Horticulture Innovation Australia

Final Report

Australian table grape quality audit 2015-2016

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Abbreviations

R&D	Research & development
DEDJTR Vic	Department of Economic Development, Jobs, Transport and Resources, Victoria
HIA	Horticulture Innovation Australia
ATGA	Australian Table Grape Association Inc
SSC	Soluble solids concentration
TA	Titratable acid

Media summary

Eating quality of table grapes can vary substantially early in the season. A major cause is sour, immature grapes with a low sugar to acid ratio. If consumers have a poor eating experience with table grapes at this time, it is unlikely that they will make repeat purchases, at least in the near future. This in turn is a major barrier to increasing table grape demand and consumption per capita.

To investigate the issue, the Australian Table Grape Association and Horticulture Innovation Australia engaged DEDJTR Horticulture Production Sciences to conduct an audit of table grape eating quality in 2015-16. This followed a national table grape quality audit in 2014-15. The audit was conducted between November 2015 and March 2016 to capture the early-season market for the major table grape varieties, particularly Menindee and Flame Seedless. Grape composition measurements included soluble solids concentration and organic acid concentration and the sugar to acid ratio. The sugar to acid ratio largely determines the flavour and consumer acceptability of table grapes. In general, ratio of 24 is considered the minimum acceptable level to provide a good eating experience.

The 2015-16 season audit showed a substantial improvement in the eating quality of early Menindee Seedless compared to the 2014-15 season. Average sugar to acid ratio in both Menindee and Flame Seedless bunches remained consistently above 28 after the first 2 weeks of the sampling period. Average sugar to acid ratios were also acceptable in Thompson Seedless and the other red varieties tested, which included Red Globe, Ralli Seedless and Flame Seedless. Overall eating quality of commercial table grape varieties in the domestic market was very good with the majority of fruit meeting consumer expectations for flavour and bunch colour.

However, there were some quality issues early in the season, particularly Menindee Seedless, the main early season variety in Australia. One chain stocked fruit in the first week of the audit, another commenced in week 2 and the third chain had their first Australian fruit on their shelves in the third week of the audit. Fruit sampled in week 1 and to a lesser extent in week 2 was of low and variable quality with some bunches having a very low sugar to acid ratio. These fruit were poor eating quality and quite sour. By week 3 of the audit the eating quality of the fruit was very good. This showed the value of waiting to market fruit until fruit quality from the vineyard reached the minimum sugar to acid ratio to provide an acceptable eating experience.

To determine when grapes should be harvested to optimise eating quality, the sugar to acid ratio of Menindee Seedless bunches was monitored during the lead up to harvest in four vineyards in Emerald, Queensland. This study demonstrated that sampling berries from grape bunches over the final four weeks prior to harvest proved a simple and effective way to inform early season producers regarding harvest timing to ensure that grapes always meet the minimum eating quality standards acceptable to consumers.

So despite the substantial improvement in grape eating quality observed over the last two seasons there are still some issues with very early season Menindee Seedless in particular. The study conducted in Emerald, where much of Australia's early grapes are produced, showed that simple sampling and monitoring program in the few weeks prior to harvest can accurately determine when grapes are ready to harvest and meet minimum eating quality standards. A grower and retailer training package to optimise and measure grape quality has been prepared and is available to industry.

Technical summary

Poor and variable table grape eating quality, particularly sour fruit early in the season, can reduce consumer satisfaction and repeat sales. This is seen as a major factor in preventing increased domestic consumption of table grapes. To investigate the issue, the Australian Table Grape Association and Horticulture Innovation Australia engaged DEDJTR Horticulture Production Sciences to conduct a follow-up audit of eating quality of table grapes in 2015-16 after a successful national table grape quality audit in 2014-15 (Lopresti & Tomkins, 2015). An audit was conducted between November 2015 and March 2016 to capture the early-season market for the major table grape varieties such as Menindee and Flame Seedless. Grape composition measurements included total soluble solids and organic acid concentration, and the sugar to acid ratio that largely determines the flavour and consumer acceptability of table grapes.

The main objective was to quantify table grape eating quality with respect to sugar and acid concentration and the sugar to acid ratio and to determine if fruit eating quality had improved in comparison to that measured in 2014-15. Vineyard sampling of early season Menindee Seedless grapes from four vineyards in Emerald (central Queensland) was also conducted to demonstrate the importance of monitoring fruit eating quality development prior to commercial harvest.

Weekly sampling of grapes was conducted in Melbourne (Victoria) over 13 weeks with representative table grape bunches sampled weekly from ALDI, Woolworths and Coles retail outlets. For each commercial variety, grape bunches were removed from bunch bags and assessed for soluble solids concentration (SSC) and titratable acidity (TA), as well as visual bunch quality.

One retail chain stocked Menindee Seedless at week 1 (18th Nov 2015) of the study. Quality of the grapes was poor and variable with an average sugar to acid ratio of 16.8 and values as low as 7.0 for some bunches (an acceptable sugar to acid ratio for good eating quality is approximately 25). These early season fruit were of very poor eating quality and would have discouraged consumers to make repeat purchases. By week 2 two retail chains had Menindee Seedless on their shelves. Quality had increased substantially with the mean sugar to acid ratio rising to 26.6. However, there were still bunches sampled with unacceptable sugar to acid ratios as low as 10.2. The third retail chain held off stocking grapes until the sugar to acid ratio of grapes supplied by its growers had increased to an acceptable eating quality (harvest value of equal to or greater than 25). This chain was the only one that participated in the grape quality training workshop in the 2014-15 project. This chain did not stock Menindee Seedless grapes until week 3 (3rd December) of the audit. Grape quality increased substantially by that time showed an average sugar to acid ratio of 35.5. By waiting until the grapes were highly acceptable to eat, consumers would have been satisfied and would be encouraged to purchase grapes again.

Despite some poor quality grapes early in the season, the 2015-16 season audit showed a substantial improvement in the eating quality of early Menindee Seedless compared to the 2014-15 season. Average sugar to acid ratio in both Menindee and Flame Seedless bunches remained consistently above 28 after the first 2 weeks of the nine week sampling period. Average sugar to acid ratios were also acceptable in Thompson Seedless and the other red varieties tested. Overall eating quality of commercial table grape varieties in the domestic market was very good with the majority of fruit meeting consumer expectations for flavour and bunch colour.

Measurement of eating quality in Menindee Seedless bunches in the lead up to harvest in four vineyards in Emerald demonstrated that sampling berries from grape bunches over the final four weeks prior to harvest can inform early season producers regarding harvest timing to ensure that harvested fruit will meet minimum eating quality standards acceptable to consumers.

As observed in 2014-15, bunch variability in sugar to acid ratio within a variety and sampling week was relatively high and future table grape auditing should focus on determining whether the cause of this variation is due to irregular maturity in the vineyard at harvest, due to differences in quality between producers, or due to supply from multiple production regions.

Future studies are also recommended to audit grape quality and variation in quality from vineyard to consumer. Particular attention is required on accurate determination of harvest maturity and adoption of production, harvest and handling practices to ensure fruit are picked at a sugar to acid ratio greater than 24 and that optimum eating and visual quality is maintained through the supply chain.

Recommendations for future research and development:

- Further auditing of early season Menindee Seedless grapes incorporating detailed vineyard sampling to explore cause of variation in sugar to acid ratio.

- Auditing of export consignments of early season fruit to establish the eating quality of export fruit.

- Assist table grape producers to implement harvest maturity monitoring as standard commercial practice.

- Assist supermarkets in providing suppliers with indicative SSC and sugar to acid ratios for each grape variety to guide producers in determining the appropriate harvest maturity.

- Assist supermarkets in developing protocols for measuring sugar to acid ratios in consignments, particularly early season, and procedures to provide immediate feedback to suppliers.

Introduction

With the increasing supply of early-season table grapes in recent years the Australian table grape industry is concerned that fruit of poor and variable eating quality is being provided to the domestic market resulting in consumer dissatisfaction and lack of repeat sales. Horticulture Innovation Australia Limited and the Australian Table Grape Association engaged DEDJTR Horticulture Production Sciences to conduct a follow-up audit of eating quality of table grapes in 2015-16 after a successful national table grape quality audit in 2014-15.

Table grape quality was measured over 13 weeks between November 2015 and March 2016 to capture both the early- and late-season market for major table grape varieties with a focus on early season Menindee Seedless and Flame Seedless. Grape composition measurements to determine the flavour and consumer acceptability of table grapes included total soluble solids and organic acid concentration and the sugar to acid ratio. Visual quality, such as rachis browning and berry colour, was also assessed for each variety.

Sugar and organic acid concentration at harvest, which are measured through soluble solids concentration (SSC, °Brix) and titratable acidity (TA, g/L), respectively, are most commonly associated with table grape flavour (Nelson, 1985). From the consumers' perspective, table grape flavour mainly depends on the sugar concentration, organic acid concentration and the balance, or ratio, between the two. Glucose and fructose are the main sugars present in grape berries at harvest while sucrose contributes less than 1% by weight. Organic acids are present in small amounts compared to sugars but they contribute significantly to overall flavour (Liu et al., 2006). In general, organic acids do not exceed 1% of total juice by weight with tartaric acid the most important acid followed by malic and citric acid. High organic acid levels are generally unacceptable to the human palate but the ratio of sugar to acid is generally a better indicator of consumer acceptance than sugar or acid concentration alone (Munoz-Robredo et al., 2011). Differences in organic acidity in table grapes at harvest can be the result of differences in varietal characteristics, environmental conditions during growth and cultural practices (Dokoozlian et al., 1995).

Despite the importance of organic acid concentration to overall grape flavour, industry may only use SSC as a measure of eating quality with most commercial varieties considered acceptable when SSC at harvest ranges from 15 to 20 °Brix. Yet the balance between sugar and acid is critical in influencing grape flavour and consumer acceptability and is generally more important than simply the total amount of sugars or organic acids in fruit. For example, palatability studies conducted in Western Australia with Crimson Seedless showed that a sugar to acid ratio of 30 satisfied at least 75% of consumers during a four year study, yet this variety has a naturally high level of tartaric acid (Jayasena & Cameron, 2008). As an example of the importance of sugar to acid ratio, fruit with a SSC of 20 °Brix and 6 g/L TA has a sugar to acid ratio of 33 that would meet consumer requirements, yet grapes with the same SSC but 8.5 g/L TA (i.e., sugar to acid ratio = 23.5) may in many cases not achieve consumer acceptability. The sugar to acid ratio may be affected by climatic conditions during fruit growth. For example, rapid fruit ripening during hot weather will result in higher ratios, and grapes will be palatable at relatively low sugar levels. In cool weather, organic acid levels will be higher, and a higher sugar concentration will be necessary to achieve an equivalent palatability (Nelson, 1985).

Recommended minimum SSC and sugar to acid ratios for varieties grown in Australia are currently only used in Western Australia (www.agric.wa.gov.au/table-grapes/minimum-maturity-standards-table-grapes-western-australia). In general, there is little information relating table grape consumer acceptability with changes in sugar to acid ratios for most commercial varieties. Based on WA maturity standards, the recommended minimum SSC and sugar to acid ratio for early-season red varieties (e.g. Flame Seedless) is 16 °Brix and 24, respectively. For white varieties such as

Menindee Seedless the recommended minimum SSC is 15 °Brix with no minimum sugar to acid ratio indicated. Grape industry information from the USA suggests that a sugar to acid ratio of less than 20 in early-season white varieties results in unacceptable flavour for consumers.

In 2003-04, the GrapeConnect grower network based in Queensland commissioned a project 'Maturity indices as a measure of eating quality of early season domestic Menindee Seedless table grapes' to correlate sugar to acid ratio with consumer perceptions of eating quality. The key results are summarised in Table 1 and show that for Menindee Seedless, consumers rated good eating quality fruit as having a SSC of greater than 17 °Brix and sugar to acid ratio of at least 27. On the other hand, consumers rated the eating quality of fruit with less than 22 sugar to acid ratio as poor.

Table 1. Menindee Seedless eating quality as related to soluble solids concentration (SSC) and sugar to acid ratio (adapted from GrapeConnect grape maturity report, 2003-04).

Eating quality level	Average SSC (°Brix)	Average sugar to acid ratio	Sugar to acid ratio rankings
Excellent	17.8	31.0	> 29
Good	17.2	27.5	27 – 29
Fair	16.9	23.3	22 – 27
Poor	16.5	18.8	< 22

Project Objectives

- Conduct weekly measurements of the composition and visual quality of table grapes supplied to ALDI, Woolworths and Coles supermarkets in Melbourne, Victoria during the 2015-16 season.
- Communicate results to project stakeholders via weekly reporting.
- Manage early season Menindee Seedless sampling and quality audit in four vineyards located in Emerald, Queensland.
- Prepare final report for Horticulture Innovation Australia (HIA).
- Make recommendations to HIA and the Australian table grape industry for future work to improve table grape eating quality.

