Research Note: Effect of Grapevine Canopy Side on Selected Sensory Attributes of Pinotage and Cabernet Sauvignon Wines

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Grapevine row direction, canopy exposure and grape maturity can define the sensory attributes of wine. From this perspective, canopy exposure that favours colour intensity, astringency, aroma intensity and balanced acidity could result in improved wine quality. The aim of this study was to examine the effect of canopy exposure on selected sensory attributes of Pinotage and Cabernet Sauvignon wines from Paarl, Durbanville and Darling in South Africa. Pinotage and Cabernet Sauvignon grapes were harvested from both sides of the canopy of vines planted to E-W and N-S directions. Wines were made from the harvested grapes. Grapes and wines underwent physicochemical and sensory analysis. Durbanville Cabernet Sauvignon from the south side had decreased alcohol content. Total acidity, residual sugar (RS) and pH were not different between sides. Wines from the east side had increased colour, aroma, mouthfeel and overall quality. Paarl Cabernet Sauvignon was not different between sides for any physicochemical characteristics, except TA. Wines from the south side had increased colour, aroma, mouthfeel and overall quality. Darling Pinotage was not different between sides for any physicochemical characteristics. Wines from the west side had increased intensity of aroma and acidity; whereas Durbanville Pinotage from the east side had increased alcohol, pH, TA, colour and aroma intensity, as well as overall quality. The results confirm that canopy exposure has an effect on the wine sensory attributes. This investigation illustrates the variation in sensory attribute scores of Pinotage and Cabernet Sauvignon wines from different canopy sides. Canopy exposure in a vineyard of a specific region, orientated to an E-W or N-S direction, which favours colour intensity, aroma intensity and/or mouthfeel, could result in improved wine quality. Future investigations should focus on samples collected over at least three consecutive vintages, as well as the monitoring of temperature and photosynthetic active radiation.

INTRODUCTION

Grapes comprise of numerous primary metabolites (white, red and teinturier cultivars), such as sugars, organic acids, amino acids as well as secondary metabolites, i.e. flavonoids and non-flavonoids (Gawel, 1998). The latter include anthocyanins, flavan-3-ols, flavonols, flavononols and phenolic acids, which are present in the grape berry (Downey et al., 2006).

Phenolic concentrations of grapes are determined by genetics (Downey et al., 2006), but can be affected by vineyard practices, microclimate (e.g. row direction, diurnal temperature, trellis system, precipitation, light interception, canopy exposure), degree of berry ripeness and vinification processes (Gawel & Godden 2008; Hunter & Volschenk 2008; Rio-SEGade et al., 2009; Chorti et al., 2010; Rustioni et al., 2011; Friedel et al., 2012; Minnaar et al., 2013; Allegro et al., 2019).

Canopy exposure altered the interception of light by Tannat grapes and hence affects the accumulation of phenols throughout grape ripening (González-Neves et al., 2004; Pérez-Lamela et al., 2007).

Hunter and Volschenk (2008) demonstrated that Syrah grapes harvested from east-west (E-W) and northwest-southeast (NW-SE) row directions showed differences in grape skin colour. An increase in grape skin tannin concentrations was reported in Nebbiolo (Chorti et al., 2010), Pinot Noir (Rustioni et al., 2011) and Riesling (Friedel et al., 2012) grapes exposed to direct sunlight (low-vigour vines) compared to grapes from dense canopies. Moderate exposure of grape bunches to light favours colour accumulation (Chorti et al., 2010). Minnaar et al. (2013) showed that grape skin colour was higher in Syrah grapes harvested from a NW-SE and northeast southwest (NE-SW) row direction, compared to an E-W and north-south (N-S) row direction.

Phenolics can define the quality and character of wine...
Grape harvesting

Grapes represented a spread over twelve rows per vineyard block, consisting of eighty individual grapevines per row, from which the most upfront exposed bunches were collected from the respective canopy sides, i.e. east, west, north and south. Grape bunches of the north and south sides of the canopies were moderately exposed to light the entire day, while east- and west-facing canopies received high light exposure in the morning and afternoon in the fruit zone (Hunter et al., 2010). One crate per row per canopy side was collected. Grapes were harvested manually, placed in crates, and transported to the cellar on the same day.

Grape ripeness levels were determined by a handheld refractometer prior to harvest. Grape ripeness levels at the time of harvest varied from 21.1°Brix (lowest level) to 25.5°Brix (highest level) among the grape cultivars (Table 1). Grapes were harvested during the months of February and March of the specific year. Grape cultivar, grape-growing region, date of harvest, rootstock, row direction, canopy side, number of samples collected and grape ripeness levels are listed in Table 1. Daytime minimum and maximum temperatures per region per month, as well as total precipitation, are listed in Table 2.

