THE FRUITS AND VEGETABLES INDUSTRY SERIES

23 May 2022

Session 3 – Technology innovations for fruit and vegetables quality control

COLEACP

OECD

FRUIT AND VEGETABLES SCHEME

Centro di ricerca
Ingegneria e Trasformazioni agroalimentari

NIR spectroscopy and Aquaphotomics as useful tools for the control of fruit and vegetable chain

The joint OECD –COLEACP webinar on Technology innovations for fruit and vegetables quality control – May 23th, 2022

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OUTLINE

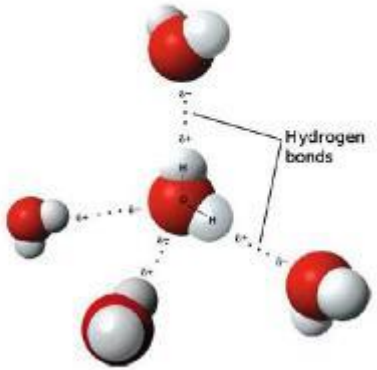
- NIR Spectroscopy and Aquaphotomics: basic principles
- Sampling, optical geometry, and instrumentation
- Last decade applications
- Process Control
- References and useful links
- Conclusions

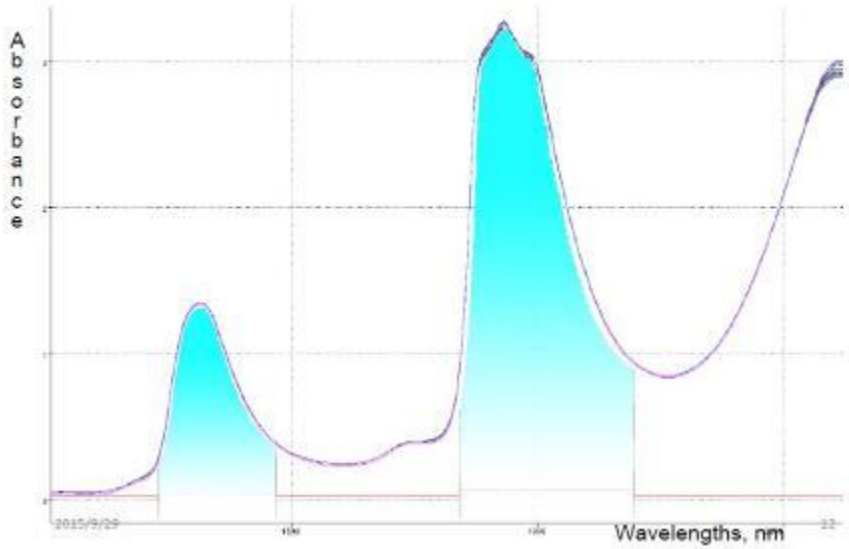
NIR Spectroscopy and Aquaphotomics: basic principles

Infrared spectroscopy is a technique based on the vibrations of the atoms of a molecule. An infrared spectrum is commonly obtained by passing infrared radiation through a sample and determining what fraction of the incident radiation is absorbed at a particular energy.

NIR and H_2O

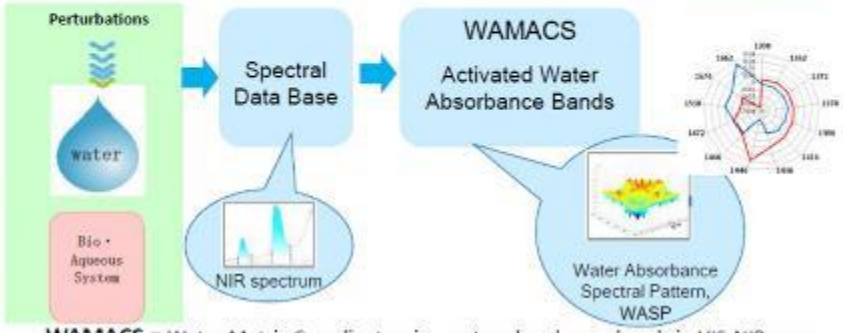
- Vibration frequency of hydrogen bonds in water are highly influenced by nearby molecules & environment
- Changes in these bonds may be used to gain information on the changing environments causing them (e.g. Presence of solutes, changing temperature)





AQUAPHOTOMICS:

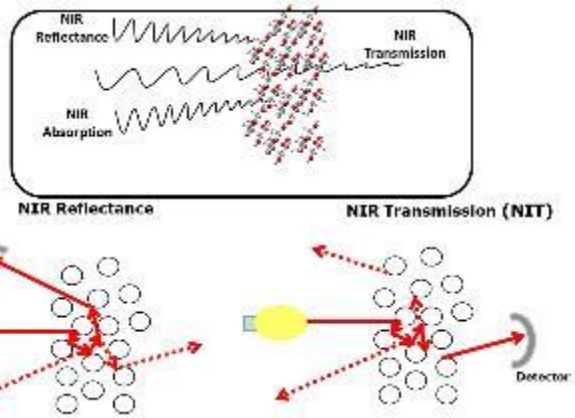
WATER as a MOLECULAR MIRROR



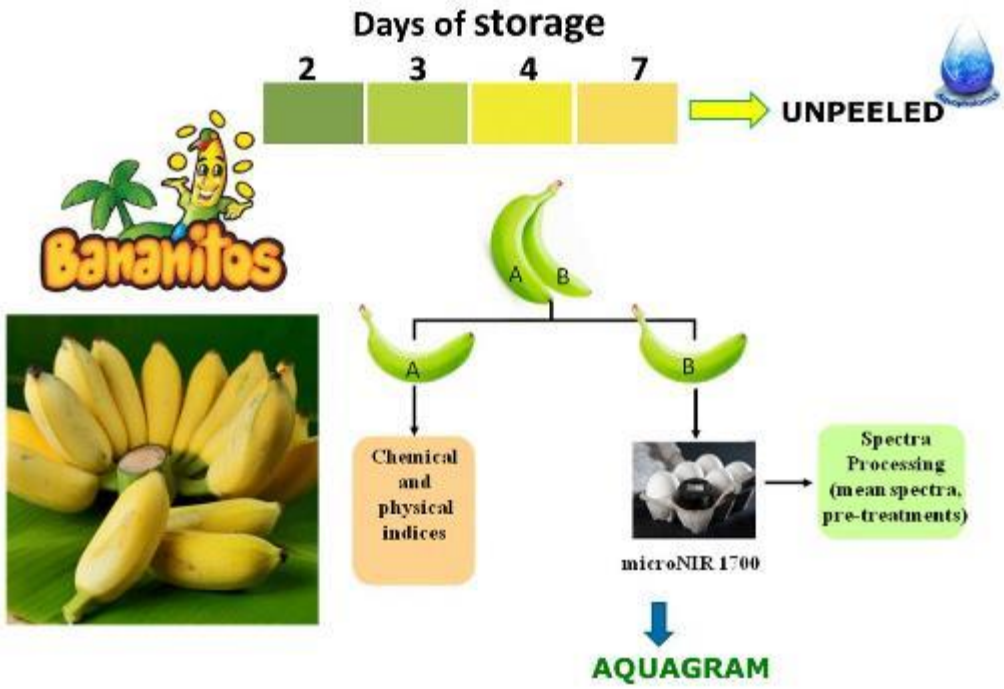
WAMACS = Water Matrix Coordinates, i.e. water absorbance bands in VIS-NIR range

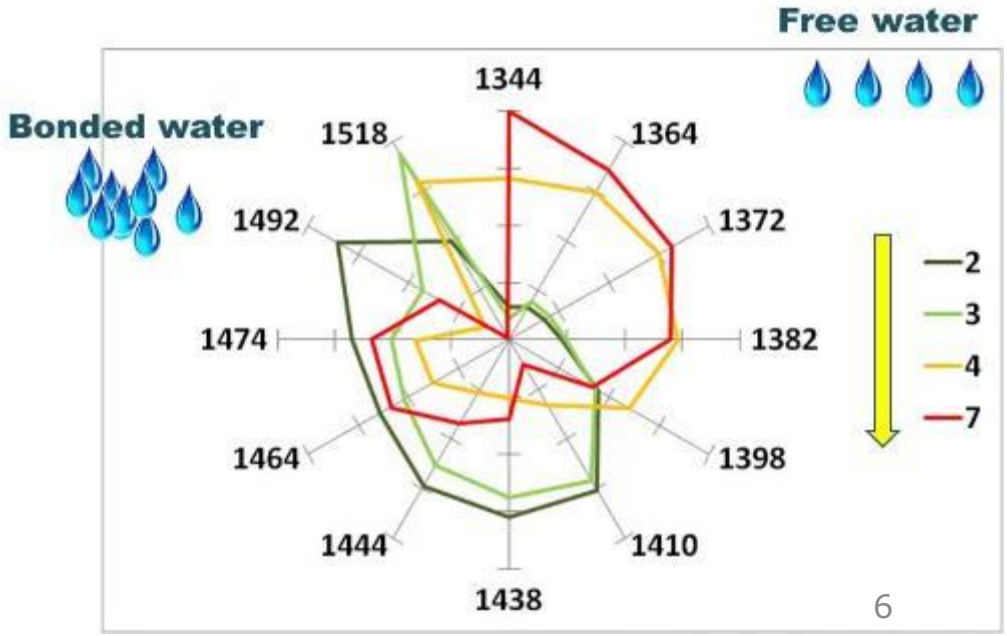
Sampling, optical geometry, and instrumentation

