Understanding the variability of juice extraction methods for quality analysis

Background

When wine-grapes undergo analysis, an important step for a range of common analytes (e.g. sugars, pH, TA) is to extract juice from the grapes and then analyse that juice. Common techniques used to extract juice include hand pressing; manual or mechanical pressing followed by sieving; or homogenisation followed by centrifugation. When harvested fruit is received at a winery, processes are similar; however, for machine-harvested fruit, free run juice present in the bottom of the harvest bin is sometimes used for analysis. For more representative sampling of a load of grapes, screw core sampling mechanisms can be used to obtain grapes for juice extraction. Juice extraction methods, however, can vary significantly between vineyards and wineries, and this may have an impact on analytical results.

Past research carried out in France investigating the variability in juice extraction methods for wine-grapes found that there was no significant effect of the pressing method on total soluble solid (TSS) analysis results (Dumas et al. 2020). Results suggested that there was a significant effect ($p < 0.001$) for all other parameters measured, with homogenisation resulting in higher pH and lower TA values when compared with other pressing methods. A past AWRI study assessed the effects of homogenisation methods and freezing, indicating that freezing of fruit and homogenates had a significant effect ($p < 0.001$) on pH (Cynkar et al. 2004).

The Australian Competition and Consumer Commission (ACCC) recently recommended that industry quality assessment standards should be reviewed to develop best practice guidance on aspects including sampling in the vineyard and at the weighbridge. As part of work addressing these recommendations, the AWRI set up a study to assess the effects of different juice extraction methods on the key quality parameters TSS, pH and TA. The experiments aimed to assess the impact of different extraction methods (e.g. hand-pressed vs homogenised) and different storage methods (e.g. fresh vs frozen).

Understanding berry composition

Understanding the composition of grapes is important in understanding the possible impacts of differing extraction techniques. In general, a grape or berry has three main zones (Figure 1, Peynaud 1984). The intermediate zone, or the pulp of the fruit, has marginally higher sugar levels than the other zones and is made up of large weak cells, which are the first point of the berry to break down under stress. The central zone, nearing the seeds, is the highest in acidity and lowest in sugar, while the peripheral zone or skin region of the grape or berry has moderate sugar levels and consists of small strong cells that require

more force to break down. While acidity levels fluctuate considerably across the berry, sugar levels remain relatively consistent.

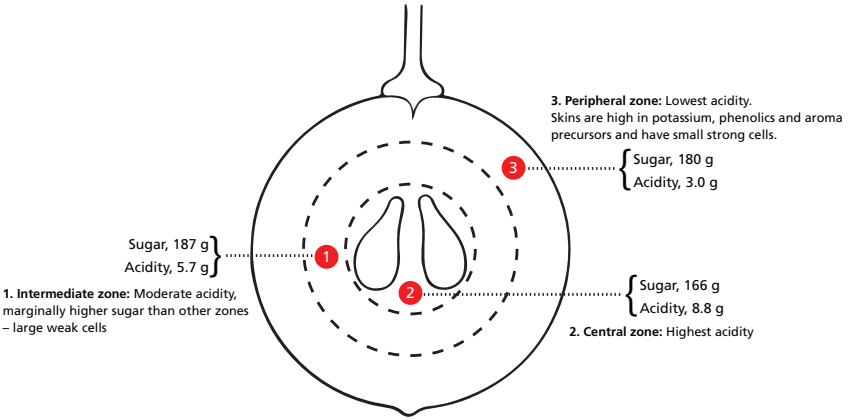

Figure 1. Distribution of sugars and acidity in different parts of the grape berry (adapted from Peynaud, 1984)

Experimental set-up

Initial experiments used samples of red and white seedless table grapes as a substitute for wine-grapes. The primary objective of the assessments was to evaluate the variability and reproducibility of analytical results obtained after differing extraction methods. Extraction methods trialled are listed below, noting that the frozen samples were analysed after one week held at -18°C:

- Hand-pressed fresh grapes
- Homogenised fresh grapes
- Hand-pressed grapes, frozen whole
- Homogenised grapes, frozen whole
- Frozen homogenised grapes.

An approximate 7 kg initial batch of each table grape type was destemmed, and berries were sub-sampled into 35 × 200 g batches with seven replicates subjected to each of the five extraction methods. The hand-pressed samples were placed into a ziplock bag and pressed to extract the juice, ensuring all grapes had been pressed. The homogenate samples were prepared using a *NutriBullet*, blending for 45 seconds, followed by centrifugation at 3,500 rpm for 5 minutes. The quality parameters analysed for each batch of fruit were total soluble solids (TSS measured in °Brix), pH and titratable acidity at pH 8.2 (TA). Total soluble solids was measured using a digital refractometer, and pH and TA were measured using a digital auto-titrator.

