Title Integrated spectral and image analysis of hyperspectral scattering data for prediction of apple fruit firmness and soluble solids content

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Abstract

Spectral scattering is useful for assessing the firmness and soluble solids content (SSC) of apples. In previous research, mean reflectance extracted from the hyperspectral scattering profiles was used for this purpose since the method is simple and fast, and also gives relatively good predictions. The objective of this study was to improve firmness and SSC prediction for 'Golden Delicious' (GD), 'Jonagold' (JG), and 'Delicious' (RD) apples by integration of critical spectral and image features extracted from the hyperspectral scattering images over the wavelength region of 500–1000 nm, using spectral scattering profile and image analysis techniques. Scattering profile analysis was based on mean reflectance method and discrete and continuous wavelet transform decomposition, while image analysis included textural features based on first order statistics, Fourier analysis, co-occurrence matrix and variogram analysis, as well as multi-resolution image features obtained from discrete and continuous wavelet analysis. A total of 294 parameters were extracted by these methods from each apple, which were then selected and combined for predicting fruit firmness and SSC using partial least squares (PLS) method. Prediction models integrating spectral scattering and image characteristics significantly improved firmness and SSC prediction results compared with the mean reflectance method when used alone. The standard errors of prediction (SEP) for GD, JG, and RD apples were reduced by 6.6, 16.1, 13.7% for firmness (R_{pred}-values of 0.87, 0.95, and 0.84 and the SEPs of 5.9, 7.1, and 8.7 N), and by 11.2, 2.8, and 3.0% for SSC (R_{pred}-values of 0.88, 0.78, and 0.66 and the SEPs of 0.7, 0.7, and 0.9%), respectively. Hence, integration of spectral and image analysis methods provides an effective means for improving hyperspectral scattering prediction of fruit internal quality.