- Representative samples
- Experimental design
- Temperature dependent
- Indirect technology, then…
- Reference methods to calibrate
- Parallel sampling for reference and spectroscopy
- Data processing



Last decade applications





Last decade applications

P-101

The Aquaphotomics and E-nose approaches to evaluate the shelf life of ready-to-eat rocket salad

Laura Marinoni,[1] Giulia Bianchi[1] and Tiziana M.P. Cattaneo[1,2]

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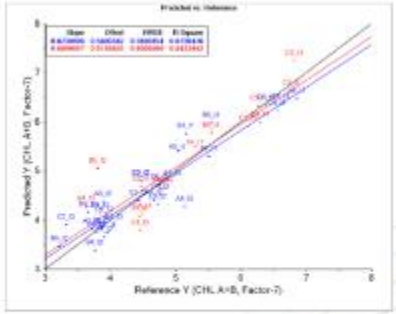
NIR ANALYSIS

E-NOSE ANALYSIS

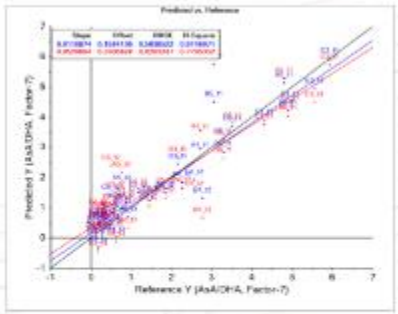
after 1, 4, 7, 11 and 13 days of storage

To evaluate the impact of innovative fertilizers on rice plants (Oryza sativa L. var. Sirio CL) and to study the possibility of using NIR spectroscopy to investigate the biochemical variations at leaf level.

- CHL and the computed AsA/DHA ratio, as plant health indexes, were used for PLS regression models.

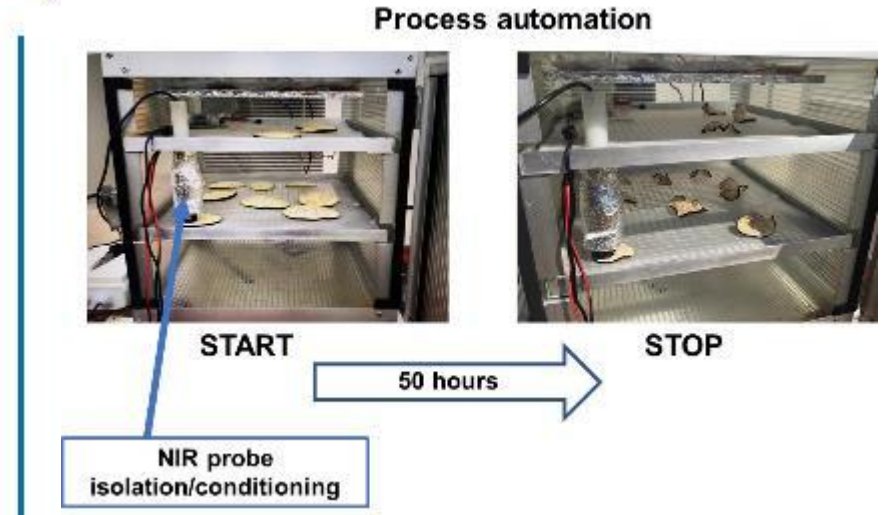


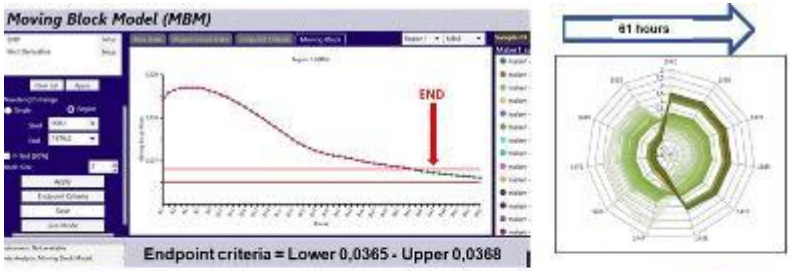
- PLS model for CHL content showed good performance in independent validation (R^2val=0.84).

