



## WINEMAKING

**Aeration across a screen with seed removal during draining of the fermentor.**  
Photo by Wendy Day, Vine Cliff Winery (Napa, CA).

## MERLOT AND CABERNET SAUVIGNON WINES

# Impact of délestage

## with partial seed removal

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**D**élestage (rack and return) involving partial seed removal was compared with Merlot produced by manual cap punch down (three years), and Cabernet Sauvignon produced by mechanical punch-down (pigeage) systems (one year).

Fermentation reduced the color derived from monomeric pigments and increased polymeric pigment color for all treatments. Délestage wines generally had more large polymeric pigment color than cap-punched or pigeage wines. Total glycosides increased during cold soak and fermentation, and were in greater concentration in cap-punched Merlot, and

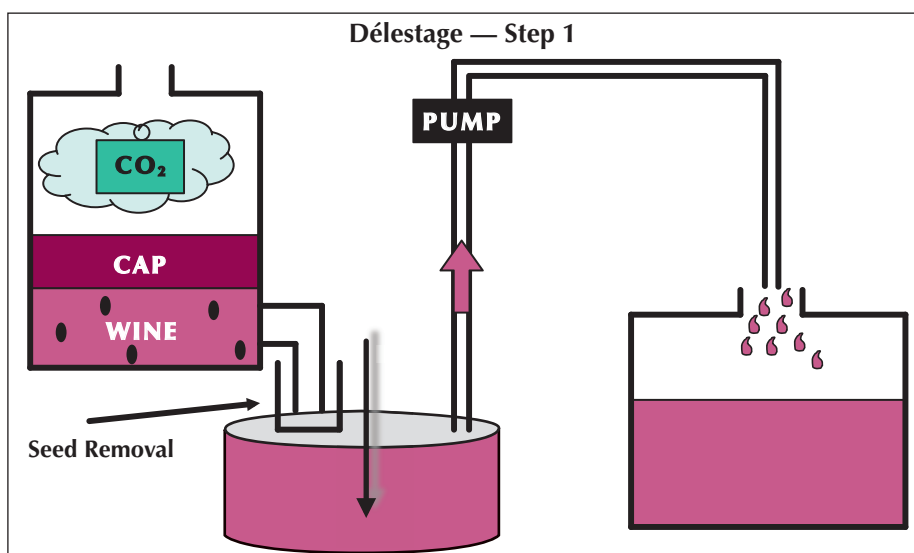
similar among Cabernet Sauvignon treatments.

Discrimination testing (triangle difference analysis) demonstrated Merlot wines generally differed in aroma and/or flavor. Cabernet Sauvignon wines differed in both aroma and flavor.

The color, structure, and aftertaste of red wines are mainly derived from the varied and complex impact of phenolic compounds. It is estimated that 50% or less of the total phenolic compounds present in the skins, seeds, and flesh of grapes can be extracted during conventional winemaking.<sup>12,36</sup>

The level of extraction depends on various factors, including fruit maturity, duration of skin contact, temperature, ethanol concentration,<sup>20</sup> and vinification practices, including cap management techniques.<sup>7,16,22,31</sup> Therefore, understanding the quantitative and qualitative influences processing has on grape and wine phenolic compounds is important in premium wine production.

Monomeric and polymeric flavan-3-ols comprise the majority of phenolic constituents in red wines,<sup>30</sup> being extracted from the skins and outer seed coat during fermentation.<sup>38</sup> Polymeric flavan-3-ols, referred to as proanthocyanidins or condensed tannins, arise either by addition of intermediates from flavan-3,4-diols to flavan-3-ol monomers, or by acetaldehyde-induced polymerization.<sup>8,35</sup>



**Délestage is a rack-and-return process modified to deport seeds, illustrated here. Fermenting juice was deported from a bottom valve through a dejuicing sleeve with holes 1/10-inch in diameter. Seeds were retained within the sleeve, and the deported juice was pumped to a separate tank while the cap was allowed to drain. Process was conducted once per day until the completion of fermentation or dejuicing, depending on the particular trial.**

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## WINEMAKING

Grape seeds differ from skins in that seed proanthocyanidins contain greater levels of monomeric flavan-3-ols, and those esterified to gallic acid.<sup>5,25,32</sup> Additionally, seed proanthocyanidins generally have a lower dp (degree of polymerization) than those found in skins, and no trihydroxylation of the B-ring.<sup>9</sup> Proanthocyanidins are reactive molecules that may form complex species thought to impact wine sensory features.

