Using non-destructive technology to measure apple quality at harvest and during storage

AGRICULTURE VICTORIA

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INTRODUCTION

Delivering quality apple fruit to consumers largely depends on managing fruit maturity. This begins before harvest by monitoring fruit on the tree to determine optimal harvest maturity. After harvest, ripening needs to be monitored during handling, storage, transport and marketing.

Until recently the only way to conduct fruit maturity testing was to take a destructive sample of the fruit population. This can be problematic for a number of reasons:

1. A large number of fruit samples need to be tested
2. Testing large samples is time-consuming
3. Tested fruit are not saleable and are discarded
4. A smaller than appropriate sample size could mean that derived information is not representative
5. The manual operation of some quality measurement equipment may introduce operator error

Traditionally growers have monitored apple maturity using destructive tests that included; Effegi penetrometer for firmness (kgf), refractometer for sugar concentration (°Brix) and 'Starch Index' (e.g. Cornell generic starch chart).

However, non-destructive technologies have recently been developed that allow repeated quality measures on the same fruit without damaging it. Most importantly once fruit are harvested, non-destructive equipment installed on grading and packing lines can very rapidly test and check every piece of fruit that a grower intends to deliver to market.

The following trial was undertaken to illustrate the potential benefits of adopting novel non-destructive testing technologies that can be applied in research institutions or in a commercial facility such as a packing shed.

METHODS

Fruit quality based on firmness, soluble solids concentration (SSC) and change in chlorophyll content was measured non-destructively on 20 apples at harvest and at weekly intervals on 10 fruit stored in air at 4°C and 18°C for up to 28 days. Apples were sourced from a commercial orchard in the Yarra Valley, Victoria, Australia.

Prior to non-destructive measurement, fruit were removed from storage and warmed to 20°C, over a two hour period. All measurements were conducted on the equatorial region midway between the stem and calyx end of the fruit on the blush and non-blush sides.

Firmness (Firmness Index, FI) was measured using a table-top acoustic firmness sensor (AWETA, Nootdorp, Netherlands) (Figure 1). The acoustic signal is generated by a solenoid plunger that gently taps the fruit and the maximum vibration is recorded as a ticking sound by a microphone.

SSC (°Brix) was measured using a digital hand-held 'Pocket' Infra-red (IR) refractometer (Atago, Tokyo, Japan) (Figure 1). The refractometer measures the amount of light absorbed by shinning a near IR light to the fruit then converts and digitally displays the sugar level in °Brix.

Chlorophyll content in the flesh (index of absorbance difference, I_{AD}) was measured using a portable Vis/NIR DA meter (Sintelela, Bolgna, Italy) (Figure 1). The chlorophyll content typically shows a high correlation with fruit ethylene production. This allows identification of up to three maturity classes at harvest; pre-climacteric, onset climacteric and climacteric based on none, low or medium-high ethylene emission, respectively. Most apple cultivars display an I_{AD} reading between 0 and 3.0.

Figure 1. Three non-destructive instruments for measuring apple quality; AWETA for acoustic firmness (left), a PAL - Infra-red refractometer for soluble solids concentration (centre) and DA-meter for fruit maturity (right). Photos: Glenn Hale.

RESULTS & DISCUSSION

Firmness

Fruit firmness declined in all apples over 28 days in storage (Figure 2). Fruit stored at 4°C lost approximately 20 % firmness compared to 53 % for fruit stored at 18°C. As expected, the advanced softening in fruit firmness was greater at the higher storage temperature and the AWETA successfully measured the change in firmness.

