

L'imagerie NIR au service de l'authentification des produits et de la détection des contaminants : avantages et perspectives

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4 MAIN RESEARCH FIELDS

PRECISION
AGRICULTURE

PRECISION
LIVESTOCK
FARMING

RISK
MANAGEMENT

UNDERSTANDING
PRODUCTS

Field &
orchard
analysis

PhenWheat II
(2022-2024)

NIR imaging
solutions for
phenotyping of
wheat



Farm &
industry
analysis

MobiLAB
(2022-2024)

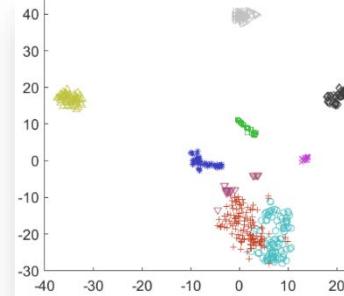
Mobile laboratory
dedicated for the
demonstration and
dissemination of
photonics and
digital solutions



Laboratory
analysis

DepiPEST
(2022-2024)

MIR & Raman
(+ chroma., U10)
for the detection of
fraud in pesticides
products



Laboratory
analysis

ValCerWal
(2022-2024)

NIR & NIR imaging
(+ optical sorting
/chemistry U11) for
cereal batch
allotment



2001



NIR Imaging

- > 35 peer review papers
- > 10 book chapters
- > 20 projects
- Numerous conferences and training courses
- > 0.6 M€ equipment investment
- > 4 M€ staff resources



2022

2001

JOURNAL OF CHEMOMETRICS
J. Chemometrics 2004; 18: 341–349
Published online 31 December 2004 in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/cem.872

Combination of support vector machines (SVM) and near-infrared (NIR) imaging spectroscopy for the detection of meat and bone meal (MBM) in compound feeds

J. A. Fernández Pierna¹, V. Baeten¹, A. Michotte Renier¹, R. P. Coqdill² and P. Dardenne^{1*}

Univariate analysis

Rev. sci. tech. Off. int. Epiz., 2003, 22 (1), 311-331

An overview of tests for animal tissues in feeds applied in response to public health concerns regarding bovine spongiform encephalopathy

G. Gizzi⁽¹⁾, L.W.D. van Raamsdonk⁽²⁾, V. Baeten⁽³⁾, I. Murray⁽⁴⁾, G. Berben⁽³⁾,
G. Brambilla⁽⁵⁾ & C. von Holst⁽¹⁾

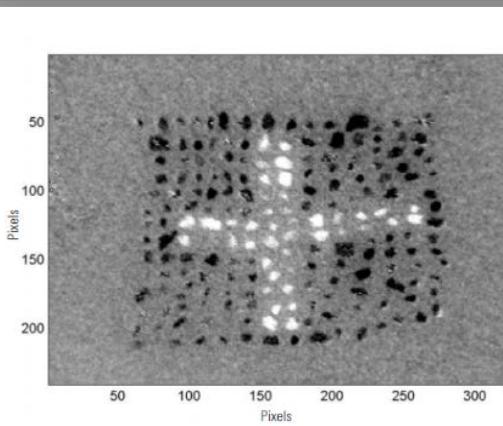


Fig. 7
Results of the analysis of an intentional positive sample using a near infrared camera
Picture of the absorbances scale at 1,470 nm
Source: Agricultural Research Centre of Gembloux (GRAGx), Belgium

Multivariate analysis

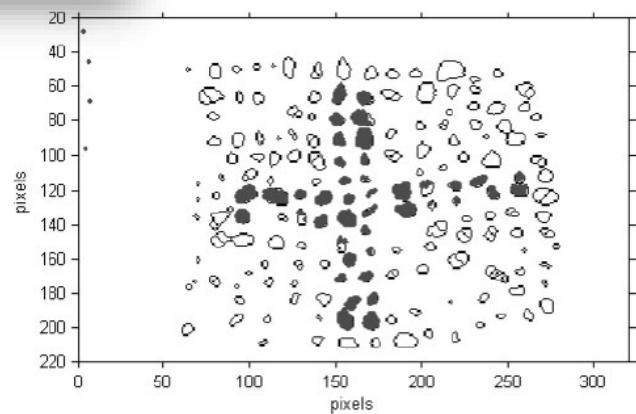
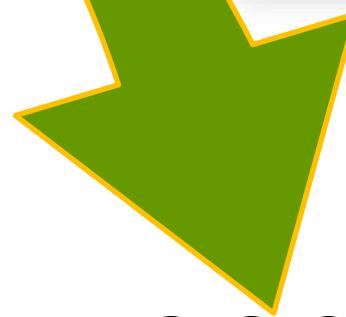


Figure 8. Results of the SVM model for the 'cross' data set using the whole spectra (76 800 pixels). Black dots are classified as animal.