A second set of trials used Merlot and Semillon wine-grapes, harvested from a vineyard on the Waite Campus, Urrbrae, South Australia. The fruit was hand-picked and sub-sampled into seven replicates for each extraction method as listed above, with freezing trials not included.

Statistical significance was evaluated through the use of f-tests and t-tests. F-tests were used to evaluate the differences in variance, and t-tests were used to evaluate the differences in means.

Total soluble solids – key findings

For white table grapes, there were no statistically significant differences between the extraction methods for TSS. Homogenisation tended to yield equivalent levels of TSS as hand pressing; however, there was some evidence to suggest freezing lowered the TSS (Figure 2). Despite mean results being the same across homogenised and hand-pressed samples, there was a significant spread of individual results, highlighting the difficulties of sampling from even a well-mixed homogenous group of berries. The spread of 1.3°Brix across homogenised samples suggested a significant degree of berry-to-berry variability between large table grapes from the same bunch.

For red table grapes, mean TSS results were similar for homogenisation and hand pressing, with a greater spread of results for the hand-pressed grapes but no statistical difference found. The source of this variability is unlikely to be the extraction process, but rather the

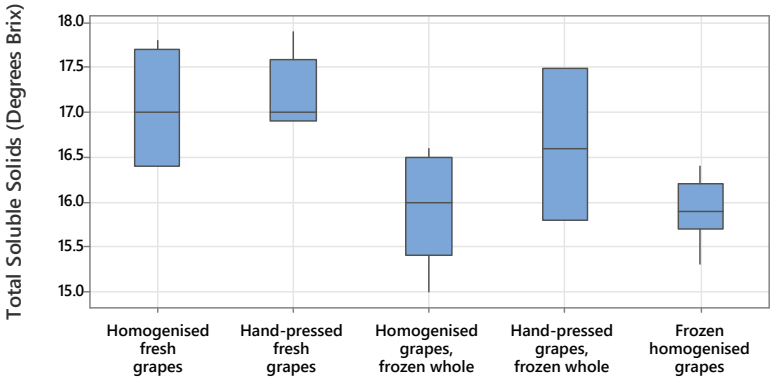

Figure 2. Range of results for total soluble solids (TSS) measured after different juice extraction methods for white table grapes. The blue boxes represent the spread from the first quartile to the third quartile of the data, with the horizontal line within the box representing the median value. The 'whisker' lines above and/or below each box extend as far as the minimum and maximum values measured, excluding outliers.

berry-to-berry variability, as observed for white table grapes. Freezing samples, whether whole or homogenised, increased the variability across the replicates (Figure 3).

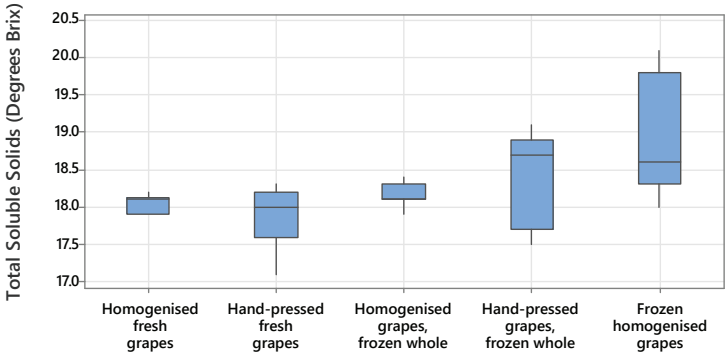

Figure 3. Range of results for total soluble solids (TSS) measured following different juice extraction methods for red table grapes. The blue boxes represent the spread from the first quartile to the third quartile of the data, with the horizontal line within the box representing the median value. The 'whisker' lines above and/or below each box extend as far as the minimum and maximum values measured, excluding outliers.

The trials assessing Merlot and Semillon wine-grapes showed that on average TSS results were higher following homogenisation than hand pressing for the Merlot grapes ($p<0.001$) (Figure 4), although the percentage difference between homogenisation and hand pressing was, in real terms, only around 2%.

