Calibration of handheld NIR to determine avocado maturity

– Progress report

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ABSTRACT

This project continued from 2011 and it was found that by including fruit from the 2012 season, the calibration of the handheld near-infrared spectrometer (NIR) was made more robust, but this did increase the standard error of prediction to 3.3% MC (R^2=72%). This project will conclude in 2013, with the addition of the third full season's data. The effect of the skin will also be examined, to see if the accuracy of the handheld NIR can be improved by removing the skin – although this means the NIR is no longer non-destructive, and is just a tool for the rapid analysis of moisture content.

INTRODUCTION

This progress report follows on from the previous reports (Blakey & Van Rooyen, 2011; Blakey, 2012), where it was found that with a range of 50 to 87% moisture content (MC), the Root Mean Squares Error of Prediction (RMSEP) = 2.8% and R^2 = 78%. With a narrower range of 70 to 87% MC, which is more critical for avocado fruit quality and maturity, the RMSEP = 2.3% MC and R^2 = 74%.

The aim of this project is to develop robust calibration models for the handheld NIR for 'Hass' and 'Fuerte' that have a commercially useful Standard Error of Prediction (SEP).

MATERIALS AND METHODS

Instrument: Fruit were again scanned at four to six locations around the equator using the Phazir 1018 handheld near-infrared spectrometer (NIR; Thermo Scientific, Wilmington, MA, USA). Further details about the instrument are available in the previous reports.

Fruit: Twelve orchards ('Hass' and 'Fuerte') on various Westfalia farms were sampled monthly (12 to 15 fruit) from January 2012 until harvest – usually in May. Further samples were taken from the Westfalia pack house until mid-September.

Sampling: The area to be sampled was scanned with the skin (exocarp) intact and then again with the skin removed. Flesh samples of approximately 1.0 g were taken from the same areas that were scanned with the handheld NIR. The samples were then oven-dried at 70°C for at least 24 hours.

Analysis: The chemometric analysis was done using Polychromix Method Generator™ version 3.101. The 2012 data set was randomly and equally divided between the calibration and external validation set, while the 2011 data set was used in the calibration. Various pre-treatments were tested and it was found that a Savitzky-Golay (SG) derivative and a Standard Normal Variate (SNV) transformation were the most suitable pre-processing treatments. The SG derivative was a five point smoothing with a second order derivative with a third order polynomial smoothing. Spectra with a Mahalanobis distance greater than 3.0 were deemed as outliers and were mostly because of poor spectral quality.

RESULTS AND DISCUSSION

Calibration: By including fruit from 2012 in the models, the robustness of the models for estimating MC increased, as (external validation) fruit from the 2012 season were predicted with equal accuracy (Standard Error of Prediction; SEP) as fruit from 2011 (Fig. 1). However, the SEP increased to 3.3% MC. Optimally this would be lower than 1% MC, but this is unlikely with this handheld NIR. It is more likely that an SEP of approximately 2.5% MC is achievable. This is higher because the spectrometer in the handheld NIR has a resolution of 11 nm, while high-end spectrometers – such as the Matrix-F FT-NIR (Bruker Optics, Ettlingen, Germany) instrument used by

Wedding *et al*. (2013) – have a much higher resolution and therefore are more accurate, but slower and more expensive than the Phazir 1018.

International research: Researchers in Australia found that three seasons' data was necessary to develop a robust model to estimate the moisture content of 'Hass' avocados using a bench top NIR (Wedding *et al*., 2013). They found that by including three seasons' data, the R^2 increased to 89% and the RMSEP decreased to 1.43% MC and a bias of -0.21% MC over a range of 60.3 to 83.9% MC, making the results feasible for commercial adoption.

Future work

Removal of the skin: If the skin was to be removed from the fruit before scanning, the use of the NIR changes from rapid and non-destructive to simply rapid. This is not ideal, because the aim of the handheld NIR was to have an instrument that could measure moisture content non-destructively. This approach will be investigated in parallel with the preferred method of scanning the fruit with the skin attached and results published in the following season.

Oil analysis: It is known that moisture content (or dry matter) is limited as a maturity marker for avocado fruit – notably in fruit from water-stressed and dry-land orchards – but it is still widely used and understood. The calibration for oil of both the online NIR and handheld NIR that Westfalia Technological Services (WTS) is testing has been considered, but it is felt that it is prudent to wait for this experiment to conclude in 2013 before embarking on this costly analysis.

