Wallonie recherche CRA-W

Centre wallon de Recherches agronomiques

SWIR Hyperspectral Imaging

Applications in impurities detection and quality assessment of seeds

Damien VINCKE

Corentin Demoitié; Juan Antonio Fernández Pierna; Philippe Vermeulen; Nicaise Kayoka; Antoine Deryck; Vincent Baeten

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Specim webinar, February 5th 2026


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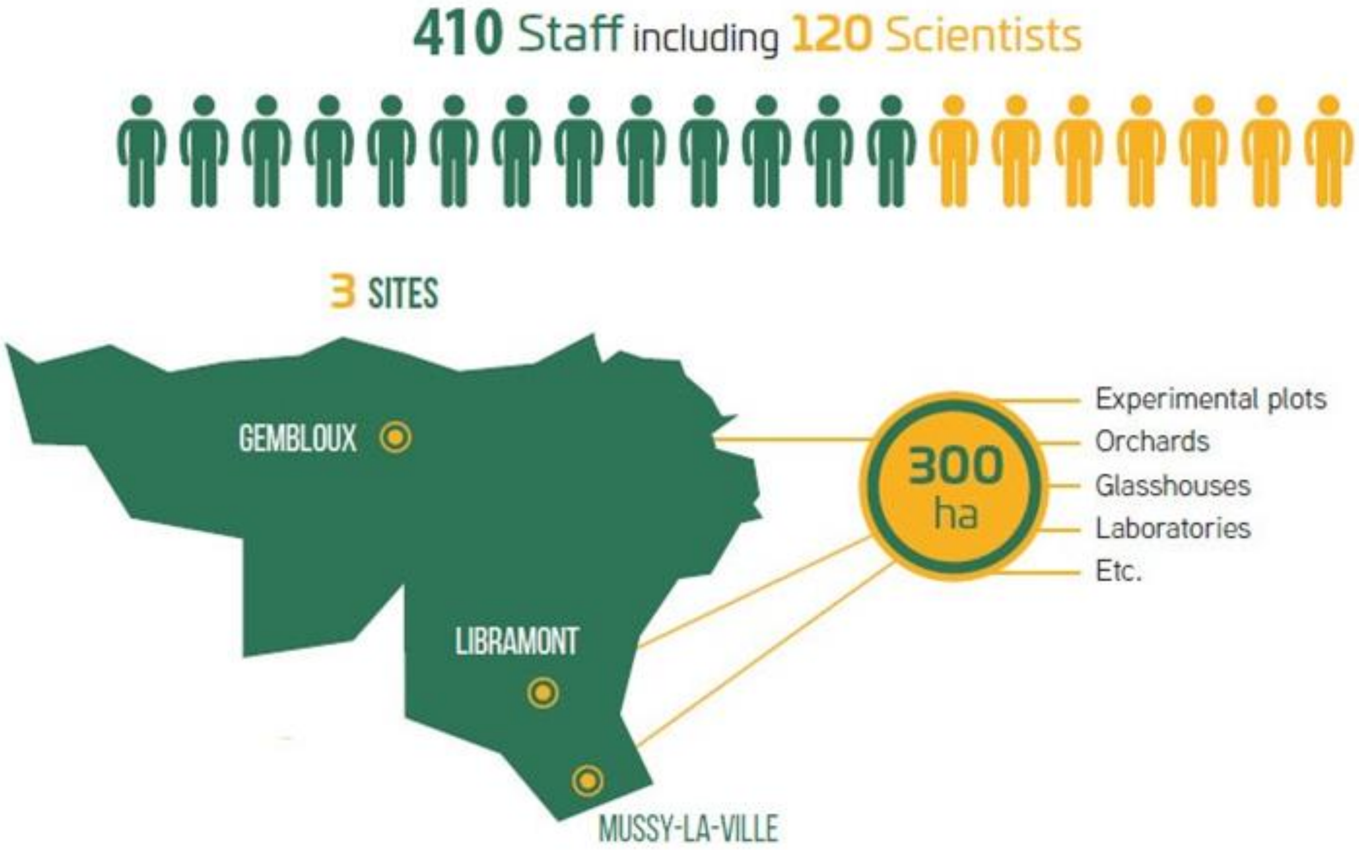
Bastogne

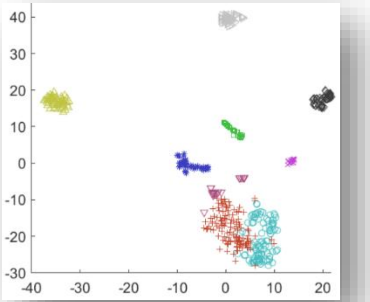

410 Staff including 120 Scientists
3 SITES
GEMBLOUX
LIBRAMONT
MUSSY-LA-VILLE
300
ha
Experimental plots
Orchards
Glasshouses
Laboratories
Etc.

