Plant & Food™ Research
Rangahau Ahumāra Kai

PFR SPTS No. 22232

# Producer friendly colour analysis of Pinot noir berries

Yvon M, Darby B, Grose C, Martin D

March 2022

## Internal report for:

Plant & Food Research



**PUBLICATION DATA**

Yvon M, Darby B, Grose C, Martin D. March 2022. Producer friendly colour analysis of Pinot noir berries. A Plant & Food Research report prepared for: Plant & Food Research. Milestone No. NA. Contract No. NA. Job code: P/471014/01. PFR SPTS No. 22232.

**Report prepared by:**

Muriel Yvon
Laboratory Manager, Viticulture and Oenology
March 2022

**Report approved by:**

Damian Martin
Science Group Leader, Viticulture and Oenology
March 2022

# Contents

# Executive summary

## Producer friendly colour analysis of Pinot noir berries

Yvon M[1], Darby B[2], Grose C[1], Martin D[1]
[1]Plant & Food Research Marlborough; [2]Marama Labs, Wellington

March 2022

Spectrophotometric measurements of red wine colour and phenolic content are proven tools for researchers and winemakers. In an effort to encourage New Zealand producers to undertake grape colour measurement to develop style, vineyard and vintage benchmarks, we have devised and tested refinements to the established Australian Wine Research Institute (AWRI) grape berry analysis protocols. In collaboration with Marama Labs, we have also assessed the role that the CloudSpec™ instrument might play in facilitating colour measurement in grapes.

Initial refinement of the reference AWRI method was undertaken using Pinot noir grape and finished wine samples derived from 120 fruit lots from 12 vineyards in three regions and spanning three vintages. The relationship between the log transformed berry extract OD520 and the wine OD520 was strong ($r^2 = 0.74$; $P < 0.001$) when individual fruit lots were plotted, indicating that the method was suitable for predicting Pinot noir wine colour from grapes. The relationship further improved ($r^2 = 0.83$; $P < 0.001$) when data from fruit and wine lots were averaged by vineyard and by year ($N = 31$). In 2021, further streamlining of the berry method to omit the centrifugation, acidification and sample dilution steps and direct feed of the extract supernatant into the CloudSpec instrument offered further improvements in efficiency and accuracy. These improvements appear to stem from the CloudSpec's ability to overcome interference from residual turbidity or scattering, especially in grape berry extracts. Method streamlining as well as introducing CloudSpec technology provide a significant advance in making grape quality assessment more accessible to Pinot noir winemakers in New Zealand.

### For further information please contact:

Muriel Yvon
The New Zealand Institute for Plant & Food Research, Marlborough
PO Box 845
Blenheim 7240
NEW ZEALAND
Email: Muriel.Yvon@plantandfood.co.nz

# 1 Introduction

Spectrophotometric measurements of red wine have long been routinely used by researchers and winemakers to objectively measure wine colour and phenolic potential (Somers 1968). While it is understood that these broad indices do not fully capture the complexities and nuances of the polyphenolic composition and matrix effects of premium wines, they offer useful style, vineyard and vintage benchmarks. More sophisticated assessments of wine phenolic composition can also be derived from basic spectrophotometric data (https://www.awri.com.au/commercial_services/analytical_services/the-winecloud/). Grape berry colour measurements have also been employed in wine research for many decades and a number of “rapid” techniques have been developed to encourage viticulturists and winemakers to undertake them during the lead up to harvest (Glories 1984, Jensen et al. 2001). According to Fragoso et al. (2010), the most widely used methods are those developed by Glories (Saint-Cricq de Gaulejac et al. 1998), the Australian Wine Research Institute (AWRI), Iland et al. (2004) and an unpublished method implemented by the Institut Technique de la Vigne et du Vin (ITV) in France. In their comparison of these methods, Fragoso concluded that while the polyphenolic recoveries were not comparable between methods, if used consistently, each method was a suitable tool to derive relative information about the phenolic ripeness of grapes. These measures have however been largely developed for Cabernet Sauvignon, Merlot and Shiraz varieties. In NZ where Pinot noir is the dominant red grape variety, it has not been rigorously established whether the existing berry colour and phenolic methods are suitable for Pinot noir. Uptake of these methods in New Zealand has therefore been very limited because of their potential unsuitability, time consuming nature and costly equipment requirements.

One of the aims of the Bragato Research Institute (BRI) funded Pinot noir (Pn) programme was to make available to winemakers analytical tools to better quantify the quality of Pinot noir. These grape and wine chemistry assays will inform downstream harvesting, winemaking and blending decisions to optimise wine quality potential.

In an effort to make grape colour measurements more accessible and more readily adopted by Pinot noir winemakers in New Zealand, The New Zealand Institute for Plant and Food Research Limited (PFR) has devised and tested some minor refinements to the long-standing AWRI grape berry analysis protocols. These refinements reduce the need for wineries to purchase expensive laboratory grade homogenisers and accelerate sample throughput while retaining acceptable accuracy for the OD520 colour measurement. PFR’s revised method generates more variation in the OD280 values than the reference because of more variable grinding and extraction of seeds (Cynkar et al. 2004) but work in other areas of the Pn programme has shown close correlations between wine OD520 and OD280 in very young wines. This relationship holds true across regions and seasons for Pinot noir in New Zealand. A single OD520 provides a broad indication of both the colour and phenolic potential in the berry skins, which is highly variable from year to year. Vine to vine variation in colour potential is also very high and it is worth remembering that grape berry sample representivity is a major source of variation which needs to be overcome irrespective of the subsequent analysis technique.