2022

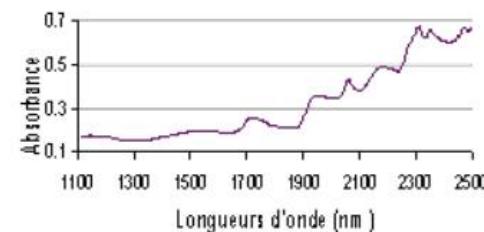


An hyper-spectrometer ...

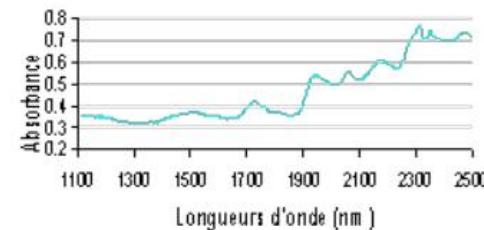
Sample holder with particles



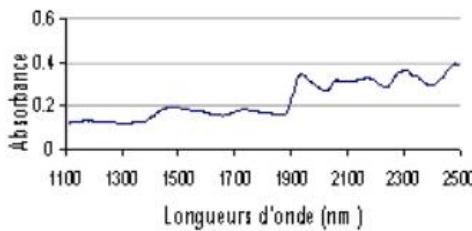
Spectre de farine de poisson



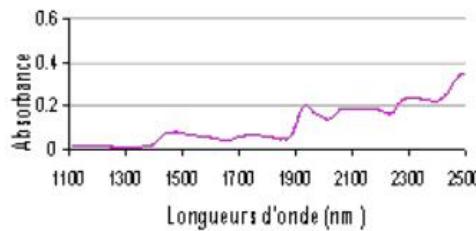
Spectre de farine animale



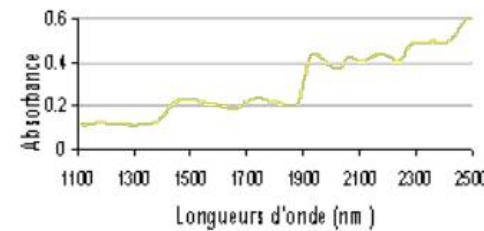
Spectre de lin



Spectre de maïs



Spectre de soja



For one sample, several hundreds spectra of particles

An hyper-spectrometer ...



From 1 spectrum/sample
(Classical NIR)



to 10^n spectra/sample

with $n \gg 3$

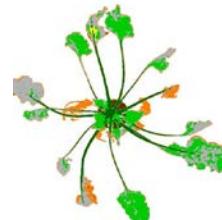
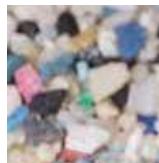
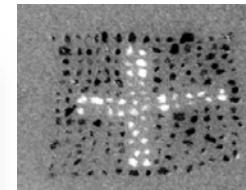
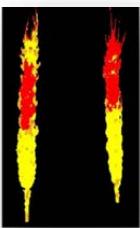
(NIR microscope (NIRM) or
NIR Hyperspectral Imaging (NIR-HSI))