Materials and Methods

Grape bunch sampling

Weekly sampling of bunch bags containing 0.5 – 1.2 kg of grapes was conducted in Victoria over 13 weeks between 18th November 2015 and 8th March 2016. During each week of sampling, a total of 15 to 20 representative bunch bags per variety were collected from ALDI, Coles and Woolworths retail stores situated in the northern suburbs of Melbourne. Weekly bunch bag sampling was conducted from the same three supermarket stores. Bunch bags were usually sampled from cartons on refrigerated retail display within supermarket stores but in some cases bunches may have also been sampled from unrefrigerated displays. Bunch bags generally contained between one and three individual grape bunches. Where possible, an equal number of red and green varieties were sampled, and supplier, grape variety and packing date details were recorded. The audit focused on early season varieties (Menindee Seedless and Flame Seedless) during the first nine weeks of sampling.

Measurement of grape bunch composition

Grape bunches were removed from each bunch bag and twenty representative grape berries detached from bunches for measurement of SSC and TA. Very small, bruised and shrivelled berries were not sampled for measurement. Twenty berries per bunch bag were allowed to warm to > 10°C and then placed in a small plastic bag and crushed by hand to release their juice. SSC was measured in 0.4 ml of grape juice using a temperature-compensated digital refractometer (ATAGO PAL-1) with a measurement accuracy of ± 0.2 °Brix. The refractometer was calibrated with distilled water prior to weekly SSC measurements.

For each variety and bunch, TA measurements were conducted using a 3 ml juice sample extracted from twenty berries per bunch. TA of each juice sample was measured after dilution in 5 ml distilled water via endpoint titration to pH 8.2 with 0.1 M NaOH using an automatic titrator (Steroglass Titre X) and AS23 Micro autosampler. The NaOH titre volume obtained was used to calculate TA (as g tartaric acid equivalents per L juice) for each bunch sampled.

Sugar to acid ratio was calculated from SSC and TA measurements obtained for each bunch among a variety using:

$$Sugar\ to\ acid\ ratio = \frac{SSCx10}{TA}$$

Measurement of grape bunch visual quality

Grape bunches from within each bunch bag were removed and weighed, and any loose (shattered) berries remaining in the bag were counted and weighed. Twenty representative berries were sampled from bunches within a bag, weighed, and used for SSC and TA measurements. Bunches were then laid out on a white plastic tray and scored for rachis browning using a 1 to 5 scoring scale where 1 = green rachis and 5 = completely brown rachis. When bunch bags contained multiple bunches, each bunch was scored separately and the average rachis browning score determined for that bunch bag. All visual quality and scoring criteria used for grape bunch assessments are described in the appendices.

In red varieties, overall colour of bunches within a bunch bag was scored as a percentage (%) using a bunch colour chart (Nelson, 1985) where 100% = uniform dark red colour and 50% = half of berries with characteristic red colour. For green varieties, a bunch colour scoring scale was developed based on berry colour charts in Chesterfield & Smith (1990) where 1 = dark green, 2 =

light green (optimal colour), 3 = green to yellow, 4 = light yellow and 5 = dark yellow. A score of 2 represents 'light green' bunch colour, and is generally considered as the minimum colour required at harvest to meet consumer preferences. Bunches scored as 4 or 5 were likely to have been highly exposed to sunlight in the vineyard resulting in advanced maturity or sunburn.

Statistical analysis and data presentation

Where possible each bunch bag sampled during the 13 week audit was given a code based on the following factors: week of sampling, state, variety, supermarket, supplier or grower, carton or store, and bunch within a carton or store. This enabled the reporting of grape composition and quality data by single or multiple factors if necessary (e.g., by variety, or by variety and supplier etc.). The mean (i.e., average) and standard deviation (± SD) was calculated for each quality measurement and factor such as variety or supermarket. The standard deviation is a measure of the dispersion of values around the mean, and represents the variability among a group of sampled bunches. The standard deviation is presented as an error bar within figures, and as a ± value in tables (e.g., 18.0 ± 0.5 °Brix).

Results and Discussion

Summary of average eating quality by variety

More than 600 grape bunches were sampled during the 13 week period of grape quality auditing with sampling primarily focused on early-season Menindee Seedless and Flame Seedless varieties (Table 2). Bunch sampling was extended to other red and green varieties as they came into production. Average SSC was lowest in Menindee Seedless grapes whilst sugar to acid ratio was lowest in Menindee Seedless and Ralli Seedless (Table 3).

Sugar to acid ratios were highest in Red Globe and Crimson Seedless red varieties. Although grape bunches were sampled from various suppliers and supermarkets, variability in SSC as measured by the standard deviation was less than 2 °Brix and consistent among grape varieties. Variability in sugar to acid ratio within a grape variety was generally between 4 to 7 ratio units indicating that sugar to acid ratio was more inconsistent than SSC among a variety when measurements from all suppliers and supermarkets were included.

Average SSC in the 2015-16 table grape audit was higher in all varieties other than in Flame Seedless when compared to results obtained in the 2014-15 audit (Table 4). In 2015-16 average sugar to acid ratios were 6 to 12 units higher than in 2014-15. For example average sugar to acid ratio in Menindee Seedless increased from 23.3 in 2014-15 to 29.3 in 2015-16 whilst over the same auditing period sugar to acid ratio in Thompson Seedless increased from 25.9 to 33.1, and increased from 25.6 to 37.1 in Crimson Seedless.

The higher average sugar to acid ratios measured in 2015-16 relative to 2014-15 are likely the result of both better climatic conditions during fruit development and ripening (i.e., resulting in a better balance between SSC and TA in fruit), greater producer awareness after the results from 2014-15 were disseminated and more intensive monitoring of fruit SSC prior to harvest to ensure that harvested fruit met minimum SSC requirements.

Table 2. Weekly frequency of sampling and number of bunches sampled by grape variety.

	Week													Total number bunch bags sampled
Grape variety	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	
Menindee Seedless														177
Flame Seedless														175
Red Globe														152
Thompson Seedless														86
Ralli Seedless														55
Crimson Seedless														57

Table 3. Average soluble solids concentration (SSC) and sugar to acid ratio across the 2015-16 sampling period by grape variety (SD = standard deviation).

2015/16	**SSC (°Brix)**		**Sugar to acid ratio**	
Grape variety	**Average**	**±SD**	**Average**	**±SD**
Menindee Seedless	16.2	1.8	29.3	6.4
Flame Seedless	17.5	1.4	32.4	4.9
Ralli Seedless	18.6	1.0	30.7	6.6
Red Globe	16.9	0.9	37.0	4.9
Thompson Seedless	19.0	1.4	33.1	4.4
Crimson Seedless	20.5	1.4	37.1	8.2

Table 4. Average soluble solids concentration (SSC) and sugar to acid ratio across the sampling period by grape variety from 2014-15 table grape audit (SD = standard deviation).

2014/15	**SSC (°Brix)**		**Sugar to acid ratio**	
Grape variety	**Average**	**±SD**	**Average**	**±SD**
Menindee Seedless	15.7	1.7	23.3	5.0
Flame Seedless	18.1	2.0	26.7	6.2
Ralli Seedless	18.0	1.8	27.9	4.0
Red Globe	16.6	1.5	27.9	5.0
Thompson Seedless	18.4	2.2	25.9	4.3
Crimson Seedless	18.6	1.8	25.6	4.4

Menindee Seedless eating quality

The three retailers in the study started marketing the early season Menindee Seedless variety at different times (Table 5). Retailer A was the first to market Australian grapes on the 18th of November. At this time the grapes were very immature with a mean sugar to acid ratio of 16.8 and with some bunches sampled as low as 7.0. At these values consumers would find the grapes very unpalatable. Retailer B started selling Menindee during the second week of the study on the 26th November. Mean sugar to acid ratio was acceptable at 26.6 but some bunches were still as low as 10.2. These bunches would still be very sour tasting. Retailer C worked closely with their grape growers and advised them to wait until the grapes on the vine reached a minimum sugar to acid ratio of 25. These stores started selling Menindee Seedless in week 3 of the study on the 3rd of December.

Table 5. Mean, standard deviation (SD) and range of sugar to acid ratio of Menindee Seedless the first time they were sold by each retailer during the first three weeks of the 2015-16 grape quality audit.

Sugar to acid ratio on the first day that Menindee Seedless grapes were sold by each retailer			
Retailer Date	**A** 18th Nov (week 1)	**B** 26th Nov (week 2)	**C** 3rd Dec (week 3)
MEAN	16.8	26.6	33.5
SD	8.3	8.8	6.2
RANGE	7.0 - 30.2	10.2 - 34.3	23.3 - 48.7

By waiting the eating quality of all bunches sampled were of very good eating quality with a mean sugar to acid ratio of 33.5 and with the lowest value measured 23.3. Waiting until grapes are acceptable eating quality will ensure that consumers will have a pleasant eating experience and will make repeat purchases. Trying to catch the early market by supplying immature grapes will result in a very poor experience for consumers and will discourage them from making repeat purchases.

In general there was little variation in average SSC among Menindee Seedless bunches during nine weeks of sampling with an average SSC of between 15 and 17 °Brix in most weeks (Figure 1). Early season fruit was supplied from a relatively small number of growers in the Northern Territory and Queensland resulting in consistent SSC in fruit with relatively little variability between sampled bunches. Other than in the first week of sampling, average SSC in Menindee Seedless during the 2015-16 season remained above a recommended minimum of 16 °Brix as determined by previous consumer studies. In the first two weeks of sampling higher fruit TA resulted in relatively low sugar to acid ratios compared to subsequent sampling weeks.

Average sugar to acid ratio in Menindee Seedless was 16.8 and 28.4 during the first and second week of sampling respectively and was generally greater than 30 over the remaining sampling period. Though the variability in sugar to acid ratio among bunches sampled at each week was relatively high, the majority of bunches sampled had sugar to acid ratios greater than 25. Beyond the sixth week of sampling, average sugar to acid was marginally lower than in previous weeks but still acceptable. This slight drop in ratios coincided with the commencement Menindee Seedless supply from Northern NSW.

Despite the issue of some retailers selling fruit at the start of the season that was immature and sour, the weekly average SSC and average sugar to acid ratio in Menindee Seedless were both higher and less variable 2015-16 when compared with the results obtained during the same period in the 2014-15 table grape audit.

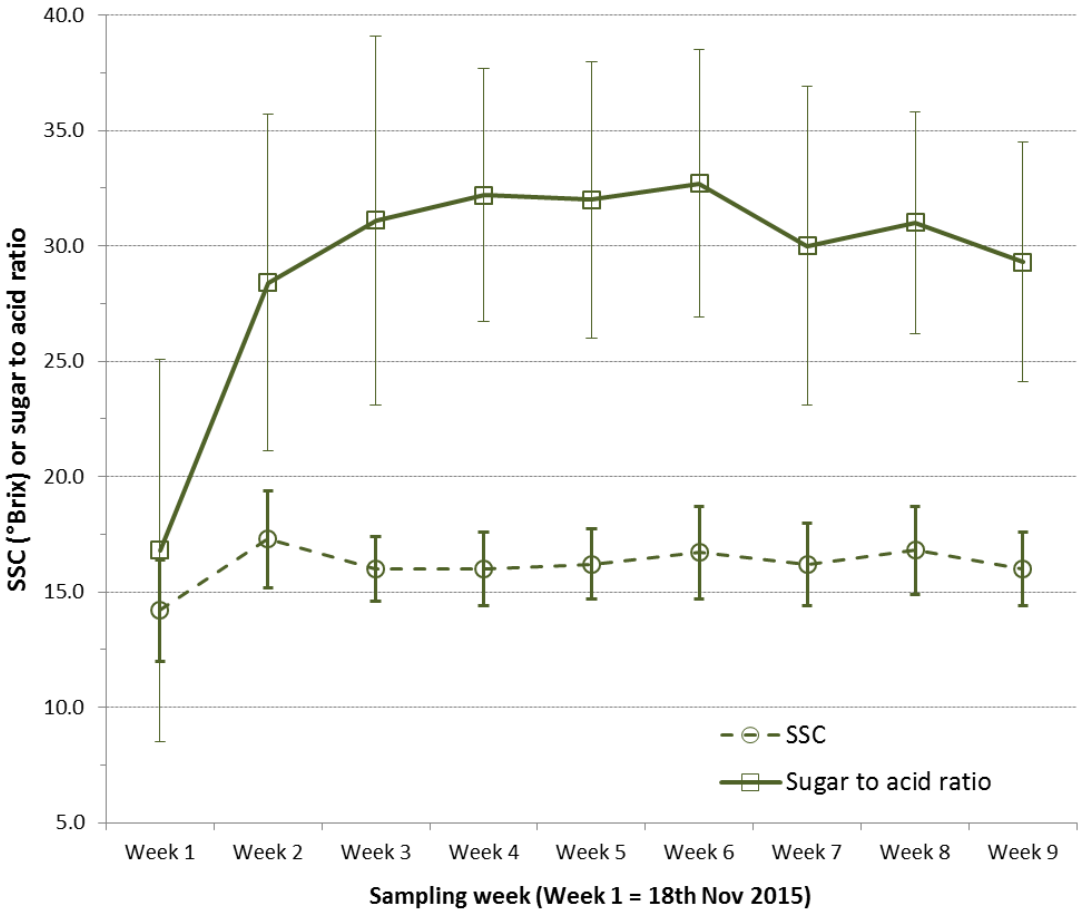

Figure 1. Average soluble solids concentration (SSC) and sugar to acid ratio for Australian Menindee Seedless table grapes across nine weeks of sampling conducted between 18th Nov 2015 and 27th January 2016. Bars represent the standard deviation (±SD) of each average SSC and sugar to acid value.

