Use of portable NIR spectrometer for the analysis of fruits quality

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History …

'POMMINO' (2008-2011)

- *Development of rapid method to select new varieties of apple with high nutritional quality : Use of NIRS for the determination of quality and nutritional parameters of apple*

'Qualipomme' *(2012-2015)*

- *Valorisation of cultivars presenting high nutritional quality by the development of a methodoly to optimize the harvest date.*

(2017-2018-..)

- *Internal evaluation of portable instruments*

Projet 'POMMINO' (2008-2011)

Research and valorisation of cultivars presenting high nutritional quality

The **breeding program** conducted in the unit of Plant Breeding and Biodiversity aims to create **new apple cultivars** presenting:

- quantitative resistance to scab.
- a **high nutritional quality**.
- and good agronomic traits in the context of a sustainable agriculture

Quality parameters ?

- **High vitamin C**
- **High phenolic compounds**
- Sugars

Use of NIRS for the determination of quality and nutritional parameters of apple

Interest for the fruit tree growing ?

For breeders:

selections of genotypes

- To develop precise **calibration models** in order to use NIRS as a **rapid tool for selection** in the breeding program

For producers:

better prediction of the harvest date

- To develop a **portable NIRS instrument** in order to determine **the optimal picking date** and to evaluate fruits **quality directly in orchards**

First studies with NIRS on fruits:

4 measures/ fruit

XDS (Foss NIRsystems. Inc.)

Phazir (Polychromix. Inc.)

Reference methods: physico-chemical analyses (lab)

- Maturity ↔ Starch regression (Indice KI)
- Firmness ↔ Penetrometer
- Sugar content ↔ Refractometer (Brix)
- Acidity ↔ Titration
- Phenolic compounds ↔ Folin-Ciocalteu

But destructive and « time-consuming »

Application of NIRS in the apple breeding program

Aim: Develop **strong calibration models** in order to use the NIR spectroscopy as a **tool for the selection of varieties** in the apple breeding program

Calibration model **with Phazir** (2009-2010)

Quality parameter	N	Mean	SD	SEC	RSQ	SECV	RPD	Nb facteurs
Maturity	227	7.87	1.36	0.97	0.64	1.17	1.16	7
Firmness (kg/cm²)	226	7.04	1.18	1.72	0.31	1.87	0.63	7
Sugar (°Brix)	236	14.13	1.55	1.04	0.68	1.19	1.30	6
Acidity (eq.g.ac.malique/l)	203	6.95	1.65	2.72	0.28	2.86	0.58	3
Phenolic compounds (µg/g MF)	225	297.92	186.79	123.24	0.70	138.57	1.35	8
Vitamin C (mg/100 g MF)	220	2.47	0.90	1.34	0.31	1.37	0.66	3

For all parameters: low RPD values and high SECV!

Better results with XDS !

Development of a methodology to determine the optimal picking date by application of NIRS and reference analyses

Picking date= very important point for quality !!

- Fruit quality at harvest time
- For long term conservation

Optimal picking date

Harvest at a early stage or late stage …

- ***Loss of mass during during storage*** ***(***Kviklienė *et al.* 2009)
- ***Losses caused by rots (***Kviklienė *et al.* 2008)

Application of NIRS for the optimal picking date

Aim: To develop a **portable NIRS instrument** in order to determine **the optimal picking date** and to evaluate fruits **quality directly in orchards**

Monitoring of the maturity in orchards

- **Monitoring of the maturity** of **'CRAW-AG 90'** and **'Pinova'**
- Analyses with **Vis-NIRS instruments** and **reference analyses**

Application of Vis-NIRS instruments

➢ **Spectro XDS (Foss)**
(400 à 2500 nm)

➢ **MicroNIR (JDSU Corp.)**
(1100 à 1600 nm)

➢ **Da Meter (Turoni srl)**

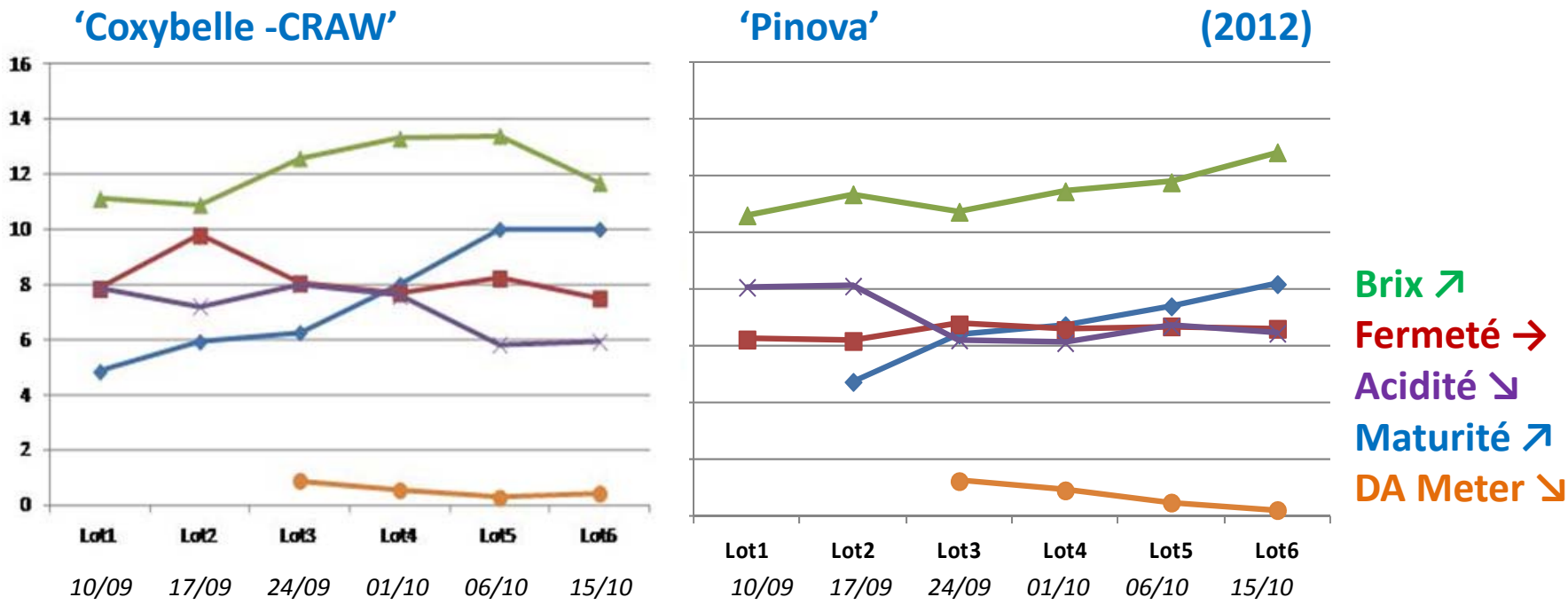
- Absorbance difference (DA)

