Programme

Venue: Alma Mater Studiorum - Università di Bologna
Piazzale Karl Marx, 180, Cesena

Tuesday, 31st January 2017

09:00 - 14:00 **Registration**

09:00 - 13:00 **Pre-Conference Events**

Aula Magna

- Research in a dish. New recipes for a safe and sustainable agri-food industry.
  The workshop will present the agri-food research projects co-funded by Region Emilia - Romagna within the POR-FESR 2014-2020.

Aula A

- Core Organic Plus projects on organic fruits.
  Strategies to improve quality of organic products in an European perspective.
- Workshop on scientific publishing by Elsevier.
  Tips on how to improve your chances of your paper being accepted.
  Tools to effectively promote your research and yourself.

Aula Anfiteatro

- Gastronomy: Tradition and Innovation.
  Practical demonstration and explanation of typical regional foods.

14:00 - 14:30 **Welcome Coffee - Put up Poster Session 1**

14:30 - 15:00 **Welcome to FoodInnova 2017 in Cesena and Opening**

Authorities: Major of Cesena, Representatives of UNIBO, SerInAr, KM4FI

15:00 - 17:30 **Plenary Session 1**

Chairs: Marco Dalla Rosa, Jorge Gerard, Pedro Fito Maupoey

15:00 **[PL01]** FOODINNOVA CONFERENCE AND THE PARADIGM OF THE INNOVATION IN TRADITIONAL FOOD PRODUCTION
Marco Dalla Rosa - Alma Mater Studiorum - Università di Bologna (Italy)

15:30 **[PL02]** TAKING ADVANTAGE OF PHASE CHANGES FOR INNOVATIVE FOOD PROCESSING: SELECTED EXAMPLES FROM LOW TO HIGH TEMPERATURES AND PRESSURES
Oliver Schlüter - Leibniz-Institut für Agrartechnik Potsdam-Bornim e.V., European Federation of Food Science and Technology (Germany)

16:00 **[PL03]** THE INTERFACE BETWEEN FOOD ENGINEERING AND GASTRONOMY
Jose Miguel Aguilera Radic - Pontificia Universidad Católica de Chile (Chile)

REAL-TIME MONITORING OF FRUIT AND VEGETABLES DURING HOT-AIR DRYING USING NIR SPECTROSCOPY

*food*Innova – January 31, 2017

Dr. Roberto Moscetti* and Prof. Riccardo Massantini

Department for Innovation in Biological, Agro-food and Forest systems (DIBAF), University of Tuscia, Viterbo (Italy)

* rmoscetti@unitus.it

Dr. Barbara Sturm and Dr. Stuart Crichton

Department of Agricultural Engineering, Universität Kassel (Germany)

International Conference on Food Innovation

foodInnova 2017

foodInnova 2017

Real-time monitoring of fruit and vegetables during hot-air drying using near-infrared spectroscopy

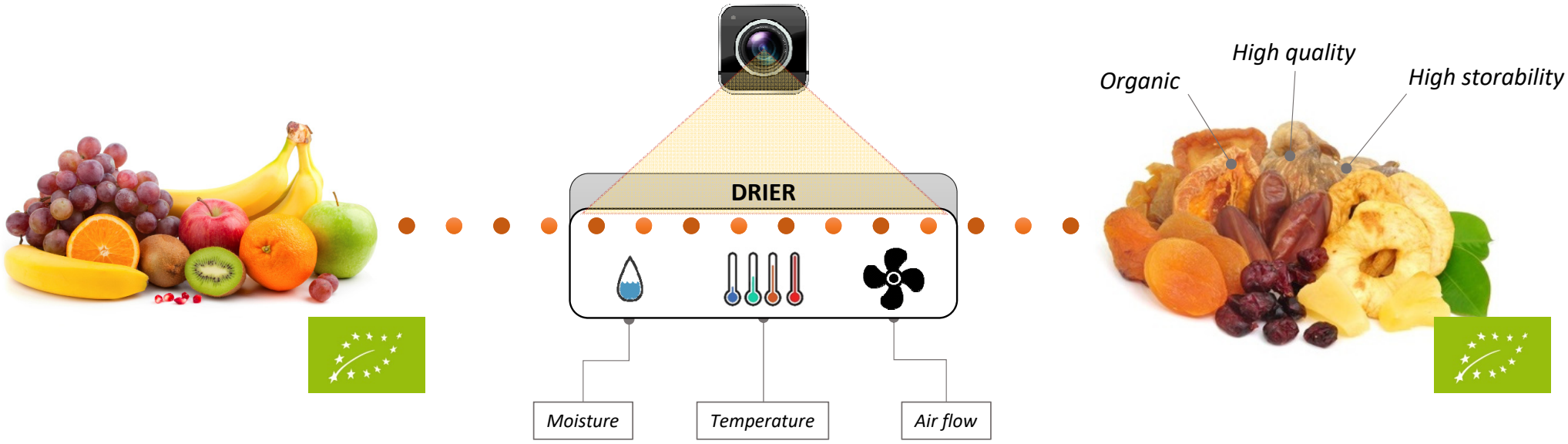
WeDIBAF

European Commission

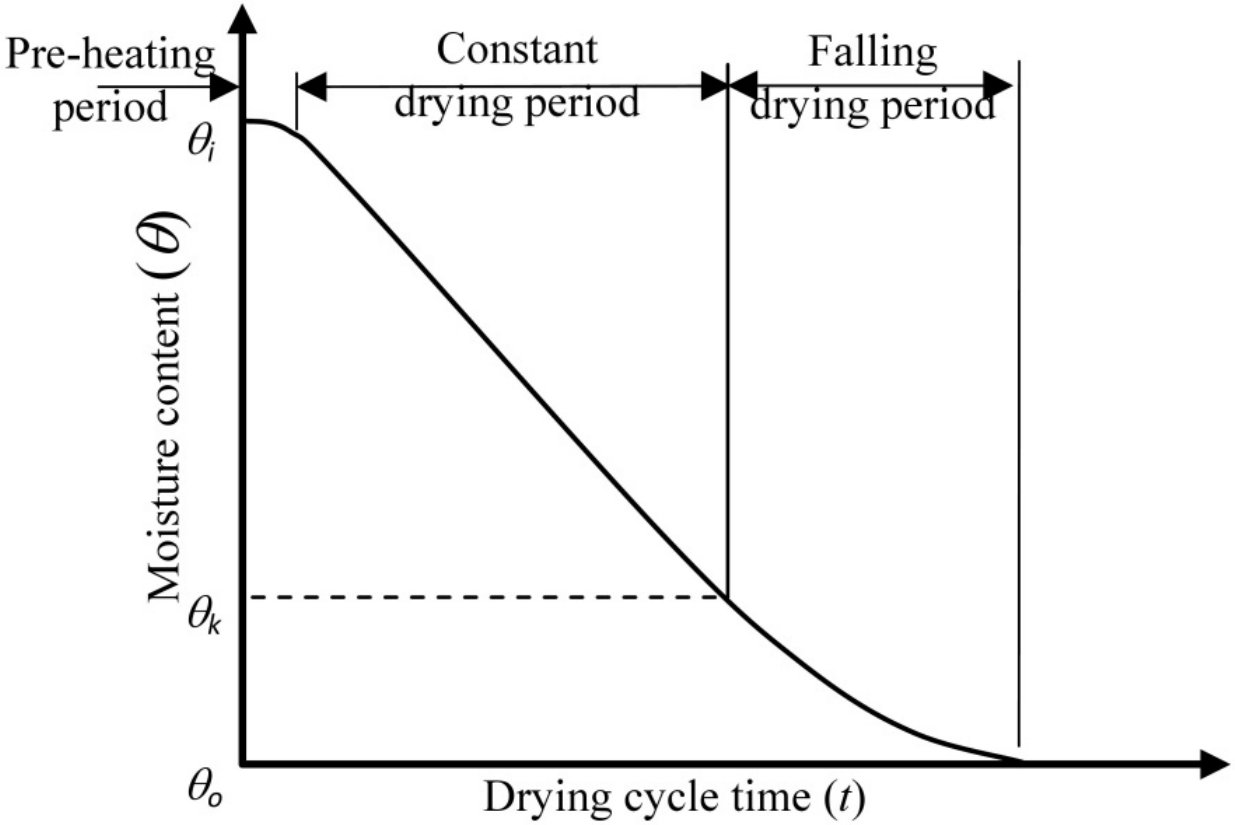
CORE organic

Sus Organic

UNIVERSITÀ DEGLI STUDI DELLA Tuscia



» HOT-AIR DRYING



Phase 1. Pre-heating period

Phase 2. Constant drying period

Phase 3. Falling drying period

» HOT-AIR DRYING

Physico-chemical changes

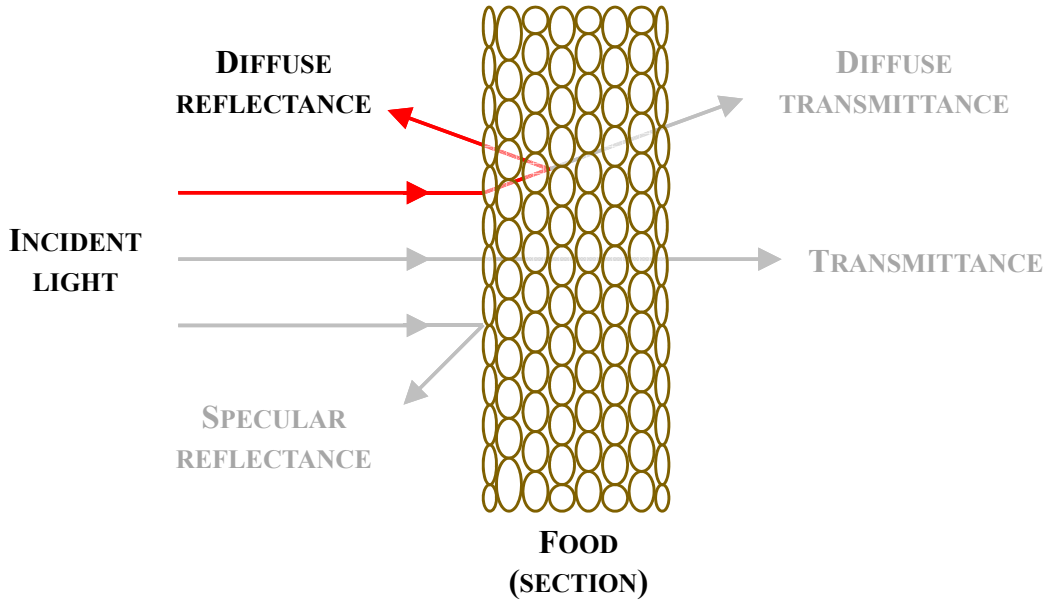
- » Moisture content and water activity
- » Shape and size
- » Firmness and texture
- » Pigments content
- » Enzymatic and non-enzymatic browning

