Impact of ethanol concentration on sensory properties of Petit Verdot (2018)

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Summary

In Virginia, wet vintages like 2003, 2011, and 2018 as well as fall rains and hurricanes like those seen in 2015, sometimes lead winemakers to pick grapes with lower potential alcohol than desired. The aim of this study was originally to determine the changes in chemistry and sensory properties in Petit Verdot chaptalized to three different levels of ethanol. At the time of harvest, fruit was divided evenly and randomly between three chaptalization regimes (1) Low rate (target change of 2% alcohol) (2) Medium rate (target change of 2.8% alcohol (3) High rate (target change of 3.6% alcohol). The fermentation with the highest rate of chaptalization also had the highest rate of volatile acidity. The middle rate of chaptalization was preferred during sensory analysis.

Introduction

In Virginia, wet vintages like 2003, 2011, and 2018 as well as fall rains and hurricanes like those seen in 2015, sometimes lead winemakers to pick grapes with lower potential alcohol than desired. This leaves the winemaker with the decision of whether to intervene to augment the potential alcohol or not intervene and make a lower alcohol wine. Options for increasing sugar include reverse osmosis of juice to remove water, addition of grape concentrate, and chaptalization. This study focuses on chaptalization.

Chaptalization is the addition of sugar to grape juice or must to raise the potential alcohol of the resulting wine. This technique has a long history, with historical documentation at least since Roman times, when honey was used to improve body or mouthfeel[1]. In 1801, Napoleon's Minister of Agriculture, Jean-Antoine Chaptal (after whom the practice is now named), made the practice famous by advocating for its use to strengthen and preserve wine. It became widespread in Germany in the 1840's during an era of poor vintages and is thought to have sustained the Mosel through this difficult time. The practice become so popular that rampant use had to be brought in check by French law in 1907 after 900,000 people rioted to protect their livelihood from "artificial" wines made from heavily chaptalized, inexpensive, over cropped fruit[2].

Chaptalization has been used widely in Europe for centuries including regions such as Germany, Champagne, Burgundy and Bordeaux[1]. EU regulations allow chaptalization on a sliding scale depending on growing region. The coolest regions (Zone A), such as Germany, are allowed up to 3% increase in alcohol percentage (not to exceed 11.5% ABV in white wines and 12% in red wines). Lower amounts of chaptalization are allowed in Zone B (including Alsace, Champagne, Jura, Loire), which allows 2% increase in alcohol with limits of 12 and 12.5%

alcohol for white and red wines, respectively. Though an increase of 1.5% ABV is legal for Zone C, many wine producing regions have their own regulation forbidding chaptalization. This includes Italy, Greece, Spain, Portugal and Southern France. In any region where chaptalization is legal, an additional 0.5% increase may be allowed in particularly difficult vintages[3].

There are chemical and sensory reasons to chaptalize. The concentration of alcohol affects the chemical stability of the wine (acting as an antimicrobial agent). The viscosity of alcohol adds weight to the palate[1], it volatilizes fruit aromas[1], augments the production of glycerol, succinic acid, and esters[4]. Peynaud (1987)[5] states that "the greater the quantity of sugar involved, the more intense is the secondary aroma, hence, chaptalization can improve the aroma." (p60). He also points out that alcohol itself has a sweet taste that can affect the perception of other flavors. Alcohol amplifies other sweet tastes (namely fruit), masks bitterness and saltiness, diminishes perception of astringency (but can accentuate unpleasant astringency)[5], and diminishes green or unripe characters[4].