NIR Imaging – a decisive analytical tool

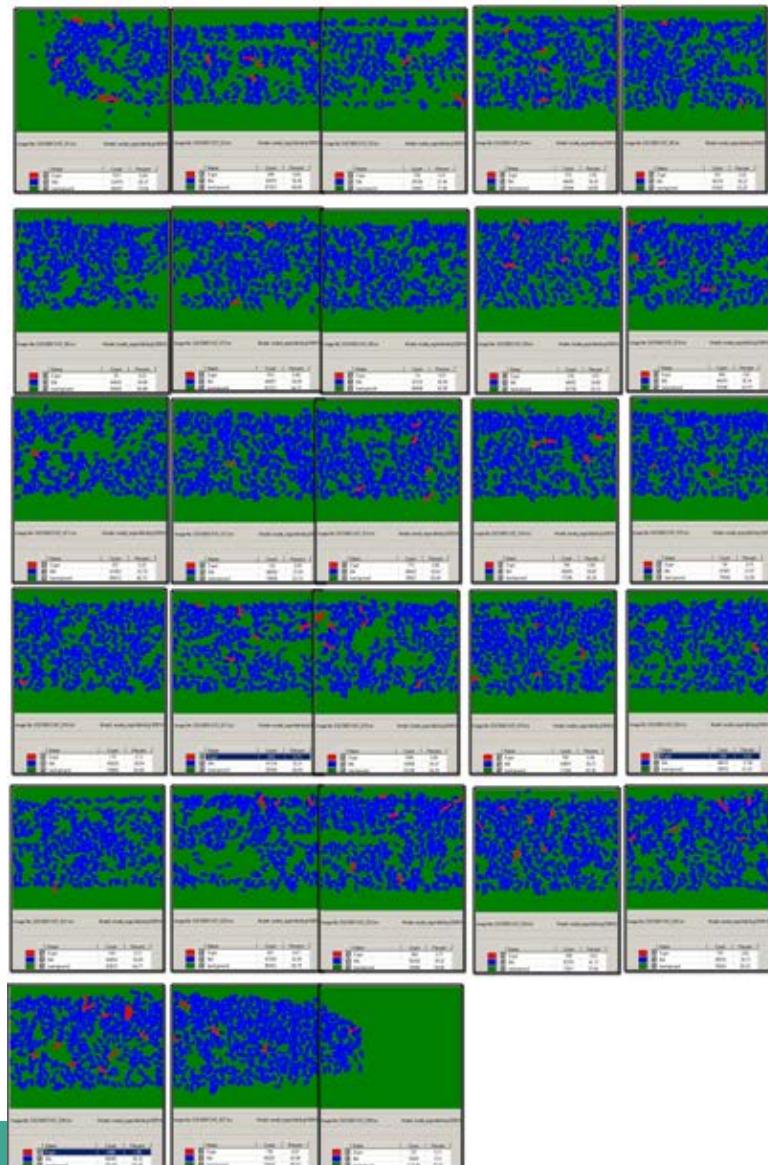
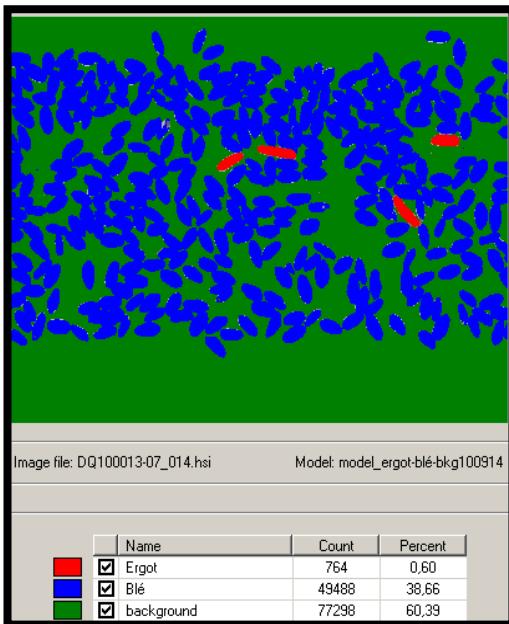
Food
Feed
Archeology
Environment
Breeding

Quality
Impurity Safety
Authentification
Defect Phenotyping
Contaminant
Homogeneity
Disease
Fraud



NIR HSI for the detection of contaminants/impurities

On-line detection



- LOD << 500 ppm
- Several analysis by kernel or by ergot body
- Fast → 30-40 kg / hour = LOD 1 ppm
(Ref method = several days)

To capture the spatial information ...



From
250 pixels by kernel
using conveyor belt
at 10 cm width
and 3 mm/sec

to
2,5 pixels by kernel
using conveyor belt
at 30cm width
and 100 mm/sec

To capture the spatial information ...