In collaboration with Marama Labs, PFR Marlborough has trialled the Marama Labs developed CloudSpec™ spectrophotometer during the 2021 vintage. The principal aim was to assess the instrument's performance relative to established reference methods for analysing colour and phenolics in juices and finished wines. Through the course of the collaboration it became apparent that the CloudSpec instrument also had the potential to facilitate colour measurement in grape berries.

# 2 Why should winemakers use berry and wine colour measurements?

Almost every winemaker monitors grape ripening to inform harvest date decisions using the measurement of berry soluble solids accumulation as a proxy for maturity. Active sugar loading occurs in the period from véraison until the end of berry fresh weight growth (Deloire 2011). During and beyond this period a number of other metabolic processes occur within the grape berry as shown in Figure 1 (Rogiers et al. 2017). Berry softening, potassium accumulation, acid reduction and colour development (in red grapes) appear to occur at more or less the same time as sugar loading. In reality, however, the synchrony of these events can differ between vineyards and between years (Deloire 2013).

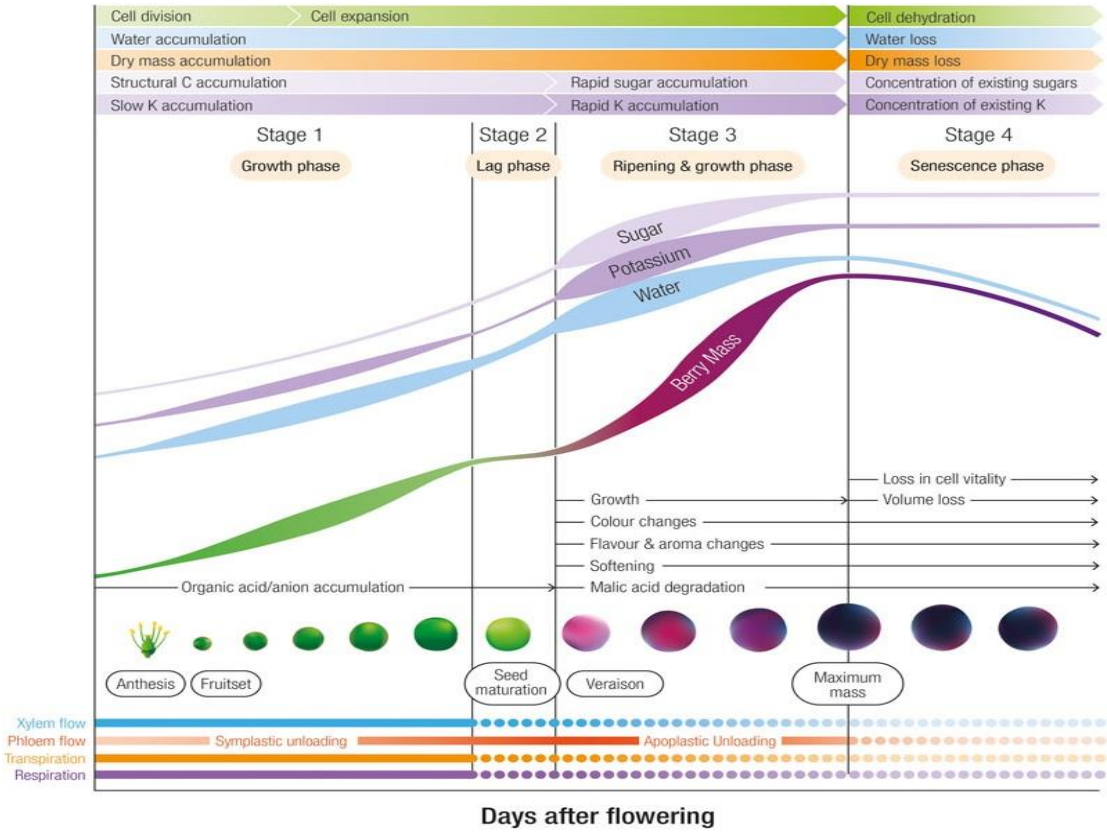



Figure 1. The four developmental stages of grape berries designating phases of rapid sugar, potassium and water accumulation. Stage 3 is associated with ripening and includes colour, flavour and aroma changes, softening and malic acid degradation. Graphic sourced from Rogiers et al. (2017) and must not be copied without permission from the copyright holder.

Because the different ripening processes are driven by independent metabolic pathways, their rates of change (e.g. sugar:colour) can also differ depending on the developmental stage of the berry and environmental factors (Sadras & Moran 2012). It is therefore likely that relative concentrations of key metabolites at any time point are also dependent on within-crop variability of berry development. Once the maximum concentration per unit of skin is reached, anthocyanins can also degrade (Stage 4). The net result is that the timing of optimum phenolic maturity can differ from that indicated by basic maturity parameters. This will translate directly into colour differences in the wine. For these reasons it is very difficult to infer from basic maturity data when berry colour has achieved a maximal value.

When berry skin colour is dark it is not possible to visually detect colour differences within or between berries. Non-destructive colour assessment techniques (colour imaging/near infrared (NIR)) suffer from

the same limitations because the light sources are typically not strong enough to penetrate into and transmit out of the berry. PFR is currently developing a laser light transmission measurement system to assess berry colour (Martin et al. 2021). To highlight the limitations of visual colour assessment, Figure 2 shows a berry that appears uniformly dark (left image) but zones of different colour intensity (variegation) appear when laser light is applied from beneath (right image).