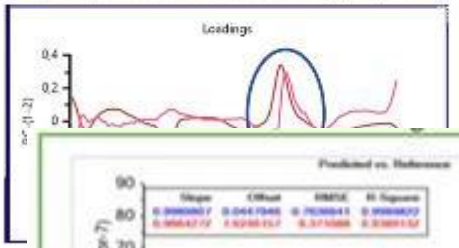


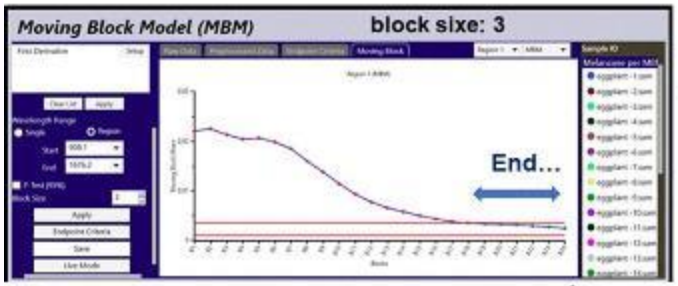
- PLS model for AsA/DHA ratio showed R^2Xval = 0.78

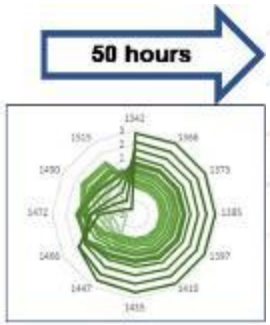
Process Control

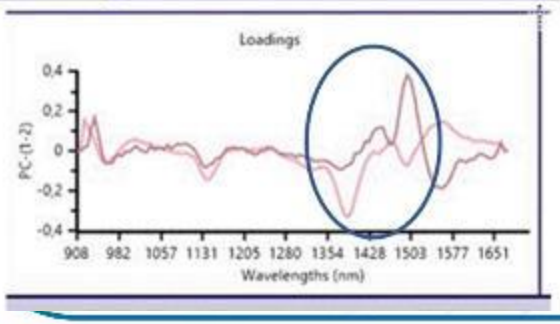






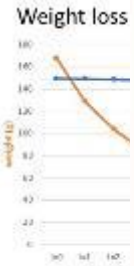






$a_w = 0.388$

Sca
plan



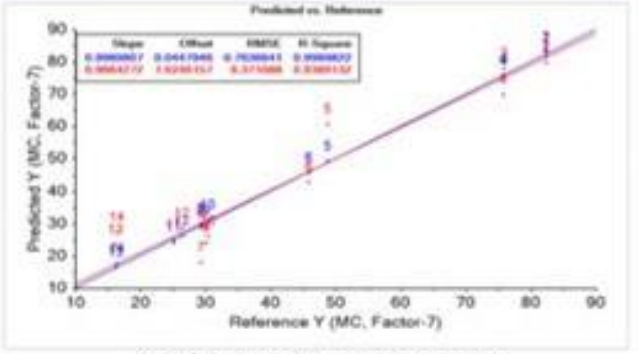


Fig. 2: PLS model for MC content of onion samples.

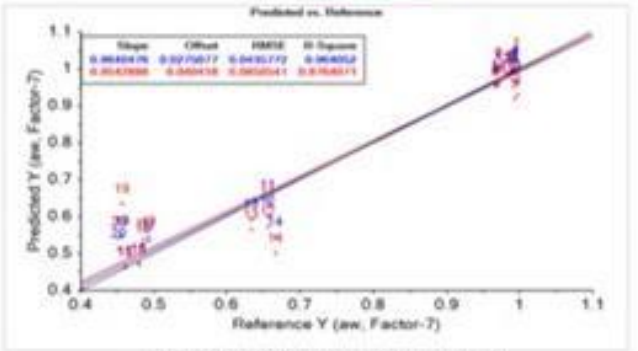


Fig. 3: PLS model for a_w content of onion samples.

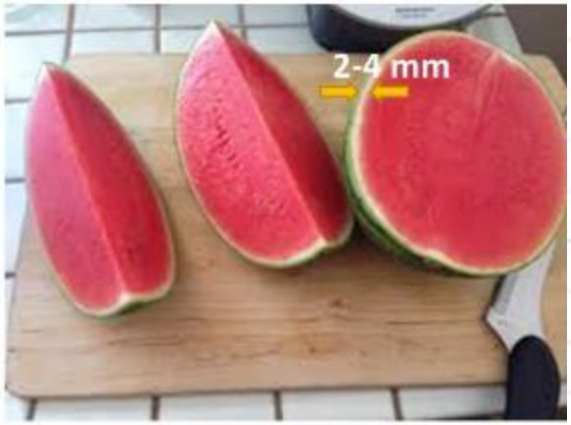
Process Control

NON-DESTRUCTIVE QUANTIFICATION OF CAROTENOIDS IN INTACT WATERMELON (*Citrullus lanatus*) USING ON-LINE NEAR INFRARED SPECTROSCOPY