Quality and Authentication of Products Unit – CRA-W

Wallonie agriculture SPW

4 MAIN RESEARCH FIELDS

PRECISION AGRICULTURE	PRECISION LIVESTOCK FARMING	RISK MANAGEMENT	UNDERSTANDING PRODUCTS
Field & orchard analysis	**Farm & industry analysis**	**Laboratory analysis**	**Laboratory analysis**
PheNet (2023-2027)	**MobiLAB (2022-2025)**	**DepiPEST (2022-2025)**	**Walprot (2023-2027)**
NIR imaging solutions for phenotyping of wheat	Mobile laboratory dedicated for the demonstration and dissemination of photonics and digital solutions	MIR & Raman (+ chroma., U10) for the detection of fraud in pesticides products	NIR & NIR imaging (+ optical sorting /chemistry U11) for protein crops



sensor FINT

farmYng

BROMEDIR

WAL'PROT

PHENET
PHENOTYPING & ENVIROTYPING SOLUTIONS FOR AGROECOLOGY

InnOBreed

HappyMoo

WHEAT WATCHER
DIGITALLY MONITORED SOIL AND CROP HEALTH

Mobilab

Qualispectra (Win4Collective)

Quality and authentication of agricultural products Unit

Implementing and validating various operations with a view to being a dynamic, innovative and sustainable research player committed to the quality and authentication of agricultural and agri-food products. The unit also seeks to boost the Walloon agri-food sectors by improving the quality, traceability and typicality of their products, focusing in particular on products from the short distribution and organic sectors.

Objectives

Developing and applying knowledge, analytical methods and innovative tools to ensure product quality and authentication.

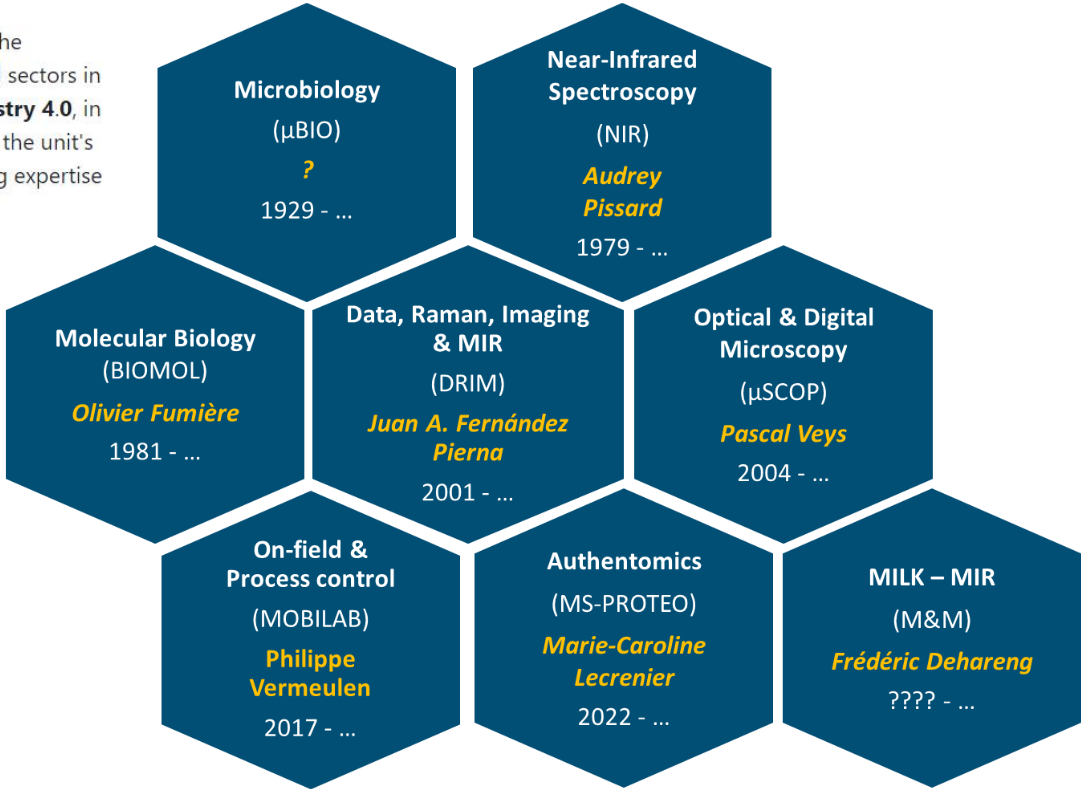
Developing knowledge in the field of agri-food product quality and authentication

Participating in the **European Research Area** (ERA).

Ensuring a **technological and analytical watch** in the field of molecular biology, chemometrics, bioinformatics, imaging, database management, microbiology, microscopy and vibrational spectroscopy.

Lending support to the agricultural and food sectors in the **roll-out of Industry 4.0**, in particular by sharing the unit's sensor and modelling expertise

Developing **innovative, rapid and sustainable analytical methods**.