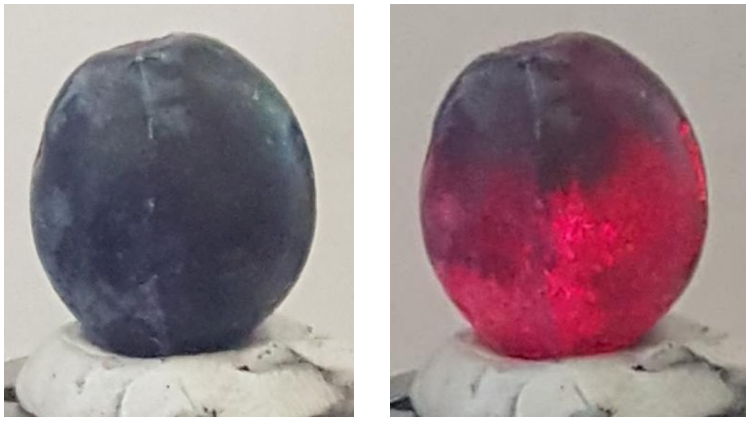


Figure 2. Variegation in skin colour of a single black grape berry. The image on the right shows the berry illuminated by laser from beneath.

Phenolic potential of the berry is not especially difficult to measure but established methods are time consuming and require specialist equipment and/or reagents. The CloudSpec instrument has proven particularly useful in performing rapid colour measurement of grape berries. PFR has successfully developed a pilot grape berry phenolic analysis method that shortcuts steps in the reference AWRI method which accelerates sample processing and achieves further improvements in accuracy. The ability for winemakers to have quick access to grape berry phenolic analysis at the time of harvest would help inform winemaking decisions that directly affect the composition and potential quality of finished wines.

# 3 CloudSpec – Marama Labs

The CloudSpec, developed by Marama Labs, differs from the traditional spectrophotometer as it contains a unique chamber (Figure 3), made of a highly reflective material, in which the light is recycled many times before exiting the sphere. Only the absorption of the sample is then measured, meaning the influence of turbidity is eliminated from the signal.

The instrument measures two optical pathways for measuring the sample:

- Transmission: Ultraviolet-visible spectroscopy (UV-Vis) pathway.
- Absorbance: Integrating sphere pathway.

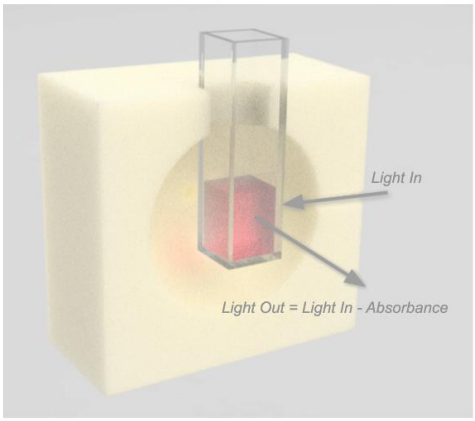



Figure 3. CloudSpec™ measuring chamber.

UV-Vis pathway: The first pathway of the CloudSpec passes light through the sample cuvette in a traditional transmission based geometry, identical to a standard UV-Vis instrument. From this, the sample's extinction spectrum (arising from the combination of sample absorption and scattering) can be measured.

Integrating sphere pathway: In the second pathway, an integrating sphere is used to pass light through the sample. This geometry allows the absorbance of the sample to be measured, independent of scattering (or turbidity).

Extinction, absorption, scattering:

With the unique set up of the CloudSpec, a single measurement of a sample will show:

1. The sample extinction spectrum (path 1).
2. The sample absorption spectrum (path 2).
3. The sample scattering spectrum (calculated).

From 1 and 2, the sample's scattering spectrum can be calculated by subtracting the absorption spectrum from the extinction spectrum.

The absorption pathway is primarily of importance for wine analysis, from which the sample's colour and phenolic content can be estimated. The extinction spectrum can also be used as a measure of the sample's turbidity.

The CloudSpec allows once problematic samples, such as hazy samples, juices, ferments and non-finished wines, to be easily assessed for colour and phenolic content, without the need for clarification or centrifugation to remove turbidity-causing particulates.

# 4 Methods

## 4.1 Sample collection

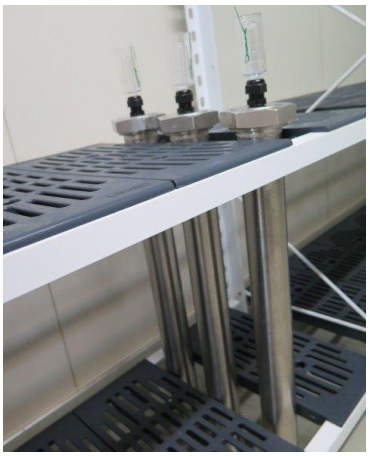
Berry juice (after 24 hours' maceration) and wine samples were generated from the BRI Pn programme "Ideal Vine" study network. The study network included four vineyards from each of three regions (Wairarapa, Marlborough and Central Otago) and samples were collected over three vintages (2018, 2019 and 2021). Grapes were harvested from 20 monitored single vines per vineyard and berry samples from each vine were taken for tannin, phenolic and colour measurements as detailed in Section 4.4. Approximately 20% of the single vine grape lots (N = 123) were made into small scale research wines (1.5 to 2 L volume). Juice samples were taken after 24 hours' cold maceration and wine samples were taken from finished wines as per winemaking protocol detailed in Section 4.2. Colour analysis was carried out on juice and wine samples as detailed in Section 4.3.

A small subset of juice and wine samples (no berries) were collected from The Vineyard Ecosystems (VE) Programme also managed by the BRI. Grapes were harvested from six Marlborough vineyards during the 2021 vintage period and research wines made using the standard Pinot noir winemaking protocol (Section 4.2). However, these wines were made at larger volumes using 15 kg grape lots. Colour and phenolic analyses were carried out on juice and wine samples as detailed in Section 4.3.