Monomeric and polymeric flavan-3-ols induce both astringent and bitter mouth sensations. S. Vidal *et al.* demonstrated that overall astringency increased with increases in dp.<sup>38</sup> Additionally, they reported that galloylation increased tannin coarseness, while trihydroxylation of the B-ring decreased coarseness.

Tannins in the skins and seeds can combine with anthocyanidin glycosides (anthocyanins) to form polymeric pigments.<sup>36</sup> These pigments are believed to be formed by condensation products of malvidin-3-glucoside and various pro-cyanidins created through acetyl bridges.<sup>9,26</sup> Anthocyanin-tannin complexes can be produced by binding between the C-4 of the flavylum salt and the C-8 of catechin.<sup>21,27</sup>

D.O. Adams *et al.* reported extractable seed tannins in Syrah grapes declined by about half from véraison to harvest, and were about three times greater than skin tannin concentrations.<sup>2</sup> Grape skin phenols are more easily extracted during fermentation than those of seeds and stems.<sup>18</sup>

Although skins contain a lower concentration of total and polymeric phenols than seeds,<sup>13</sup> they may be the primary source of polymeric phenols in wine.<sup>14</sup> For the first five to seven days of fermentation, phenolic compounds are extracted mainly from skins, followed by extraction from seeds.<sup>23</sup>

Several reports have suggested that seeds contribute significant concentrations of proanthocyanidins to wines,<sup>15,29</sup> while others have reported the seed contribution to be limited.<sup>4,24,39</sup> These contradictory observations may be the result of differences in cultivar, fruit maturity, and winemaking style.

For example, duration of maceration primarily influences the extraction of phenolic compounds from the

seeds,<sup>40</sup> while fermentation temperature appears to be a primary factor influencing extraction from skins.<sup>23</sup>

Délestage, or rack and return, is a maceration technique designed to help optimize the exchange between the liquid and solid phase by emptying the fermentation vessel of liquid while aerating the juice.

Following several hours of cap draining, the liquid is gently pumped over, or returned, to the cap. This procedure is designed to help oxygenate, while minimizing mechanical grinding of the skins, seeds and stems (Dominique Delteil, personal communication, 2003). This study evaluated délestage in conjunction with partial seed removal, to determine the impact on Merlot wine composition for three seasons and on Cabernet Sauvignon for one season.

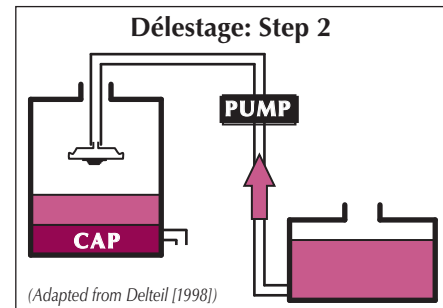
### Materials and Methods

MERLOT fruit (approximately 8,500 kg), grown in central Virginia, was hand-harvested in each of three years at a minimum of 21.0° Brix (a common soluble solids concentration for Merlot grown in central Virginia). Fruit was immediately destemmed, crushed, and divided into six equal-weight (1,416 kg) replicates. Must fermentable nitrogen levels were measured,<sup>10</sup> and adjusted to 250 mg/L adding either Fermaid K™ (Scott Laboratories, Petaluma, CA) or Superfood™ (The Wine Lab, Napa, CA). Sulfur dioxide (30 mg/L) was added at crush to each lot.

Each must was given a cold maceration (cold soak) period of 24 hours at 10°C, prior to fermentation. D-254™ yeast (Scott Laboratories, Petaluma, CA) was hydrated, microscopically examined for budding, viability and purity, cooled to within 3°C of the must temperature, and added to each lot (24 g dry yeast/100 L).

The six equal-weight lots were randomly assigned to treatments consisting of 1) control, conventional fermentation, with cap manually punched down two times per day, or 2) délestage, consisting of a rack and return procedure with seed removal conducted once per day until dryness, as follows.

Following cap rise, fermenting juice was drained from a bottom valve through an external cylindrical dejuic-



Juice was brought back to top of the fermentation tank using a cap irrigation system. Délestage, therefore, involves two main features which are impacting the tannin profile of the wine (and therefore the structural/textural qualities):

- 1) removal of seeds could reduce the contribution of immature phenols;
- 2) oxidative polymerization could result in partial reduction of monomeric pigments as they are incorporated into large polymeric pigments.

