HOW CAN TECHNOLOGY SUPPORT POST HARVEST TABLE GRAPE QUALITY?

ANDRIES DANIELS, a researcher at the ARC Infruitec-Nietvoorbij and PhD student explores infrared technology to measure table grape quality.

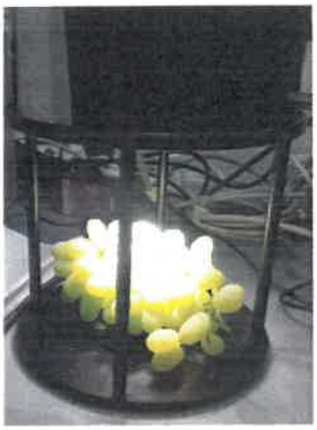

Figure 1: *A whole table grape bunch scanned contactless with the MATRIX-F NIR spectrometer.*

To maintain its competitive edge, it is important that South Africa continually works towards supplying good quality table grapes to all of its markets. One of the greatest challenges is probably that table grapes are non-climacteric fruit which do not continue to ripen after harvest, and which also do not improve during storage. This means that table grape quality will deteriorate once bunches have been harvested and it is particularly important to carefully monitor grape maturation to identify when to harvest.

The consumer perceives quality through visual and organoleptic perception and these have a huge impact on their buying decisions. Visual attributes such as the bunch shape and size can easily be manipulated by the producer through either the application of plant growth regulators such as Gibberellic Acid (GA3), and viticultural practices such as the shortening, thinning and removal of berries from the bunch. Manipulating the organoleptic properties such as sweetness related to sugars and sourness related to acids, however, can prove to be quite daunting. This is because these are of a chemical nature (accumulation of sugars and breakdown of acids in the cells) and are determined through specific processes which occur during the different stages of grape development. The level of sugars and acids can only be determined through measuring the total soluble solids (TSS in °Brix) in the vineyard through the use of a handheld refractometer and the titratable acidity (TA in g/L) measured in the laboratory with the help of specific equipment. Measuring TSS and TA, however, is destructive, slow and may not be completely representative of the whole block seeing that only a few berries of a few bunches in a whole block are tested. In instances where results are inaccurate, decisions can be taken to harvest the whole block and can lead to rejection of grapes for export if they do not meet the TSS and TSS/TA ratio. Technological solutions to limit or prevent these losses by looking at ways in which these measurements can be done in a fast, accurate and most importantly non-destructive way, could be used to overcome these challenges – one such technology is near infrared (NIR) spectroscopy.

WHAT CAN NIR SPECTROSCOPY DO?

NIR spectroscopy is a very versatile technique that has been used for many many years in a variety of fields including agriculture. It can determine a wide range of attributes simultaneously in different fruit and vegetables. It makes use of light in the region between the visible and infrared regions of the electromagnetic spectrum. The light with which samples are irradiated can either be reflected (the light beam is reflected from the sample), transmitted (the light beam is guided through the sample) or absorbed (the beam is absorbed by the sample), depending on the composition of the samples. The chemical information (for example concentration of sugars and acids) that is captured in the fruit spectra (that is obtained from scanning the fruit) is then extracted through the use of chemometric techniques such as partial least squares (PLS) regression. These chemometric techniques are complex mathematical formulas that are used to obtain the relevant information from the fruit spectra (sugar concentration and acid levels) by making use of the Beer-Lambert law. The near-infrared instrument is trained to predict the sugar and acid concentrations based on the reference data that was obtained through the regular measurements (making use for example of a handheld refractometer to measure sugars and automatic titrator instrument to measure acidity) in the laboratory. The reference values of the fruit is matched with the reference values to build models. The models that are built through this process are evaluated for their accuracy in terms of specific statistics.

HOW DID WE OBTAIN A BUNCH SPECTRUM NON-DESTRUCTIVELY?

NIR spectral data of whole table grape bunches were obtained contactlessly by placing each bunch below the four air-cooled tungsten NIR light sources of the MATRIX-F Fourier Transform (FT) NIR spectrometer (Figure 1). After each bunch had been scanned a total of 20 grape berries were taken from within the focus area of the light source (8 cm in diameter). All 20 berries were put into a plastic bag, crushed by hand for one minute and then filtered through cheesecloth to obtain free flowing juice.

The TSS measured in °Brix was then determined, using a handheld digital refractometer (ATAGA Palete Digital Refractometer PR-32 Alpha, Tokyo, Japan). The TA measured in grams/Liter (g/L) and pH was determined by using a TIM 865 Titration Manager (Radiometer Analytical, Villeurbanne Cedex, France) automatic titrator.