## 4.2 Winemaking

Pinot noir grapes were hand harvested from single vine fruit lots from the Pn programme "Ideal Vine" study network from vineyards in Wairarapa, Marlborough and Central Otago, and from the VE Programme Marlborough vineyards, for research scale winemaking. A maximum 2 kg subsample of grapes from each vine was crushed and destemmed in a manual crusher (Marchisio Cervino 400–600 kg/H) (Figure 4).

- Single vine grape lots crushed and destemmed.



- Research scale 1.5-2 L ferments
- 3-days' cold soak at 6°C
- Inoculation with RC212 yeast
- 28°C to 32°C ferment peak.

- After 15-days' maceration – Press.

Figure 4. Small scale research wine, Pinot noir standard winemaking protocol.

Must was loaded into stainless steel fermentation tubes (1.5 or 2 L capacity) and cold soaked for 3 days at 6°C. Juice samples for colour and phenolics analysis were collected 24 hours after cold soak began (see Section 4.3). Must was then warmed to 18°C and inoculated with RC212 yeast (Lallemand, Denmark) (rate 250 mg/L) and fermented with a ferment peak of 28°C to 32°C. When ferments had completed primary fermentation they were pressed after a standardised 15-day maceration period (Figure 4). Wine samples were taken for colour and phenolics analysis (see Section 4.3).

## 4.3 Juice and Wine colour assay

Juice and wine samples were collected for colour analysis as detailed in Section 4.1.

Optical density (OD) was measured in a UV transparent 96-well microplate at 280 nm, 320 nm, 420 nm, 520 nm and 620 nm using a Molecular Devices (San Jose, California, USA) Spectramax 384 Plus plate reader. All samples were centrifuged and analysed in duplicate in microplate. The method was adapted from a published protocol (Somers & Evans 1977).

Subsamples were collected before centrifugation and analysed on the CloudSpec, 1 mm quartz cuvette.


Figure 5. Two different spectrophotometers: on left, Spectramax 384 Plus plate reader used for high throughput enzymatic, colour phenolic assay; on right, CloudSpec™ used to analyse hazy samples.

Measuring the UV-Vis absorbance spectrum of a wine is a powerful way to assess its chemical and visual attributes. All spectra are given for the wavelength range 280 nm to 700 nm. This is also the range of interest for the CloudSpec colour measurements.

In the visible region, the optical densities of the following wavelengths (in nm), OD320, OD420, OD520 and OD620, are used to quantify wine colour and compare juices and wines on their colour intensity, hue, colour composition and degree of red coloration, while OD280 is used to assess total phenolics.

## 4.4 Grape tannin, phenolic and colour, AWRI method

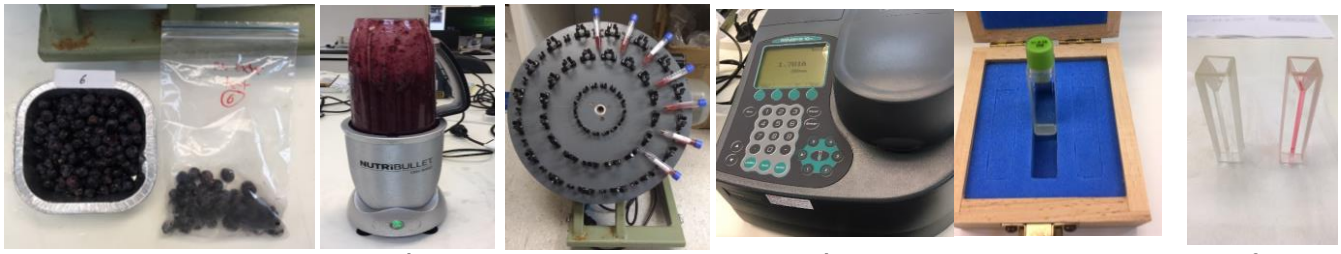
Berry samples were collected for tannin, colour and phenolics as detailed in Section 4.1. They were analysed using a modified method originally developed by the AWRI for their WineCloud™ service:

https://www.awri.com.au/commercial_services/analytical_services/the-winecloud/
https://www.awri.com.au/wp-content/uploads/2013/08/sample-prep-guide-grape-portal.pdf
https://www.awri.com.au/wp-content/uploads/2014/01/measuring-grape-tannins.pdf

Our method has substituted the expensive laboratory grade blender used by the AWRI with a high-speed kitchen blender (1200 Series Nutribullet®). To overcome some of the grinding limitations, we found that a ratio of 75% thawed and 25% frozen berries provided the best texture for consistent grinding.

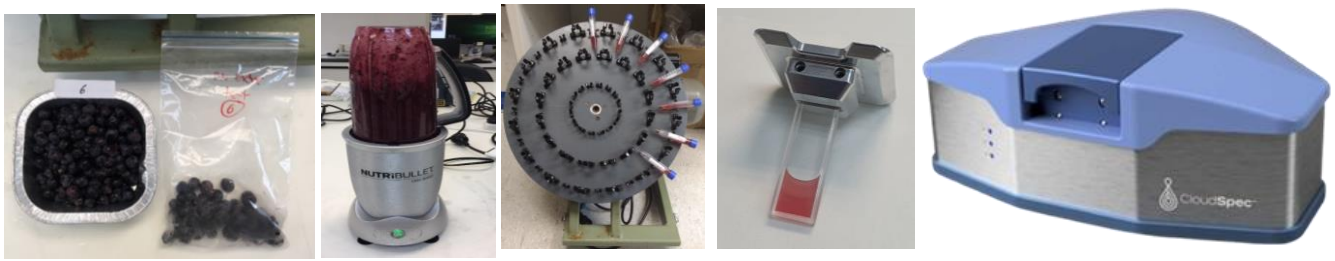
In other respects, the method follows that of the AWRI up to the end of the incubation step and extractions step as follows:

