Effects of harvest time, fruit size and cultivar on the bulk optical properties of Satsuma mandarin

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Abstract

As Satsuma mandarin is a multi-layered fruit, the optical properties of the different tissue layers influence the performance of spectroscopy-based quality detection models. Therefore, the variation in the bulk optical properties (BOP) of the inner (juice vesicles) and outer (flavedo) tissue layer of Satsuma mandarin was investigated for different harvest times, fruit sizes and cultivars. Satsuma mandarin fruit from three different cultivars (Iwasaki, Okitsu and Goku Wase) were harvested at three different times around the recommended harvest date and the BOP of the inner and outer tissue layers were estimated from double integrating spheres measurements. Along the harvest time, the absorption peak related to carotenoids in the bulk absorption coefficient (μ_a) spectrum increased in both tissue layers, while the values attributed to chlorophylls decreased in the flavedo. Moreover, a slightly increasing trend over the harvest time was observed in the bulk scattering coefficient (μ_s) spectra of juice vesicles, especially at the early stage. The μ_a values of both tissue layers and the μ_s values of juice vesicles deviated among different fruit sizes, which can be related to the development stage. Smaller fruit presented a higher carotenoids concentration in juice vesicles, an advanced color change in flavedo throughout the maturation stages and higher μ_s values in juice vesicles at earlier maturation stages. The μ_a differences in pigment absorption among different cultivars were related to the maturation order. Earlier maturing cultivars possessed higher μ_a values related to carotenoids absorption in juice vesicles and advanced color changes in flavedo. The μ_s values of the flavedo differed among the cultivars and these differences were enhanced during maturation. These insights in the sources of variation in the bulk optical properties of Satsuma mandarin tissues can be used for simulation-based optimal design of an optical measurement configuration and interpretation of the acquired signals in spectroscopy-based quality detection and monitoring.