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Pinot Noir provenance: Australian benchmarking to support growing, making, perception of quality, and marketing to add value to the Pinot Noir supply chain



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Research Organisation: **Tasmanian Institute of Agriculture, University of Tasmania**

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UT 1503 - Pinot Noir provenance: Australian benchmarking to support growing, making, perception of quality, and marketing to add value to the Pinot Noir supply chain

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- Hill-Smith Family Vineyards, Shaw + Smith, ~50 other Australian Pinot noir producers

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1 ABSTRACT

Premium Pinot noir growing regions, wineries and wines were identified with Masters of Wine and wine guides, and then targeted for participation in this project. Commercial Pinot noir wines from ten regions across Australia were detailed and compared, then also compared with wines from five non-Australian regions. Background viticultural, oenological and site information was obtained from producers to investigate drivers of colour, phenolics, volatile and sensory profiles of the wines. In addition, the project overlayed value chain analysis to determine where additional value could be derived for Pinot noir wines, as “the more information we have, the easier it is to tell the story” (Producer 6).

2 EXECUTIVE SUMMARY

This project was co-designed with industry to investigate if there were drivers of provenance which could be identified from premium commercial Pinot noir wines. The project sought to:

1. To establish an evidence base to support claims of Australian Pinot Noirs as distinctive, unique and of high quality.
2. To identify chemical profiles in Pinot noir wines which can be attributed to their region of origin, and to compare these to international Pinot noir growing regions.
3. To identify and articulate key points within the value chain where the quality, unique character and sustainability of Australian Pinot Noir can be communicated and optimised.

This project addressed the above aims by firstly engaging with Masters of Wines, and reputable wine guides, by way of determining appropriate regions, wineries and wines to be sought for inclusion in this project. By targeting the top ten, and representative, regions from across Australia a broad set of wines from the 2015 and 2016 seasons were generously provided by producers. This broad set of wines was analysed for chromatic and colour structure across the two vintages, with results indicating that parameters such as anthocyanins, pigment and hue could differentiate regions such as Southern Tasmania, Geelong, Mornington Peninsula and Northern Tasmania.

To complement the broad set of 2015 and 2016 wines, a comprehensive survey was sent to producers to determine site, weather, viticultural and oenological influences on wine profiles. A low return rate of the survey limited firm conclusions being able to be drawn, however it did not appear from the surveys returned that there was a single stand out driver of wine chromatic and/or colour structure. This really highlighted the complexity of producing premium Pinot noir wines and the need to understand the site and then respond with appropriate viticultural and oenological practices.

From producers who were able to successfully complete the survey, a subset of five wines from five regions (Yarra Valley, Northern Tasmania, Southern Tasmania, Mornington Peninsula and Adelaide Hills) from the 2015 and 2016 vintages underwent further volatile compound analysis for known compounds which was then compared to wine from five non-Australian regions (Burgundy, Willamette Valley, Ontario, Central Otago and Marlborough). The most interesting finding from this analysis was the similarities between wines within each vintage, , indicating that weather could be a driver of aroma profiles of Pinot noir wines.

The opportunity arose during the course of this project to collaborate with Dr Wes Pearson of the AWRI, to utilise the Pivot © profile method of sensory analysis, which had concurrently to this project been used in a project regarding terroir in Shiraz/Syrah wines (Pearson et al., 2019). A panel of 11

experienced wine professionals, evaluated 15 sample wines from the 2018 vintage, and colour, phenolics and volatile compositions were analysed. From the five regions used (Yarra Valley, Northern Tasmania, Southern Tasmania, Mornington Peninsula and Adelaide Hills), ethyl decanoate, ethyl 2-methylpropanoate, ethyl 2-methylbutanoate and decanoic acid were important contributors to differentiating between regions. The Pivot © profile method revealed that 'red fruit' aromas were associated with Mornington Peninsula wines along with 'acidic' and 'astringency' palate descriptors, whereas Adelaide Hills wine were described as having 'brown' colour Longo et al. (2020b).

The project was an excellent demonstration of collaboration between a regional agricultural research institute, being the Tasmanian Institute of Agriculture (TIA) at the University of Tasmania and the Australian Wine Research Institute (AWRI). TIA staff have a strength in understanding cool climate viticulture and oenology, thus a Pinot noir project was a natural fit and when coupled with the research excellence at the AWRI, including Metabolomics Australia, made for an effective research team. TIA is also very closely connected to the cool climate wine sector in Australia, and this project would not have been possible without the idea and support from industry, particularly in co-design from Louisa Rose at Hill-Smith Family Vineyards and Adam Wadewitz at Shaw + Smith. The inclusion of Dr Bob Dambergs, of Wine TQ, to the project team underpinned the strength in understanding influences on wine composition, and multivariate data analysis.

3 BACKGROUND

Historically, Pinot noir has been associated with France's cool northern regions, specifically Burgundy and Champagne. This grape cultivar gives some of the finest and most expensive red wines anywhere in the world that are characterised by a light red colour and fruity/floral flavours. While Pinot noir is extensively cultivated in many European countries such as France, Switzerland, and Germany, it is also grown in several cool regions of the New World, including the coolest coastal areas of California, Oregon, New Zealand, Argentina and Australia (O.I.V., 2017). In O.I.V. (2017) it was reported that around 112,000 ha of Pinot noir were planted globally.

In the 2018 vintage, around 53,000 tonnes of Pinot noir were crushed, with the major production regions being Yarra Valley, Tasmania, Adelaide Hills and Mornington Peninsula (Wine Australia, 2019a), however a range of wine regions across Australia successfully grow Pinot noir (Figure 3-1). Despite Pinot noir being first planted in Australia in the 1830s, its popularity in Australia is relatively recent. Today, it is the second most popular red cultivar with a ~23% share of red wine consumed in the domestic on-trade behind Shiraz (~31%) (Wine Australia, 2019b).

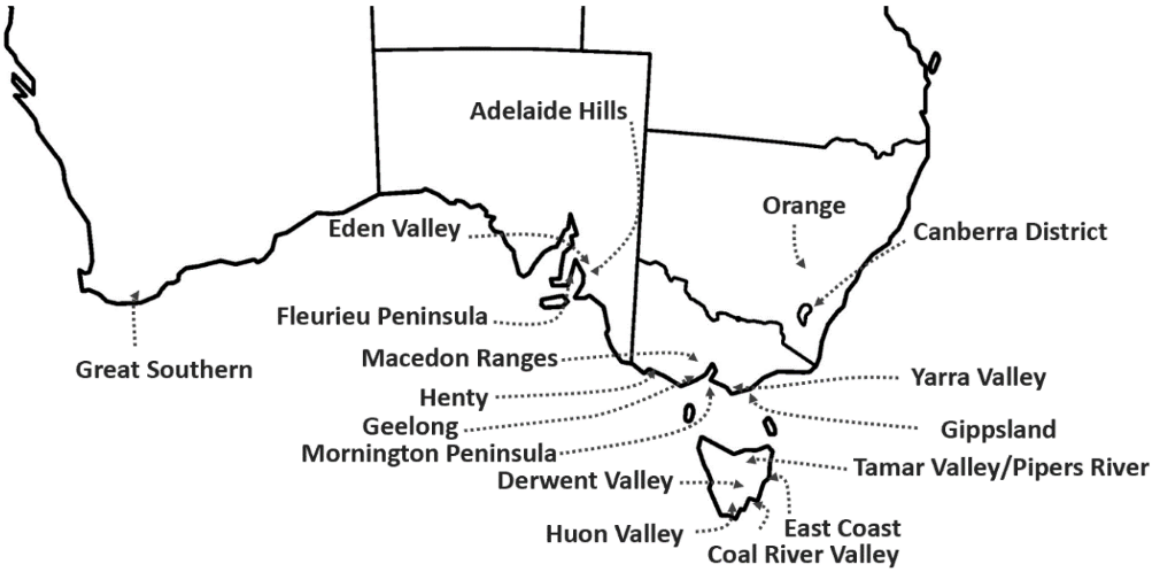


Figure 3-1 Australian wine region growing Pinot noir

Climate, soil, cultivar, biodiversity, and human inputs (e.g. viticultural and winemaking practices) all contribute to the terroir of a given site (Van Leeuwen et al., 2004). Many studies on terroir deal with the climate effects, in part because it is considered one of the main drivers of the wine quality (Roullier-Gall et al., 2014). For instance, the high diurnal temperature was the most important climatic factor for the discrimination of top- and bottom-ranked vintages of Burgundy's red wines (Robert et al., 2019). Pinot noir is an early-ripening cultivar better adapted to the cool climate of the Burgundy's

Côte d'Or appellation. Burgundy's climate can be defined as the middle zone between a cold continental and a cool maritime climate (Shaw, 2012); it corresponds to Region I according to the Winkler degree-day index classification (Winkler et al., 1974). The colour and phenol composition of Pinot noir grapes and wines from different geographical origins can be affected by climate (Saavedra et al., 2011), and these attributes are some of the most important factors defining the quality of wine. Australian geography is very heterogenous, which results in a range of climatic zones with many cool climate regions influenced more by the Pacific Ocean and others influenced more by the Tasman Sea.

Pinot noir grapes generally produce wines with light red colour of low astringency, due to the relatively low concentration of anthocyanins and a low skin-to-seed tannin ratio (Agati et al., 2007, Harbertson et al., 2008). Knowledge of wine's colour and phenolic composition is important and can be used to discriminate wines by the region where the grapes are grown with other red wine grape varieties (Pena-Neira et al., 2004, Serni et al., 2020). Saavedra et al. (2011) used ultraviolet-visible (UV-Vis) spectroscopy and chemometric tools to classify 108 commercial Pinot noir wines from nine geographical locations of Chile's Casablanca valley, successfully discriminating the samples of the "Zona Alta" from those of the "Zona Baja". A similar approach (that included near-infrared and midinfrared spectroscopy) was also used by Riovanto et al. (2011) to discriminate 98 commercial Shiraz wines from five Australian regions.

In addition to colour and phenolic features, relationships have been hypothesised between the geographical origin of Pinot noir grapes and the aroma composition of the resulting wines (Cantu et al., 2021). For instance, ethyl decanoate, ethyl octanoate and 2-phenylethanol were proposed as important compounds for the sensory discrimination of 32 New Zealand Pinot noir wines (Tomasino et al., 2015).

4 PROJECT AIMS

The objectives of this project were to:

1. To establish an evidence base to support claims of Australian Pinot Noirs as distinctive, unique and of high quality.
2. To identify chemical profiles in Pinot noir wines which can be attributed to their region of origin, and to compare these to wines from international Pinot noir growing regions.
3. To identify and articulate key points within the value chain where the quality, unique character and sustainability of Australian Pinot Noir can be communicated and optimised.

5 METHOD

The overall approach and components of the project are depicted in Figure 5-1 and described below.

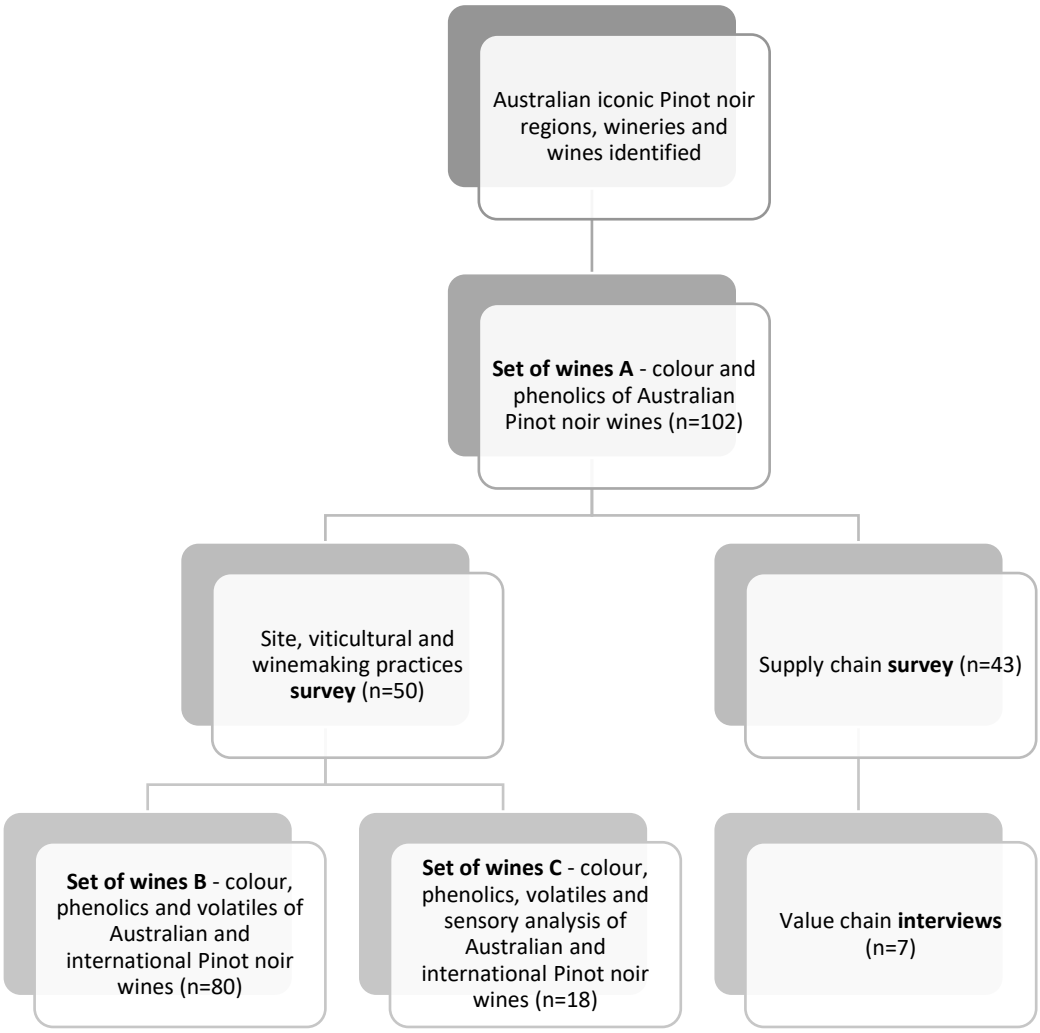


Figure 5-1 Provenance of Pinot noir project overview

5.1 Region and winery selection

To best, and independently, understand the Pinot noir category in the Australian wine sector, four Masters of Wine (Wendy Cameron, Greg Melick, Jeni Port and Michael Hill-Smith), and three respected wine guides (Halliday's 2017 Wine Companion, Geddes' 2016 Gold Book and Langton's 2014 Classification), were utilised to understand which regions the project should focus in on, and a starting list of which producers should be approached for participation. The four selected

Masters of Wine were asked to provide a list of 30 'Australian Pinot Noirs you feel are iconic, great regional representatives or beautiful examples of a particular style of Pinot Noir we make in Australia?'. From Halliday's Wine Companion Pinot noir wines were selected that scored 97 or 98 in (Halliday, 2017). From Geddes' Gold Book those Pinot noirs selected were mentioned in the top 100 Australian wines and those listed in the larger list that were scored 96 or higher and of a vintage of 2012 or later were selected (Geddes, 2016). From Langton's Classification all the Pinot noirs mentioned in their Classification VI wine list were selected (Exceptional, Outstanding, Excellent) (Caillard and Langton, 2014).

The returned lists from the four Masters of Wines varied in terms of how the task was interpreted. In some cases, wineries were mentioned, in others specific types of wine and in others the specific wine and vintage. The lists from the three guides all included winery, wine, and vintage. To reconcile these differences the list was sorted and analysed to the winery level. Each winery was given a score for the number of times it received a mention from one of the seven sources used. Given the need to finalise the list through the other two criteria (a regional spread and winery willingness to participate), this was considered a sufficient level of detail. See 9.5.1 for full detail of regions, wineries, and wines. From the above process, the ten most recognised Pinot noir producing regions were selected for this project and targeted for participation in this project, according to the list derived from the MWs and wine guides (Figure 5-2).

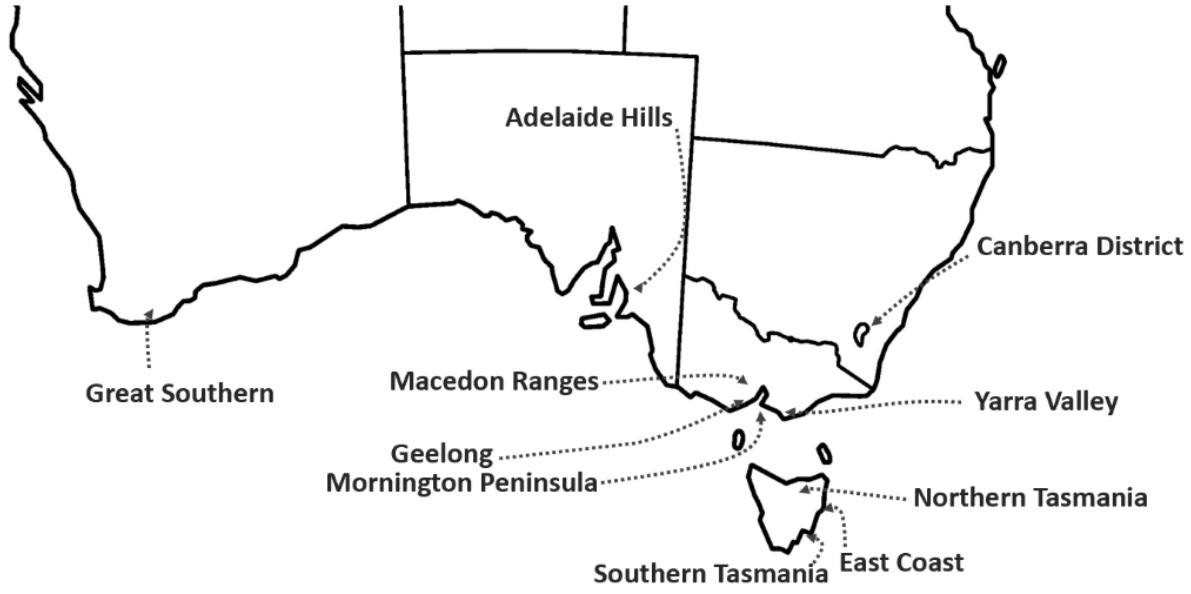


Figure 5-2 Australia's ten most recognised Pinot noir producing regions

5.2 Survey of site, viticulture and winemaking information

Producers of the wines used for the colour and phenolics analyses (set of wines A, see 5.3) were requested to complete a comprehensive online survey (~170 questions) to cover contributing factors to final wine composition such as site, climate, vineyard attributes, viticultural practices, fruit composition and winemaking practices (see 6.2 for the full survey). An additional section was included with questions regarding the producers supply chain and a request for face-to-face interviews for value chain analysis. Questions can be summarised as:

- Site
  - Altitude, soil type and depth, parent material
- Climate
  - Growing degree days (GDD), Mean January temperature (MJT), Mean February temperature (MFT), annual rainfall, growing season rainfall, significant weather events
- Vineyard
  - Rootstocks, row and vine spacing, clones, trellis, irrigation setup
- Viticultural practices
  - Fertiliser, pruning, shoot thinning, leaf plucking, bunch thinning, harvest method, fruit sorting
- Fruit
  - Yield, total soluble solids (TSS), pH, titratable acidity (TA)
- Winemaking practices
  - Whole berries/bunch, saignée, fermenter type and capacity, maceration, ferment duration and temperature, yeast, malo-lactic fermentation (MLF), additions, oak, wine composition, bottling
- Supply chain
  - Distribution, markets, consumer demographic and information shared

Weather data were sourced from the meteorological stations installed in each of the vineyards involved in the study. If not available for a specific location, the data were retrieved from sources that include the Australian Bureau of Meteorology Online Database (www.bom.gov.au). In this case, a standard meteorological station was chosen with the assistance of the wine producer to represent the macroclimate of the area (Table 5-1).

Table 5-1 The coordinates, elevation, and representative meteorological stations.

State	Region	Station	Latitude	Longitude	Elevation (m)
Victoria	Geelong	She Oaks	37˚ 91´ S	144˚ 13´ E	237
		Bannockburn*	38˚ 04´ S	144˚ 17´ E	120
	Mornington Peninsula	Cerberus	38˚ 36´ S	145˚ 18´ E	13
		Mornington*	38˚ 23´ S	145˚ 06´ E	46
	Macedon Ranges	Redesdale	37˚ 02´ S	144˚ 52´ E	290
		Lancefield*	37˚ 27´ S	144˚ 72´ E	475
		Kilmor Gap*	37˚ 38´ S	144˚ 97´ E	528
	Yarra Valley	Coldstream	37˚ 72´ S	145˚ 41´ E	83
South Australia	Adelaide Hills	Parawa West	35˚ 57´ S	138˚ 29´ E	341
		Lenswood	34˚ 94´ S	138˚ 80´ E	452
Tasmania	Northern Tasmania	Beaconsfield*	41˚ 20´ S	146˚ 81´ E	33
	East Coast Tasmania	Apslaw*	41˚ 96´ S	148˚ 18´ E	15
	Southern Tasmania	Kincora	42˚ 69´ S	147˚ 43´ E	45
		Grove	42˚ 98´ S	147˚ 08´ E	63
Western Australia	Great Southern	Mount Barker	34˚ 62´ S	146˚ 85´ E	300

*Meteorological station used only for rainfall data.

5.3 Colour and phenolic structure of Pinot noir wines: Understanding Australia (A)

The next stage of the project was to source a broad set of commercial wines (A) from 10 most recognised Australian Pinot noir producing wine regions (Figure 5-2) across two vintages (2015 and 2016) and analyse them for colour and phenolic composition. The original intention was to have 10 wines from each of the 10 regions (n=100 for each vintage), however given the importance of single vineyard wines of known clone(s) for this project, it was difficult for the research team to procure this volume for each vintage (n=54 for 2015 vintage, n=48 for 2016 vintage). The challenging conditions faced in the 2016 vintage in some regions also precluded some winemakers from repeating their single vineyard wines for this vintage.

5.4 A 2-year volatile and colour study of Pinot noir Wines from Australian and non-Australian regions (B)

From the broad set of Australian wines, a sub-set of Australian samples (B) was selected (primarily based on survey completion) for grape and fermentation derived volatile analysis (n=50) from five regions (Figure 5-3) and compared to a set of non-Australian samples (n=30). Methods for these are described in 5.6.

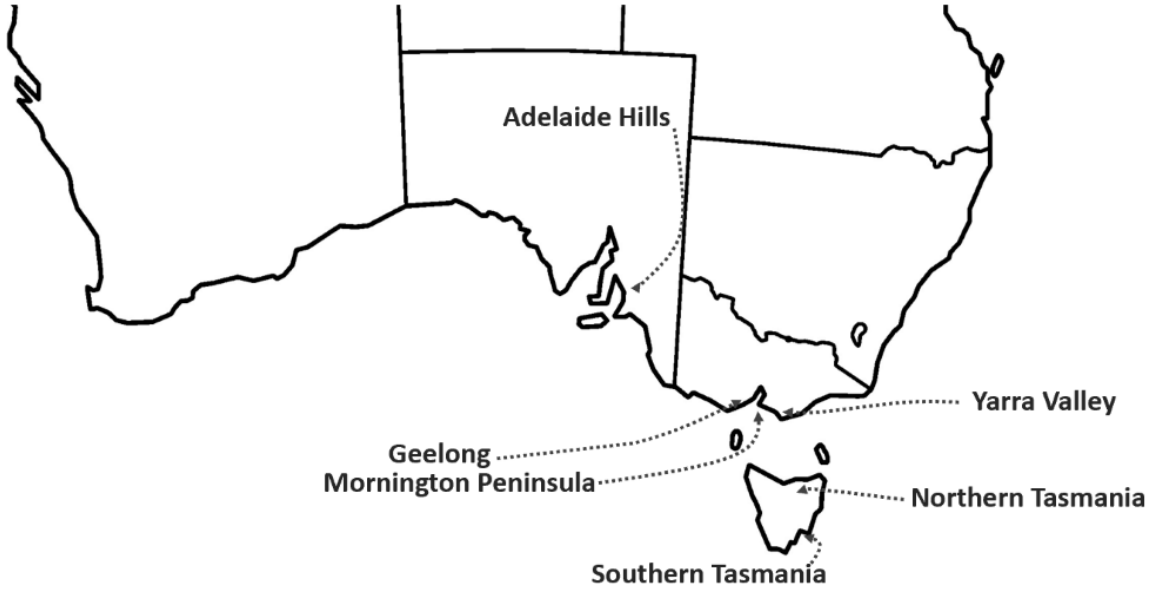


Figure 5-3 **Five Australian Pinot noir producing regions used for wine sub-sets B and C**

5.5 Chemical and sensory study with Australian Pinot noir (C)

A smaller set of commercial wines (C) was sourced from 5 Australian Pinot noir producing wine regions from the 2018 vintage (n=15) for sensory (Pivot© Profile, Photo 5-1) and volatile analysis, using the rubric sourced from Pearson et al. (2019). Methods for these are described in 5.6 and described in further detail in Longo et al. (2020b).



Photo 5-1 **Pivot © profile sensory analysis of Pinot noir wines**

5.6 Wine analyses

Full description of wine analytical methods can be found in papers published associated with the project (Longo et al., 2020b, Kerslake et al., 2020), but are summarised very briefly here.

Colour and phenolic analyses - The Modified Somers method (Mercurio et al., 2007) was used for colour structure and chromatic component characterisation. Tannin concentrations were determined by the Methyl Cellulose Precipitable Tannin (MCPT) assay (Mercurio et al., 2007).

Volatile compounds analyses - In collaboration with Metabolomics Australia, a HS-SPME-GC-MS method (Siebert et al., 2005) was used to quantify esters, alcohols and fatty acids. The concentration of analytes in the samples were determined using stable isotope dilution analysis (SIDA). The quantifier ions were used to identify the compounds at their expected retention time as reported in Table 9-3. C_{13}-norisoprenoids were analysed by GC-MS by Mr Mark Solomon, at the AWRI, as per the method outlined in Longo et al. (2020b).

Sensory analysis - A panel of eleven wine professionals (eight males and three females, aged 35-55 years) was convened in Launceston, Tasmania and in collaboration with Dr Wes Pearson, of the AWRI, the Pivot© Profile method (Thuillier et al., 2015) was utilised. The Pivot© Profile method was selected given its rapid application and suitability for use with product category experts, such as winemakers or wine judges (Pearson et al., 2019).

5.7 Value chain interviews

In-person or telephone interviews were held with Pinot noir wine producers to explore how and where value was created by regional characteristics and wine provenance. Expressions of interest (EOIs) to participate in a value chain interview were called for in the comprehensive online producer survey, which also contained a small number of questions regarding the producer's supply chain and wine business (see 9.5.7 for the full list of questions and a summary of data collected via these questions). The EOI list was cross-checked with the list of Australian iconic Pinot noir wines and producers who appeared on this list and who expressed interest in an interview, were sent an email invitation to participate in a value chain interview. Follow up emails and phone calls were used to increase the response rate. Responses were received from seven producers, who were broadly representative of the regions included in this project.

A semi-structured interview schedule was devised in accordance with the aims of the project and relevant literature regarding wine provenance and value chains (similar to Warman and Lewis, 2019). The following were identified as key topic areas to explore during the interviews: drivers of regionality and provenance, decision making and impact, storytelling and communication, information sharing and the identification of end-users of provenance information.