(For more details see [www.icv.fr/kiosqueuk/procedure/delestage.htm](http://www.icv.fr/kiosqueuk/procedure/delestage.htm) or [www.vtwines.info/enologynotes/onlinepublications](http://www.vtwines.info/enologynotes/onlinepublications))

ing sleeve (2.39 mm diameter holes) into a stainless steel vat. Seeds were retained within the sleeve.

The juice was pumped to a separate tank while the dejuiced cap was allowed to drain freely for two hours. Juice was then returned to the top of the cap via a tank cap irrigator, using deflection plates to minimize skin breakage. The separated seeds were drained free of liquid, weighed, and discarded.

Treatment and control vessels averaged filled height-to-diameter ratios of 0.64 and 0.75 for the délestage and conventional fermentations, respectively.

Fermentations were conducted at an average liquid temperature of 28°C (range 26° to 35°C) and an average cap temperature of 30°C (range 28° to 37°C) in 1,000-L capacity vessels. Pressing was performed at dryness (2.0 g/L reducing sugar) using a tank press to 1 bar. Free-run and press-run wines were combined.

CABERNET SAUVIGNON fruit (18,144 kg) grown in northern Virginia was hand-harvested at 23° Brix, and immediately destemmed, crushed, sulfur dioxide (30 mg/L) added, fermentable nitrogen levels were measured and adjusted, and it was divided into treatment lots (as described above). Musts were given a cold maceration (cold soak) period of 48

**Table I: Effect of manual cap punching (control) and délestage on Merlot wine chemistry for three seasons.**

	Season 1		Season 2		Season 3	
	Control	Délestage	Control	Délestage	Control	Délestage
Alcohol % (v/v)	12.8a <sup>a</sup>	12.7a	11.5a	11.7a	13.1a	13.1a
TA (g/L)	6.57a	6.70a	6.20a	6.38a	4.85a	4.88a
Tartaric Acid (g/L)	2.21a	1.97a	3.06a	3.41a	1.50a	1.74a
Malic Acid (g/L)	trace	trace	trace	trace	trace	trace
Lactic Acid (g/L)	3.15a	2.23a	3.35a	4.07a	3.87a	2.44a
pH	3.60a	3.66a	3.65a	3.66a	3.87a	3.91a
Total Tannin (mg CE/L)	191.6a	173.0b	177a	150b	197.5a	171.1b
Total Phenol (AU <sup>280</sup> )	59.8a	58.3a	43.1a	37.6b	40.1a	37.0b
Total Anthocyanin (AU <sup>20</sup> -AU <sup>502</sup> )	ND <sup>b</sup>	ND	3.89a	3.04b	2.37a	2.21b
AU <sup>420+520</sup>	8.23a	6.92b	8.21a	7.82a	8.87a	7.64a
AU <sup>420/520</sup>	0.793a	0.780a	0.794a	0.789b	0.575b	0.585a

<sup>a</sup>Different letters within rows and years denote significant difference ( $p \leq 0.05$ ) of treatment means; <sup>b</sup>ND = not determined; n = 3.

hours at 10°C prior to fermentation, and yeasted (as described above).

Treatments consisted of 1) control, fermentation using a 10,000-L mechanical pigeage, or 2) délestage, conducted in similar size and shape conventional stainless steel fermentation tanks (fill height to diameter ratio, 1:1).

Pigeage consisted of punching three times daily, 10 minutes per punch, with punching consisting of cycles of one minute down and 30 seconds up. Délestage was conducted daily as described above with the following exception: liquid was drained onto a flat tray (0.75 x 1.2 m) with a screen (2.39 mm diameter holes). Fermentations were conducted at an average liquid temperature of 27°C (range 26° to 33°C) and an average cap temperature of 30°C (range 28° to 34°C). Mechanical punching and délestage were conducted for seven days.

Pressing was performed post-dryness (2.0 g/L reducing sugar), 22 days following the beginning of fermentation, with a 5,000-L tank press, by allowing free drainage for one hour, followed by pressing to one bar. Free-run and press-run wines were not combined.