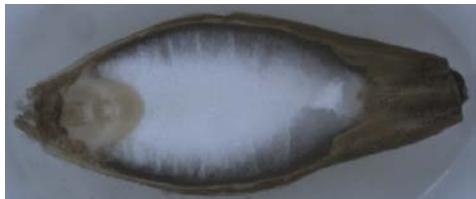
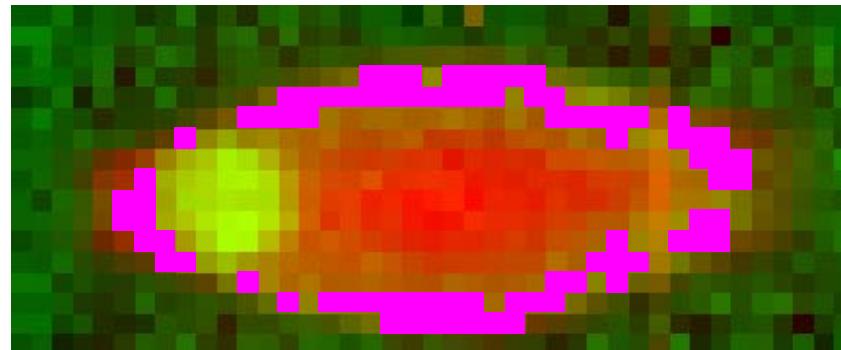
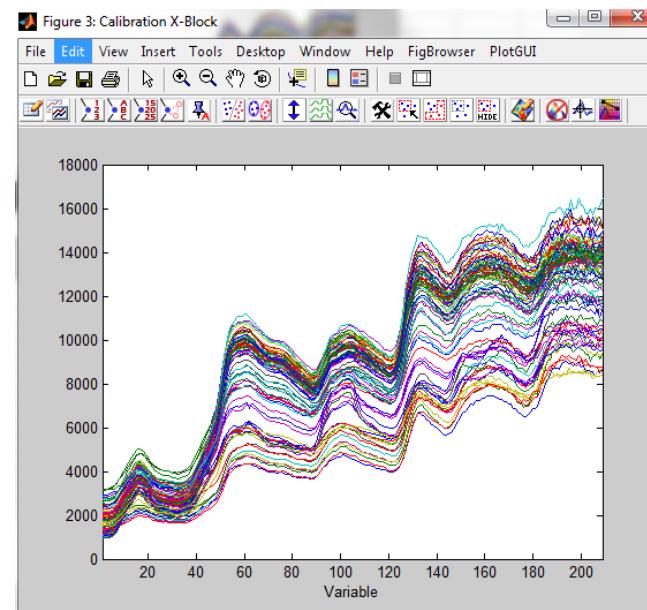
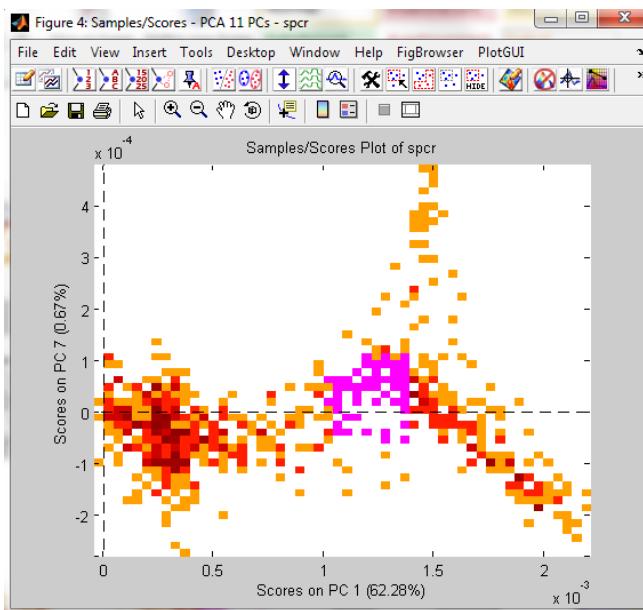


Image of Scores on PC 1 (62.28%) & Scores on PC 7 (0.67%)



Selection of hull area



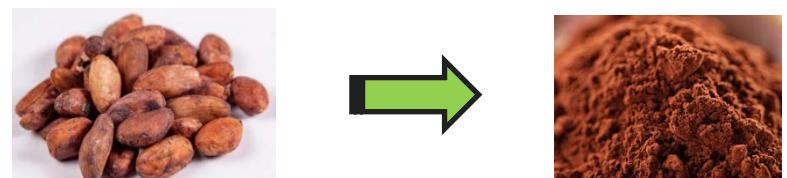
An example : Cocoa Bean authentication



Cruz-Tirado, J.P., Fernández Pierna, J.A., Rogez, H., Barbin, D.F., Baeten, V. (2020). **Authentication of cocoa (*Theobroma cacao*) bean hybrids by NIR-hyperspectral imaging and chemometrics.** Food Control, 118, art. no. 107445.