Most of the interviews were conducted in person at a winery or cellar door (two interviews were conducted via telephone for convenience). On average the interviews lasted 45 minutes. Two interviews involved two interviewees (i.e., the chief winemaker and general manager). The other five were one-on-one conversations between the researcher and the wine producer. All interviewees signed a consent form prior to the interview commencing. As part of this consent, permission was granted to audio-record the interview.

Each audio recording was then transcribed to enable the data to be grouped and categorised using thematic analysis. At the start of this process, transcripts were imported into a computer-aided qualitative data analysis software program (NVivo 12 Pro) and from there emergent themes were 'coded' into nodes. Some of these were derived from the interview schedule, and others were created deductively from the data. At the end of the analysis stage, several themes were drawn, which are discussed in section 6.6 below. Direct quotes from the producers interviewed are also included as evidence of these themes.

Prior to the value chain interviews, we examined back label information contained on Australian Pinot noir wines for analysis to identify any common themes in how producers described their wine in terms of sensory and regional characteristics. The results are preliminary in nature and as such, are included as other relevant material in 9.5.6.

6 RESULTS AND DISCUSSION

6.1 Region and winery selection

From the seven sources (MWs and wine guides) there were 183 wines mentioned in total. These covered 84 wineries/vineyards (see list at 9.5.1). Of these, 52 wineries had one mention only. There were 12 wineries with two mentions and 20 had three or more mentions. See Figure 6-1 for details.

Victoria was the state with the most mentions (106 mentions or 58% of total) followed by Tasmania (49 mentions or 27% of total), with full state numbers available in Figure 6-1. The winery mentions were also categorised by region and are shown in Figure 6-2. Table 9-1 and Table 9-2 list the wineries, and the number of mentions they received.

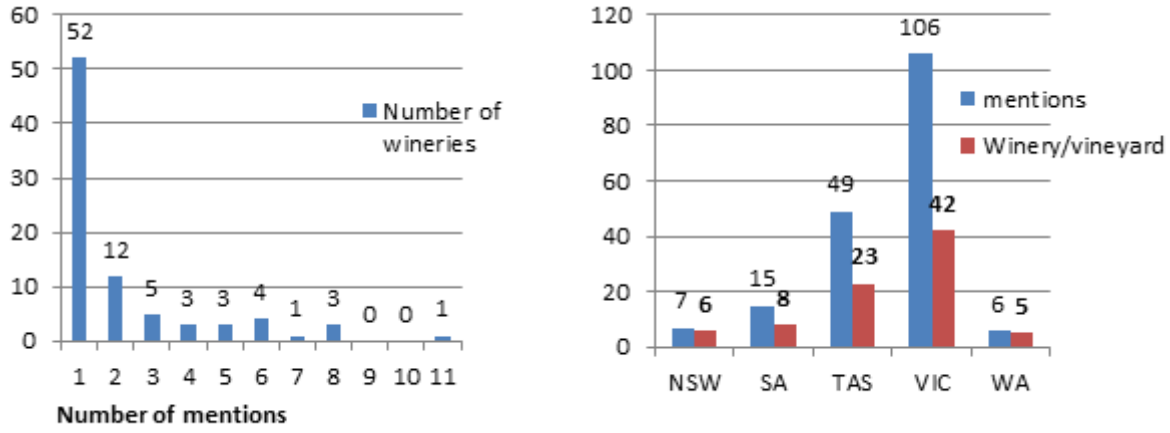


Figure 6-1 Graph on left showing number of wineries that received mentions and the number of mentions. Graph on right shows the number of wineries and total mentions for each state.

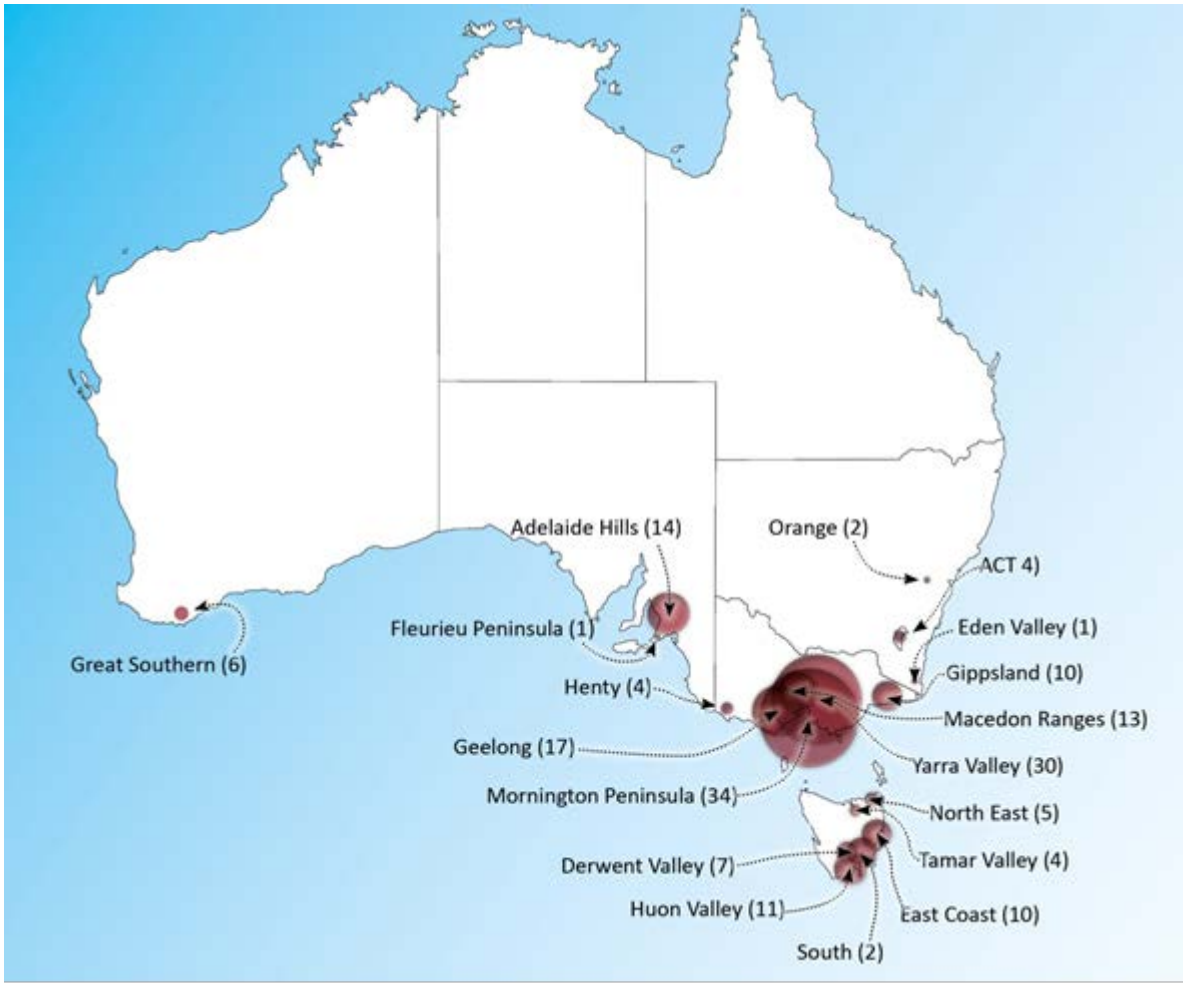


Figure 6-2 Map showing number of wineries mentioned and locations by region

6.2 Survey of site, viticulture and winemaking information

Although many producers willingly, and enthusiastically, participated in the online survey, the ~50 % return rate has impacted the usefulness of this aspect of the project. The volume of information required (9.5.2) to successfully complete the survey was significant and likely a hinderance. However, the volume of data required was appropriate for analysis, given the number of factors in the whole system of winemaking which could influence phenolic and volatile composition and sensory evaluation.

From the returned surveys, there was no single attribute which discriminated one Pinot noir producing region entirely from the others, nor was there one single attribute common amongst these premium wineries. Rather the complexity of the interaction between human decision making and the vineyard, viticulture and winemaking attributes was highlighted. This did not come as a surprise to many Pinot noir producers the project team spoke with as the project progressed, however it was reported to give

some comfort that they were not alone in dealing with this multifaceted and complex system. See 9.5.3 for more detail on survey responses and 6.3 for association with wine composition.

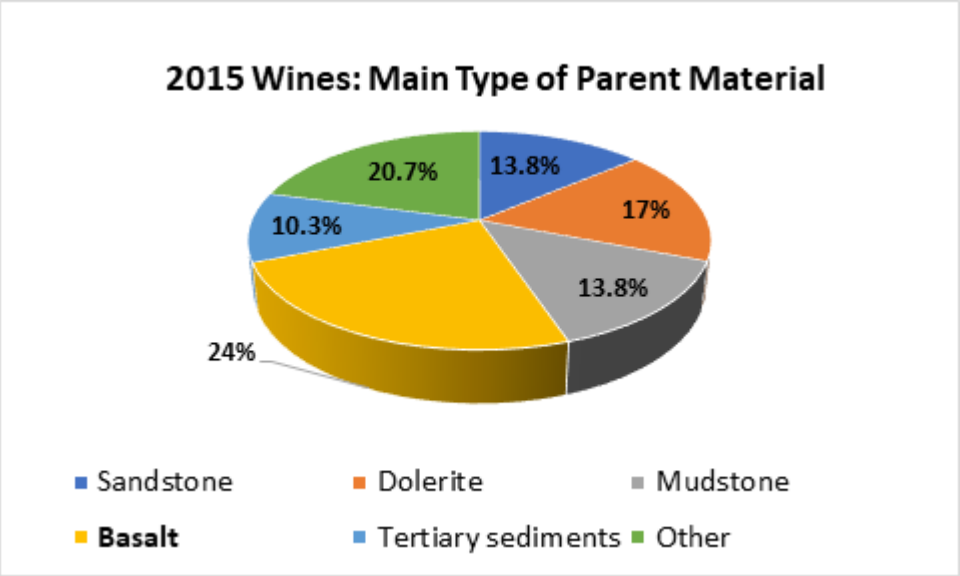


Figure 6-3 Example of survey responses regarding parent material

6.3 Colour and phenolic structure of Pinot noir wines: Understanding Australia (A)

A total of 102 Australian, single-vineyard Pinot noir wines were selected and analysed for wine colour and tannin attributes. As a general outcome, seven of the 11 chemical attributes showed significant differences for the 2015 wines (Table 6-1) and all attributes were significantly different for the 2016 wines (Table 6-2). This suggests there are regional trends when it comes to Australian Pinot noir, and this could be linked to the vineyard's site climate conditions rather than winemaking techniques or grape ripeness at harvest.

Within the 2015 sample set, the wines from Southern Tasmania and Great Southern had the highest values in colour density (Table 6-1). Colour density is equivalent to the sum of absorbance at 420 nm and that at 520 nm and is essentially due to monomeric anthocyanins in young red wines. Monomeric anthocyanins derive intact from grape skin tissue and are later replaced by more stable, darker pigments originated from the vinification process (Somers and Verette, 1988). Interestingly within the State of Victoria, the samples from Geelong had a higher Chemical age 2 than those from Mornington Peninsula. Chemical age indices are a measure of wine maturation (Somers and Evans, 1977) and show the predominance of oligomeric and polymeric pigments having progressively decreased susceptibilities to pH change and to bleaching by SO_2 (Somers and Verette, 1988).

Another important result was a higher concentration in total anthocyanins and free anthocyanins found in the Southern Tasmania Pinot Noir compared to those from Adelaide Hills and Geelong. The 2015 samples from Southern Tasmania were also the wines with the highest total pigment expressed as absorbance units (Table 6-1). Wine total pigment is a measure of total red colour and is predominantly made up from free anthocyanins and pigmented tannins. The Southern Tasmania wines selected for this study were obtained from hand-harvested Pinot noir grapes grown in own-rooted, vertically shoot positioned and cane pruned vineyards. Leaf removal between fruit set and veraison, together with shoot thinning when shoots were less than 10 cm, was also applied. This information was gathered by the authors through an online survey sent to each one of the selected wineries. These findings are important to winemakers as they provide insights into their wine's colour stability. There is no doubt that pigments determine quality in Pinot noir. Analysis at the AWRI of wines in the two-year-old Pinot Noir category at the 2010 Tasmanian Wine Show found that gold and silver medal-winning wines had high tannin and high pigment concentrations (Dambergs et al., 2012).

Unlike the 2015 results, hue values for the 2016 wines were significantly different among regions. Wines from Geelong had the highest hue value while those from Southern Tasmania had the lowest. Hue (or tint) is calculated as the ratio of absorbance at 420 nm to that at 520 nm and tend to increase while the wine ages. This is mainly due to the occurrence of oxidative influences involving *o*-quinonoid structures. These give typically brown tints which are visible in particular at the edges of the glass.

Table 6-1 **Means of Modified Somers measurements of 2015 Pinot noir wines.**

	Victoria				Tasmania			South Australia	Western Australia	Australian Capital Territory	
Attribute	**Geelong (n = 6)**	**Yarra Valley (n = 7)**	**Mornington Peninsula (n = 10)**	**Macedon Ranges (n = 3)**	**Northern Tasmania (n = 6)**	**Southern Tasmania (n = 6)**	**East Coast Tasmania (n = 5)**	**Adelaide Hills (n = 6)**	**Great Southern (n = 2)**	**Canberra District (n = 3)**	***p***
CD (AU)	3.81 c	3.50 c	3.43 c	3.60 bc	4.12 bc	5.33 ab	4.09 bc	3.62 c	6.36 a	3.50 c	** *
Hue	0.92	0.83	0.82	0.96	0.83	0.78	0.80	0.99	0.90	0.97	ns
Chemical age_1	0.59	0.54	0.49	0.57	0.54	0.52	0.55	0.59	0.59	0.50	ns
Chemical age_2	0.28 a	0.22 ab	0.19 b	0.27 ab	0.22 ab	0.21 ab	0.22 ab	0.28 a	0.30 ab	0.19 ab	**
Total anthocyanins (mg/L)	42.7 b	59.4 ab	64.6 ab	60.5 ab	62.1 ab	88.1 a	61.2 ab	44.7 b	60.0 ab	70.5 ab	** *
% Non-bleachable pigment	28.5 a	22.7 ab	19.6 b	26.9 ab	23.7 ab	21.9 ab	22.8 ab	30.2 a	29.6 ab	19.7 ab	**
Total tannins (mg/L)	789	1125	889	707	982	855	1033	1182	1785	1236	ns
Total pigments (AU)	4.20 b	4.69 b	4.93 b	4.24 b	5.14 ab	7.26 a	5.68 ab	3.68 b	6.77 ab	4.85 ab	** *
Total phenolics (AU)	35.0	40.4	37.4	30.3	37.5	37.3	42.7	39.9	54.8	43.1	ns
Pigmented tannins (AU)	1.17 bc	1.03 c	0.92 c	1.04 bc	1.21 bc	1.60 ab	1.27 abc	1.09 bc	2.00 a	0.89 c	** *
Free anthocyanins (AU)	2.25 b	2.97 ab	3.39 ab	2.51 ab	3.13 ab	4.60 a	3.56 ab	1.75 b	3.45 ab	3.37 ab	** *

Different letters along a row, discriminate the samples significantly different from one another (p-value < 0.05, Tukey's HSD test). *, **, and *** indicate significance at p-value < 0.05, 0.01, and 0.001, respectively.

Table 6-2 **Means of Modified Somers measurements of 2016 Pinot noir wines.**

	Victoria				Tasmania			South Australia	Australian Capital Territory	
Attribute	**Geelong (n = 6)**	**Yarra Valley (n = 5)**	**Mornington Peninsula (n = 6)**	**Macedon Ranges (n = 6)**	**Northern Tasmania (n = 7)**	**Southern Tasmania (n = 6)**	**East Coast Tasmania (n = 4)**	**Adelaide Hills (n = 6)**	**Canberra District (n = 2)**	***p***
CD (AU)	3.67 ab	3.39 ab	3.61 ab	4.43 a	2.98 b	3.35 ab	3.04 b	3.46 ab	3.37 ab	*
Hue	1.14 a	0.99 bcd	0.96 cd	1.01 bcd	0.99 bcd	0.94 d	0.98 bcd	1.07 abc	1.15 ab	***
Chemical age_1	0.65 a	0.62 ab	0.56 ab	0.61 ab	0.57 ab	0.53 b	0.61 ab	0.62 ab	0.59 ab	*
Chemical age_2	0.35 a	0.33 ab	0.25 ab	0.30 ab	0.25 ab	0.20 b	0.25 ab	0.32 ab	0.27 ab	*
Total anthocyanins (mg/L)	30.8 b	38.1 ab	50.4 ab	47.1 ab	41.2 ab	62.4 a	42.6 ab	1.04 b	27.9 ab	*
% Non-bleachable pigment	35.7 a	33.4 ab	24.6 ab	30.1 ab	24.7 ab	19.7 b	25.4 ab	31.5 ab	26.7 ab	*
Total tannins (mg/L)	1243 ab	1153 ab	1176 ab	1218 ab	917 ab	603 b	1032 ab	1331 a	1242 ab	*
Total pigments (AU)	3.39	3.63	4.26	4.58	3.46	4.65	3.68	3.34	3.51	*
Total phenolics (AU)	43.5	41.0	42.4	41.4	35.6	32.8	38.8	43.0	43.5	*
Pigmented tannins (AU)	1.11 ab	1.04 ab	1.04 ab	1.34 a	0.84 b	0.92 b	0.93 ab	1.04 ab	0.94 ab	*
Free anthocyanins (AU)	1.54 b	1.90 ab	2.52 ab	2.35 ab	2.06 ab	3.12 a	2.13 ab	1.60 b	1.94 ab	*

Different letters along a row, discriminate the samples significantly different from one another (p-value < 0.05, Tukey's HSD test). *, **, and *** indicate significance at p-value < 0.05, 0.01, and 0.001, respectively.

Individual wine data was returned to participating producers, with each parameter supplied as in Figure 6-4, so that producers could benchmark themselves both within their region and with other regions across Australia. Feedback from producers was that this was useful for understanding not only the Australian Pinot noir landscape, but also where their wines sat.

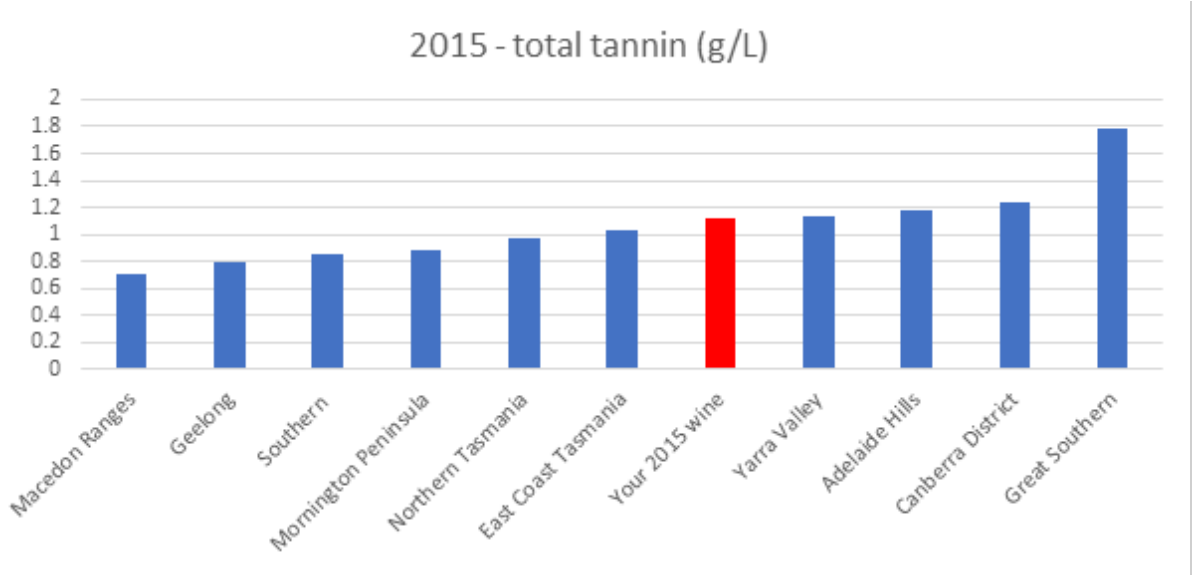


Figure 6-4 An example of MCP tannin assay wine analysis data supplied to producers.

Analysis of the colour and phenolic parameters measured by the Modified Somers assay by principle component analysis (PCA), and then labelling the data points in the scores plot by survey question responses, provided limited insight. As described in 6.2, the low return rate of the survey made it challenging to draw firm conclusions regarding drivers of Pinot noir wine colour and phenolics. Figure 6-5 is analysis of the colour and phenolic parameters when labelled by soil type of the associated block from which the grapes were sourced for the wine. It could reasonably be expected that soil type would be a primary driver of wine composition, as there were significant differences in the data between regions for many parameters as described above. However, as Figure 6-5 shows, the lack of consistency of soil type within regions, displayed as the lack of regional clustering of data points, infers (again) greater complexity within regions than can just be attributed to soil type alone. All figures associated with survey findings and association with colour and phenolic composition of the 2015 and 2016 wines can be found in 9.5.4.

Soil Type (1st Block)

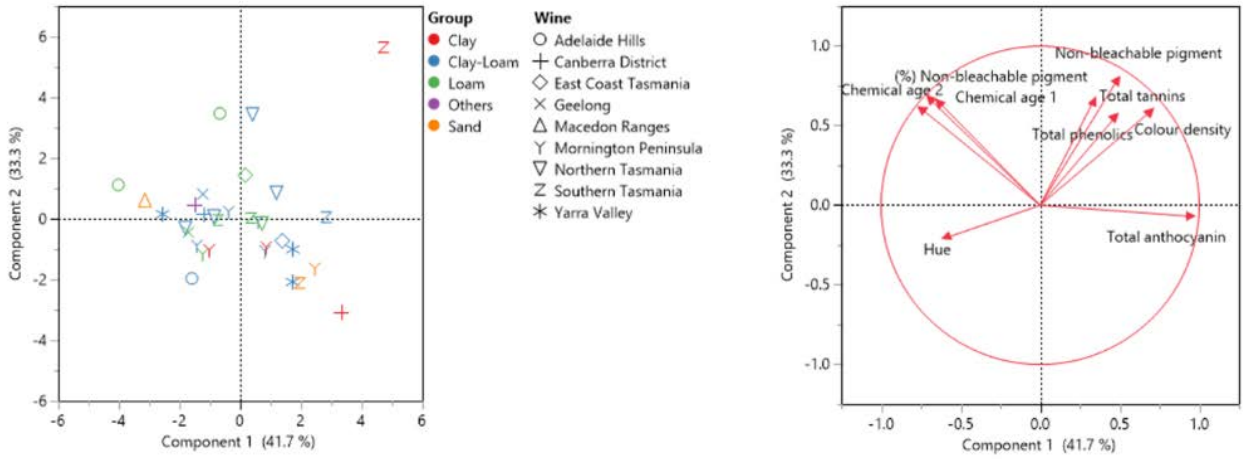


Figure 6-5 Principal component analysis of Modified Somers parameters by site characteristic soil type (from survey)

Similar to the findings of inconsistent influence of site characteristics on colour and phenolics of the commercial Pinot noir wines, viticultural practices also were not conclusively regional or clearly driving wine composition, as exemplified by defoliation in Figure 6-6. It was reasonable to expect that a regional response to viticultural practices was aspirational, as Carew et al. (2020) reported two vineyards in the 'Northern Tasmania' region (as classified in the current project) can exhibit different grape phenolic composition responses to the same defoliation treatment in the same season, similar to a comparison between 'Northern Tasmania' and 'Southern Tasmania' Pinot noir trials for sparkling wine production (Kerslake et al., 2013). Beyond Tasmanian trials, a variety of responses have been reported in the literature in response to viticultural practices, and especially the common practice of defoliation in Pinot noir from increased flavonols and no impact on anthocyanins (Price et al., 1995, Cortell and Kennedy, 2006), to increased anthocyanins (Sternad Lemut et al., 2011, Lee and Skinkis, 2013, Sternad Lemut et al., 2015).

Defoliation 1st Block



Figure 6-6 Principal component analysis of Modified Somers parameters by viticultural practice of defoliation (from survey)

No single winemaking practice resulted in data points for wines clustering closely according to region on the scores plots when analysed by PCA. Interestingly, when examining practices which could reasonably be assumed to drive colour and phenolic composition of the wines, such as total days on skins pre-ferment (Figure 6-7), there was still no overtly consistent response. There are a multitude of possible reasons for this, such as differences between clones used for the commercial wines and/or rootstocks, planting density etc., however in isolation there was not one individual attribute driving composition. There could be further opportunity for interrogation of this dataset with different statistical approaches in the future.

Total Days on Skins

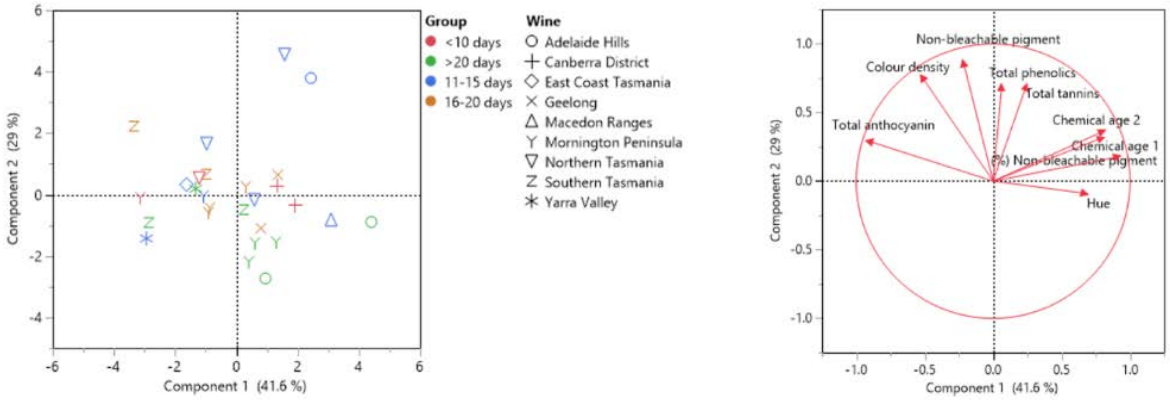


Figure 6-7 Principal component analysis of Modified Somers parameters by oenological practice of total time on skins (from survey)

6.4 A 2-year volatile and colour study of Pinot noir Wines from Australian and non-Australian regions (B)

To better understand regional drivers of Pinot noir wine chemical composition, 80 single-vineyard samples (2015 and 2016 vintages) from Australian and non-Australian regions were analysed for important volatile compounds, as well as colour and phenolic measures. The wines were sourced from five Australian and five non-Australian regions: Adelaide Hills, Yarra Valley, Mornington Peninsula, Southern Tasmania, Northern Tasmania, Burgundy (France), Willamette Valley (Oregon, USA), Central Otago and Marlborough (NZ), and Niagara Peninsula (Ontario, Canada). This volatile data was also returned to the producers (like Figure 6-1), to further deepen the benchmarking of the project participants around potential drivers of Pinot noir wine aroma. The research team then further explored these results with an additional, single vintage (2018), study which included sensory evaluation (6.5).

