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PORTABLE VIS-NIR SPECTROMETER FOR NON-DESTRUCTIVE DETERMINATION OF QUALITY TRAITS IN APPLES AND PEARS

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INTRODUÇÃO

Apple and pear are temperate species that require chilling environmental conditions to break tree dormancy and produce flower and fruit. In Brazil, these temperate climate conditions are mainly found in the Southern region, which is responsible for the majority of temperate fruit production. However, the use of low chilling requirement varieties associated with crop management techniques such as irrigation, defoliation and application of chemical treatment for dormancy break have allowed the production of temperate fruit in warmer regions, such as the Northeastern Semi-arid region in Brazil (LOPES et al., 2013).

The national and international markets for apples and pears are high quality demanding, requiring an effective quality control to ensure fruit quality to consumers (PISSARD et al., 2021), which is determined by traits such as flesh firmness, soluble solids content, titratable acidity, peel and flesh color, among others. Most of the methods used to measure these quality traits require sample processing, use of expensive chemicals and manual labor, in addition to being destructive (MARQUES et al., 2016). Therefore, there is a need for a fast, reliable, accurate and non-destructive method for assessing fruit internal quality (OLIVEIRA et al., 2014).

During the last decade, near infrared (NIR) spectroscopy has been applied as a rapid and accurate method to determine physical and chemical traits in a wide range of fruit and vegetables fresh and processed products (OLIVEIRA-FOLADOR et al., 2018; PISSARD et al., 2021).

The objective of this study was to assess the performance of a handheld VIS-NIR spectrometer for non-destructively quality analysis of apples and pears produced in the Brazilian Semi-arid region.

MATERIAL E MÉTODOS

A total of 100 ‘Eva’ apples and 100 ‘Triunfo’ pears were harvested from an experimental orchard located at the Bebedouro Experimental Station, Embrapa, Petrolina, PE, Brazil (9°09' S and 40º22' W; at an altitude of 365.5 m above sea level). The climate of this region is Bswh, according to Köppen’s climate classification, which corresponds to a semi-arid region with a dry period of nine months and rainfall concentrated from February to April, and an average annual temperature of 26 ºC.

The fruit were harvested at the physiological maturity, and transported to the Postharvest Laboratory at Embrapa. The fruit were then washed, dried and stored in a cold room at 0.5 °C (± 0.5 °C) and 90% (± 2%) RH. Every week, 10 fruit of both species were taken for spectra data and reference analysis.

The VIS-NIR spectral data were registered using a handheld NIR spectrometer F-750 Produce Quality Meter (Felix Instruments, Portland, USA). Spectral acquisition was performed on the equatorial region of each fruit by positioning the spectrometer directly on the fruit skin. The measurements were accomplished at three different temperatures (2, 10 and 20 °C).

Reference analyses were performed on the same fruit region used for spectra acquisition. Two samples of 2 × 2 × 1 cm per fruit were used for reference analysis. One sample was used for dry matter (DM) and the other sample was pressed in a manual juicer and used for soluble solids (SS)

analyses. DM was determined by weighting fresh fruit sample followed by drying at 65 °C in an oven model SL-102 (Solab, São Paulo, Brazil) until constant weight. The DM was calculated as the ratio between dry weight and fresh weight of samples, and the results were expressed in percentage. The SS content was quantified using a digital refractometer model MA871 (Milwaukee, Budapest, Hungary) with automatic temperature compensation, and the results were expressed in percentage.

The calibration models were developed using the spectral range from 750 to 1065 nm. Standard Normal Variate (SNV) transformation was applied to the spectral data to eliminate radiation scattering effects. Partial least squares (PLS) regression models were built for the prediction of DM and SS, using the spectral data (matrix X) and measurements of reference analysis (matrix Y).

Data preprocessing, sample selection and regression were performed using the Unscrambler X version 10.5 (CAMO, Oslo, Norway) and MATLAB version R2015a (Mathworks, Natick, USA) software. Figures were developed using the SigmaPlot version 14.0 (Systat Software, San Jose, USA) software platform.

RESULTADOS E DISCUSSÃO

According to the results, there was a high variability in DM and SS content in the samples used for calibration and validation (Table 1). The mean values for SS content were 14.91% and 12.28% for apples and pears, with ranges of 10.30 - 18.80% and 9.70 - 15.30%, respectively. DM content averaged 20.07% and 14.11% and ranged between 17.27 - 24.75% and 11.79 - 17.97% for apples and pears, respectively. The observed high variability in quality traits was possibly due to the wide different ripening stages of the fruit used in our study, which was important to guarantee robustness, reliability and reproducibility of prediction models (LI et al., 2017).

Table 1 - Statistical parameters related to the calibration and external validation steps for the models developed to determine SS and DM in apples and pears, using SNV as spectral preprocessing method and the PLS regression for build the multivariate calibration models.

Parameter	Mean	Range	SD	Calibration			Validation			
				N	R^2	RMSECV	N	R^2	RMSEP	RMSEPr
Apple										
SS (° Brix)	14.91	10.30 - 18.80	2.01	120	0.70	1.19	51	0.58	1.13	7.6
DM (%)	20.07	17.27 - 24.75	1.51	200	0.71	0.83	88	0.55	0.94	4.7
Pear										
SS (° Brix)	12.28	9.70 - 15.30	0.98	210	0.78	0.48	96	0.55	0.59	4.8
DM (%)	14.11	11.79 - 17.97	1.01	240	0.78	0.51	108	0.65	0.50	3.5

SD: Standard variation; RMSECV: Root Mean Square Error of Cross Validation; RMSEP: Root Mean Square Error of Prediction; RMSEPr: Relative RMSEP calculated in relation to the mean value of the range for the quality parameter evaluated, expressed in percentage.

Apples and pears analyzed with the VIS-NIR spectrometer were used to build the multivariate calibration models using the PLS regression method for the determination of SS and DM. Statistical parameters related to the calibration and external validation (prediction) steps are shown in Table 1. Calibration models developed for both quality parameters presented satisfactory predictive

performance, with RMSEPr values (relative RMSEP, calculated in relation to the mean value of the range of the quality parameter) ranging from 4.8% (pear) and 7.6% (apple) for SS content and between 3.5% (pear) and 4.7% (apple) for DM content. Pissard et al. (2021) observed a RMSEPr value of 6.3% when developing calibration model for SS in apples using the same regression method.

The results show that R^2 values increased as follows: 0.55 for DM in apples and SS in pears, 0.58 for SS in apples and 0.58 for SS in pears (Table 1). Therefore, the coefficient of determination for predicting SS and DM is considered acceptable for both fruit species, since they are greater than 0.50 (PRATIM ROY et al., 2009). In addition, the RMSEPr values were lower than 10%, which is recommended for high precision analysis.

CONCLUSÃO

This is the first report on the use of a VIS-NIR spectrometer for non-destructively quality analysis of apples and pears produced in the Brazilian Semi-arid region. The models developed allow using the VIS-NIR spectrometer to determine apples and pears SS and DM content with high prediction.

The VIS-NIR spectrometer is a promising tool to be used by growers, shippers, and retailers for a rapid and non-destructive determination of internal quality traits in apples and pears.

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