Small-scale winemaking

Wines were made from the harvested grapes, i.e. twelve crates per vineyard block, representing a canopy side and twelve replicate treatments (Table 1). Wines were made according to a standard small-scale winemaking procedure at the ARC Infruitec-Nietvoorbij research cellar. Grape bunches were mechanically de-stemmed and crushed. The must was inoculated with 30 g/hl Saccharomyces cerevisiae strain VIN 13 yeast (Anchor Oenology, South Africa). Grape must was fermented in temperature-controlled rooms (ca. 25°C) on the skins in open fermenters, with three punch downs per day for approximately four days until the sugar levels dropped to approximately 5°Brix. Thereafter, wines were pressed using a small balloon press (ca. 200 KPa) and transferred to stainless steel canisters (20 L) equipped with fermentation locks. The wines were allowed to ferment further for approximately one week until glucose levels were below 2 g/L as determined by a Clinistix® method (Bayer, South Africa). Malolactic fermentation was not induced for any of the wines. Wines were cold stabilised for two weeks.
### TABLE 1
Grape cultivar, vineyards, harvest date, rootstock, trellis system, row direction and canopy side, including grape ripeness and number of samples collected.

<table>
<thead>
<tr>
<th>Grape cultivar</th>
<th>Vineyards (drip irrigation)</th>
<th>Harvest month</th>
<th>Rootstock</th>
<th>Trellis system</th>
<th>Row direction</th>
<th>Canopy side</th>
<th>Replicate grape samples</th>
<th>Grape ripeness (°Brix)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cabernet Sauvignon</td>
<td>Durbanville</td>
<td>March</td>
<td>Richter 110</td>
<td>Four-wired VSP</td>
<td>E-W³</td>
<td>North/South</td>
<td>12/12¹</td>
<td>22.7 ± 1.51/23.1 ± 1.62²</td>
</tr>
<tr>
<td></td>
<td>Paarl</td>
<td>March</td>
<td></td>
<td></td>
<td></td>
<td>North/South</td>
<td>12/12</td>
<td>22.5 ± 1.42/22.1 ± 1.33</td>
</tr>
<tr>
<td>Pinotage</td>
<td>Durbanville</td>
<td>February</td>
<td>Richter 99</td>
<td>Four-wired VSP</td>
<td>N-S¹</td>
<td>East/West</td>
<td>12/12</td>
<td>23.8 ± 1.45/23.4 ± 1.37</td>
</tr>
<tr>
<td></td>
<td>Darling</td>
<td>February</td>
<td></td>
<td></td>
<td></td>
<td>East/West</td>
<td>12/12</td>
<td>25.2 ± 1.31/25.5 ± 1.43</td>
</tr>
</tbody>
</table>

¹Number of crates collected per vineyard per canopy side, i.e. 12 replicate wines per vineyard; ²Vertical shoot position trellis; ³East-west; ⁴Standard deviation; ⁵North-south.

### TABLE 2
Minimum and maximum temperatures (°C) for January, February and March, including minimum and maximum precipitation (mm) recorded for Durbanville, Paarl and Darling.

<table>
<thead>
<tr>
<th>Vineyard</th>
<th>Min and max temperature (°C)¹</th>
<th>Precipitation (mm)²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>January</td>
<td>February</td>
</tr>
<tr>
<td>Durbanville</td>
<td>13.1-33.2</td>
<td>13.6-33.6</td>
</tr>
<tr>
<td>Paarl</td>
<td>13.4-42.1</td>
<td>14.0-42.2</td>
</tr>
<tr>
<td>Durbanville</td>
<td>13.1-33.2</td>
<td>13.6-33.6</td>
</tr>
<tr>
<td>Darling</td>
<td>14.6-39.3</td>
<td>12.6-38.3</td>
</tr>
</tbody>
</table>

¹Degrees Celsius; ²Millilitres
filtering and bottling under nitrogen at room temperature.

**Physicochemical characteristics**
Grape must was analysed for total soluble solids prior to inoculation (Foss® Winescan). Standard chemical analyses of wine were done, viz. pH, total acidity (TA), ethanol and residual sugar levels were determined by means of Foss® Winescan (IWBT, Stellenbosch University) one month after bottling.

