Bulk optical properties of citrus tissues and the relationship with quality properties

Chanjun Sun, Robbe Van Beers, Ben Aernouts and Wouter Saeys

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Abstract

Vis-NIR spectroscopy and hyperspectral imaging are useful tools for citrus quality evaluation in postharvest grading lines. The bulk optical properties (BOP) of citrus tissues determine the interaction of light with citrus fruit, and thereby influence the measured spectral signal. Therefore, knowledge about the BOP of citrus tissues is important for the improvement of spectral techniques and interpretation of spectral signals. In this study, the BOP of different citrus tissues (flavedo, albedo and juice vesicles) were measured for different fruit types (grapefruit, orange, lemon and lime) and the relationship between the BOP and different quality properties was explored. The bulk absorption coefficient (μ_a) spectra in the NIR range were dominated by the absorption peaks of water around 980, 1200 and 1450 nm. For the flavedo tissues, absorption peaks around 480 nm were observed for all the species and an absorption peak around 680 nm was found for lime, which could respectively be attributed to carotenoids and chlorophyll. The differences in the bulk scattering coefficient (μ_s) among different tissue layers were obvious: flavedo and albedo had high μ_s values, ranging from 25 mm^{-1} to 35 mm^{-1}, while the μ_s values of the juice vesicles were below 3 mm^{-1} in the whole wavelength range (440 nm–1840 nm). The changes in anisotropy factor (g) with wavelength varied among different tissue layers. The g values for flavedo were relatively flat over the whole wavelength range, while an increasing and slightly decreasing trend could respectively be observed for albedo and juice vesicles. The absorption coefficient spectra for the flavedo tissues of the different species showed different absorption peaks related to the pigments which determine their skin color. The differences in μ_s and g between the different species were smaller than the variation among different tissues. The bulk optical properties were then related to the quality properties. A negative correlation was found between the average value of μ_s and the diameter of the oil glands in the flavedo. The best

prediction models for total soluble solids (TSS) and titratable acidity (TA) were respectively achieved based on the attenuation coefficient (μ_t) and μ_a of juice vesicles. This study was the first attempt to measure the BOP of citrus tissues and gave a view on the correlation between BOP and quality properties, which made the foundation for further development and optimization of the optical design of quality sensors for citrus fruit.