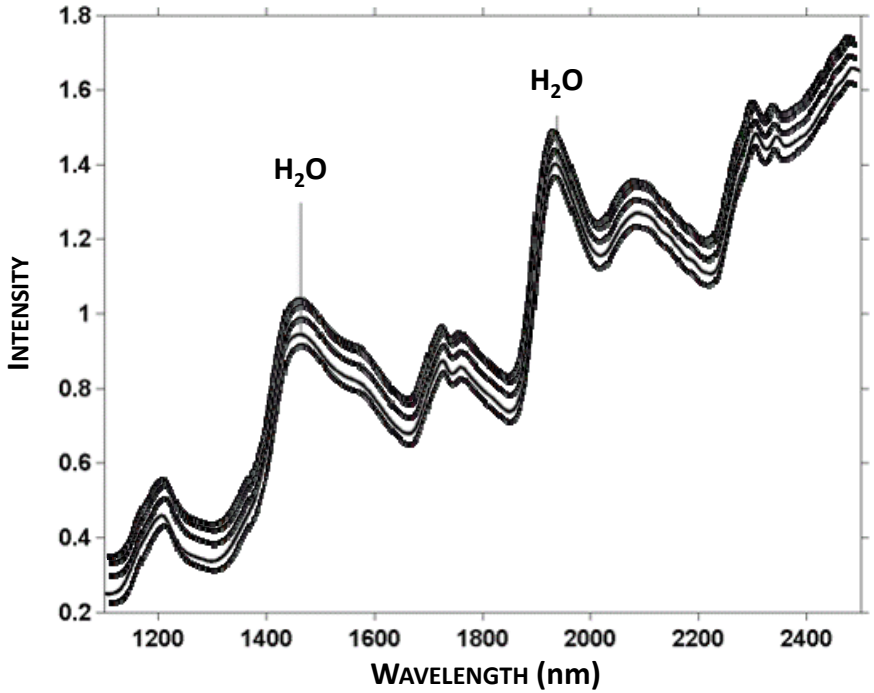
Nutritional changes

- » Vitamins content
- » Carotenoids content
- » Total polyphenolic content and antioxidant capacity

Sensorial characteristics

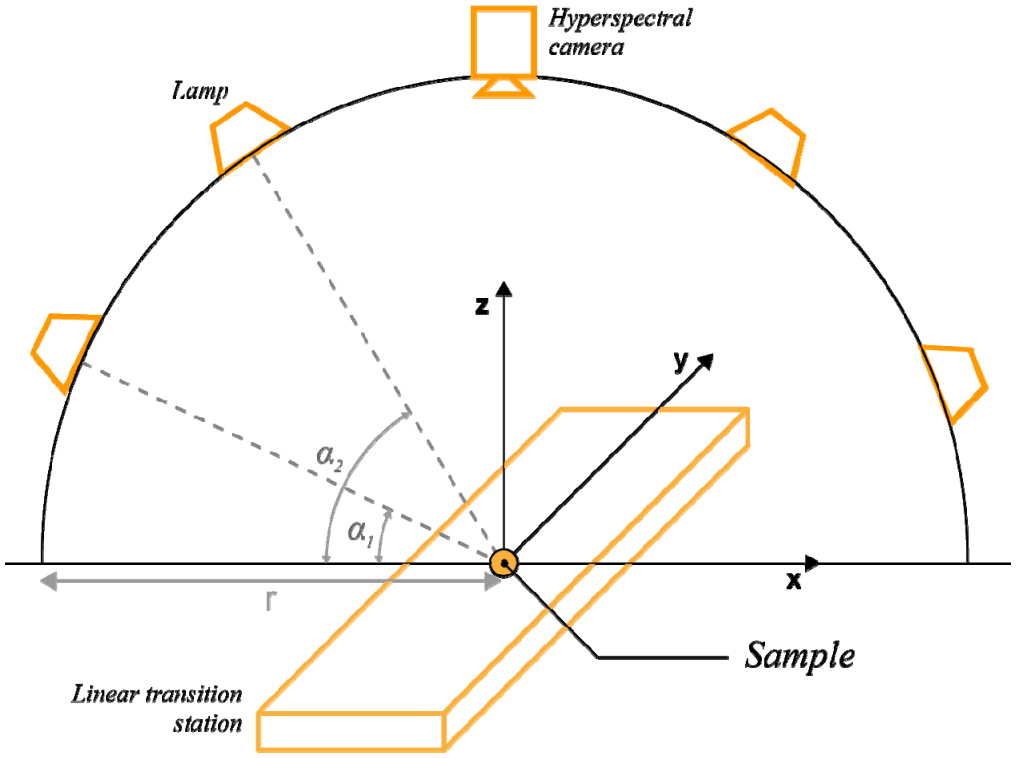
» NEAR-INFRARED (NIR) SPECTROSCOPY



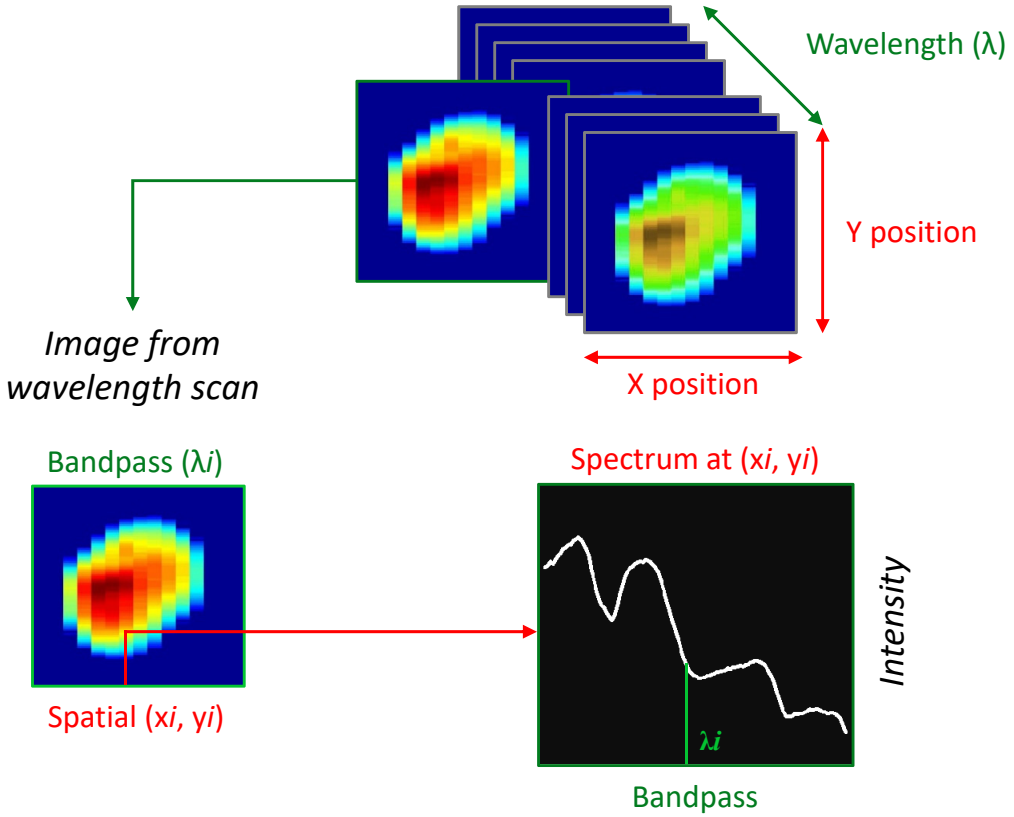


» HYPERSPECTRAL IMAGING

HYPERSPECTRAL SETUP



HYPERCUBE

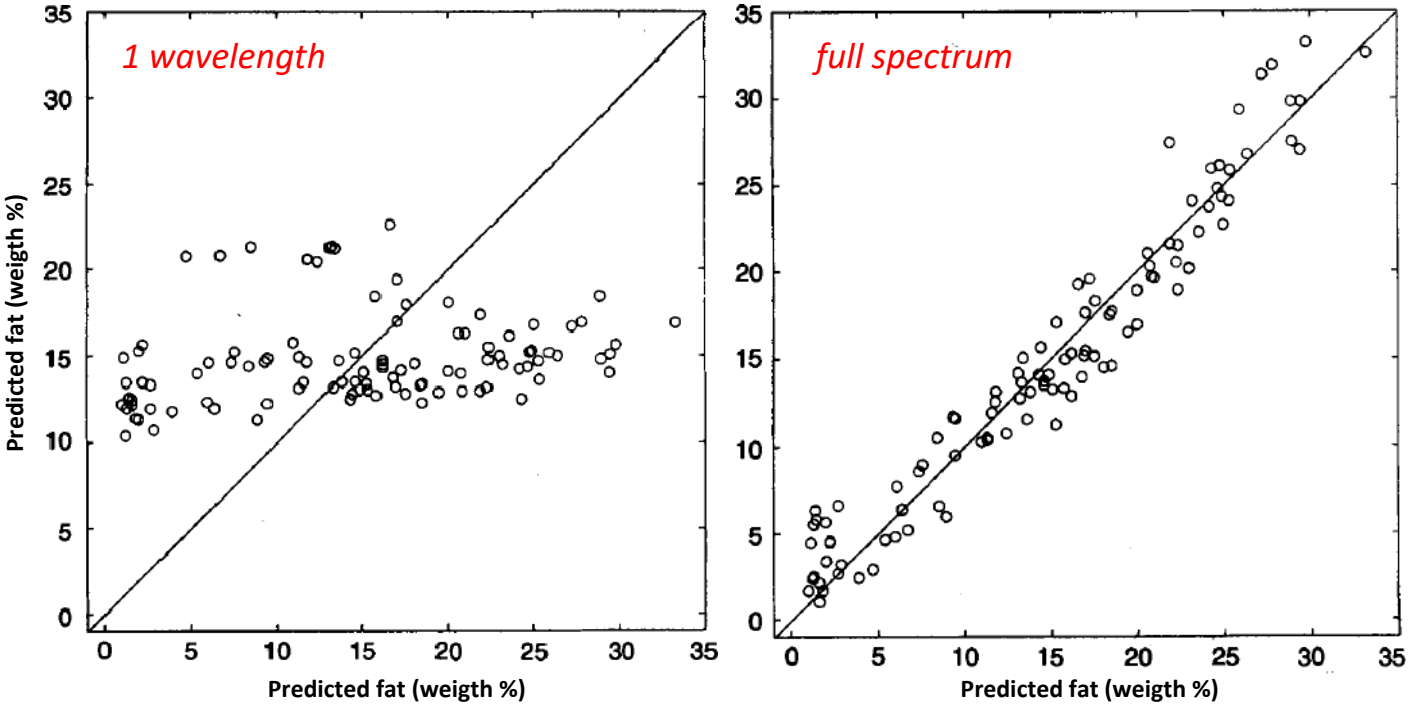


» BASIC PROBLEMS OF NIR SPECTROSCOPY

MAIN PROBLEMS

- ❑ Non-selectivity
- ❑ Collinearity
- ❑ Non-linearity
- ❑ Calibration data selection
- ❑ Outliers

Example of non-selectivity problem



» BASIC PROBLEMS OF NIR SPECTROSCOPY

$$I = a + bI_0 + e$$

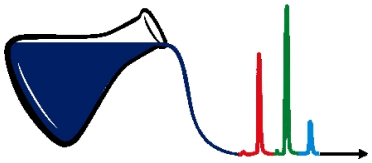
I	=	**resulting intensity**
I_0	=	*real intensity*
a	=	*additive effect*
b	=	*multiplicative effect*
e	=	*instrumental noise*