Head of Unit: Dr Vincent Baeten

Scientific Director Unit QAP

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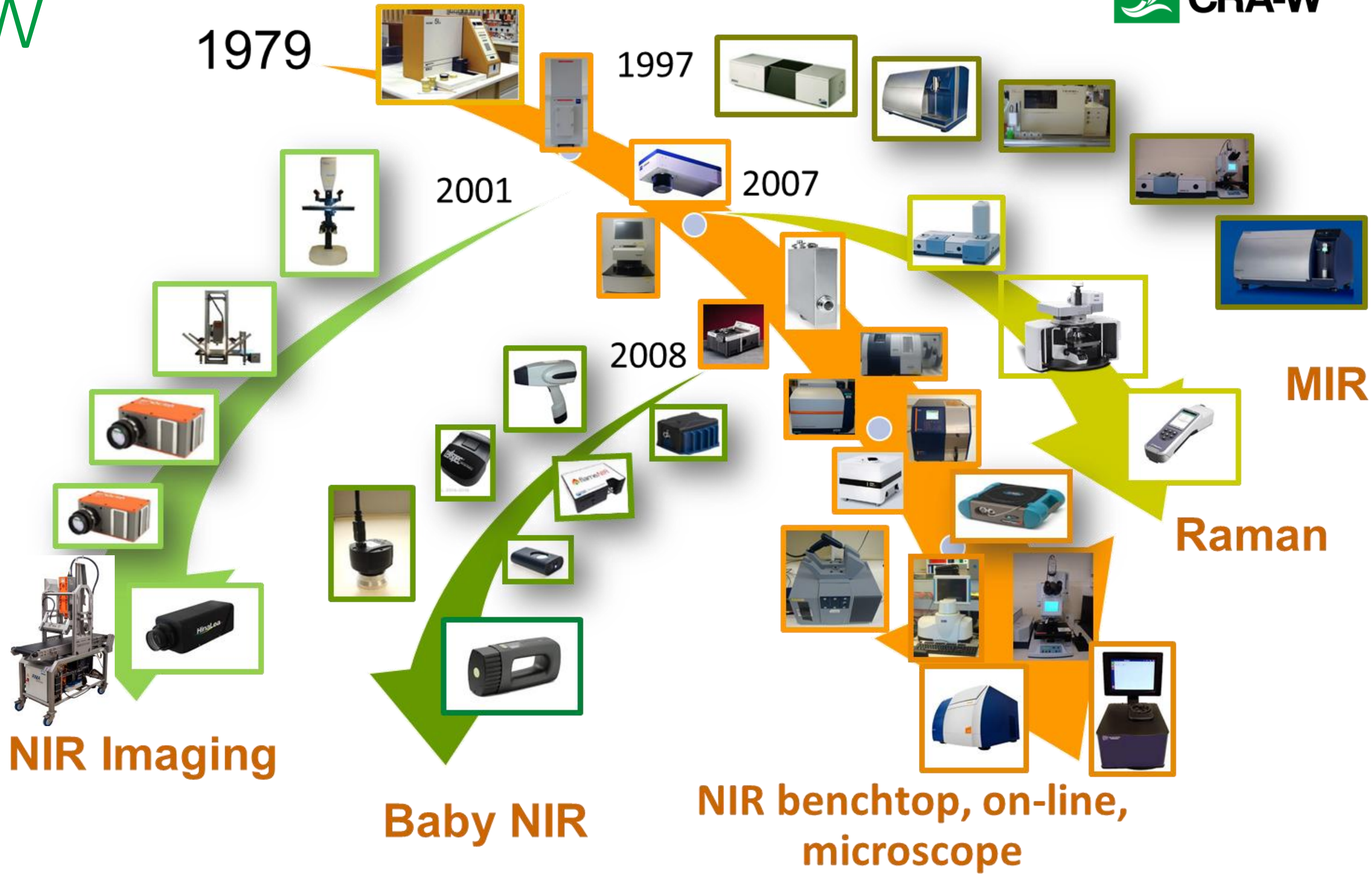
Vibrational Spectroscopy

At the CRA-W

Vibrational Spectroscopy

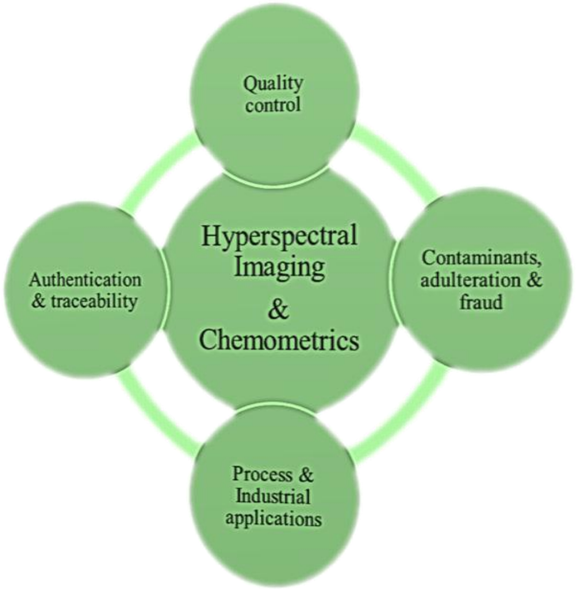
- No or limited sample prep (drying, grinding, …)
- No additional reagents necessary
- Fast measurement even on moving sample (conveyor belt, ..)
- Non-invasive (do not alter the sample)
- Simultaneous determination of different constituents

Fast	Easy
Cost-efficient	Eco-friendly



Hyperspectral Imaging at the CRA-W

20 years of history



- 2006 • EASIM – 06 Umeå
- 2009 • **EASIM – 09 Gembloux**
- 2010 • IASIM-10 Dublin
- 2011 • Hyperfest-2011 – Riga
- 2012 • IASIM 2012 – Sigulda
- 2014 • IASIM-14 Rome
- 2016 • IASIM-16 Chamonix-Mont-Blanc
- 2018 • IASIM-18 Seattle
- 2022 • IASIM-22 Esbjerg
- 2024 • **IASIM-24 Bilbao**