Index I $_{AD}$ **= Abs 670 – Abs 720**

- Index I_{AD} ↘ during ripening
- Specific values to each sp and cultivar

Analysis with reference methods

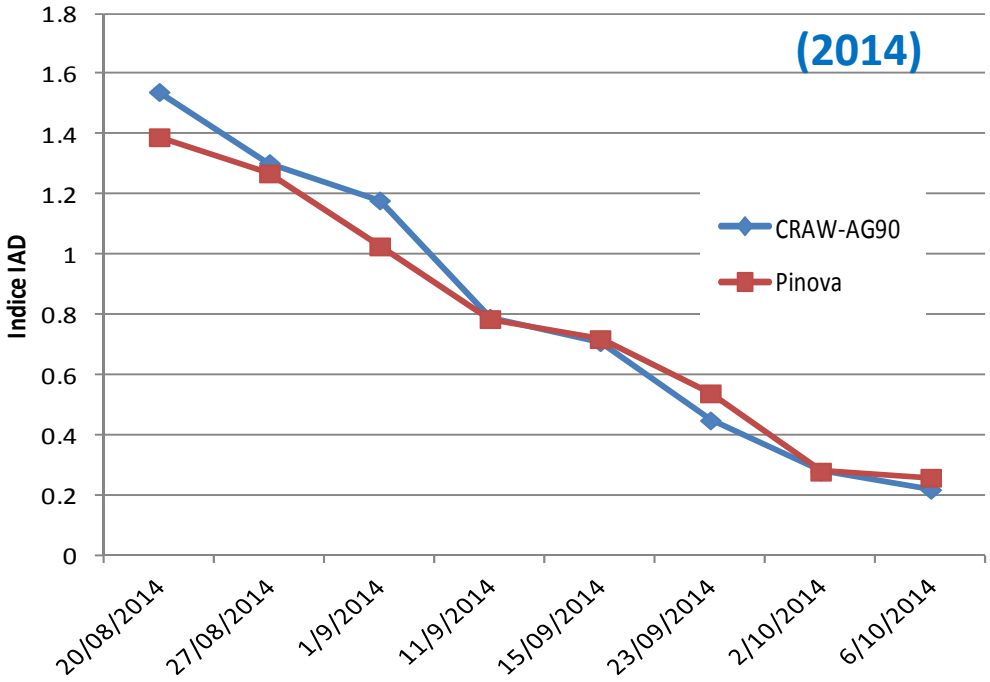
Monitoring of the quality parameters during maturation



Evolution of quality during maturation

Analysis with DA Meter

Evolution of the Index I_{AD} (DA Meter)

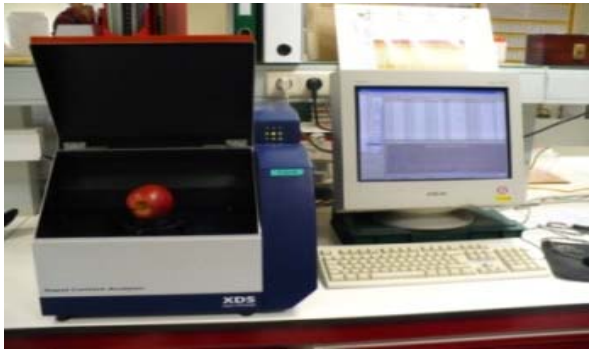


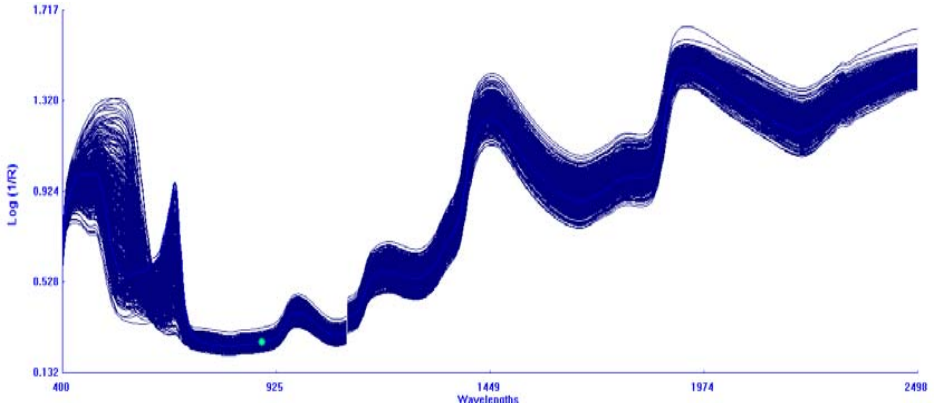
- Decrease during maturation
- Same trend and slope over several years
- Determination of specific value for each variety