NIR SPECTROSCOPY

- Composition estimation (for example, caffeine, fat, protein, etc)
- Adulteration in cocoa powder
- Geographical origin
- Identification of varieties



An example : Cocoa Bean authentication

- Low industrialized cocoa production
- Cocoa beans can be mixed during harvest
- Cocoa beans can be misidentified during post-harvest processing (fermentation and drying)
- There could be the possibility of "counterfeiting" or "substitution"

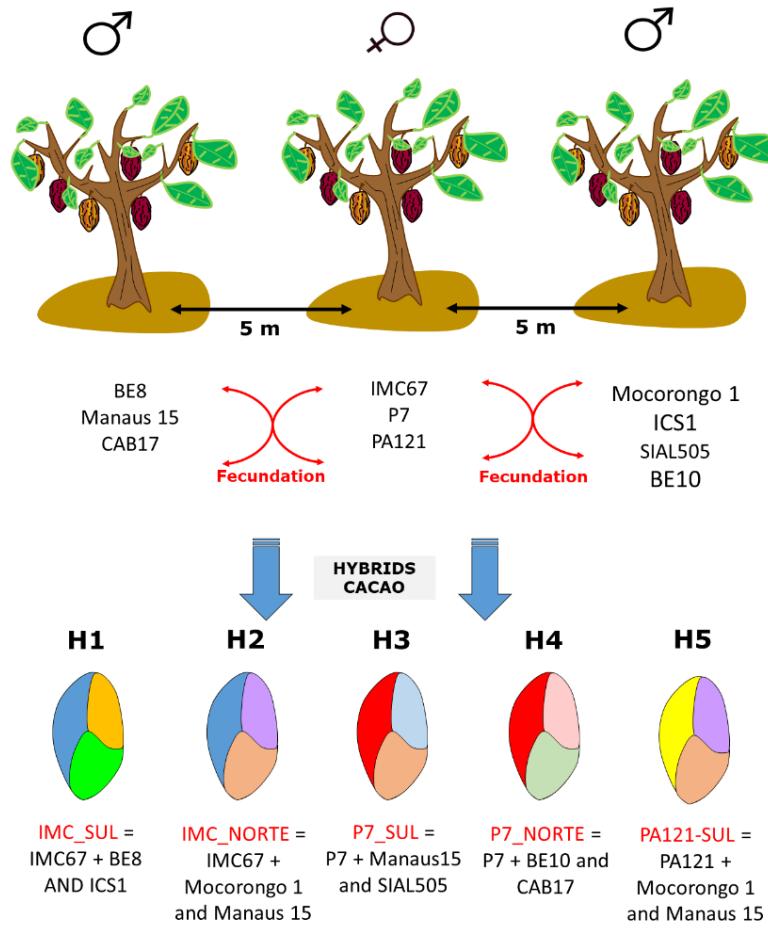
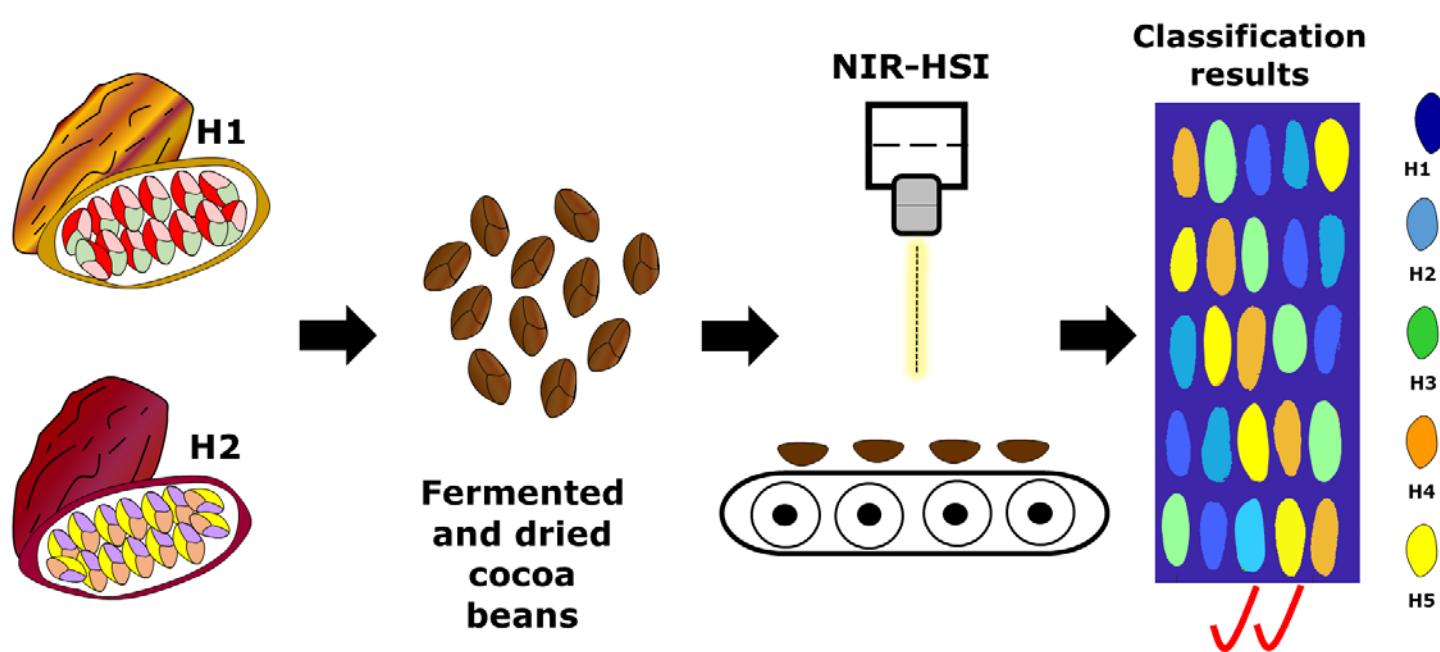