8 DIFFERENT IMAGING SYSTEMS

> 45 PEER REVIEW PAPERS

> 10 BOOK CHAPTERS

> 15 PROJECTS

NUMEROUS CONFERENCES AND TRAINING COURSES

Specim Spectral Imaging — BurgerMetrics

Specim Spectral Imaging — SpectraPartners — RMA Techniek

Contaminant detection
Maize kernels

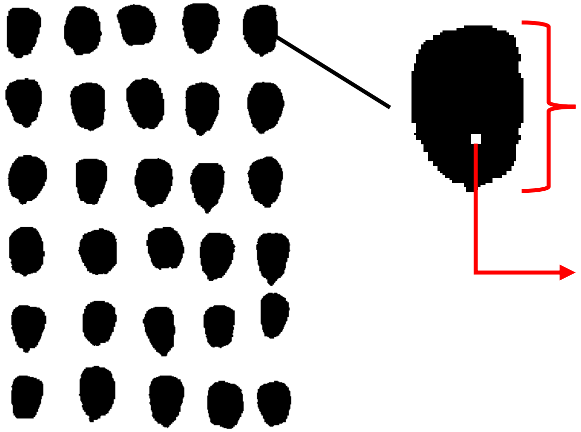
Detection of undesirable materials in white maize from South Africa

Sound kernels

13 classes of undesirable materials:
- **Damaged kernels (heat water, fungus, rodent, ...)**
- **Foreign material (other seed or plant material)**
- **Other colour maize (yellow)**

Classification with Partial Least Squares Discriminant Analysis (PLS-DA)

One model per contaminant, **Two approaches:**



Object wise (average spectrum)

Pixel wise (individual spectrum/pixel)

Food Analytical Methods
https://doi.org/10.1007/s12161-019-01464-0

Near Infrared Hyperspectral Imaging for White Maize Classification According to Grading Regulations

Kate Sendin[1] · Marena Manley[1] · Vincent Baeten[2] · Juan Antonio Fernández Pierna[2] · Paul J. Williams[1]

Stellenbosch University Iyunivesithi Universiteit

Contaminant detection

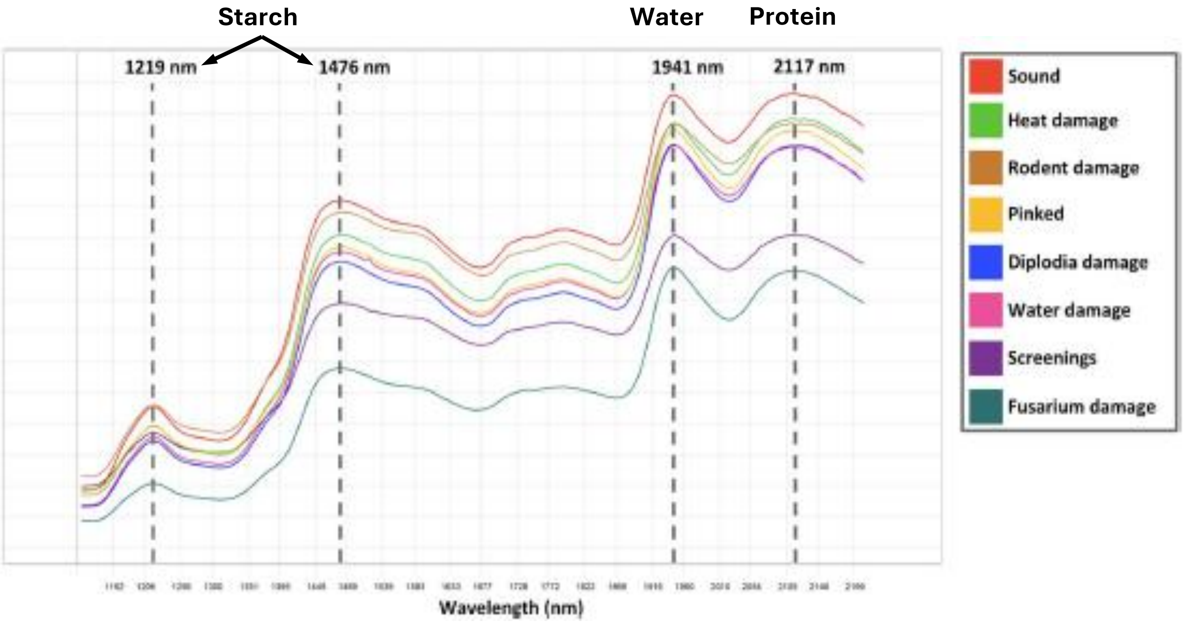
Maize kernels

Detection of undesirable materials in white maize from South Africa

PLS-DA results:

At object level
8 models have an accuracy of 100%, lowest accuracy = 98%

At pixel level
Large incidence of errors, with classification accuracy varying between 63% - 99.7%



Important wavelengths for the discrimination are related to starch, water and protein

Food Analytical Methods
https://doi.org/10.1007/s12161-019-01464-0

Near Infrared Hyperspectral Imaging for White Maize Classification According to Grading Regulations