6.4.1.1 Wine colour and phenolic compounds

The one-way ANOVA performed on the colour and phenolic measurements of the 2015 wines showed a few notable regional differences, which are presented in Table 6-3 and Table 6-4. A higher total anthocyanin content (expressed as mg/L) was found in the Oregon's Willamette valley samples, compared to the Australian wines, except for those from Southern Tasmania (Table 6-3). Likewise, a higher colour intensity (calculated as the sum of 420 nm and 520 nm absorbance) was found in the Marlborough wines when compared to the Australian samples, except for the Tasmanian ones. Since Pinot noir grapes are characterised by low anthocyanin amounts, which are also in their less stable form (Agati et al., 2007), it could be possible that these variations are associated with the different pigment extraction and stabilisation during the maceration/fermentation process (Dambergs et al., 2012).

Table 6-3 Means of chromatic and phenolic measures determined in the 2015 Pinot noir wines.

Parameter	Australian regions (n = 5 wines each)					Non-Australian regions (n = 3 wines each)					*p*
	AH	YV	MP	NT	ST	CO	B	Or	On	M	
Total anthocyanins (mg/L)[a]	69 d	85 cd	82 cd	91 bcd	126 abc	118 abcd	88 abcd	144 a	98 abcd	139 ab	***
Total phenolics (AU)[b]	33.9 b	34.0 ab	33.3 b	31.0 b	31.2 b	37.0 ab	31.0 b	36.7 ab	49.8 a	40.0 ab	*
Hue[c]	1.11 a	1.03 ab	1.04 ab	0.94 b	0.96 b	0.93 b	0.90 b	0.88 b	1.03 ab	0.93 b	**
Colour intensity (AU)[d]	3.83 bc	3.89 bc	3.64 c	4.25 abc	5.78 abc	5.12 abc	4.01 abc	6.41 ab	4.15 abc	6.70 a	***
Non-bleachable pigment (AU)[e]	1.36 a	1.32 a	1.19 a	1.46 a	1.92 a	1.47 a	1.27 a	1.90 a	1.20 a	2.13 a	*
Total tannin (mg/L)[f]	977 ab	860 b	915 b	997 ab	923 ab	1202 ab	1074 ab	1495 ab	1864 a	1118 ab	*

- AH, Adelaide Hills; YV, Yarra Valley; MP, Mornington Peninsula; NT, Northern Tasmania; ST, Southern Tasmania; CO, Central Otago; B, Burgundy; Or, Oregon; On, Ontario; M, Marlborough.
- Different letters along a row, discriminate the samples significantly different from one another (p-value < 0.05, Tukey's HSD test). *, **, and *** indicate significance at p-value < 0.05, 0.01, and 0.001, respectively.

[a] Anthocyanins as mg/L malvidin-3-glucosides equivalents determined colorimetrically.

[b] Phenolic concentration as absorbance units.

[c] Wine hue as absorbance units calculated from the ratio of 420 nm:520 nm absorbance.

[d] Wine colour intensity as absorbance units calculated as the sum of 420 nm and 520 nm absorbance.

[e] Measure of wine pigmented polymers as absorbance units.

[f] Tannin as mg/L epicatechin equivalents determined by the methyl-cellulose precipitation assay.

Table 6-4 Means of chromatic and phenolic measures determined in the 2016 Pinot noir wines.

Parameter	Australian regions (n = 5 wines each)					Non-Australian regions (n = 3 wines each)					*p*
	AH	YV	MP	NT	ST	CO	B	Or	On	M	
Total anthocyanins (mg/L)[a]	72 c	75 c	83 bc	67 c	88 bc	118 abcd	88 abcd	144 a	98 abcd	139 ab	***
Total phenolics (AU)[b]	37.1 ab	33.6 abc	33.9 abc	27.3 bc	24.0 c	37.0 ab	31.0 b	36.7 ab	49.8 a	40.0 ab	*
Hue[c]	1.07 a	1.01 abc	0.98 abcd	0.99 abc	0.96 bcd	0.93 b	0.90 b	0.88 b	1.03 ab	0.93 b	**
Colour intensity (AU)[d]	3.99 bc	3.87 bc	4.08 bc	3.15 c	3.73 bc	5.12 abc	4.01 abc	6.41 ab	4.15 abc	6.70 a	***
Non-bleachable pigment (AU)[e]	1.25 bc	1.20 bc	1.20 bc	0.94 c	1.05 c	1.47 a	1.27 a	1.90 a	1.20 a	2.13 a	*
Total tannin (mg/L)[f]	1224 ab	1153 abc	1100 abc	743 bc	459 c	1202 ab	1074 ab	1495 ab	1864 a	1118 ab	*

- AH, Adelaide Hills; YV, Yarra Valley; MP, Mornington Peninsula; NT, Northern Tasmania; ST, Southern Tasmania; CO, Central Otago; B, Burgundy; Or, Oregon; On, Ontario; M, Marlborough.
- Different letters along a row, discriminate the samples significantly different from one another (p-value < 0.05, Tukey's HSD test). *, **, and *** indicate significance at p-value < 0.05, 0.01, and 0.001, respectively.

[a] Anthocyanins as mg/L malvidin-3-glucosides equivalents determined colorimetrically.

[b] Phenolic concentration as absorbance units.

[c] Wine hue as absorbance units calculated from the ratio of 420 nm:520 nm absorbance.

[d] Wine colour intensity as absorbance units calculated as the sum of 420 nm and 520 nm absorbance.

[e] Measure of wine pigmented polymers as absorbance units.

[f] Tannin as mg/L epicatechin equivalents determined by the methyl-cellulose precipitation assay.

For the 2016 data set, the highest total anthocyanin content was again found in the Oregon samples (Table 6-4). Interestingly, they also had higher stable, or non-bleachable, pigment (i.e., SO_2-resistant pigment) content compared to the Australian Pinot noir and the highest colour intensity of all but the Burgundy samples. These findings may be important to the wine producers as red wine colour has been shown to be an important feature for wine consumers (Dooley et al., 2012).

It is worth noting that except for the Southern Tasmania wines, all Australian samples had a higher hue value than all non-Australian wines other than Ontario. Wine hue was calculated from the ratio of absorbances at 420 nm to 520 nm and describes the colour shift from deep purple to brick-red to brown tones in a wine (Somers and Verette, 1988).

Since hue values increase as a wine ages (Bindon et al., 2014b), it is suggested that the Australian wines appear more mature, by colour, than their non-Australian counterparts at a similar age post-vintage. The regional differences found in this study will be altered by the inevitable bottling time differences between the two hemispheres (around six months) and different winemaking and viticultural decisions where the grapes were grown. Nevertheless, the overall trend of the wine colour measurements is still apparent and supported by the multivariate analysis.

6.4.1.2 Wine volatiles

The concentration of 20 aroma compounds important to Pinot noir wine are presented in Table 6-5 and Table 6-6 for the 2015 and 2016 samples, respectively. It is important to note that only the compounds detected above the limit of quantification (LOQ) in both seasons were presented in the tables. For instance, β-damascenone was the only C_{13}-norisoprenoid detected above LOQ in both years, with the Oregon samples having the greatest amounts (up to 3.18 µg/L), followed by those from Burgundy and Southern Tasmania (up to 2.30 and 2.24 µg/L, respectively). β-Damascenone has a very low odour threshold of 50 µg/L (determined in 10 % v/v ethanol solution) (Guth, 1997), although this value in red wine is estimated to be between 2 and 7 µg/L (Pineau *et al*., 2007). Where the aroma of β-damascenone was investigated in Pinot noir matrices, it was described with “tea”, “floral”, “sweet”, “honey”, “fruity”, and “green apple” aromas (Longo et al., 2020a).

Of all volatile compounds quantified, acetic acid was the most abundant (Table 6-5). A lower concentration of acetic acid was found in the Burgundy samples. This compound is often associated with wine spoilage and can be formed during the alcoholic fermentation or from the metabolization of residual sugars by acetic and lactic acid bacteria (Ribéreau-Gayon et al., 2000).

Regional differences (p-value < 0.05) were also found within the 2016 Australian wine sample set (Table 6-6). The concentration of ethyl 2-methylbutanoate in the Adelaide Hills wines was twice that found in the Southern Tasmania samples and well above its odour threshold of 3 µg/L in aqueous ethanol solution (Ferreira et al., 2000). Ethyl 2-methylbutanoate has been associated with pleasant "cherry", "sweet apple" and "fruity" aromas when analysed by means of aroma extraction dilution analysis (AEDA) in Pinot noir wine extracts (Fang and Qian, 2005, Rutan et al., 2018). Although ethyl esters of branched acids, such as ethyl 2-metylbutanoate are essentially formed during wine aging by esterification of ethanol with a branched acid (Díaz-Maroto et al., 2005), a small fraction is synthetized by yeasts via branched amino acid metabolism (Hazelwood et al., 2008).

Table 6-5 Mean concentrations (µg/L, unless expressed otherwise) of volatile aroma compounds determined in the 2015 Pinot noir wines.

Parameter	Australian regions (n = 5 wines each)					Non-Australian regions (n = 3 wines each)					*p*
	AH	YV	MP	NT	ST	CO	B	Or	On	M	
Higher alcohols											
2-Methylpropanol (mg/L)	79	86	64	88	80	63	64	60	106	89	ns
3-Methylbutanol (mg/L)	182	160	156	213	159	166	180	214	209	179	ns
2-Methylbutanol (mg/L)	68	64	63	81	64	65	64	80	83	68	ns
2-Phenylethanol (mg/L)	27 a	27 a	26 a	47 a	29 a	40 a	24 a	46 a	40 a	28 a	*
1-Hexanol	2259 ab	878 b	1107 ab	2276 ab	3428 a	1382 a	171 b	1513 ab	913 ab	2064 ab	*
Esters											
Ethyl propanoate	469 a	181 b	311 ab	236 b	285 ab	231 b	203 b	253 ab	224 b	227 b	*
Ethyl butanoate	268 ab	205 ab	247 ab	214 ab	264 ab	296 a	281 ab	212 ab	167 b	277 ab	*
Ethyl hexanoate	472 a	365 a	437 a	438 a	455 a	415 a	434 a	359 ab	208 b	462 a	***
Ethyl octanoate	398 a	377 a	389 a	413 a	398 a	435 a	480 a	358 a	160 b	459 a	***
Ethyl decanoate	163 a	152 a	114 ab	119 ab	140 ab	141 ab	87 ab	79 ab	29.0 b	129 ab	*
Ethyl acetate (mg/L)	92	85	100	85	87	83	69	92	85	96	ns
Ethyl 2-methylpropanoate	358	372	243	378	327	250	235	211	408	345	ns
Ethyl 2-methylbutanoate	58	39.1	16.8	57	26.1	41.2	51	51	55	39.7	ns
2-Methylpropyl acetate	77	80	76	90	74	64	63	57	99	70	ns
2-Methylbutyl acetate	47.2	102	45.9	58	41.6	48.0	41.1	66	60	60	ns
3-Methylbutyl acetate	240	184	201	282	188	178	215	284	201	217	ns
Acids											
Acetic acid (mg/L)	655 a	606 a	632 a	612 a	587 ab	543 ab	391 b	604 ab	536 ab	655 a	*
Octanoic acid	1517 a	1568 a	1481 ab	1657 a	1533 a	1498 ab	1860 a	1149 ab	688 b	1700 a	**
Decanoic acid	609 a	461 ab	453 ab	542 a	490 ab	424 ab	355 ab	299 ab	81 b	429 ab	*
C_{13}-Norisoprenoids											
β-Damascenone	1.51 bc	0.95 c	1.18 bc	1.68 bc	2.24 ab	1.80 bc	2.30 ab	3.18 a	0.67 c	1.63 bc	***

AH, Adelaide Hills; YV, Yarra Valley; MP, Mornington Peninsula; NT, Northern Tasmania; ST, Southern Tasmania; CO, Central Otago; B, Burgundy; Or, Oregon; On, Ontario; M, Marlborough.

Different letters along a row, discriminate the samples significantly different from one another (p-value < 0.05, Tukey's HSD test). *, **, and *** indicate significance at p-value <0.05, 0.01, and 0.001, respectively.

[a] Anthocyanins as mg/L malvidin-3-glucosides equivalents determined colorimetrically.

[b] Phenolic concentration as absorbance units.

[c] Wine hue as absorbance units calculated from the ratio of 420 nm:520 nm absorbance.

[d] Wine colour intensity as absorbance units calculated as the sum of 420 nm and 520 nm absorbance.

[e] Measure of wine pigmented polymers as absorbance units.

[f] Tannin as mg/L epicatechin equivalents determined by the methyl-cellulose precipitation assay.

Table 6-6 Mean concentrations (µg/L, unless expressed otherwise) of volatile aroma compounds determined in the 2016 Pinot noir wines.

Parameter	Australian regions (n = 5 wines each)					Non-Australian regions (n = 3 wines each)					*p*
	AH	YV	MP	NT	ST	CO	B	Or	On	M	
Higher alcohols											
2-Methylpropanol (mg/L)	77 a	94 a	70 a	100 a	74 a	64 a	94 a	49 a	86 a	108 a	*
3-Methylbutanol (mg/L)	206	185	154	213	149	186	200	188	220	203	ns
2-Methylbutanol (mg/L)	70	65	55	74	51	63	67	58	79	72	ns
2-Phenylethanol (mg/L)	37 ab	28 ab	27 ab	36 ab	19 b	35 ab	30 ab	30 ab	44 a	35 ab	*
1-Hexanol	1983	1352	1467	1880	2376	1465	1765	2203	1081	1787	ns
Esters											
Ethyl propanoate	116	74	94	92	92	78	64	108	110	89	ns
Ethyl butanoate	148 ab	156 ab	142 ab	142 ab	167 ab	210 a	157 ab	153 ab	114 b	169 ab	*
Ethyl hexanoate	187 a	209 a	180 a	187 a	230 a	238 a	190 a	205 a	105 b	219 a	***
Ethyl octanoate	206 ab	283 a	226 ab	250 a	269 a	295 a	229 ab	202 ab	100 b	253 a	***
Ethyl decanoate	52	75	56	80	79	85	40	39	18	68	ns
Ethyl acetate (mg/L)	79	95	96	80	74	73 a	68	80	78	94	ns
Ethyl 2-methylpropanoate	247 ab	284 a	235 ab	265 ab	198 ab	131 b	193 ab	137 ab	269 ab	252 ab	*
Ethyl 2-methylbutanoate	63 a	56 ab	46 ab	46 ab	30 b	28 b	34 ab	36 ab	53 ab	42 ab	**
2-Methylpropyl acetate	74	113	79	103	71	67	84	56	77	123	ns
2-Methylbutyl acetate	52	60	47	61	44	48	45	47	54	61	ns
3-Methylbutyl acetate	188	217	155	233	137	203	212	218	186	215	ns
Acids											
Acetic acid (mg/L)	587	693	629	661	558	589	544	561	690	721	ns
Octanoic acid	1260 ab	1840 a	1294 ab	1570 ab	1700 a	1843 a	1484 a	1184 ab	876 b	1574 ab	**
Decanoic acid	1953	3133	1768	2855	2400	2374	1139	1282	843	1776	ns
C_{13}-Norisoprenoids											
β-Damascenone	0.56 bc	0.74 bc	0.59 bc	0.58 bc	0.86 b	0.66 bc	0.97 ab	1.50 a	0.27 c	0.49 bc	***

AH, Adelaide Hills; YV, Yarra Valley; MP, Mornington Peninsula; NT, Northern Tasmania; ST, Southern Tasmania; CO, Central Otago; B, Burgundy; Or, Oregon; On, Ontario; M, Marlborough.

Different letters along a row, discriminate the samples significantly different from one another (p-value < 0.05, Tukey's HSD test). *, **, and *** indicate significance at p-value < 0.05, 0.01, and 0.001, respectively.

[a] Anthocyanins as mg/L malvidin-3-glucosides equivalents determined colorimetrically.

[b] Phenolic concentration as absorbance units.

[c] Wine hue as absorbance units calculated from the ratio of 420 nm:520 nm absorbance.

[d] Wine colour intensity as absorbance units calculated as the sum of 420 nm and 520 nm absorbance.

[e] Measure of wine pigmented polymers as absorbance units.

[f] Tannin as mg/L epicatechin equivalents determined by the methyl-cellulose precipitation assay.

6.4.1.3 Principal component analysis

Principal component analysis (PCA) was used to identify clusters and patterns among the Australian and non-Australian regions. The data sets from the 2015 and 2016 vintages were modelled by PCA with separate models developed for the colour and phenolic attributes (Figure 6-5) and GC/MS analytical responses (Figure 6-6). For the colour/phenolic data set, the first principal component (PC 1) reported in Figure 6-5 accounted for about 63 % of the variance, while the second component (PC 2) for over 25 %, for a total of 88 %. Most of the samples from the Tasmanian regions (NT, ST), Adelaide Hills (AH), Yarra Valley (YV), and Mornington Peninsula (MP) had in general negative scores for PC 1. On the other hand, wines from Central Otago (CO), Marlborough (M) and Oregon (Or) had positive scores, with samples from Burgundy (B) and Ontario (On) spread across the left and right quadrants of the plot (Figure 6-5a). While wines from regions with the negative scores for PC 1 such as those from the Adelaide Hills (AH) and Mornington Peninsula (MP) were associated with higher hue values, those associated with the positive scores showed a relationship with total phenolics, tannin, non-bleachable pigment, colour intensity, and total anthocyanins (Figure 6-5b). The high hue values associated with the Pinot noir wines from the Adelaide Hills and Mornington Peninsula (MP) are in agreement with previously published results (Longo et al., 2020b).

PCA of the volatile aroma compound data accounted for a total of 49 % of the variability between the wines by PC 1 and PC 2 (Figure 6-6). PC 3 accounts for another 10 % (data not shown). It is of interest to note that many wines from the 2015 vintage have negative scores for PC 1 while those from the 2016 vintage have positive values (Figure 6-6) and the wines with the negative scores appear to be driven by higher concentrations of octanoic acid, ethyl octanoate, ethyl butanoate, ethyl hexanoate, ethyl propanoate, and β-damascenone. On the other hand, those with the positive scores are associated with 3-methylbutyl acetate, 2-methylbutanol, ethyl 2-methylpropanoate, 2-phenylethanol, ethyl acetate, 2-methylpropyl acetate, 3-methylbutanol, 1-hexanol, ethyl decanoate, ethyl 2-methylbutanoate, 2-methyl propanol, 2-methylbuty acetate, acetic acid, and decanoic acid (Figure 6-6b). It is also interesting to note that the Ontario (On) subset from both vintages was the only one to cluster regardless of the vintage. This is demonstrated by the proximity of its samples on the left half of the PCA scores plot (Figure 6-6a). Since two of the three Ontario wines were produced by the same winemaker, factors other than the geographical origin, such as fermentation conditions and barrel maturation may be responsible for these findings (Schueuermann et al., 2016).

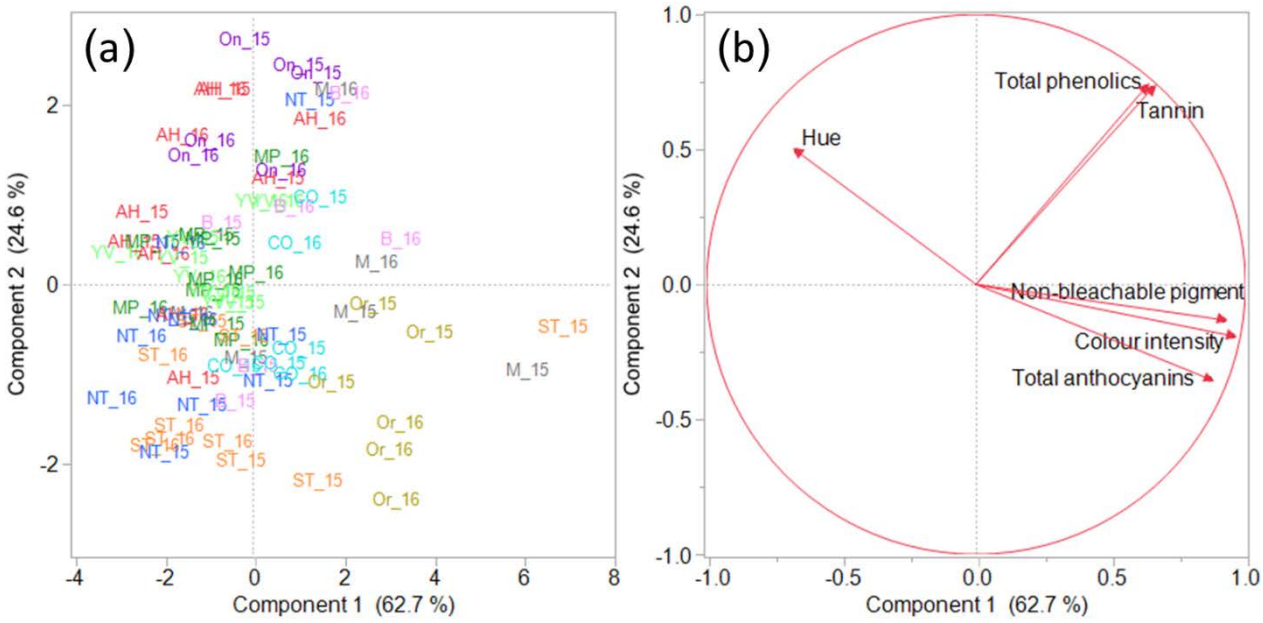


Figure 6-8 **PCA scores (a) and loadings (b) plots of 2015 and 2016 Pinot noir wines and colour and tannin analysis. AH, Adelaide Hills; YV, Yarra Valley; MP, Mornington Peninsula; NT, Northern Tasmania; ST, Southern Tasmania; CO, Central Otago; B, Burgundy; Or, Oregon; On, Ontario; M, Marlborough.**

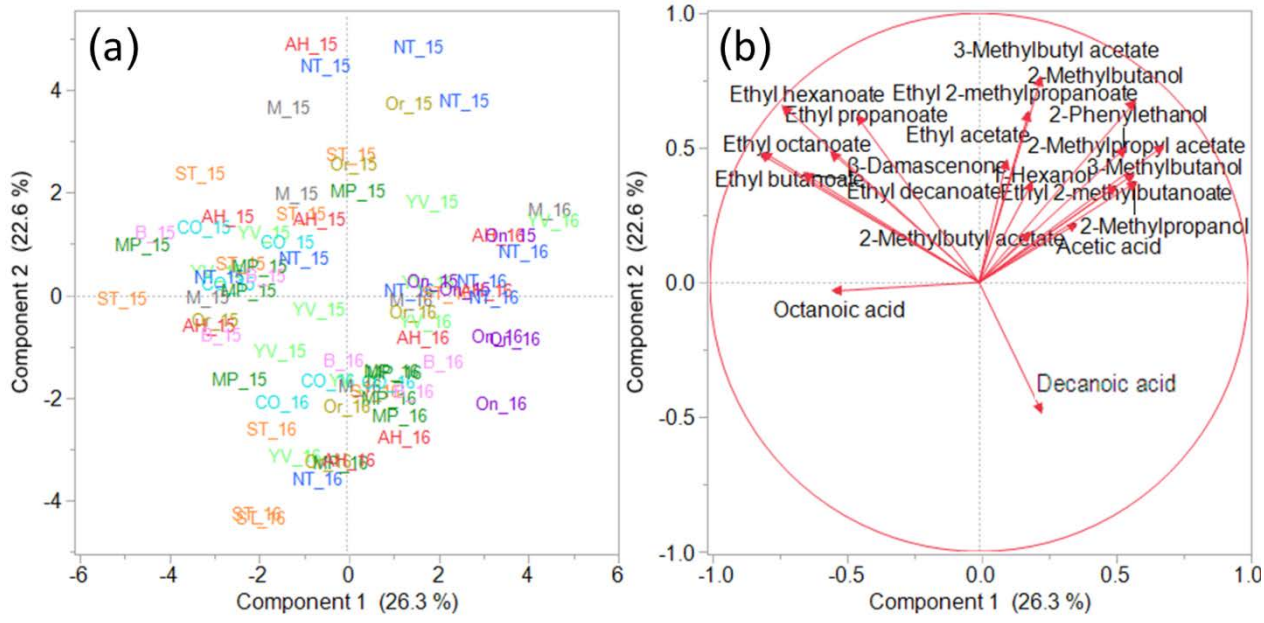


Figure 6-9 **PCA scores (a) and loadings (b) plots of 2015 and 2016 Pinot noir wines and volatile compounds. AH, Adelaide Hills; YV, Yarra Valley; MP, Mornington Peninsula; NT, Northern Tasmania; ST, Southern Tasmania; CO, Central Otago; B, Burgundy; Or, Oregon; On, Ontario; M, Marlborough.**

6.4.1.4 Discriminant analysis

Although visualisation of sample clustering with PCA scores can be performed with up to 3 principal components (PCs), discriminant analysis offers an opportunity to use more PCs to further interrogate clustering of the data and provide evidence on how well the groups can be classified (Esbensen et al., 2018). In this study, discriminant models prepared from the aroma compound data performed best for vintage classification (Table 6-7), with 100 % correct prediction (6 PCs, Figure 6-10), as compared with 73 % correct when using colour and tannin data (5 PCs, Figure 6-11). These results indicate a strong seasonal influence on volatile aroma compounds, but they also suggest a weaker relationship between vintages and colour/phenolic composition. This in part agrees with the study by Cliff et al. (2007), who found that the discrimination of commercial wines by vintage lacks a clear relationship with phenols. This could be attributed to the complex nature of phenolic compounds and how they are affected by different climate, as well as a different degree of aging (Bindon et al., 2014b, Bindon et al., 2014a). Discriminant models generated from the GC/MS data set also performed best for region classification with 94% correct prediction (6 PCs), as compared with 86 % correct when using the data set from the colour and tannin analysis (5 PCs).

Table 6-7 Classification statistics for discrimination of vintage and region with PCA scores from data related to color and tannin and volatile compounds.