Light scattering

Because of scattering, snow appears whiter than ice or wet snow

» MULTIVARIATE CALIBRATION AND CLASSIFICATION

CHEMOMETRICS



The International Chemometrics Society (ICS) gives the following definition:

'Chemometrics is the science of relating measurements made on a chemical system or process to the state of the system via application of mathematical or statistical methods'

General scopes of chemometrics are the following:

1. Design experiments, select and optimize experimental parameters, etc.
2. Extract information from data
3. Obtain graphical abstract from data, which are useful for human comprehension

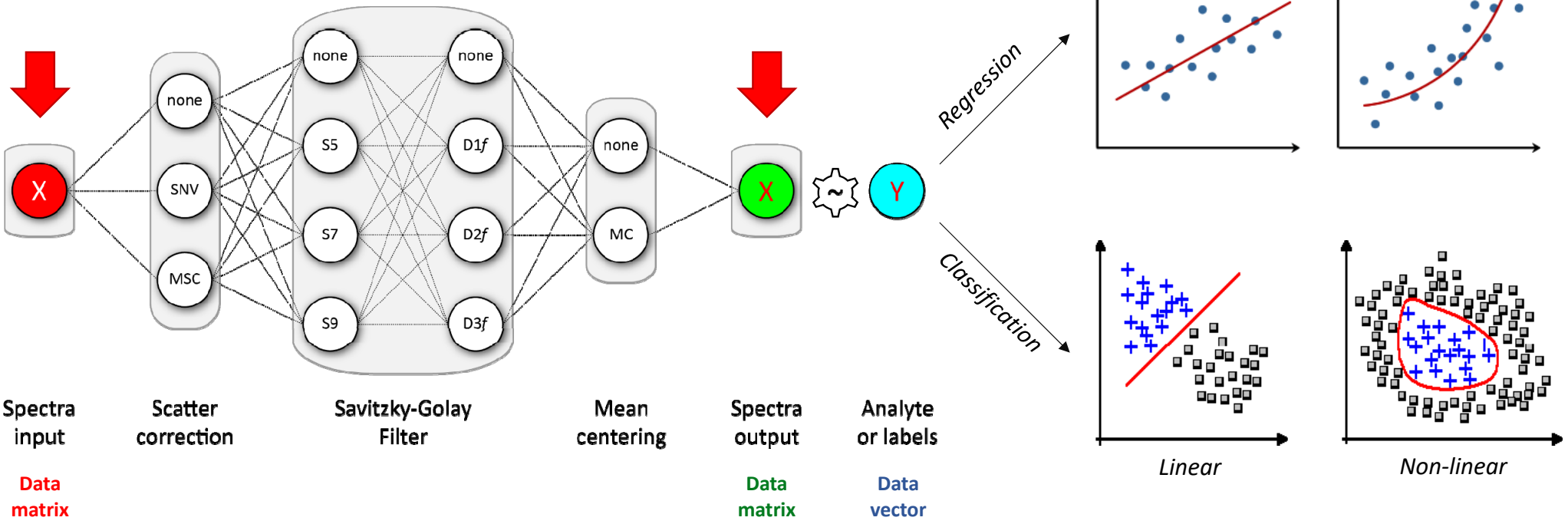
ARTIFICIAL INTELLIGENCE

Technology and methods inspired by **informatics** and **psychology**

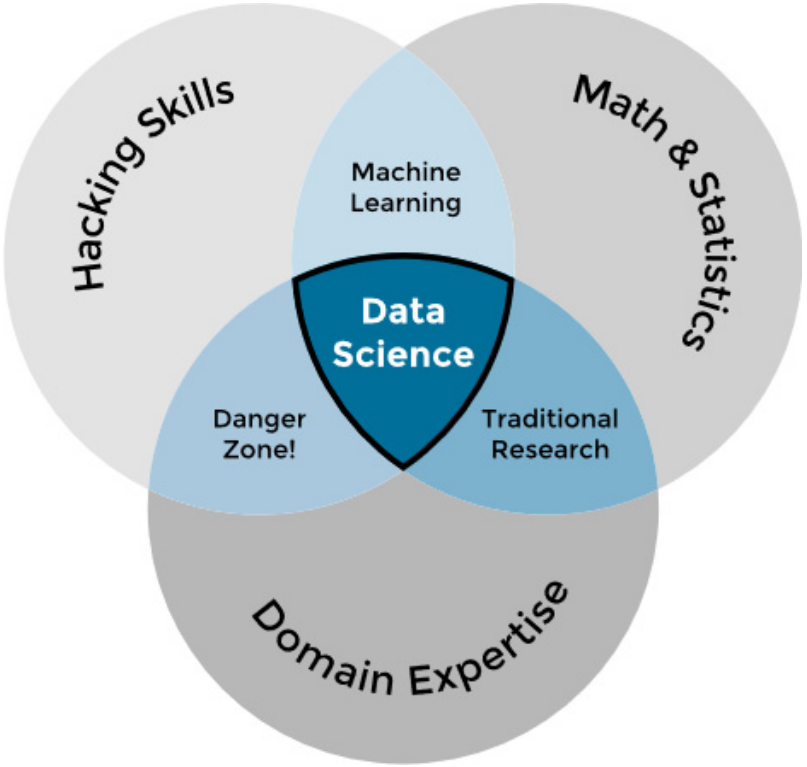
Construction of machines which way of acting can be considered as 'human' (caused by 'human intelligence')

» MULTIVARIATE CALIBRATION AND CLASSIFICATION

Example of 96 spectral pretreatments



» MULTIVARIATE CALIBRATION AND CLASSIFICATION



DOMAIN EXPERTISE

Knowledge related to specific facts, to relationships about certain subject matter, not just a technical process

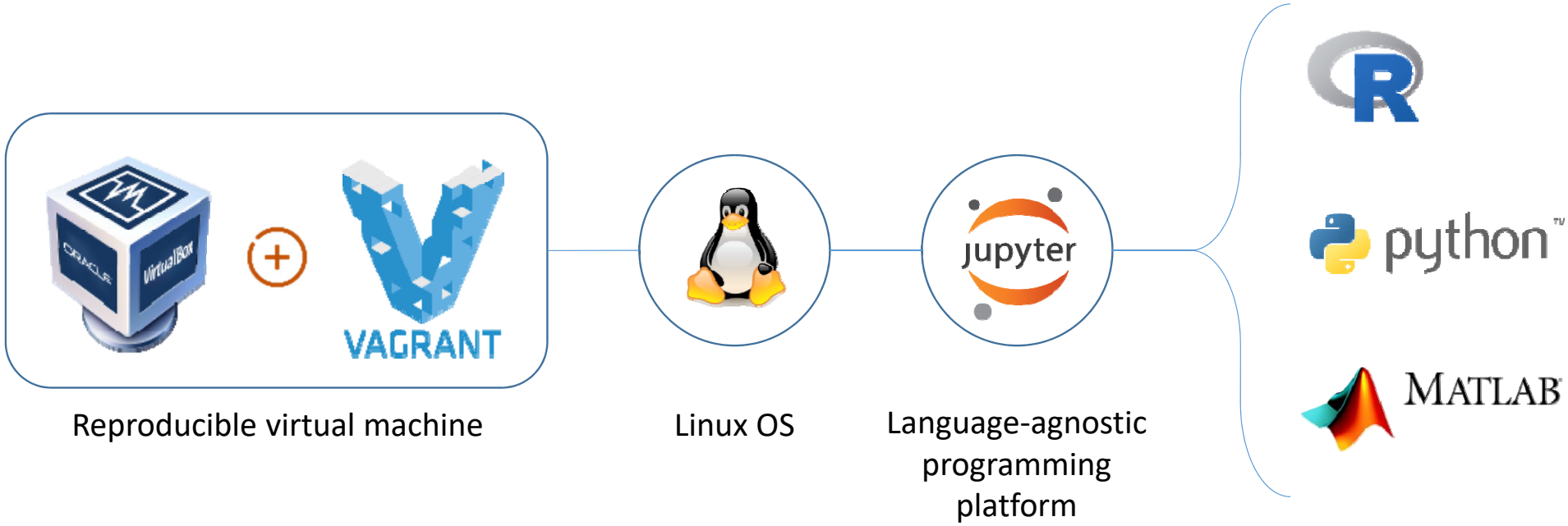
MATH & STATISTICS

Use of appropriate mathematical and statistical methods, both classical statistics and machine learning or pattern recognition

HACKING SKILLS

Ability to cleverly draw up code from scratch to solve problems

» MULTIVARIATE CALIBRATION AND CLASSIFICATION



» DRYING TESTS

NIR spectroscopy (1100-2300 nm)

Malus domestica B.
var. Gala

Shape and size
Wedges of 3-mm thickness

Pretreatment
Microwave blanching

Drying temperature
60°C (for 8 h)

Daucus carota L.
var. Romance

Shape and size
Slices of 3-mm thickness

Pretreatment
Hot-water blanching

Drying temperature
40°C (for 8 h)

Hyperspec. imaging (400-1000 nm)

