"Opportunities in partial whole cluster fermentation on Shiraz (Vitis vinifera L Syrah) from the Great Southern Wine Region, WA, Australia "

Professional internship report

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Dissertation to obtain the degree of

European Master of Science in Enology and Viticulture

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Abstract

Whole cluster fermentation as an ancient winemaking technique seems to be a newly discovered fashionable way to elaborate elegant, complex Shiraz wines in Australia

Our experimental study conducted at Rockcliffe Winery during the 2018 vintage with Australian Shiraz from the Great Southern Wine Region (WA) in order to evaluate the impact of high level (1/3 and 1/2) whole cluster incorporation on the wines fermentation kinetics, chemical composition, and organoleptic properties at pre malolactic stage. The results were compared with Shiraz wines obtained by conventional winemaking techniques under the same experimental conditions

Regarding fermentation kinetics, minor differences were detectable between the samples, however, the whole berry component resulted a sluggish phase at the end of the fermentation.

Presumably the introduced stems, absorption properties were responsible for the lower values in Color Intensity, Total Pigments, Polymerized Pigments, Total Anthocyanins, and Colorized Anthocyanins. However, the differences were negligible in Total Phenol concentration. .The highest proanthocyanidin levels were obtained in the red wines elaborated with grape stems, especially in the modality with the highest stem percentage.

The tasters rewarded the aromatic and flavor complexity, related to the contribution of the whole clusters and supposedly to the longer maceration time applied on the whole cluster incorporated ferments. The intact whole berry effect was less pronounced on the wines organoleptic properties than the impact of the stem originated phenolic compounds. The green/herbaceous attributes were observed and described by the tasters with terms like stalkiness and capsicum

The whole-cluster incorporation and longer maceration time clearly impacted and modified positively the wine sensory and chemical properties, compared to the hand harvested, destemmed-crushed and the machine harvested destemmed-crushed samples.

The application, the potential integration into the Rockcliffe Winery’s industrial-scale Shiraz winemaking technology requires further research

Keywords: Shiraz, whole cluster, fermentation, stem - berry effect,

Resumo

A fermentação de uvas com engaços, técnica ancestral de vinificação parece agora voltar a ser uma maneira moderna e recém-descoberta de elaborar vinhos elegantes e complexos da casta Shiraz na Austrália.

Este estudo experimental foi conduzido na empresa vinícola RockcliffeWinery durante a vindima de 2018 com a casta Shiraz da Austrália, da região Great Southern (WA), para avaliar o impacto no alto nível de incorporação de engaços (1/3 e 1/2) na cinética de fermentação dos mostos, na composição química e nas propriedades sensoriais, mesmo antes da fase de fermentação maloláctica.

Os resultados obtidos destas vinificações com engaços foram comparados com os obtidos com vinhos da mesma casta Shiraz, usando técnicas convencionais de vinificação com uvas desengaçadas, nas mesmas condições experimentais.Em relação à cinética da fermentação, apenas pequenas diferenças foram detectadas entre as amostras, no entanto, as fermentações com engaços, originaram uma fase mais lenta no final da fermentação.Presumivelmente, a presença de engaços durante a maceração/fermentação, pelas suas propriedades de absorção, será a responsável pela perda de intensidade de cor, antocianinas totais e antocianinas coradas. No entanto, as diferençasforam quase insignificantes na concentração de compostos fenólicos totais. O teor mais elevados de proantocianidinasforam obtidos nos vinhos tintos vinificados com engaços, em particular na modalidade com maior percentagem de engaços.

Os provadores valorizaram a complexidade aromática e de sabor, relacionada com a possível contribuição dos engaços e, supostamente, com o maior tempo de maceração aplicado em todas as modalidades que tiveram a presença de engaços. As vinificações sem engaços originaram contudo vinhos menos apreciados pelos provadores. Os atributos verde e herbáceo foram observados e descritos pelos provadores, bem como aspereza e pimentos.

A incorporação de engaços durante a vinificação e o tempo de maceração mais longo que também ocorreu nessas situações, tiveram um efeito claro, modificando positivamente as propriedades sensoriais e químicas do vinho, em comparação com os vinhos obtidos de colheita manual, com uvas desengaçados e esmagadas, bem como com os vinhos obtidos de uvas de vindima mecânica, posteriormente esmagadas. A integração potencial desta tecnologia de vinificação à escala industrial, com a casta Shiraz, da Rockcliffe Winery, requer todavia mais investigação.

Palavras-chave: Shiraz, cachointeiro, fermentação, efeitoengaço-bago;

Resumo Alargado

A fermentação de uvas com engaços, técnica ancestral de vinificação parece agora voltar a ser uma maneira moderna e recém-descoberta de elaborar vinhos elegantes e complexos da casta Shiraz na Austrália.

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Os resultados obtidos destas vinificações com engaços foram comparados com os obtidos com vinhos da mesma casta Shiraz, usando técnicas convencionais de vinificação com uvas desengaçadas, nas mesmas condições experimentais Os fermentos de Monte parcial (amostra B e C da amostra) eram mais quentes, mas lento, atingiu o grau de Baume negativo desejado mais lento, resultou um período de mais vatting tempo semana, 24 dias no total, em comparação com os 16 dias tempo pele contato sobre os vinhos feitos sem todo cluster (amostra e amostra D) a liberação de açúcar mais lenta das bagas restantes toda na última fase da fermentação poderia ser uma possível explicação para este fenômeno

A redução em valores de álcool, possivelmente relacionado com as propriedades de adsorção do tronco entre o alto teor de água e açúcar. No entanto, o mesmo fenômeno de absorção, não pode ser justificada em valores de acidez PH e Total

Presumivelmente, a presença de engaços durante a maceração/fermentação, pelas suas propriedades de absorção, será a responsável pela perda de intensidade de cor, antocianinas totais e antocianinas coradas. No entanto, as diferençasforam quase insignificantes na concentração de compostos fenólicos totais. O teor mais elevados de proantocianidinasforam obtidos nos vinhos tintos vinificados com engaços, em particular na modalidade com maior percentagem de engaços.

O principal associado a risco em tecnologia de fermentação de todo o cluster a introdução de notas "verde/herbáceas". Esses atributos são também observados e descritos pelos provadores com termos como stalkiness, pimento.Recentemente em vinhos feitos da casta Shiraz na Austrália foi identificado a 2-isobutil-3-metoxipirazina, que poderá estar na origem da explicação dessas notas aromáticas (Capone et al, 2018) introduzido por hastes poderia ser responsável por esses atributos.

Os provadores valorizaram a complexidade aromática e de sabor, relacionada com a possível contribuição dos engaços e, supostamente, com o maior tempo de maceração aplicado em todas as modalidades que tiveram a presença de engaços. As vinificações sem engaços originaram contudo vinhos menos apreciados pelos provadores. Os atributos verde e herbáceo foram observados e descritos pelos provadores, bem como aspereza e pimentos.

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desengaçados e esmagadas, bem como com os vinhos obtidos de uvas de vindima mecânica, posteriormente esmagadas. A colheita de mão relacionados com custos adicionais de produção tem que ser levado em consideração. A integração potencial desta tecnologia de vinificação à escala industrial, com a casta Shiraz, da Rockcliffe Winery, requer todavia mais investigação.

Content

List of figures, tables, and abbreviations

ABS = Australian Bureau of Statistics

AWRI = Australian Wine Research Institute

IBMP = 2-isobutyl-3-methoxypyrazine

DMS = dimethyl - sulfide

MOG = material other than grape

1.Introduction

It is impossible to assign who and when vinified the first grape wine and more importantly to this study who fermented grape juice with whole clusters. However it can be hypothesized easily, the fermentation took place “accidentally “and spontaneously in stored grape vine bunches.

An International archaeological team lead by Patrick McGovern in 2017 near Gadachrili Gora and Shulaveris Gora, excavated the oldest possible historical evidence of winemaking from two Neolithic sites in Georgia in the South Caucasus mountain. Extensive microbotanical and chemical analysis have focused on pottery jar residues. The excavation has not found grape seeds or other grape-related tissue on the site but high levels of tartaric acid, provide very strong evidence for the presence of ancient grape/ wine in certain jars from Gadachrili.

McGovern (2017) point out a further more important result of the Gadachrili pottery artifact compared with younger findings “…One disparity between the analyses of Hajji Firuz (Iran) and Georgian jars is that the latter showed no signs of a tree resin or any other additive, according to the GC-MS analyses. Pine and terebinth saps were commonly added to wine throughout antiquity. They acted as antioxidants to keep the wine from going to vinegar, or barring that, to cover up offensive aromas and tastes…” The discovery can make us hypothesize, the Neolithic “natural winemakers’’ were only relying on the antioxidant capacity of the grape skins, seeds and stems in order to preserve their wines?

