Determining the optical properties of apple tissue and their dependence on physiological and morphological characteristics during maturation. Part 1: Spatial frequency domain imaging

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Abstract

Relying on the optical properties of apple tissue for nondestructive quality or maturity prediction requires a detailed understanding of the dependence on its structure and ongoing physiological processes. In this study, a multispectral spatial frequency domain imaging (SFDI) setup was used to investigate local changes in the effective scattering coefficient and absorption coefficient μ_a related to vascular bundles or heterogeneous starch distribution. Weekly measurements during the maturation period for the cultivars 'Elstar', 'Gala', 'Jonagold', and 'Braeburn' allowed further study of how different ripening processes affect the scattering and absorption properties. The results show both a characteristic location-dependent decrease of between the cortex and core region of up to 30 % and an additional temporal decrease of up to 35 % during maturation. The absolute changes depended strongly on the respective cultivar. In general, transport structures such as vascular bundles led to a local decrease of in combination with an increased absorption in the spectral regions that can be attributed to water and chlorophyll *b*. To our knowledge, it was demonstrated for the first time that the presence of starch granules in the cortex of immature apples had a significant effect on, associated with an increase of up to 60 %. Based on the temporal development of μ_a, the buildup and degradation of important plant pigments in the cortex during the maturation period could be traced. At a wavelength of 656 nm, a decrease in chlorophyll content and at 447 nm, an increase in carotenoid content was observed upon reaching ripeness. Thus, SFDI proved capable of providing deeper insight into the heterogeneous optical properties of apple tissue and linking these properties to physiological variables. Part 2 of this study investigates the observed effects from a theoretical point of view based on a Mie model considering microstructural properties.