Flame Seedless eating quality

Little weekly variation was observed in average SSC among Flame Seedless bunches over nine weeks of sampling with an average SSC of between 16 and 19 °Brix in most weeks (Figure 2). In general, average SSC during the 2015-16 season remained above the recommended minimum of 17 °Brix determined by previous consumer studies with little variation among bunches during each week of sampling.

In the first two weeks of sampling, average sugar to acid ratio in Flame Seedless was above 35 and generally over 30 for the remainder of the sampling period. In the first two weeks of sampling, lower TA resulted in relatively high sugar to acid ratios relative to subsequent sampling weeks. The decrease in values after the first 2 weeks may have been due to grapes coming on stream from other sources. Although the variability in sugar to acid ratio among bunches sampled at each week was relatively high, the majority of bunches had sugar to acid ratios greater than 27.

Weekly average SSC in Flame Seedless was marginally lower over the sampling period in 2015-16 when compared with the results obtained during the 2014-15 but average sugar to acid ratio was generally higher due to lower TA in bunches and less variable when compared to 2014-15.

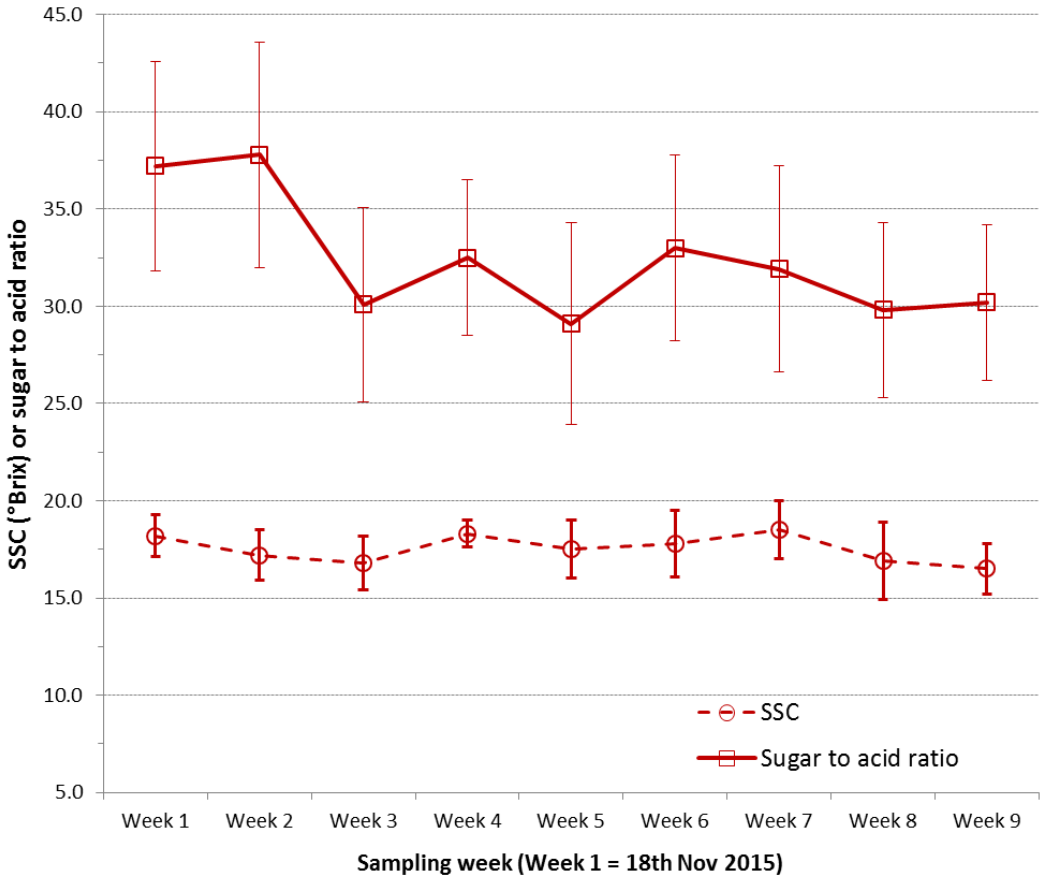

Figure 2. Average soluble solids concentration (SSC) and sugar to acid ratio for Flame Seedless across nine weeks of sampling conducted between 18th Nov 2015 and 27th January 2016. Bars represent the standard deviation (±SD) of each average SSC and sugar to acid value.

Thompson Seedless eating quality

Thompson Seedless bunches grown in the Sunraysia district were sampled during the first four weeks they were available in store. At each week of sampling relatively high SSC with low variability between bunches was observed among Thompson Seedless with average SSC of between 17 and 20 °Brix (Figure 3). Eating quality of Thompson Seedless was very good based on average sugar to acid ratios measured during the four weeks of sampling although variability in sugar to acid ratio was relatively large due to differences in TA among bunches sampled each week. Average sugar to acid ratios were consistently greater than 30 over the four weeks of sampling.

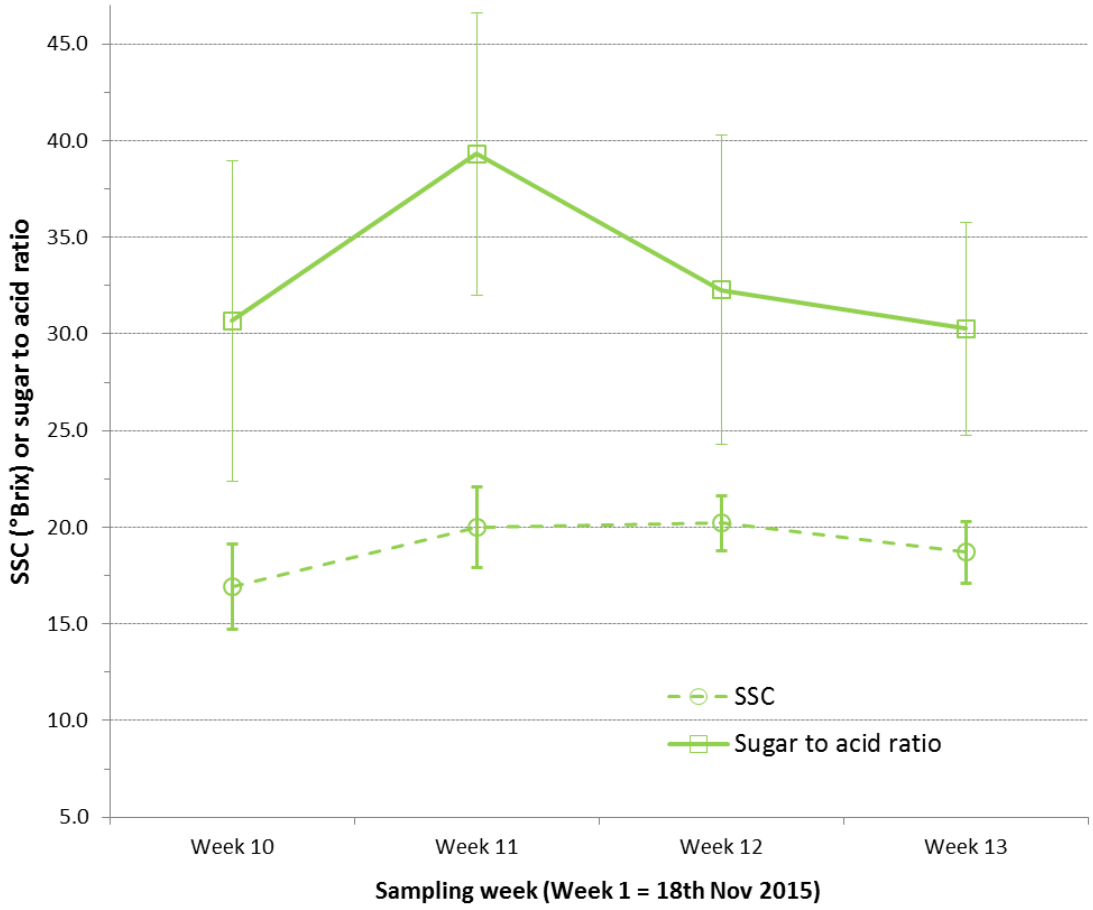

Figure 3. Average soluble solids concentration (SSC) and sugar to acid ratio for Australian Thompson Seedless across four weeks of sampling conducted between 7th Feb 2016 and 8th March 2016. Bars represent the standard deviation (±SD) of each average SSC and sugar to acid value.

Red Globe eating quality

Red Globe, a seeded red variety, became available in late December with sampling conducted over six weeks until early February. Red Globe bunches were usually displayed loose in cartons within supermarkets and thus bunches were randomly sampled from cartons on display. Average SSC in Red Globe bunches was between 15 and 18 °Brix over six weeks with only minor variation among bunches at each week of sampling (Figure 4). Average sugar to acid ratio was variable with an increase over the first 2 weeks of sampling followed by a steady decrease in the ratio as the season progressed. Both average SSC and sugar to acid ratio dropped after week 2 of sampling possibly as a result of early Red Globe supply from other districts. In the first three weeks of sampling an average sugar to acid ratio of greater than 35 was measured in Red Globe bunches but this declined to below 30 as the season progressed.

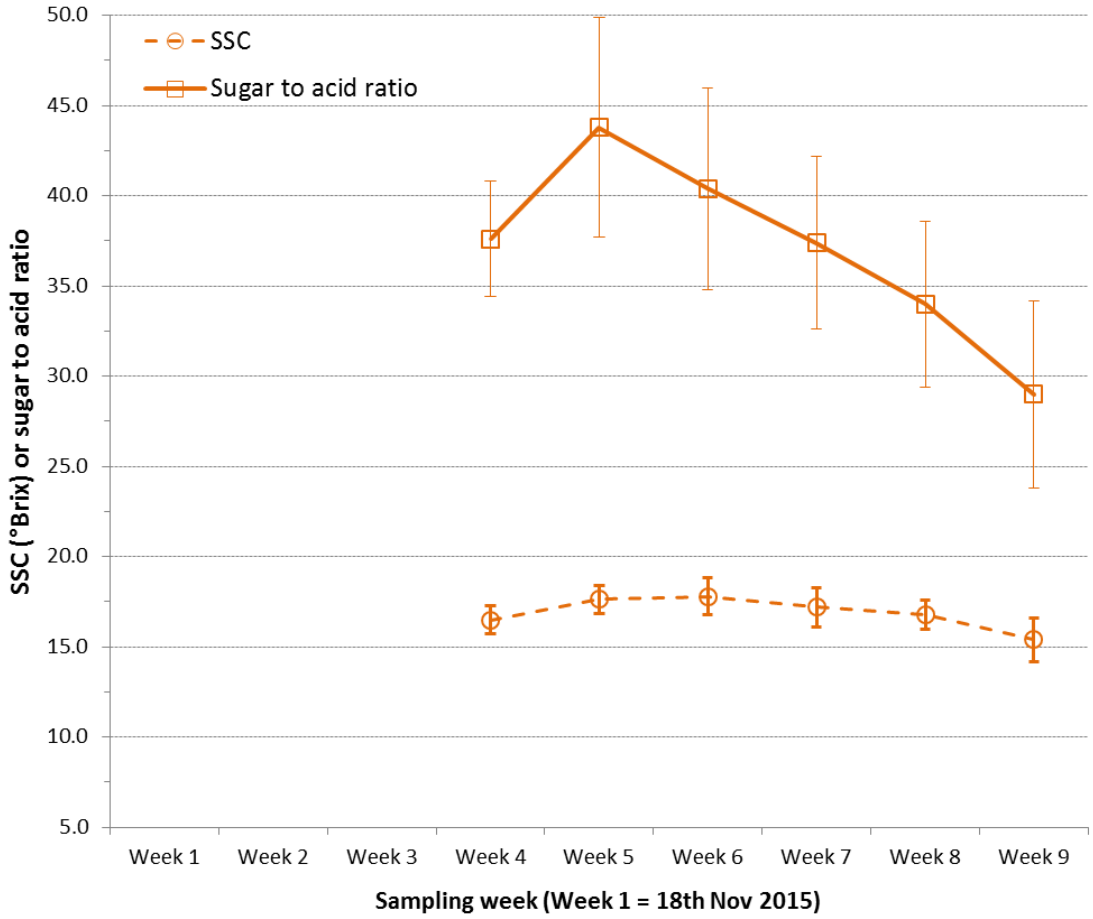

Figure 4. Average soluble solids concentration (SSC) and sugar to acid ratio for Australian Red Globe across six weeks of sampling conducted between 28th December 2015 and 7th Feb 2016. Bars represent the standard deviation (±SD) of each average SSC and sugar to acid value.

Crimson and Ralli Seedless eating quality

Crimson Seedless and Ralli Seedless bunches were sampled over a three week period beginning on the 21st February. Crimson Seedless eating quality was excellent during the three weeks of sampling with average SSC between 19 and 22 °Brix and average sugar to acid ratio greater than 35 (Figure 5). Ralli Seedless eating quality was very good with average SSC greater than 18 °Brix beyond the first week of sampling and sugar to acid ratio above 30 in all three weeks of sampling.

