

# NIR Platform Workshop: Quality control and contaminant detection

27/03/2013



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

P. Dardenne, V. Baeten, A. Mouteau,  
J.A.Fernández Pierna,  
G. Sinnaeve, J-M Romnee  
Valorisation of Agricultural Products Dpt  
*Agricultural Product Technology Unit &  
Food and Feed Quality Unit*

**Audrey Pissard**,  
M. Lateur, P. Dupont  
Life Sciences Department,  
*Breeding & Biodiversity Unit*  
[a.pissard@cra.wallonie.be](mailto:a.pissard@cra.wallonie.be)

# 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 ?

- **Vitamin C**
- **Phenolic compounds**
- Sugar
- Fibers



**Antioxydants**



## Advantages of NIR spectroscopy

- rapid
- non-destructive,
- few or no sample preparation,
- multiparametric,
- online,...



### In the case of fruits analysis :

more fruits →  
more  
representative

no loss & easy  
for fruit  
producers

in orchards (for  
portable  
instruments)



## Interest for the fruit tree culture ?

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**

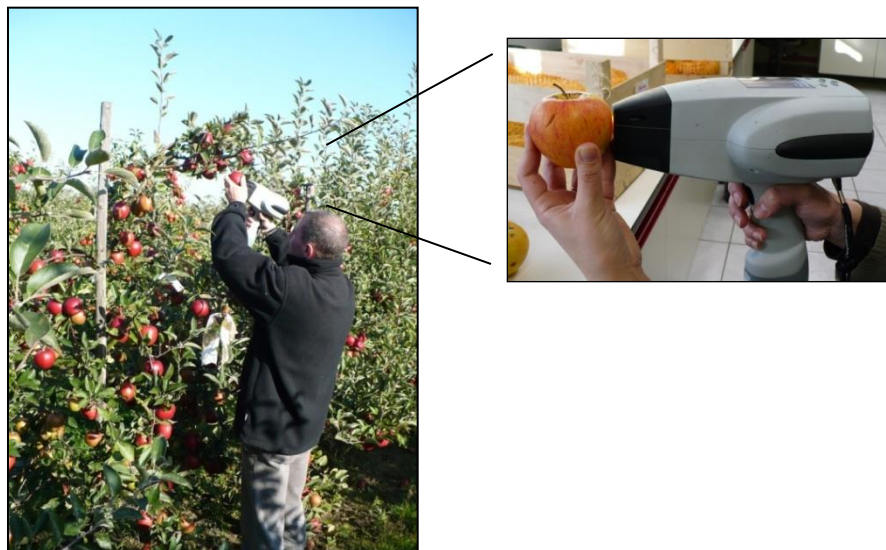
# Use of NIRS for the determination of quality and nutritional parameters of apple

## Lab instrument



**XDS (FOSS NIRSystems, Inc.)**

## Portable instrument



**Phazir (Polychromix, Inc.)**

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

## A. « HiDRAS » European program (2004-2006) (High-Quality Disease Resistance Apples for Sustainable Agriculture)

- 2004, 2005 and 2006
- 37 varieties and 126 genotypes
- from INRA (Angers, France) and CRA-W
- vitamin C, polyphenol and sugar
- **LS-SVM calibration models**

Quality parameter	Calibration			Validation		
	n	SEC	RPD	n	SEP	RPD
Vitamin C (mg/100 g FW)	800	3.4	3.7	295	4.9	2.0
Polyphenol (µg/g FW)	2000	178	4.1	627	140	5.1
Sugar (°Brix)	1000	0.45	3.6	853	0.37	4.3

(Pissard et al., 2013)



Very good results of calibration and validation

**B. « POMINNO » (2008 – 2011)**

**Research of rapid methods to select new apple cultivars presenting high nutritional quality in the context of a sustainable agriculture**



**Develop a rapid tool for the selection of new apple varieties  
using NIR spectroscopy:**



**1. Application of NIR in the apple breeding program**



**2. Monitoring of the maturity of 'Braeburn' in the orchard**

# 1. Application of NIR in the apple breeding program



## Calibration model for 2009-2010 with XDS

Quality parameter	N	Mean	SD	SEC	RSQ	SECV	1-VR	RPD	Nb termes
Maturity	231	7.89	1.70	0.74	0.81	0.90	0.72	1.89	11
Firmness(kg/cm <sup>2</sup> )	230	7	2.09	1.17	0.68	1.36	0.58	1.54	11
Sugar (°Brix)	224	14.01	1.82	0.54	0.91	0.63	0.88	2.89	11
Acidity (eq.g.ac.malique/l)	224	7.91	4.89	1.60	0.89	1.85	0.85	2.64	12
Phenolic compounds (µg/g MF)	220	312.31	267.2	84.93	0.89	107.5	0.84	2.48	12
Vitamin C (mg/100 g MF)	205	2.41	1.4	0.59	0.82	0.75	0.71	1.87	12



Good results for **sugar, acidity & phenolic compounds**

Not for maturity, firmness and vit C!!