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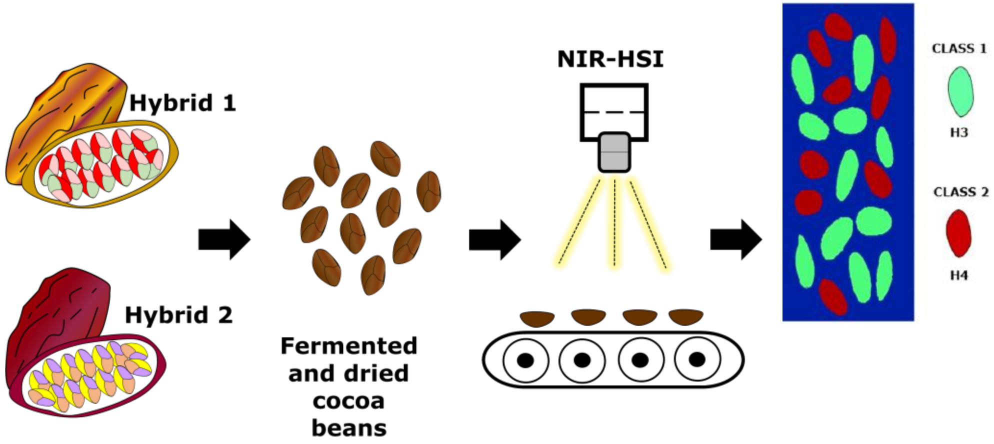
Authentication & Traceability

Cocoa beans

Discrimination of beans from 5 different hybrid genotypes



Classification with two methods:

- Partial Least Squares Discriminant Analysis (**PLS-DA**)
- Support Vector Machines (**SVM**)

Two classification strategies:

1) Two-class models (one hybrid against another)

→ **PLS-DA and SVM are comparable** (prediction error = 0-22.5%)

2) Five-class models (all hybrids together)

→ **SVM provides the best results** (prediction error = 3.8-23.1%)

Better predictions obtained with the average spectrum of a bean instead of its individual pixels

Food Control 118 (2020) 107445

Contents lists available at ScienceDirect

Food Control

journal homepage: www.elsevier.com/locate/foodcont

ELSEVIER

Authentication of cocoa (*Theobroma cacao*) bean hybrids by NIR-hyperspectral imaging and chemometrics

J.P. Cruz-Tirado[a], Juan Antonio Fernández Pierna[b], Hervé Rogez[c], Douglas Fernandes Barbin[a,*], Vincent Baeten[b]

Quality control & fraud detection

Durum wheat

Detection of potential contamination with common wheat

Classification with Partial Least Squares Discriminant Analysis (PLS-DA)

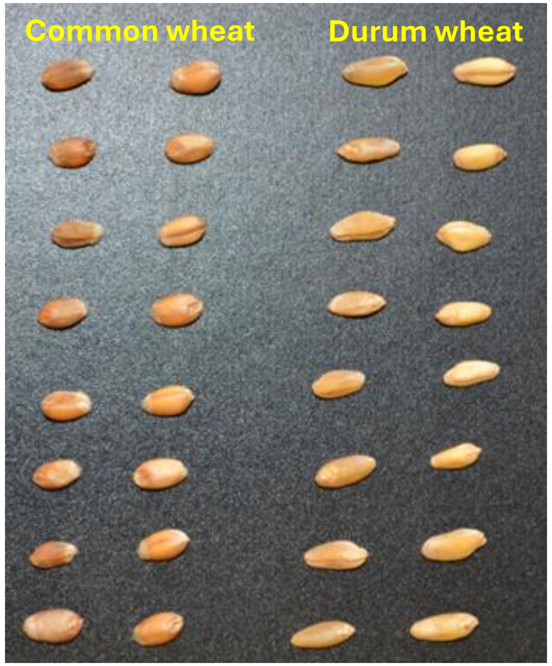
Four discrimination approaches:

1) Kernel morphology
Using 8 geometric features derived from the images at single kernel level

2) NIR spectral profile at kernel level
Using the mean spectrum of each kernel

3) Protein content
Discriminating between high (>12%) or low (<12 %) protein content

4) Vitreousness of the kernel
Using the percentage of vitreous pixels on each kernel



Philippe Vermeulen

Discrimination between durum and common wheat kernels using near infrared hyperspectral imaging

Philippe Vermeulen[a,*], Michele Suman[b], Juan Antonio Fernández Pierna[a], Vincent Baeten[a]

[a] Food and Feed Quality Unit (U15), Valorisation of Agricultural Products Department (D4), Walloon Agricultural Research Centre (CRA-W), Henseval Building, Chaussée de Namur 24, 5030, Gembloux, Belgium
[b] Research Development & Quality, Barilla G. & R. Fratelli S.p.A, Via Mantova 166, 43100, Parma, Italy