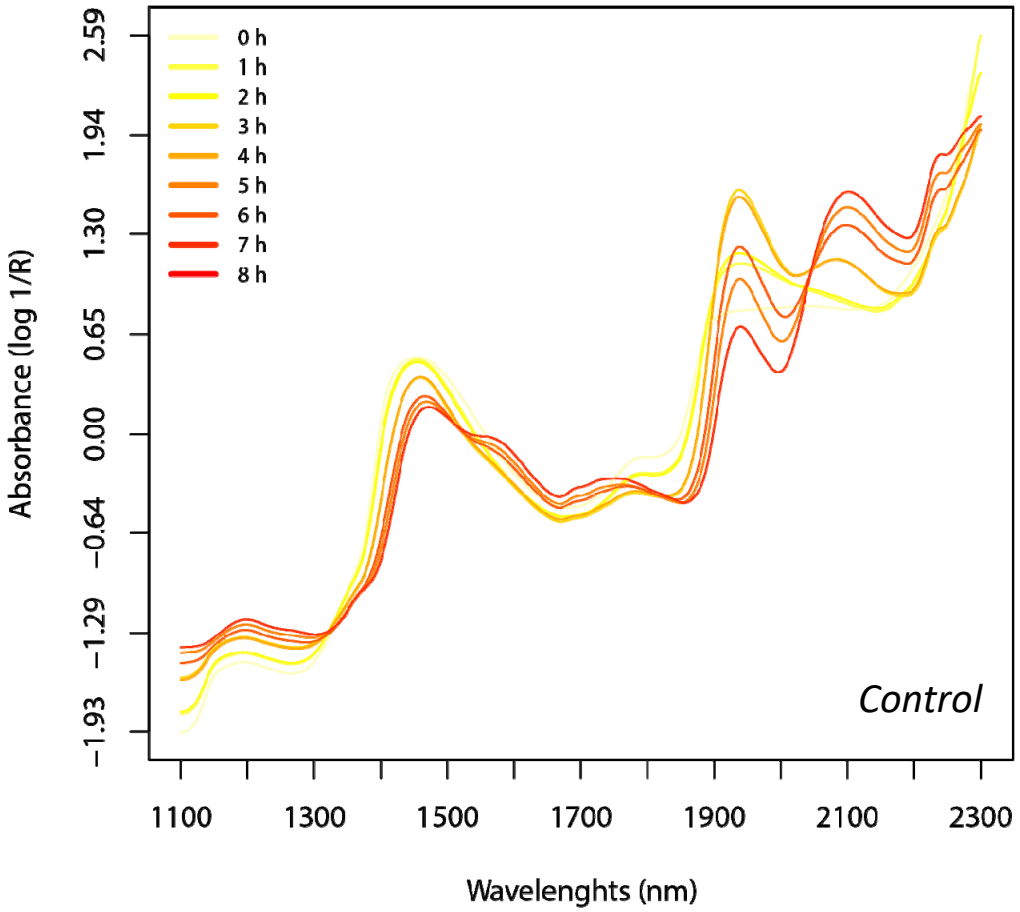
Solanum tuberosum L.
var. Anuschka

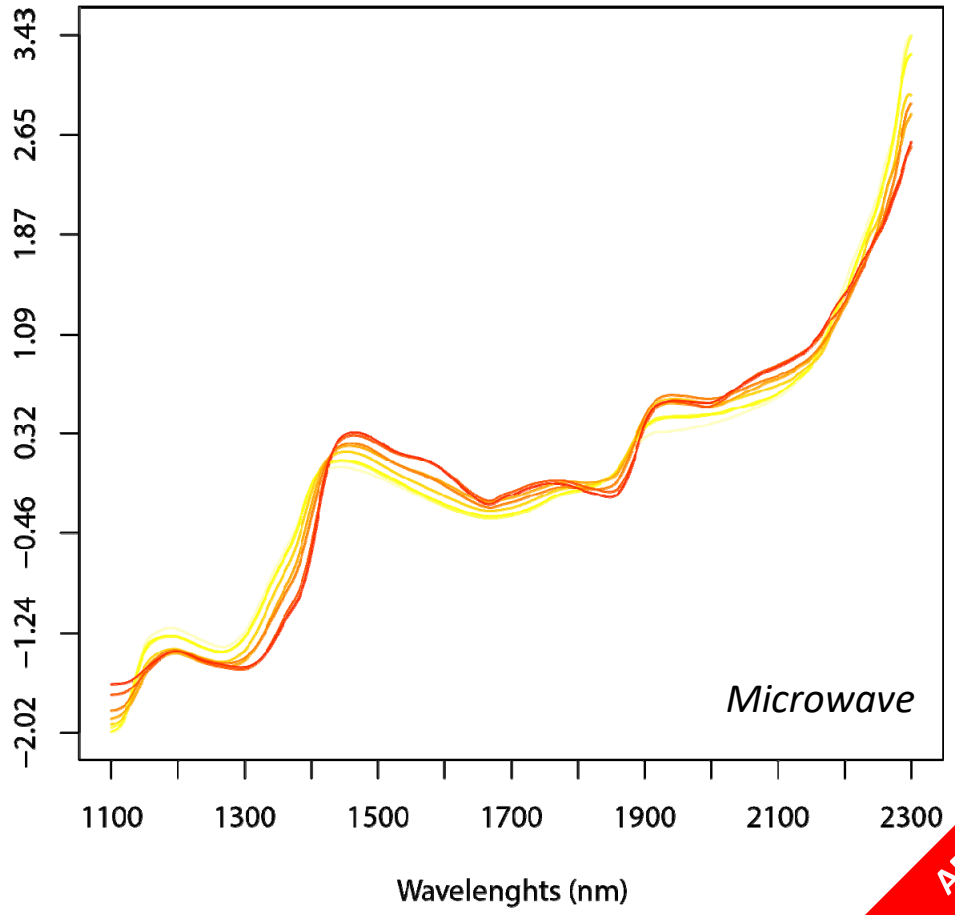
Shape and size
Slices of 5-, 7- and 9-mm thickness

Pretreatment
None

Drying temperature
50°C (for 8 h)

» DRYING TESTS – APPLE | *Regression models: spectral acquisition (X matrix)*





APPLE

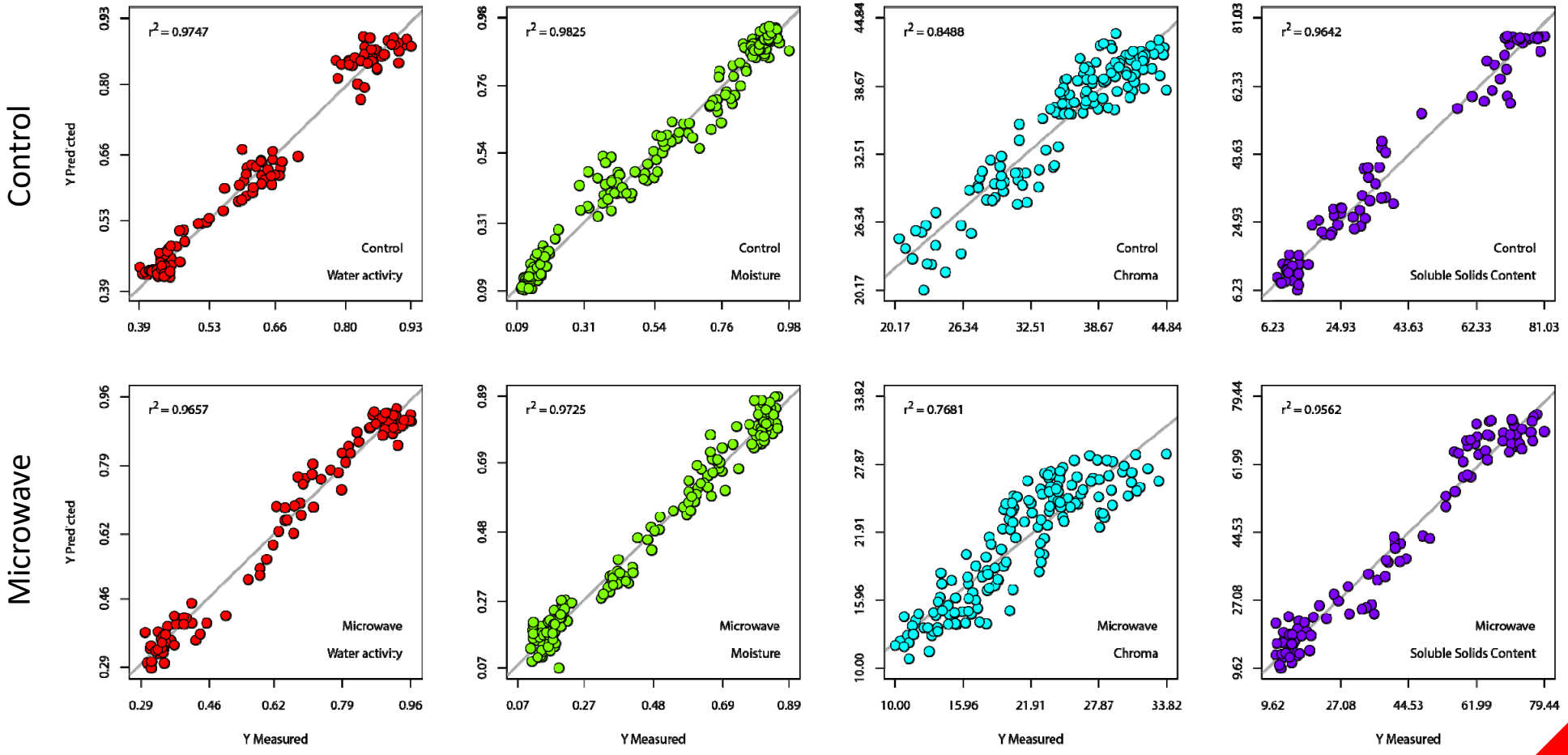
» DRYING TESTS – APPLE | *Regression models: state variables measurement (Y vector)*

	Drying time (hour)	Water activity (a_w)	Moisture (relative)	Soluble solids content (°Brix)	Green / Red (a*)	Blue / Yellow (b*)	Hue angle (h)	Chroma (C*)
CONTROL	0	0.88 ± 0.04 a	0.89 ± 0.00 a	11.39 ± 1.43 e	2.92 ± 0.96 c	23.30 ± 1.83 g	82.93 ± 1.97 a	23.49 ± 1.89 f
	1	0.84 ± 0.04 ab	0.85 ± 0.02 a	13.01 ± 0.35 e	5.01 ± 0.73 b	28.71 ± 1.33 f	80.13 ± 1.02 bc	29.14 ± 1.42 e
	2	0.82 ± 0.05 b	0.83 ± 0.03 a	14.74 ± 0.52 e	6.06 ± 0.80 b	31.59 ± 1.76 e	79.17 ± 0.99 bcd	32.17 ± 1.85 d
	3	0.64 ± 0.03 c	0.58 ± 0.09 b	24.85 ± 1.96 d	8.16 ± 1.24 a	37.67 ± 2.76 bcd	77.79 ± 1.44 de	38.56 ± 2.86 bc
	4	0.62 ± 0.03 c	0.50 ± 0.09 c	35.77 ± 4.40 c	6.17 ± 1.05 b	36.07 ± 2.55 d	80.34 ± 1.23 bc	36.60 ± 2.65 c
	5	0.45 ± 0.03 d	0.16 ± 0.06 e	38.85 ± 2.29 c	6.46 ± 2.00 b	39.28 ± 2.44 abc	80.75 ± 2.35 b	39.84 ± 2.67 ab
	6	0.46 ± 0.04 d	0.25 ± 0.11 d	58.50 ± 4.93 b	8.34 ± 2.03 a	40.48 ± 2.49 a	78.43 ± 2.50 cde	41.37 ± 2.67 ab
	7	0.45 ± 0.04 d	0.10 ± 0.04 ef	69.11 ± 5.42 a	8.89 ± 1.19 a	37.49 ± 2.65 cd	76.63 ± 1.73 e	38.55 ± 2.65 bc
	8	0.42 ± 0.02 d	0.10 ± 0.04 f	75.48 ± 2.64 a	9.03 ± 1.76 a	40.07 ± 1.67 ab	77.33 ± 2.30 de	41.11 ± 1.78 ab
	p value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
	HSD	0.04	0.06	7.59	1.60	2.56	2.09	2.68
MICROWAVE	0	0.91 ± 0.03 a	0.87 ± 0.02 a	11.97 ± 1.15 d	-2.07 ± 0.45 c	13.61 ± 2.25 d	98.70 ± 1.46 ab	13.77 ± 2.27 d
	1	0.92 ± 0.02 a	0.83 ± 0.02 ab	15.20 ± 1.21 d	-2.03 ± 0.75 c	13.19 ± 2.54 d	99.35 ± 4.40 a	13.38 ± 2.45 d
	2	0.88 ± 0.04 a	0.81 ± 0.02 b	16.84 ± 3.36 d	-1.48 ± 0.59 c	16.32 ± 2.54 cd	95.31 ± 2.14 bc	16.40 ± 2.53 cd
	3	0.75 ± 0.07 b	0.62 ± 0.04 c	34.25 ± 11.43 c	-1.52 ± 0.70 c	19.28 ± 2.22 c	94.72 ± 2.34 c	19.35 ± 2.18 c
	4	0.60 ± 0.12 c	0.42 ± 0.09 d	46.75 ± 9.74 b	0.54 ± 1.86 b	25.08 ± 3.95 ab	89.17 ± 3.92 d	25.14 ± 4.00 ab
	5	0.58 ± 0.11 c	0.36 ± 0.06 e	48.63 ± 12.31 b	1.23 ± 1.90 b	27.23 ± 3.56 a	87.80 ± 3.63 d	27.31 ± 3.64 a
	6	0.36 ± 0.02 d	0.19 ± 0.01 f	73.21 ± 13.23 a	0.98 ± 0.90 b	24.64 ± 2.85 ab	87.87 ± 2.00 d	24.68 ± 2.87 ab
	7	0.35 ± 0.02 d	0.18 ± 0.02 f	63.49 ± 6.14 a	0.79 ± 2.03 b	22.95 ± 2.37 b	88.28 ± 4.64 d	23.04 ± 2.45 b
	8	0.32 ± 0.02 d	0.19 ± 0.03 f	73.22 ± 3.80 a	3.87 ± 3.32 a	25.75 ± 6.21 ab	82.19 ± 5.37 e	26.15 ± 6.58 ab
	p value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
	HSD	0.08	0.04	10.73	1.64	3.37	3.54	3.46