**Sensory analysis**
Sensory analyses were conducted four months after bottling on 96 wines, i.e. 48 each for Cabernet Sauvignon and Pinotage. A panel of 13 expert wine tasters (three women and 11 men, aged between 22 and 50 years), comprising mainly Agricultural Research Council staff members but also invited commercial winemakers, participated in the sensory analysis. Panel members had between two and 20 years’ experience in wine evaluation. Wines were evaluated in one session (one day) in a temperature-controlled room at ± 20°C with fluorescent light. Water and wheat biscuits (neutral taste) were provided to tasters for palate cleansing between samples.

Sensory analysis involved the evaluation of colour intensity, aroma intensity, acid intensity, astringency, mouthfeel, and overall quality. Tasting took place in separate tasting booths. Each taster received ca. 30 mL of each wine sample in an ISO international wine-tasting glass. Twenty-four wine samples, representing both treatments (canopy side) of each grape cultivar, were presented to the tasters in a random order per tasting session. The tasters rated the wine attributes on a 10 cm unstructured line scale from low to high intensity (colour, aroma, acidity), thin to full bodied (astringency, mouthfeel), and unacceptable to excellent (overall quality).

**Statistical analysis**
Univariate analysis of variance was performed on all variables using the general linear models procedure of the SAS statistical software, version 9.2 (SAS Institute Inc., 1999). To confirm panel reliability, sensory data was pre-processed employing the model suggested by Næs et al. (2010) that includes panellist, replicate, treatment and interaction effects, with only treatment as fixed effect and all other effects random. The Shapiro-Wilk test was performed on the standardised residuals from the model to test all variables for deviation from normality (Shapiro & Wilk, 1965). Outliers were removed when the standardised residual for an observation deviated by more than three standard deviations from the model value. Following the confirmation of panel reliability and normality, univariate analysis of variance was performed according to the experimental design, using the means over tasters. Fisher’s F least-significant difference was calculated at a 5% level of significance to compare treatment means (Ott, 1998). A probability level of 5% was considered significant for all tests. Sensory attributes and physicochemical characteristics variables were subjected to analysis of variance.

**Results and Discussion**

**Cabernet Sauvignon**
The results are reported in Table 3. Grapevines growing in E-W directions receive low light exposure all day in the fruit zone (Hunter et al., 2010). Alcohol, TA, pH and acid intensity were not significantly different between sides for the Durbanville wines (cool climate). However, wines from the north side scored significantly higher in colour, aroma, mouthfeel and astringency than wines from the south side. The tasters preferred wines from the north side. Gawel et al. (2013) reported that a low pH could contribute to mouthfeel differences. The reduced aroma in wines from the south side may be due to the decrease in methoxypyrazines (Ryona et al., 2008). Hunter and Volschenk (2008) reported that Shiraz grapes from E-W and NW-SE row directions were notably different in berry skin colour.

In contrast to the Durbanville wines, Paarl Cabernet Sauvignon (warm climate) from the south side were significantly higher in TA, colour and aroma intensities, as well as in mouthfeel, compared to wine from the north side. Alcohol, pH, acid intensity and astringency were not significantly different between the sides. The tasters preferred wines from the south side. Hunter and Volschenk (2018) found that acid intensity was significantly different between the north and south sides of the canopy in Shiraz wines from South Africa. Allegro et al. (2019) reported that increased light exposure of grapes could result in decreased grape acidity.

**Pinotage**
Hunter et al. (2010) found that vines planted to N-S directions receive high light exposure in the fruit zone in the morning and afternoon. The west side of the canopies of Darling Pinotage wines (warm climate) showed that the increase in grape bunch light exposure induced an increase in aroma and acid intensity. Alcohol, TA, pH, colour intensity, mouthfeel, astringency and overall quality were not significantly different between sides. Aroma and acid intensity were significantly different between the east and west sides. Hunter and Volschenk (2018) reported that acidity was significantly different between the east and west sides of canopies in Shiraz wines from Robertson, South Africa. Allegro et al. (2019) reported that increased temperature in the fruit zone (N-S vine direction) did not modify mouthfeel or astringency of Grechetto Gentile wines from Spain. Hunter and Volschenk (2018) found that Shiraz wines from the east side of the canopy (N-S direction) were not significantly different in colour intensity from wines from the west side. They also reported that wines from the north side (E-W direction) were not significantly different in colour from wines from the south side.

