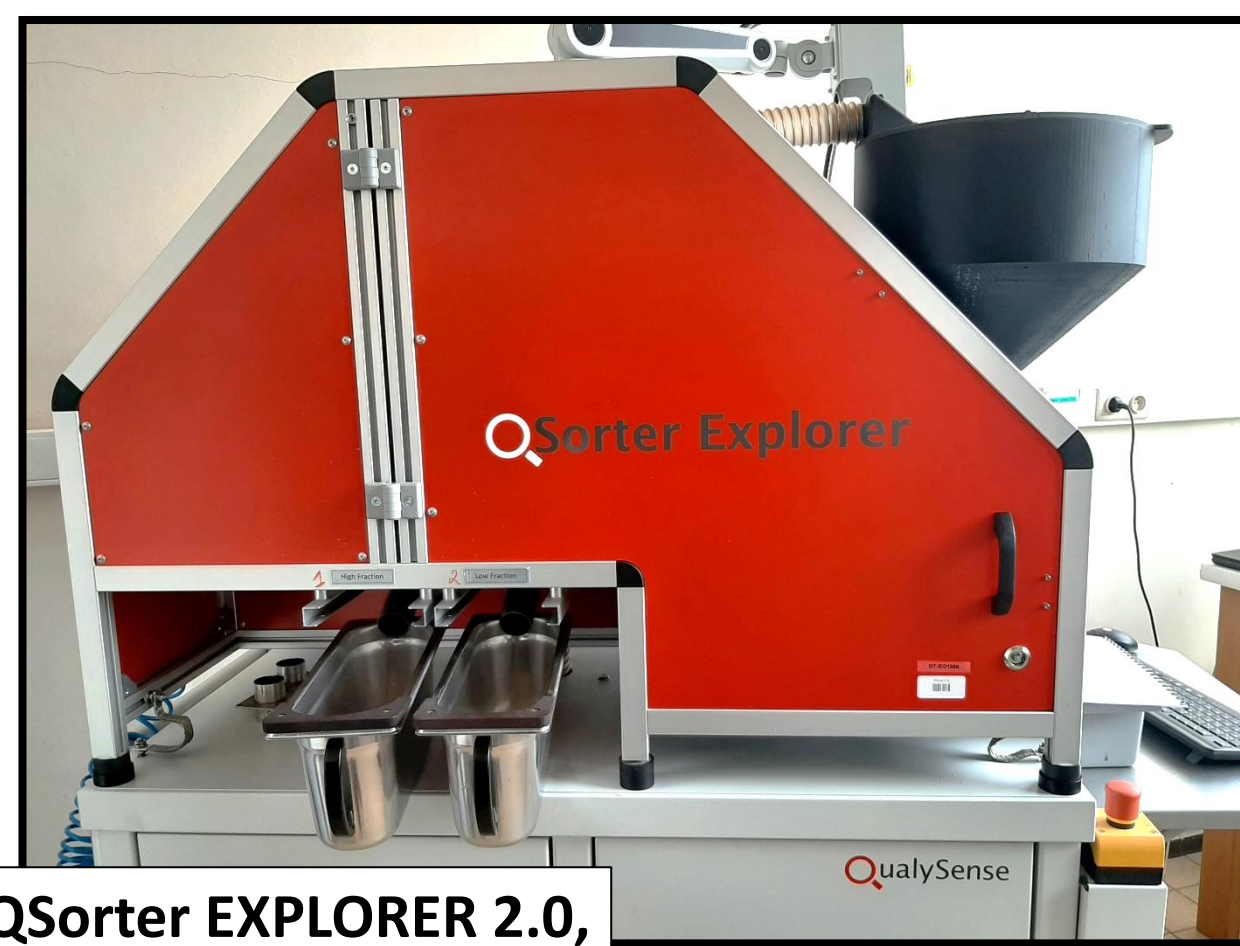
Predictions models can be developed for specific or generic products and on whole or ground samples.



Prediction performances of the models developed for protein-rich crops for the XDS NIR Rapid Content Analyzer on ground samples

Parameter	Unit	Mean	SD	Range	R ²	Error (CV)
Moisture	%	12.1	1.87	1.9 – 17.7	0.92	0.52
Fat	% as is	1.8	0.65	0.0 – 3.8	0.97	0.11
Protein	% as is	24.0	4.87	9.3 – 38.6	0.99	0.60
Fiber	% as is	8.34	3.22	0.0 – 18.0	0.96	0.68
Ash	% as is	3.81	1.78	0.0 – 9.2	0.99	0.21
Starch	% as is	31.3	14.9	0.0 – 76.0	0.99	1.25

NIR optical sorting: an effective way to add value to products



Spectrometers can be used for **single-kernel** analysis and coupled with a **sorting** system (30 kernels/sec). These devices allow for the classification of kernels in different fractions based on their intrinsic properties such as protein content.

Single-kernel sorting is useful to **remove impurities** and/or **segment** batches in fractions of desired composition to **better** match the **quality** to the processing needs.

In the case of peas sorting, a model based on protein content enables the creation of high-protein batches which can, for instance, help identify kernels with superior traits for **breeding purposes**, thus supporting the selection of lines with higher breeding potential.