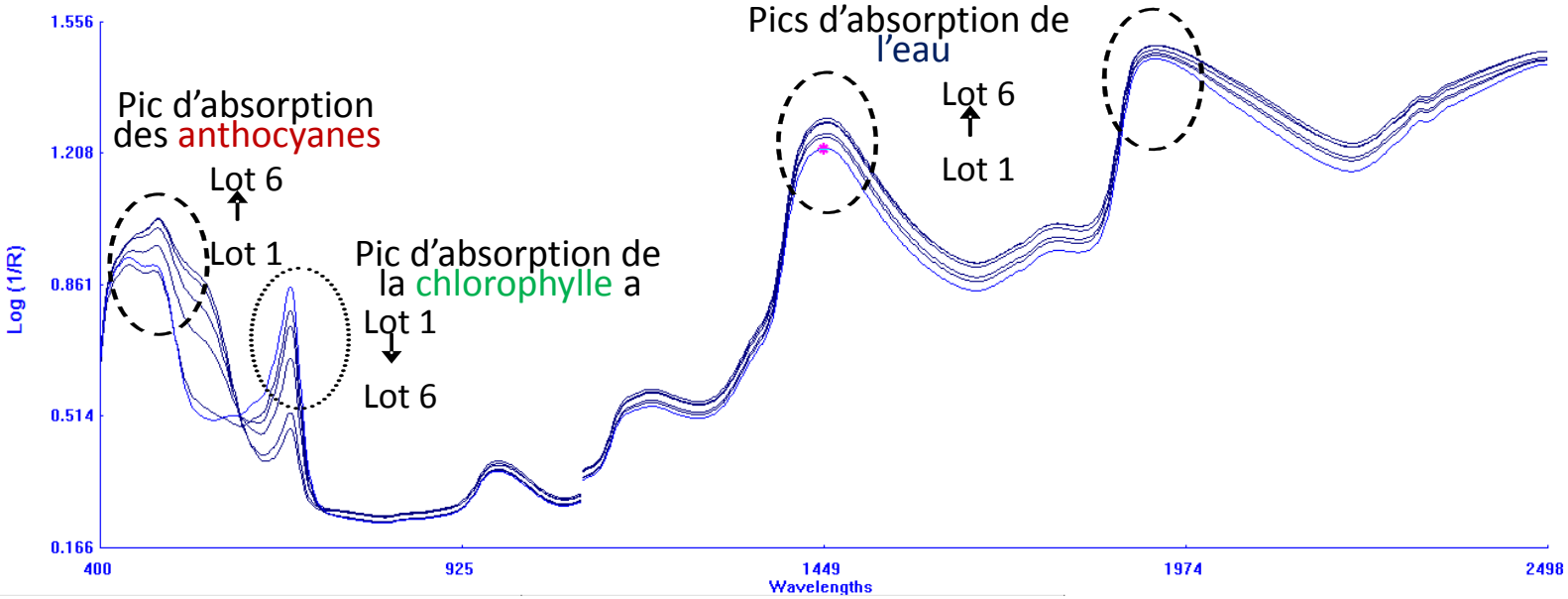
Thanks to Ph. Thirry (GAWI) for the current follow up

Analysis with NIR - XDS

Measurement of fruits and collect of spectra







Evolution of spectra during maturation

« apples database »

Development of calibration models - XDS

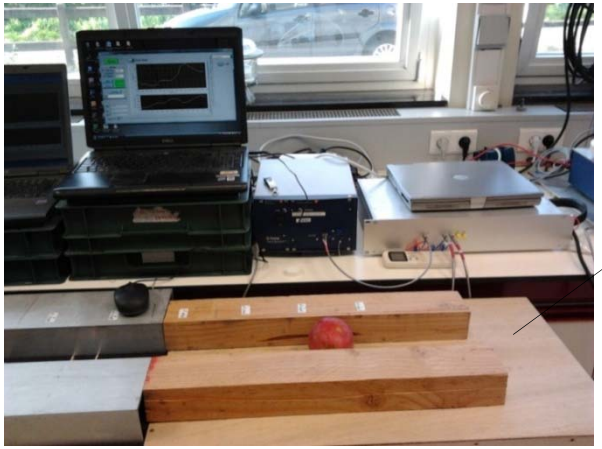
	N	SEC	RSQ	SECV	1-VR	Nb termes	SD	RPD
Maturity	1689	0.83	0.83	0.86	0.87	13	2.00	2.5
Firmness	1673	0.9	0.77	0.93	0.76	11	1.88	2
Brix	1685	0.67	0.86	0.68	0.85	12	1.75	2.6
Acidity	1655	0.85	0.76	0.87	0.74	15	1.73	2
Phenolic compounds	1719	131.01	0.90	145.03	0.88	13	422.10	2.9
Indice I_{AD}	1738	0.09	0.96	0.09	0.96	10	0.45	5
Indice Streif	1728	0.017	0.72	0.018	0.70	8	0.032	1.8

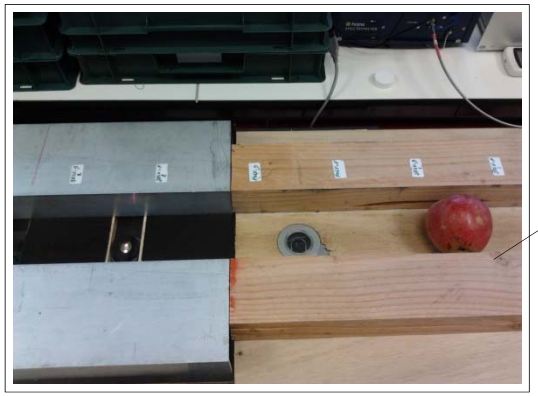
Good to very good precision of calibration !