Durbanville Pinotage wines (cool climate) from the east side were significantly higher in alcohol, pH, TA, colour and aroma intensity compared to wines from the west side. Acid intensity and astringency were significantly highest in wines from the west side. The tasters preferred wines from the east side. The lack of differences in the mouthfeel of wines from canopy sides from both Darling and Durbanville are explained by the findings of Gawel et al. (2013), who reported that mouthfeel differences are more evident at a
### TABLE 3
Average values and standard deviation of physicochemical parameters and sensory attributes of Cabernet Sauvignon and Pinotage wines.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Cabernet Sauvignon</th>
<th>Pinotage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Durbanville</td>
<td>Paarl</td>
</tr>
<tr>
<td>Ethanol (% v/v)</td>
<td>13.15a ± 0.24(7)</td>
<td>13.22a ± 0.15</td>
</tr>
<tr>
<td>Residual sugar (g/L)</td>
<td>4.32a ± 0.32</td>
<td>4.77a ± 0.21</td>
</tr>
<tr>
<td>pH</td>
<td>3.44a ± 0.144</td>
<td>3.34a ± 0.09</td>
</tr>
<tr>
<td>Total acidity (g/L)</td>
<td>6.25a ± 0.144</td>
<td>6.35a ± 0.09</td>
</tr>
<tr>
<td>Colour intensity</td>
<td>44.33b ± 7.81</td>
<td>69.58a ± 2.87</td>
</tr>
<tr>
<td>Aroma intensity</td>
<td>51.25b ± 9.08</td>
<td>59.58a ± 8.91</td>
</tr>
<tr>
<td>Acidity intensity</td>
<td>54.75ba ± 12.09</td>
<td>59.25a ± 6.28</td>
</tr>
<tr>
<td>Mouthfeel</td>
<td>47.58b ± 8.59</td>
<td>56.25a ± 12.45</td>
</tr>
<tr>
<td>Astringency</td>
<td>42.91b ± 13.56</td>
<td>46.16a ± 11.82</td>
</tr>
<tr>
<td>Overall quality</td>
<td>35.41b ± 9.40</td>
<td>55.83a ± 14.59</td>
</tr>
</tbody>
</table>

1East-west; 2South side of canopy; 3North side of canopy; 4North-south; 5East side of canopy; 6West side of canopy; 7Standard deviation.
wine alcohol content of ca. 13%.

The high astringency found in Durbanville Cabernet Sauvignon and Pinotage from the north and west sides respectively may be a result of the direct contribution of low pH to this mouthfeel sensation (Gawel et al., 2013). Phenolics can contribute to astringency and mouthfeel (Ferrer-Gallego et al., 2014); however, the mouthfeel of phenolics is complex because tannins and hydroxycinnamic acids have a synergistic effect on the perception of wine structure. Allegro et al. (2019) found that wines from exposed Grechetto Gentile grape bunches were more astringent and bitter than shaded grapes.

Generally, wines with the highest levels of alcohol scored highest in colour intensity and aroma intensity, as well as in overall quality. Casassa et al. (2013) reported that alcohol concentration defines the preferred sensory attributes in Merlot wines. Alcohol levels, pH, polysaccharides, glycerol and TA (Demiglio & Pickering 2008; Fontoin et al., 2008; McRae & Kennedy 2011) affect the perception of astringency and mouthfeel. Increasing the wines’ viscosity and/or pH can result in a decrease in the intensity of astringency, but an increase in the concentration of alcohol has no effect on the perception of astringency (Oberholster, 2008).

Sadras et al. (2012) found that TA, pH, aroma intensity and astringency could have additive effects with temperature and canopy side. Sadras et al. (2012) also reported that grape cultivar and canopy side responded with effects that were greater in warmer climates compared to cooler climates. Bonada and Sadras (2014) showed that the effect of diurnal temperature on grape berry composition has practical implications for wine attributes.

CONCLUSIONS

The results of this investigation confirm that canopy side affects overall wine quality. Differences among wines were distinguishable by means of selected sensory attributes and physicochemical characteristics. This investigation illustrates the variation in sensory attribute scores of Cabernet Sauvignon and Pinotage wines from different canopy sides and regions. From this perspective, canopy side in a vineyard of a specific region, orientated to an E-W or N-S direction that favours colour intensity, aroma intensity and/or mouthfeel, could result in improved wine quality. The results are based on samples representing only a single vintage. Light incidence and temperature monitoring throughout berry development were not reported. Therefore, future investigations should focus on samples collected over at least three consecutive vintages, as well as include temperature and photosynthetic active radiation monitoring.

LITERATURE CITED


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