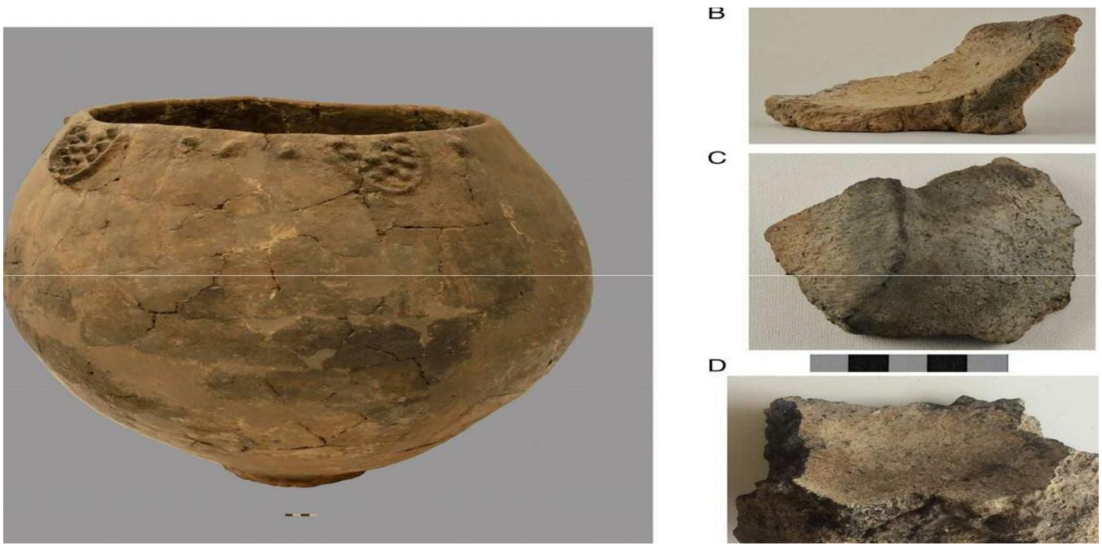


Figure.1. Jar base Photo by Mindia Jalabadze and courtesy of the National Museum of Georgia.

Throughout history, the separation process of grape berries from the stems until the invention of destemmer carried out by hand or different ways of rubbing the grapes on a specific surface (Ribéreau-Gayon et al., 2006; Goddy, 2014)

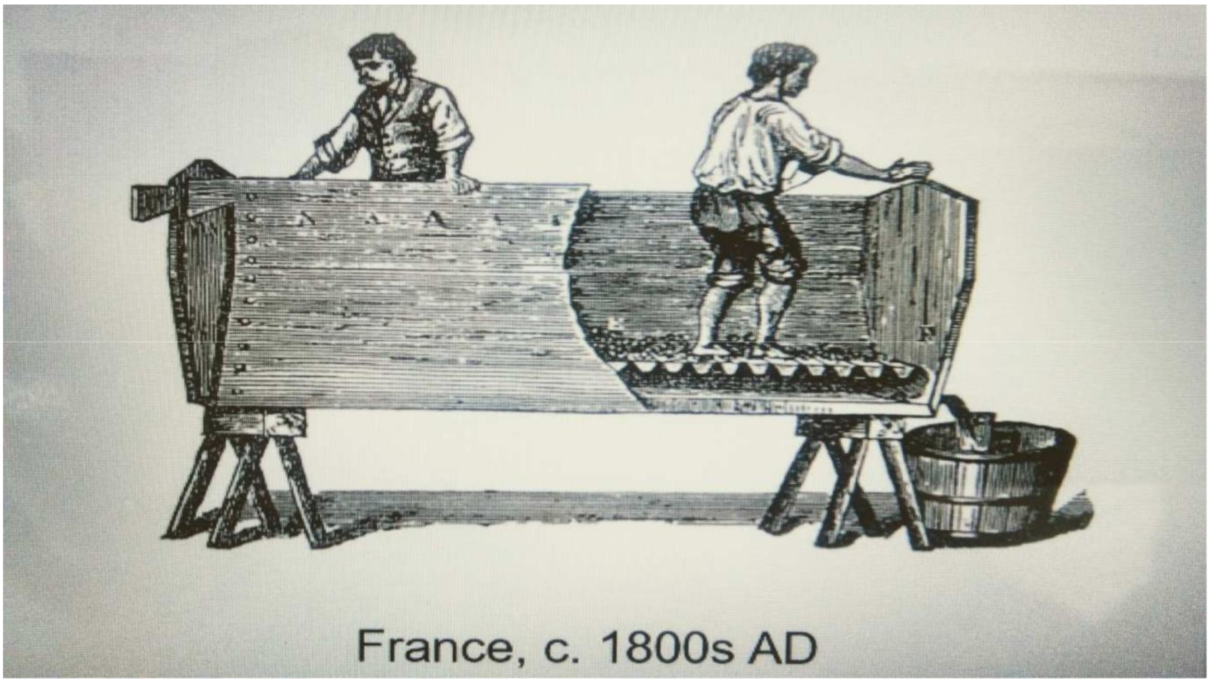


Figure 2: Old destemming –crushing technique by Nordestgaard, (2017).

As a well-known fact, the vast majority of today's wines are machine harvested and destemmed. Even in the Rhone Vale (the birthplace of Syrah) where according to Livingstone-Learmonth, (2005) ''… whole-bunch fermentation of Cornas Syrah as the natural heritage of the place and its wine… Whole-bunch fermentation is now extremely rare, certainly because of the lack of confidence by growers in this way: life is easier without the added risk or complication of any excess firmness in the wine…"

However Jamie Goode (2014) a British wine writer point out an important current change in wine fashion "... winemaking trends seem to move in cycles. It seems we are currently in a phase where elegance and complexity are being pursued by winegrowers at the expense of power and strength... Its perhaps for this reason that there is increasing interest in winemaking techniques that foster this elegance and complexity ....."According to Hooke (2011), Australia produces many styles of Shiraz but "…The age of elegance has dawned on Australian wine…",

Probably not every wine region and country follows the mentioned pattern however the writer of these lines during an extended winemaker role between 2010-2016 at Brackewood Vineyard (Adelaide Hills, South Australia) has experienced a similar trend in the Melbourne and Sydney market, especially in the high-end 30 + AUD segment.

Small cool climate regions like the Adelaide Hills (SA) or the Great Southern, Western Australia, WA often overshaded by high-quality Shiraz focused " big brothers "located in warmer climate conditions like Barossa Vale or McLaren Vale in SA (see Figure 4. Figure 5.)

Shiraz, probably Australia's most significant grape variety occupies over one-quarter of the total vineyard surface area and its future seems stable, it is the leader cultivar in newly planted vineyards (see Figure 3.) The country has almost an emotional connection to it. Shiraz has built a strong reputation domestically and internationally but because of its position, not easy to surprise the market with it. Especially for a small size cool climate but less known wine region like the Great Southern. The important well-defined distinguishing point could be achievable by winemaking techniques like partial whole bunch fermentation

