A non-destructive method to measure the light penetration depth and optical properties of “Rojo Brillante” persimmons

Alejandro Rodríguez-Ortega1, Sandra Munera2, Salvador Castillo-Gironés2, José Blasco2, Sergio Cubero2 and Nuria Aleixos1\*

1 Departamento de Ingeniería Gráfica. Universitat Politècnica de València. Camino de Vera, s/n, 46022, Valencia (Spain)

2 Centro de Agroingeniería. Instituto Valenciano de Investigaciones Agrarias (IVIA). Ctra. Moncada-Náquera Km 4.5, 46113, Moncada, Valencia (Spain). \*Email: naleixos@dig.upv.es

Hyperspectral imaging is commonly used to estimate the quality of fruits and vegetables. Reflectance and transmittance are specific to each biological tissue, and their values are linked to its chemical composition and physical characteristics. However, these properties are influenced by other extrinsic factors, such as the instrumentation or the light source, which can reduce their reproducibility (Lu *et al.*, 2020). Estimating the theoretical light penetration depth could be helpful to validate the non-contact methods, such as hyperspectral imaging, as accurate tools for assessing quality properties based on optical properties. A non-destructive protocol, based on the spatially resolved spectroscopic principle (Sun et al., 2021), was developed to estimate the light penetration depth in persimmons for all bands in the range 450-1050 nm, in steps of 10 nm. Backscattering images of intact persimmons (‘Rojo Brillante’) of similar size were obtained. The light was produced by one halogen lamp and concentrated on a single point. The absorbance (µa) and scattering (µ’s) coefficients from Farrell’s diffusion theory (Lorente *et al.*, 2015) were calculated using the backscattered light measured at different distances from the incident point at each spectral wavelength. A destructive experiment was performed to obtain the actual light penetration depth. Each fruit was cut into pieces of different controlled thicknesses and placed on a dark surface. For every set of fruit pieces, hyperspectral images were acquired. The reflectance was measured for each thickness and wavelength, obtaining the actual light penetration depth. Linear regression was used to relate the penetrability depth results from both protocols (theoretical and real), showing a high relationship (R2>0.8 and RPD>2.5) for the range 610-1050 nm (persimmon is red), confirming that our non-destructive protocol based on hyperspectral imaging technique to estimate the light penetration depth and the optical properties of persimmon is accurate.

**Keywords:** Penetrability depth, Persimmon, Scattering, Absorption, Optical properties

**Acknowledgements:** This work is co-funded by the projects AEI PID2019-107347RR-C31, PID2019-107347RR-C32, IVIA-GVA 51918 and 52204 and the European Union through the European Regional Development Fund (ERDF) of the Generalitat Valenciana

REFERENCES

Lu, R. et al. (2020) Measurement of optical properties of fruits and vegetables: A review, Postharvest Biology and Technology, 159(September 2019), p. 111003.

Sun, Y., Huang, Y., Pan, L., & Wang, X. (2021). Evaluation of the changes in optical properties of peaches with different maturity levels during bruising. Foods, 10(2).

Lorente D et al., (2015) Laser-light backscattering imaging for early decay detection in citrus fruit using both a statistical and a physical model. Journal of Food Engineering, 154, 76-85