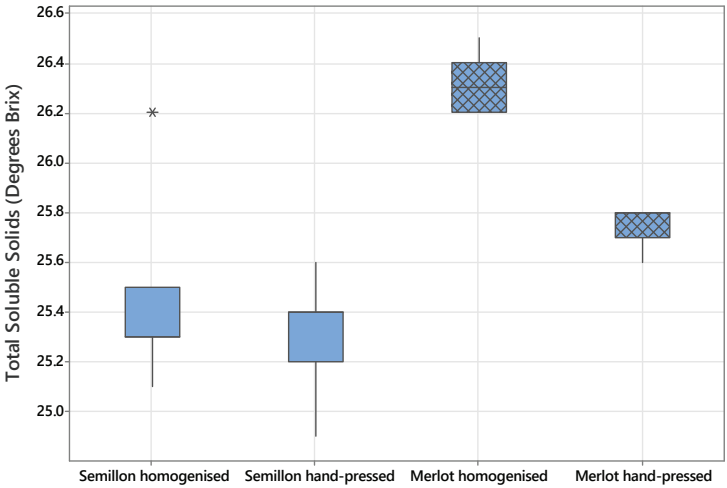

Figure 4. Range of results for total soluble solids (TSS) measured in Merlot and Semillon grapes after different juice extraction methods. The blue boxes represent the spread from the first quartile to the third quartile of the data, with the horizontal line within the box representing the median value. The 'whisker' lines above and/or below each box extend as far as the minimum and maximum values measured, excluding outliers.

pH and titratable acidity – key findings

Homogenisation of all grape types resulted in a significantly elevated pH compared to samples which were hand pressed ($p<0.0001$) (Figure 5).

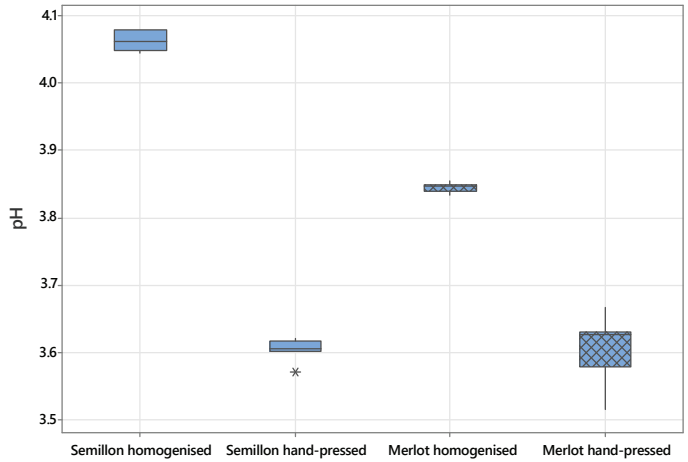

Figure 5. Range of results for pH measured for Merlot and Semillon wine-grapes after different extraction methods. The blue boxes represent the spread from the first quartile to the third quartile of the data, with the horizontal line within the box representing the median value. The 'whisker' lines above and/or below each box extend as far as the minimum and maximum values measured, excluding outliers.

Freezing of samples led to an increase in the pH of the extract, with the strongest evidence observed in white table grapes. Freezing of samples led to a decline in the TA of both red and white fruit, seen in both table and wine grapes ($p<0.001$) (Figure 6). The differences observed between extraction methods could be related to the relative accessibility of the acids within the berry structure.

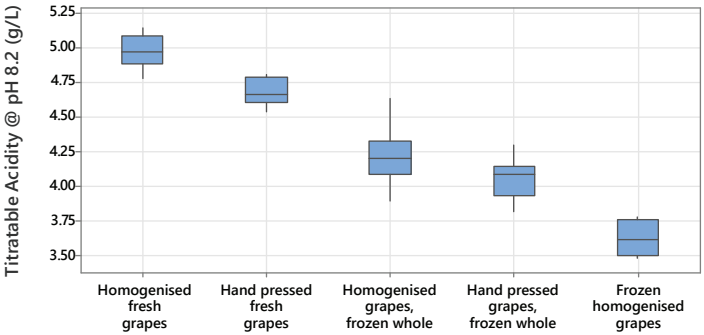

Figure 6. Range of results for titratable acidity at pH 8.2 measured in white table grapes after different juice extraction methods. The blue boxes represent the spread from the first quartile to the third quartile of the data, with the horizontal line within the box representing the median value. The 'whisker' lines above and/or below each box extend as far as the minimum and maximum values measured, excluding outliers.

The spread of pH and TA results within samples analysed by each extraction method was negligible for all samples analysed. For wine-grapes, the data variation across seven replicates never exceeded 0.2 for pH and 0.4 g/L for TA at pH 8.2.

Conclusions

Based on the experiments undertaken in a laboratory setting, measurement of total soluble solids in grapes was not greatly influenced by the juice extraction method employed, with differences observed within 2% of the respective means.

Extraction methods did have a greater influence on results for pH and TA, which could potentially be attributed to the distribution of acids within grape berries.

Freezing affected the variability of results for total soluble solids, but not the mean; whereas it affected the mean values for pH and TA.

Notable variability was seen between replicates, especially in total soluble solids measurements, indicating that berry-to-berry variation within bunches can have a significant impact on analytical results.

References

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