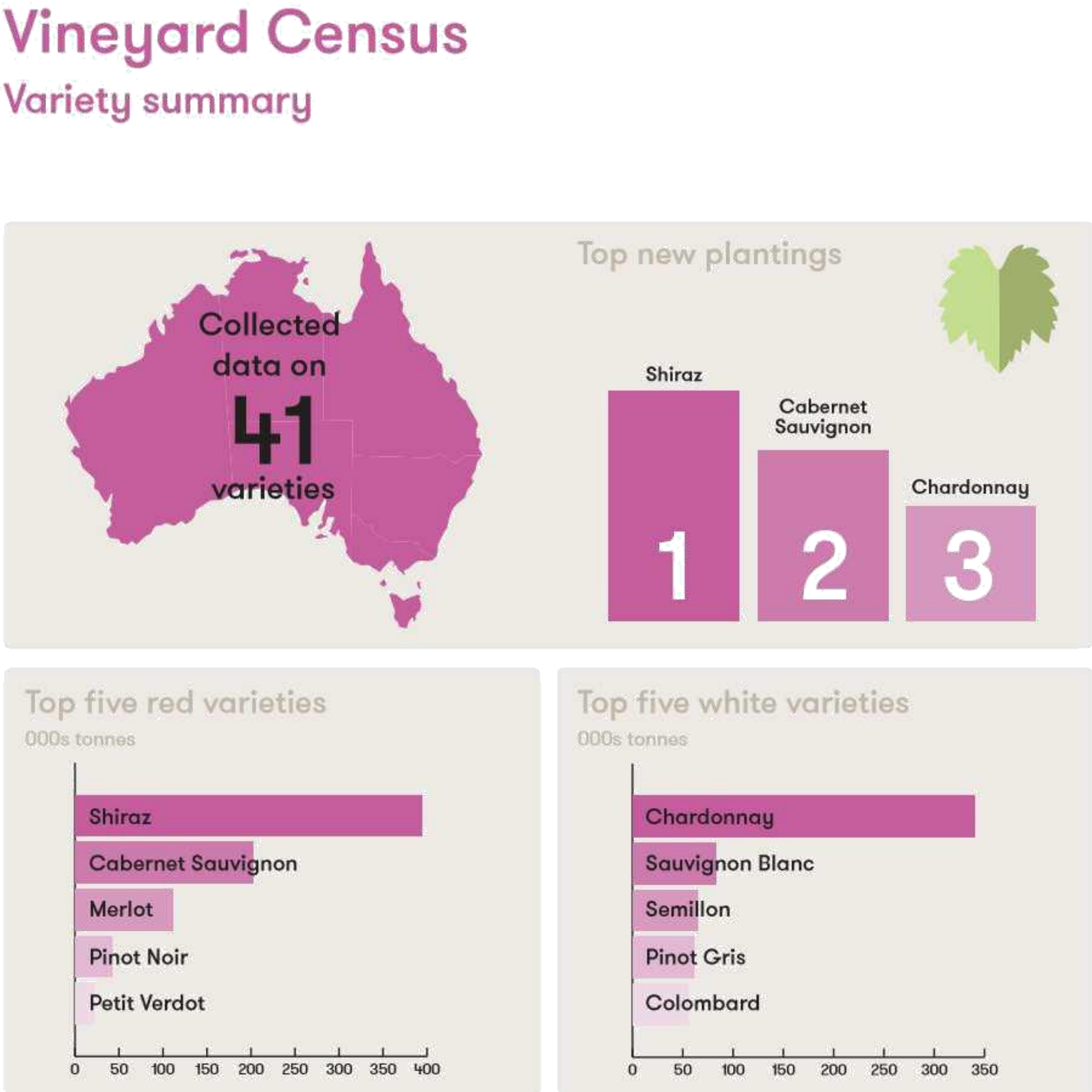


Figure.3. Shiraz and its position in the Australian wine industry (source: Wine Australia)

At Brackenwood Vineyard we were experimenting different proportion of whole cluster inclusion in Shiraz ferments along with Pinot Noir, Gamay, and Barbera grape variety and as a result; Brackenwood Vineyard Syrah has been awarded numerous medals on regional and national wine shows.

We suppose the partial whole cluster fermentation is a possible way to express typicity on cool climate Shiraz. However, a wild range of associated risk is involved with such as fermentation technique. The application needs to be evaluated carefully and specifically.

Table.1. Shiraz surface area and yield in high quality growing regions (source: ABS)

Wine Regions	Total surface area (ha)	Shiraz surface area (ha)	Total Yiel (t/ha)	Shiraz Yield (t/ha)
Adelaide Hills (SA)	3052	283	8.6	6.5
Great Southern (WA)	1949	5549	3.3	3.6
McLaren Vale (SA)	6209	3412	5.9	5.7
Barossa Vale (SA)	9310	5748	5.2	5.0
Australia	135133	39893	13	

Figure.4. The Great Southern Wine Region (source : ABS)

Table.2. Characteristics of the climate and Shiraz wines in, high quality growing regions (source :ABS)

Wine Regions	Characteristics of Shiraz	Characteristics of the climate
Adelaide Hills (SA)	While the concept of Shiraz and Pinot Noir performing well in the same region may be a beguiling concept to some, the success of these varieties in the Adelaide Hills speaks volumes for the size of the region and diversity of microclimates available to grape growers and winemakers. In recent years the region has become a leader in cool-climate Australian Shiraz, producing wines with elegance, length, and balance.	• Altitude creates various meso-climates but overall the climate is cool • The region is very hilly with various valleys and sub-valleys • Some west facing slopes in the northern area are warm enough to ripen Cabernet Sauvignon • Most of the region is best suited to early ripening varieties
Great Southern (WA)	High-quality Shiraz is produced in this region. Great Southern Shiraz exhibits a compelling combination of liquorice, spice, pepper, black cherry and plum. Many producers use well-balanced oak treatment, allowing the fruit quality to fully express itself.	• As one moves north and inland from the strongly maritime-influenced climate of Denmark, the Continental influence and temperature variability increase significantly. Elevation, aspect and sites vary widely, but in general terms the climate of these northern areas is slightly warmer on the higher sites. • Though rainfall is greater and relative humidity increases in the south around Denmark, heat summation and sunshine hours do not change greatly, so careful site selection allows the production of virtually every wine style.
McLaren Vale (SA)	While many varieties do well in McLaren Vale Shiraz is still considered king and still accounts for almost 50% of the total crush each year. A range of sub-regional styles exist but dark chocolate, blueberry and spice characters are common. The best examples are typically medium to full-bodied with vibrant, pure fruit.	• The cooling effect from the ocean creates substantial meso-climate variation • Exposure to or protection from ocean influence dictates success of varieties planted • Low summer rainfall
Barossa Vale (SA)	Occupies 50% of the vineyard plantings and is the most famous variety in the Barossa. The Barossa has some of the oldest Shiraz vines in the world dating back to 1843. The style is typically full-bodied with ripe fruit and plush tannins; the very best examples moderate this natural richness with balanced acidity and a focused pure fruit character.	• The region has a Mediterranean climate ideal for full-bodied red wines, excellent fortified wines and generally robust white wines. • The climate ranges from warm on the valley floor to cool at the higher altitudes in the hills surrounding the Valley. • The region has a large diurnal temperature range, high maximum temperatures, high sunshine days and low humidity and rainfall.

1.2 Whole cluster inclusion in red wine fermentation

The incorporation of whole bunches into red ferments is a historical and common practice employed mostly by Pinot Noire and Syrah however often used with other varieties. Recently the technique has a growing popularity in Australia. During fermentation, the implanted intact berries and the extracted stems can modify the wine aromatic and phenolic profile. Godde .,(2018).According to Barros et al.,(2014) the grape stems are a rich source of potential health-promoting phytochemicals such as hydroxycinnamic acid and flavonoid derivatives, with strong antioxidant activity. Enological practices like whole cluster fermentation can also result in higher resveratrol levels and antioxidative capacity in red wines Eder., et al(2004)

1.2.1 The Intact berry component

The major sensory differences between whole-bunch fermented and conventional wines made from de-stemmed fruit relate to phenolic profiles and wine aroma. During the period that intact berries remain attached to the stems, it is possible that similar enzymatic reactions occur as with carbonic maceration , and thus the wines may contain some similar 'fruity' or 'spicy' aromas, namely benzaldehyde ('cherry', 'kirsch', 'almond'), vinylbenzene ('styrene', 'plastic') and ethyl cinnamate ('cinnamon', 'strawberry', 'honey') (Ducruet 1984; Capone et al.,2016; Godde.,2018)

1.2.2 The stem extraction component

The stem inclusion in red wine ferment has a number of advantages and disadvantages according to Ribéreau-Gayon et al.,(2006)

- Reduction of tank capacity by 30%, higher press capacity required, however, stem facilitates juice extraction during pressing.
- Quicker more complete ferments, the stems are ensuring the presence of air, also absorbing calories, limiting temperature increases.
- . With botrytized grapes, stems protect wine color from oxidasic casse.
- The stems modify wine composition
    1. Contain water and very little sugar, thus lowering alcohol content.
    2. Stem sap is rich in potassium thus decrease acidity and alcohol.
    3. Most significantly affects tannin concentrations, in total phenolic compounds in the presence of stems, color intensity diminishes. This long-observed fact is interpreted as the adsorption of grape skin anthocyanins on the ligneous surface of the stems.
    4. . Although wines made from stemmed harvests have less color when young, they become more colored than their destemmed counterparts in the course of aging.
    5. The increased tannin and phenolic compound concentration of wines made from stemmed harvests can increase wine quality in certain cases

According to Godden (2018), The inclusion of stems can result in higher concentrations of compounds which introduce

- ‘cut-grass’ and ‘herbal’ aromas,
- as well as potentially ‘fruity’ and ‘floral’ aromas,
- there is some evidence that it can also result in higher pH and decreased acidity.
- There is also strong evidence of increased tannin concentrations, which if overdone can lead to excess astringency and perception of ‘greenness’ in the wines.