- Incubation step – from there, an undiluted sample is introduced directly into the traditional spectrophotometer, Thermo Scientific GENESYS 10UV spectrophotometer (Waltam, Massachusetts, USA), Figure 6.
- Extraction step – then an undiluted sample is introduced directly into the CloudSpec, Figure 7.




a b c d e f

Figure 6. Modified Australian Wine Research Institute (AWRI) tannin assay steps using a traditional spectrophotometer: (a) mix of thawed and frozen berry, 200 berry samples; (b) blender used to get an homogenous slurry; (c) rotating wheel where phenolic extraction occurs in acidified ethanol solution; (d) after acidification incubation, spectrophotometer to measure optical densities; (e) QC standard cuvette used for results adjustment on the grape portal/WineCloud™; and (f) 10 mm path length quartz cuvettes.




a b c d e

Figure 7. Modified Australian Wine Research Institute (AWRI) tannin assay steps using the CloudSpec™: (a) mix of thawed and frozen berry, 200 berry samples; (b) blender used to get an homogenous slurry; (c) rotating wheel where phenolic extraction occurs in acidified ethanol solution; (d) homogenous sample in the 1 mm quartz CloudSpec cuvette; and (e) CloudSpec reading, CloudSpec Wine Analysis Lab Procedure, February 2021 V1.1.

# 5 Results and discussion

## 5.1 The wine spectrum

UV-Vis absorbance spectra of all red juice samples measured in the CloudSpec (Figure 8) illustrate the instrument's ability to obtain representative colour data, despite samples being highly turbid. The flat zone at the end of the spectra, shows that sample turbidity has no influence on the CloudSpec spectra, meaning that the colour of the juice can be assessed directly, without needing to centrifuge. When samples have high turbidity, standard colour analysis methods can include an additional absorbance measurement at 700 nm to account for the influence of turbidity on colour measurements (Mazza et al. 1999; Birse 2007). The CloudSpec's ability to overcome interference from residual turbidity or scattering, especially in grape berry extracts, appears to improve efficiency and precision.

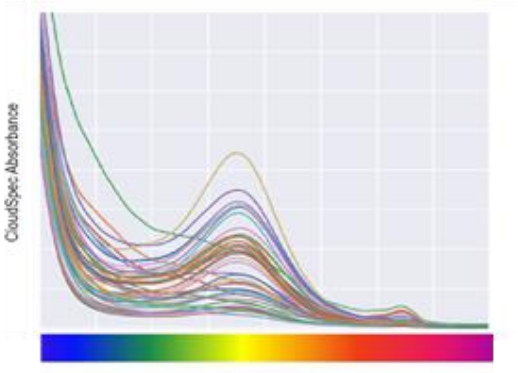



Figure 8. Absorbance spectra of juice samples, obtained with the CloudSpec™.

## 5.2 Practical use aspects between CloudSpec and traditional spectrophotometer

Our laboratory team has been using the CloudSpec over the 2021 vintage on almost all the samples we have received for analysis. The CloudSpec is an intuitive instrument and users do not require a lot of training. It can be used by any wine industry laboratory to help and improve winemaking decisions. The key practical points to using the CloudSpec are:

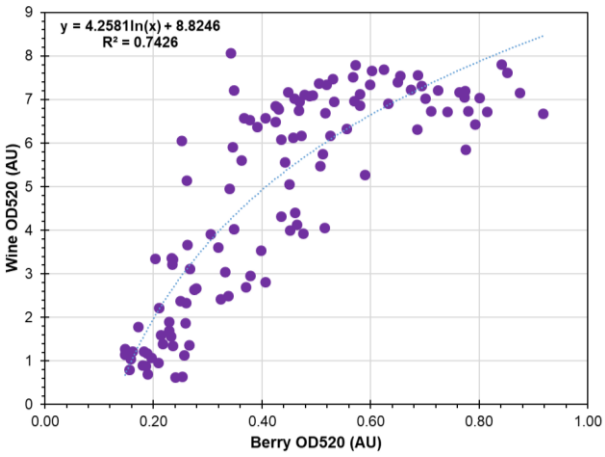
- It is essential to follow a good cleaning routine of the quartz cuvette. It is time consuming but it needs to be part of the protocol for instrument use.
- Be gentle with the instrument when manipulating to open and close the chamber, and the cuvette holder. The instrument needs a set volume in the cuvette and absolutely no spill of sample in the integrating sphere.
- Rinse the cuvette with the following sample, not water. The latter creates some sample dilution.
- The sample may require a dilution before analysing, especially if the laboratory is using the most convenient 10 mm cuvette.
- The CloudSpec needs a couple of minutes, including sample preparation, to analyse each sample. The software then gives the full spectrum of the sample, as described in Section 5.1, as well as all the optical densities of the pre-selected wavelengths. The sample spectrums can be easily

compared between samples. On a traditional spectrophotometer the technician would need to select each wavelength one at a time and use blanks between each wavelength.

## 5.3 Relationship between berry colour measurement and finished wine colour

Berry and wine samples were generated from the Pn programme “Ideal Vine” study network as outlined in section 4.1. From each vineyard, 20 single vines were monitored with approximately 20% of the single vine grape lots (N = 123) made into wine. Colour was measured in berry and wine samples using the AWRI method. Measuring berry colour is not usually considered by winemakers as part of their routine analysis but our results show it can be a useful grape quality assessment tool to predict colour in the finished wines. Measuring colour in the berry is not difficult using the AWRI method with a few modifications to streamline the method.

