Rapid and nondestructive evaluation of soluble solids content (SSC) and firmness in apple using Vis–NIR spatially resolved spectroscopy

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Postharvest Biology and Technology, Volume 173, March 2021, 111417

Abstract

Visible–near infrared (Vis–NIR) spectroscopy is a rapid and nondestructive method used to characterize organic compounds in postharvest fruit and vegetable assessment. However, developing robust calibration models is a challenge as conventional spectrometers collect only the cumulative effects of light absorption and scattering. In this study, a multifiber-based Vis–NIR spatially resolved spectra measurement system was designed for simultaneous evaluation of soluble solid content (SSC) and firmness in apple. Thirty silica fibers separated into five groups at 1, 2, 3, 4, and 5 mm away from the light illumination point and connected to a cost-effective Vis–NIR hyperspectral imaging camera were used to acquire spectral data with an improved signal-to-noise ratio (S/N) by a two-step signal averaging process (i.e., 30 camera pixels per fiber and six optical fibers per group). Reflectance ratio spectra were then calculated by dividing the diffusely reflected light intensity detected at distance d $+\Delta$ by that detected at distance d to realize a light reference-free approach. Finally, the useful explanatory variables were selected by competitive adaptive reweighted sampling (CARS) to construct individual calibration models for various regions. The coefficients of determination (R^2_{cal}) and the root mean square errors ($RMSE_{cal}$) of the best-performing calibration models were approximately 0.97 and 0.20 % for SSC and 0.96 and 0.37 N for firmness, respectively. Furthermore, the predicted results were 0.92 and 0.35 % for SSC and 0.87 and 0.71 N for firmness. Our method offers low-cost and portable detection of SSC and firmness for postharvest fruit evaluation.