Semi-commercial testing of handheld NIR to determine avocado maturity

Progress report – Year 4

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ABSTRACT

The calibration of the handheld near-infrared (NIR) spectrometer for avocado flesh moisture content continued in 2013. The calibration models that were developed during this time were tested in the early season of 2014. For this particular NIR instrument, the flesh of 'Hass' and 'Carmen®-Hass' has to be removed to obtain an accurate estimation of flesh moisture content. Further testing continues in the 2014 season.

INTRODUCTION

Near-infrared spectroscopy (NIR) has potential to rapidly and non-destructively measure the maturity of avocados by using light in the near-infrared region of the electromagnetic spectrum (780 to 2,500 nm). The method is used widely in other agricultural sectors and its commercial use has been growing in the fruit sector (Blakey *et al.*, 2008; Nicolaï *et al.*, 2007).

This project was started in the second half of 2010 and when the Phazir 1018 (Thermo Fisher Scientific, MA, USA) was purchased by Westfalia Technological Services. Data collection began in September 2010 with late season fruit from Westfalia (Blakey & Van Rooyen, 2011). Refinements were made to the technique, more locations were included in the dataset and the effect of removing the skin before NIR-measurement was determined (Blakey, 2013). The robustness of the model for moisture content of avocados after two seasons' data was poor, so a third season's data was included, based on the findings of Wedding *et al.* (2013). To become commercially acceptable, the handheld NIR needs to improve on the measurement of moisture content of avocados, i.e. more rapid analysis with a comparable standard deviation and optimally non-destructively. An external validation of the models developed in 2011-2013, as well as semi-commercial evaluation of handheld NIR was planned for the 2014 season.

Aims

Complete three full seasons' (2011-2013) data collection for calibration of the handheld NIR in 2013 for moisture content of avocado flesh and test the instrument on a semi-commercial basis in 2014. Emphasis was placed on early season, high moisture content (low dry matter) fruit.

MATERIALS AND METHODS

Fruit

Model development

The methodology is the same as previously described (Blakey, 2013). 'Fuerte', 'Hass' and 'Carmen®-Hass' were included in this study. Fruit were scanned 4 to 6 times around the equator, both with skin (exocarp) intact and with the skin removed. Flesh samples of approximately 1 g were taken from each area that was scanned and analysed separately. Fruit were obtained from growers in Tzaneen, Levubu and Soekmekaar. Samples were taken randomly from the Westfalia Pack House and repeat samples were also taken from specific Westfalia orchards each season. Samples were dried at 70-75°C for at least 24 h to determine moisture content (MC).

External validation and semi-commercial testing

The maturity of 'Carmen®-Hass' from five Westfalia farms was monitored from week 4 of 2014. Fruit were tagged in the orchard for non-destructive sampling and five fruit per orchard per week were taken for destructive moisture content measurement. At the time of writing, the tagged fruit were not harvested and results are presented for the harvested fruit. 'Fuerte' fruit used for moisture content testing at Westfalia Pack House were scanned with the NIR with skin intact and skin removed, as from the last week of February 2014. The number of fruit are too

few at the time of writing for presentation. These final results will be presented in the final report in the following Yearbook (Vol. 38).

Chemometrics

Various pre-processing treatments were investigated and any samples with obvious outlying spectra were discarded. For each model, about 10,000 samples were used as this is the maximum sample number that the software (Polychromix-MG v 3.101.0.0) can include in a model. For readers outside South Africa who use dry matter (DM) for maturity, results are easily convertible as DM = 100% - MC.

RESULTS AND DISCUSSION

The late season fruit from 2010 were excluded from the final dataset because the error from these samples was too high, presumably from human error while the method was being optimised. Also, fruit with a low moisture content (50-60% MC) are of less importance than early season fruit where minimum maturity is critical. Hence the NIR was calibrated for fruit from 2011, 2012 and 2013. Three seasons' data were found to be required for a robust model for avocado dry matter (moisture content) in Australia (Wedding *et al.*, 2013).

Three models were calculated: i) 'Fuerte' with skin, ii) 'Hass' and 'Carmen®-Hass' with skin, and iii) 'Fuerte', 'Hass' and 'Carmen®-Hass' without skin (flesh). A model for fruit with skin intact combining all three cultivars was abandoned, because the results were very poor. This is likely because of the difference in the composition of the skin between 'Fuerte' (thin and smooth) and 'Hass' and 'Carmen®-Hass' (thicker and rougher). The results for the three models are presented in Table 1.

The models developed in 2011-2013 (Table 1) were tested on 'Carmen®-Hass' fruit from various Westfalia farms in 2014 (Figs. 1 and 2). Generally the model for skin removed performed fairly well. The difference between the convection oven method and NIR method was less than 1% MC and the two methods have a similar standard deviation, however, the error from the farm Waterval (Fig. 1) and some orchards at Goedgelegen Estate (Fig. 2) was unacceptably high. It is recommended that a small sample per orchard is taken at the beginning of the season for conventional moisture content determination to confirm that the NIR is accurately estimating moisture content.