The best correlations we found were between berry extract and wine colour using spectrophotometric measurements at OD520. The absorbance measure at 520 nm gives an estimate of the concentration of all the red coloured pigments in the berry or wine sample, including anthocyanins and red polymeric compounds. There is a strong ($r^2$ = 0.74; P < 0.001) relationship between the log transformed berry extract OD520 and wine OD520, indicating that the method is suitable for predicting Pinot noir wine colour from grapes (Figure 9). Each data point on the graph represents individual fruit lots from a single vine for the 2018, 2019 and 2021 vintages. The variation observed in the graph is generated from vine to vine variation present in the vineyard and not the sample analysis method.




AU = Absorbance unit

Figure 9. The relationship between the log transformed berry extract OD520 and the wine OD520 for 2018, 2019 and 2021 vintages (1 data point represents individual fruit and wine lots from a single vine)

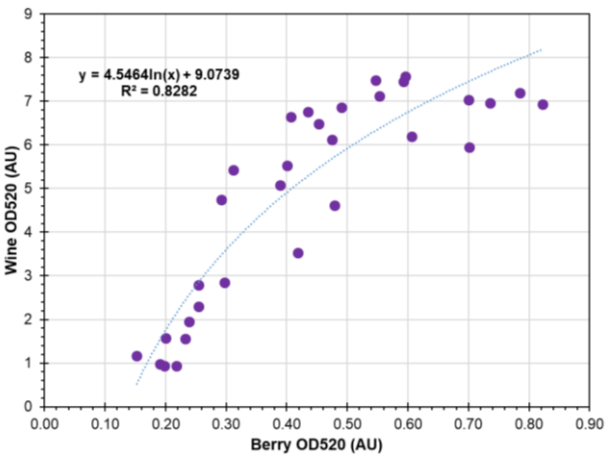



Figure 10. The relationship between the log transformed berry extract OD520 and the wine OD520 for 2018, 2019 and 2021 vintages (individual fruit and wine lots from a single vine averaged by vineyard and by year).

Averaging data from the individual fruit lots for berry OD520 and wine OD520 by vineyard and by year (N = 31) further improved ($r^2$ = 0.83; P < 0.001) the relationship between berry colour and wine colour (Figure 10). Averaging the berry and wine measurements overcomes the biological variation from sample to sample and the predictive relationship between berry OD520 and wine OD520 becomes very good. Figure 10 shows the predictive relationship between berry OD520 and wine OD520 reaches a plateau at around 0.5 (OD520) for berry and around 7 for wine (OD520). Correlation in the

upper part of the graph shows the relationship between berry colour and wine colour is not as strong. This is less critical for Pinot noir because there is already good colour in the wine in this upper area of the graph. The relationship in the lower part of the graph is stronger where the berry colour is lower, leading to lower colour wines. This part of the graph is useful in a practical winemaking sense where low berry colour measurements would indicate wines made from these grapes would produce lower colour wine. The ability to predict poor colour in wine is useful information for winemakers to know in advance. If winemakers know the colour status of the fruit coming into the winery, decisions can be made on the best fruit processing and winemaking techniques to enhance the colour potential of the finished wines.

## 5.4 Juice and wine colour – CloudSpec validation

To interpret the 2021 results, we used some simple regressions at the three optical densities (OD420, OD520, OD620) of the CloudSpec (x-axis) and standard spectrophotometer (y-axis), of all juices (blue dots) and wines (orange dots). The results are summarised in Figure 11.

The green line, labelled 1:1 line, is a visual aid, all points should lie on this line if both methods agreed perfectly.

We observe a natural scatter around the 1:1 line. Colour data obtained with the CloudSpec compared with centrifuged samples in a standard UV-Vis indicate that the CloudSpec results correlate well with the reference method.

The points significantly above this line correspond to strong scattering (more turbid) samples, where the reference method seems to consistently over-report colour values. The colour analyses of the samples in the grey circle would be impacted by sample turbidity.

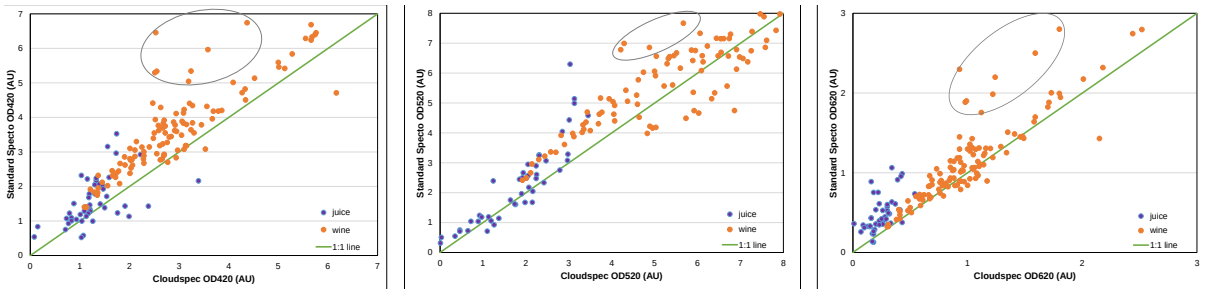



Figure 11. Data comparison of the CloudSpec™ and the standard spectrophotometer.

Figure 12 shows the extinction and absorbance spectra of the outliers in Figure 11, data from the CloudSpec.