Input data	PCs	Classification	Correct %
Color and phenolics	5	Vintage	73
Color and phenolics	5	Region	86
Volatiles	6	Vintage	100
Volatiles	6	Region	94

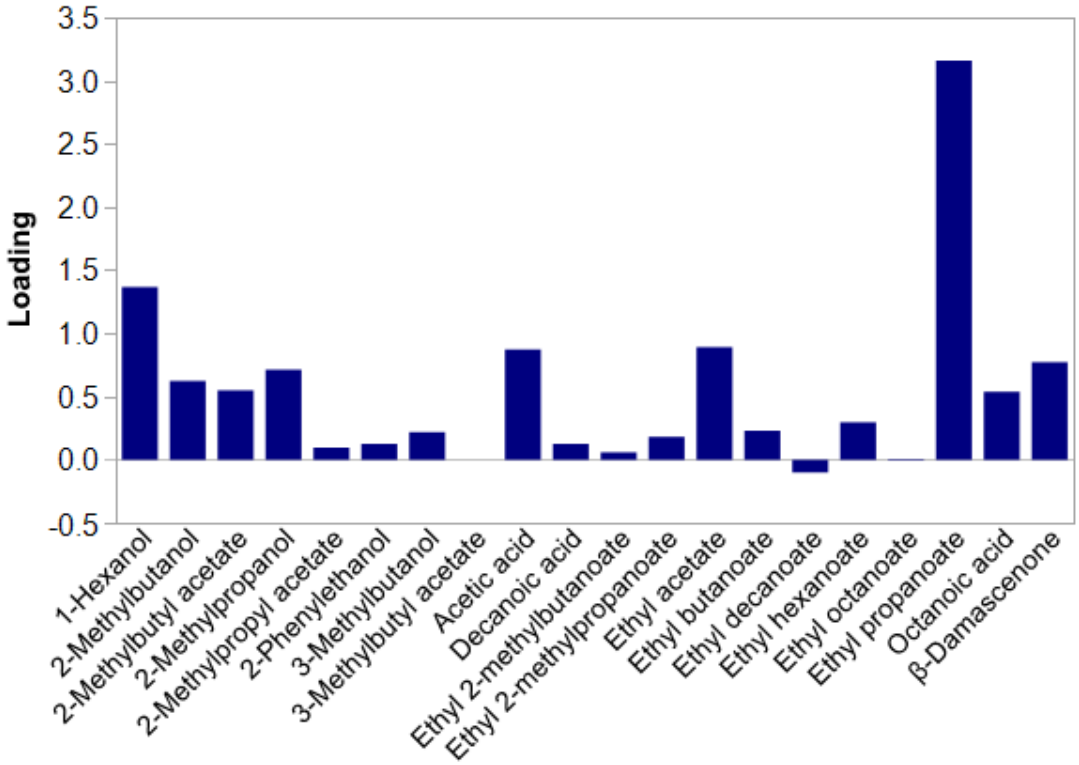


Figure 6-10 **Contributions to PCA Model (6 PCs) of volatile compounds.**

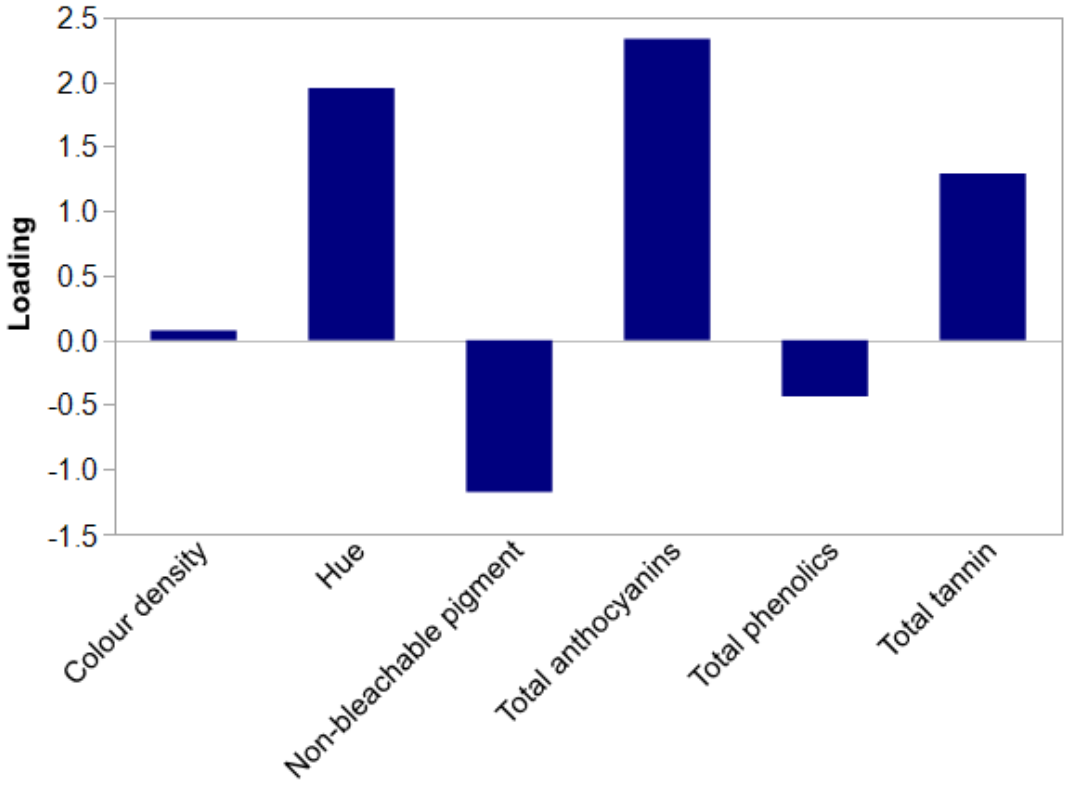


Figure 6-11 **Contributions to PCA Model (5 PCs) of colour and tannin analysis.**

Examination of the confusion matrices for discriminant analysis can give an indication of similarities between regions where some misclassification occurs. For example, using colour and phenolic data, one Adelaide Hills sample was classified as Mornington Peninsula and two Adelaide Hills samples were classified as Northern Tasmania (Table 6-8). On the other hand, using the GC/MS results, non-Australian regions were classified correctly, excepting one Oregon sample that was classified as being from Adelaide Hills (Table 6-9).

Examination of the contribution of the various analytical parameters to the PCA models may give some insight to their variation with regionality. The three strongest contributors to the PCA model of colour and phenolic data were anthocyanins, hue, and total tannin (Figure 6-7). The three strongest contributors to the PCA model of volatile compounds data were ethyl propanoate, 1-hexanol, and ethyl acetate (Figure 6-8). These findings suggest that anthocyanins, hue, and tannin levels may be important features for the geographical classification of Pinot noir wines while ethyl propanoate, 1-hexanol, and ethyl acetate could help in the classification of different vintages.

Table 6-8 Confusion matrix for discriminant analysis of region using PCA scores from colour and tannin analysis from both vintages (actual regions in columns, predicted in rows).

Region	AH	YV	MP	NT	ST	CO	B	Or	On	M
Adelaide Hills	7	0	0	0	0	0	0	0	0	0
Yarra Valley	0	6	0	0	0	0	0	0	0	0
Mornington Peninsula	1	3	9	0	1	0	0	0	0	0
Northern Tasmania	2	0	1	9	0	0	0	0	0	1
Southern Tasmania	0	0	0	1	9	0	0	0	0	0
Central Otago	0	0	0	0	0	6	0	0	0	0
Burgundy	0	0	0	0	0	0	6	0	0	0
Oregon	0	0	0	0	0	0	0	6	0	0
Ontario	0	0	0	0	0	0	0	0	6	0
Marlborough	0	1	0	0	0	0	0	0	0	5

AH, Adelaide Hills; YV, Yarra Valley; MP, Mornington Peninsula; NT, Northern Tasmania; ST, Southern Tasmania; CO, Central Otago; B, Burgundy; Or, Oregon; On, Ontario; M, Marlborough.

Table 6-9 Confusion matrix for discriminant analysis classification of region using PCA scores from volatile compounds analysis from both vintages (actual regions in columns, predicted in rows).

Region	AH	YV	MP	NT	ST	CO	B	Or	On	M
Adelaide Hills	8	0	0	1	0	0	0	1	0	0
Yarra Valley	0	9	0	0	0	0	0	0	0	0
Mornington Peninsula	0	0	10	0	0	0	0	0	0	0
Northern Tasmania	1	0	0	9	0	0	0	0	0	0
Southern Tasmania	1	1	0	0	10	0	0	0	0	0
Central Otago	0	0	0	0	0	6	0	0	0	0
Burgundy	0	0	0	0	0	0	6	0	0	0
Oregon	0	0	0	0	0	0	0	5	0	0
Ontario	0	0	0	0	0	0	0	0	6	0
Marlborough	0	0	0	0	0	0	0	0	0	6

AH, Adelaide Hills; YV, Yarra Valley; MP, Mornington Peninsula; NT, Northern Tasmania; ST, Southern Tasmania; CO, Central Otago; B, Burgundy; Or, Oregon; On, Ontario; M, Marlborough.

6.5 Chemical and sensory study with Australian Pinot noir (C)

This set of wines (C) and associated chemical and sensorial analyses were published in Longo et al. (2020b).

To evaluate associations between sensory and chemical analyses, 11 wine professionals (eight males and three females, aged 35-55 years) participated in sensory analysis of 15 single-vineyard, 2018 Pinot noir wines from five Australian wine growing regions (Adelaide Hills, Yarra Valley, Mornington Peninsula, Northern Tasmania and Southern Tasmania) (Longo et al., 2020b). The Pivot© Profile method was used given its rapid application and suitability for use with product category experts, such as winemakers or wine judges (Pearson et al., 2020). A HS-SPME-GC-MS method was used to quantify multiple volatile compounds, while the Modified Somers method was used for colour structure and chromatic component characterisation.

From the GC-MS analysis, ethyl decanoate, ethyl 2-methylpropanoate, ethyl 2-methylbutanoate, and decanoic acid differed significantly between regions (p<0.05) and were proposed as

potential regional markers for Australian Pinot noir wines (Longo et al., 2020b). It has previously been shown that the concentration of esters is strictly associated with specific grape juice nitrogen composition and lipid metabolism, which are affected either by the ripening level of grapes at harvest or nitrogen management in the vineyard or the winery (Antalick et al., 2015). Hence, inherent grape nitrogen composition and concentration attributable to region can influence fermentation health and kinetics.

Some similarities were also apparent in terms of chromatic components and colour structure, in particular for the Adelaide Hills samples, which appeared to age more quickly than other regions, having significantly higher hue values than the wines from the other regions. Some sensory similarities among wines from the same region were observed despite wines likely being produced using different winemaking techniques. The biplot combining all the most important descriptors from the appearance, aroma, and palate dimensions can be seen in Figure 6-12. Wines from the Mornington Peninsula (MP), and to a lesser extent two from Northern Tasmania (NT) were associated with 'red fruits' aroma, and 'acidic', and 'astringent' palate descriptors, while the majority of wines from Adelaide Hills (AH), Southern Tasmania (ST), and Yarra Valley (YV) was associated with the attributes 'brown' appearance, 'floral' and 'oaky' aroma, and 'complex' and 'soft' palate.

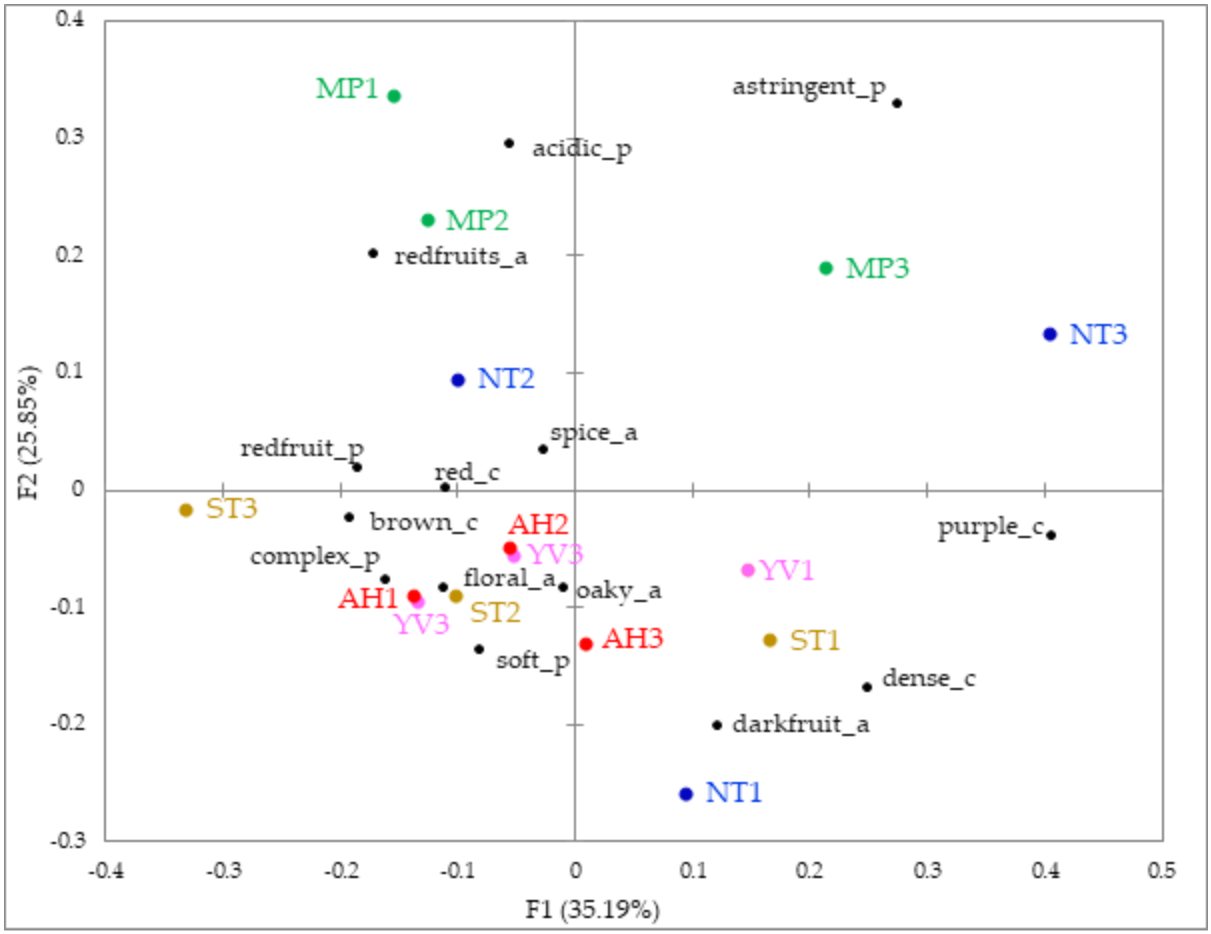


Figure 6-12 Correspondence analysis biplot of the 15 Pinot noir wines characterised using the Pivot© Profile sensory method. Regional samples designated as follows: AH - Adelaide Hills; MP - Mornington Peninsula; YV - Yarra Valley; ST - Southern Tasmania; NT - Northern Tasmania. Sensory attributes designated as c - colour; a – aroma and p - palate. From Longo et al. (2020b).

6.6 Value chain

As highlighted earlier, the third aim of this project was to identify key points within the value chain where the quality, unique character and sustainability of Australian Pinot Noir can be communicated and optimised. In today's global market, an increasing number of consumers are becoming more conscious of where (and how) their food is grown and produced. From a value chain perspective, where grapes are grown and how wine is made are fundamental to a wine's unique character and quality, which ultimately impacts on its value. Obtaining and communicating such provenance information to consumers in a format they understand and appreciate can therefore play a critical role in increasing the market share for Australian premium wines and encouraging consumers to trade up from commercial wine to high quality wines that display regional characteristics.

6.6.1 Sample characteristics

Seven wine producers were interviewed for the value chain analysis. Interviewees were drawn from a cross-section of the Australian regions included in the project, specifically: Adelaide Hills (n=2), Mornington Peninsula (n=3), Yarra Valley (n=1), and Northern Tasmania (n=1). Five of the interviewees could be classified as micro or small wine businesses in terms of their annual grape crush. One was medium-sized, and the final interviewee was much larger in scale. All interviewees had well-established brand reputations and positions within their regions. Two of the seven were in the growth/early development phase of their business, however their owners had significant experience and expertise in growing and making premium wine. Although small, the sample was representative of premium pinot noir producers, particularly those that sell single vineyard wines retailing for $>35 a bottle and target high-involvement wine consumers that have an interest in wine and regionality.

6.6.2 Background to value chain results

The concept of a wine supply chain (or value chain) continues to evolve as does the complexity of wine trade and increasing impact of environmental conditions. Broadly speaking, supply chains comprise the sequence of activities which occur from production through to the consumption, the various actors involved, and their relationships. According to Cooper et al. (1997) and Lambert et al. (1998), supply chains can be modelled according to 1) the actors or activities involved, 2) the structural dimensions of the supply chain and the broader network (horizontal – i.e., across business and vertical – i.e., up and down stream), or 3) the characteristics of the links between supply chain partners. In this study, we focused on 'end-users' or actors in the supply chain, who perform the various activities required to grow, make, and market premium wine.

Although the terms supply chain and value chain are often used interchangeably, there are important differences in how they are defined in the literature. Supply chains is the term given to the 'chain' of businesses or actors involved in the production of a good or service. The focus of a supply chain is on the flow of this good or service through the various parts. Value chains involve the same actors or activities, however there is a greater emphasis on how each can create or enhance value for the end consumer.

Similar to the western concept of a value chain, French commodity chain researchers talk about 'filiere' (translated literally as thread) to describe the network of connections that are involved in a product's life, from its initial material extraction to final consumption (Raikes et al., 2000). While such networks typically comprise a producer, processor, wholesaler, retailer and consumer, in the

case of wine, it is important to note the diversity of value chains that exist. For example, commercial/global wine companies may have a very long and complex chain, where growers and winemakers are themselves separate actors and then wholesalers, distributors, retailers and marketers are active intermediaries between the wine producer and consumers. Further linkages are then created between the national markets in which they operate. This contrasts with a more simplified or local wine producing system, where a producer grows their own grapes, makes their own wine and in many cases sells most of their product direct to the consumer via a cellar door or wine club. This latter type of value chain therefore excludes any major reliance on distribution networks or other intermediaries. In between these two types is a variety of value chains of varying complexity.

Figure 6-13 below represents a typical wine supply chain. In addition to these stages, other actors and activities may feed into the creation of value. For example, the winery cellar door represents an important channel for selling wine, developing relationships with visitors and the trade, and educating consumers about the wine, wine brand, and the region (Bruwer, 2002). In addition, wine writers (and the broader media) play a role in the marketing of individual wines and creating awareness of the regional characteristics of wine produced in a particular geographic area.

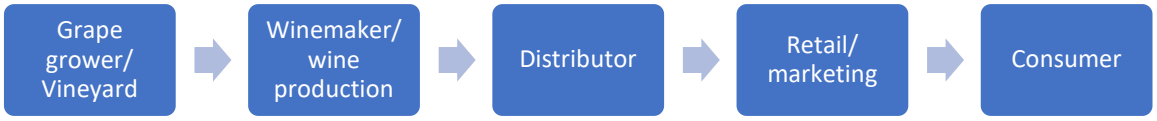


Figure 6-13 A typical wine supply chain

Given the constraints of this study we focused on obtaining the perspectives of the 'wine producer'. Regarding Figure 6-13 above, this actor generally assumes responsibility for both growing grapes (often in company-owned vineyards) and making wine (often themselves in their company owned winery). Some of the larger producers we interviewed carried out their own distribution and marketing via sales teams, which meant they had greater control over their value chain. For small-scale producers, third party distributors represent an efficient and cost-effective way to outsource the time, resources and expertise associated with this important activity. According to Goncharuk (2017), distribution can be understood at a local, regional, national, or international level depending on the strategy and production capacity of the wine business. In the section below, we present the results of the value chain interviews. Starting with a discussion of what provenance means in the context of Pinot noir, and why it is important.

6.6.3 Perceptions of provenance

In the past twenty years there has been a concerted effort to increase the size of the premium wine market in Australia, shifting industry's focus from quantity to quality and encouraging more consumers to drink wines that display regional characteristics (Francis and Williamson, 2015, Lockshin and Corsi, 2012, Johnson et al., 2013).

According to Warman and Lewis (2019) place is more than just a physical location on a map—as well as being spatial, place has social, cultural, and discursive qualities that greatly influence its value on wine. Like place, provenance is important to many Australian wine producers, particularly those who compete in the premium and ultra-premium segments of the market. As Australia's wine sector matures and the number of wineries in different regions increase, it is important to understand how representatives from wine businesses define provenance and how, as a concept, it can enhance the growing, making, and marketing of Australian pinot noir.

Analysis of the interview data collected for this project revealed that provenance is typically defined as "*the geographic and the climate conditions and how that impacts your grapes and in turn your wine*" (Producer 4), which is in line with what the French term terroir.

Other definitions included "*an expression of your site*" (Producer 2) and "*the different growing conditions [such as] soil types, climate, rainfall, aspects, age of vines and then an overlaying regional difference*" (Producer 1).

In addition to these traditional definitions, producers indicated how their definition (and indeed the importance) of provenance differs according to whether they are referring to the attributes of a region, subregion, single vineyard, or vineyard block. This scaling up of thinking represents a shift from some time ago, when provenance was understood and applied almost exclusively at the national level, for example "*for years provenance was Australia*" (Producer 2). Decades ago, a wine producer's understanding and interest in provenance was mostly limited to conversations around the varieties grown in well-established regions (e.g., Shiraz in the Barossa). Today, it is has moved beyond this to include not just varieties but clones, not just regions but subregions or single sites, and their rainfall, soil types, climate, and age of vines. In other words, the thinking has become more sophisticated and now includes consideration of the different layers or levels of a wine place. At the same time, the number of wine producers "making really serious examples of pinot" has increased, which has strengthened the subregional picture.

> *"There is more material, there are more people doing interesting things, so the gaps are gradually being filled in with a bit of detail."* (Producer 1)

Moreover, today it is not just the vignerons and winemakers who understand and are interested in regionality and terroir, but several other actors in the value chain, such as wine marketers, cellar door managers, distributors, sommeliers, and retailers. These end-users are increasingly engaging in and leading these more sophisticated provenance conversations, which represents an opportunity to add value given their proximity and contact with the consumer.

Not surprisingly, many of the interviewees felt that a growing number of consumers are interested in provenance, which is reflected in restaurants, for example, "*naming up the sub-region of where Pinot is from*" (Producer 2) and the popularity of wine flights at a cellar door to display the differences between sites or growing areas. When executed correctly, these strategies can reaffirm the provenance characteristics and regional story consumers are seeking, and ultimately can have a positive impact on sales through encouraging wine consumers to 'trade up' to better quality and more premium wines in the category, and/or the producer's own range.

> *"As they delve deeper and become more engaged, they will actually want to spend more money"* (Producer 2).

During our interviews, it also became clear that other end-users in the value chain are becoming more interested in (and aware of) how a particular site, clone or soil type produces a different style and quality of wine. This growing appreciation for the differences "*adds value or brings value because its distinctive*" (Producer 1). As the end-users become educated and engaged in understanding terroir and provenance, regional differences become a greater and more convincing part of the wine story. What is important to note here however is that as wines enter higher price points, consumers become more discerning and demand more complexity or "layers" to a producer's provenance story.

> *"When you move into higher price points you are looking at collectors, and the gatekeepers in the trade. They are looking for more layers that they can communicate to their friends or to their customers, and that is where the subregions become part of the story."* (Producer 1)

The additional layer is where communicating the findings of wine science can add value. Through projects such ours, producers have access to an evidence base regarding regional attributes, and how their wine is benchmarked against such attributes. While such scientific data is not directly translatable to consumers, it can be captured in more 'simple' terms and integrated with other more qualitative aspects of the wine story.

At a national level, regional data can add value to the overall Australian story and verify the messaging that some wine producers and organisations have been trying to communicate for some time.

> *"We've got to focus more on terroir than we have been…Australia is a very unique viticultural country, (yet) all the people and the stories of the people are predominant"* (Producer 7).

Telling more regional specific provenance stories, comprising information about geography and the place (rather than brands, varieties, and people) will elevate Australia's reputation as a destination for premium pinot noir, and enable individual producers to add value to their wine. As Producer 7 explained, stories based on people "*arrive and fade…whereas terroir is a constant*". A similar comment was made by Producer 1:

> *"The problem with provenance is that you need a collective to be expressing the regional characters that you see readily...if you pick your grapes very late or very early, if you use lots of new oak [and so on] you can push wines outside of reflecting where they naturally come from."*

The quote above highlights another potential issue for some of Australia's wine regions in that they are still developing in terms of number of producers and the degree of unity between them. Some may have a network of established winemakers, as well as 'new' winemakers or new owners of established vineyards. If so, it is important to find ways where through mutual benefit and cooperation, knowledge and experience can be shared, and a consistent provenance story can be told. From a regional perspective, maintaining the stories or heritage of the original vineyards and brands can also optimise the provenance attributes of a place. For example, as one of the oldest vineyards in their region, Producer 4 explained:

> *"when we took over the property people were making sure what we were doing was [true to the region]. I think over time we realised it's because if the old original places in a region start to die away it's not good for the region's story".*

Protecting this heritage (or historical) aspect is potentially very important when selling in international markets, where Australia is classified as a very young wine producing country compared to regions in France, for example. Moreover, provenance stories that emphasise heritage, as well as the diversity of the regions and subregions will help persuade end-users (such as distributors, retailers, and

consumers) in international markets that Australia is "*a valid Pinot producer" (Producer 7), capable of producing wines that are sophisticated and cool climate*.

6.6.4 End-users and their capacity to enact change

During the value chain interviews we also sought to identify the specific end-users who have the capacity to enact change regarding the quality, unique character, and sustainability of Australian Pinot noir. The following is grouped according to how each end-user may extract value, especially in relation to how they acquire and share information about regional characteristics, and their role in provenance storytelling. Complementing this section is the International Journal of Wine Business article by Warman and Lewis (2019), which was associated with this project.

6.6.4.1 Grape grower/ Vineyard

Not surprisingly, according to the wine producers interviewed the actor responsible for growing grapes and/or the vineyard, was the most significant end-user in terms of enacting change regarding provenance. This was because of the vital importance of having fruit that expresses the natural characteristics of the site, and then being able to transform this into high quality wine. Comments such as "*the big thing I have realised is that I spend 90% of the year in the vineyard and the winemaking is just the little finishing bit at the end*" (Producer 4) illustrate this. As part of the shift towards more sustainable grape growing and winemaking practices, many of the producers we interviewed noted they had moved away from more scientific or conservative techniques that arguably produce a "*sterile environment in the vineyard*" (Producer 6) to a more hands-on and natural (fewer chemicals) approach. Comments such as *"[we] try to be really minimal and just look after the vineyard*", "*we are just really gentle…we just want the fruit*" and "*basically what we're hoping will happen is that the wines express the vineyard as well as the vintage, and to a lesser extent, the winemaker*" (Producer 6) demonstrate the significance of the vineyard site and staying true to the conditions of that area.

Analysis of the interview data also revealed that the more established wine producers had learnt about the unique character of their vineyard, their region, and the environmental conditions affecting both, through years of experience and vintages. This knowledge added immense value to their ability to produce quality wine reflective of its provenance, while also adding a more sophisticated understanding of growing pinot noir as a variety and how to protect the unique character attributed to each region. For example, Producer 6 explained that when they first planted the vineyard their approach was "*try and minimise the risk*", while 20 years on and "*you learn the*

boundaries and also the property…you learn how far you can push it". Similarly, Producer 2 commented:

> *"In the last 18 or 19 years of seeing the evolution of [brand] wines…we are trying to unleash the greatest potential that the fruit gives us from that site…through the [winemaker's] efforts and the vineyard guys, the way the fruit is being expressed is improving greatly".*

In addition to learning and developing independently, there is also a significant role for vineyard associations and collaboration between producers to share knowledge and engage in benchmarking. Many of the producers interviewed realised value in "*drinking collectively or tasting collectively with other members of the region*" (Producer 1) or trialling new techniques with other vineyards and winemakers. With premium pinot noir there appeared to be an even stronger desire to share ideas and collaborate, perhaps because of the fragility or intricacy of the variety, and the "*nature of the people behind it*" (Producer 3). Many of the wine producers had witnessed a marked improvement in their wine quality "*from asking questions and doing those trials*" (Producer 5). Interviewees also explained how new players in the industry benefit from the collaboration and knowledge sharing that has taken place before them, and hence capturing this and being able to pass it on in a reliable and user-friendly form is important.