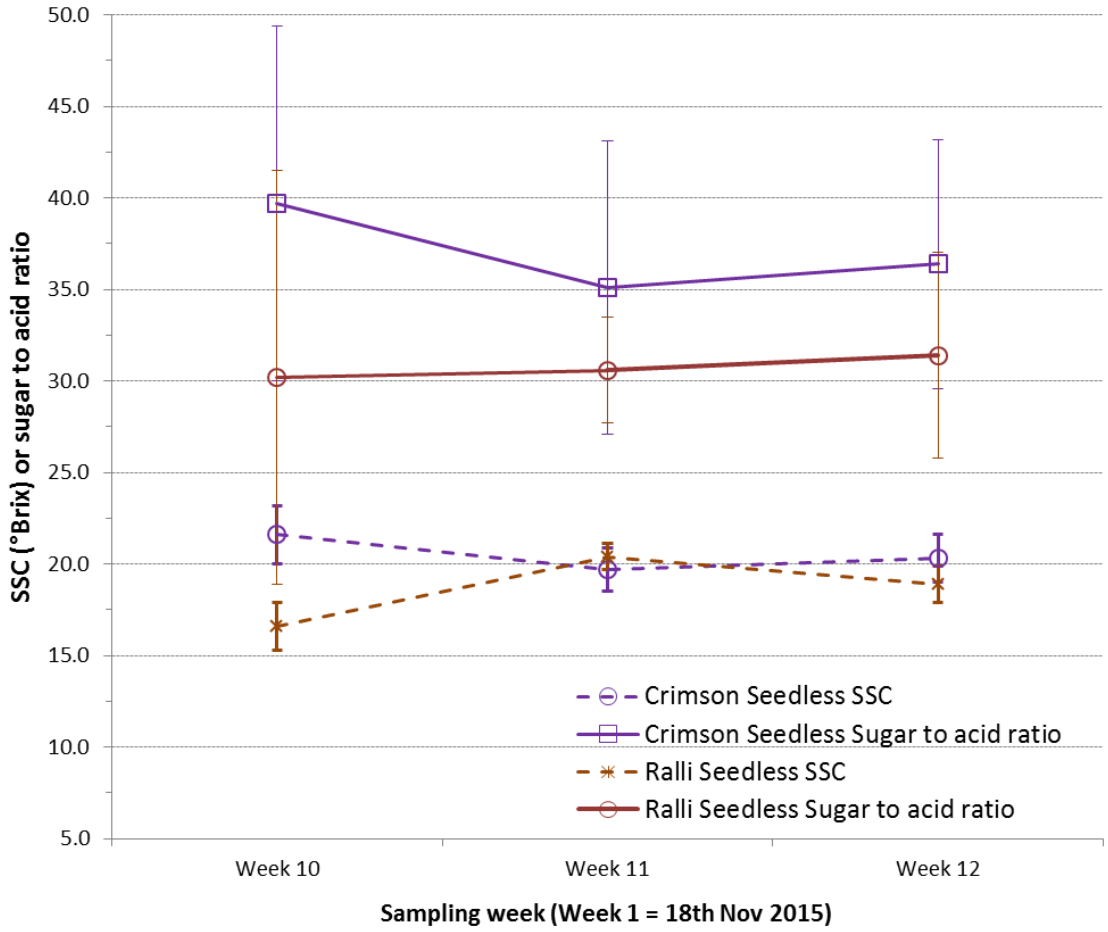

Figure 5. Average soluble solids concentration (SSC) and sugar to acid ratio for Crimson and Ralli Seedless table grapes during three weeks of sampling conducted between 21st February 2016 and 2nd March 2016. Bars represent the standard deviation (±SD) of each average SSC and sugar to acid value.

Titratable acidity in grape varieties

During the first two weeks of sampling, TA in Menindee Seedless table grapes was relatively high indicating less mature berries. By week 3 the values for Minindee Seedless were in the same range as those measured in the other varieties over the sampling period which averaged between 4.0 and 6.5 g/L (Figure 6). TA in Red Globe increased over the 6 weeks sampling period which indicated that less mature fruit were being introduced from new production regions as the season progressed. Even so, values remained between 4 and 6 g/L.

Over the 2015-16 season changes in grape eating quality as measured by sugar to acid ratio closely followed the pattern of average TA content. Average SSC within and between varieties was relatively consistent and did not accurately reflect changes in SSC to TA ratio and therefore overall eating quality. These results emphasise the importance of measuring TA to determine table grape eating quality.

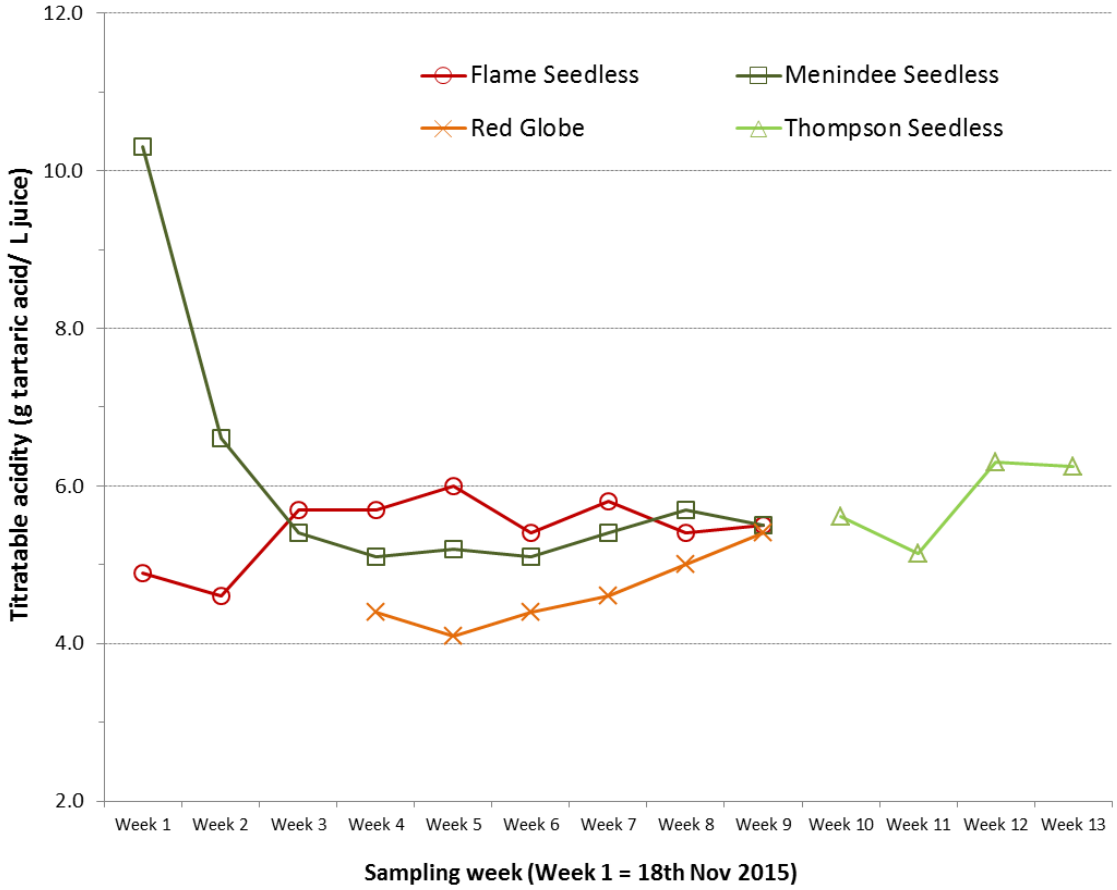

Figure 6. Average titratable acidity (TA) for Australian Menindee Seedless, Flame Seedless, Red Globe and Thompson Seedless across thirteen weeks of sampling between 18th Nov 2015 and 8th March 2016.

Rachis browning in grape varieties

Average rachis (stem) browning severity in Menindee Seedless increased steadily over a nine week sampling period. Flame Seedless followed a similar pattern after an initial rapid rise during weeks 2 and 3 then a decrease in week 4 (Figure 7). The pattern of observed for Flame Seedless indicates that there was a change in the source of the grapes at week four with less mature grapes introduced into the market. This was supported by the TA data. Browning severity score generally fell between 2 and 3 with rachides in Flame Seedless bunches having marginally higher browning severity than those in Menindee Seedless. Greater rachis browning severity observed later in the season probably resulted from both longer cool storage of bunches prior to marketing, unrefrigerated display and slow sales periods with bunches on retail display for an extended time due to high supply.

Rachis browning severity in Red Globe bunches sampled from loose display in supermarkets was marginally higher than in other table grape varieties sampled and severity score was approximately 3 for the duration of the sampling period (Figure 8). Average rachis browning severity was well below 3 in Ralli, Crimson and Thompson Seedless varieties at the beginning of supply for each of these varieties.

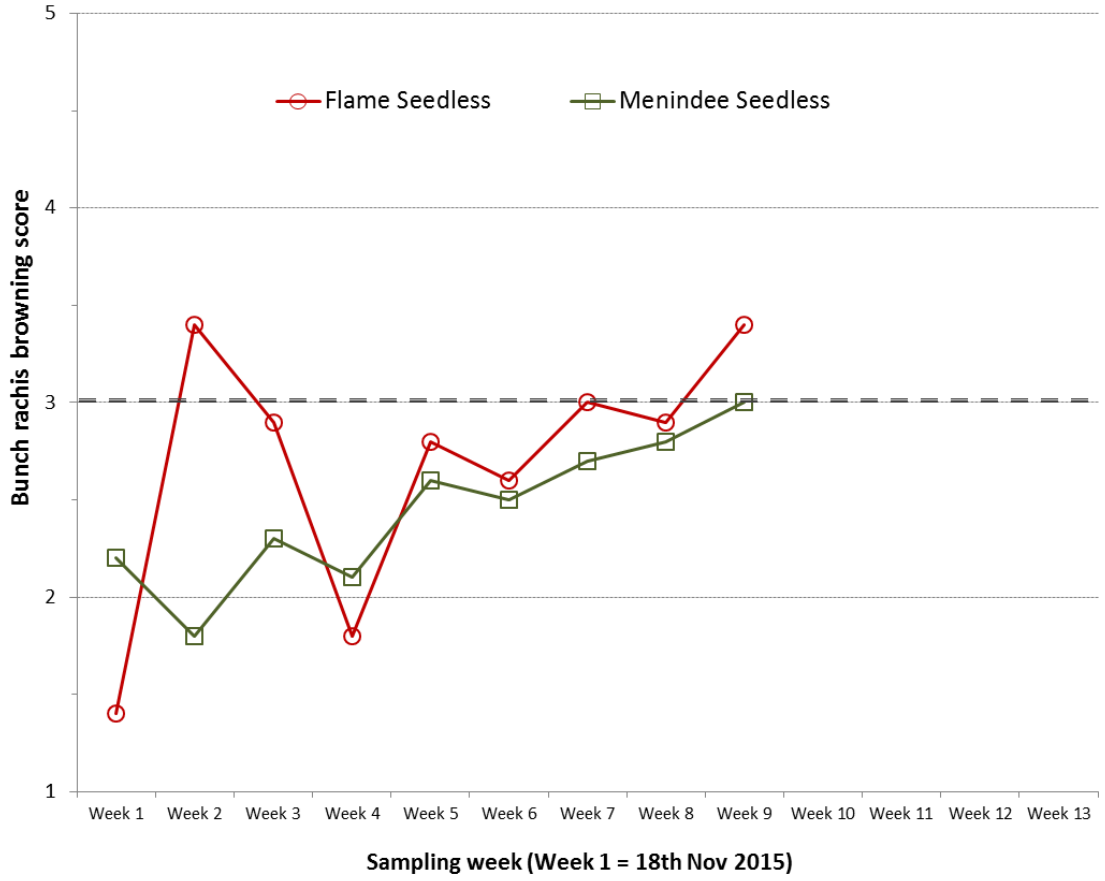

Figure 7. Average rachis browning score in Australian Menindee Seedless and Flame Seedless across nine weeks of sampling conducted between 18th Nov 2015 and 27th January 2016. Dashed line represents the upper limit of bunch marketability (i.e., rachis browning score = 3).

