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Assessment of 'Crimson Seedless' Table Grape Ripeness Using NIR Spectroscopy

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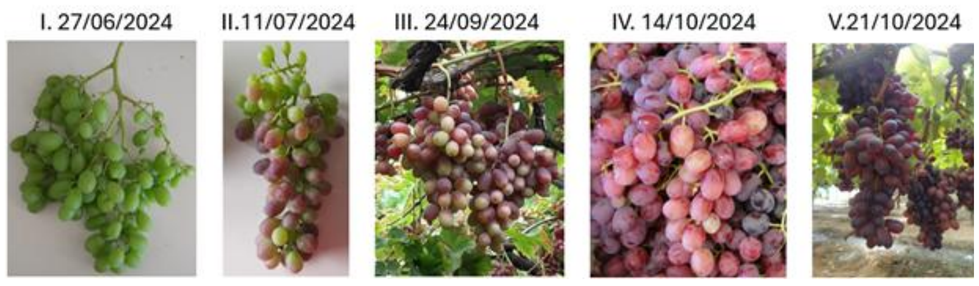
INTRODUCTION AND OBJECTIVE

Determining ripeness is crucial in table grape production to ensure fruit quality and optimize harvest timing. 'Crimson Seedless' holds high commercial value, its external berry color variations do not reflect internal ripeness. The main parameters used for ripeness assessment are total soluble solids (TSS), titratable acidity (TA), and the ripeness index (TSS/TA). Near-infrared (NIR) spectroscopy offers a rapid, non-destructive alternative. The main objective of this study is to evaluate the feasibility of utilizing Near-Infrared (NIR) spectroscopy as a non-destructive tool for evaluating the ripeness and quality of ‘Crimson Seedless’ table grapes.

MATERIAL AND METHODS

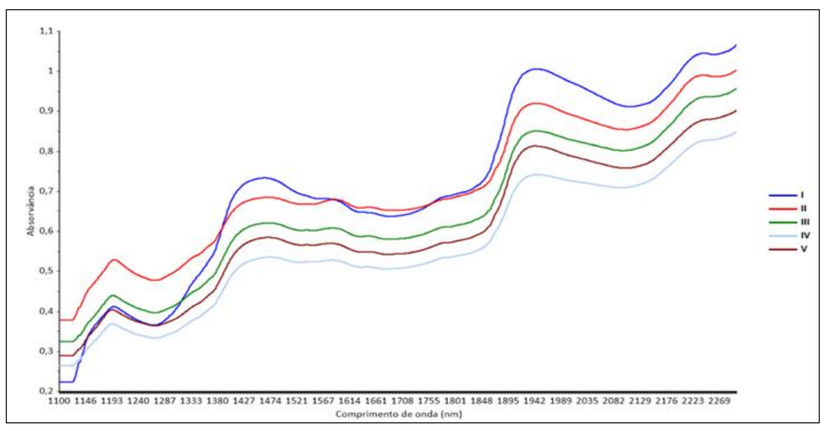
'Crimson Seedless' clusters were harvested at five distinct ripeness stages and their spectra were taken individually.



Spectral measurements of whole clusters were acquired using a Luminar 5030 NIR analyzer (Brimrose Corp., USA) with an InGaAs detector across the 1100–2300 nm range (1-nm increments) via Acquire software (Brimrose Corp., USA). Reference analytical parameters were determined using a refractometer (TSS, ºBrix) and an automatic titrator (TA, % tartaric acid). Quantitative models were developed through partial least squares regression (PLSR) on absorbance spectra (Log 1/R, where R is the reflectance) using CAMO® Unscrambler X (v10.5). Models were evaluated via cross-validation coefficient of determination (1-VR) and the root mean square error after cross-validation (RMSECV).

RESULTS AND DISCUSSION

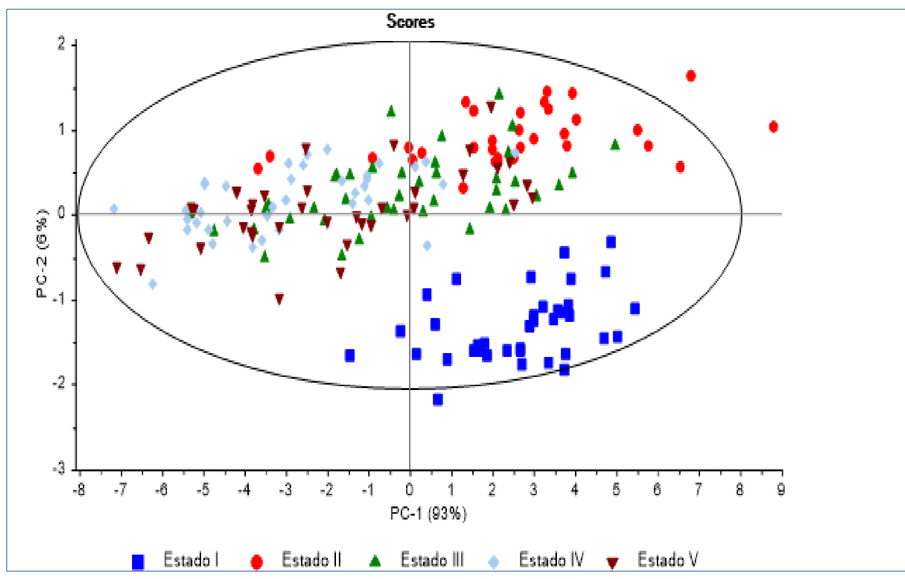
Differences are gradual among states.
State I shows the highest absorbance.
Greater emphasis on zones located at 1150–1200 nm, 1400–1450 nm, 1880–1960 nm, and 2200–2250 nm.



Average NIR spectra (1100–2300 nm), expressed in absorbance (log 1/R), obtained from whole bunches of 'Crimson Seedless' table grapes, for the five ripening stages (I to V). I and II - Immature stage, III and IV - full commercial ripeness, V - overripe stage.

The Principal Component Analysis (PCA) performed on the full dataset of raw NIR spectra showed that the first two principal components (PCs) explained 99.04% of the total variance, with 92.98% attributed to PC1 and 6.06% to PC2.

These results demonstrate that most of the spectral variability was captured by the first two principal components. A grouping of samples based on their ripening stage was observed, although with varying degrees of separation between the groups.



PCA scores plot applied to the full dataset of raw NIR spectra, representing the first two principal components (PC1 and PC2) for the different ripening stages of 'Crimson Seedless' table grapes.

The model selected for TSS presented the best overall performance in external validation, with R^2p = 0.9534, RMSEp = 1.3908 °Brix, BIAS = -0.0838 °Brix, Slope = 0.9470, RPDp = 4.6603 and RERp = 12.7984, confirming high predictive capacity and good agreement between predicted and reference values.

The PLSR quantitative models demonstrated high predictive accuracy for all internal attributes, SST with R^2p = 0.9534 and RMSEp = 1.3908 and as well as favorable results for AT with R^2p = 0.9125 and IM with R^2p = 0.9155. Among the variables studied, the best results were obtained for total soluble solids.

CONCLUSION

The results obtained reinforce the potential of NIR spectroscopy as a tool to support the monitoring of ripeness and the definition of the ideal time to harvest table grapes, namely ‘Crimson Seedless’, contributing to the development of fast, non-destructive methodologies with practical interest for the sector.

Acknowledgements

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