

Early detection of chilling injury in green bell peppers by hyperspectral imaging and chemometrics

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Abstract

The feasibility of using hyperspectral imaging in the combined wavelength regions comprising of visible to near infrared (VIS-NIR) (400–1000 nm) and short wave infrared (SWIR) (1000–2500 nm) was investigated for discriminating fresh bell peppers from those stored under refrigeration. In addition, the technique was used for early detection of chilling injury (CI) in mature fruit. Supervised classification models were developed using Partial Least Square Discriminant Analysis (PLS-DA) for raw and pre-processed spectra followed by wavelength selection using VIP scores. Reliable classification of fresh and stored fruit was achieved using pre-processed data in VIS-NIR range by 88 % and 84 % non-error-rate (NER) for calibration (Cal) and cross-validation (CV), respectively, but a slightly higher classification accuracy was manifested in the SWIR range using raw spectra; in this case, wavelength selection resulted in six wavelengths in VIS-NIR reaching to 87 %, 83 NER for Cal, CV, respectively, and four wavelengths in SWIR range yielding to NER of 84 % for Cal and 81 % to satisfy the aforementioned objective. Secondly, classification of fruit based on days of cold storage was achieved using pre-processed data both for VIS-NIR and SWIR whole ranges where wavelength reduction resulted in 12 wavelengths in the VIS-NIR and 13 wavelengths in SWIR range without impressive varying model performance in case of VIS-NIR and decreasing model accuracy in SWIR range. In addition, Partial Least Square Regression (PLSR) was conducted on the data extracted from VIS-NIR HSI, to predict days of cold storage both in full spectral range and selected wavelengths obtained from VIP scores. PLSR models based on full range spectra yielded $R^2_{CV} = 0.92$, while for the PLSR model based on selected wavelengths $R^2_{CV} = 0.79$ was obtained, along with reasonable RMSEC and RMSECV. Conclusively, based on the results, VIS-NIR hyperspectral imaging is a reliable option for on-line classification of fresh versus refrigerated fruit and for identifying early incidence of CI.