The skin intact method was not accurate for 'Carmen®-Hass' – as was expected from the model results (Table 1). Monitoring of these orchards will continue until harvest in March 2014.

No results are available for the semi-commercial testing of 'Fuerte' at the Westfalia Pack House at the time of going to press.

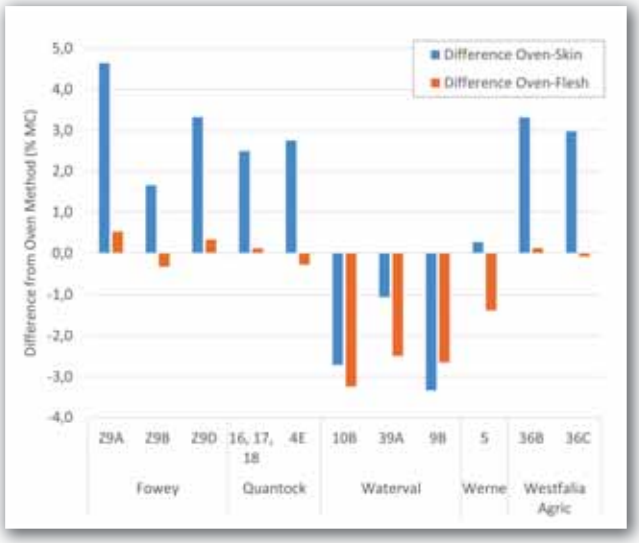

Figure 1. External validation of two handheld NIR methods (skin intact and skin removed/flesh) for 'Carmen®-Hass' from 11 orchards from five Westfalia farms between week 4 and week 7 in 2014.

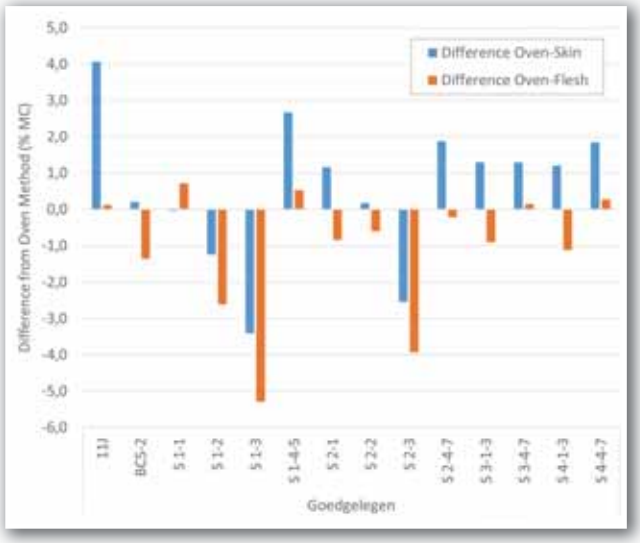

Figure 2. External validation of two handheld NIR methods (skin intact and skin removed/flesh) for 'Carmen®-Hass' from 14 orchards at Goedgelegen Estate in Mooketsi between week 4 and week 7 in 2014.

Table 1. R^2, root mean standard error of prediction (RMSEP), range and number of PLS factors for NIR models to estimate the moisture content of avocado flesh for 'Fuerte' fruit with skin intact, 'Hass' and 'Carmen®-Hass' fruit with skin intact and skin removed (flesh) for all three cultivars. Fruit from 2011, 2012 and 2013 were used for these models.

Parameter	Skin – Fuerte	Skin – Hass	Flesh – combined
R^2	65%	40%	83%
RMSEP	2.37%	2.85%	2.25%
Range	70 - 85% MC	70 - 85% MC	60 - 85% MC
PLS Factors	8	7	8

CONCLUSION

For the Phazir 1018, the removal of the skin is recommended to get an accurate estimation of avocado moisture content. Using this method, the accuracy of the handheld NIR is comparable to the convection oven method. Semi-commercial testing continues in the 2014 season for both 'Carmen®-Hass' and 'Fuerte'. A handheld NIR unit with greater light penetration into the flesh should provide greater accuracy when used non-destructively.

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REFERENCES

BLAKEY, R.J., BOWER, J.P. & BERTLING, I. 2008. The potential of near-infrared spectroscopy in the avocado industry. *South African Avocado Growers' Association Yearbook* 31: 47-50.

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.

BLAKEY, R.J. 2013. Calibration of handheld NIR to determine avocado maturity - Progress Report. *South African Avocado Growers' Association Yearbook* 36: 33-34.

NICOLAÏ, B.M., BEULLENS, K., BOBELYN, E., PEIRS, A., SÆYS, W., THERON, K.I. & LAMMERTYN, J. 2007. Nondestructive measurement of fruit and vegetable quality by means of NIR spectroscopy: A review. *Postharvest Biology and Technology* 46: 99-118.

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(0): 9-16.