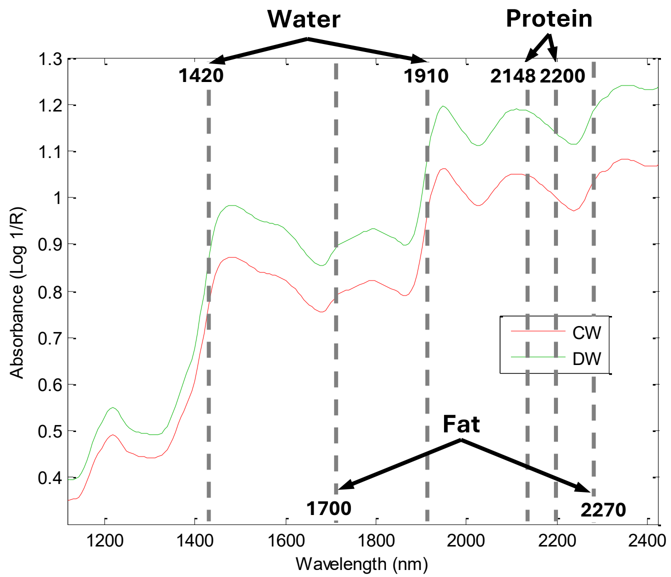
Quality control & fraud detection

Durum wheat

Detection of contamination with common wheat

Classification performance

Discrimination approach	Classification error [%]	Correct classification [%]
Morphology	18	96.5
Spectral profile	9.7	88.3
Protein content	9.7	85.2
Vitreousness	6	88.3



Important wavelengths for the discrimination are related to water, fat and protein

DATA FUSION

Better results by combining two approaches (spectral and morphological)

		on 4,105 grains				on 257 samples			
		DW (1,231 grains)		CW (2,874 grains)		DW (77 samples)		CW (180 samples)	
		Nb	%	Nb	%	Nb	%	Nb	%
	1 criterion	*1 right criteria*		*0 right criteria*					
Morphological criteria	C1 (16 grains)	1,084	88.1	2,712	94.4	73	94.8	180	100
NIR spectral profile	C2 (16 grains)	1,156	93.9	2,618	91.1	77	100	174	96.7
	2 criteria	*1 or 2 right criteria*		*0 right criteria*		*mean 2 criteria*		*mean 2 criteria*	
	C1+C2 (16 grains)	1,216	98.8	2,471	86.0	77	100	180	100

FOOD INTEGRITY

Philippe Vermeulen

Discrimination between durum and common wheat kernels using near infrared hyperspectral imaging

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Quality control

Pesticide coating

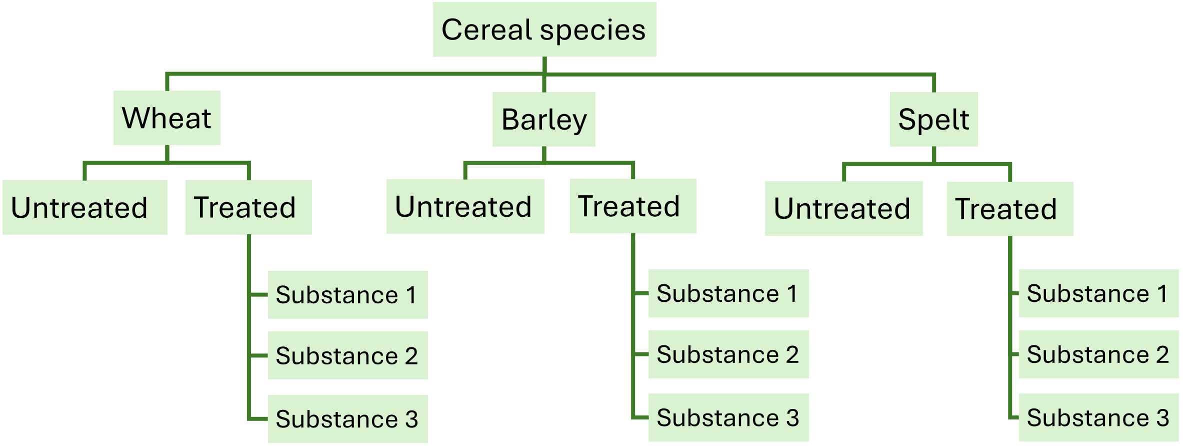
Assessing the coating quality and homogeneity

Three cereal species (wheat, barley and spelt)

For each species

- **Untreated seeds**
- **Treated seed (3 groups of formulation based on 3 active substances)**

Dichotomous classification with PLS-DA models



Philippe Vermeulen

JSI Ph. Vermeulen *et al.*, *J. Spectral Imaging* **6**, a1 (2017)

Peer Reviewed Paper openaccess Paper Presented at IASIM 2016, July 2016, Chamonix, France

Assessment of pesticide coating on cereal seeds by near infrared hyperspectral imaging

Quality control

Pesticide coating

Assessing the coating quality and homogeneity

Classification performance

- ✅ Species (sensitivity = 100%)
- ✅ Treated/untreated (sensitivity = 87-100%)
- ⚠️ Type of pesticide (sensitivity = 25-93%)