NIR hyperspectral imaging: a precise and targeted detection method

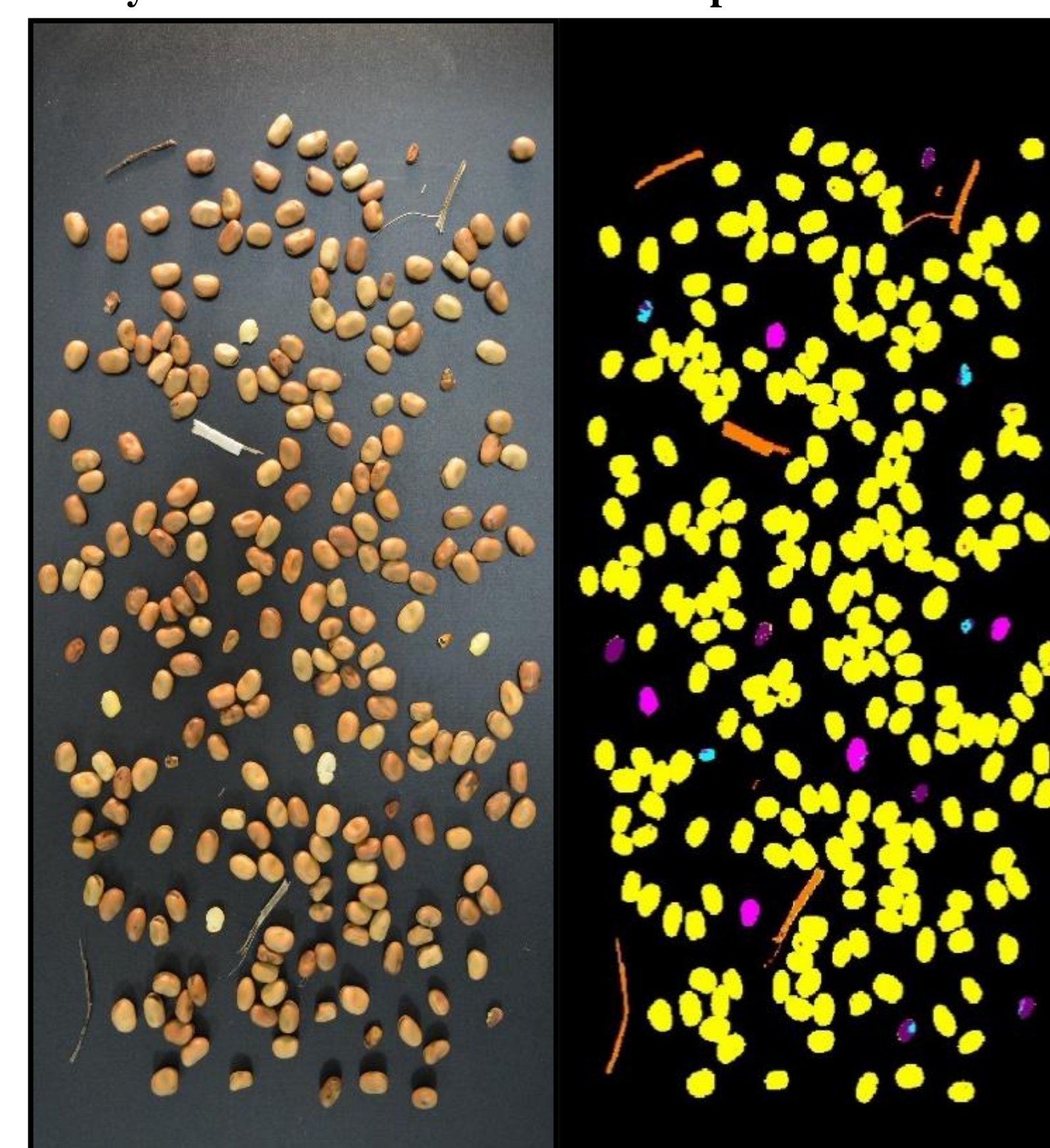
Impurities detection and quality assessment of crops can be carried out using hyperspectral cameras. By combining both the **spatial** and **spectral information** of the measured samples, this method provides a targeted and reliable detection of contaminants which may be difficult to identify for the human eye. Sample purity can therefore also be easily assessed.

In the case of faba beans **purity assessment**, 7 models are applied consecutively in a dichotomic way to identify different impurity groups and extrapolate purity from a ratio of pixels.

Performances of faba bean impurities classification models applied consecutively on a pixel basis for the SWIR camera

Model level	Classes	Sensitivity (Cal) [%]	Specificity (Cal) [%]	Sensitivity (Val) [%]	Specificity (Val) [%]
Model 1	Soil & Pebbles vs. Rest	97.1	98.7	100	97.7
Model 2	Plastic Waste vs. Rest	100	100	99.8	99.8
Model 3	Insects vs. Rest	99.7	98.4	96.3	98.6
Model 4	Bean Stalks, Pods & Germs vs. Rest	97.6	97.9	95.1	96.7
Model 5	Broken Beans vs. Rest	98.8	98.9	96.0	96.3
Model 6	Bean Shells vs. Rest	88.1	89.2	98.0	88.0
Model 7	Shriveled Beans vs. Healthy kernels	97.4	90.8	91.4	92.5

Purity assessment of faba beans and specific detection of impurities



Sample purity: 93.8%

Color legend

Yellow	Healthy faba beans
Purple	Shriveled beans
Cyan	Bean shells
Magenta	Broken beans
Orange	Beanstalks, bean pods & straw
Blue	Insects
Green	Plastic waste
Red	Soil & pebbles
Black	Background



Quality assessment using **NIR spectroscopy** has a lot of **potential** to make the use of **protein-rich crops** as effective as possible. As presented, this **versatile** technology can be **easily applied** along the processing chain to **ensure quality** from the producer to the end-user.

However, to be efficient, predictive models need to be **carefully calibrated** and **validated** with a large panel of samples covering all potential variations and reliable reference data, as well as regularly **monitored** to check the conformity of the prediction.