6.6.4.2 Winemaker/winery

A strong theme in the interviews was that extracting value from provenance at the winemaking stage or in the winery takes systems and commitment. This was perhaps best articulated by Producer 2, who explained:

> "*it (a commitment to provenance) adds a huge layer of complexity into the management of a winery, especially if you have fruit coming from all sorts of different blocks and vineyards, and then being fermented, and records, and barrels*".

All the interviewees also commented that rather than aiming to make a particular style of pinot noir, they were committed to making wines that expressed their site and region. Producer 5, for example, stated "*we're not trying to formulate wines that we think will sell. We're making wines that we like and hopefully express where they're grown*". Although trying to make a particular style of pinot was not common, it is important for the industry to have benchmark wines.

> *"But that doesn't mean to say we're trying to make burgundy…we're going to make new-world pinot noir that is very high quality…that is what we're hoping people will embrace, and if they like the wines, buy them"*. (Producer 5)

During interviews it was also apparent that to optimise value at this stage, it was vital to make wines expressive of the region. To achieve this, the producers interviewed used what they described as mostly simple "non-destructive" winemaking techniques. Over time, some had trialled new techniques and moved away from conventional practices, but according to Producer 7 this was mostly in a "*an evolutionary fashion, rather than jumping into something that might have a big impact on the character of the wine*".

6.6.4.3 Distributor

Another of the most critical end-users in the value chain is the distributor, and for the larger wine businesses, their national sales team. For small wine producers, developing a strong relationship with a distributor was critical for extracting value from provenance attributes. Finding a distributor who was a 'good fit' for the business and was empathetic to the demands of being a winemaker and small business owner was also important, as Producer 3 explained:

> *"Twenty years ago, the distributors really expected a lot of time of winemakers in the trade. There were less of us, so we were still a novelty. These days, I think we might be a nuisance"* .

Several of the interviewees spoke about the changing emphasis their distributors placed on regional attributes, and the importance of educating them about their wine's characteristics and regional story. Within the premium wine segment especially, a growing number of distributors are opting to specialise in a particular portfolio of brands and themselves develop relationships with other supply chain partners such as sommeliers and restauranteurs. These relationships are important because as per Producer 6's commented:

> "*they're the people who are telling the story to consumers as well. So, you need to make sure one they are informed, and two you listen to their opinion and see what they think*".

Though for some smaller producers "*putting that time and effort to get that relationship going in a considerable way is a hard business*" (Producer 4), hence why some producers opt for national distribution companies rather than independents. Analysis of the interview data also suggests that in

premium wine markets, it is increasingly important that a distributor had an appreciation for the wine style, the brand's story, and the producer's target markets. If a distributor understood the importance of all three and could represent them accordingly, they would extract greater value. As Producer 5 explained:

> "*the distributors we have now are very sympathetic to our situation. It's a competitive market out there…part of it is persuading potential customers that the product is good, and worth the money, but more than that they will be subjected to great pressures to do deals and give discounts...how do we ensure that they're telling the right stories? Well, we can't do that. We're hoping that they'll tell the stories that we want them to – and I think generally they do. I think dealing with three separate, relatively small companies helps with that*."

This attention to detail was highlighted by Producer 1 also, who explained selling their wine well, meant having the "*right amount of stock into the right venues at the right prices*". Ensuring the distributor or national sales team can confidently and correctly describe the wine and its provenance was another key factor in extracting value through their ability to target and sell to restauranteurs and retailers more efficiently. As Producer 3 explained, sommeliers and wine buyers these days "*are inundated*".

6.6.4.4 Retail/ marketing

Staff training is another critical activity for extracting value from provenance attributes and adding value to the retail stage of the supply chain. Before producers can 'work with' other end-users in their supply chain around provenance storytelling, they must themselves have:

> *"a clear idea of what your message is...and if you are going to use provenance as a cornerstone to your messaging you better actually be committed to it"* (Producer 2).

This focus on internal marketing, not just external marketing via retailers and promotional channels, enabled producers to extract greater value. For example, another well-established producer spoke about how provenance was a core principle to their business and how:

> *"we are not only trying to educate outwardly, but we are trying to educate inwardly with our internal teams"* (Producer 1).

Several of the producers we spoke to conducted guided tastings, workshops and training sessions with their cellar door staff and sales teams. In some cases, this internal marketing and training would extend outwards to distributors, restaurants, sommeliers, and retailers, thus recognising the important role they play in protecting and enhancing value. From the perspective of the smaller wine producers, third party endorsements from wine writers and other wine professionals were extremely valuable in terms of getting their provenance story out into the market. Producer 4, for example, spoke of how important it was "*to make sure everyone's out there invoking it and not being afraid to talk to wine journalists, rather than just sending them a bottle silently at the end of each year*".

In addition to internal marketing, our interviewees emphasised that telling a consistent story via social media, websites and other direct marketing channels is important, particularly for encouraging consumers to trade up from entry level wines to the more premium.

All the producers we interviewed were not surprisingly in favour of selling their wine at independent speciality stores compared with 'big box' retailers. This is in part because of the type of consumer they were targeting (i.e., professional, higher income), but also because the risk of diluting or damaging their provenance story in a speciality store is less than what it is for a big box retailer. For example, Producer 3 explained how they were "*always cautious*" regarding their retail channels because "*with a premium brand like ours, positioning is critical*". Other small producers relied heavily on direct-to-consumer channels such as wine clubs or cellar doors where they could communicate a more powerful and persuasive story to consumers.

On-premise outlets such as restaurants and bars were a further opportunity to extract value from provenance attributes. More restaurants and bars are curating their wine lists to include several wines of the same variety, as well as showcase a particular region or wine style. For one relatively medium sized producer, maintaining good relationships with restauranteurs was important because "*they're the people who are telling the story to consumers as well. So, you need to make sure that one, they are informed, and two, you listen to their opinion and see what they think*.". Compared with retail, Producer 6 also commented that restaurants and bars offer a better opportunity to convey or explain "*the messaging a lot better*", because the consumer is ordering wine to enjoy with a meal or drink socially, and not necessarily buying simply because of price.

At the regional level, telling stories via collaborative marketing is important for growing and enhancing the premium category. Producers 6 and 7, for example, commented:

> *"that's the beauty about sub regions or regional messaging, you can tell a story. It's not all mass produce or bulk…a lot of the producers who are making pinot are not big…there's a lot of smaller producers so you can convey that message and you can tell a story".*

> *"regions have to develop their own stories and make them consistent and make them geographically believable so that the winemakers in that region can fit into that slot and reinforce their particular vineyard and its differences in soil and geology [and climate]."*

6.6.4.5 Consumer

The consumer market for Australian premium pinot noir is evolving. Nearly all the interviewees, for example, spoke about noticing "younger professionals" becoming more interested in pinot as a variety, as well as single vineyard or even single block wines that express the unique character of their region. As Producer 6 explained:

> *"consumers have come a long way…now we might have five different pinots (in our range). Twenty years ago, it was hard enough getting the message across with one or two pinots".*

Similarly, Producer 4 had found that "*consumers are definitely getting more savvy, right down to they want absolute specifics in what your winemaking is, what your soil profiles are, what aspects of the vineyard, everything*". Another strong theme during the interviews was that consumers looking to buy premium Australian pinot noir are influenced by access to information. It is widely accepted that wine consumers will go online to find out information about a region, a producer, or a particular variety or wine style. "*They are asking all these questions…and they are more passionate about it than we are about making wine*" (Producer 6). This apparent growth in the premium segment has made events like Pinot Palooza popular among younger consumers, and smaller tasting events in the regions popular among the older, more discerning consumers. Producer 3 described some of his customers as:

> *"really enthusiastic people…wine nerds…they're like we were when we started 40 years ago… but there are still plenty of customers out there that are buying the brand first and the region second"*.

While access to information is beneficial for adding value, particularly when producers have information easily available on their websites, Producer 7 suggested the industry must find ways of making provenance or place-based stories more interesting for younger consumers, particularly those form the millennial generation. “They are caught up in the world of social media, and that’s very personality driven…as opposed to factual, scientific or geographic”.

7 OUTCOMES AND CONCLUSIONS

A primary outcome from this project has been a deepening of understanding of the variety of Pinot noir wine styles able to be produced across Australia, particularly for the >50 producers who participated in this project. The provision of data individually back to producers that enabled it to be compared within and between regions, was described by one producer as of great value in "understanding their patch of dirt and being able to tell its story".

Despite no single site characteristic, viticultural or winemaking practice being able to be described as 'regional' nor a contributor in its own right to provenance of the commercial Pinot noir wines, there is an opportunity to embrace the complexity and individual producer uniqueness of this challenging variety. Pinot noir has long held a reputation as being fickle to grow in the vineyard and unforgiving in the winery, however this also gives the wines allure and mystique as a firm wine profile cannot be ascribed to any one region, rather there are general trends for regions. However, wine analyses in the current project did find colour and phenolic profiles of the wines were predominantly driven by the region from which they came, rather than the vintage, although the survey to uncover which site characteristic was driving this was inconclusive. Conversely, the aroma profiles of the wines were more driven by vintage, than by region, and was consistent between hemispheres which could indicate larger scale climatic drivers impart their influence, such as the Indian Ocean Dipole or Southern Oscillation Index in the Southern Hemisphere.

Given the higher price points that premium Pinot noir wines command, this complexity sits well with the demographics of the Pinot noir consumer which generally tend towards the affluent, discerning and well educated who exhibit a thirst for knowledge. Upon examination of the back labels of the wines used in the current project, there was a tendency to provide data, rather than wine descriptors, to satisfy this consumer interest. Variation between vintages and regions is generally well understood and accepted by the cohort, and most often, celebrated.

Projects such as this serve to highlight the importance of provenance to premium Pinot noir producers in a sample of Australian regions. Given the variety itself is in a relatively early stage of category development and the number of producers is small comparable to other red varieties such as Shiraz and Cabernet Sauvignon, one of the key benefits from extracting provenance related information is it enables regions and producers to add more detail into their provenance stories. Overall, "the more information we have, the easier it is to tell the story". (Producer 6). The debate around regions versus subregions is still dominant in the industry, and this feeds into collective conversations and messaging around provenance. More than one of the producers we interviewed spoke about how they were

involved with other producers in “identifying subregions and mapping those properly…more for education and consumers and trade” (Producer 6).

It would appear that the provenance of Pinot noir cannot be explained without the creativity and scientific approach of the winemaker being included as part of the equation. Trends, and indicators of regionality, such as the colour and phenolics of the wines, can be observed, but there will more often than not be a completely contrasting response in other Pinot noir wines from the same region. The inherent understanding of site, vineyard and fruit and the experience and knowledge with how to work with these to produce a desired style, cannot be replaced by prescriptive approaches.

8 RECOMMENDATIONS

The current project has served well as a preliminary investigation into a complex grape variety, however it is recommended that a more reductionist approach is required if the complexity is to be further unravelled. Interestingly, throughout the course of the project, it would appear that there are a cohort of producers who wish to unravel the complexity so as to better understand and manipulate their own vineyards and wines, however there is also a cohort of producers who wish to maintain the mystique of Pinot noir wines. The latter appear to frequently be the storytellers, who bring the human element into the narrative. The story includes the region, the place, the season, the viticulturist, the winemaker and the brand as parts of a whole. It is recommended that any project which follows the reductionist approach employ standardised winemaking practices across various sites and regions to eliminate the winemaking influence.

It is recommended that businesses, particularly medium to large businesses, develop an internal understanding in a Pinot noir wine business of provenance and place before going out to others to then communicate the value of the product. Cementing a narrative amongst larger teams can be challenging, but different versions communicated externally can complicate the position of the brand in the marketplace.

It is recommended that the impacts of climate change be investigated for Pinot noir wines, as the vintage variation observed in the current study will most likely be amplified with predicted climate change and variability. A deeper understanding of how the weather influences the flavour and aroma profiles can assist producers to start to climate-proof high performing vineyards through adaptation strategies, or seek new locations if intending to continue to produce certain wine styles.

Developing the value chain analysis further, it is recommended that a consumer survey be undertaken to explore how they understand provenance, what specific information are they interested in, how does this affect their purchasing decisions and in what context, and how this all differs according to the level of involvement or engagement the consumer has with Pinot noir.

9 APPENDICES

9.1 Communication

9.1.1 Journal Papers

- Longo, R., Pearson, W., Merry, A., Solomon, M., Nicolotti, L., Westmore, H., Dambergs, R. & Kerslake, F. 2020. Preliminary Study of Australian Pinot Noir Wines by Colour and Volatile Analyses, and the Pivot© Profile Method Using Wine Professionals. *Foods*, 1142. DOI: https://doi.org/10.3390/foods9091142
- Longo, R., Carew, A., Sawyer, S., Kemp, B. & Kerslake, F. 2020. A review on the aroma composition of Vitis vinifera L. Pinot noir wines: origins and influencing factors. *Critical Reviews in Food Science and Nutrition*. https://doi.org/10.1080/10408398.2020.1762535
- Warman, R., D. & Lewis, G. L. 2019. Wine place research: Getting value from terroir and provenance in premium wine value chain interventions. *International Journal of Wine Business Research,* 31**,** 493-508. https://doi.org/10.1108/IJWBR-09-2018-0052

9.1.2 Conference Papers

- Fiona Kerslake, Rocco Longo, Wes Pearson, Samantha Sawyer, Angela Merry, Mark Solomon, Luca Nicolotti, Hanna Westmore, Jacqui McRae, Amanda Ylia and Robert Dambergs, (2020) "Understanding regionality and terroir in Australian Pinot noir", XIIIth International Terroir Congress, Adelaide, South Australia – Keynote presentation
- Fiona Kerslake, Rocco Longo, Wes Pearson, Samantha Sawyer, Angela Merry, Mark Solomon, Luca Nicolotti, Hanna Westmore, Jacqui McRae, Amanda Ylia and Robert Dambergs, (2020) "Understanding regionality and terroir in Australian Pinot noir", XIIIth International Terroir Congress, Adelaide, South Australia – Conference paper
- Fiona Kerslake, Rocco Longo (2020), "Provenance of Pinot noir – drivers of regionality", AWRI webinar, https://www.youtube.com/watch?v=muDnykcp2z4&feature=youtu.be
- Longo, R and Merry, A and Dambergs, R and Lewis, G and Westmore, H and Kerslake, F, (2019) "Pinot Noir provenance project overview", 21 - 24 July, Adelaide, Australia, – poster presentation
- Lewis, G and Warman, R, (2019) Placing wine in post-colonial agrifood worlds, Agri-food XXVI, 1-5 December 2019, Christchurch, New Zealand - Conference Extract
- Longo, R and Kerslake, F and Lewis, G and Doyle, R and Close, D and Merry, A and Westmore, H and Donachie, L, (2018) "Australian Pinot Noir wine benchmarking: understanding from a terroir concept appro

ach", *Crush 2018: the Grape and Wine Science Symposium*, 25-26 September 2018, Adelaide, South Australia - Plenary Presentation

9.1.3 Field days, Workshops and Meetings

- Longo, R and Kerslake, F and Lewis, G and Dambergs, B and Doyle, R and Close, D and Merry, A and Westmore, H and Donachie, L, (2018) "Australian Pinot noir wine benchmarking: understanding from a terroir concept approach", *2018 Winemakers Symposium: Regionally First and Foremost*, 16 October 2018, Tamar Ridge, Tasmania - Keynote Presentation
- Kerslake, F and Longo, R and Lewis, G and Dambergs, RG* and Doyle, R and Close, D and Merry, A and Westmore, H and Donachie, L, (2019) "Pinot Noir provenance", Pinot Noir Wine Symposium, 4 July 2019, Marnong Estate, Mickleham - Plenary Presentation

9.1.4 Press and newsletter articles

- "Pinot noir provenance project aims to deduce if there are regional characteristics to wine grapes", *The Examiner*, 2 September (2020) https://www.examiner.com.au/story/6906975/can-you-bottle-tasmania-into-a-pinot-noir/
- Longo, R. (2020) "Chemical and sensory comparison of Australia Pinot noir wines: A preliminary study", *TIA facebook*, https://www.facebook.com/watch/?v=303073774290276
- "When you taste a wine can you tell exactly where it came from?" ABC Radio The Country Hour, 30 January (2020) https://www.abc.net.au/radio/programs/tas-country-hour/sensory-wine/11913714
- "Dr Rocco Longo is working on two wine projects at TIA", *The Examiner*, 15 May (2018) https://www.examiner.com.au/story/5396001/tia-researcher-studies-sparkling-consistency/
- "TIA's Pinot Noir Provenance project research the wine's character", *The Advocate*, 16 May (2018) https://www.theadvocate.com.au/story/5404358/tia-puts-pinot-noir-to-the-test/
- UTAS Research Division announcement (2016) - https://www.utas.edu.au/research-admin/research-news/investigating-the-secrets-behind-quality-australian-pinot-noir
- "Trio of wine scientists spearhead new national research projects from Tasmania", *The Examiner*, 7 June (2016) https://www.examiner.com.au/story/3954705/wine-projects-splash-onto-national-stage/

– LONGO, R. 2021. Pinot noir regional distinctiveness – does it exist in Australia. Wine & Viticulture Journal, Autumn, 36-38. https://winetitles.com.au/wvj/articles/wine-viticulture-journal-volume-36-no-2-2021/pinot-noir-regional-distinctiveness-does-it-exist-in-australia/

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9.4 Other Relevant Material

9.4.1 Region and winery selection

Table 9-1 Top 32 wineries listed by number of mentions

Winery	*State*	*Region*	*No of mentions*
By Farr	VIC	Geelong	11
Bass Phillip	VIC	Gippsland	8
Bindi	VIC	Macedon Ranges	8
Home Hill	TAS	Huon Valley	8
Yabby Lake	VIC	Mornington Peninsula	7
Freycinet	TAS	East Coast	6
Giant Steps	VIC	Yarra Valley	6
Moorooduc Estate	VIC	Mornington Peninsula	6
Tolpuddle Vineyard	TAS	Coal River Valley	6
Ashton Hills	SA	Adelaide Hills	5
Coldstream Hills	VIC	Yarra Valley	5
Curly Flat	VIC	Macedon Ranges	5
Bay of Fires	TAS	North	4
Dawson James	TAS	Derwent Valley	4
Paringa Estate	VIC	Mornington Peninsula	4
Clyde Park Vineyard	VIC	Geelong	3
Mac Forbes	VIC	Yarra Valley	3
Main Ridge Estate	VIC	Mornington Peninsula	3
Mount Mary Vineyard	VIC	Yarra Valley	3
Shaw + Smith	SA	Adelaide Hills	3
Bannockburn	VIC	Geelong	2
Castle Rock Estate	WA	Great Southern	2
Chatto	TAS	Huon Valley	2
De Bortoli	VIC	Yarra Valley	2
Dexter	VIC	Mornington Peninsula	2
Eldridge Estate	VIC	Mornington Peninsula	2
Lerida Estate	NSW	ACT	2
Oakridge	VIC	Yarra Valley	2
Riposte	SA	Adelaide Hills	2
Seppelt	VIC	Great Western	2
Stefano Lubiana	TAS	Derwent Valley	2
Stoney Rise	TAS	North	2

Table 9-2 All wineries mentioned sorted by state and region

Winery/vineyard	*State*	*Region*	*No of mentions*
Eden Road	NSW	ACT	1
Lark Hill	NSW	ACT	1
Lerida Estate	NSW	ACT	2
Henschke	NSW	Eden Valley	1
Mayfield Vineyard	NSW	Orange	1
Swinging Bridge	NSW	Orange	1
Ashton Hills	SA	Adelaide Hills	5
Deviation Road	SA	Adelaide Hills	1
Grosset	SA	Adelaide Hills	1
Michael Hall	SA	Adelaide Hills	1
Penfolds	SA	Adelaide Hills	1
Riposte	SA	Adelaide Hills	2
Shaw + Smith	SA	Adelaide Hills	3
Tappanappa Foggy Hill	SA	Fleurieu Peninsula	1
Domaine A	TAS	Coal River Valley	1
Heemskerk	TAS	Coal River Valley	1
Pooleys	TAS	Coal River Valley	1
Pressing Matters	TAS	Coal River Valley	1
Tolpuddle Vineyard	TAS	Coal River Valley	6
Dawson James	TAS	Derwent Valley	4
Moorilla Estate	TAS	Derwent Valley	1
Stefano Lubiana	TAS	Derwent Valley	2
Apsley Gorge	TAS	East Coast	1
Bream Creek	TAS	East Coast	1
Freycinet	TAS	East Coast	6
Gala Estate	TAS	East Coast	1
Milton	TAS	East Coast	1
Chatto	TAS	Huon Valley	2
Home Hill	TAS	Huon Valley	8
Stargazer	TAS	Huon Valley	1
Bay of Fires	TAS	North East	4
Eddystone Point	TAS	North East	1
Domaine Simha	TAS	South	1
Glaetzer Dixon	TAS	South	1
Holm Oak	TAS	Tamar Valley	1
Stoney Rise	TAS	Tamar Valley	2
Tamar Ridge	TAS	Tamar Valley	1
Bannockburn	VIC	Geelong	2
By Farr	VIC	Geelong	11
Clyde Park Vineyard	VIC	Geelong	3
Provenance	VIC	Geelong	1
Bass Phillip	VIC	Gippsland	8

Winery/vineyard	*State*	*Region*	*No of mentions*
Dirty Three	VIC	Gippsland	1
Lightfoot and Sons	VIC	Gippsland	1
Basalt Wines	VIC	Henty	1
Hochkirch Winery	VIC	Henty	1
Seppelt	VIC	Henty	2
Bindi	VIC	Macedon Ranges	8
Curly Flat	VIC	Macedon Ranges	5
Dexter	VIC	Mornington Peninsula	2
Eldridge Estate	VIC	Mornington Peninsula	2
Garagiste	VIC	Mornington Peninsula	1
Handpicked Wines	VIC	Mornington Peninsula	1
Kooyong	VIC	Mornington Peninsula	1
Main Ridge Estate	VIC	Mornington Peninsula	3
Montalto	VIC	Mornington Peninsula	1
Moorooduc Estate	VIC	Mornington Peninsula	6
Paringa Estate	VIC	Mornington Peninsula	4
Port Phillip	VIC	Mornington Peninsula	1
Quealy Musk Creek	VIC	Mornington Peninsula	1
Stonier Family Vineyard	VIC	Mornington Peninsula	1
TarraWarra Estate	VIC	Mornington Peninsula	1
Ten Minutes by Tractor	VIC	Mornington Peninsula	1
Yabby Lake	VIC	Mornington Peninsula	7
Coldstream Hills	VIC	Yarra Valley	5
De Bortoli	VIC	Yarra Valley	2
Giant Steps	VIC	Yarra Valley	6
Hoddles Creek Estate	VIC	Yarra Valley	1
Mac Forbes	VIC	Yarra Valley	3
Mayer	VIC	Yarra Valley	1
Mount Mary Vineyard	VIC	Yarra Valley	3
Oakridge	VIC	Yarra Valley	2
Punch	VIC	Yarra Valley	1
Rochford Wines	VIC	Yarra Valley	1
Toolangi Vineyards	VIC	Yarra Valley	1
William Downie	VIC	Yarra Valley	1
Yarra Yering	VIC	Yarra Valley	1
YarraLoch	VIC	Yarra Valley	1
Yering Station	VIC	Yarra Valley	1
3 Drops	WA	Great Southern	1
Abbey Creek Vineyard	WA	Great Southern	1
Castle Rock Estate	WA	Great Southern	2
Larry Cherubino	WA	Great Southern	1
Rockcliffe	WA	Great Southern	1

9.4.2 Survey of site, viticulture and winemaking practices – full survey questions

This is an abbreviated version of the questions supplied to producers via Google Forms.

Provenance of Pinot noir Project

Should you choose to participate, we require x2 bottles of 2015 or 2016 single-vineyard Pinot noir and associated vineyard and winemaking data for those wines. To obtain high quality data for this project, the preference of wines to be submitted are listed below, with 1 the most preferred. We are unfortunately unable to accept wines that are from multiple vineyards as this will be it difficult to identify the primary drivers of the wine composition.

1. Single block, single clone
2. Single vineyard, single clone
3. Single block, multiple clones
4. Single vineyard, multiple clones

Questions

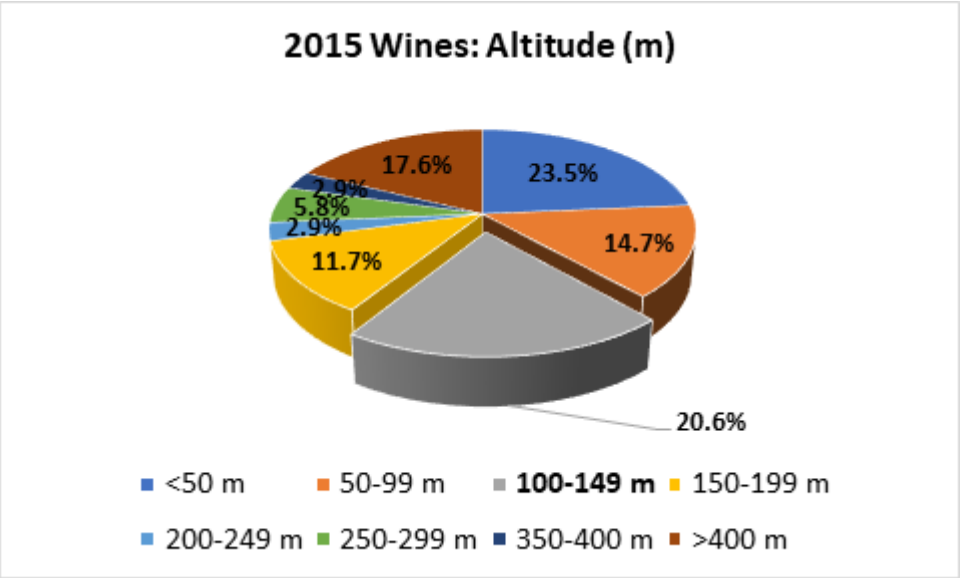
1. Name
2. Company
3. Position
4. Mobile number
5. Email
6. Winery
7. Wine names
8. Vineyard names
9. Vintage
10. Region
11. Where do you get your weather information?
12. Do you have an on-site weather station?
13. What was the GDD for the season?
14. What was the growing season temperature (GST) for the season?
15. What was the mean January temperature (MJT) for the season?
16. What was the mean February temperature (MFT) for the season?
17. What was the total annual rainfall (July-June)?
18. What was the growing season rainfall (Oct-Apr)?