### Chemical analysis

General fruit, must, and wine chemistries were conducted as described by B. Zoecklein *et al.*<sup>43</sup>

HPLC analysis was conducted 18 months post-fermentation on selected

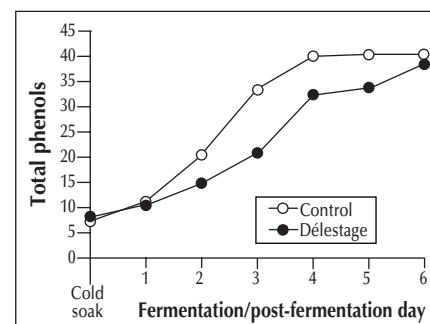
phenols in finished aged wines described by Price *et al.*<sup>19</sup>

Total tannins (catechin equivalents), and the percentage of color from monomeric pigments, small polymeric pigments, and large polymeric pigments was estimated using the procedures of Adams and Harbertson,<sup>1</sup> and Harbertson *et al.*<sup>11</sup> The concentration of total glycosides was estimated by the analysis of glycosyl-glucose in thawed samples as described by P.J. Williams *et al.*,<sup>41</sup> and modified by R.S. Whiton and B.W. Zoecklein.<sup>40</sup> Analysis of phenol-free glycosides was conducted as described by B. Zoecklein *et al.*<sup>44</sup>

### Sensory analysis

Discrimination testing was performed on pooled wine replicates of Merlot and Cabernet Sauvignon, using triangle difference comparison described by M. Meilgaard *et al.*<sup>17</sup> The wines were evaluated six to eight months post-fermentation in the Virginia Tech wine sensory laboratory, under controlled conditions that included red lighting to help eliminate color bias.

Panel membership required regular wine consumption (at least one glass per week) and attendance at two informational sessions where the methodology of evaluation was described. Evaluation was done based on olfactory (aroma) and retronasal aroma and mouthfeel (referred



**Figure 1. Effect of cold soak, fermentation, and post-fermentation on total phenols of control (cap punched) and délestage-produced Merlot wines in season 3; n = 3.**

to as flavor). Evaluations of aroma and flavor occurred at different times.

Descriptive analysis was performed nine months post-fermentation on non-pooled Cabernet Sauvignon wine treatment replicates, using 11 trained panelists as described by M. Meilgaard *et al.*<sup>17</sup> Panel members evaluated three replications of the two products (pigeage and délestage) six times.

Panelists had one to 10 years experience in descriptive or consensus sensory analysis. A list of descriptors was developed from three pre-evaluation training sessions with standards used for training prepared as reported by B. Zoecklein *et al.*<sup>43</sup>

### Statistical analysis

#### RESULTS

#### Merlot

The Merlot fruit averaged 21.5° Brix, 3.7 pH and 5.62 TA for the three years, typical of the region. Berries averaged 1.18 g, with 2.4 seeds, for the three seasons of this study. In years 2 and 3, Merlot fruit monomeric pigments were responsible for an average of 70.5%, SPP 19.7%, and LPP 9.8% of the total color.

By the end of délestage-treated fermentations, an average 25% of seeds had been removed each year. Fermentation rates were similar among treatments. Total phenols, estimated by the absorbance at 280 nm, increased linearly from crush until dejuicing for both délestage and control wines (Figure 1). At day-six (dryness), control lots had a total phenol concentration slightly greater (7.7%) than the délestage (typical of this study).

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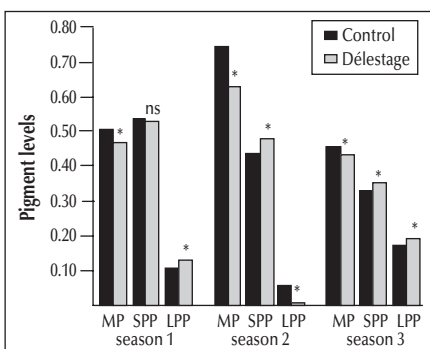
The percentage of color derived from the monomeric pigments was greater in the fruit than the wine, while the percentage of color from polymeric pigment forms showed the opposite trend.

Merlot délestage and control wines showed slight differences in the percentage of color from the different pigment sources. Délestage wines produced over three seasons averaged 4.8% lower color derived from monomeric pigments, 1.4% higher from SPP, and 4.5% higher color from LPP, compared to control wines (Figure II).

Following fermentation, control and délestage-produced Merlot wines did not differ in alcohol percent (v/v), TA, tartaric, malic, and lactic acids, or pH (Table I).