Better than the model for 2009 only!



# 1. Application of NIR in the apple breeding program



## Calibration model for 2009-2010 with Phazir

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/cm <sup>2</sup> )	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 !

## 2. Monitoring of the maturity of 'Braeburn' in the orchard



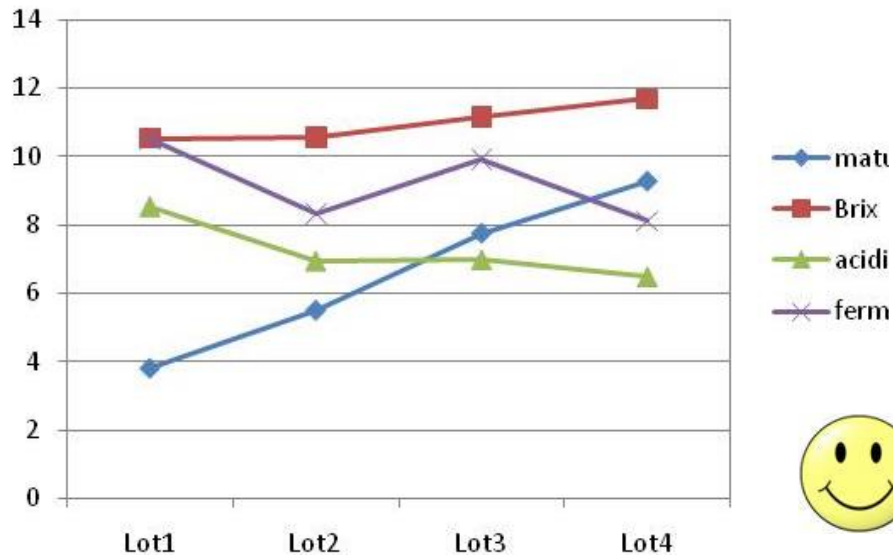
- 4 sets of 'Braeburn' in the orchard
- Monitoring with Phazir
  - 1-2 measure(s)/week
  - Before maturity → after maturity
- Harvest at **different stage of maturity**
  - Set 1: before
  - Set 2: at maturity
  - Set 3: after maturity
  - Set 4: long after maturity
- At harvest: **NIR + reference analyses**
- Variability intra-fruit >>> 4 measures/fruit  
(Pissard et al., 2012)



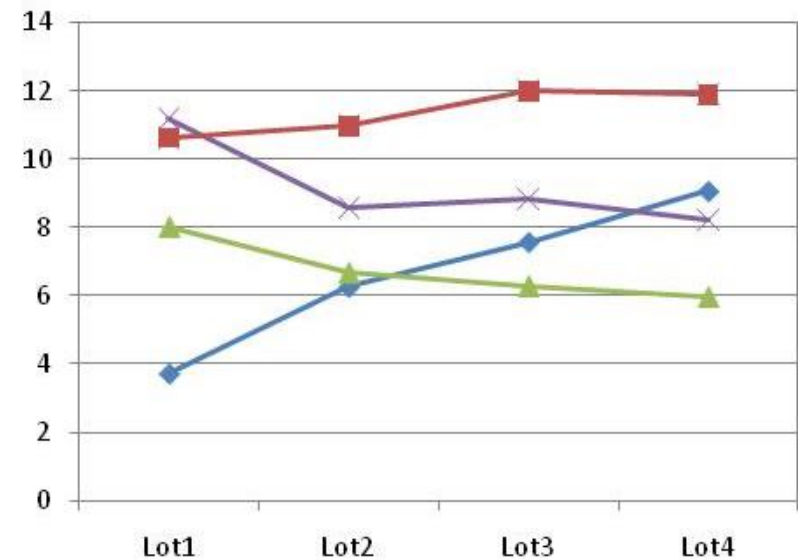
## 2. Monitoring of the maturity of 'Braeburn' in the orchard