NIRS : Rapid tool for the analysis of quality/maturity of apples

Analysis with NIR - MicroNIR

Mesurement of fruits and collect of spectra

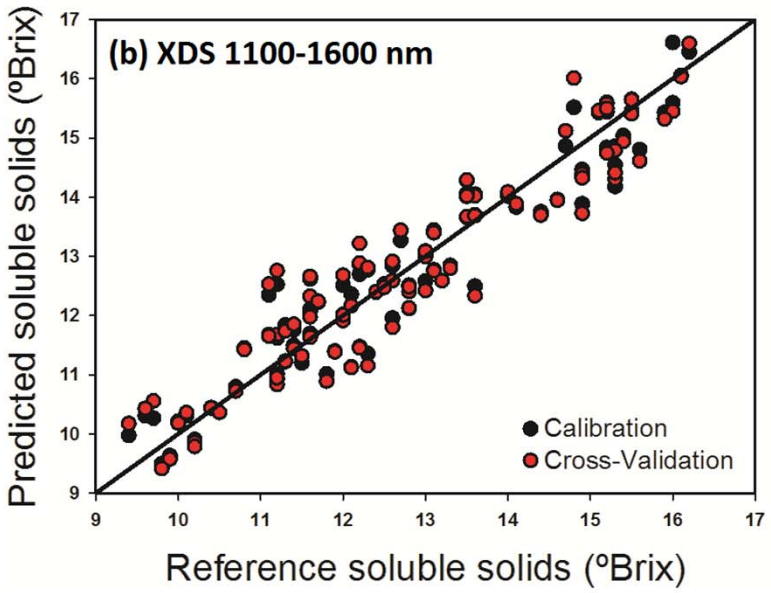


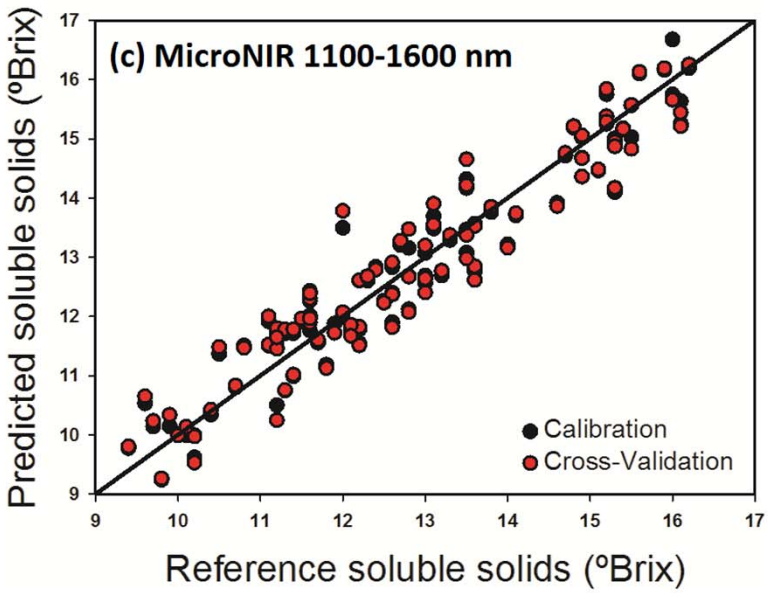


- Very small instrument
- Spectra from 1100 to 1600 nm
- In the lab or in a portable mode

Development of calibration models: **XDS *versus* microNIR**

‘Brix’ calibration





➢ Similar performances

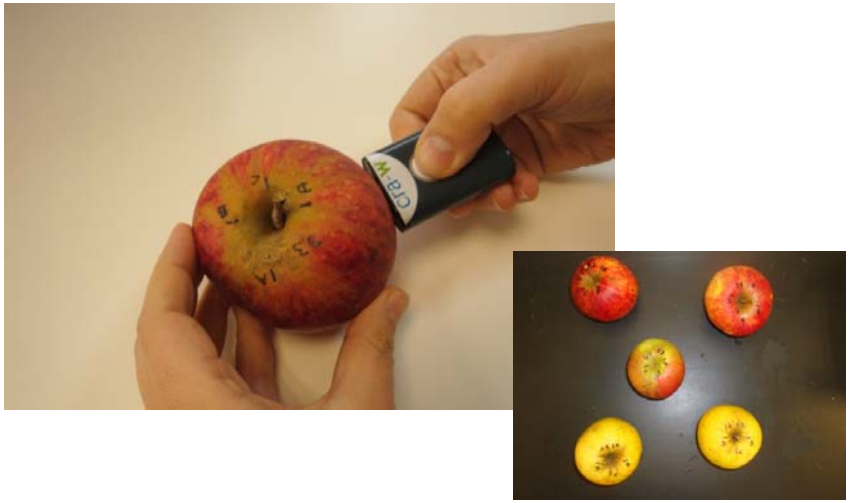
Development of calibration models: **XDS *versus* microNIR**

Under publication: Marques et al. «Evaluation of a handheld ultra-compact NIR spectrometer for rapid and non-destructive determination of apple fruit quality»

Innovation in progress … what will the role of the NIR spectroscopy community?

Determination of fruit quality ??

Experiment 1: BRIX determination by SCIO



Spectra of SCIO
740-1067 nm

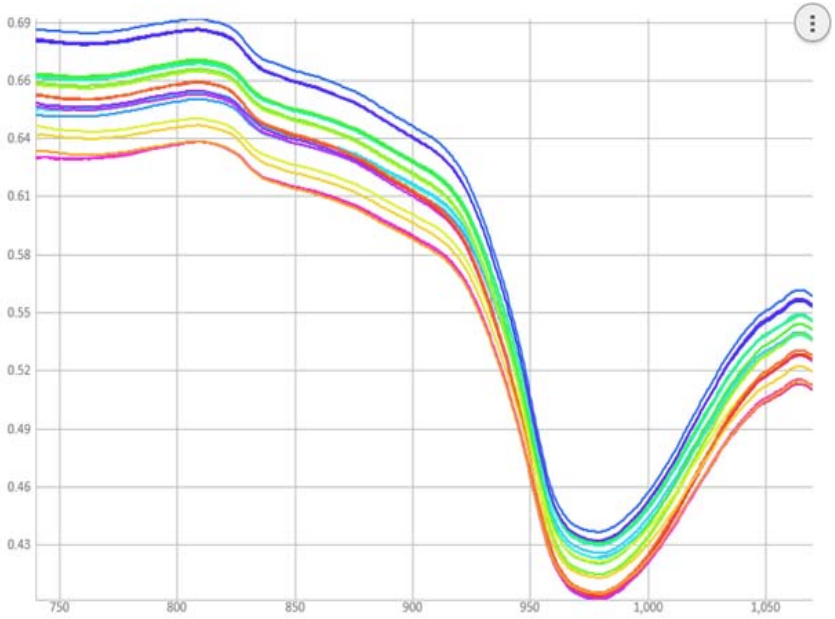
Measurement:

5 varieties - 2 fruits/var

- var 1 : AF34
- var 2 : AM84
- var 3 : Jonagold
- var 4 : Pinova
- var 5 : Braeburn

4 spots/fruit

3 scans/spot (mean)



BRIX determination by SCIO

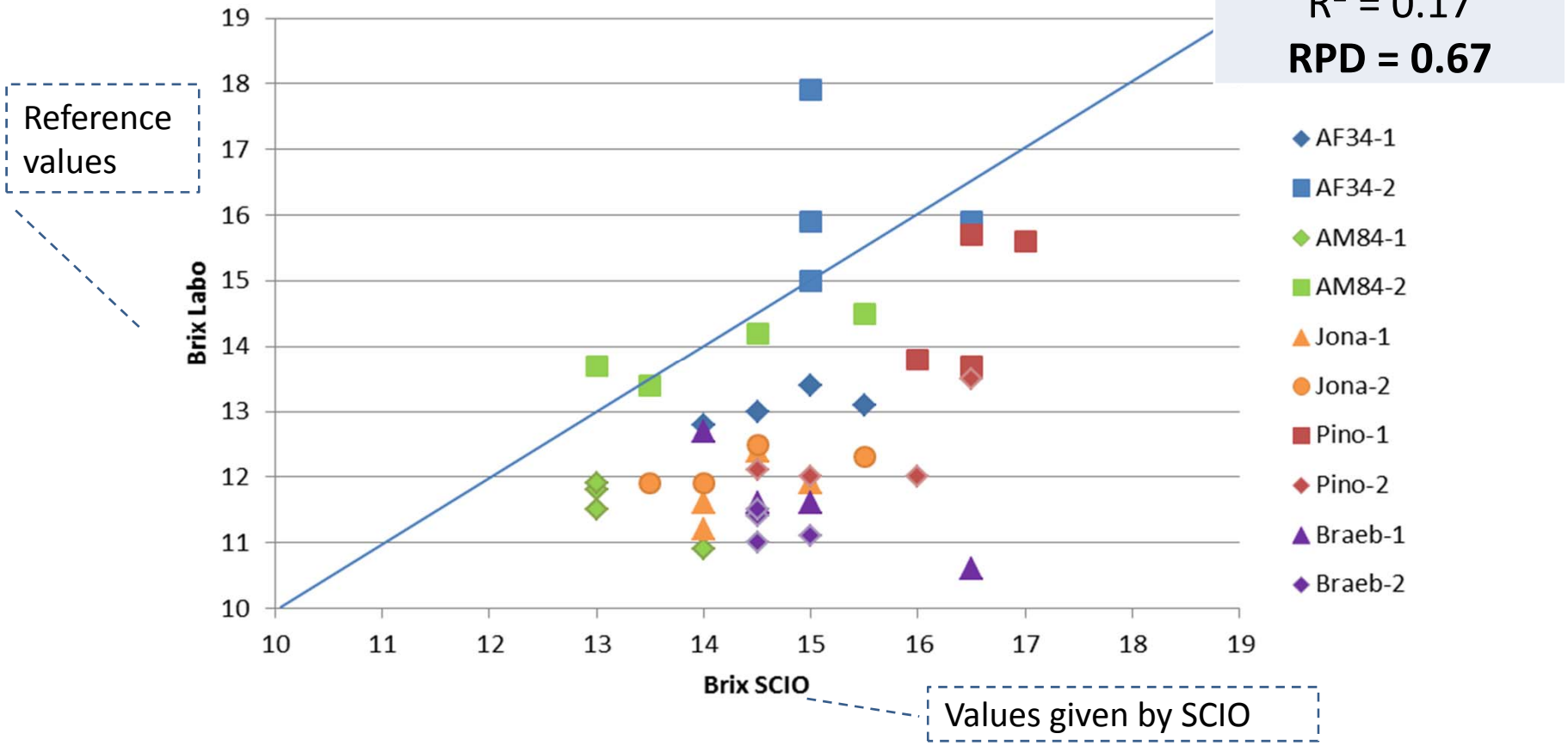
Use of the **application 'Fruits'** of SCIO for the prediction of Brix:

- 4 faces/fruit
- 1 scan/face

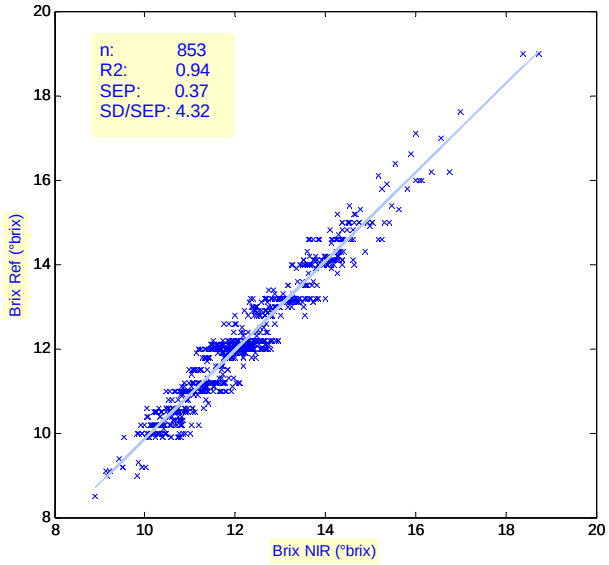
RMSEP = 2.47

R^2 = 0.17

RPD = 0.67

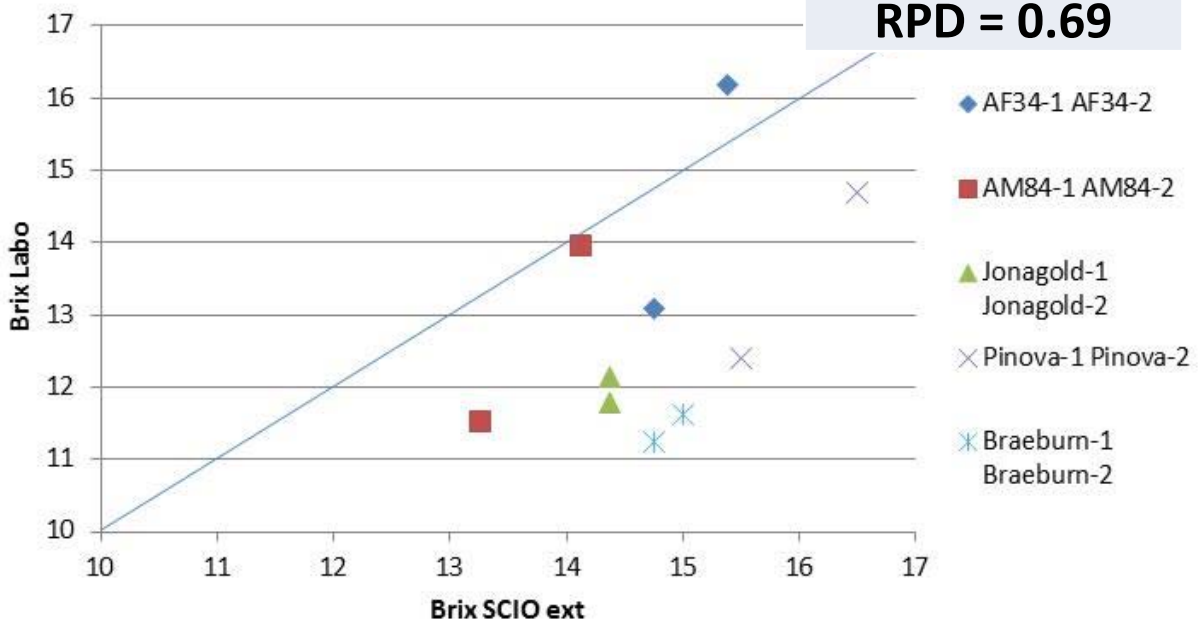


BRIX determination by SCIO



mean/apple

RMSEP = 2.33
R^2 = 0.27
RPD = 0.69



Source: Pissard et al. 2013. Non-destructive measurement of vitamin C. total polyphenol and sugar content in apples using near-infrared spectroscopy. J Sci Food Agric. 93(2): 238-44.

➢ Poor prediction performances

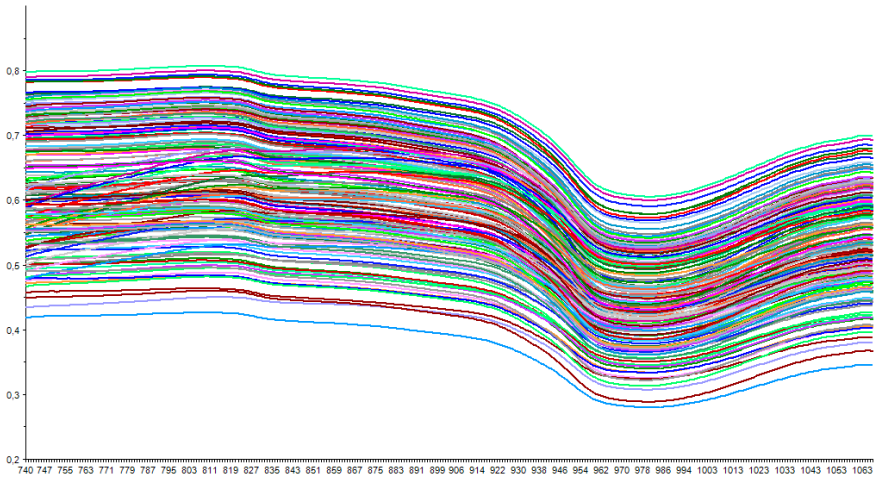
Experiment 2: SCIO Spectra of apples

Measurement with SCIO (740-1067 nm)