The total tannin concentration was greater in the control wines upon completion of fermentation each year. The total phenol estimations demonstrated a higher concentration in control wines in two of the three years. Total anthocyanins were higher in the control wines in the two years measured, while absorbance at 420 nm + 540 nm, and 420 nm/520 nm, did not demonstrate consistent patterns between délestage and control wines.

Table II provides the concentration of selected phenolic compounds on aged Merlot determined by HPLC analysis. Significant differences among treatments were not observed. Catechin and epicatechin concentrations averaged 37 and 26 mg/L for the control and délestage-produced wines, respectively.



**Figure II. Effect of control (cap punched) and délestage on Merlot — percent color derived from monomeric pigments (MP), small polymeric pigments (SPP), and large polymeric pigments (LPP) for three seasons; n = 3.**

Merlot total glycosides increased by day-two, the first day of fermentation (Table III). By the completion of fermentation (dejuicing), the total glycoside concentration had increased by an average of 388% and 296% for the control and délestage wines, respectively.

At dejuicing, the total glycoside concentration was greater in the control wines. Phenol-free glycosides increased by day-two. They generally

declined by the end of fermentation, and were in greater concentration in the délestage-produced wines at dejuicing.

Results of discrimination sensory analysis suggested that Merlot wines were perceived to differ in aroma and/or flavor in two of three years.

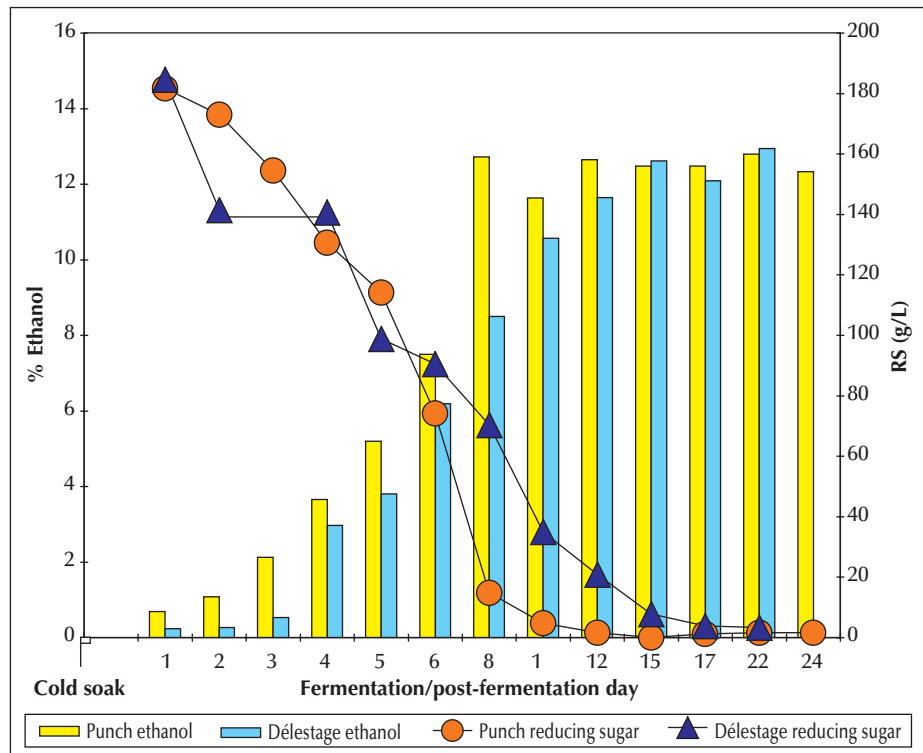
**Cabernet Sauvignon**

Cabernet Sauvignon must undergo cold maceration for 48 hours, prior

**Table II: Mean values of C/MS phenolic profiles of aged Merlot wines (for three seasons), and Cabernet Sauvignon wine (produced one season). Significant differences were not observed at  $p \leq 0.05$ .**

	Merlot		Cabernet Sauvignon	
	Control	Délestage	Pigeage	Délestage
Gallic Acid (mg/L)	22 <sup>a</sup>	21	55	37
Catechin (mg/L)	23	17	49	39
Epicatechin (mg/L)	14	9	29	16
Caftaric Acid (mg/L)	11	11	<1	6
Caffeic Acid (mg/L)	14	12	16	20
Quercetin (mg/L)	8	4	3	3
Malvidin Glucoside (mg/L)	30	13	20	21
Polymeric Anthocyanins (mg/L)	34	36	36	41
Total Anthocyanins (mg/L)	100	83	71	61
Monomeric Anthocyanins (mg/L)	50	28	25	30