APPLE

» DRYING TESTS – APPLE | *Regression models: results using the full spectrum*

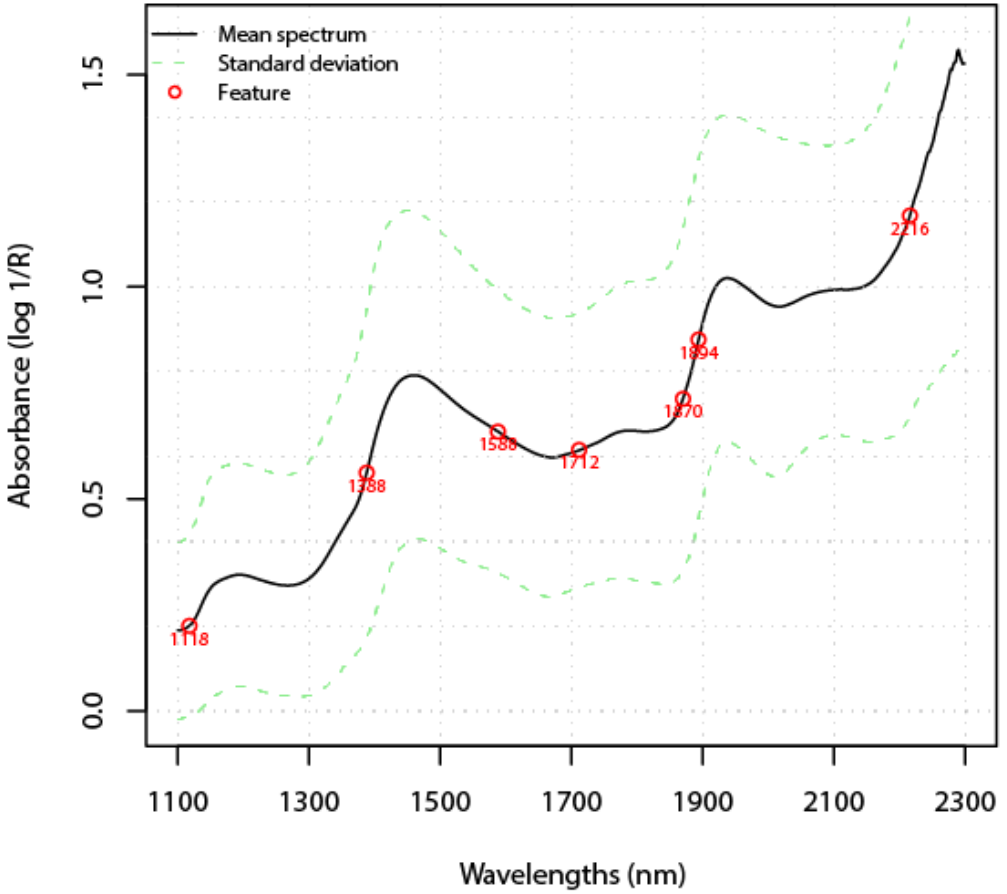
Sus Organic

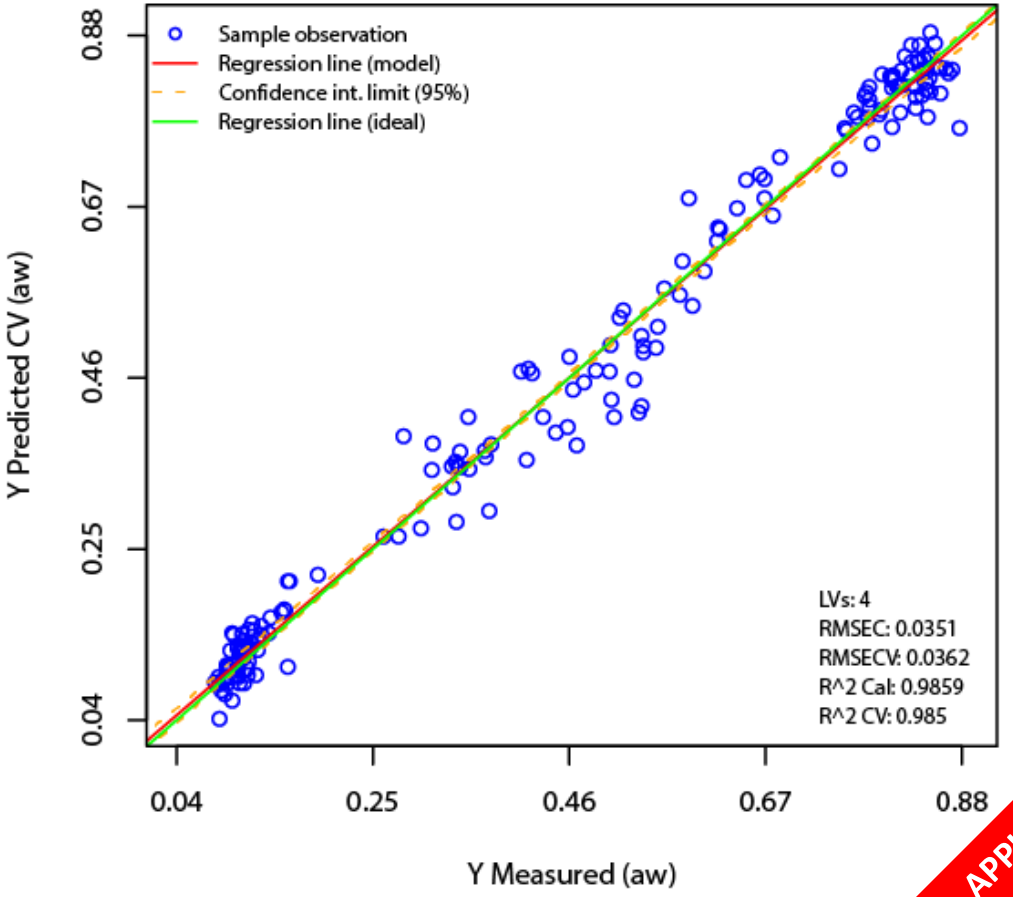


APPLE

» DRYING TESTS – APPLE | *Regression models: results using features selection*

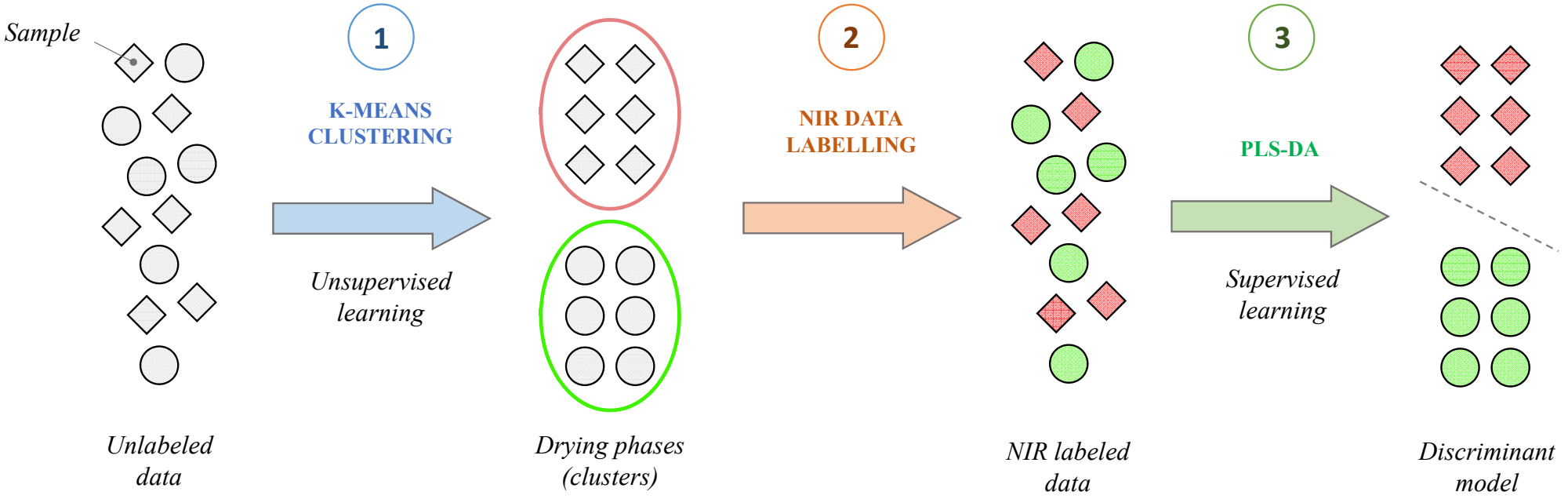
Sus Organic





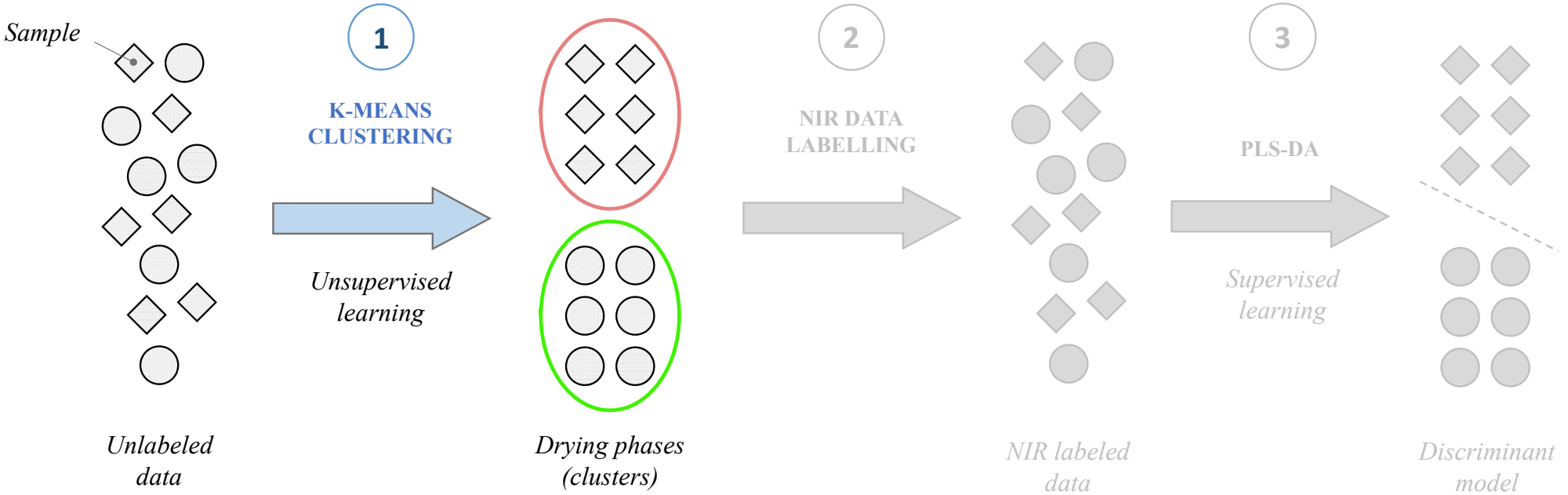
APPLE

» DRYING TESTS – APPLE | *Classification models*



APPLE

» DRYING TESTS – APPLE | *Classification models: cluster analysis*



APPLE

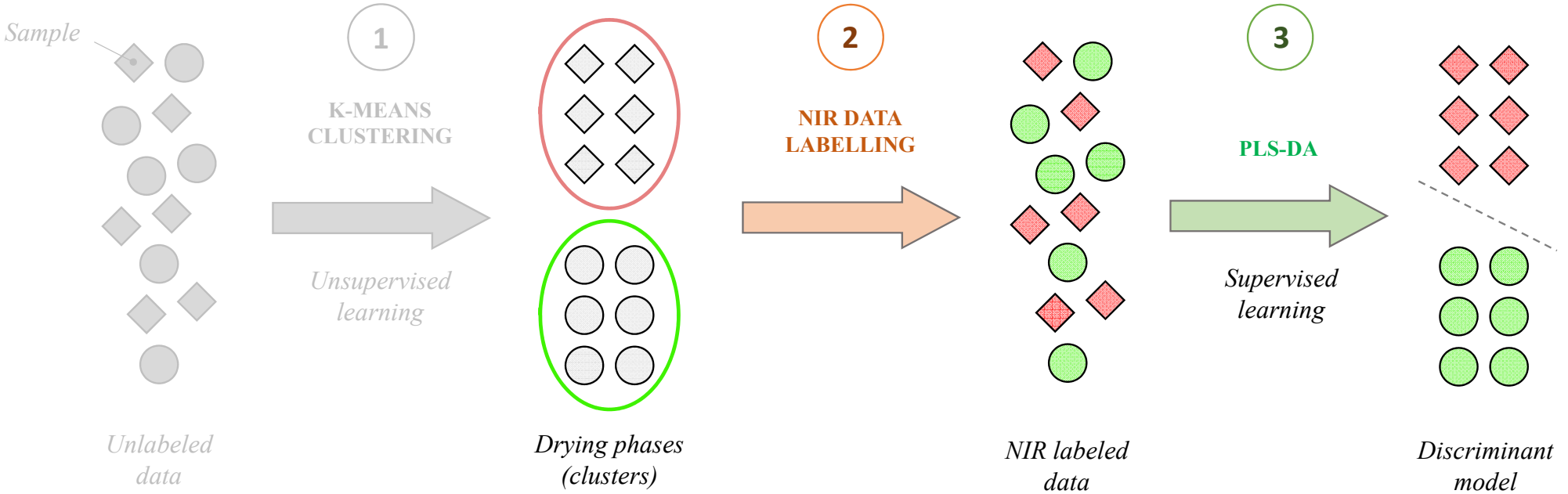
» DRYING TESTS – APPLE | *Classification models: cluster analysis*

Sus Organic

	Drying time (hour)		Water activity (a_w)		Moisture (relative)		Soluble solids content (°Brix)		Green / Red (a*)		Blue / Yellow (b*)		Hue angle (h)		Chroma (C*)	
CONTROL	0		0.88 ± 0.04	a	0.89 ± 0.00	a	11.39 ± 1.43	e	2.92 ± 0.96	c	23.30 ± 1.83	g	82.93 ± 1.97	a	23.49 ± 1.89	f
	1	***Phase 1***	0.84 ± 0.04	ab	0.85 ± 0.02	a	13.01 ± 0.35	e	5.01 ± 0.73	b	28.71 ± 1.33	f	80.13 ± 1.02	bc	29.14 ± 1.42	e
	2		0.82 ± 0.05	b	0.83 ± 0.03	a	14.74 ± 0.52	e	6.06 ± 0.80	b	31.59 ± 1.76	e	79.17 ± 0.99	bcd	32.17 ± 1.85	d
	3	***Phase 2***	0.64 ± 0.03	c	0.58 ± 0.09	b	24.85 ± 1.96	d	8.16 ± 1.24	a	37.67 ± 2.76	bcd	77.79 ± 1.44	de	38.56 ± 2.86	bc
	4		0.62 ± 0.03	c	0.50 ± 0.09	c	35.77 ± 4.40	c	6.17 ± 1.05	b	36.07 ± 2.55	d	80.34 ± 1.23	bc	36.60 ± 2.65	c
	5		0.45 ± 0.03	d	0.16 ± 0.06	e	38.85 ± 2.29	c	6.46 ± 2.00	b	39.28 ± 2.44	abc	80.75 ± 2.35	b	39.84 ± 2.67	ab
	6	***Phase 3***	0.46 ± 0.04	d	0.25 ± 0.11	d	58.50 ± 4.93	b	8.34 ± 2.03	a	40.48 ± 2.49	a	78.43 ± 2.50	cde	41.37 ± 2.67	ab