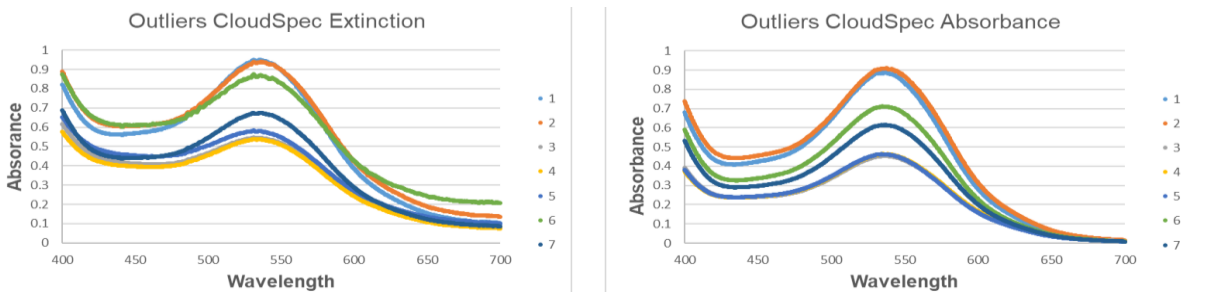



Figure 12. Spectra comparison of the CloudSpec™, extinction versus absorbance on turbid samples.

The absorbance spectra relate to the integrating-sphere, turbid-free measurement, “true” absorbance, while the extinction is the pathway that will be affected by turbidity. The extinction value would be similar to the results recorded with our reference method.

The comparison of these two graphs (Figure 12) shows that those selected samples have a significant background in the >650 nm region of the CloudSpec extinction spectra, compared with the CloudSpec absorbance spectra which is practically zero in that region. This is an indication of sample turbidity, the sample has no real absorbance (CloudSpec absorbance mode is zero absorbance) but the extinction value has a non-zero value, which arises from scattering due to sample particulates.

The turbidity will occur across the entire spectrum, then contributes to the 420 nm, 520 nm and 620 nm values in extinction, causing the extinction values at those values to be significantly higher than what they should be if no turbidity was present.

The spectra therefore clearly shows the extinction values are higher than the CloudSpec values due to turbidity and this explains why the outlier values circled are above the 1:1 line in the scatter plots in Figure 11.

The CloudSpec method is also more representative of juice colour because it measures the intact juices. Traditional methods can remove colour content through centrifugation.

## 5.5 AWRI method – Berry analyses – CloudSpec Validation

A shortened method has been applied in our study to compare the traditional AWRI method (y-axis), with unclarified extract subsample for CloudSpec’s analyses (x-axis). Each dot corresponds to a 200 Pinot noir berry sample.

Figure 13 shows the results of the comparison of both methods at three different optical densities, OD280, OD320 and OD520. There is a clear correlation with correlation coefficient above 0.79 for all three wavelengths.

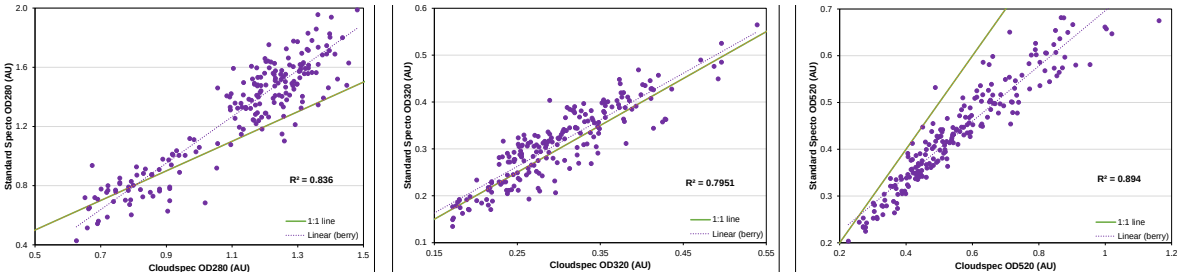



Figure 13. Data comparison of the CloudSpec™ and the standard spectrophotometer for berry samples analyses using the Australian Wine Research Institute (AWRI) method.

For OD320, the visual aid, 1:1 line, is parallel to the linear fit of the correlation between the two methods with a correlation coefficient of $r^2 = 0.79$. The correlation is even stronger for the other two wavelengths, OD280 ($r^2 = 0.836$) and OD520 ($r^2 = 0.894$). However, the linear fit is not parallel. This strong relationship can show that even with a shorter methodology, the CloudSpec is a suitable tool for relative comparison. In this study we were not looking for an absolute colour value or evaluation, rather, a ratio or data that can be comparable and eventually used to inform picking decisions at harvest. Method consistency and repeatability are valuable when measuring colour for early winemaking decisions.

## 5.6 Colour prediction

The Pn programme “Ideal Vine” study allowed us to subsample grapes for berry analyses. The remaining samples were used for small scale winemaking, including juice analyses as well as finished wine analyses. The samples generated from grapes, juice and wine were then used to look at colour prediction from grape to juice, juice to wine and also grape to wine with both methods of analyses. Figure 14 shows the best correlation between the berry (x-axis) and wine colour (y-axis) for OD520.

