

Quantitative and qualitative VIS-NIR models for early determination of internal browning in ‘Cripps Pink’ apples during cold storage

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Abstract

‘Cripps Pink’ apples are prone to develop internal browning disorder during cold storage rendering their commercialization particularly difficult after long-term storage. The purpose of this research was to predict internal browning defect quantitatively and qualitatively in apple, by a non-destructive equipment from spectra collected before the disorder develops. In order to obtain a broad expression of the disorder in severity and incidence, fruit treated and non-treated with 1-methylcyclopropene (1-MCP) were studied under three temperature regimes: T1) pre-cooled with forced air at $-1\text{ }^{\circ}\text{C}$ for 24 h and subsequently stored for 149 d at $0\text{ }^{\circ}\text{C}$; T2) placed directly at $0\text{ }^{\circ}\text{C}$ and stored for 150 d; and T3) stored for 90 d at $5\text{ }^{\circ}\text{C}$ then for 60 d at $0\text{ }^{\circ}\text{C}$. Every fruit was subjected to semi-transmittance spectral analysis between 100–1,100 nm at 0, 60, 90, 120 and 150 d of storage and matched with the presence and severity of internal browning. The disorder was quantified using image analysis in one half of cut fruit at the end of the 150 d plus 7 d at $20\text{ }^{\circ}\text{C}$ (157 d) after verification that the damage was not evident in fruit stored before 120 d. Quantitative Support Vector Machine Regression (SVMR) model satisfactorily predicted the percentage of internal browning area per fruit shown after 157 d, as early as 90 d of storage with $R^2 \sim 0.70$, and a root mean square error for calibration (RMSEC) and prediction (RMSEP) datasets of $\sim 18\%$ and $\sim 15\%$ respectively. On the other hand, qualitative Partial Least Squares Discriminant Analysis (PLS-DA) model was able to predict the damaged fruit at the onset of storage (0 d) and to reach an accuracy values $\sim 87\%$ in calibration and test datasets, and 12% of misclassified fruit at 90 d. Quantitative and qualitative neural network models were also evaluated, reaching similar correlation coefficients, in cross validation or accuracy rate as multivariable models did, offering a novel way for modelling biological processes. This study shows different models for predicting internal browning before the disorder appears in stored apple using semi-transmittance spectra.