1.2.3 The question of stem lignifications

Grape stems contain significant amounts of polyphenolic compounds, thus potentially important source of polymeric proanthocyanidins and catechin. Tannins consisted of polymeric proanthocyanidins (up to 27 units) mainly consisting of (−)-epicatechin units along with smaller amounts of (+)-catechin, (−). (Souquet., et al 2000; Sun et al1999; Jordao., et al 2001). After quantification of polyphenolic compounds of Merlot grapes by HPLC Souquet., et al (2000) found quercetin 3-glucuronide, most important one followed by catechin. Stems may be a source of phenolic acids (caftaric and coutaric acids) in lower quantities than pulp and skin. The percentage of galloylation are close to values found in the seeds

The stem-condensed tannins were qualitatively intermediate between seed and skin. Sun., et al (1999) found the great majority of the extractable catechins, oligomeric and also polymeric proanthocyanidins released into wine.

Most authors (Boulton at al., 1996; Ribéreau-Gayon et al., 2006; Capone.,2016; Godden., 2018; Aebischer.,2017)) highlight the importance of the degree of grape stem lignification. The best results are achievable by highly lignified woody rather green stems. The inadequate lignification could increase significantly the green/herbal aromas and flavors in whole bunch ferments

The conditions of stems show high seasonal variation(Boulton at al.,1996) According to Godden (2018) Lignification is likely to be lower in cool climates, and in cooler years. Consequently, lignification tends to be lower in wet years, especially when there is mid- to late-season rainfall which stimulates vine growth, and in high-vigor vineyards.

However, Capone et al .,(2016) reports a growing interest in recent years among winemakers, especially in cooler climate regions using whole bunch fermentations for red wines.

1.2.4 Methoxypyrazine and Rotundone

The Australian Wine Research Institute (AWRI) as a part of a larger project - focused on volatile aromas and flavor compounds - investigating the origin of the ‘green’ flavor characteristics in Shiraz wines.

Along the well known, dimethyl sulfide (DMS) and C6 compounds such as cis-3 hexanol; the team successfully identified the 2-isobutyl-3-methoxypyrazine (IBMP) as a key contributor to capsicum/bell pepper, stalky character in the whole bunch Shiraz ferments with an elevated concentration (10 ng/L) which has a clear sensory effect. The compound is known to be responsible for ‘green’ flavor in Cabernet Sauvignon, which was previously thought not to be biosynthesized in Shiraz grapevines, the origin of the compound likely to be the grape stem (AWRI 2017, Capone et al .,2016,2018)

Rotundone responsible for ‘’peppery’’ aroma in wine and it is a very important and distinctive for cool climate Australian Shiraz. Higher rotundone concentrations were typically reported for grapes from certain vineyards located in cooler regions. The compound present in wine is mainly from the grape skin, but can also be found in non-grape tissues, such as leaves and stems. viticultural practices and environmental factors can have a major impact on rotundone concentration. Beyond grape ripeness and harvest date, key variables are sunlight and/or temperature in the bunch zone, which can be related to the topography of a vineyard; bunch exposure; soil properties; vine vigor; and water status. (Zhang., et al 2016; AWRI,2015)

Zhang., et al 2016 confirmed non-grape tissues contained higher concentrations and amounts of rotundone compared to berries, which showed that non-grape tissues were the larger pool of rotundone within the plant. However, an AWRI study in 2017 found lower rotundone concentrations in semi-carbonic macerated Shiraz wines.

1.2.5 “The Green Tannins”

The presence of stems or stalks in Shiraz ferments can allow additional tannins to be extracted, affecting astringency and mouth-feel, but they can also give rise to ‘green’ ‘stemmy’ aroma, and potentially bitterness (Capone et al., 2016). The ‘’green character “ in wine links to chemical markers, specific tannins. The proportion of catechin and percentage galloylation in the tannin can be associated with bitterness, and the ‘green stalks’ attribute was linked to IBMP and DMS concentration. (AWRI 2017)

1.2.6 Chromatic characteristics

Goode (2014); and Aebischer (2017) summarised many winemakers anecdotal observations on the lower color of whole-bunch fermented wines as an effect is thought to be due to the color being adsorbed onto the grape stems during fermentation. Godden (2018) and AWRI (2014) supporting the hypothesis that higher polymeric anthocyanin content is presumably due to increased polymerization of pigments with phenolic fractions from the stems. The cluster effect on wine color is unclear however according to Ribéreau-Gayon et al.,(2006) the color of young wine made with stems generally reduced and become more colored than their destemmed counterparts in the course of aging. Suriano et al., (2015) experimenting by Primitivo grape, observed also increase the color stability over time along with higher anthocyanins concentrations in most cases

2. The aim of the Study

Shiraz plays an important role in the Western Australian RockCliff Winer's portfolio, currently producing 2 monovarietal wines at different price-points, the Third Reef Shiraz (30 AUD) and Single Sites Shiraz (45 AUD) The winery's main interest was to find alternative ways to achieve overall quality improvement particularly on the premium Single Sites label . Also, assess possible new market opportunities with a nonconventional Shiraz wine. Currently, the winery employs only machine harvested fully crushed and destemmed fruit during Shiraz wine production.

Many anecdotal and empirical observation linked to whole - cluster fermentation. Due to the very limited specific publication on such fermentation technology we don't have sufficient knowledge regarding how is whole cluster inclusion influences the fermentation kinetics, sensory and physicochemical attributes of the wine.

In order to assess the potential, evaluate the risks and opportunities in partial whole cluster fermentation technology, a small-scale experiment has carried out during the 2018 vintage.

3. Material, and Methods

3.1 Location, source of the material

Mount Barkers has excellent fruit ripening conditions, the climate characterized by high daily temperature fluctuations, average annual rainfall of 600-700mm The subregion along Shiraz has an established reputation for producing high-class Riesling, Cabernet, and Pinot Noir wines as well.

The Shiraz fruit has been sourced from a block located between two historical towns Denmark and Mount Barker in the Mount Barker Subregion, Great Southern Wine Region, Western Australia. The 19 years old 10.7 ha vineyard is an ungrafted, drip irrigated, VSP trained spur pruned block, regularly producing a moderate 5-7 t/ha fruit annually. Simultaneously with the conventional machine harvester 100kg of Shiraz grape in perfect sanitary condition hand harvested and processed on the 14th of April at RockCliff Winery's cellar (16 Hamilton Road, Denmark, WA)

3.2 Fruit processing and fermentation

The hand harvest grape partially destemmed by hand (noteworthy to mention they were fairly green /unmatured see Figure 8.) and distributed into 3 food grade plastics fermenter.

Table.3. Coding of the treatment and the whole cluster inclusion

modelati sample A
hand harvest with NO whole cluster, barries only, crused, time of maceration/fermentation 16 days
modelati sample B
hand harvest with 1/3 whole cluster, non crushed, time of maceration/fermentation 24 days
modelati sample C
hand harvest with 1/2 whole cluster, non crushed, time of maceration/fermentation 24 days
modelati sample D
machine harvest with NO whole cluster, but MOG, crushed, time of maceration/fermentation 16 days

With the aim to broaden the study a forth similar size sample has been taken from the conventional machine harvested and processed fruit. Table 3 shows the treatments and percentage of the whole cluster inclusion.

In terms of additions, cap management and fermentation time on skins we were following the basic protocol of the winery's premium red Shiraz winemaking technology, trying to replicate the conditions similar to the "1000 liter Omni bin "ferments.

The microvinifacition experiment conducted in a cotton-based sheet covered open top, food grade plastic "blue drum" fermenters, without temperature control. Fermentation temperature ranges between 15- 20 c. The partial whole bunch ferments (Sample B and Sample C) were reaching negative Baume in 24 days the same level of dryness achieved in only 16 days by the fully destemmed fermenters (Sample A and Sample D)

From the beginning of the alcoholic fermentation, cap management carries out only gentle hand-plunging, 2 times a day until the ferment reaches negative Baume. The separation of the skins (hand pressing) followed by two days long sedimentation period prior to placing the wines in storage containers (in wine bottles) for further chemical and sensory analysis.