Evolution of reference values



Evolution of predicted values



Similar evolution of quality parameters

Tool for monitoring the ripening of the fruits

C. « QUALIPOMME » (2012 – 2014)



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

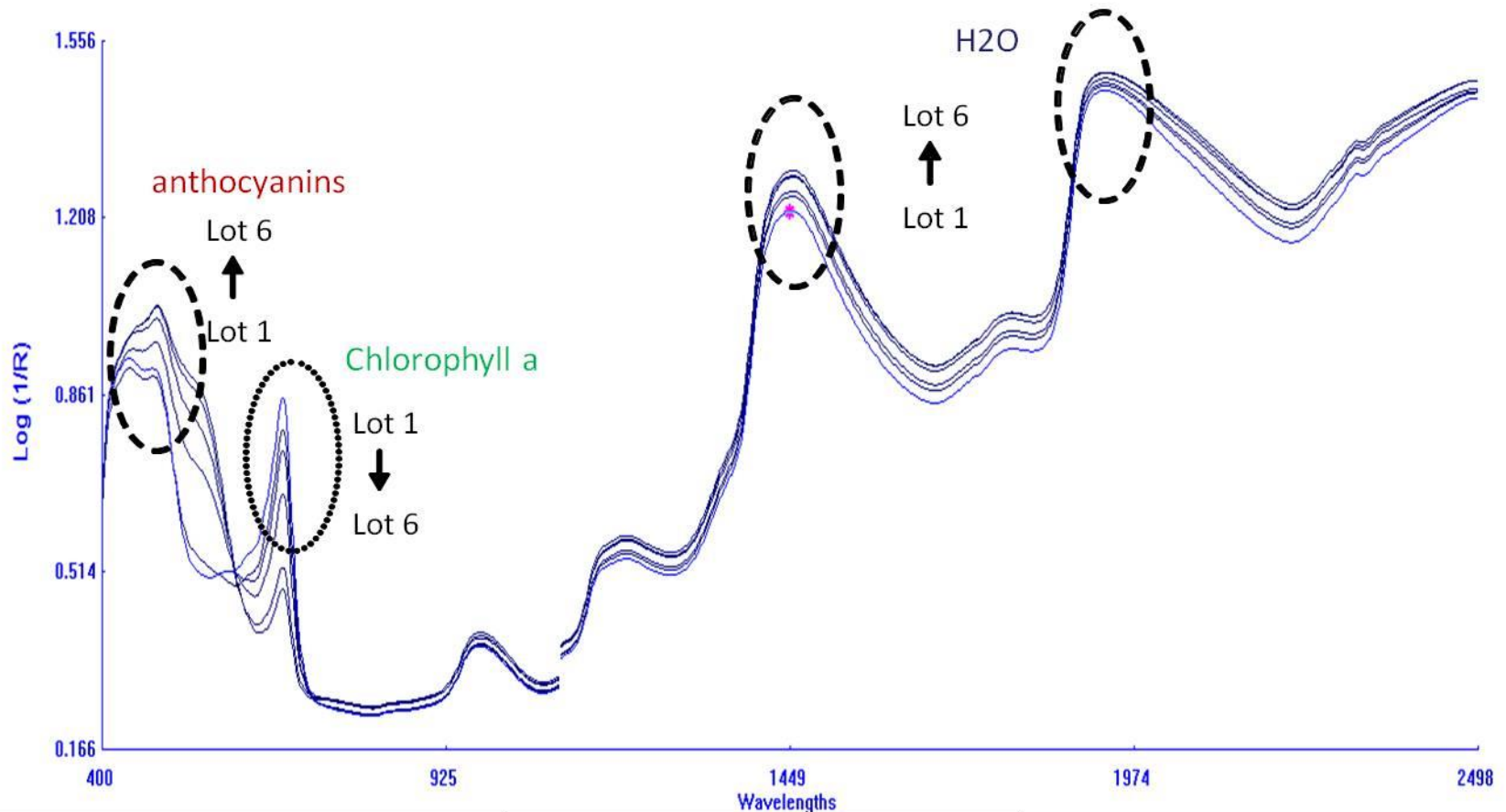


**Monitoring of the maturity of  
'Coxycelle' (CRAW-AG 90) and 'Pinova'**

- monitoring over the course of the ripening in orchard
- during **6 weeks** (10 Sept. -15 Oct. 2012)
- analyses with NIRS and reference methods

**Optimal  
picking date**

# Monitoring of the maturity of 'CRAW-AG 90' and 'Pinova'



Evolution of NIR spectra over the course of ripening of the fruits (set 1 to 6)

## Calibration model with PLS (XDS spectra)

### 'Coxybelle' (CRAW-AG90)

	SEC	RSQ	Nb termes	SD	RPD
<b>Maturité</b>	0.58	0.92	7	2.07	3.6
<b>Fermeté</b>	0.84	0.49	7	1.18	1.4
<b>Sucre</b>	0.44	0.88	7	1.31	3.0
<b>Acidité</b>	0.37	0.80	7	0.85	2.3
<b>Polyphénols</b>	145	0.67	7	252	1.7



**Good, even very good precision of calibration for:**

- maturity
- sugar
- acidity

Better results for variety-specific models !

## **NIRS : RAPID TOOL FOR THE ANALYSIS OF THE QUALITY OF APPLES**



### **Precision of calibration/prediction depends on:**

- **Quality parameter**
  - ok for sugar, phenolic compounds, acidity
  - desappointing results for vitamin C, firmness
- **Size of the database**
  - big (n = 1000-3000) >> small database (n = 200-300)
- **Spectrophotometer**
  - XDS >>> Phazir
- **« year effect »**
  - climatic conditions, prevalence of diseases,...



## Limitations/disadvantages:

- Reference analyses
- Development of calibration equations  
time required & not easy for inexperienced users...
- **Big database required for a good precision**  
ex: in the case of breeding program
- **Database according to the application**  
ex: breeding program vs. monitoring
- **Portable instrument**  
less precision & influence of external conditions





Thanks !