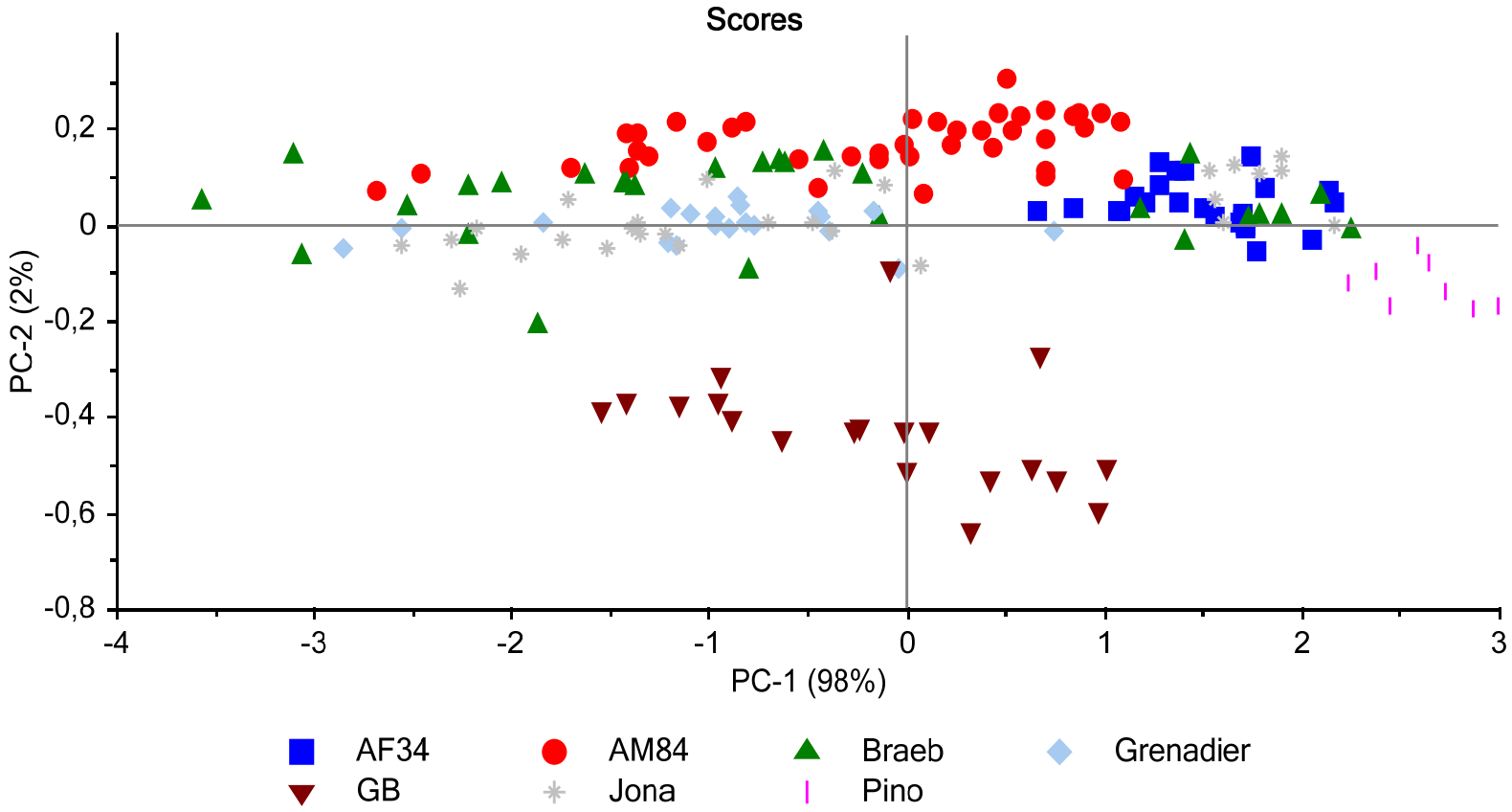
- Several varieties, 2-6 fruits/var, two dates
- 4 spectra/fruit