Sherman et al (2018)[6] tested the effects of ethanol concentration on chemical and sensory properties of wines harvested at three levels of ripeness in Washington State Merlot. In an elegant experimental design, they harvested the same block at three intervals: underripe, ripe, and overripe. For each harvest, they broke the grapes into three treatments and used either chaptalization (to raise the Brix) or saignée and watering back with acidulated water (to lower Brix) so that they could compare chemistry and sensory responses for wines of each harvest interval with each resulting alcohol concentration. They found that there were expected differences in chemistry between wines from different harvest dates, however, adjustments for ethanol "had a greater effect on wine sensory properties than fruit maturity" Specifically, "wines made from ripe (24° Brix) or overripe fruit adjusted to low ethanol concentrations were described similarly to wines made from unripe fruit" including green and sour, and "wines made from unripe or ripe fruit adjusted to high ethanol concentrations were described similarly to wines made from overripe fruit" including descriptors such as red fruit and flora. They conclude that "wine ethanol concentration is more important for the sensory profiles of wines than is fruit maturity at harvest."

Practically, chaptalization usually involves the addition of cane sugar (though occasionally beet sugar or corn syrup are used) to the juice or must at a rate of 17 g sucrose to produce 10 g ethanol[4]. It is important to make sure all of the sugar is fully dissolved, as any remaining undissolved sugar will not be fermented and will leave the wine at microbial risk. The timing of addition is the subject of much debate, with winemakers advocating for additions before, during, and toward the end of fermentation. The debate tends to rest on the effect on the rate of fermentation, with some wanting to ensure a longer, slower fermentation while others are more concerned about finishing a potentially difficult fermentation.

A few things few things to keep in mind when deciding when to chaptalize include:

1. Additions must be fully dissolved, which is easier in warmer, fermenting must than during cold soak or just after cold settling.
2. Sugar addition has been shown to slow down yeast multiplication and affect the overall biomass at the end of fermentation[7]. This may be a benefit (if you are concerned about fermentation proceeding too quickly) or a drawback (if you are concerned about having adequate biomass to finish a difficult fermentation).
3. Aeration at the time of sugar addition improves the survival rate of yeast biomass (presumably by encouraging the production of cell membrane components)[7].
4. Sugar must be transported into the cell by proteins in the cell membrane. These membrane proteins are somewhat inhibited by ethanol and acetic acid and become less efficient as fermentation proceeds, though some yeast have proteins better suited for this than others. Additions very late in fermentation have the risk of sticking[8].

For these reasons, prevailing instruction is that sugar can be added prior to or early in fermentation for temperature controlled white wines as there is little concern about fermentations running out of control, and higher concern about a healthy yeast population to finish low temperature (slow) fermentation. For red wines, addition is recommended after the end of the exponential phase of yeast growth (day 2-4) when the must is warm, the yeast are finished multiplying but ethanol has not yet built up to levels that inhibit cell membrane trafficing[4,7]. However, many winemakers add sugar at times other than these with good results.

The aim of this study was originally to determine the changes in chemistry and sensory properties in Petit Verdot chaptalized to three different levels of ethanol. As the 2018 vintage progressed, winemakers in Virginia began to wonder how much a low Brix wine can be chaptalized before becoming unbalanced. Anecdotally, several winemakers had been trained that the limit for chaptalization was two degrees of alcohol while others had been trained 1.5 degrees was the limit (perhaps reflecting the region of training). The 2018 vintage challenged these limits. Due to its design, this study may also provide some insight into this question.

Methods

At the time of harvest, fruit was divided evenly and randomly between three chaptalization regimes (1) Low rate (target change of 2% alcohol) (2) Medium rate (target change of 2.8% alcohol (3) High rate (target change of 3.6% alcohol).

Fruit was processed according to the standard protocols of the winery. Fruit was destemmed, sorted, and crushed into T-bins. Each bin received 25ppm SO_2, 60 mL/ton Color X, and 1 lb/ton oak chips, mixed with a punchdown. There was no saignée for this experiment. Chaptalization occurred before inoculation according to the following calculation:

Gal * Brix increase * .1 (assuming 160 gal per ton) = lbs sugar

Must was inoculated the following day with 166g/ton D254 rehydrated in 208g/ton Go Ferm. Fermentations were monitored for Brix and temperature daily. Temperature regulation consisted of moving bins from the cellar (60°F) outside to the sun or inside the cooler (45°F). When necessary, bins were moved together to maintain similar ambient environment for the fermentations.