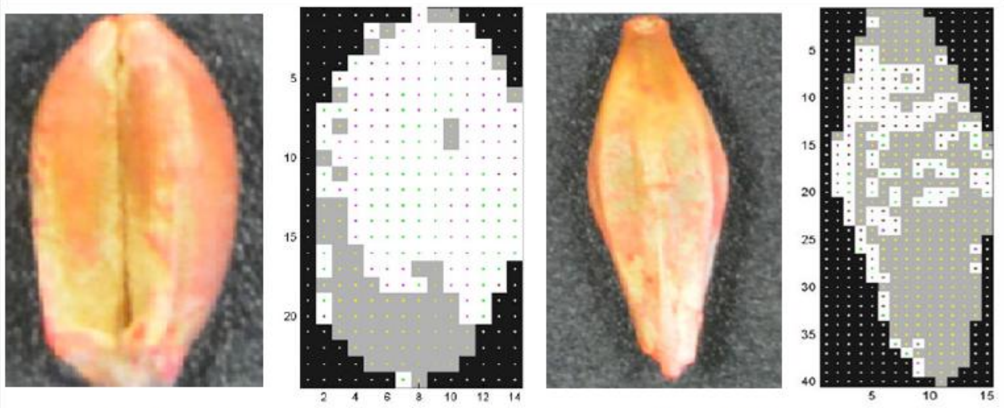


Figure 3. RGB pictures and predicted images showing on single seeds (wheat and barley) pixels detected as treated in white and pixels detected as untreated in grey.

Homogeneity and quality of the dosage

		% Target dose						% Seeds		
	Sample	*n*	mean	*sd*	min	max	*cv*	<30%	>30%	±30%
Ultra performance liquid chromatography										
Wheat	1	24	86.60	30.30	35.80	159.00	37.60	33	4	37
	2	24	239.70	147.50	143.70	795.70	61.50	0	100	100
Barley	3	24	49.60	30.50	23.10	149.20	61.60	83	4	87
	4	24	55.20	27.50	22.00	107.20	50.00	71	0	71
NIR hyperspectral imaging										
Wheat	1	24	93.60	26.30	40.70	165.60	28.10	12	8	21
	2	24	187.30	35.70	115.20	269.40	19.00	0	96	96
Barley	3	24	44.50	22.10	8.50	103.50	49.60	87	0	87
	4	24	49.50	25.00	17.10	93.70	50.40	79	0	79

Philippe Vermeulen

JSI Ph. Vermeulen *et al.*, *J. Spectral Imaging* **6**, a1 (2017)

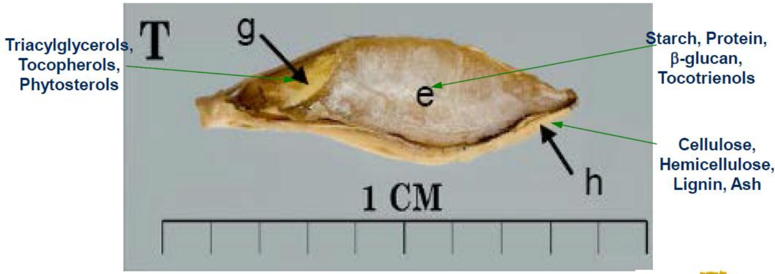
Peer Reviewed Paper openaccess Paper Presented at IASIM 2016, July 2016, Chamonix, France

Assessment of pesticide coating on cereal seeds by near infrared hyperspectral imaging

Fundamental research

Anatomy of a kernel

Assessing different anatomical structures in Barley

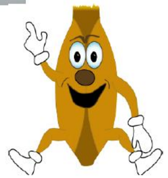


T = Thoroughbred Hulled Barley Kernel

g = Germ (Embryo)