Tamburini et al., ICNIRS 2015, Brasil

ON-LINE APPLICATION

Cultivar MINIROSSA



Nutrition information (Serving size 100 g)
Calories 13 kcal
Total fat 0
Cholesterol 0
Sugar NIR DATA
Lycopene NIR DATA
β-carotene NIR DATA

References and useful links

- Cattaneo T.M.P. and Stellari A. (2019) Review: NIR Spectroscopy as a Suitable Tool for the Investigation of the Horticultural Field, Agronomy, 9, 503; doi:10.3390/agronomy9090503
- Muncan, J., & Tsenkova, R.(Molecules 24(15): 2742, 2019, Aquaphotomics—From Innovative Knowledge to Integrative Platform in Science and Technology
- Marinoni L. , Buccheri M., Bianchi G. and Cattaneo T.M.P. (2022) Molecules. 27, 2252, https://doi.org/10.3390/molecules27072252.
- Cattaneo T.M.P., Marinoni L., Cammerata A., Stellari A., Brambilla M., Romano E. (2022) Lecture Notes in Civil Engineering, vol 252. Springer, Cham. https://doi.org/10.1007/978-3-030-98092-4_51; Print ISBN 978-3-030-98091-7; Online ISBN 978-3-030-98092-4
- Buccheri M., Grassi M., Lovati F., Petriccione M., Rega P., Lo Scalzo R. and Cattaneo T.M.P. (2019) Journal of Near Infrared Spectroscopy, Vol. 27(1) 86–92, Special issue NIRItalia 2018, DOI: 10.1177/0967033518811796

- https://www.aquaphotomics.com/
- https://icnirs.org/
- https://www.sensorfint.eu/
- http://www.sisnir.org/

Conclusions

- Sample preparation is not required leading to significant reductions in analysis time.
- Waste and reagents are minimized (sustainable approach).
- Spectra may be obtained in non-invasive manner.
- NIR allows us to create calibration models for predicting concentrations in real time (during the transformation process)
- Possibility of using it in a wide range of applications (physical and chemical) and viewing relationships difficult to observe by other means.

- Overlapping bands (combination), not easy to interpret.
- Differences in spectra are often very subtle.
- Usually not for trace level analysis.
- Precision of reference methods.
- Number of samples.

Conclusions

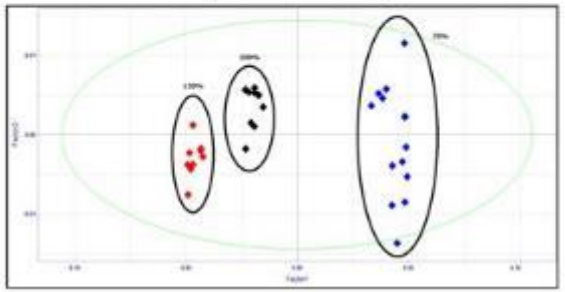
Why NIR now?

Improvements in the fields of

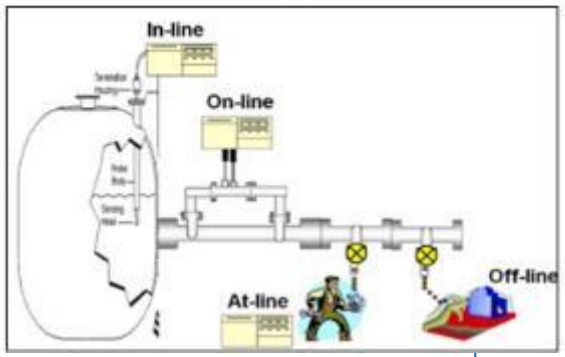
1. **Optical fibers, portable probes, drones**

2. **Computing power**

3. **Chemometrics**



4. **Interest in procces analysis**



THANK YOU FOR YOUR ATTENTION

THE FRUITS AND VEGETABLES INDUSTRY SERIES

The OECD-COLEACP Fruits and Vegetables Industry Series focuses on market access conditions and opportunities for the fruit and vegetable sector, especially for fruit and vegetables producers and exporters from ACP-countries. This activity is supported by the Fit For Market SPS programme, implemented by COLEACP within the Framework of Development Cooperation between the Organisation of African, Caribbean and Pacific States (OACPS) and the European Union.

Thank you

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