	7		0.45 ± 0.04	d	0.10 ± 0.04	ef	69.11 ± 5.42	a	8.89 ± 1.19	a	37.49 ± 2.65	cd	76.63 ± 1.73	e	38.55 ± 2.65	bc
	8		0.42 ± 0.02	d	0.10 ± 0.04	f	75.48 ± 2.64	a	9.03 ± 1.76	a	40.07 ± 1.67	ab	77.33 ± 2.30	de	41.11 ± 1.78	ab
	p value		< 0.001		< 0.001		< 0.001		< 0.001		< 0.001		< 0.001		< 0.001	
	HSD		0.04		0.06		7.59		1.60		2.56		2.09		2.68	
MICROWAVE	0		0.91 ± 0.03	a	0.87 ± 0.02	a	11.97 ± 1.15	d	-2.07 ± 0.45	c	13.61 ± 2.25	d	98.70 ± 1.46	ab	13.77 ± 2.27	d
	1	***Phase 1***	0.92 ± 0.02	a	0.83 ± 0.02	ab	15.20 ± 1.21	d	-2.03 ± 0.75	c	13.19 ± 2.54	d	99.35 ± 4.40	a	13.38 ± 2.45	d
	2		0.88 ± 0.04	a	0.81 ± 0.02	b	16.84 ± 3.36	d	-1.48 ± 0.59	c	16.32 ± 2.54	cd	95.31 ± 2.14	bc	16.40 ± 2.53	cd
	3		0.75 ± 0.07	b	0.62 ± 0.04	c	34.25 ± 11.43	c	-1.52 ± 0.70	c	19.28 ± 2.22	c	94.72 ± 2.34	c	19.35 ± 2.18	c
	4	***Phase 2***	0.60 ± 0.12	c	0.42 ± 0.09	d	46.75 ± 9.74	b	0.54 ± 1.86	b	25.08 ± 3.95	ab	89.17 ± 3.92	d	25.14 ± 4.00	ab
	5		0.58 ± 0.11	c	0.36 ± 0.06	e	48.63 ± 12.31	b	1.23 ± 1.90	b	27.23 ± 3.56	a	87.80 ± 3.63	d	27.31 ± 3.64	a
	6		0.36 ± 0.02	d	0.19 ± 0.01	f	73.21 ± 13.23	a	0.98 ± 0.90	b	24.64 ± 2.85	ab	87.87 ± 2.00	d	24.68 ± 2.87	ab
	7	***Phase 3***	0.35 ± 0.02	d	0.18 ± 0.02	f	63.49 ± 6.14	a	0.79 ± 2.03	b	22.95 ± 2.37	b	88.28 ± 4.64	d	23.04 ± 2.45	b
	8		0.32 ± 0.02	d	0.19 ± 0.03	f	73.22 ± 3.80	a	3.87 ± 3.32	a	25.75 ± 6.21	ab	82.19 ± 5.37	e	26.15 ± 6.58	ab
	p value		< 0.001		< 0.001		< 0.001		< 0.001		< 0.001		< 0.001		< 0.001	
	HSD		0.08		0.04		10.73		1.64		3.37		3.54		3.46	

APPLE

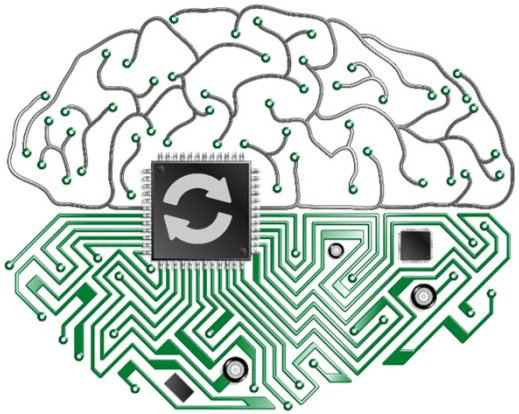
» DRYING TESTS – APPLE | *Classification models: PLS-DA model development*