TO DETERMINE THE RELATION BETWEEN THE SPECTRAL INFORMATION OF THE BUNCHES AND THE CONTENT OF SUGAR, PH AND TA

PLS regression method was used to build the models for sugar, pH and TA. What this basically means (PLS regression) is that the reference data that was obtained in the laboratory for sugar, pH and TA is matched or compared with the information in the spectra of the bunch and it is then determined how strongly or accurately these values are correlated with the values that are suggested by the near infrared instrument. When bunches were scanned they were scanned at two positions on "Top" and then turned over and scanned at the "Bottom". Bunches are three-dimensional and do not have a "Top" and "Bottom" side. This was only done to simulate different positions that data could be obtained from bunches. This was to see how many times bunches would have to be scanned in the packhouse in order to get the most accurate results for the parameters. Models were thus built with the "Top" spectra alone, with the "Bottom" spectra alone, with the Average spectrum of the two positions and the two spectral positions were combined ("Top+Bottom"). Test set validation was done on the models. Two-thirds of the samples were used to test the models and one third was used to test how accurate the models were. The model accuracy was tested with the root mean square error for prediction (RMSEP) value that gives the average uncertainty that can be expected for predictions of future samples. For example if this value is one in the model that was built and the true value of the new sample that is being tested is 16°Brix, it means that the model will then predict this new sample either as 15°Brix or 17°Brix. The other statistic used was the coefficient of determination (R2) value that represents the proportion of explained variance of the response variable in the calibration or validation set. This value should be as high as possible or close as possible to 100. The TSS model performed best when the average of the spectra that was obtained was used with a R2 value of 76 and a RMSEP value of 0.89°Brix. This was not the case with pH and TA. Both delivered better results when the Top+Bottom spectra was used to build the models (Figure 2). The RMSEP value for pH was 0.13, and that of TA was 0.58 g/L. In the case of TSS the better prediction statistics is obtained due to not only the higher concentration level of TSS present in the grapes, but also due to the wide range over which it is spread (10.175-22.42°Brix). The values of pH and TA are spread over a very narrow range, 3.31-4.07 for pH and 3.2- 7.62 making the construction of a proper calibration model extremely difficult.

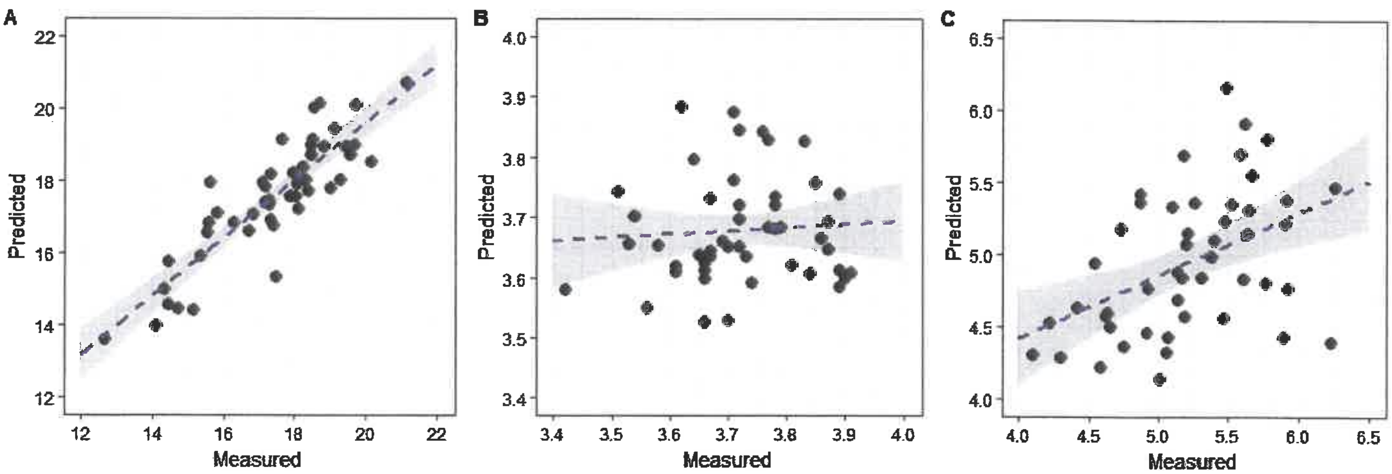

Figure 2: *Predicted versus measured values of validation samples. A. Sugar, B. pH and C. TA.*

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CONTINUED FROM PAGE 53 Review of other similar work showed that other researchers obtained better results. The reason for this was that they scanned individual grape berries and not whole bunches. Additionally, the focus area of the light was smaller – less than 17 cm, which was used in this experiment. It is thus not only remarkable that the spectra could capture enough of the information in the grape bunches, despite the heterogeneous nature of grape bunches which consists of a rachis, berries and pedicels, but also due the low penetration depth of NIR usually into a sample.

From this experiments it could clearly be seen how high the variability in whole table grape bunches are, given that the best models were obtained either by using the average of the spectra or a combination of the Top and Bottom spectra obtained of the bunches. This is important information for establishing this type of technology, as careful consideration would have to be made as to how the samples should be presented for scan if placed on the conveyer belt, for example. To achieve the highest spectra quality, grape bunches would have to be scanned in slices over the length of the bunch. In future work the Sugar-Acid and BrimA sensory parameters will also be included.

This will all lead to a reduction in the postharvest losses suffered by producers due to the incorrect determination and classification of TSS and or TSS/ TA ratio of grapes for the export market.

ACKNOWLEDGEMENTS

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