Transfer in Unscrambler

Matrice of 168 data *328 λ

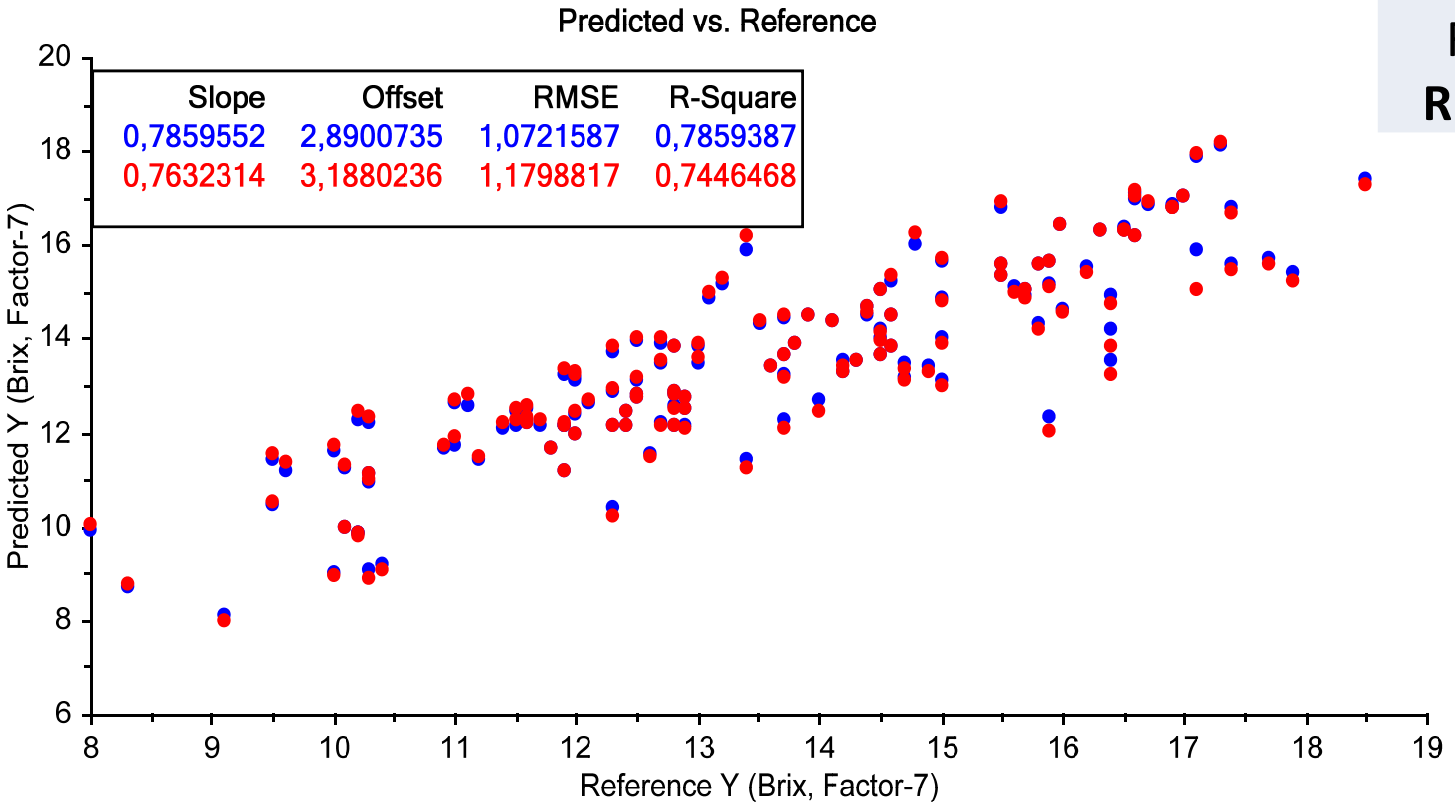


Principal Component Analysis



Development of calibration models

PLS – leave **one** out



RMSECV = 1.18

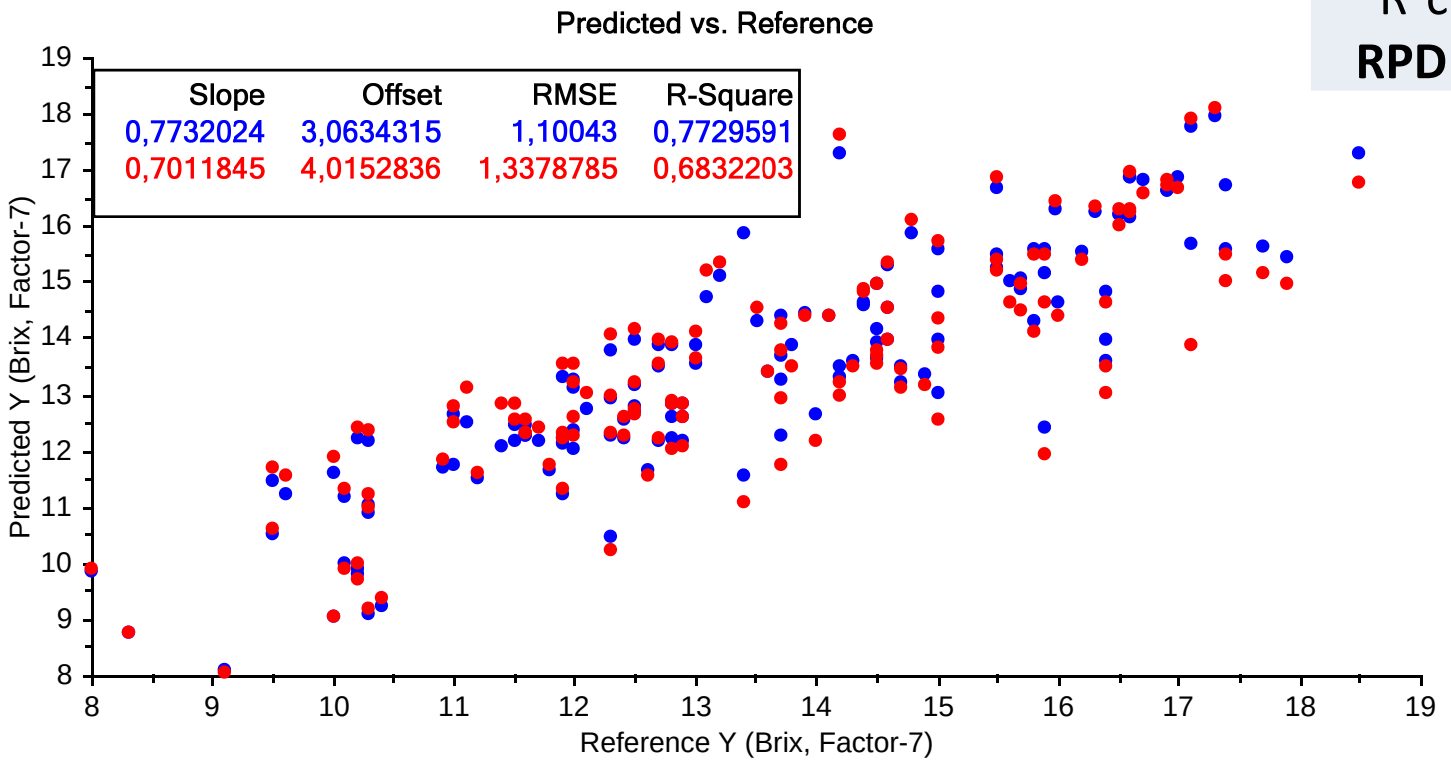
$R^2cv = 0.74$

RPD cv= 1.96

➢ Better prediction performances with our calibration models

PLS – leave **one apple** out

RMSECV = 1.34
R^2cv = 0.68
RPD cv= 1.73



Development of calibration models

PLS – leave **one variety** out

	RMSECV
AF34	1.65
AM84	1.18
Jonagold	1.47
Pinova	0.83
Braeburn	1.78
Grenadier	4.34
GB	1.14

RMSECV = 1.77
RPDcv = 1.31

Comparison of instruments

	N	Min	Max	Factors	RMSECV	R^2cv	RPDcv
SCIO							
Leave one out	162	8	18.5	7	1.33	0.68	1.96
Pommes moyennées-leave one apple out	42	8.8	17.5	6	1.22	0.71	1.86
MicroNIR							
MicroNIR 1100-1600 nm	90	9.4	17.1	6	0.57	0.91	3.3
XDS							
XDS 1100-1600 nm	90	9.4	16.2	6	0.62	0.89	3.0
XDS (400-2500 nm) + SVM	853	8.5	19	?	SEP=0.37	R^2pred= 0.94	4.2

Actual study…

➢ Analyses with **Felix Instrument F-750**

- ✓ Carl Zeiss MMS-1 Spectrometer
- ✓ Spectra from 310 to 1100 nm
- ✓ Multi-parameters:
  - Brix
  - MS
  - Acidity
- ✓ Rapid (4-6 sec)
- ✓ Non-destructive
- ✓ GPS included

And you??...

Feedback with other instruments?

….We are open to collaboration to test new instruments!

For more information:

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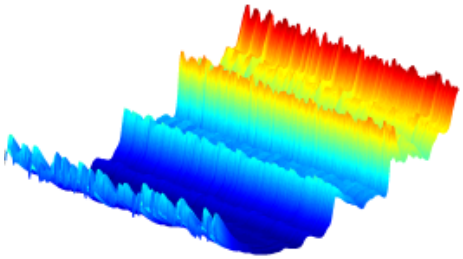
Wallonie recherche CRA-W

Vibrational Spectroscopy and Chemometrics

Training Session

11 March–15 March 2019



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Merci de votre attention