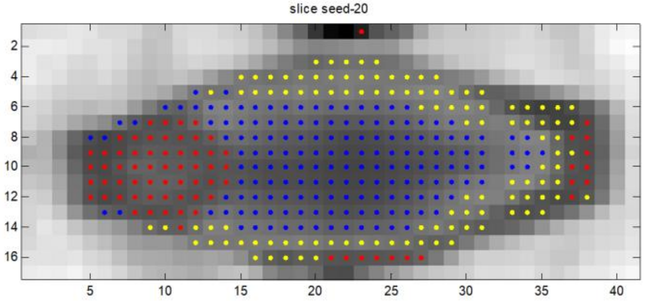
e = Endosperm

h = Hull

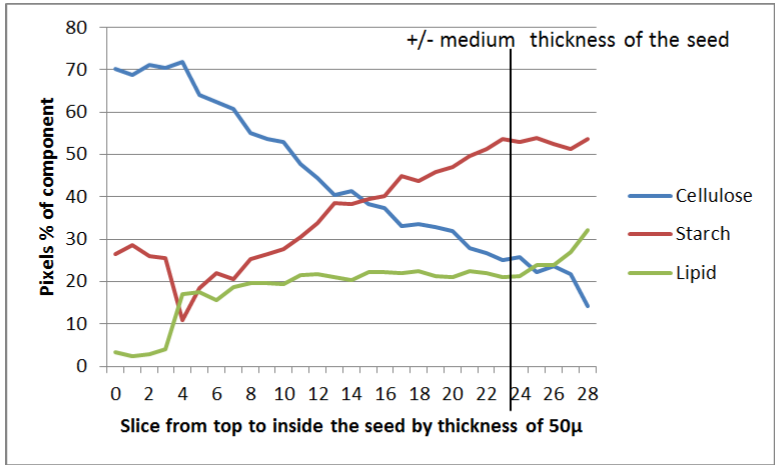


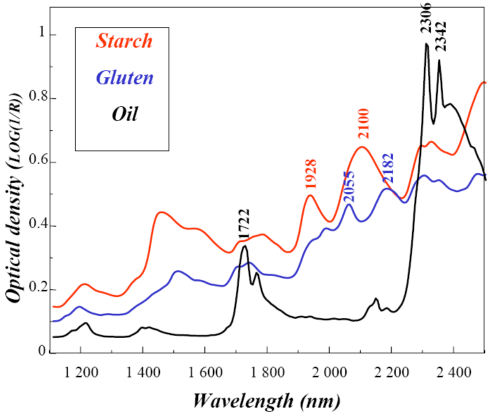
Images: Paul Pierlott, ERRC

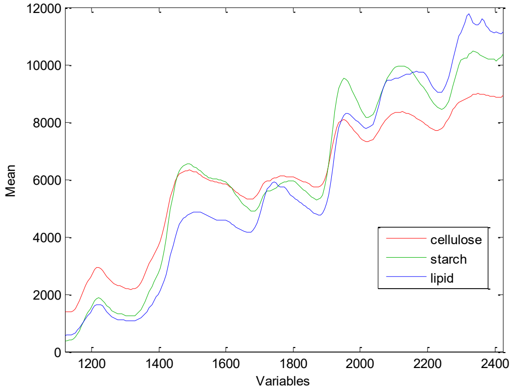
Source: http://www.sebioenergy.org/2011/speakers/Hicks.pdf



PLS-DA results
32% of cellulose
47% of starch
21% of lipids







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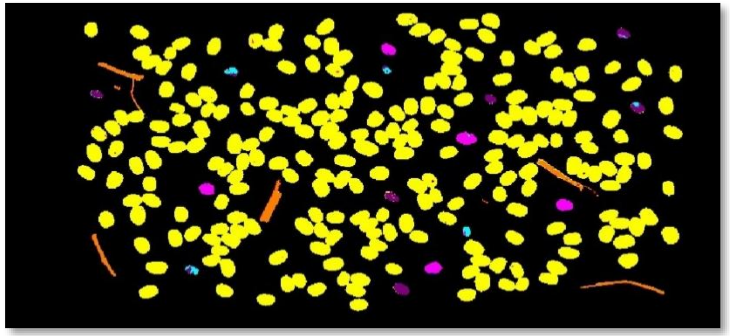
Unpublished results

System demonstration

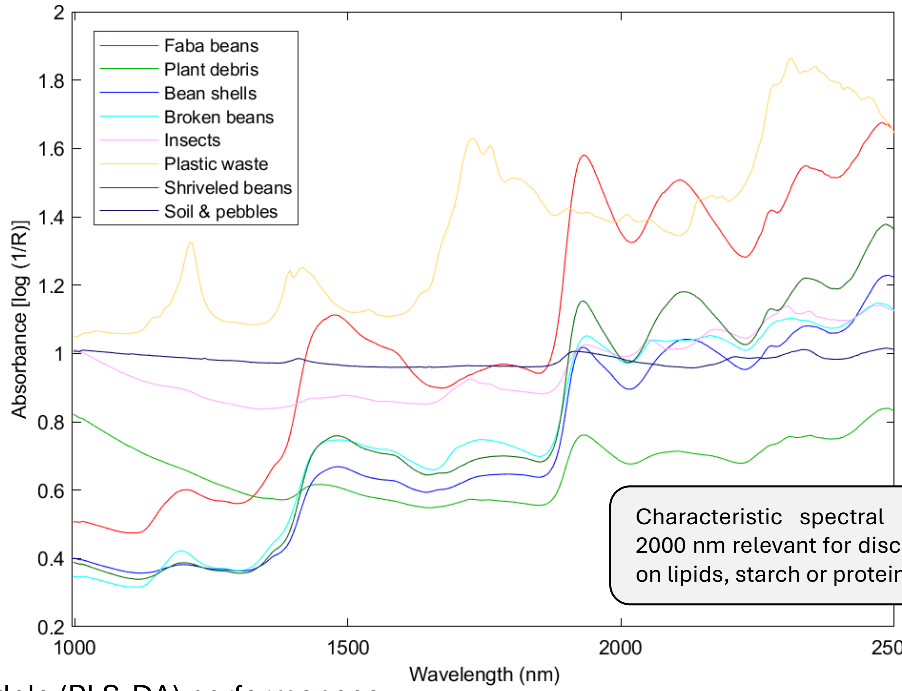
Purity assessment

Online purity assessment of a batch of faba beans

How pure is this sample?



Sample purity : 93.2 %



Characteristic spectral response above 2000 nm relevant for discrimination based on lipids, starch or protein content.

Successive classification models (PLS-DA) performances

Parameters	Soil & pebbles	Plastic waste	Insects	Plant debris	Broken beans	Bean shells	Shriveled beans
Sensitivity val. (%)	100	99.8	96.3	95.1	96.0	98.0	91.4
Specificity val. (%)	97.7	99.8	98.6	96.7	96.3	88.0	92.5
Relevant bands in VIP scores (nm)	1430, 2048, 2180, 2363	1688, 1893, 2269	1682, 2037, 2064, 2142, 2252, 2313	1410, 2224, 2285, 2318	1682, 2075, 2153, 2318	1450, 1937, 2213	1143, 2037, 2108, 2451

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Wallonie
recherche
CRA-W

XVIIth Vibrational Spectroscopy and Chemometrics Training Course

16 to 20 March 2026 (new dates)

Walloon Agricultural Research Center (CRA-W)
Gembloux, Belgium