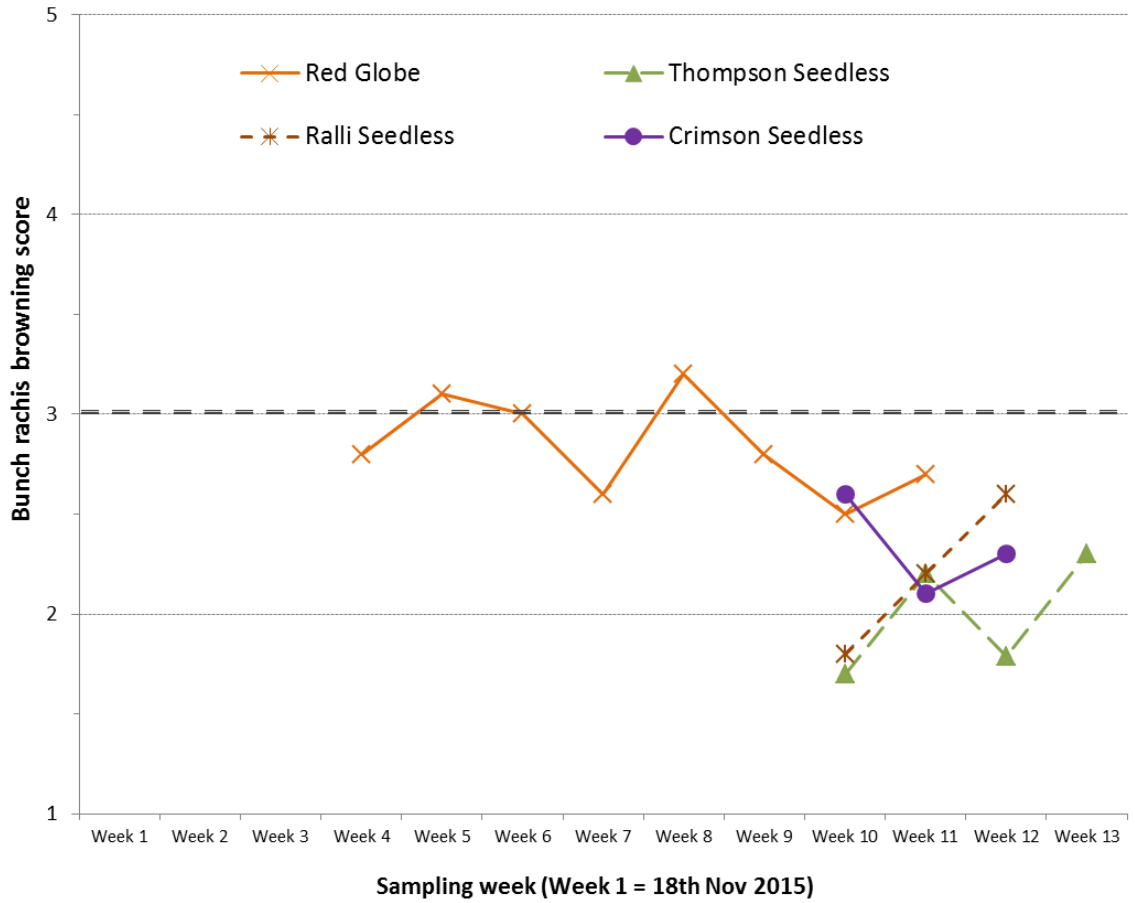

Figure 8. Average rachis browning score in Australian Red Globe, Thompson Seedless, Ralli Seedless, and Crimson Seedless during the sampling period. Dashed line represents the upper limit of bunch marketability (i.e., rachis browning score = 3).

Bunch colour in grape varieties

Menindee Seedless average bunch colour score increased during the first three weeks of sampling from less than 2 (dark green to light green berries) and stabilised at approximately 3 (green-yellow berries) for the remaining sampling period (Figure 9). This green to green-yellow change in berry colour was associated with increasing sugar to acid ratio as a result of lower TA in fruit.

Average % uniform bunch colour in Flame Seedless was consistently between 85 and 90 % during the nine week sampling period and changes in bunch colour uniformity were not associated with changes in average sugar to acid ratio over this period. Berry colour was generally very uniform among bunches in both early season varieties and was visually acceptable for retailing.

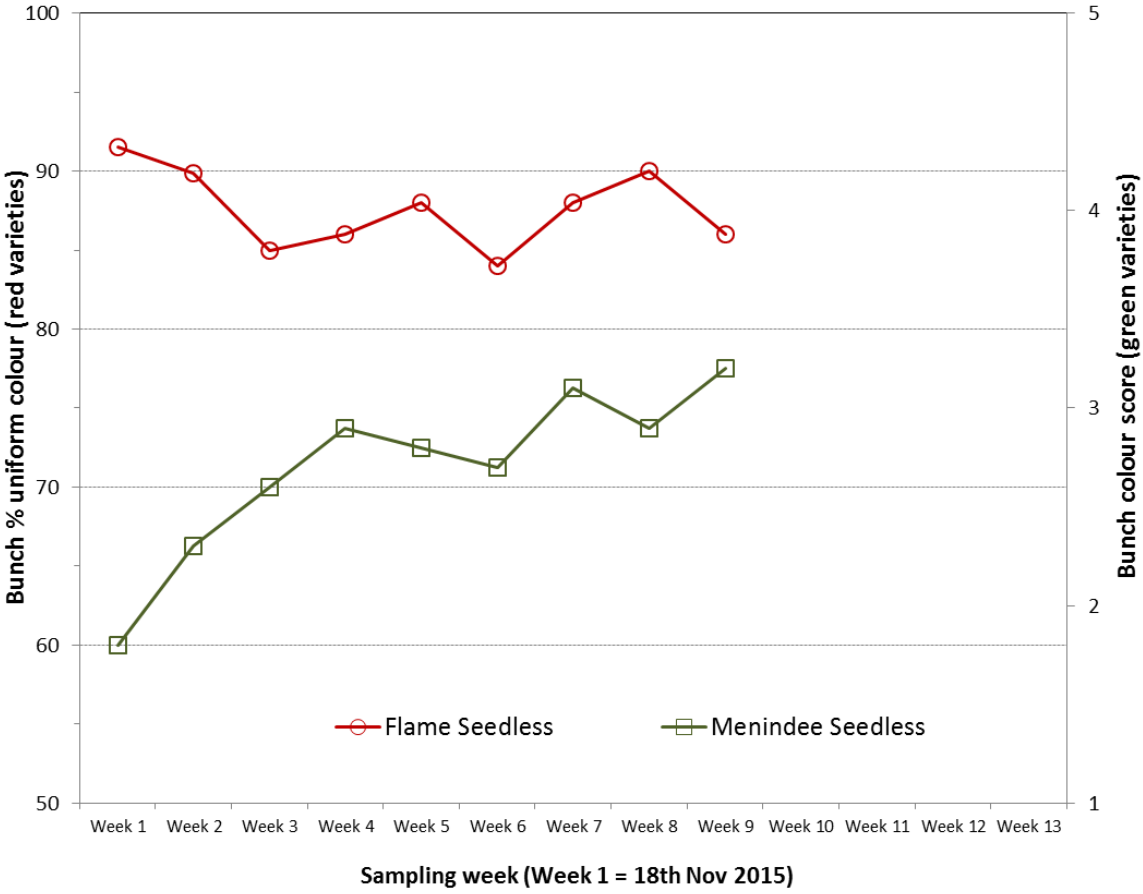

Figure 9. Average bunch colour in Australian Menindee Seedless (green variety) and Flame Seedless (red variety) across nine weeks of sampling conducted between 18th Nov 2015 and 27th January 2016.

Thompson Seedless average bunch colour score averaged between 2.5 and 3 during four weeks of sampling and berry colour was generally uniform (Figure 10). Average % uniform bunch colour in Red Globe was consistently less than 85 % during a seven week sampling period but this relatively low colour uniformity was unrelated to eating quality with high average sugar to acid ratios in Red Globe during the sampling period.

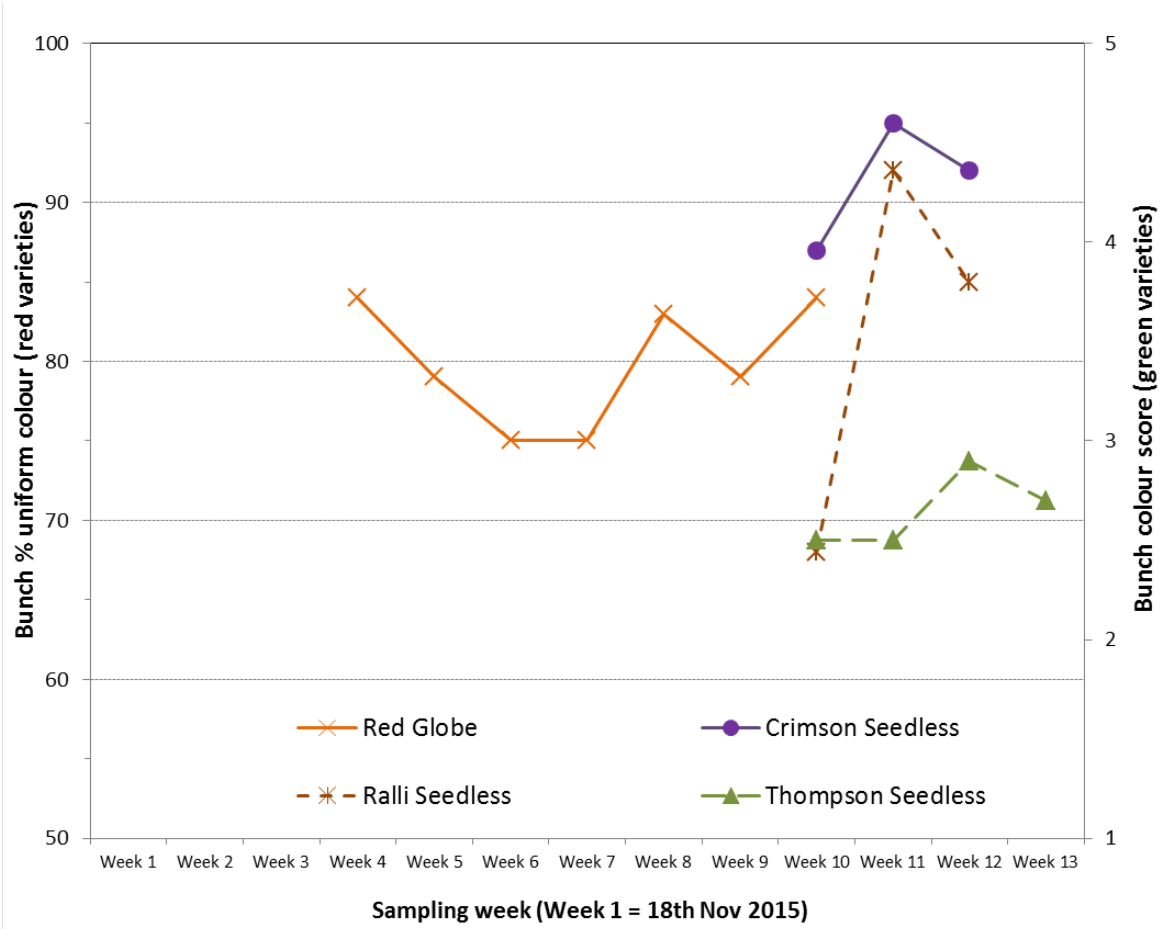

Figure 10. Average bunch colour in Australian Red Globe (red variety), Thompson Seedless (green variety), Ralli Seedless, (red variety) and Crimson Seedless (red variety) during the sampling period.

Technology Transfer

Fortnightly reports on grape quality were sent to HIA and ATGA. A grape quality training manual has been prepared and forwarded to ATGA to discuss with the major supermarket chains, Coles, Aldi and Woolworths (See Appendix 1).

Conclusions and Recommendations

An eating quality audit of the major Australian table grape varieties during the 2015-16 season demonstrated that SSC and sugar to acid ratio can be effectively used to monitor variation in fruit eating quality among commercial varieties. Measurement of sugar to acid ratio at regular intervals can be an effective method for following table grape maturity and eating quality through the season.

Only one retail chain stocked Menindee Seedless at week 1 of the study. Quality of the grapes was poor and variable with sugar to acid ratios as low as 7.0 for some bunches. These fruit were of very poor eating quality and would have discouraged consumers to make repeat purchases as the season progressed. By week 2 another retail chain had Menindee Seedless on their shelves. Quality had increased substantially with the mean sugar to acid ratio rising to 26.6. However there were still a proportion of bunches with sugar to acid ratios as low as 10.2, which would be sour and

unpalatable. The third retail chain held off stocking grapes until the sugar to acid ratio of grapes supplied by its growers had increased to an acceptable eating quality. Consequently, this chain did not stock Menindee Seedless grapes until week 3. An audit of grape quality in store at that time showed an average sugar to acid ratio of 35.5. By waiting until the grapes were highly acceptable to eat consumers would have been satisfied and would be encouraged to purchase grapes again.

By the third week of sampling during 2015-16, eating quality of sampled Menindee Seedless grapes from all retail chains was very good with average sugar to acid ratio above 30 and eating quality was consistently high for the rest of the season. Eating quality of grapes as measured by sugar to acid ratio was consistently higher than the grapes sampled in the 2014-15 table grape audit suggesting that more effective monitoring of harvest maturity by producers was successful in providing consumers with a product of higher eating quality.

Eating quality of Flame Seedless during 2015-16 was consistently high over the nine week sampling period but average sugar to acid ratios were marginally lower than those observed in the 2014-15 season. This result was mainly due to higher TA in fruit as average SSC was actually higher than that found in 2014-15. For both Menindee and Flame Seedless, the variation around each average sugar to acid ratio was relatively high due to sampled bunches being sourced from various producers and production regions at each week of sampling.

Average sugar to acid ratio of Thompson Seedless bunches sampled over the first four weeks of availability was relatively high and eating quality excellent with sugar to acid ratio consistently above 30. Again there was relatively high variation in sugar to acid ratio among bunches sampled from three different retailers during each week of the audit. Average sugar to acid ratio in Red Globe was highly variable with a decrease in the ratio as the season progressed from very high early season levels. Both average SSC and sugar to acid ratio dropped marginally in the final few weeks of sampling but Red Globe eating was generally excellent throughout the 2015-16 season.