Harvest date: 14/04/2018 Initial pre enoculation and addition values

Temperature: 17.7c , Baume degree :13.9, pH: 3.42 , Titrable Acidity :6.49 g/L

Table .4.Additions during vinification

Additions	Brand	Dosage	Rate
Yeast, Saccharomyces cerevisiae	BP 725 "Maurvin"	25g/hl	7.5g
Starter,Organic nitrogen+Egosterol	Superstart ruge " Lafort "	30g/hl	9.0g
Pectolytic enzyme	HE grand cru "Lafase "	30g/T	0.9g
Tannin, Ellagic+Proanthocyanidic	VP supra "Laffort"	10g/hl	3.0g
Sulphur, Potassium Metabisuphite	E224 winy " Enartis "	10g/hl	3.0g
Yeast nutrient supplement	Fermcontrol "Kauri "	20g/hl	6.0g

Figure 5, Representative Shiraz vine from the harvested block by Horvath, L.

Figure 6, Phases of the wines elaboration process by Horvath, L.

3.3Analytical methods

The first phase of the measurements, the fermentation monitoring the routine chemical analysis for Alcohol, PH, Total Acidity, Volatile Acidy, Malic Acidy, and Glucose /Fructose content. Followed by a simple descriptive organoleptic assessment took place at Rockcliffe Winery (WA).

The second phase of the analysis on focused on the samples phenolics composition and conducted in Lisbon, Portugal at the Laboratorio Ferreira Lapa (Sector Enología) Insituto Superior de Agronomia (University of Lisbon)

3.3.1Fermentation monitoring

Ones a day after the second cap submerging treatment (plunging down) the temperature and Baume values are measured by the portable Anton Paar, DMA 35 Density Meter in order to obtain a clear view of the fermentation kinetics.

3.3.2 Routine chemical analysis

The routine multi-parameter analysis carried out by FOSS Wine ScanTM, FT120 model analysis of liquid samples. The analytical method based on the Fourier Transform Infrared principle, the routine analysis involves infrared scanning of must or wine samples. Through mathematical modeling, the concentration of wine constituents is determined within 30 seconds, the obtained results are collected on the software platform.

3.3.3 Descriptive organoleptic assessment

Two weeks following the end of the alcoholic fermentation a randomized ‘’blind’’ descriptive sensory analysis focused on aroma and palate attributes, took place by the chief winemaker Michael Ng and assistant winemaker Antony Paume.

3.3.4 Condensed tannins separation and quantification

The separation of proanthocyanidins was performed using a C18 Sep-Pak cartridge (Waters, Milford, Ireland) according to their degree of polymerization into three fractions, monomeric, oligomeric and polymeric, following the method described by Sun et al. (1998). The total flavan-3-ol content of each fraction was determined using the vanillin assay according to the method described by Sun et al. (1998). Quantification was carried out by means of standard curves prepared from monomers, oligomers, and polymers of flavan-3-ol isolated from the wines as described elsewhere (Sun et al., 1998; Sun et al., 2001).Cosme et al. (2009)

3.3.5 Coloring pigments, phenolic composition

The identification of samples chromatic characteristic performed by the spectrophotometer methods developed by Somers and Evans, 1977

The simple and polymeric pigment forms by measuring the absorbance of wine at 520nm, before and after addition of excess S02.Anthocyanins decolorize upon addition of SO2, while polymeric pigment forms do not The total anthocyanin content and ionized anthocyanin content
were determined using the methodology developed by Somers and Evans (1977),
by spectrophotometry in a cuvette with a 10 mm path length.

Total anthocyanins (mg⁄L)is given by the following expression =

$$20 * (A_{520}^{HCl} - \frac{5}{3} A_{520}^{SO_2})$$

Colorized anthocyanins (mg⁄L)is given by the following expression =

$$20 * (A_{520} - A_{520}^{SO_2})$$

A spectrophotometric method was applied to determine color intensity and shade, in order to obtain the absorbency values necessary to calculate these parameters – radiation measurements of wavelengths 420, 520 and 620 nm (OIV 2015).

Color intensity (u.a), is given by the following expression =

$$A_{420} + A_{520} + A_{620}$$

Total color shade, hue (u.a) is given by the following expression:

$$N = \frac{A_{420}}{A_{520}}$$

The total pigments are calculated through the methodology described by Boulton (1999) based on the following expression:

Total pigments (u. a.) is given by the following expression =

$$A_{520}^{HCl} \times 101$$

Polymeric Pigments (u. a.) is given by the following expression =

$$A_{520}^{SO_2} \times 10$$

For the total phenols determination, the methodology used consisted in the measurement of the absorbency at wavelength 280 nm (A280) of the diluted wine sample (Somers and Evans 1977).

Total phenols (u.a) is given by the following expression =

$$\text{Total phenols} = A_{280} * \text{dilution factor}$$

The used method is based on the absorbency measurement at 280 nm wavelength of the sample before and after the precipitation of the flavonoids through a reaction with formaldehyde under certain conditions (low pH, room temperature) (Kramling and Singleton 1969).

Nonflavonoid phenols (u.a.)

$$A_{280} * \text{dilution factor}$$

Nonflavonoid phenols (mg/L)

Gallic acid calibration curve has been applied for the previous formula in order to obtain the results in mg/L

Flavonoids (u.a)

Flavonoids (mg/L)

Flavonoid values calculated by Total phenol values deducted with Nonfalvonid phenols

4. Results and Discussion

4.1 Fermentation kinetic

Due to the ongoing difficulties involved with temperature control during fermentation one of the most important question, was for the winery, how is the whole bunch inclusion influences the fermentation speed and temperature.

In Figure 5 we can observe similar temperature ranges between 15 -20 c degree in all cases, Figure 6 shows a corresponding trend on fermentation speed, however, the hand-harvested no whole cluster incorporated but crushed (Sample A) runs a slightly quicker fermentation curve, presumably because of the faster yeast dispersion in the better-homogenized medium . In order to avoid further residual sugar problems, the winery has a stricted policy on red wine pressing protocol. The separation of skins can only take place after the ferments reached negative Baume degree for at list two consecutive days.

The partial whole bunch ferments (Sample B and Sample C) were detectably warmer however reached the desired negative Baume degree 7 days later , resulted a week longer vatting time period ,24 days in total compared to the 16 days long skin contact on the wines made without whole cluster (Sample A and Sample D) The slower sugar release from the remaining whole berries at the last phase of the fermentation could be a possible explanation of this phenomena . We were unable to verify the results of Ribéreau-Gayon et al.,(2006) regarding quicker, more complete ferments with the least temperature increase in the presence of stems

Figure.7.remaining whole berries attached to the stem at the end of the fermentation, by Horvath, L.