Figure 1a. Scheme showing the process for production of cocoa bean hybrids in CEPLAC (Medicilândia, Para, Brazil).

An example : Cocoa Bean authentication

OBJECTIVE ➔

To develop a non-destructive methodology for the classification of hybrids of cocoa beans based on hyperspectral images in the NIR region combined with chemometry



An example : Cocoa Bean authentication

Classification –
2-clases model: **ICM vs P7**



4 strategies:

a - PLS-DA (pixel)

b - Majority vote

c - Filter (<65)

d - Mean spectra

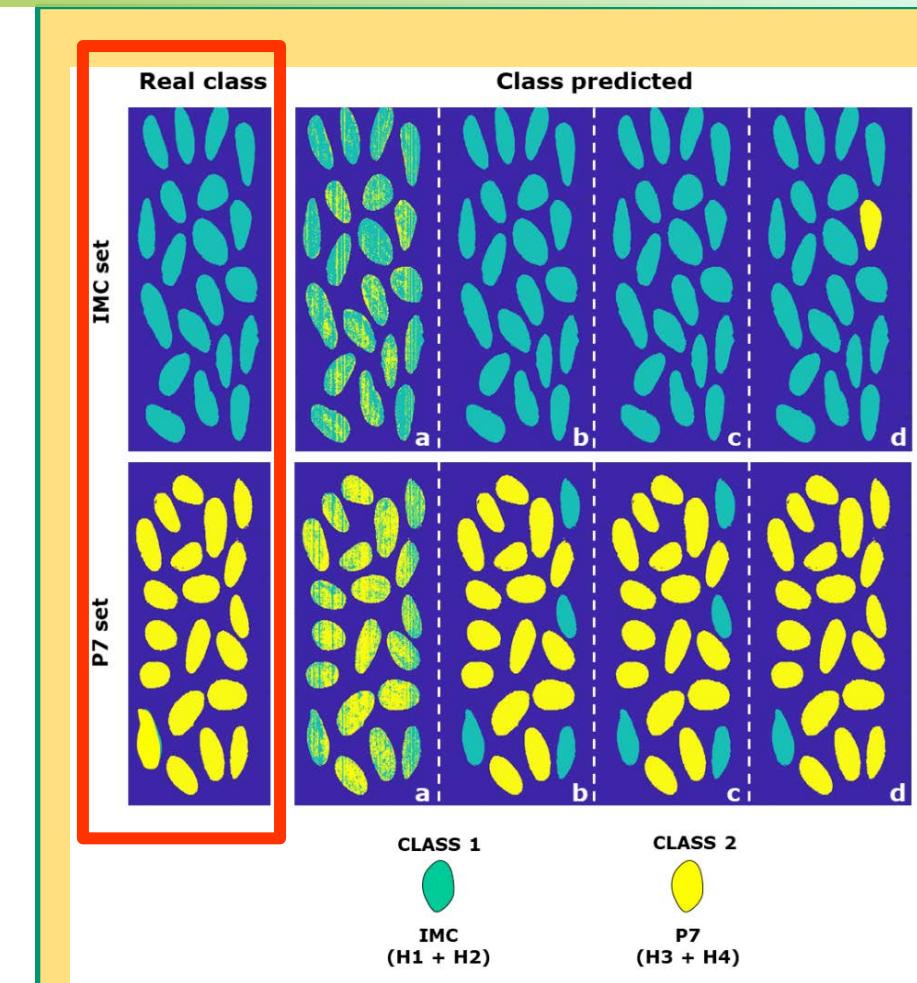


Figure : PLS-DA pixel-to-pixel analysis in cocoa beans according to “mother”: BMI vs P7. PLS

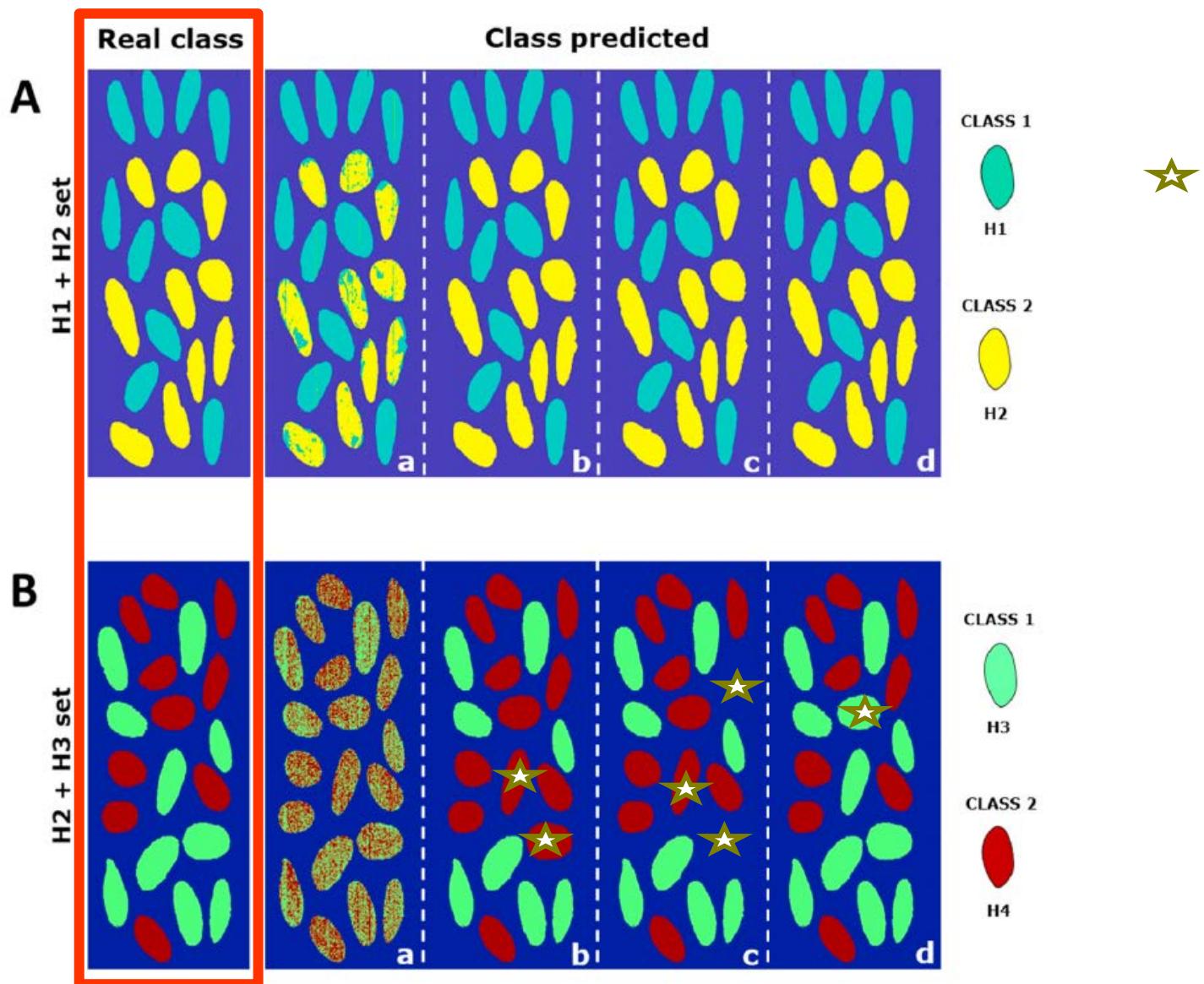
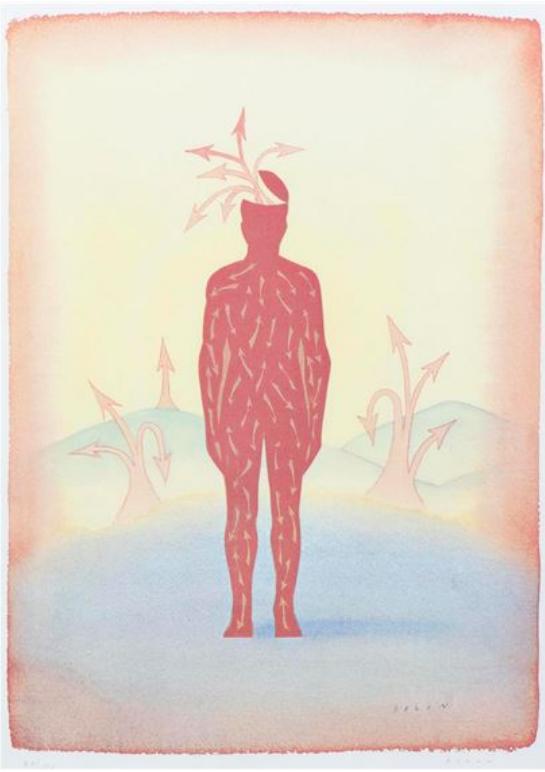