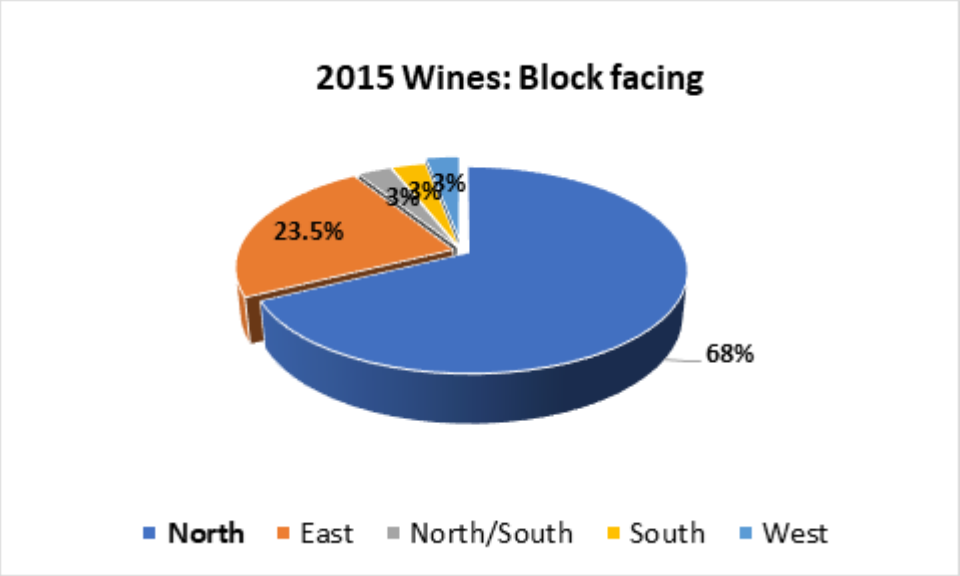
19. Did you experience any significant weather events (frost, hail, flood, heatwave etc)? Please provide details and dates.
20. How many blocks of fruit did you use? (subsequent questions were per block)
21. Please provide GPS coordinates for the middle of the block
22. What is the altitude of the block?
23. What is the main soil type of this block?
24. What is the depth of the soil in this block?
25. Are the vines on rootsock in this block?
26. What is the vine spacing?
27. Which clone(s) is/are in this block?
28. Which trellis type is in this block?
29. Please provide irrigation information (e.g. drop subterranean)
30. Did you fertilise this season?
31. What was the pruning method for this block?
32. Did you shoot thin this block?
33. Did you inflorescence/bunch thin this block?
34. If yes, when?
35. What was the yield in this block?
36. What was the harvest date of this block?
37. What was the estimated value of this fruit?
38. What was the sugar level of the fruit?
39. What was the pH of the fruit?
40. What was the TA of the fruit?
41. How was the fruit harvested (machine/hand)?
42. Which machine harvester was used?
43. Was the fruit sorted?
    a. Repeat above for other blocks if more than one block
44. Which fermenter did you use for this wine?
45. What was the fermenter size?
46. Please describe crusher/destemmer and regime
47. Pre-ferment SO2 addition (ppm)
48. Pre-ferment tartaric acid addition (g/L)
49. Pre-ferment DAP (mg/L)
50. Type and rate of other pre-ferment nutrient (mg/L)

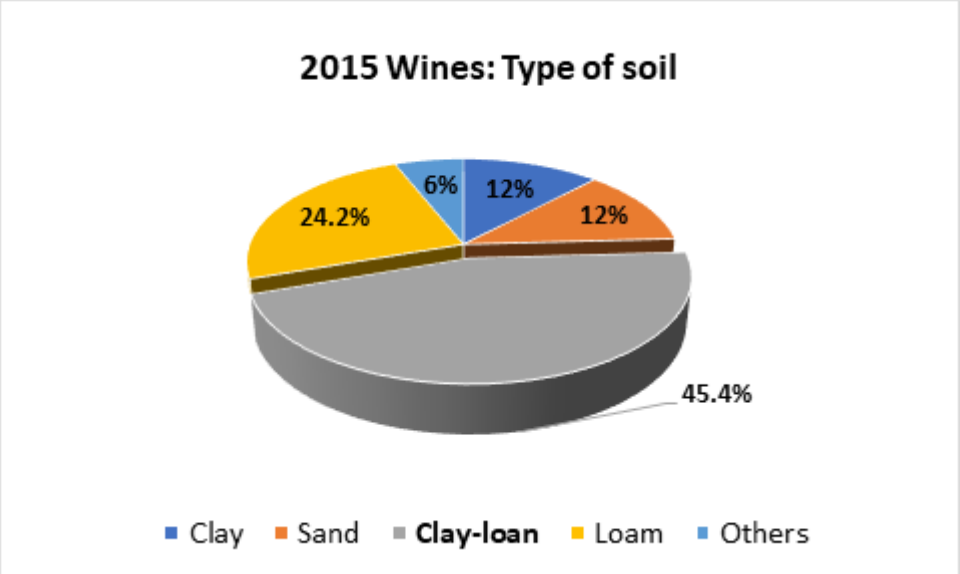
51. Pre-ferment tannin type and rate
52. Pre-ferment enzyme type and rate
53. Yeast used
54. What strain of yeast did you use?
55. Primary ferment duration (days)
56. Primary ferment peak temp (C)
57. Primary ferment low temp (C)
58. During ferment tartaric acid rate (g/L)
59. During ferment DAP (mg/l)
60. During ferment tannin type and rate
61. During ferment enzyme type and rate
62. During ferment other winemaking practices
63. Total days on skins
64. If you added sulphur at the end of the primary ferment, please provide rate
65. Did you carry out post-ferment maceration?
66. Post-ferment peak temp (C)
67. Post-ferment low temp (C)
68. Please describe your press and pressing regime
69. Post-press tartaric acid rate (g/L)
70. Post-press tannin type and rate
71. Post-press other
72. Did you perform malo-lactic fermentation?
    a. Type
    b. When
    c. Length
    d. Comment
73. Is the maturation for this wine in oak or tank?
74. Did you add oak in any form to the tank for this wine?
75. Please describe oak addition to tank
76. Did you perform micro-oxygenation for this wine?
77. % 1st use oak and time spent in this oak
78. % 2nd use oak and time spent in this oak
79. % 3rd use oak and time spent in this oak
80. % 4th use and older oak and time spent in this oak

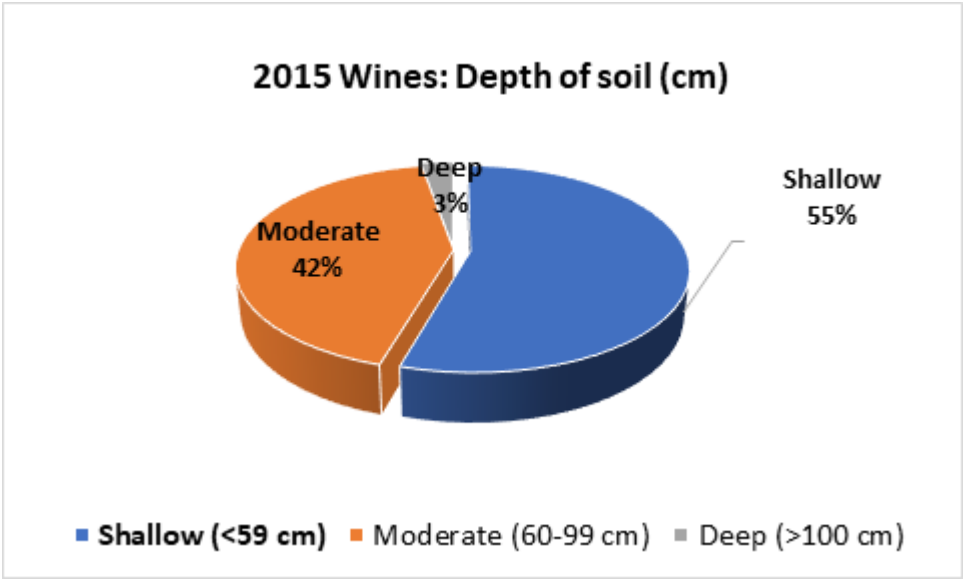
81. Predominant country of origin for your oak
82. Topping Regime
83. Bottling date
84. Planned or actual release date
85. Number of cases of this wine produced
86. RRP per bottle ($)
87. Closure type
88. Bottle type
89. Approx. bottle weight
90. Alcohol % v/v
91. Malic acid (g/L)
92. Glucose + Fructose (g/L)
93. TA (g/L)
94. VA (g/L)
95. pH
96. Do you plan to enter this wine in any wine shows?
97. Where is the majority of this wine sold?
98. Is this 2015 Pinot noir wine made in-house or by a contract winemaker?
99. If by a contract winemaker, how long (in years and months) have you had a relationship with that contract winemaker?
100. Is this 2015 Pinot noir wine exported (i.e. sold internationally)?
101. If yes, where is it sold?
102. Does your organisation collect information (e.g. demographics, wine preferences) relating to the consumers/end-users of this 2015 Pinot noir wine?
103. Can you describe the typical wine drinker/consumer of this 2015 Pinot noir wine?
104. Do you share information (such as a typical wine drinker profile, sales, winemaking notes) with other businesses in your supply chain to assist them with selling or adding value to this 2015 Pinot noir wine?
105. What is the approximate annual wine grape crush for your entire wine business, not just this 2015 Pinot noir?
106. Does your wine business currently operate a cellar door open to the public?
107. Are you interested and available to participate in subsequent stages of this research, which would include participating in a semi-structured interview regarding your perceptions of wine provenance and the make-up of your 2015 (or current) Pinot noir supply chain?

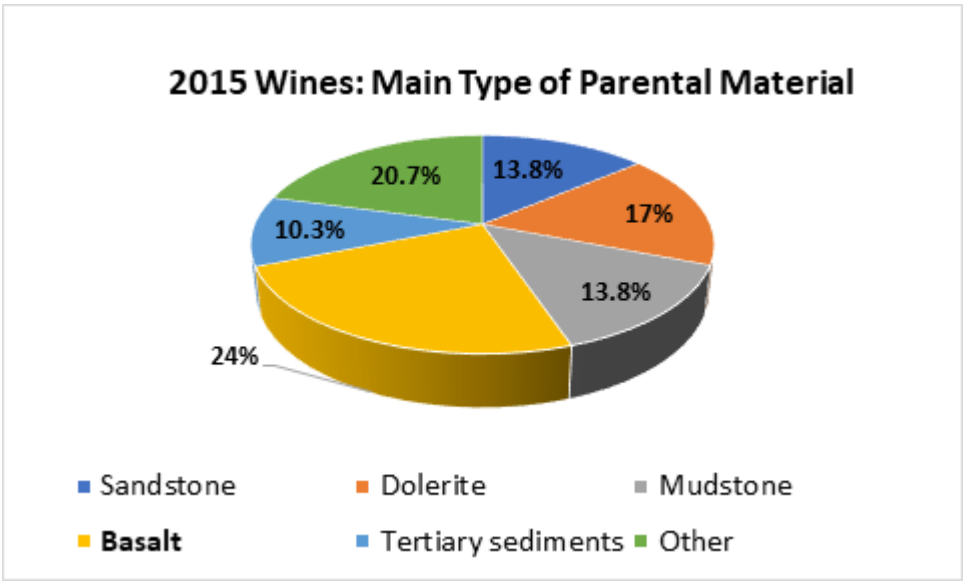
9.4.3 Main survey findings for 2015 wines

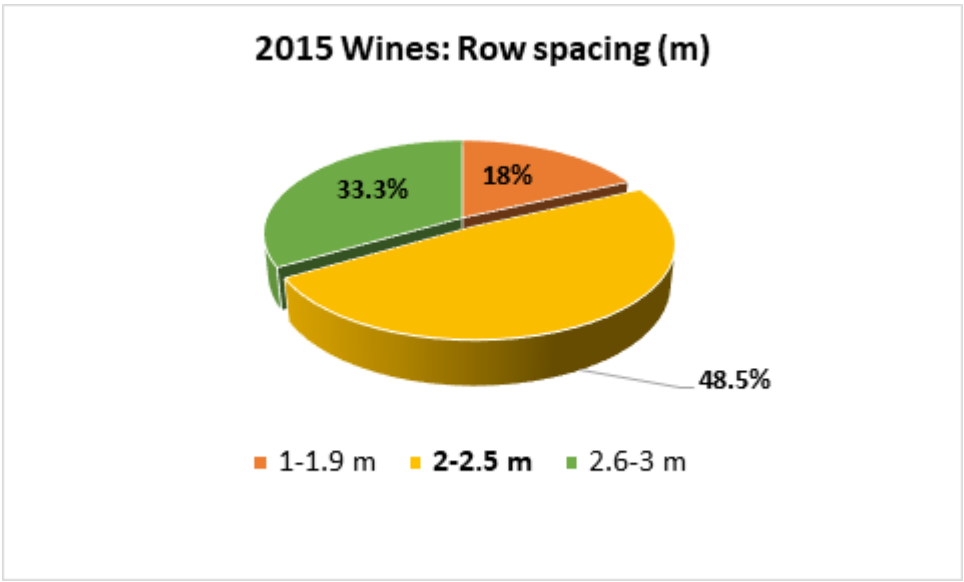


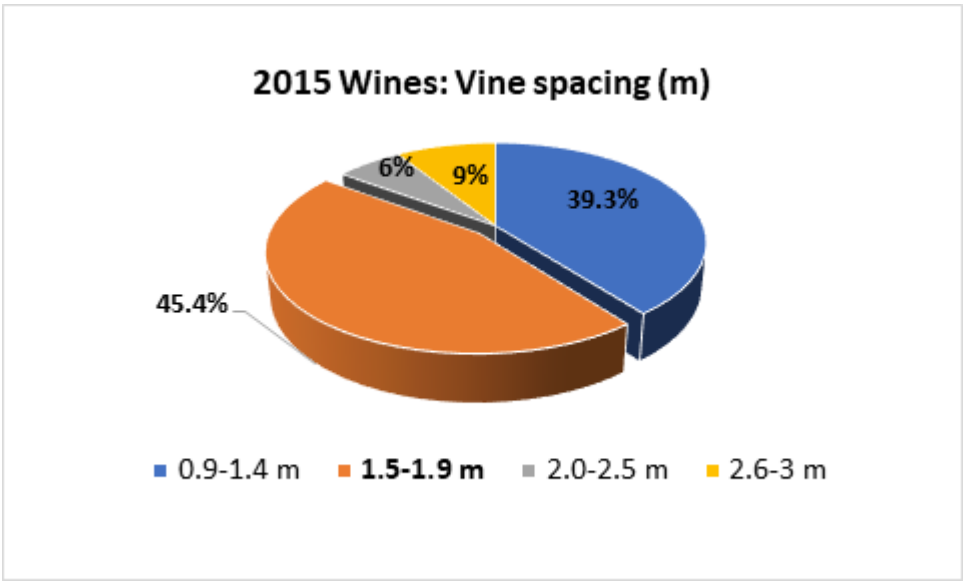


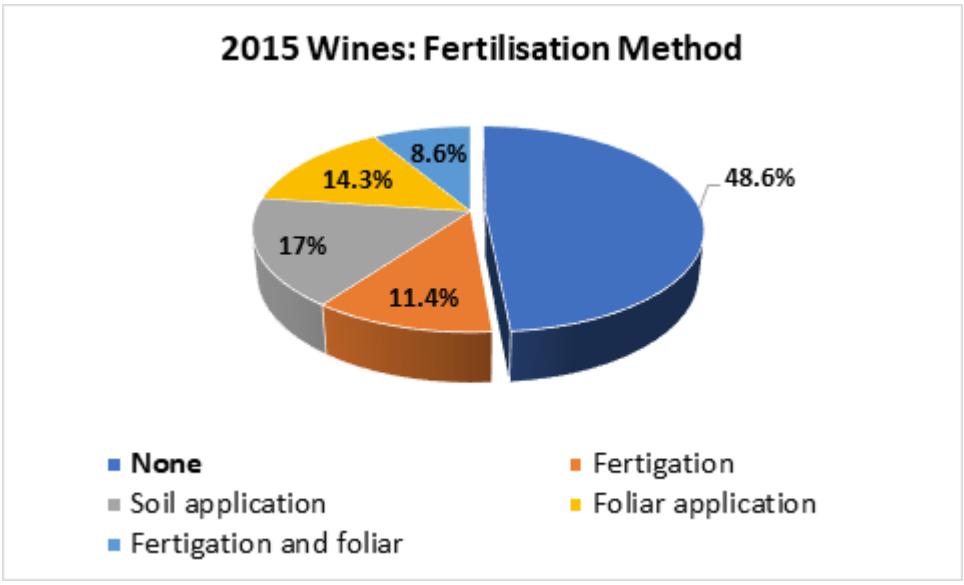



2015 Wines: Depth of soil (cm)
Deep
3%
Moderate
42%
Shallow
55%
Shallow (<59 cm)
Moderate (60-99 cm)
Deep (>100 cm)


2015 Wines: Main Type of Parental Material
20.7%
13.8%
17%
10.3%
13.8%
24%
Sandstone
Dolerite
Mudstone
Basalt
Tertiary sediments
Other

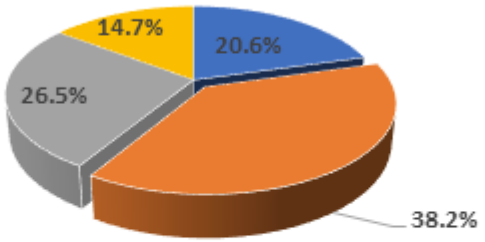

2015 Wines: Row spacing (m)
33.3%
18%
48.5%
1-1.9 m
2-2.5 m
2.6-3 m


2015 Wines: Vine spacing (m)
6%
9%
39.3%
45.4%
0.9-1.4 m
1.5-1.9 m
2.0-2.5 m
2.6-3 m


2015 Wines: Fertilisation Method
8.6%
14.3%
48.6%
17%
11.4%
None
Fertigation
Soil application
Foliar application
Fertigation and foliar

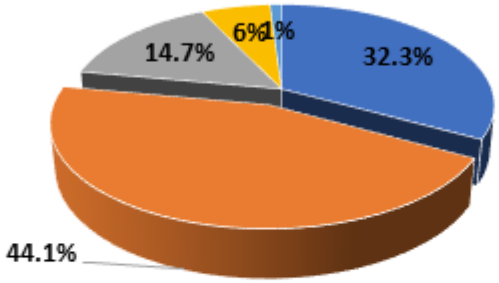

2015 Wines: Pruning method
29.4%
70.6%
Hand spur
Hand cane

2015 Wines: Shoot thinning



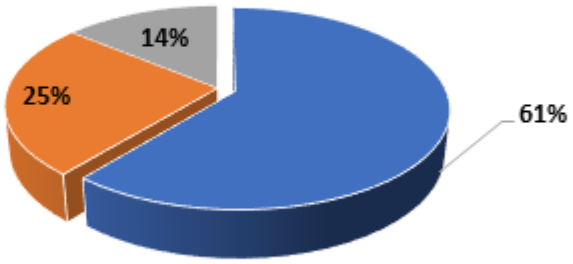
- No
- **Yes (when shoots were less than 10 cm long)**

2015 Wines: Leaf removal method

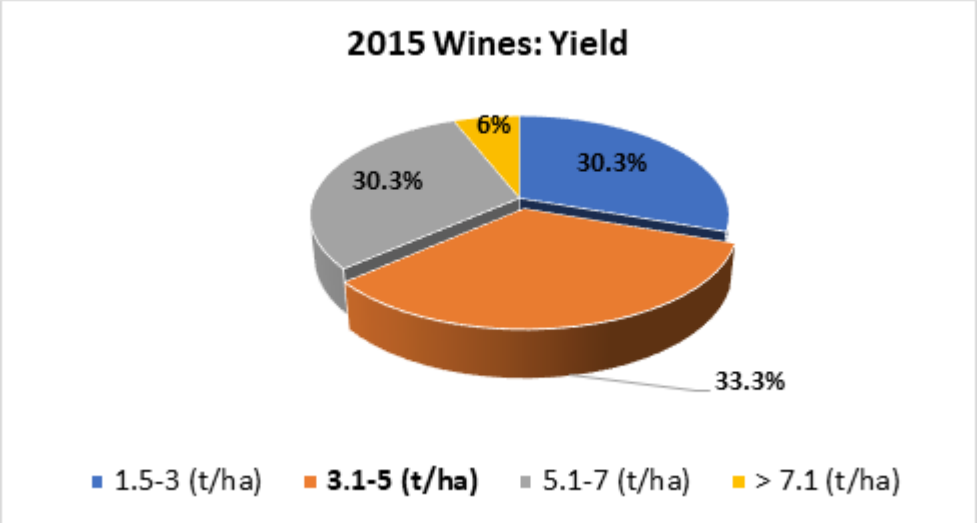


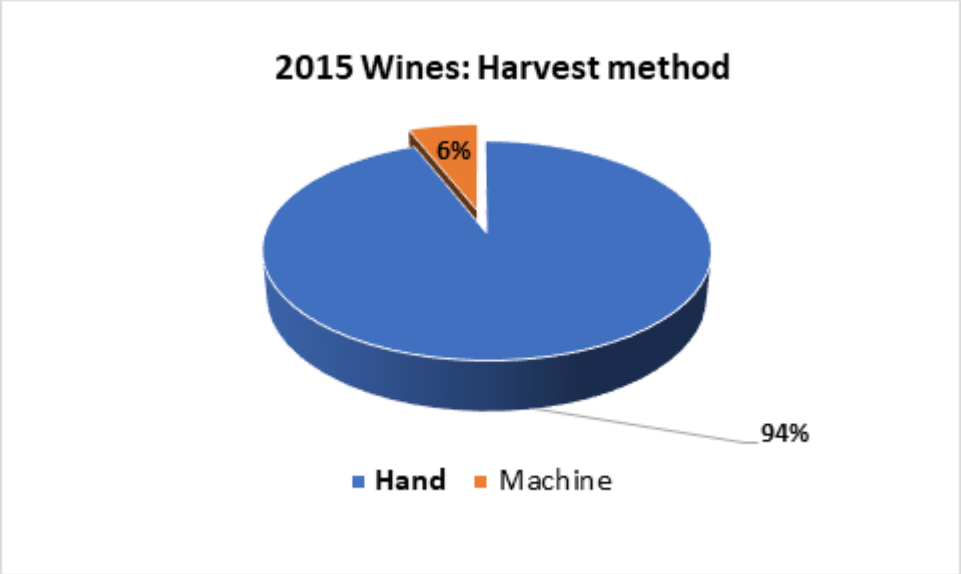
- No
- At veraison
- At fruit set
- **Between fruit set and veraison**
- Between flowering and veraison

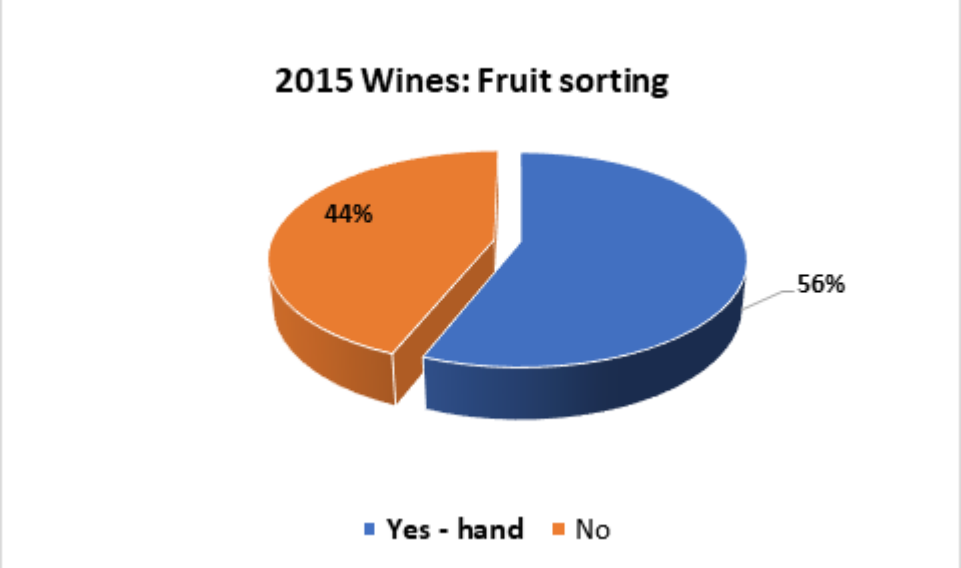
2015 Wines: Infloresence/bunch thinning

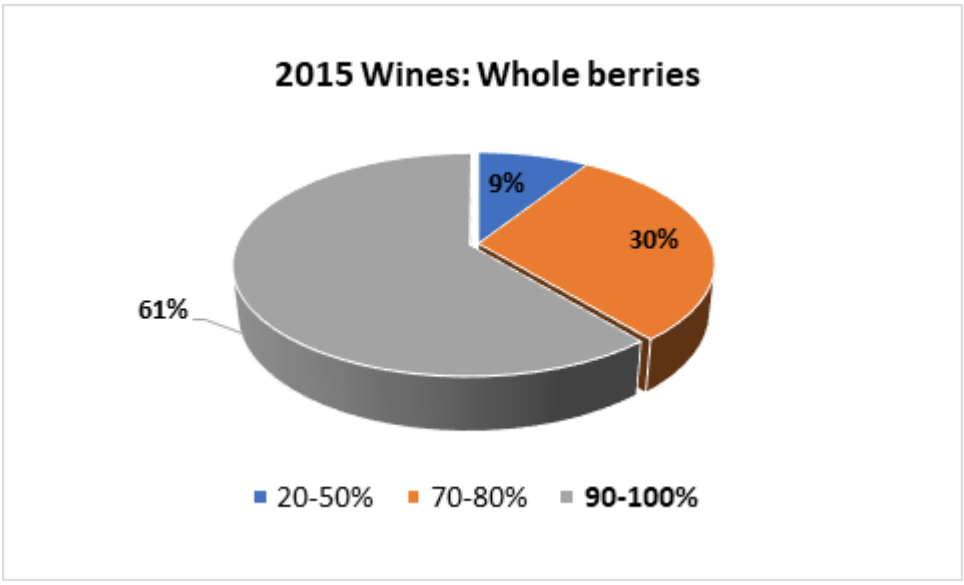


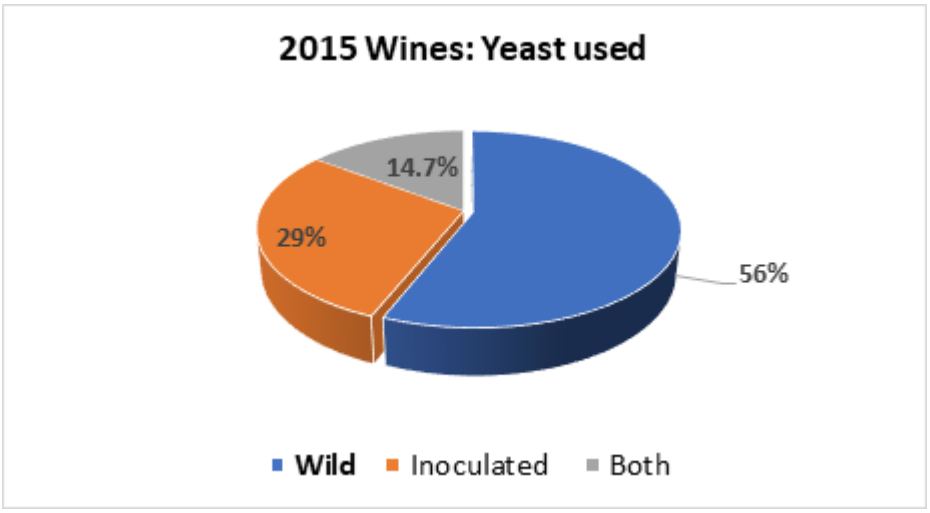
- **No**
- Yes (to reach target yield)
- To remove green bunches