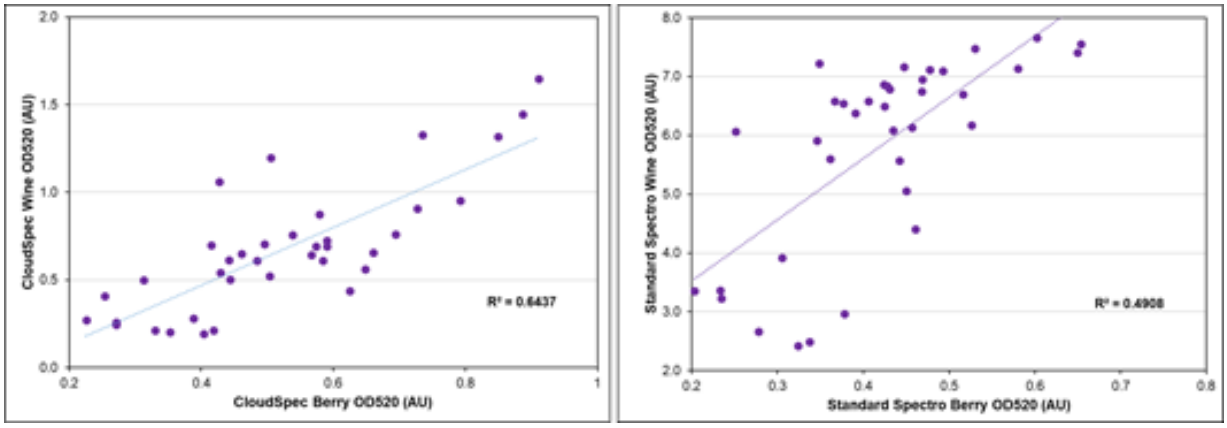



Figure 14. Correlations between berry and wine OD520 values for the CloudSpec™ (left) and the standard spectrophotometer methods (right).

Although this work has been carried out with a limited number of samples (n = 37), we can observe that the correlation for the CloudSpec, $r^2 = 0.64$, is noticeably better than the standard AWRI method with $r^2 = 0.49$.

# 6 Conclusions

The PFR Marlborough laboratory in Blenheim, in collaboration with Marama Labs, trialled the CloudSpec instrument for analysis of Pinot noir grape and wine samples during the 2021 vintage period. Over 300 samples of grape berry, juice and wine were compared using the CloudSpec with our reference methods (Spectrophotometric measurements, AWRI grape berry analysis method).

The CloudSpec instrument has proven accurate when compared with standard spectroscopy and plate reader systems. It provides considerable advantages when dealing with cloudy sample materials, especially those derived from berry extracts which have high solids content. The standard method, where samples are centrifuged, appears to result in lower transmission of some samples at the upper end of the visible range. This would suggest that there is residual turbidity affecting the measurement. However, analysing the same sample uncentrifuged in the CloudSpec gives higher transmission results.

The CloudSpec instrument has proven particularly useful when attempting to develop rapid colour measurements for grape berries. We have successfully developed a pilot grape berry phenolic analysis method that shortcuts the centrifugation, acidification and sample dilution steps of the reference AWRI method. This accelerates sample processing while achieving further improvements in accuracy. More work however is required to validate these findings and optimise the methodology using a larger set of samples.

Discussions with winemakers and winery laboratory technicians at a workshop in December 2021 also highlighted considerable opportunities for the application of the CloudSpec technology to juice measurements in the winery, especially in white wine production during the processing stages from pressing to juice clarification.

The CloudSpec opens the possibility for winemakers to easily capture colour and phenolics information on wines throughout the winemaking process: from grapes to juice, through to ferment and bottling without any clarification.

# 7 References

Birse MJ 2007. The colour of red wine. University of Adelaide, Research Thesis https://hdl.handle.net/2440/42834.

Cynkar W, Cozzolino D, Dambergs R, Janik L, Gishen M 2004. The Effects of Homogenisation Method and Freezing on the Determination of Quality Parameters in Red Grape Berries of Vitis Vinifera. Australian Journal of Grape and Wine Research. 2004, 10, 236-242.

Deloire A 2011. The concept of berry sugar loading. Wineland Wynboer 257: 93-95.

Deloire A 2013. Wine aroma and grapevine berry ripening: How to capture the complexity. Wine & Viticulture Journal 28(5): 65-68.

Fragoso S, Mestres M, Busto O, Guasch J 2010. Comparison of three extraction methods used to evaluate phenolic ripening in red grapes. Journal of agricultural and food chemistry 58(7): 4071-4076.

Glories Y 1984. The colour of red wines. Part II. Measurement, derivation and interpretation. Connaissance de la Vigne et du Vin

Iland P 2004. Chemical Analysis of grapes and wine: Patrick Iland Wine Promotions PTY LTD.

Jensen J, Blachez B, Egebo M, Meyer A 2001. Rapid extraction of polyphenols from red grapes. American Journal of Enology and Viticulture. 58 (4), 451-460.

Martin D, Oliver R, Birch S, Schaare P. December 2021. New Zealand Winegrowers Research Centre Pinot Noir programme, Research Aim 4.1 – Bunch sorting. Annual report December 2021. A Plant & Food Research report prepared for: New Zealand Winegrowers Research Centre Limited. PFR SPTS No. 21937.

Mazza G, Fukumoto L, Delaquis P, Girard B, Ewert B 1999. Anthocyanins, phenolics, and color of Cabernet franc, Merlot, and Pinot noir wines from British Columbia. Journal of agricultural and food chemistry 47(10): 4009-4017.

Rogiers SY, Coetzee ZA, Walker RR, Deloire A, Tyerman SD 2017. Potassium in the grape (Vitis vinifera L.) berry: transport and function. Frontiers in Plant Science 8: 1629.

Sadras V, Moran M 2012. Elevated temperature decouples anthocyanins and sugars in berries of Shiraz and Cabernet Franc. [https://doi.org/10.1111/j.1755-0238.2012.00180.x]. Australian Journal of Grape and Wine Research, 18(2), 115-122. doi: https://doi.org/10.1111/j.1755-0238.2012.00180.

Saint-Cricq de Gaulejac N, Vivas N, Glories Y 1998. Maturité phénolique: définition et contrôle. Revue française d'oenologie(173): 22-25.

Somers T 1968. Pigment profiles of grapes and of wines. Vitis 7: 303-320.

Somers TC, Evans ME 1977. Spectral evaluation of young red wines: Anthocyanin equilibria, total phenolics, free and molecular SO2, “chemical age”. Journal of the Science of Food and Agriculture 28(3): 279-287.

A smart green future. Together.