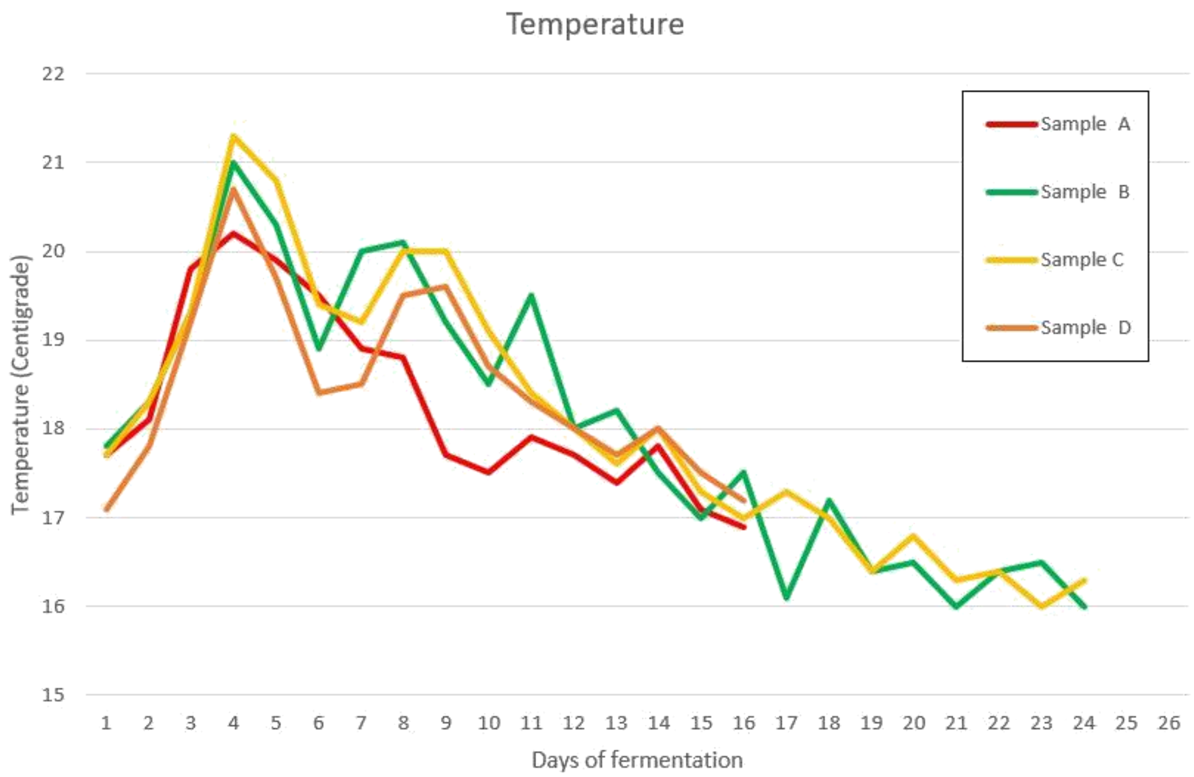


Figure.8.Fermentation kinetics: Temperature

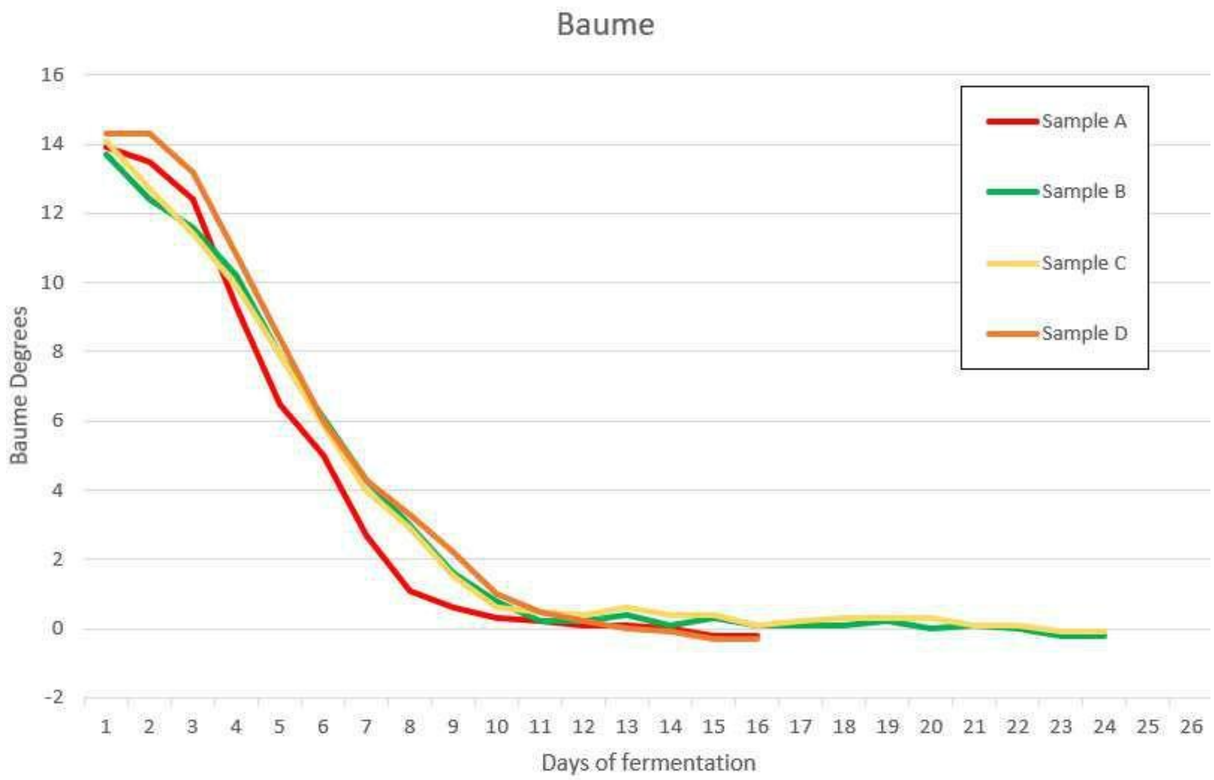


Figure.9. Fermentation kinetics: Baume

4.2 Routine chemical analysis

The conventional machine harvested destemmed and crushed (Sample D) obtained from the winery's industrial-scale size fruit processing line and by its nature fully represents the fruit quality of the harvested block, unlike the hand-harvested samples. The significantly higher alcohol and lower malic acid values are linked to a different initial level of ripeness and fruit quality.

Regarding the alcohol content, the hand-harvested Sample A, slightly higher than, Sample B and significantly higher than sample C.The alcohol reduction possibly related to the stem adsorption properties and it's high water and low sugar content. However, the same absorption phenomena, can not be justified on PH and Total acidity values thus minor differences in the values.

The differences are negligible in Acetic Acid content on the hand-harvested samples. The lower value could be resulted by the different initial fruit quality.

The samples are fermented successfully dry, the potential residual sugar level, expressed in Glucose / Fructose under the technical limit in all cases.

Table.5. Routine chemical analysis results

Samples	Alcohol Content	pH	Titrable Acidity (g/l)	Volatile Acidity (g/l)	Malic.Acidity (g/l)	Glucose/Fructose (g/l)
sample A hand harvest with NO whole cluster, barries only, crushed	13.8	3.50	7.30	0.48	2.3	0.17
samaple B hand harvest with 1/3 whole cluster, non crushed	13.7	3.50	7.02	0.52	2.4	0.01
sample C hand harvest with 1/2 whole cluster, non crushed	13.1	3.50	6.89	0.51	2.4	0.11
sample D machine harvest with NO whole cluster, but MOG, crushed	14.6	3.50	6.84	0.43	1.8	0.23

4.3 Descriptive organoleptic assessment

Capone at all 2018 pointing out on the terminology problematic in the descriptive analysis regarding "green flavor" in red wine.

Our tasters concept(Table.4.) of green character was also different both detected herbaceous notes in wines made with whole cluster inclusion (Sample B, Sample C). The recently identified Isobutyl Methoxypyrazine (IBMP) in Shiraz wines made with stem inclusion (AWRI 2018) could be compound behind the " capsicum nose " described by assistant winemaker Antony Paume.

However in such high proportion, 1/2 of whole cluster (Sample C) influences on the wine were not overwhelming, it can be hypothesized some parts of the "greenness" have been reduced or modified due to the food grade plastics adsorption properties. AWRI (2017) demonstrated a dramatic reduction of IBMP concentration in small-scale fermentation study with food grade PVC.

Rotundon as an important Shiraz characteristic described as "light pepper" by one of the tasters in Sample C.

According to Zhang, P .,at all 2016 grape stem can be a larger pool of rotundon compared to the berries However an AWRI (2017) study found lower rotundone concentrations in semi-carbonic macerated Shiraz wines It can be hypothesized that extra rotundone concentration originated from the incorporated stems and positively contributed to the wine aromatic and complexity .

The whole cluster component clearly alternated the organoleptic characteristics of the wines towards herbaceous notes but brought "complexity" compare to the destemmed crushed samples where " fruity " notes were dominating the wine profile.

The University of Melbourne graduate Michael Ng and the Montpelier Supagro (France) graduate Antony Paume represent two different winemaking approaches however interestingly both evaluated the samples in a similar order, favored wines the most, made with the incorporation of whole clusters. Valued "complexity rather fruit forwardness "

Noteworthy to mention after the 2 days long sedimentation period the wines were stored in 5 c degree cold environment in order to avoid the start of the malolactic fermentation (which would make the wine transportation riskier) that explains the reason why the tasters commented on "tartness, acidity " multiple times