Rachis browning severity in bunches across varieties was generally well below the upper acceptable limit of marketability other than in Menindee and Flame Seedless in the final two weeks of sampling where stem browning severity in bunches from retail outlets was relatively high and had a negative impact on visual market quality. Average rachis browning severity score for Red Globe bunches was approximately 3, which is considered the upper acceptable limit, throughout the sampling period and browning severity in approximately 20% of bunches at each sampling was considered unacceptable.

This study showed a substantial improvement in the eating quality of early Menindee Seedless compared to that observed in the 2014-15 study (Lopresti and Tomkins, 2015). Apart from the first week of sampling, the average sugar to acid ratio in Menindee Seedless bunches remained consistently above 28 during the remainder of the nine week sampling period. Values for Flame Seedless were also above 28 for the entire sampling period. Average sugar to acid ratios were also acceptable in Thompson Seedless and the other red varieties sampled. As in 2014-15, variation in sugar to acid ratio among bunches within a variety and sampling week was relatively high and future table grape auditing should focus on determining whether the cause of this variation is due to variability among bunches at harvest in particular vineyards, due to differences in quality between producers, or due to supply from multiple production regions.

Recommendations for future research and development:

- Further auditing of early season Menindee Seedless grapes incorporating detailed vineyard sampling to explore cause of variation in sugar to acid ratio.

- Auditing of export consignments of early season fruit to establish the eating quality of export fruit.

- Assist table grape producers to implement harvest maturity monitoring as standard commercial practice.

- Assist supermarkets in providing suppliers with indicative SSC and sugar to acid ratios for each grape variety to guide producers in determining the appropriate harvest maturity.

- Assist supermarkets in developing protocols for measuring sugar to acid ratios in consignments, particularly early season, and procedures to provide immediate feedback to suppliers.

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Appendices

Appendix 1. Menindee Seedless vineyard quality monitoring

Background

Early season Menindee Seedless grapes were sampled from four vineyards in Emerald (central Queensland) over approximately 30 days prior to commercial harvest. Vineyard sampling was commenced in mid-October 2015. At each sampling date six berries were picked from each of ten bunches per vineyard. Measurements included berry size distribution and sugar and organic acid concentration, which were measured via soluble solids concentration (SSC; °Brix) and titratable acidity (TA; g tartaric acid equivalent/L juice), respectively. Berries from each bunch were crushed by hand to release their juice and SSC measured using a temperature-compensated digital refractometer (ATAGO PAL-1). TA measurements were conducted by titration with 0.1M NaOH to pH 8.2. Titratable acidity of each sampled bunch was calculated as g tartaric acid equivalent/L juice using the NaOH titre volume. Average SSC and TA at each sampling date were calculated from 10 bunch samples per vineyard. Sugar to acid ratio was calculated using:

$$sugar\ to\ acid\ ratio = \frac{SSCx10}{TA}$$

Sugar to acid ratio is considered a good measure of eating quality as it largely determines the flavour and consumer acceptability of table grapes. For each vineyard figures for changes in SSC and sugar to acid ratio, as well as berry size distribution, have been provided (Figs. 3 to 10).

Vineyard sampling outcomes (14th October to 17th November 2015)

Average sugar to acid ratio based on sampling from four vineyards increased steadily from mid-October to mid-November, increasing from approximately 5 to 25 at commercial harvest (Fig. 1). Variation between vineyards measured by the standard deviation was highest between Day 5 and Day 18 of sampling mainly as a result of a large difference in sugar to acid ratio between Vineyard C and D (Fig. 2). At commercial harvest variation in sugar to acid ratio among vineyards was 60% lower than at the mid-point of the sampling period with sugar to acid ratios ranging from 22.5 to 25.5. A sugar to acid ratio of 24 is generally considered the lowest ratio that provides an acceptable eating experience for consumers. Thus for early season Menindee seedless grown in Emerald (central QLD) in 2015, fruit harvested prior to mid-November were unlikely to provide an acceptable eating experience for consumers. Furthermore, the variation between orchards is substantial with fruit from orchard D reaching an acceptable sugar to acid ratio up to 2 weeks before fruit from some of the other orchards.

Increase in sugar to acid ratio among vineyards was mainly due to a decrease in TA over the sampling period rather than due to increase in SSC, with SSC levels stabilising to approximately 15 °Brix over the final 1.5 weeks prior to commercial harvest (Fig. 2). The slowing rate of increase in SSC during the sampling period was consistent among all vineyards except Vineyard C where SSC increased steadily from a very low base and fruit only reached 15 °Brix at commercial harvest (Fig. 7). Variation in SSC among vineyards at all sampling dates was consistently low which again suggests that differences in sugar to acid ratio among vineyards were mainly a result of differences in TA. Thus SSC alone is not a good harvest maturity index as SSC values reached their highest level before the SSC to acid ratio was acceptable.

Change in berry size distribution over the sampling period was consistent among vineyards with the percentage of small berries (10 – 13 mm) decreasing to zero by the end of October and percentage of large berries between 22 – 25 mm in diameter increasing in the last week prior to commercial harvest. Although berry size increased during bunch ripening there was little correlation between final berry size distribution and SSC, or sugar to acid ratio (data not shown).

This work demonstrated that simple sampling of berries from grape bunches over the final 3 to 4 weeks prior to harvest can inform early season Menindee Seedless growers on harvest timing to ensure that harvested fruit will on average meet minimum eating quality acceptable to consumers.

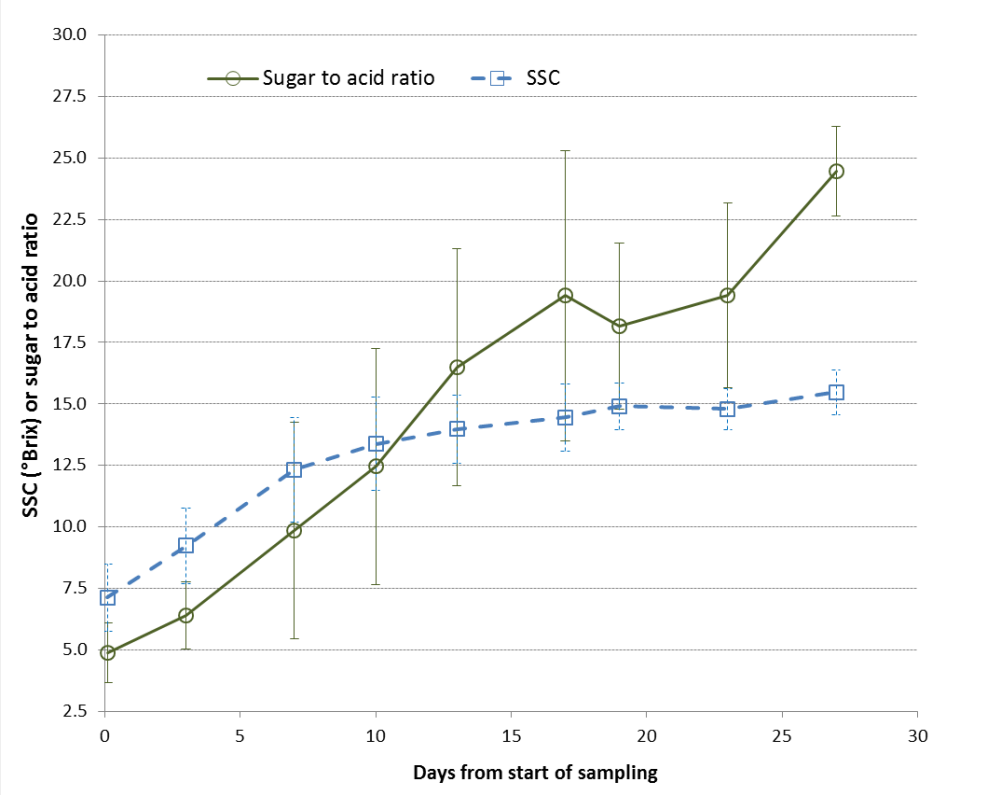


Figure 1. Average change in sugar to acid ratio in Menindee Seedless bunches based on sampling of four vineyards in Emerald, QLD; Error bars represent the standard deviation of each average sugar to acid ratio, and SSC value.

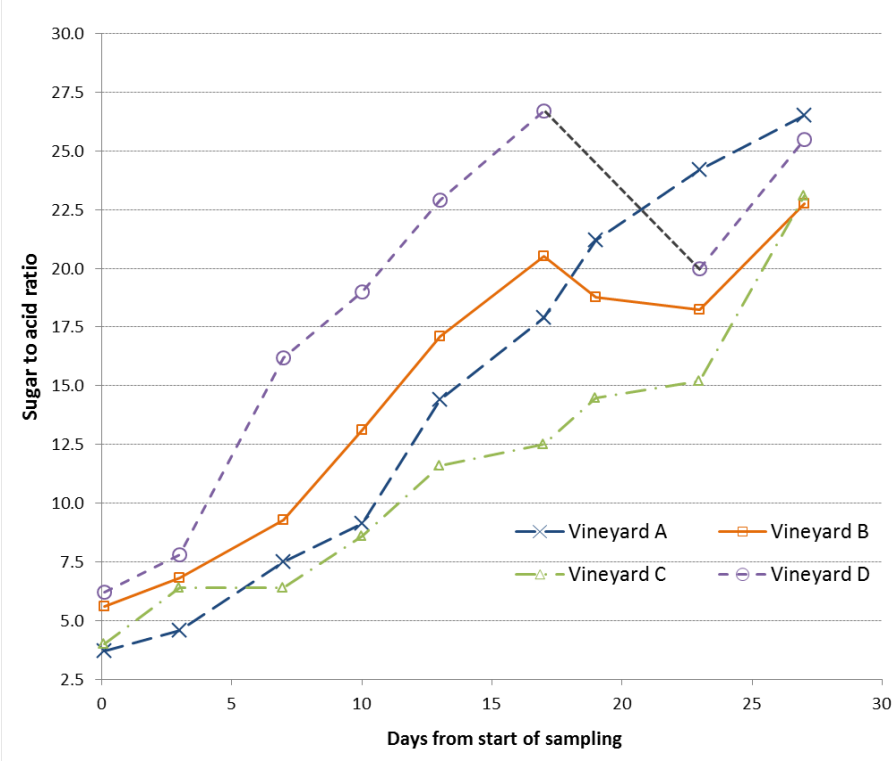


Figure 2. Change in sugar to acid ratio in Menindee Seedless bunches sampled from four vineyards in Emerald; Day 0 =14th Oct for vineyard A; Day 0 =20th Oct for vineyard B, C and D.

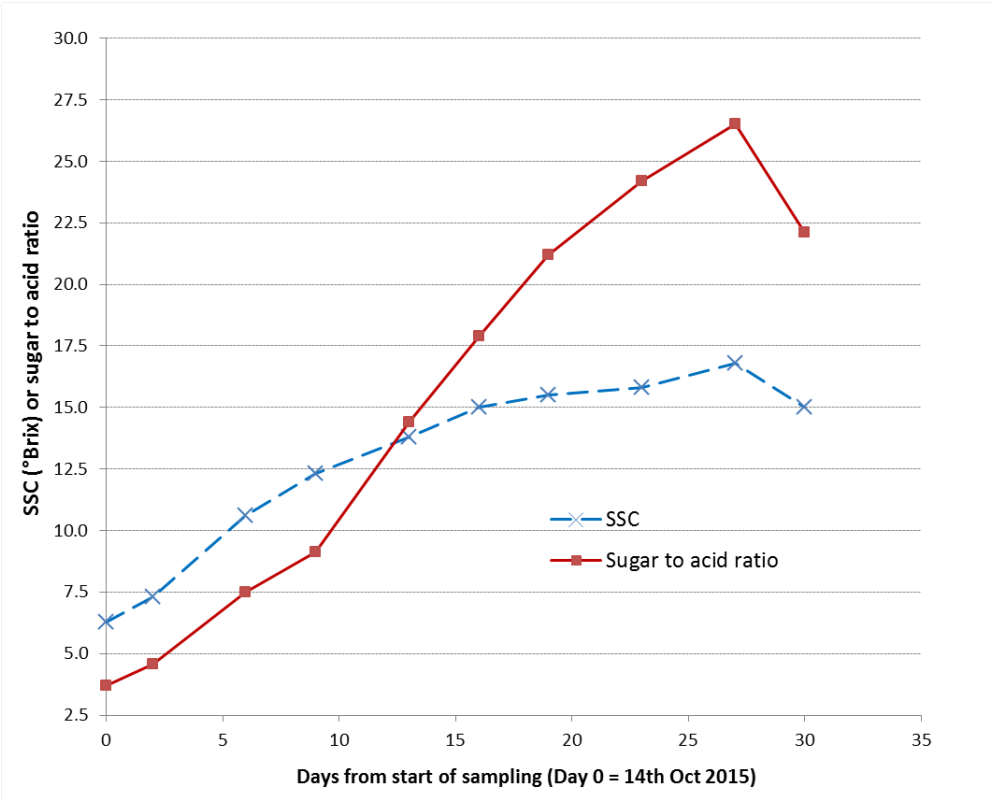


Figure 3. Change in SSC, and sugar to acid ratio, in berries sampled from Menindee Seedless bunches in **Vineyard A** (Emerald, QLD); Bunches were randomly sampled from cartons in cold storage at Day 30.