Each T bin received 2 punchdowns per day. Fermaid K was be added to a target of 250 mg N/L in two equal additions (at 18-19 brix and again at 13 brix). All lots were pressed separately on the same day at the end of fermentation with no extended maceration, then inoculated with VP41 malolactic bacteria. SO2 was added at the completion of malolactic fermentation without racking.

Sensory analysis was completed by a panel of 26 wine producers. Wines were presented blind in randomly numbered glasses. Tasters were presented with three wines and asked to rank the wines in order of preference with 1=most preferred and 3=least preferred. There were three tasting groups, each presented with wines in a different order. Tasters were then asked to score each wine on a scale of 0 to 10 for aromatic intensity, fruit maturity and herbaceous/green character. They were also given open ended questions to describe the wines. Results for the ranking test were analyzed using Friedman's test. Descriptive scores were analyzed using repeated measures ANOVA.

Results

At harvest, fruit had 16.9°Brix and a pH of 3.4. Table 1 indicates sugar addition and Brix targets for each treatment. Finished wine chemistry is shown in Table 2. Wines did not achieve expected alcohol targets based on Brix (using a conversion rate of 0.55 for red wine fermentation). This may be due to the calculation of sugar based on weight with a standard volume of conversion. In a wet year, higher volume of juice would be expected due to swollen berries, leading to higher volume of wine per ton.

Table 1: Sugar addition (per 1.5 tons) and Brix targets for three levels of Chaptalization

Rate	Sugar addition (lbs)	Target Brix (alcohol) after addition	Change in Brix	Increase in Potential Alcohol
Low	85	20.7 (11.4)	3.8	2.1
Medium	114	22 (12.1)	5.1	2.8
High	148	23.5 (12.9)	6.6	3.6

There was little difference in pH or TA among treatments, however the fermentation with the highest rate of chaptalization also had a notably higher rate of VA than the other two fermentations (Table 2). Higher alcohol in the finished wine correlated with higher color intensity (Table 3) and tannin (Table 4) but not anthocyanins or catechin (Table 4).

Table 2: Finished wine chemistry for Petit Verdot made with three levels of chaptalization (ICV labs)

	Alcohol (%)	pH	TA (g/L)	VA (g/L)
Low rate	10.7	3.87	5.63	0.76
Medium rate	11.21	3.88	5.74	0.75
High rate	12.03	3.93	5.71	0.96

Table 3: Comparison of color in chaptalized wines (ICV labs)

	DO420	DO520	DO620	Hue	Intensity
Low rate	2.64	3.69	0.96	0.72	7.29
Medium rate	2.75	3.82	1.01	0.72	7.58
High rate	3.12	4.17	1.19	0.75	8.48

Table 4: Comparison of phenolics in chaptalized wines (mg/L) (ICV labs)

	Polymeric Anthocyanins	Total Anthocyanins	Catechin	Tannin
Low rate	31	433	26	354
Medium rate	33	426	27	360
High rate	37	416	22	423

When wines were presented for a ranking test, respondents preferred the middle level of chaptalization to the low and high levels (Q=12.4, p=0.002)(Figure 1). Open ended responses indicated that the added alcohol gave the wine better balance and diminished herbal character. The volatile acidity on wine with the high level of chaptalization was distracting. There were no significant differences in scores for aromatic intensity (F=1.65, p=0.2), fruit maturity (F=0.99, p=0.38) or herbaceous/green character (F=2.58, p=0.08)(Figure 2). High levels of variation were seen for each descriptor.

Figure 1: Mean ranking scores for preference test. 1=most preferred, 3 = least preferred.