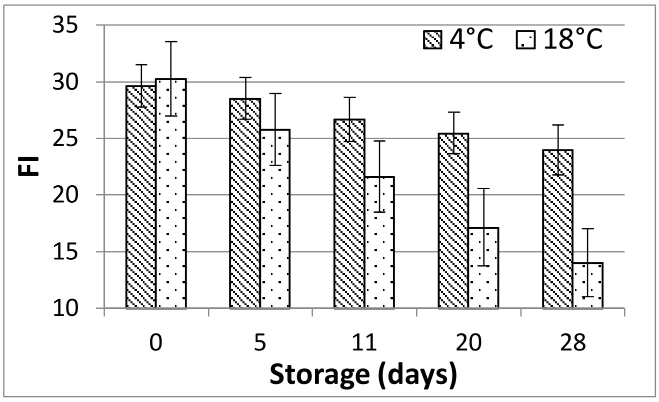

Figure 2. Change in mean Firmness Index (FI) for Pink Lady™ apples over 28 days storage at 4°C and 18°C. Bars represent the standard deviation (± SD) and N = 10 fruit at each storage and temperature assessment.

Soluble solids concentration

At harvest, mean SSC was approximately 12 °Brix as measured non-destructively with the Atago Infra-red refractometer (Figure 3). The unit was not available on Day 5 of the trial. However, after 28 days in storage SSC had increased by over 1 °Brix in fruit stored at both temperatures. The non-destructive refractometer successfully tracked the hydrolysis of starch to sugar.

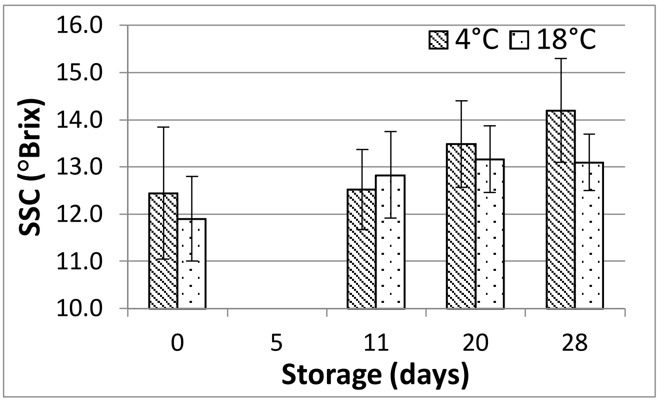

Figure 3. Change in mean soluble solids concentration (SSC) for Pink Lady™ apples over 28 days storage at 4°C and 18°C. Bars represent the standard deviation (± SD) and N = 10 fruit at each storage and temperature assessment.

Chlorophyll content

Decrease in the mean I_{AD} was significantly greater in fruit stored at 18°C compared to 4°C (Figure 4). This non-destructively derived information follows a trend known to be true of ripening in temperate fruit such as apples. As fruit ripen, ethylene production increases and chlorophyll concentration decreases. A lower I_{AD} value is associated with riper fruit.

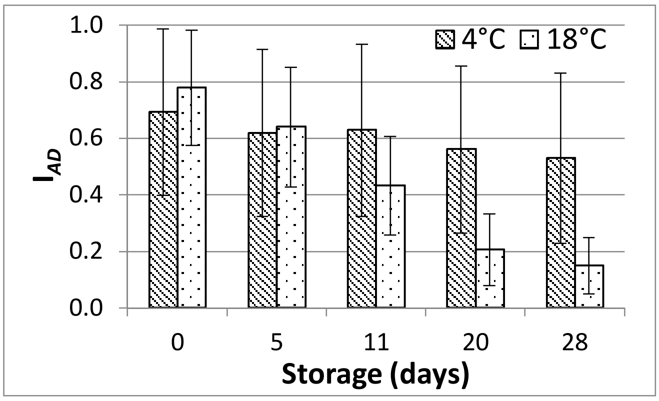

Figure 4. Change in mean index of absorbance difference (I_{AD}) for Pink Lady™ apples over 28 days storage at 4°C and 18°C. Bars represent the standard deviation (± SD) and N = 10 fruit at each storage and temperature assessment.

CONCLUSION

This trial has shown that even at this relatively early stage in development and commercial adoption of non-destructive sensor technologies it was possible to monitor apple maturity right through the handling chain without sacrificing fruit to destructive testing. Results reported here demonstrate that new, non-destructive technologies are an equally reliable measure for monitoring changes in fruit quality compared to destructive tests that have been used over many decades.

ACKNOWLEDGEMENTS

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FURTHER INFORMATION

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