Table.6. Discriptive Organoleptic results

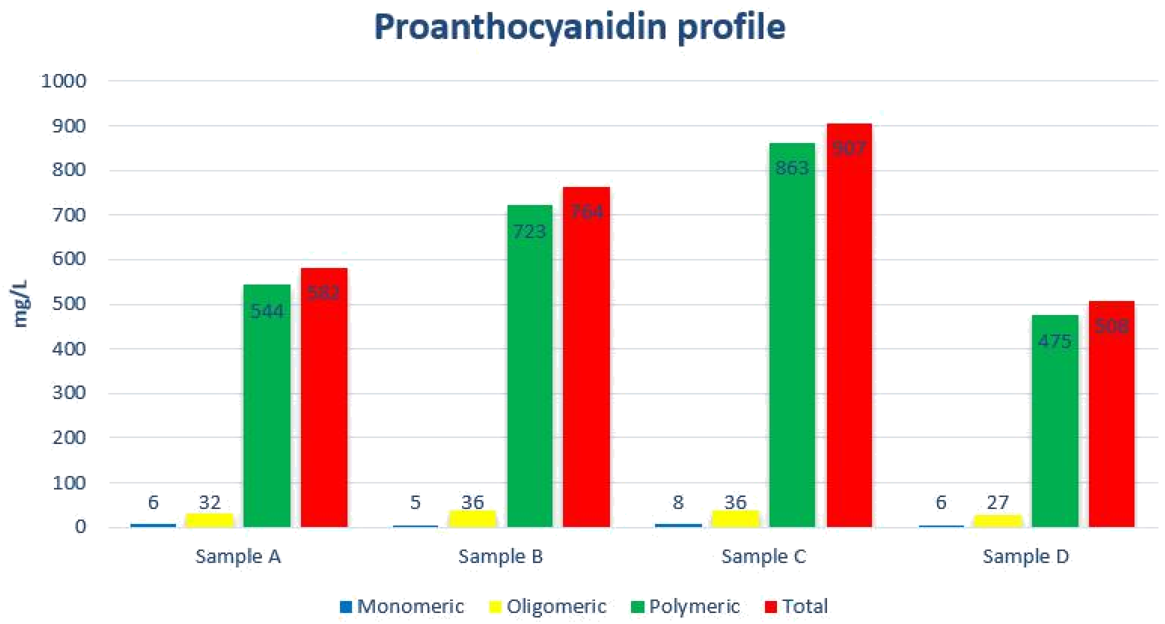
	Michael Ng	Order of preference	Anthony Poule	Order of preference
Sample A, hand harvest with NO whole cluster, berries only, crushed	•Red berries, fruit bright • Tart, berry fruit on the palate.Short finish almost simple palate	4	• Very ripe plum, pate, smoky meat • Tight start, acidity. Short in mouth ,tannin light ,elegent ,no dryness	3
Sample B, hand harvest with 1/3 whole cluster, non crushed	•Slightly green edge aromatics, bright stalkiness • Similar tartness, denser palate to the previous, more savory palate more length	1	• Nose a bit closed, Flintstone • Elegance in the mouth but a bit short, smoky meat.	2
Sample C, hand harvest with 1/2 whole cluster, non crushed	•Slightly green notes but inviting •Tartness, Red berry flavors, chalky tannins grippy palate with slight zappiness	2	•Nose very capsicum, light pepper • Acidity very tight. Thyme, rosemary in mouth, tannin interesting	1
Sample D, machine harvest with NO whole cluster, crushed, MOG	•Fruity aromas, violets and a hint of plum. •Slightly hallow palate but softer than above.	3	•Nose very lifted but less complexity •Acid tight, fruit good ripeness, tannin soft, elegant in the mouth	4

4.4 Condensed Tannins

Regarding the fractionation of the condensed tannins, there were significant differences between the samples (Figure.8.) However, the concentration values of the monomeric and oligomeric fraction were low and similar in all cases.

The highest values of polymeric tannins measured in Sample C and Sample B.The same tendency can be observed in the total condensed tannin concentration, which seems to be related to the extracted additional tannins from stems and furthermore to the longer maceration time. Interestingly no higher polymeric and total condensed tannin values were detectable in the machine harvested MOG included sample compared to the hand-harvested destemmed wine.

Figure.10. Proanthocyanidin profile by fractions



4.5 Chromatic characteristics

Concerning the anthocyanins (Figure.9.) the stems absorption properties resulted in lower values on both Total and Colorized Anthocyanins. The fully destemmed sample represent the highest values followed by the machine harvested MOG included sample. Referring to the relevant literature we can expect a shift in more stable anthocyanins and color towards the whole- bunch fermented wines during aging

Minor differences observed only (Figure.12.) in Tonality values however Color Intensity, Total Pigments, and Polymerized Pigments were notably lower with the whole- cluster ferments that. The phenomena presumably linked to the stem absorption properties

Regarding the phenolic composition (Figure 11 and Figure 12) the Flavonoid compounds in Total phenols are representing a percentage between 85 and 90 % across all the samples. Only minor differences are detectable however ones again the totally destemmed Sample A takes the lead, display the highest content in Total phenols and Flavonoid

This study was unable to justify the results of Ribéreau-Gayon et al.,(2006) Suriano et al., (2015) regarding the increased phenolic compound concentration of wines made with stem inclusion.