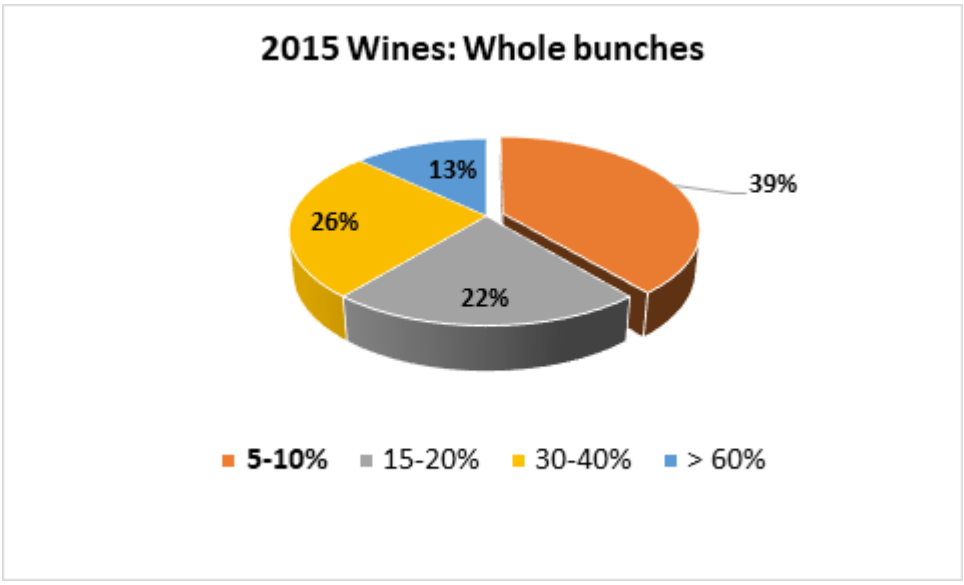

2015 Wines: Yield
6%
30.3%
30.3%
33.3%
1.5-3 (t/ha)
3.1-5 (t/ha)
5.1-7 (t/ha)
> 7.1 (t/ha)

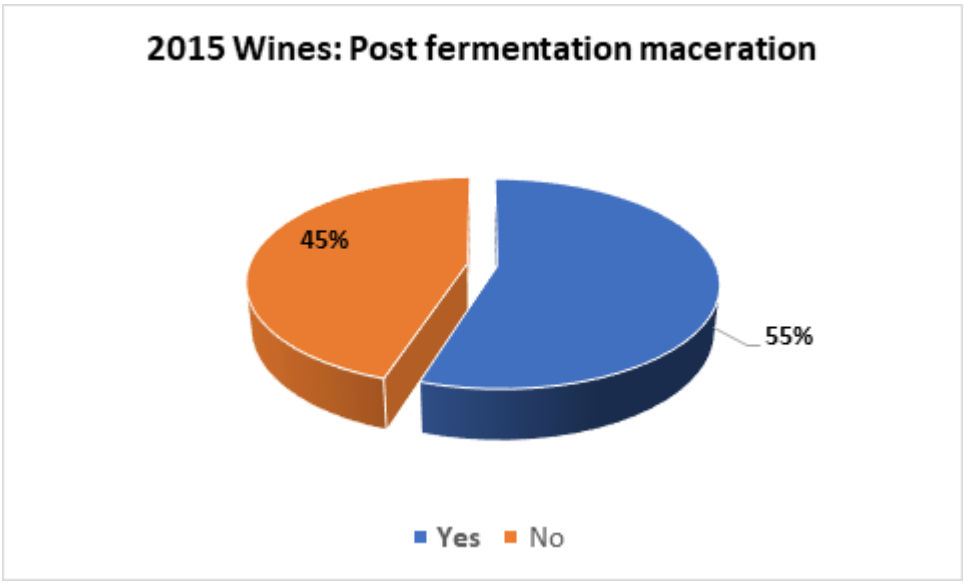

2015 Wines: Harvest method
6%
94%
Hand
Machine


2015 Wines: Fruit sorting
44%
56%
Yes - hand
No


2015 Wines: Whole berries
9%
30%
61%
20-50%
70-80%
90-100%


2015 Wines: Yeast used
14.7%
29%
56%
Wild
Inoculated
Both


2015 Wines: Whole bunches
13%
39%
26%
22%
5-10%
15-20%
30-40%
> 60%


2015 Wines: Post fermentation maceration
45%
55%
Yes
No

9.4.4 Colour and phenolic structure of Pinot noir wines: Understanding Australia

Altitude 1st Block

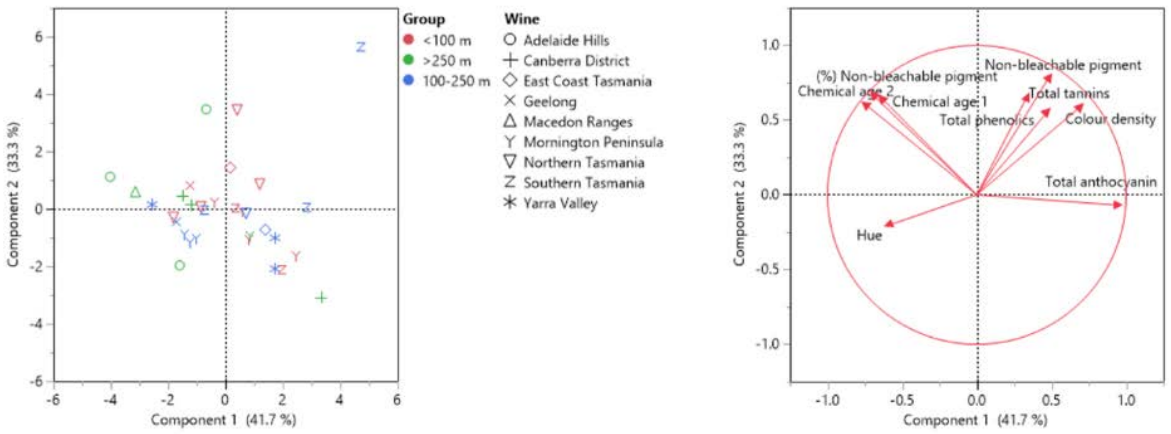


Figure 9-1 Principal component analysis of Modified Somers parameters by site characteristic of altitude (from survey)

Soil Type (1st Block)

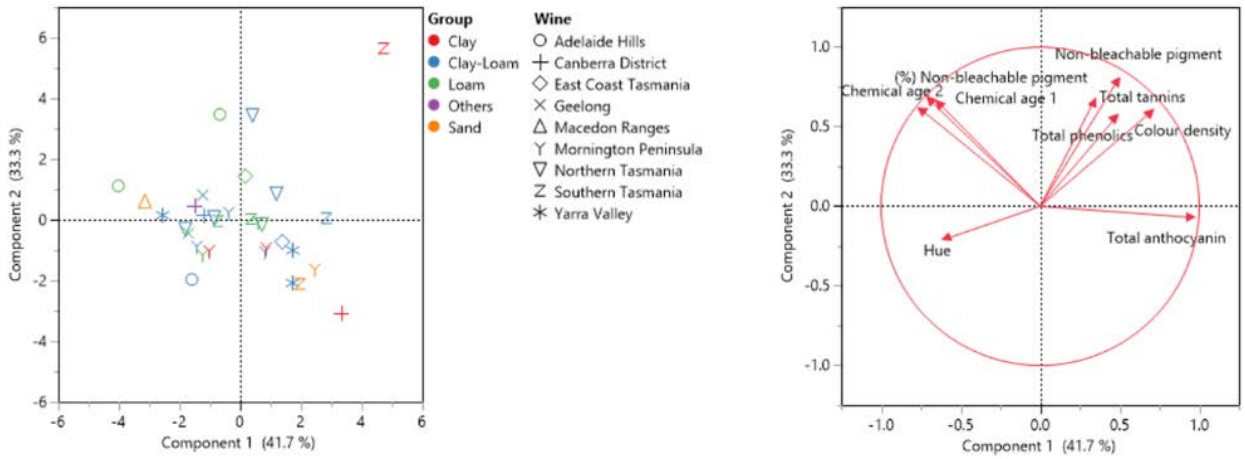


Figure 9-2 Principal component analysis of Modified Somers parameters by site characteristic of soil type (from survey)

Depth of soil (1st block)

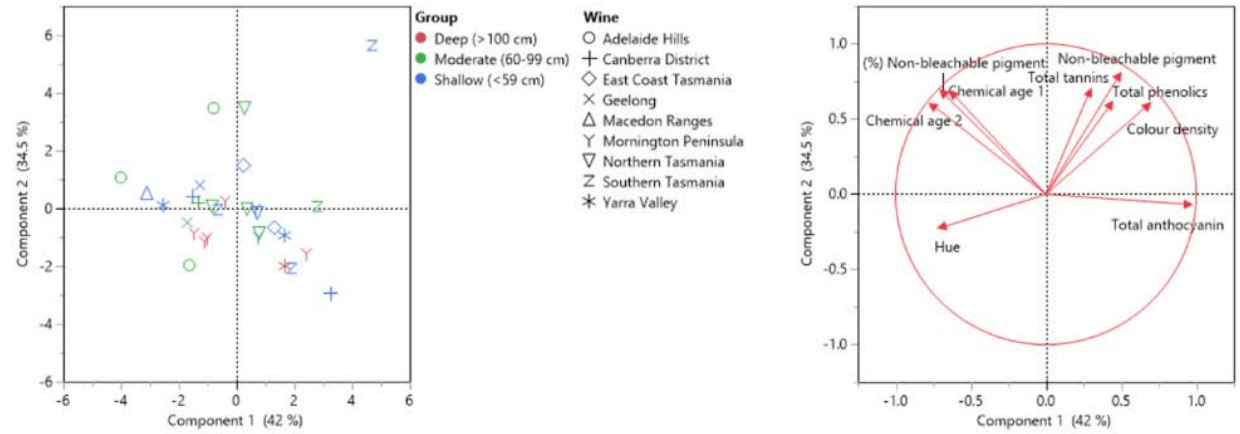


Figure 9-3 Principal component analysis of Modified Somers parameters by site characteristic of depth of soil (from survey)

Vine spacing 1st Block

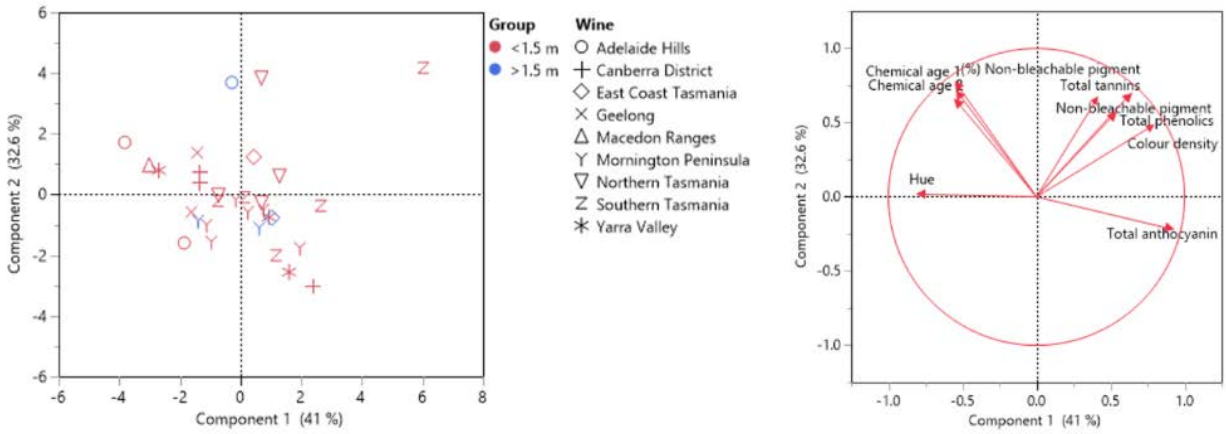


Figure 9-4 Principal component analysis of Modified Somers parameters by site characteristic of vine spacing (from survey)

Fertilisation 1st block

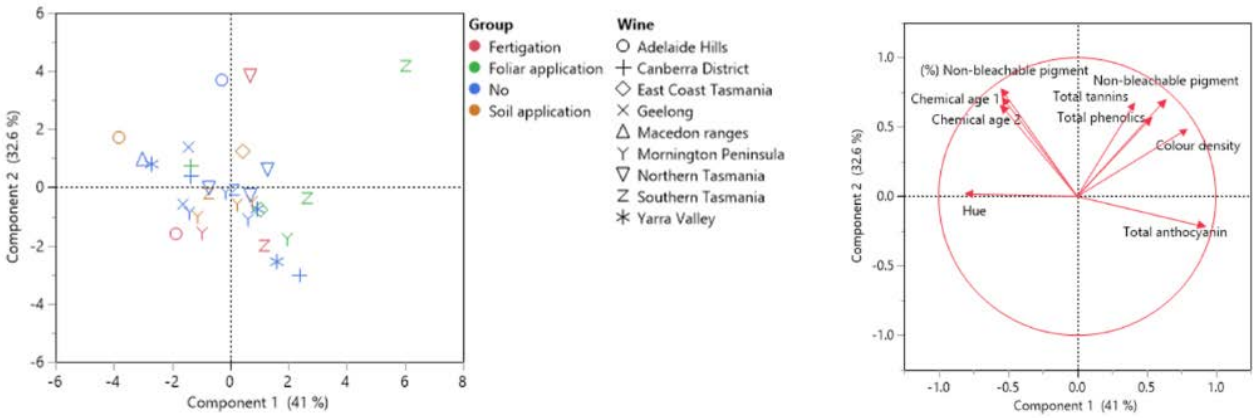


Figure 9-5 Principal component analysis of Modified Somers parameters by viticultural practice of fertilisation (from survey)

Shoot thinning

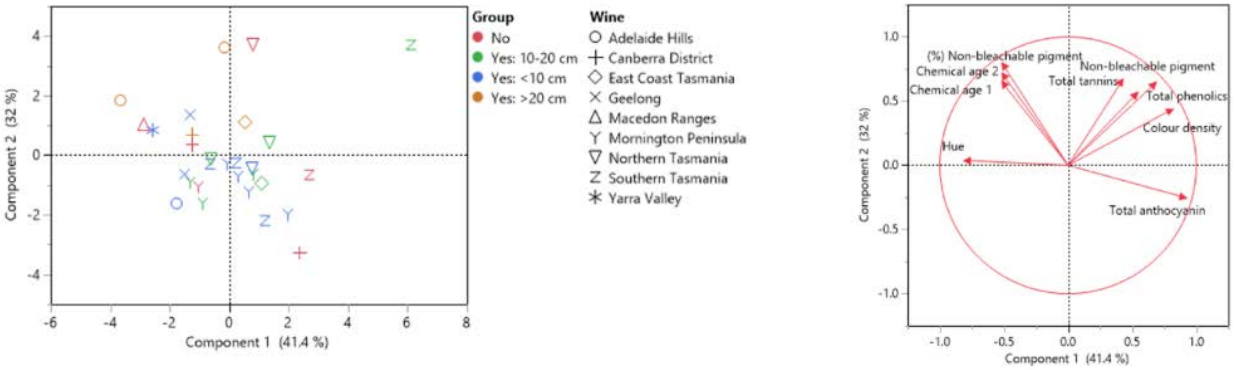


Figure 9-6 Principal component analysis of Modified Somers parameters by viticultural practice of shoot thinning (from survey)

Fruit sorting (1st Block)

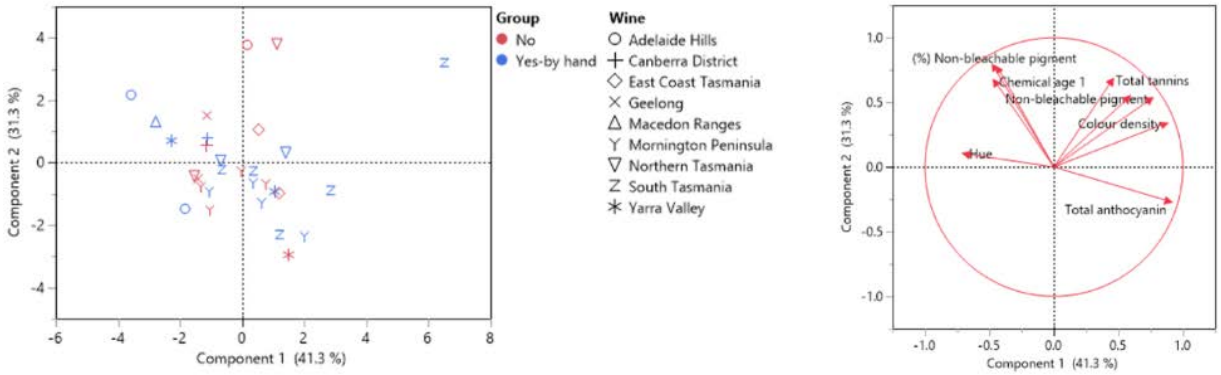


Figure 9-7 Principal component analysis of Modified Somers parameters by oenological practice of fruit sorting (from survey)

Grape total soluble solids (Brix)

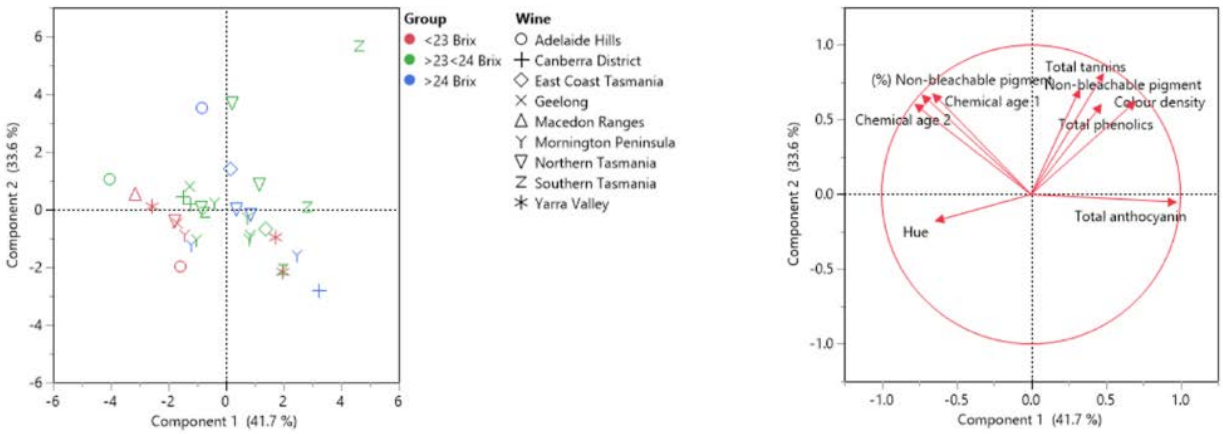


Figure 9-8 Principal component analysis of Modified Somers parameters by oenological parameter of total soluble solids (from survey)

Ferment size (L)

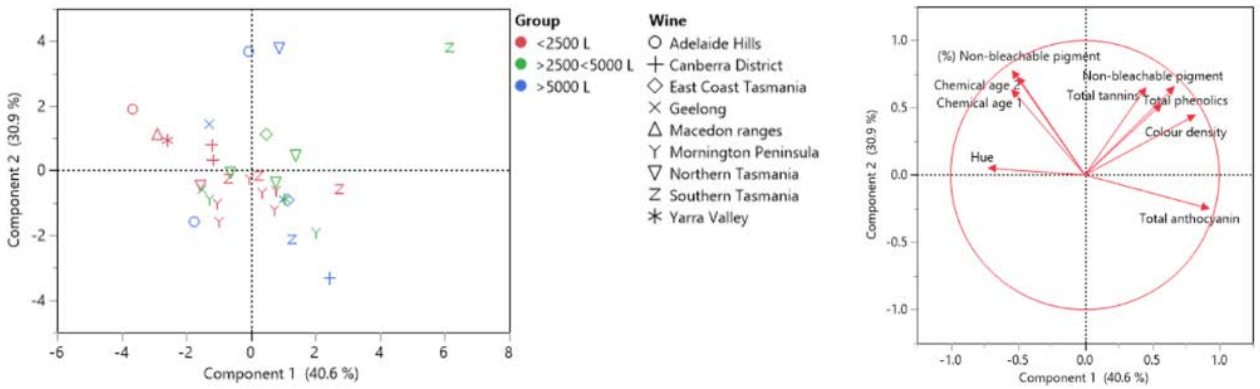


Figure 9-9 Principal component analysis of Modified Somers parameters by oenological practice of ferment size (from survey)

Yeast Used

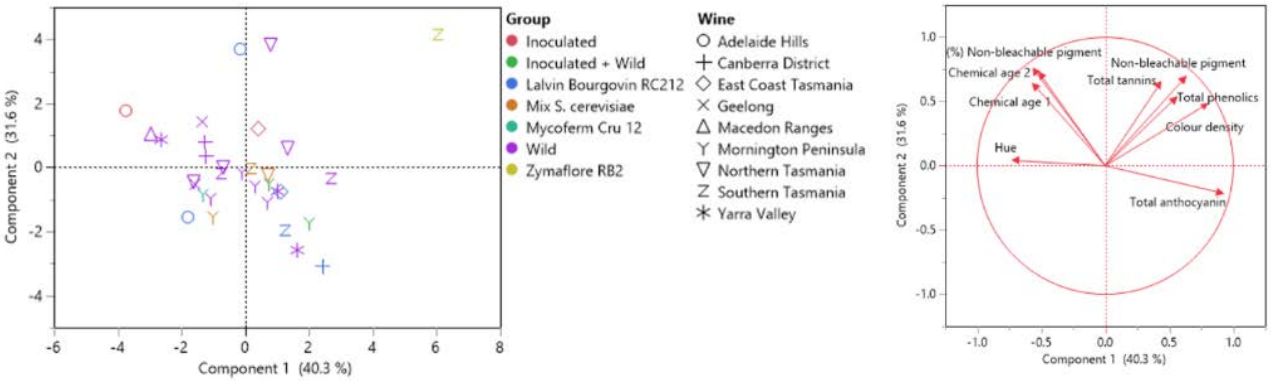


Figure 9-10 Principal component analysis of Modified Somers parameters by oenological practice of yeast used (from survey)

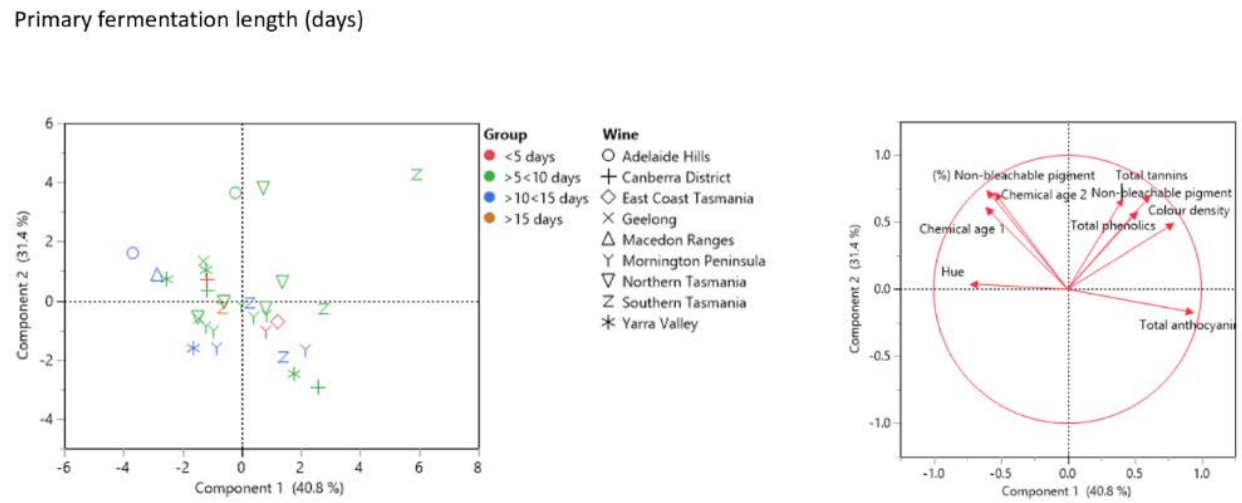


Figure 9-11 Principal component analysis of Modified Somers parameters by oenological practice of primary fermentation length (from survey)

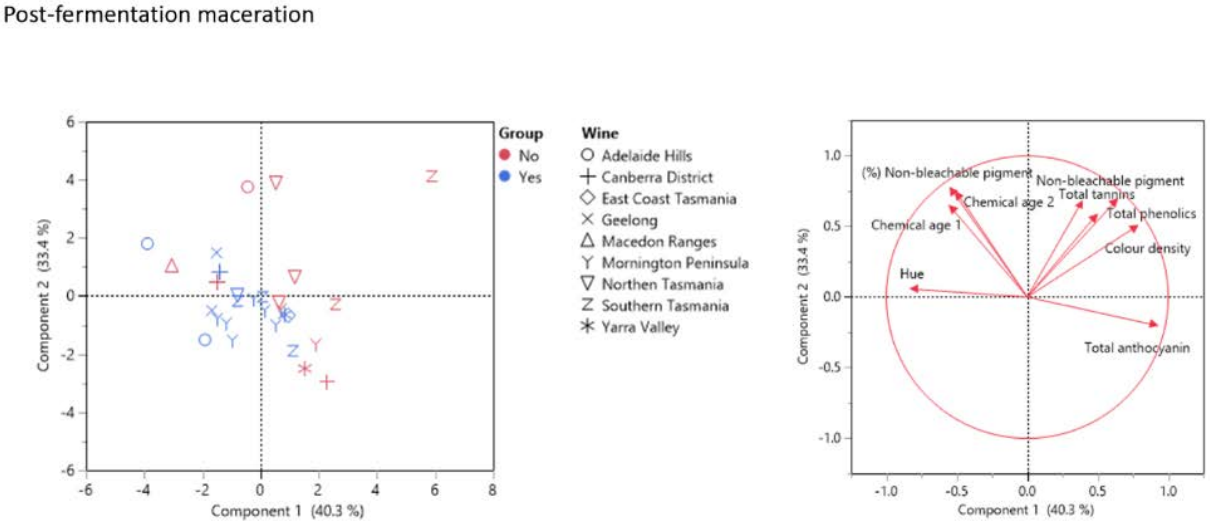


Figure 9-12 Principal component analysis of Modified Somers parameters by oenological practice of post-fermentation maceration (from survey)