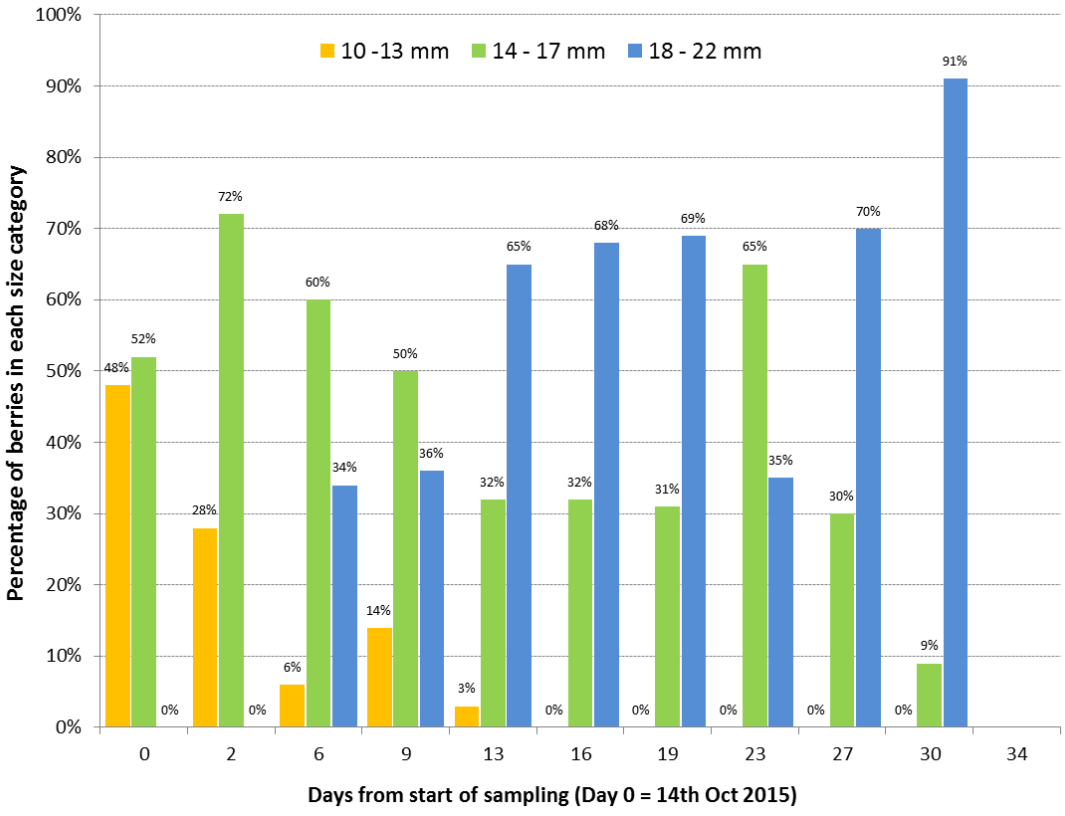


Figure 4. Change in berry size distribution within Menindee Seedless bunches grown in **Vineyard A** (Emerald, QLD).

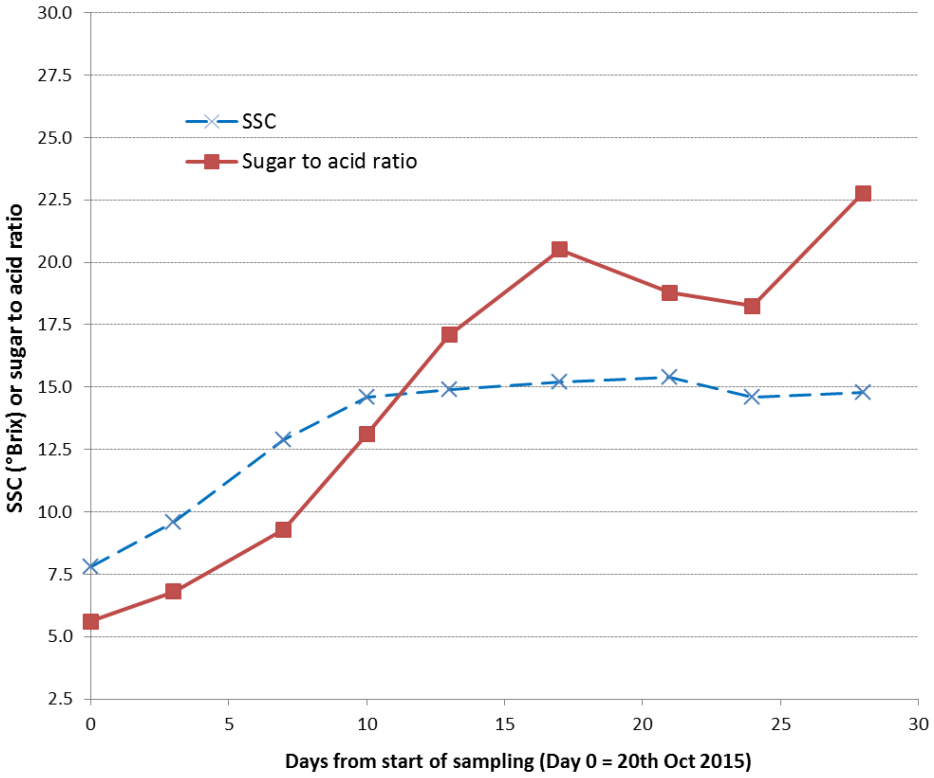


Figure 5. Change in SSC, and sugar to acid ratio, in berries sampled from Menindee Seedless bunches in **Vineyard B** (Emerald, QLD).

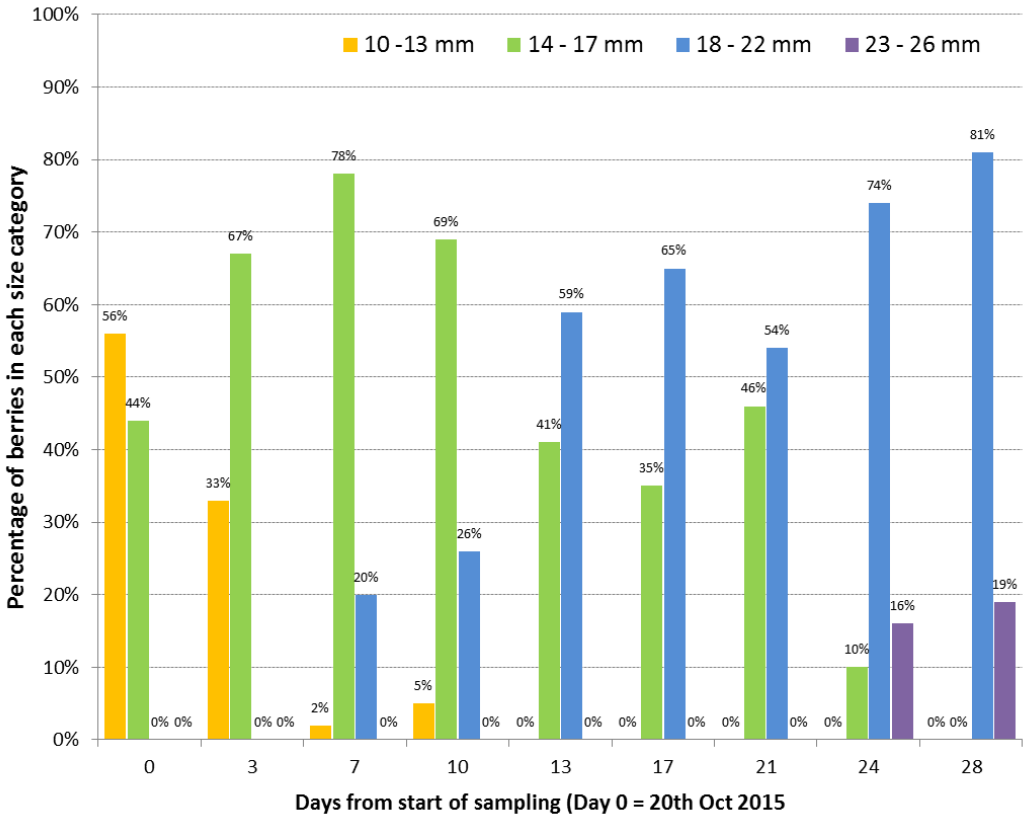


Figure 6. Change in berry size distribution within Menindee Seedless bunches grown in **Vineyard B** (Emerald, QLD).

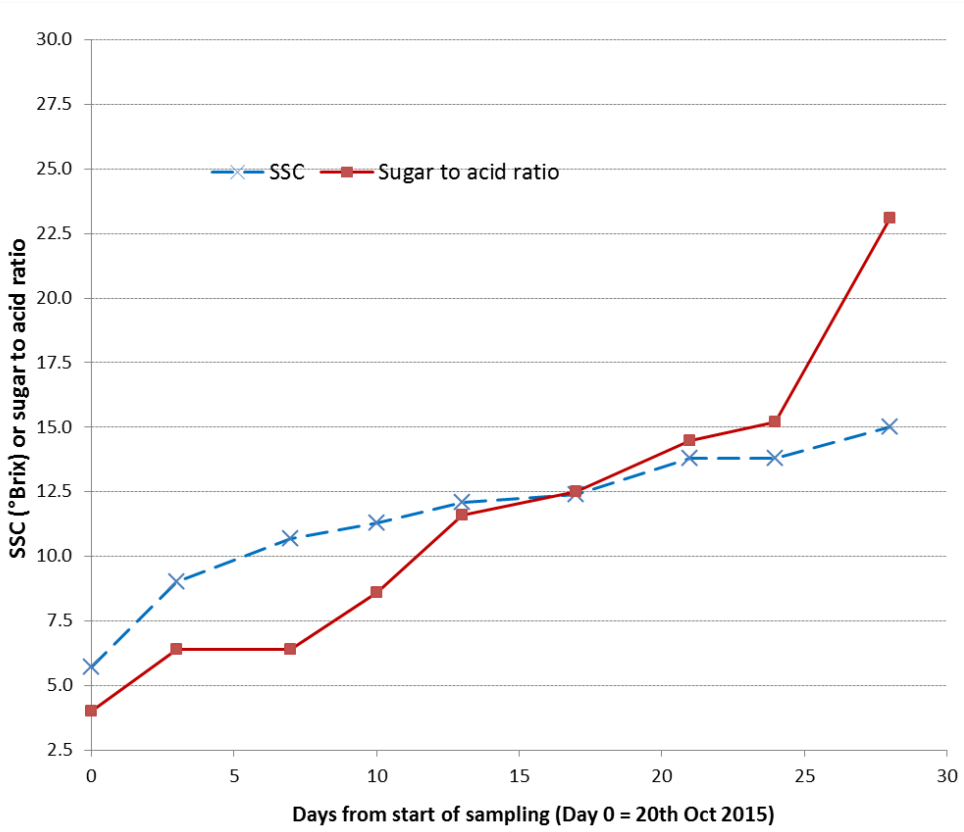


Figure 7. Change in SSC, and sugar to acid ratio, in berries sampled from Menindee Seedless bunches in **Vineyard C** (Emerald, QLD).

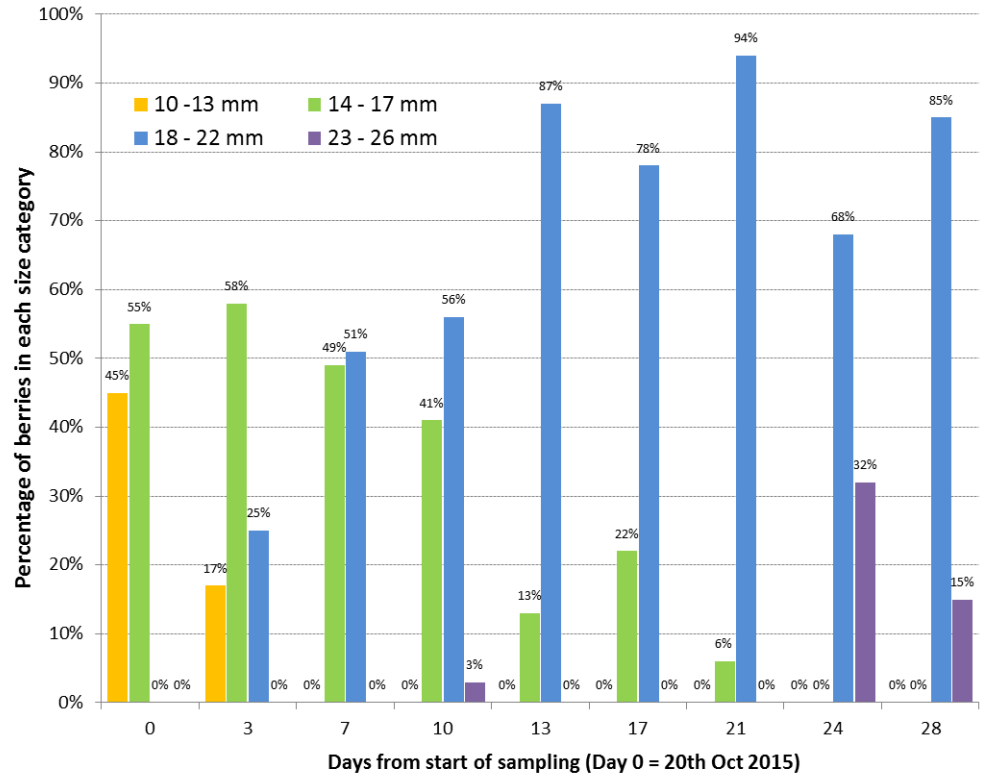


Figure 8. Change in berry size distribution within Menindee Seedless bunches grown in **Vineyard C** (Emerald, QLD).