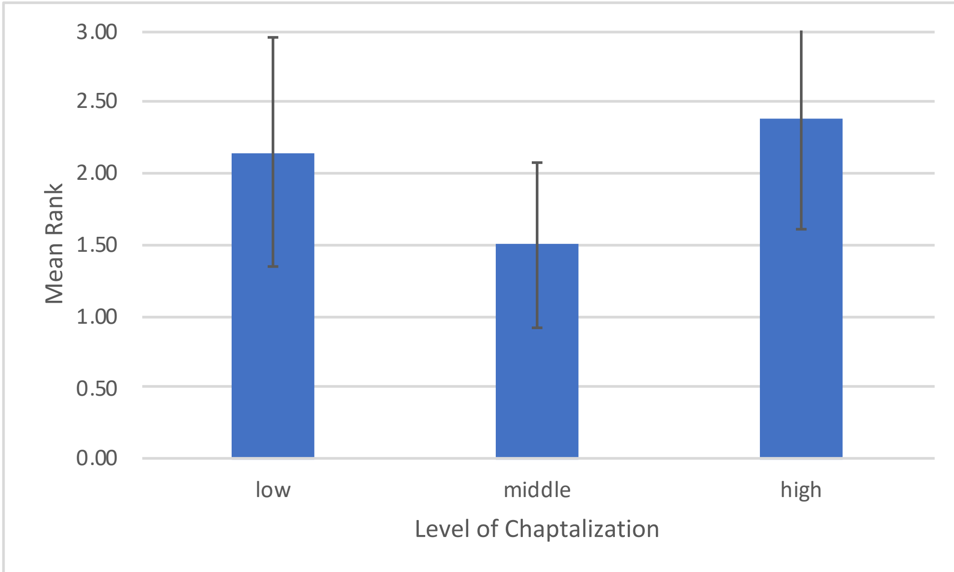
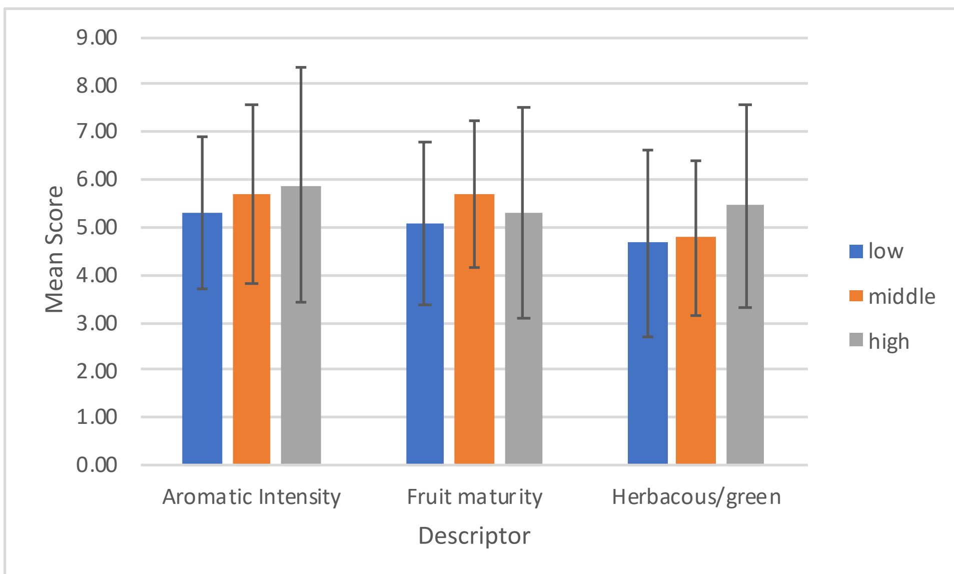


Figure 2: Mean scores for aromatic intensity, fruit maturity and herbaceous/green character



Conclusions

- The wine that was chaptalized by 2% alcohol was preferred. The wine with the highest rate of chaptalization also had higher volatile acidity, so it is unclear if respondents disliked that wine due to VA or alcohol levels.
- 2018 was a very wet year with many wines that lacked concentration. It may be that there is a limit to chaptalization after which the wine becomes unbalanced.

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