APPLE

» DRYING TESTS – APPLE | *Classification models: PLS-DA model development*

Unclassified products

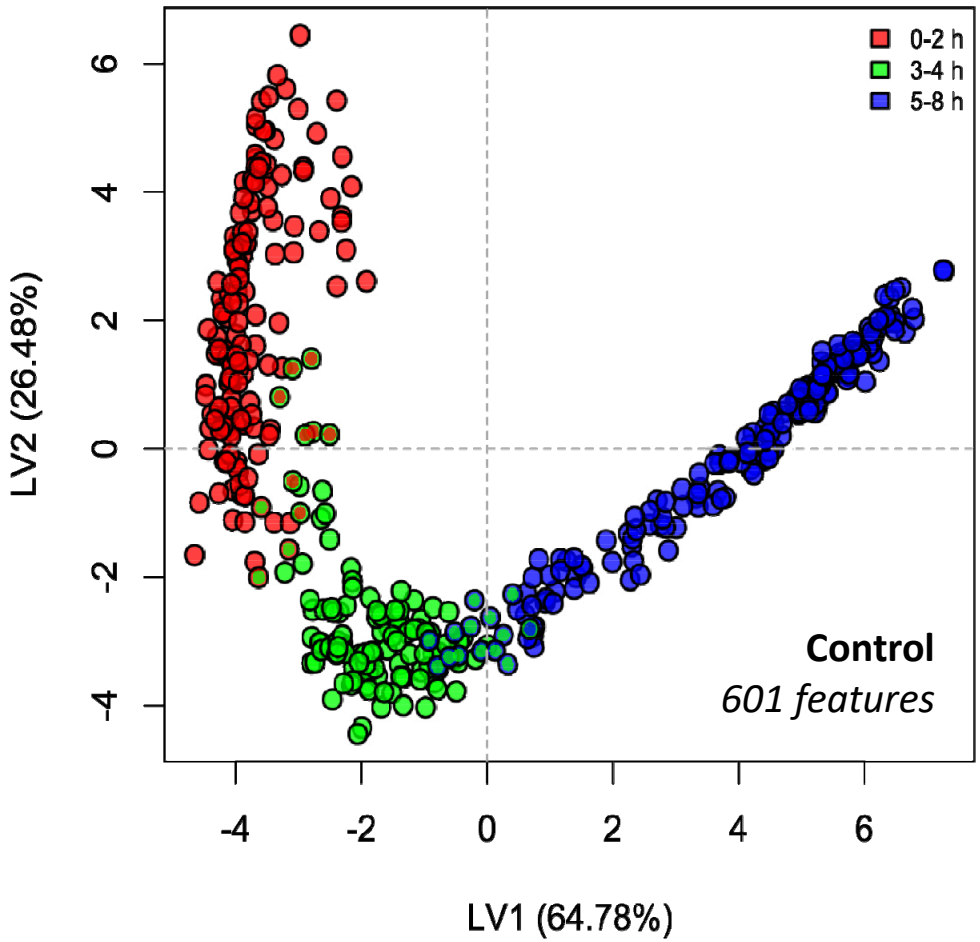


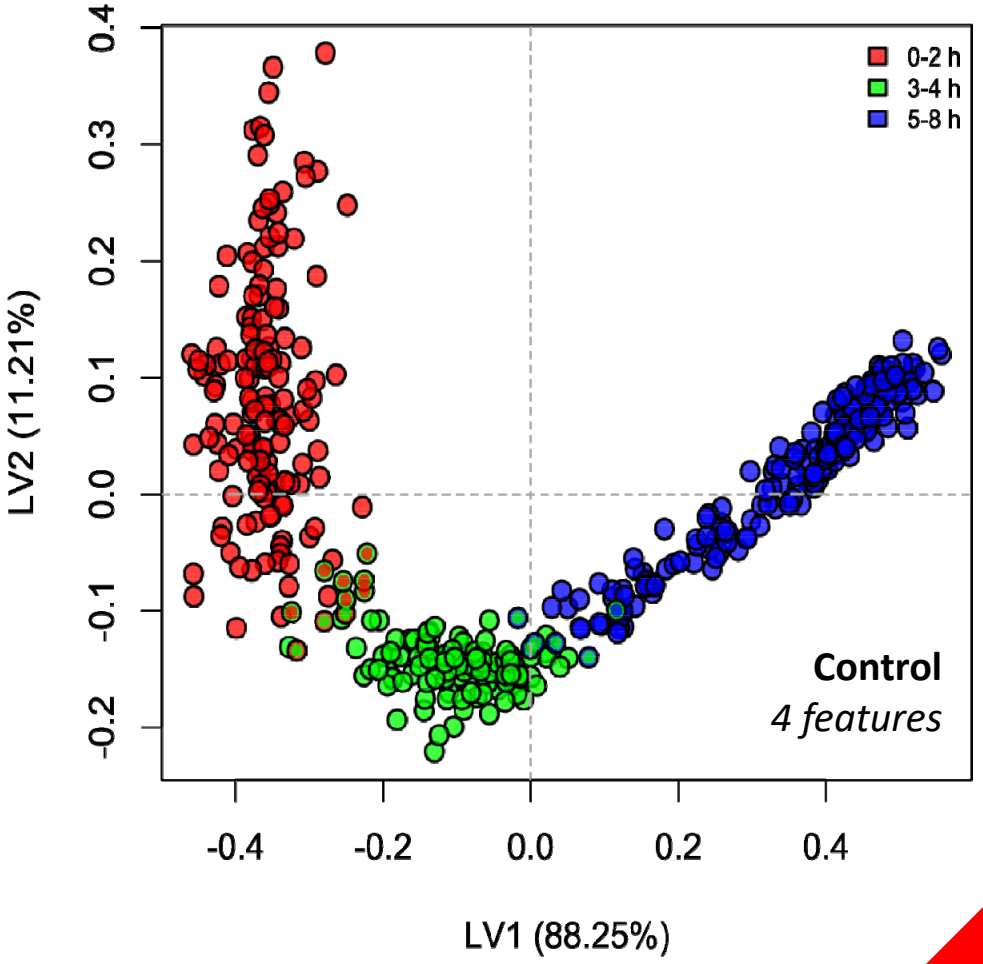
ARTIFICIAL INTELLIGENCE

Classified products

APPLE

» DRYING TESTS – APPLE | *Classification models: results using features selection*





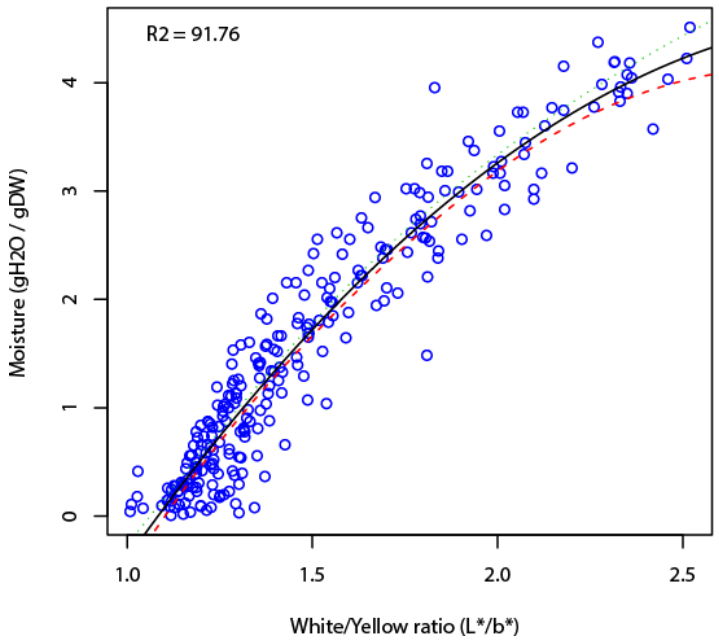
APPLE

» DRYING TESTS – POTATO | *Regression models: color and moisture relationship*

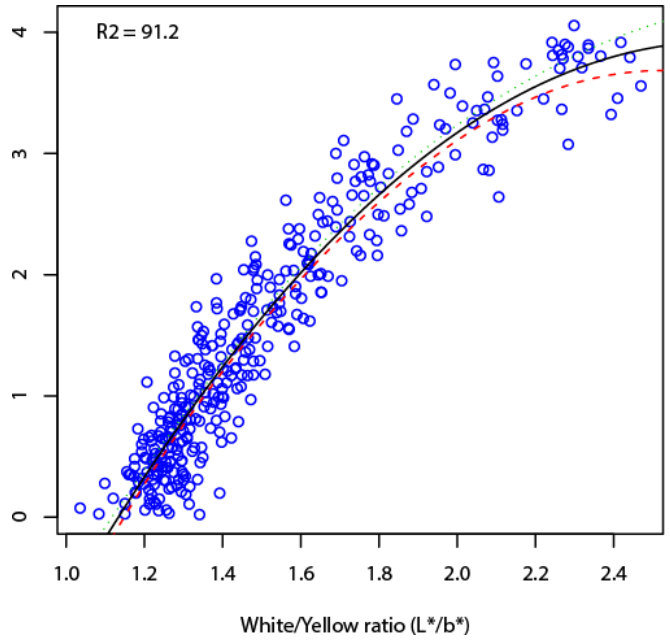
Sus Organic

Quadratic relationship between the white/yellow ratio color index and the moisture content during hot-air drying

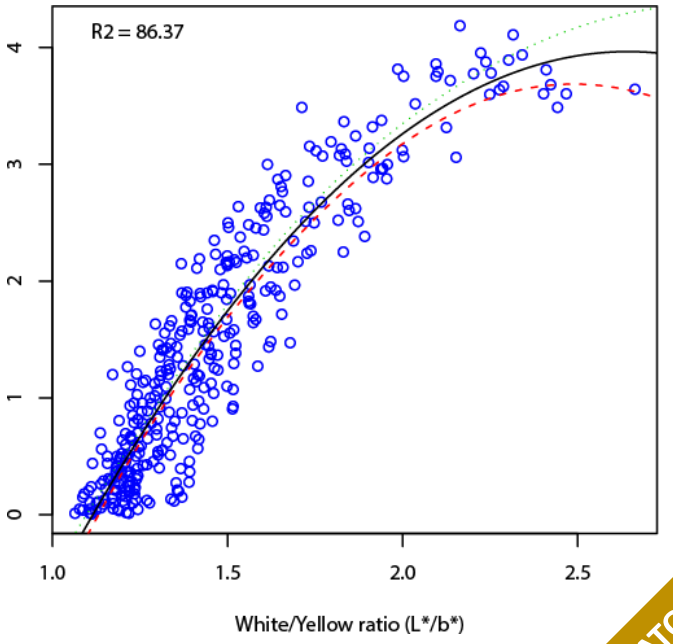
5-mm thickness



7-mm thickness



9-mm thickness



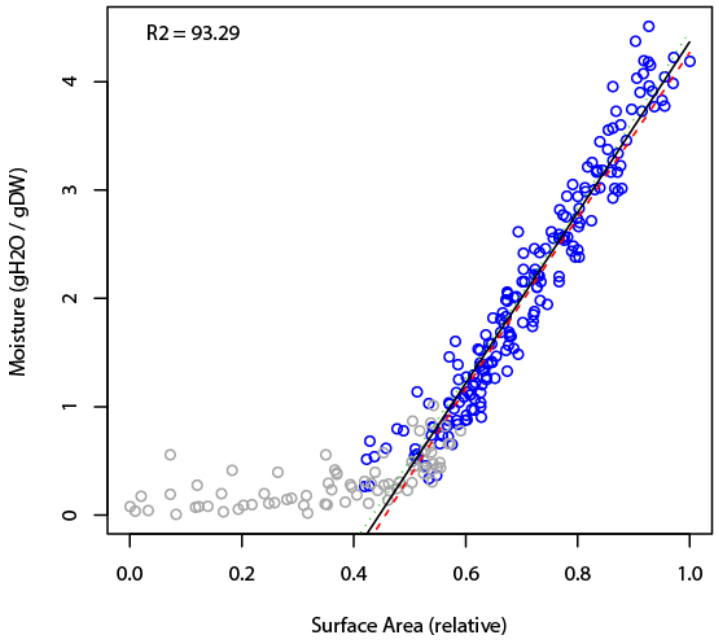
POTATO

» DRYING TESTS – POTATO | *Regression models: shrinkage and moisture relationship*