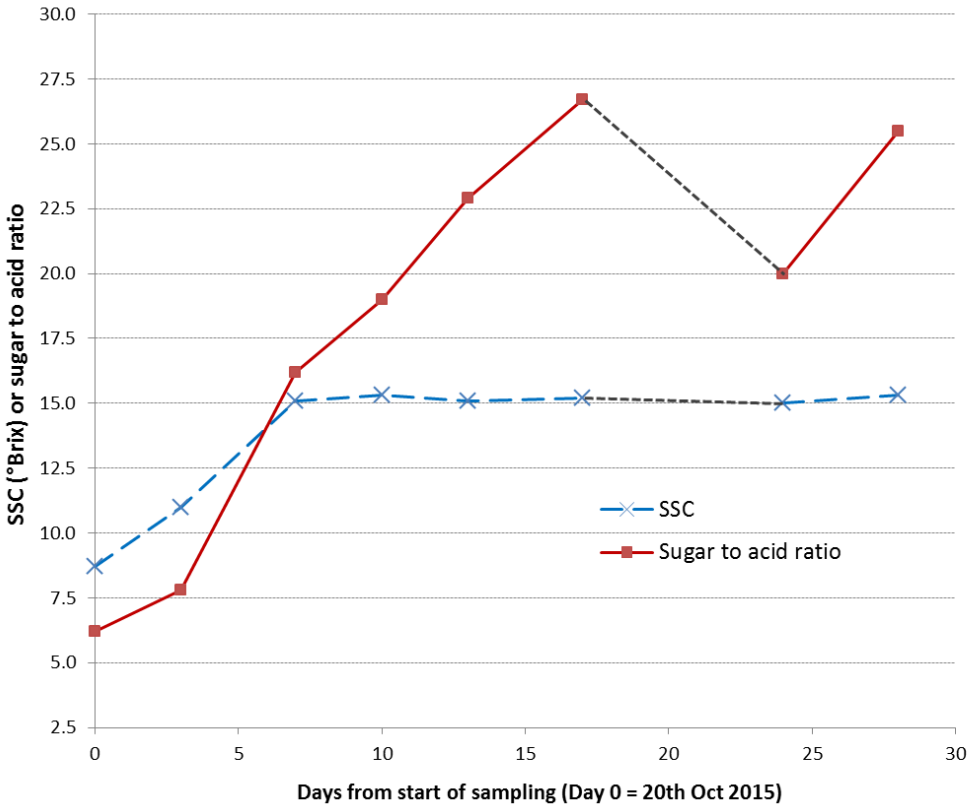


Figure 9. Change in SSC, and sugar to acid ratio, in berries sampled from Menindee Seedless bunches in **Vineyard D** (Emerald, QLD). No berry sampling conducted at Day 21.

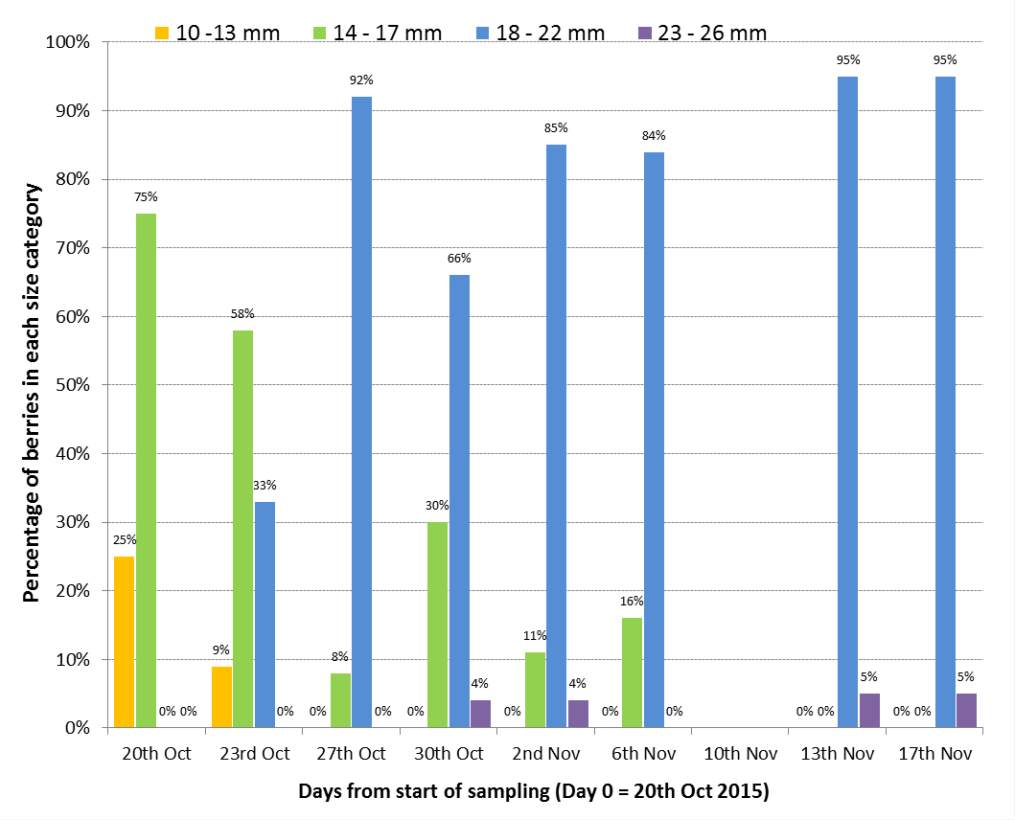
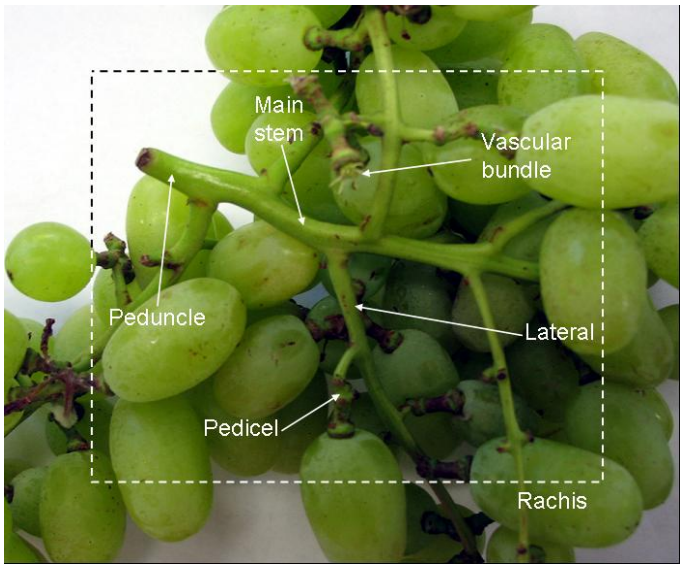


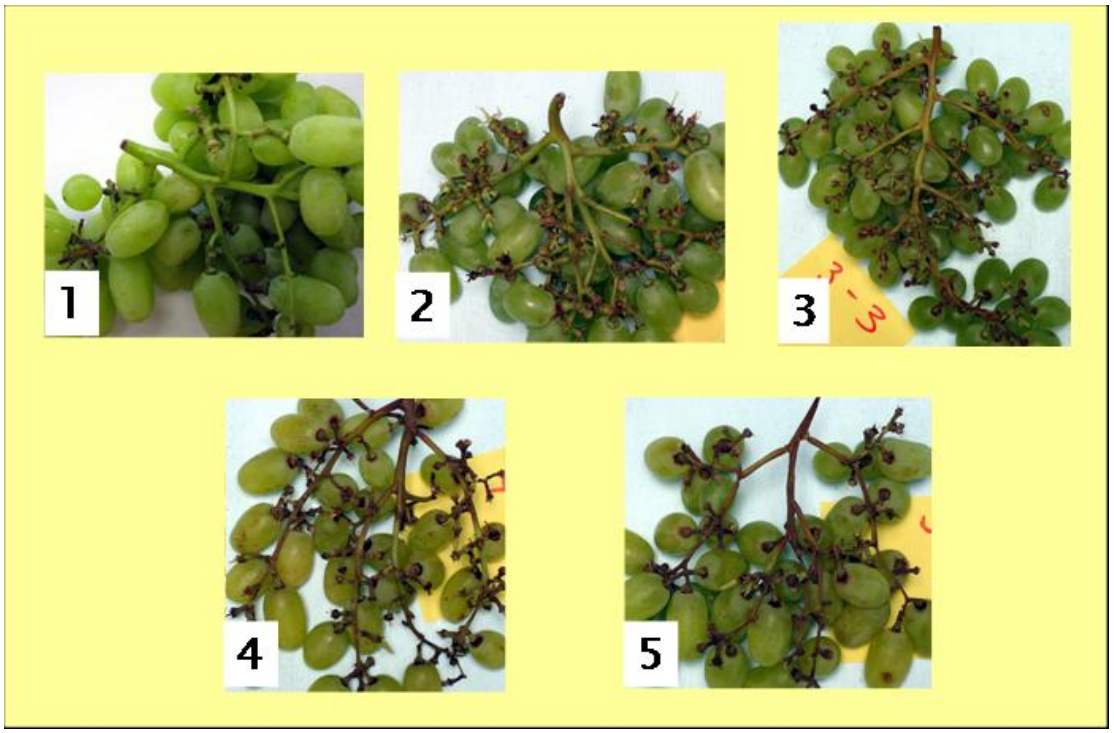
Figure 10. Change in berry size distribution within Menindee Seedless bunches grown in **Vineyard D** (Emerald, QLD).

Appendix 2. Grape visual quality criteria

Table grape bunch components

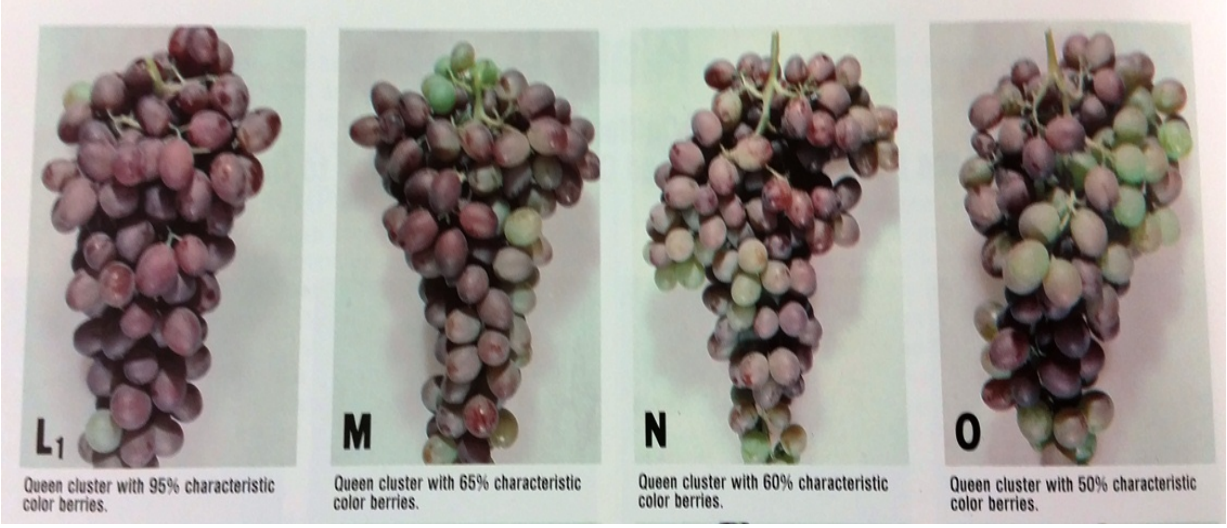


Visual rating scales and descriptions used for scoring of bunch rachis browning



Severity of Stem Browning Rating Descriptions				
1 (none)	**2 (trace)**	**3 (slight)**	**4 (moderate)**	**5 (severe)**
All green	Most pedicels showing browning	Pedicels brown and laterals partially brown	Pedicels and all laterals showing browning	Whole rachis severely browned

Description of colour ratings used to score overall bunch colour in red varieties (modified from Nelson, 1985).



Description of colour ratings used to score overall bunch colour in green varieties

Colour rating	**Bunch Colour Ratings Descriptions**				
	1	**2**	**3**	**4**	**5**
Description	**Dark green** (berries look firm and immature)	**Light green** (optimal colour)	**Green to Yellow** (more light green berries than yellow berries)	**Light yellow** (more yellow berries than green berries)	**Dark yellow** (majority of berries are dark yellow)

Appendix 3. Retailer Table Grape Quality Workshop Presentation

A table grape quality training workshop was held for Aldi staff at the end of the 2014-15 season. Aldi were the only chain that responded to the invitation. The notes have been updated and provided to Jeff Scott CEO ATGA and he is offering the workshop to the supermarket chains. The authors of this report will present the workshop(s) if they are interested. See embedded course notes here:

Retailer table grape quality workshop 201