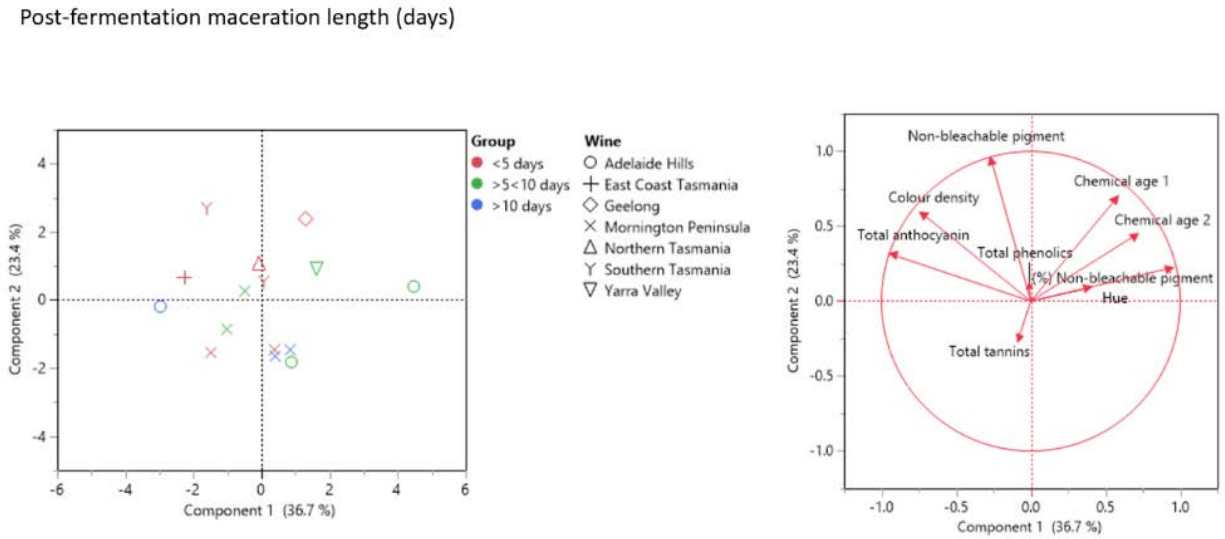


Figure 9-13 Principal component analysis of Modified Somers parameters by oenological practice of post-fermentation maceration length in days (from survey)

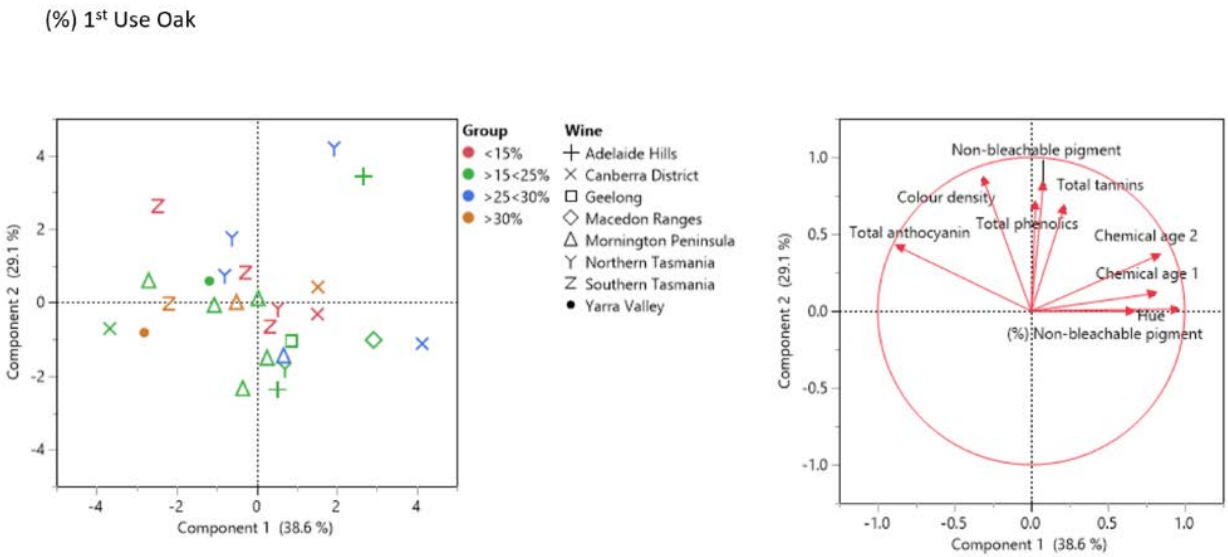


Figure 9-14 Principal component analysis of Modified Somers parameters by oenological practice of percentage of wines which went into 1st use oak barrels (from survey)

9.4.5 A 2-year volatile and colour study of Pinot noir wines from Australian and non-Australian regions

9.4.5.1 Wines

Eighty commercial, single-vineyard Pinot noir wines (retail price per bottle ranged from AUD$30 to AUD$125) were selected from the vintages 2015 and 2016 (n = 40 per vintage). Apart from their commercial availability, the other requirement considered in the selection of the wines was that the grapes used were sourced from a single vineyard to avoid other blending components could have a confounding effect on the results. Five wines were sourced from each of the following Australian regions: Yarra Valley and Mornington Peninsula (Victoria), Adelaide Hills (South Australia), Northern, and Southern Tasmania (Tasmania). In addition, three wines were analysed from each of the following non-Australian regions: Willamette Valley (Oregon, USA), Central Otago and Marlborough (New Zealand), and Niagara Peninsula (Ontario, Canada). Where commercially available, the same wines were selected for both vintages and analysed 12 months apart, so that the wine age was comparable.

9.4.5.2 General analysis of wine volatiles

9.4.5.2.1 2.1 Fermentation compounds

The wine samples were diluted 1:10 to ensure that the concentrations of the detected analytes where within the linear range of the calibration curve. Each sample (1 mL) was transferred into 20 mL SPME vials with 9 mL of saturated potassium hydrogen tartrate (KHT) buffer (pH 3.66) and 2 g of NaCl. A calibration set consisting of 13 levels (including a blank) for a total of 29 compounds belonging to acetate, ester, alcohol, and acid classes was prepared. Acetates, esters, alcohols, and acids were analysed by gas chromatography/mass spectrometry (GC/MS) according to Siebert et al. (2005). All GC/MS equipment was from Agilent Technologies Ltd (Melbourne, Australia) unless otherwise stated. GC/MS analyses of the 2015 wines were performed in June 2018 whereas those of the 2016 wines in June 2019. The analysis was performed using an Agilent 7890A GC equipped with a Gerstel MPS2 multi-purpose sampler and coupled to an Agilent 5975C VL mass selective detector. The GC was fitted with an Agilent DB-624UI column (30 m × 0.25 mm × 1.4 µm). Ultra-high purity He was used as the carrier gas in constant flow mode. The oven was started at 40 ˚C, increased to 60 ˚C at 20 ˚C/min (held for 14 min) and then followed by series of temperature ramps. First ramp to 70 ˚C at 10 ˚C/min, second ramp to 80 ˚C at 10 ˚C/min, third ramp to 160 ˚C at 20 ˚C/min, and final ramp to 260 ˚C at 10 ˚C/min and held for 2 min for a total run time of 45.5 min. The SPME vials and its contents were heated to 40 ˚C for 5 min with agitation. The SPME fibre was exposed to the headspace in the sample for 15 min and then desorbed in the injector (splitless mode) for 15 min. The injector was set at 260 ˚C. The MS quadrupole was set at 150 ˚C, the source was set at 230 ˚C and the transfer line was held at 260 ˚C.

Positive ion electron impact spectra at 70 eV were recorded in SIM and SCAN mode with a solvent delay of 4 min.

The raw data from Agilent's ChemStation software (ver. E.02.02.1431) were converted into MassHunter data files and processed using MassHunter Workstation Software for Quantitative Analysis for GC/MS (ver. B.09.00). The concentration of analytes in the samples were determined using stable isotope dilution analysis (SIDA). The quantifier ions were used to identify the compounds at their expected retention time (Table 9-3).

Table 9-3 Retention times, target ions and qualifier ions of internal standards and analytes.

Internal Standard	RT (min)	Target Ion	Qualifier Ions	Analyte	RT (min)	Target Ion	Qualifier Ions
d_8-Ethyl acetate	4.8	96	46, 76	Ethyl acetate	5.1	88	61, 70
d_9-2-Methylpropanol	5.9	83	46, 50	2-Methylpropanol	6.1	74	41
d_3-Acetic acid	6.4	63	48, 77	Acetic acid	6.7	60	43, 45
d_{10}-Butanol	7.3	64	46, 48	Butanol	7.6	56	41, 55
d_5-Ethyl propanoate	8.6	107	76, 77	Ethyl propanoate	8.8	102	57, 75
d_5-Ethyl-2-methylpropanoate	11.0	121	93, 106	Ethyl-2-methylpropanoate	11.2	116	88, 101
d_9-3-Methylbutanol	11.0	78	60, 77	2-Methylbutanol	11.5	70	41, 57
				3-Methylbutanol	11.4	70	41, 57
d_5-Propanoic acid	11.4	79	62, 77	Propanoic acid	11.7	74	57, 73
d_9-2-Methylpropyl acetate	12	64	75, 78	2-Methylpropyl acetate	12.3	56	73, 86
d_5-Ethyl butanoate	13.9	93	106, 121	Ethyl butanoate	14.1	88	71, 101
d_7-2-Methylpropanoic acid	15.8	95	50, 77	2-Methylpropanoic acid	16.4	88	43, 73
d_5-Ethyl-3-methylbutanoate	18.29	93	120, 135	Ethyl-2-methylbutanoate	18.22	115	88
				Ethyl-3-methylbutanoate	18.5	88	85, 115
d_7-Butanoic acid	18.9	63	50, 77	Butanoic acid	18.8	60	45, 73
d_9-3-Methylbutyl acetate	20.2	79	78, 89	2-Methylbutyl acetate	21.1	55	57, 72
				3-Methylbutyl acetate	20.8	55	87, 88
d_{13}-Hexanol	21.4	78	62, 64	Hexanol	22.3	69	55, 56

d_7-3-Methylbutanoic acid	23.8	91	61, 62	2-Methylbutanoic acid	25	87	57, 74
				3-Methylbutanoic acid	24.4	87	60, 61
d_5-Ethyl hexanoate	28	93	106, 120	Ethyl hexanoate	28.1	88	99, 115
d_{13}-Hexyl acetate	28.3	96	50, 78	Hexyl acetate	28.5	84	69, 73
d_{11}-Hexanoic acid	28.9	63	77, 93	Hexanoic acid	29.7	60	73, 87
d_3-2-phenylethanol	32	125	93, 94	2-Phenylethanol	32.1	122	91, 92
d_5-Ethyl octanoate	32.7	93	106, 177	Ethyl octanoate	32.8	88	101, 127
d_{15}-Octanoic acid	33.3	109	77	Octanoic acid	33.7	101	85, 115
d_3-2-Phenylethyl acetate	35.4	106	93, 107	2-Phenylethyl acetate	35.4	104	65, 91
d_5-Ethyl decanoate	37.7	106	162, 205	Ethyl decanoate	37.7	101	157, 200
d_{19}-Decanoic acid	37.9	63	77, 141	Decanoic acid	38.1	73	60, 172

9.4.5.3 2.2 C_{13}-Norisoprenoids

The C_{13}-norisoprenods α-ionone, β-ionone and β-damascenone were analysed as follows. The wine sample (10 mL) was transferred into 20 mL SPME vials with 2 g of NaCl and 50 µL of a combined d_4-β-damascenone, d_3-α-ionone and d_3-β-ionone internal standard solution. The GC/MS analysis was performed on an Agilent 6890 GC equipped with a Gerstel MPS2 autosampler and coupled to an Agilent 5973N mass selective detector. The GC was fitted with an Agilent DB-5ms 30 m × 0.25 mm × 0.5 µm. Ultra-high purity He was used as the carrier gas. The oven was started at 40 °C, held at this temperature for 2 min then increased to 190 °C at 8 °C/min and held at this temperature for 5.25 min. The vials and its contents were heated to 60 °C for 10 min in the heater/agitator. The SPME fibre was exposed to the sample during this heating time and injected into a split/splitless inlet in splitless mode. The analytes were desorbed into a Supelco 0.75 mm ID sleeveless SPME liner (Supelco, Bellefonte, PA) for 10 min which was held at 200 °C. The purge flow to the split vent was 50 mL/min at 2.1 min with the septum purge flow turned off. The mass spectrometer quadrupole temperature was set at 150 °C, the source was set at 230 °C and the transfer line was held at 250 °C. EMV Mode was set to Gain Factor = 1.00 and spectra were recorded in SIM mode. The ions monitored in SIM mode were: *m/z* 73, 179 and 194 for d_4-β-damascenone and *m/z* 69, 175 and 190 for β-damascenone; *m/z* 112, 139 and 195 for d_3-α-ionone and *m/z* 109, 136 and 192 for α-ionone; *m/z* 180, 181 and 195 for d_3-β-ionone and *m/z* 177, 178 and, 192 for β-ionone.

9.4.5.4 Analysis of colour and phenolics

Wine colour was measured using the Somers Colour Measures and tannin concentrations were measured using the Methylcellulose Precipitable Tannin (MCPT) assay as described in Mercurio et al. (2007). Measurements were conducted using a 370 µL 96 well UV plate (Greiner Bio-One, Kremsmünster, Austria) with a SpectraMax M2 Microplate Reader (Molecular Devices, San Jose, CA). Total phenolics, wine colour intensity, total anthocyanins, and non-bleachable (bisulfite-resistant) pigment of wines were determined from spectral data according to the calculations outlined in the method. Total tannin quantification with the MCPT assay was performed by analysing the difference in 280 nm absorbance between the control and methyl cellulose polymer (MCP) treated sample. (-)-Epicatechin (Sigma Aldrich, St. Louis, MO) was used as the quantitative standard and isolated grape seed tannin was included as a positive control.

9.4.5.5 Data analysis

All data sets were analysed by one-way ANOVA for each vintage separately using R (R Core Team, 2019). Tukey's Honest Significant Difference (HSD) at p-value = 0.05 were used to test differences between region means. Principal component analysis (PCA) was performed with JMP ver. 14 (SAS Institute, Cary, NC). Separate PCA were performed for colour/phenolic and volatile data sets. The models were developed using all variables, as non-significant parameters ($p > 0.05$) may also contribute to the classification of these wines. The data sets of the 2015 and 2016 vintages were analysed together to ensure factors driving regional differences were not governed by seasonal differences. Discriminant analysis was performed with The Unscrambler X ver. 10.5 (CAMO Software, Oslo, Norway). PCA scores from the chemical analysis data were used as input data for the discriminant analysis, satisfying two important criteria for robust discriminant analysis: reduction of input variables and input variables are orthogonal. To remove any scaling effects the input data was normalized using the standard deviation before performing PCA. Discriminant analysis was performed with the minimum number of principal component (PC) scores to give optimal discrimination: 5 in the case of colour and phenolics and 6 in the case of volatile compounds.

9.4.6 Wine Back Label Analysis – Results

Alongside the value chain interviews conducted for this project, a simple analysis of the written content on the back labels of a sample of Australian pinot noir wines was undertaken, to:

1. Explore how Australian pinot noir producers describe their wines,
2. Identify any commonalities between the descriptors used within certain regions, and

3. Explore if a higher price influences the amount or type of information on the back label.

A total of 53 back labels of 2015 Australian pinot noir wines were examined and accordingly coded using a computer aided qualitative data analysis program (NVivo 12 Pro). The text/information appearing on the front label of these wines was not included as the aim was simply to analyse how pinot noir is described via tasting notes, and what other information might be included in the back label blurb.

After extracting the back label information into a word document, this was imported into NVivo and the labels were divided into three categories based on how much sensory information they contained. Earlier research has suggested that consumers prefer different levels of sensory information depending on their level of involvement with the wine product (Mueller et al., 2010). Interestingly, the results of our analysis suggest that there was an all or nothing trend regarding how much sensory information (e.g. flavour, aroma, colour) was included on the back label of premium Australian Pinot Noir. After the initial coding, we found:

- 45% (n=24) of the wines contained *no* sensory information.
- 13% (n=7) contained *simple* taste descriptors of one line or less. E.g., 'dark fruit aroma and structure'
- 42% (n=22) were more *elaborate* both in terms of the amount, and the description. E.g., 'an elegant wine showing spicy cherry notes on the nose; the palate delivers with delicious savoury flavours framed by fine tannins and a spicy oak touch'.

When we compared this data with the recommended retail price (RRP) of the wines in our sample, there was some preliminary evidence that as a wine's price increases, the type and amount of sensory information changes[1]. For example, for some of more expensive wines, the back label contained less information pertaining to traditional tasting notes or sensory information, and more information regarding how the wine was grown and/or made.

Around 80% of the wines that contained *no* sensory information were in the highest price bracket of $50-$100 (five of these wines however did belong to the one label and were made by the same winemaker thus explaining a portion of this category). For the wines containing an *elaborate* amount

[1] Note: No wines in the sample had an RRP of more than $100 per bottle. The lowest RRP for a wine in the sample was $30.

of sensory information, there was an equal percentage in the $30-49.99 price category and the $50-100 price category.

The notion that ultra-premium wines (i.e., those with a RRP of $50 and above) may include less sensory information on their back label may be related to a trend among more involved wine drinkers to learn more about the characteristics of Pinot noir according to where it is grown or made. Indeed, prior research has confirmed that highly involved wine consumers want to learn and educate themselves about the scientific aspects of growing and making of wine, and that more discerning consumers seek to collect regional information from wine labels, and that in turn this increases their confidence in the quality of the wine product (Johnson and Bruwer, 2007). However, with changes to how consumers search for and find information on the internet, it could be likely that wine consumers are becoming less reliant on a wine's back label for making purchase decisions. Instead, it is possible they choose a wine based on typical front label information such as the geographic region where it is made, the brand and/or the winemaker. They may then draw on their existing knowledge of that region, brand and/or winemaker, rather than refer to sensory descriptors or tasting notes. Similarly, it could be that wine consumers of today (particularly those aged 35-44) are more experimental with their wine purchase decisions and are more attracted to wine brands and winemakers who choose not to include traditional sensory information, and instead include very scientific information. If the consumer can understand and recognise this information, then they feel 'special' or 'knowledgeable'. One of the wines in the sample here, for example, stated: "*For wine nerds like me: 2015 was a very early vintage due to poor winter rains and a warm spring. Rain in early January brought respite and 4 weeks of ideal, cool weather, hand-picked on 27 February and 6 March, wild yeast fermented, 38% whole bunch, 10% long maceration (54 days), pressed to barrel, 11 months in French oak (15% new)*."

Interviews with producers for this project also confirmed changes are occurring in where and how consumers can access provenance information and tasting notes. Increasingly consumers search for this information on their smartphone. The more sophisticated and advanced producers will ensure that 1) they can be easily found online or in social media, and 2) this information is easy for consumers to find and understand.

Regarding the **type** of information included, not surprisingly **flavour** was the most common way in which the wine was described on the back label, in particular, fruit flavours (e.g. berry type, plum or cherry); herbs or spices (e.g. Asian spice, exotic spice, thyme), and tannins (e.g. chalky tannin, fine tannin, sturdy tannin).

Next came reference to the wine's **aroma**, and then **palate**. Most common in terms of aroma were references to floral fragrances, often combined with a note or reference to flavour (e.g. rose petal, orange blossom). **Colour** and **texture** were only mentioned on a few of the labels. There were no meaningful differences between regions regarding the type or amount of sensory information included.

Aside from sensory descriptors, over 67% of the sample wines contained some reference to **winemaking or production practices**, in particular: the *maturation technique*, *fermentation method*, *vine management*, the *cultivation* or *sourcing* of *grapes*, fermentation method, and maturation technique. The wines in this category did differ somewhat in terms of how they described these practices. Some, for example, used plain language, for example, *Cold soaked in small open top fermenters for 5 days and naturally fermented, then aged for 12 months in French oak barriques of which 30% were new; the wine was bottled with no fining or filtration*. While others tended to describe the practices used in a slightly more expressive and romantic manner, for example, *Winemaking includes small batch open fermentation, gentle hand plunging and maturation in seasoned French oak barriques for approximately 18 months to ensure true varietal expression. Bottled unfined and unfiltered*. Previous research has found that back label information on the history of a winery, including production methods such as those listed above, has the strongest influence on consumer wine choice behaviour, compared with tasting notes or chemical wine ingredients (Mueller et al., 2010).

The **environmental conditions** under which the grapes were grown also featured on around half of the labels we analysed, and not surprisingly these blurbs referred to terroir attributes such as the *vintage weather*, *vineyard altitude*, and *soils*. Around 33% of wines leveraged such a **description of their climate** to convey that their wine was unique or flavourful because of this terroir. However, there were no meaningful differences in the inclusion of terroir information across regions, nor across price categories.

The next most common type of information could be classified as **historical**, in other words the *age of the planting,* or the history associated with the *family* or the *region*. A small number of wines specifically mentioned **cellaring potential**, or the **ingredients/chemical composition** of their wine. Most of the labels did not specify whether they were single or multi-clone, or whether the grapes were sourced from a single or multi-block.

Although the observations presented here do not contribute directly to the research aims of this project, they do provide some interesting context to the broader question of how best to

communicate provenance and regional information to consumers. In future, it would be worthwhile analysing a much larger sample of wine back labels, and potentially combining this with a survey of consumer preferences and perceptions of terroir, to identify whether the type of sensory information appearing on premium wine labels is in fact changing, and to what extent this influences the consumer purchase decision.

9.4.7 Summary of supply chain survey questions

As mentioned earlier, the comprehensive online producer survey contained a small number of 'supply chain' questions to obtain background information regarding the business model and supply chains of the producers participating in this project. A total of 43 producers responded to these questions, thus making the sample sufficient for descriptive purposes only.

Not surprisingly, the survey found that the majority of premium Australian Pinot noir is sold directly to consumers, followed by on-premise, and then off-premise. In our sample, the number of respondents that sell their wine directly to consumers is nearly 3.5 times the number that sell their wine off-premise. The vast majority of Pinot noir in this sample is made in-house; only five respondents said they used a contract winemaker. Three of these winemakers had a relationship of roughly three years with their contract winemaker, and the other two had a relationship of eight years or above.

A slight majority of Pinot noir in this sample is only sold domestically (i.e. n = 22 sell only domestic versus n = 21 who sell internationally). Out of the 21 who sell their Pinot internationally, the United Kingdom was the most common destination (n = 11), followed by USA (n = 8) and then Japan or China (both n = 7), then Hong Kong (n = 6), Europe (n = 5), broader Asia (unspecified, n = 4), and Singapore (n = 3). One winemaker each sold to Canada, Denmark, Germany, Dubai, and Brazil. In classifying exports across continents, Asia was by far the most popular destination (n = 28), followed by Europe (n = 19).

The vast majority (n = 39 / 91%) of survey respondents did not collect information pertaining to their consumers. Twenty-five producers responded to the question of if they could describe a typical customer/consumer, with two saying they could not: out of the remaining 23 responses the most common characteristics mentioned were that they were Pinot lovers (n = 8), wealthy (n = 7), knowledgeable (n = 5), older (n = 4; usually described 45+ or 50+ or simply mature) and generally enthusiastic about wine or collectors of wine (n = 4).

The survey also revealed that most producers did not share information with other businesses regarding their supply chain: only six out of 43 (14%) said Yes to this question. Two who did share information briefly noted what/why: one noted they shared tasting notes, whilst another noted that sharing information in similar regions was useful (specifically in the context of Mornington Peninsula, or Victoria broadly).

The majority of pinot producers surveyed (n = 38 /88%) said they produced less than 750 tonnes per year (of the particular pinot wine they were responding to questions about). Three respondents in the comment box following this question noted that they were very small, producing 20 or less tonnes a year. Finally, the large majority of survey respondents said that yes, they operated a cellar door that was open to the public (n = 31 / 72%). For a breakdown of results per individual question please see below.

Where is the majority of this 2015 Pinot noir sold?

- 43 responded.
- 16 (37.2%) said on-premise; 14% (6) said off-premise; and 21 (48.8%) said direct to consumers.

Is this 2015 Pinot noir wine made in-house or by a contract winemaker?

- 43 responded.
- 38 (88.4%) said in-house; whilst 5 (11.6%) said by a contract winemaker.

If by a contract winemaker, how long (in years and months) have you had a relationship with that contract winemaker?

- There were 9 responses to this question, even though in the previous question only 5 said they had their wine made by a contractor.
- 3 had a relationship of three years (33.33%); 2 had 0 years (<1 year) relationship with contractor; 1 each had a 10-year, 8 year and 3 years. 1 also responded “Na” - perhaps they mistakenly responded to the question

Is this 2015 Pinot noir wine exported (i.e. sold internationally)?

- 43 responded.
- 21 (48.8%) said Yes to being exported; 22 (51.2%) said No.

If yes, where is it sold?

- 20 responded, despite 21 saying they sold internationally
- 7 wines were sold in two international regions (regions usually denoted nation-states but sometimes denoted broader polities such as the European Union or Asia); 5 wines in three international regions; 4 wines in four international regions; 2 wines in five international regions; and finally, 1 wine was sold in only one international region.

Table 9-4 Export regions/locations in ascending order

International location	**Number of respondents exporting there**
United Kingdom	11
United States of America	8
Japan	7
China	7
Hong Kong	6
Europe/ European Union	5
Asia*	4
Singapore	3
Canada	1
Denmark	1
Germany	1
Dubai	1
Brazil	1

* Note: This was an open-ended question, hence Asia was the location as stated by respondents with unspecified country or region.

Does your organisation collect information (e.g. demographics, wine preferences) relating to the consumers/end-users of this 2015 Pinot noir wine?

- 43 responded.
- 39 (90.7%) said No; the remaining 4 (9.3%) said Yes.

Does your organisation collect information relating to the consumers/end-users of this 2015 Pinot noir wine?

- 43 responded.
- 39 (90.7%) said No; the remaining 4 (9.3%) said Yes.

Can you describe the typical wine drinker/consumer of this 2015 Pinot noir wine?

- 25 responded.
- Two producers said no/not really, they could not describe the typical wine drinker/consumer.
- The table below illustrates the number of times every characteristic was mentioned.
- Characteristics most frequently mentioned were pinot lovers, affluence, a knowledgeable customer base, and an older/mature demographic.

Table 9-5 Description of the typical wine drinker/consumer

Characteristic	**Frequency of mentions (*n* = 23)**
Pinotphile(s)/Pinot Lover	8
Affluent/money to spend/rich	7
Wine geeks/knowledgeable/educated/savvy	5
Elder/mature/45+	4
Wine enthusiasts/collectors	4
Higher end/premium/discerning wine drinkers	2
Cool/Hipster	2
Mixed demographic	1
30-50 years of age	1
(from) Melbourne	1
(from) Sydney	1
Consumed in restaurants	1
Consumed at home	1
(aged) 25-50	1

Do you share information (such as a typical wine drinker profile, sales, winemaking notes) with other businesses in your supply chain to assist them with selling or adding value to this 2015 Pinot noir wine?

- 43 responded.
- 37 (86%) said No; 6 (14%) said Yes.
- There were two comments:
    - one that said they shared tasting notes with other businesses;
    - the other said that producers work well together in the state of Victoria, particularly in the region of the Mornington Peninsula.

What is the approximate annual wine grape crush for your entire wine business, not just this 2015 Pinot noir?

- 43 responded.
- 38 (88.4%) said less than 750 tonnes per year/vintage; 5 (11.6%) said between 750 and 7,000 tonnes per year/vintage.
- There were five comments:
    - Three said they produced < 20 tonnes per year;
    - One said they produced 120 to 140 tonnes;
    - The last comment said 'much less' - but no specific number.

Does your wine business currently operate a cellar door open to the public?

- 43 responded.
- 31 (72.1%) said Yes; 12 (27.9%) said No.

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