Fig. 4. PLS-DA analysis for two classes of hybrids of cocoa beans. A) Model H1 vs H2; B) Model H3 vs H4; C) Model H1 vs H5; D) Model H3 vs H5. PLS-DA maps for the most probable class assigned to new test sample set were produced using: a) PLS-DA model; b) model applying majority vote; c) filtered model by deleted samples no possible to classify (difference between two classes with more probability < 65 pixels); d) PLS-DA model applied to pixels with mean spectra value.

An example : Cocoa Bean authentication

CONCLUSION

- PLS-DA and SVM : comparable results for the 2-class cocoa hybrid models.
SVM superior to PLS-DA for the 5-class cocoa hybrid models.
- 5-class model allows a 100% correct classification of hybrids H1, H2 and H4, in an independant external validation set.
- Future work : 19 hybrids are waiting us



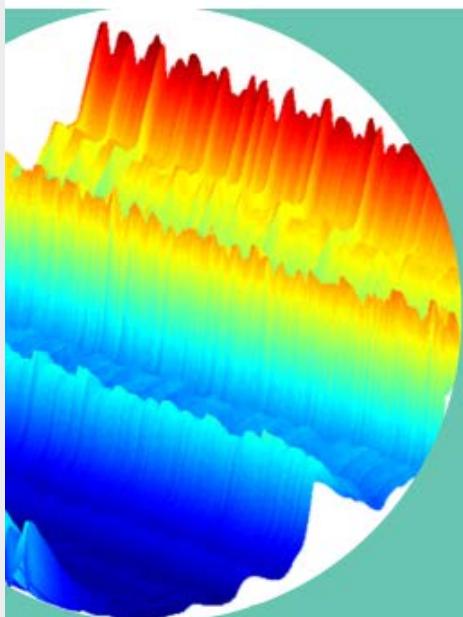
**Jean-Michel FOLON
(1934-2005),
"Personnage sur fond
imaginaire"**



**Belgium, 2022
« QAP Dream team »**

Thank you

Vibrational Spectroscopy and Chemometric course



17-21 OCTOBER 2022
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ICNIRS
2023

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