CONCLUSION

The robustness of the models for estimating moisture content of 'Hass' and 'Fuerte' with the handheld NIR has increased, but at the expense of accuracy. Further testing is needed to improve the models. It may be necessary to make the models more specific than just 'Hass' and 'Fuerte', as has been seen in the online NIR that WTS is also testing. A final report will be published after the 2013 season, once three full seasons' data has been collected.

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LITERATURE CITED

BLAKEY, R.J. 2012. Detection of Preharvest Cold Damage in Avocado Fruit using an Online Near-Infrared Spectrometer. *South African Avocado Growers' Association Yearbook* 35: 76-78.

BLAKEY, R.J. & VAN ROOYEN, Z. 2011. Non-destructive measurement of moisture content using handheld NIR. *South African Avocado Growers' Association Yearbook* 34: 9-12.

WEDDING, B.B., WRIGHT, C., GRAUF, S., WHITE, R.D., TILSE, B. & GADEK, P. 2013. Effects of seasonal variability on FT-NIR prediction of dry matter content for whole Hass avocado fruit. *Postharvest Biology and Technology* 75: 9-16.

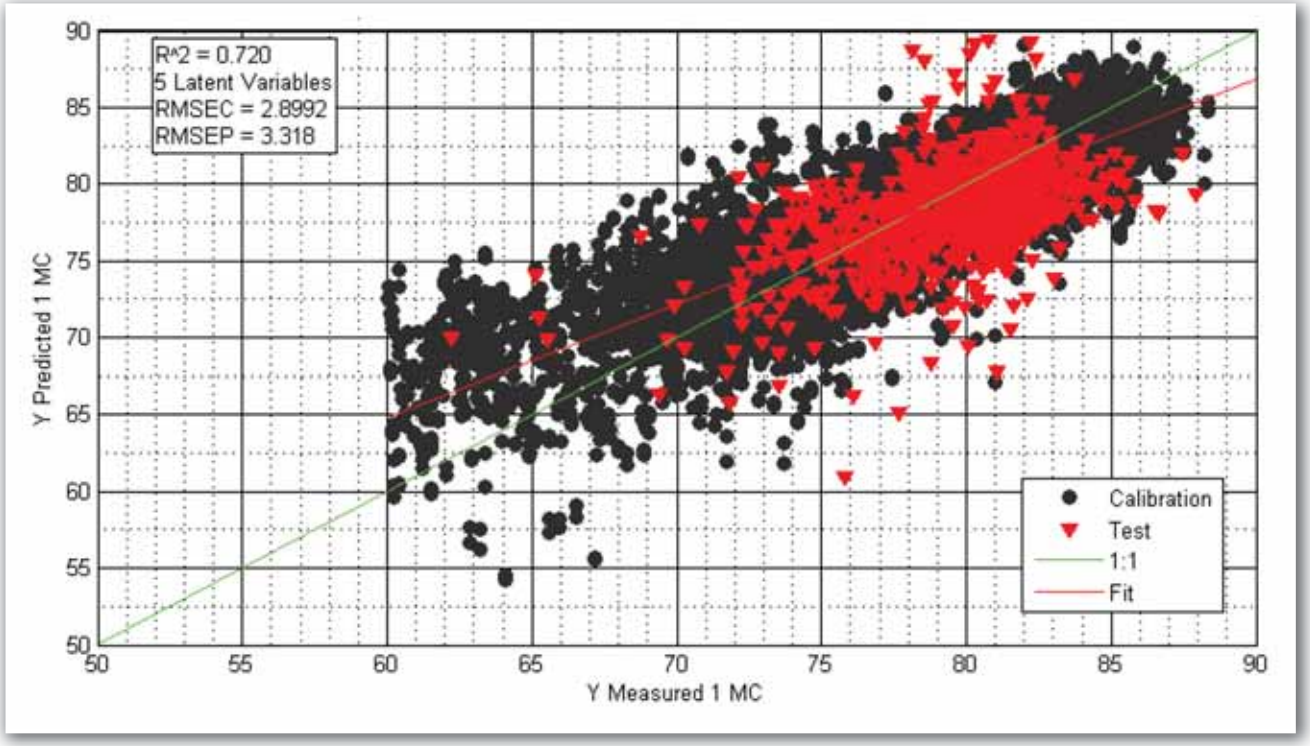

Figure 1. Actual (measured) moisture content (MC) *vs*. NIR-Predicted MC for the Phazir Handheld NIR over the range of 60 to 88% MC. Model includes data from 2011 and 2012 avocados seasons.

(●) = calibration set

(▼) = external validation (test) set from 2012.