Figure.11. Anthocyanins, Chromatic Characteristics

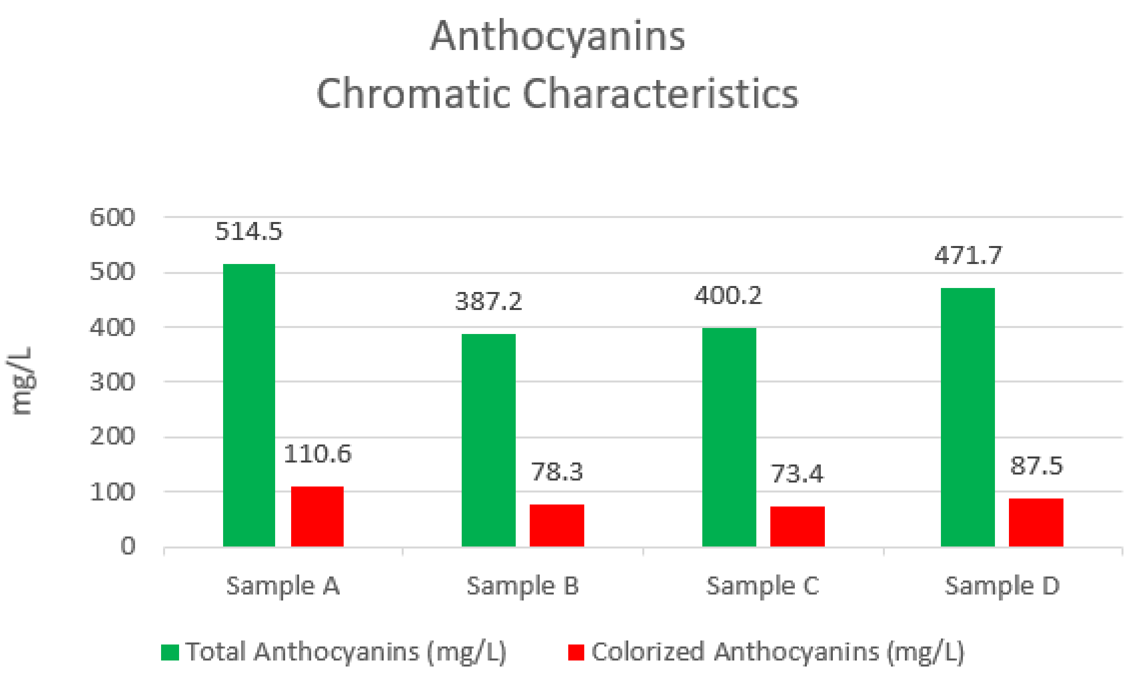


Figure.12. Chromatic Characteristics

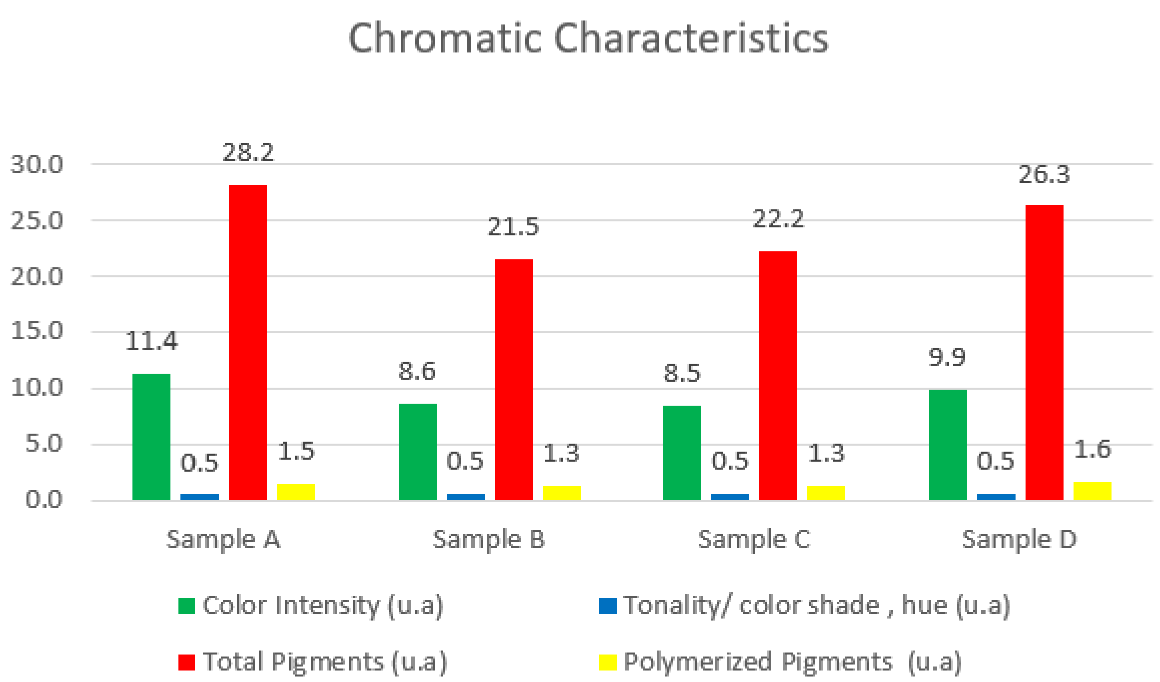


Figure.13.Phenolic composition expressed in absorbance unit

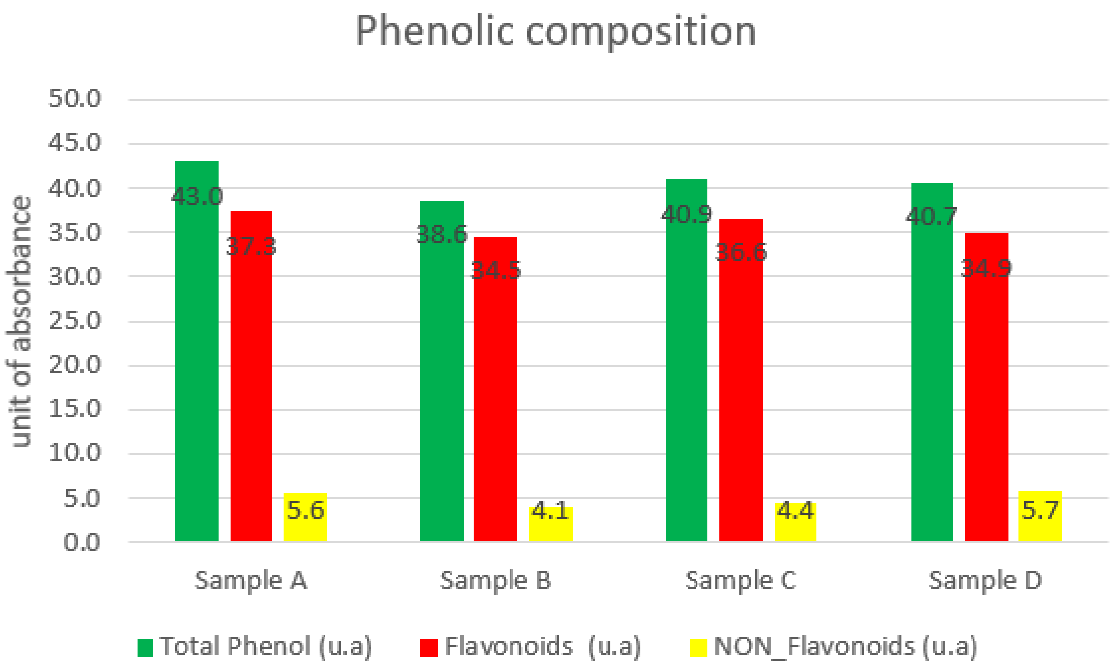
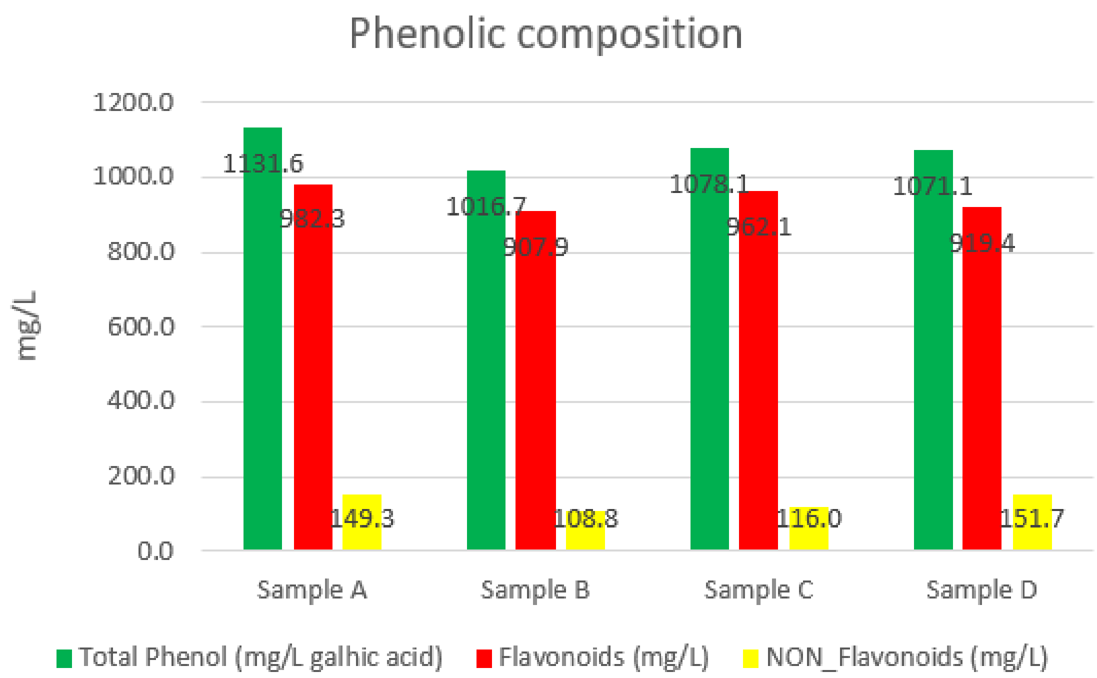


Figure.14. Phenolic Composition expressed in mg/L



5. Conclusion

Whole cluster fermentation as an ancient winemaking technique seems to be a newly discovered fashionable way to elaborate elegant, complex Shiraz wines in Australia

This experimental study conducted at Rockcliffe Winery during the 2018 vintage with Australian Shiraz from the Great Southern Wine Region (WA) in order to evaluate the impact of high level (1/3 and 1/2) whole cluster incorporation on the fermentation kinetics, chemical composition and organoleptic properties of Shiraz ferments. The results are compared with wines obtained (under same experimental conditions) by conventional winemaking techniques, namely, hand harvested destemmed, crushed and machine harvested destemmed, crushed.

Regarding fermentation kinetics, only minor differences were detectable between the samples, however, the whole berry component resulted a sluggish phase at the end of the fermentation. The whole-bunch incorporation and longer maceration time clearly impacted the wines sensory and chemical properties, compared to the hand harvested, destemmed-crushed and the machine harvested destemmed-crushed samples.

The introduced stems, absorption properties resulted lower values in Color Intensity, Total Anthocyanins, and Colorized Anthocyanins. However, the differences were negligible in the Total Phenol concentration. The highest proanthocyanidin levels were obtained in the red wines elaborated with grape stems, especially in the modality with the highest stem percentage (Sample C, where 1/2 of the stems were present during the maceration)

The main associated risk in whole-cluster fermentation technology the introduction of "green/herbaceous" notes. These attributes are also observed and described by the tasters with terms like stalkiness, capsicum. In Australian whole-bunch fermented Shiraz wines recently identified 2-isobutyl-3-methoxypyrazine (Capone., et al 2018) introduced by the stems could be responsible for those attributes.

The winemakers rewarded the aromatic and flavor complexity, related to the contribution of the whole clusters and presumably the longer maceration time applied on the whole cluster incorporated ferments. The intact whole berry effect was less pronounced on the wines organoleptic properties than the impact of the stem originated phenolic compounds.

Incorporation of whole clusters into Shiraz ferments seem to be a useful tool to modify positively the wines aromatic- favor and chemical profile, even the wines were evaluated at such an early stage (pre malolactic fermentation).

The hand harvest related additional cost of production has to be taken into consideration. The application, the potential integration into the Rockcliffe Winery's industrial-scale Shiraz winemaking technology requires further research.

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