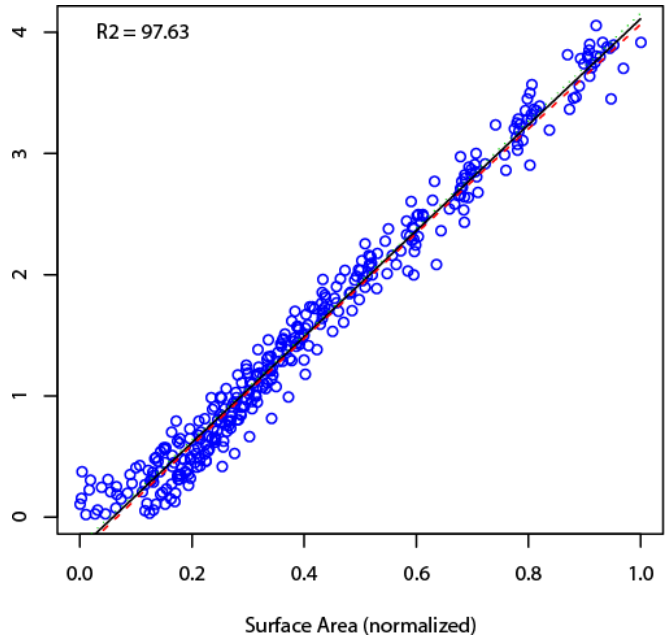
Sus Organic

Linear relationship between the surface area and the moisture content during hot-air drying

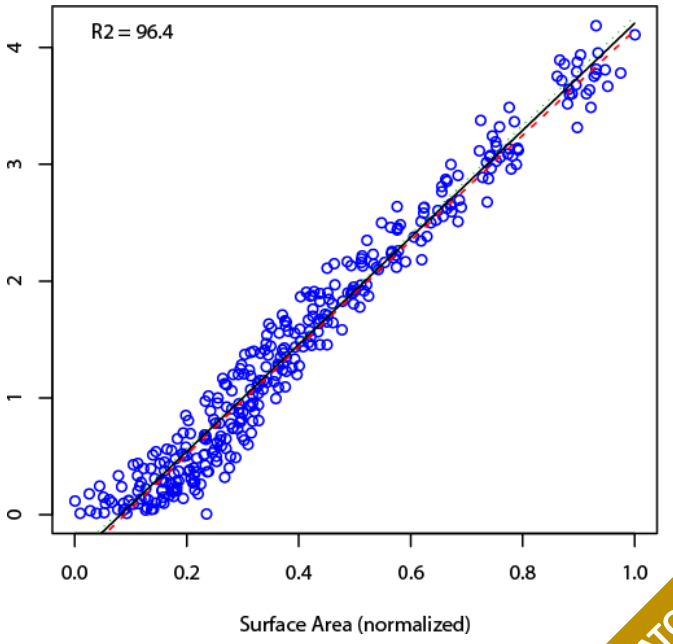
5-mm thickness



7-mm thickness



9-mm thickness

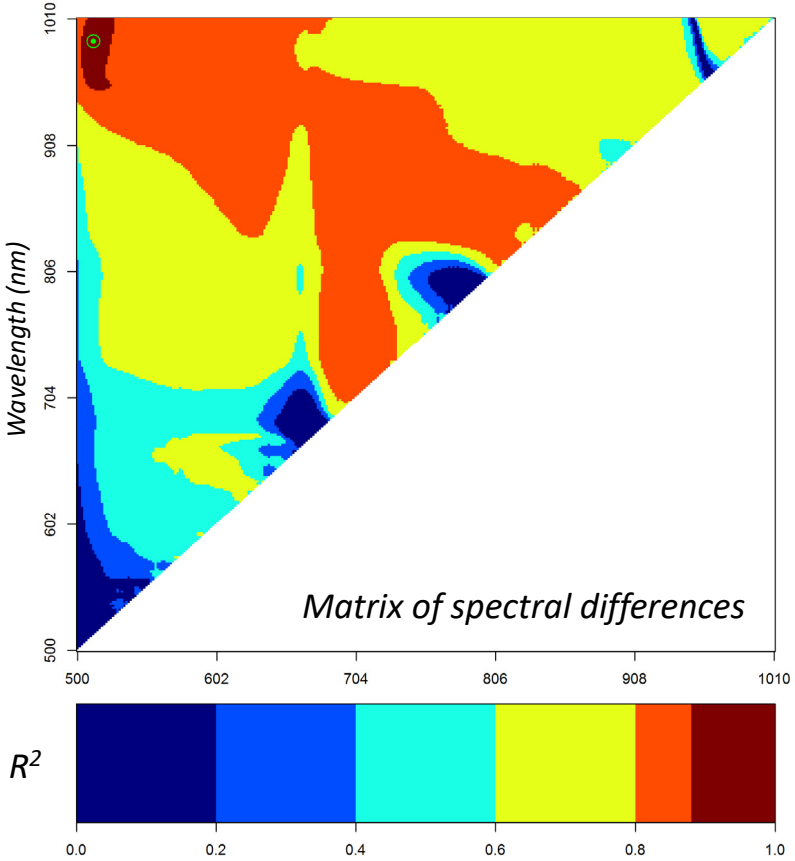


POTATO

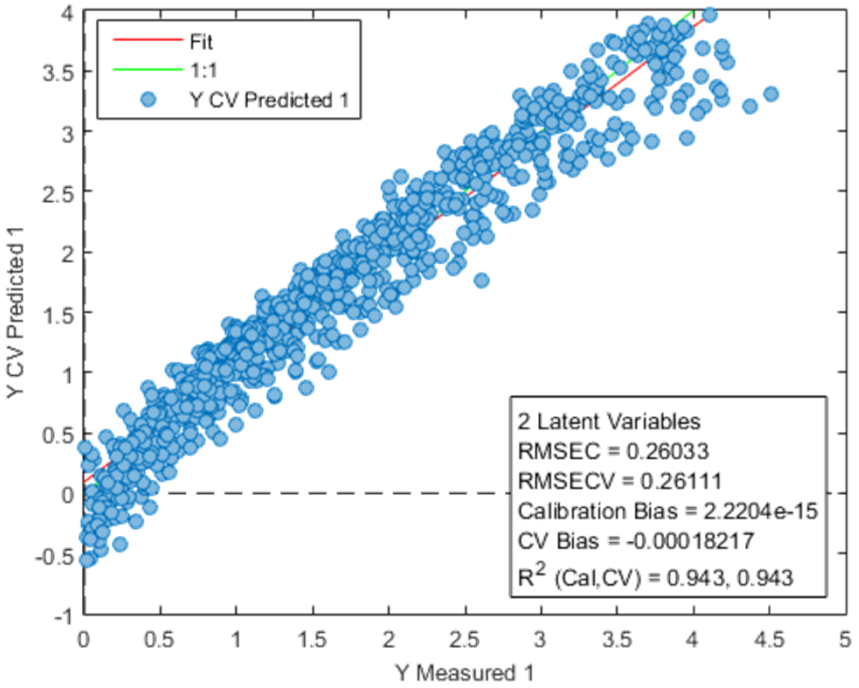
» DRYING TESTS – POTATO | *Regression models: results using features selection*

Sus Organic

Moisture prediction models



Best PLS prediction model: spectral difference + size



POTATO

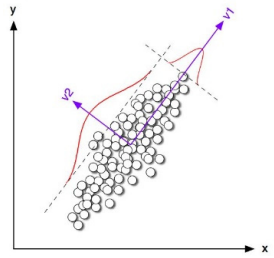
» WORK IN PROGRESS...

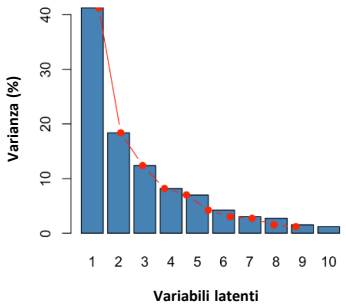
Sus Organic

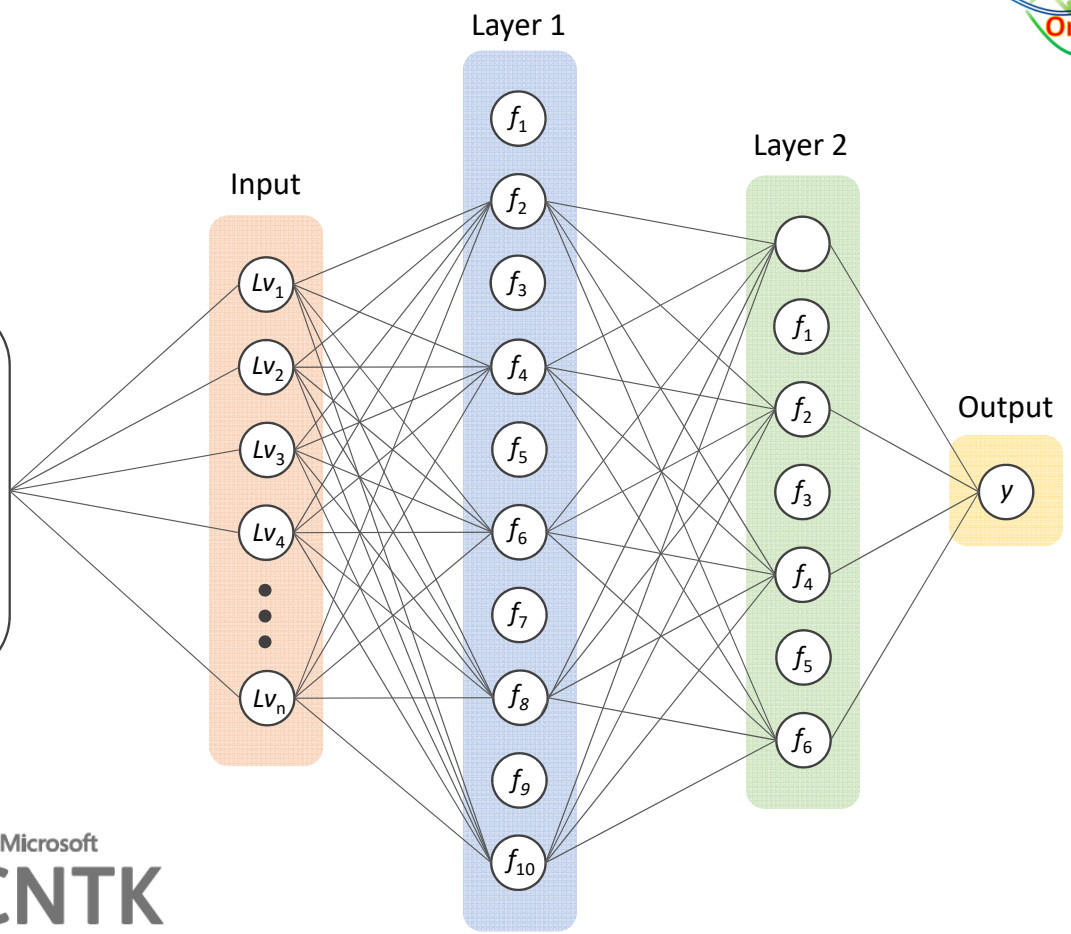
Y
analyte

X
image

Partial Least Squares regression







TensorFlow

cuDNN

theano

Microsoft CNTK

» CONCLUSIONS

1. *Experimental studies showed advantages of NIR spectroscopy for online monitoring of important state variables, such as moisture, water activity, color and nutrients in apples and carrots*

2. *NIR spectral profiles allowed recognition of drying phases*

3. *Prediction models based on few wavelengths showed metrics comparable to models obtained from the full spectrum*

4. *Vis/NIR spectral region showed direct and indirect relationships with moisture loss in potato*

5. *Area shrinkage was identified from image morphological attributes, providing excellent information about moisture loss in potato when combined to spectral differences*

THANK YOU FOR YOUR ATTENTION