<sup>a</sup>n = 3



**Figure III. Effect of mechanical punch (pigeage) and délestage on Cabernet Sauvignon ethanol production and reduced sugar decrease; n = 3.**

to yeast addition. The effect of fermentation on reducing sugar concentration and percent alcohol (v/v) at various sampling periods was determined by comparing one fermentation vessel each of délestage- and pigeage-produced Cabernet Sauvignon (Figure III).

While the fermentation rates were generally similar between treatments, some differences in the wines were noted. There were no differences in alcohol percent (v/v), TA, pH, or tartaric, malic, or lactic acids, between pigeage and délestage-produced wines (Table IV).

Total tannin, total phenols, and total anthocyanins were greater in pigeage-produced wines. Differences in absorbance at 420 nm + 520 nm, and 420 nm/520 nm, were noted between délestage and pigeage. Table II provides the concentration of selected phenol compounds on aged Cabernet Sauvignon. Significant differences among treatments were not observed.

Tannin concentrations remained stable until active fermentation, then increased and were higher in pigeage-produced wines at most sample periods (Figure IV). Total phenols (AU 280) increased for both treatments during pre-fermentation maceration, and significantly during fermentation (Figure V).

At dejuicing, the total phenol concentration in the press wines averaged 14.5% and 9.8% higher than free run for délestage and pigeage wines, respectively (data not shown). At the completion of fermentation, free-run pigeage-produced wines had higher absorbance at 420 nm + 520 nm, and lower 420 nm/520 nm absorbance than délestage wine (Table IV).

During the cold soak period, the percentage of color from monomeric anthocyanins declined dramatically in the juice, then declined or remained constant for the first three days of fermentation (Figure VI).

By sampling on day-10 (completion of alcoholic fermentation), the

percentage of monomeric pigments had declined for both treatments. At dejuicing, day-22, the percentage of color from monomeric pigments in the pigeage free-run wine averaged 33% higher than the délestage wine.

Press wines showed a similar trend (data not shown). The percentage of color from small polymeric pigments increased during the cold soak period, remained or declined during the first five days of fermentation for both treatments, then increased slightly (Figure VII).

The percentage of color from large polymeric pigments increased during cold soak and fermentation for both pigeage and délestage treatments, and was slightly higher in the délestage wines at dejuicing (Figure VIII).

Post-fermentation, free-run Cabernet Sauvignon délestage and pigeage wines demonstrated 34.6% compared to 43.5% color from monomeric pigments, 53.8% compared to 49.6% color from SPP, and 11.6% compared to 6.9% color from LPP (Table IV), respectively.

Following cold soak, total glycoside concentration was greater in the pigeage than délestage tanks by an average of 49% (Table V). Total glycosides increased during fermentation (cold soak to day-10) for both treatments. By the completion of fermentation (day-10) and at dejuicing, total glycoside concentrations were similar in pigeage and délestage wines. Phenol-free glycosides were in higher concentrations in pigeage wines post-cold soak and at dejuicing.

Discrimination sensory analysis of Cabernet Sauvignon délestage- and pigeage-produced wines indicated differences in aroma and flavor. The principal component analysis (PCA) for aroma indicated variation among treatment replicates that accounted for 59% of the variance (Figure IX). The first and second principal component analysis of flavor accounted for 63% of the variance (Figure X).

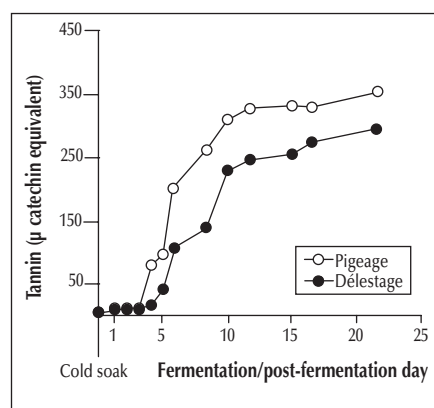
### Discussion

A relatively high concentration of extractable seed tannins has been shown to negatively impact wine quality in Virginia and other wine-producing regions. The study was conducted using 1,416 kg lots, and seed removal in con-

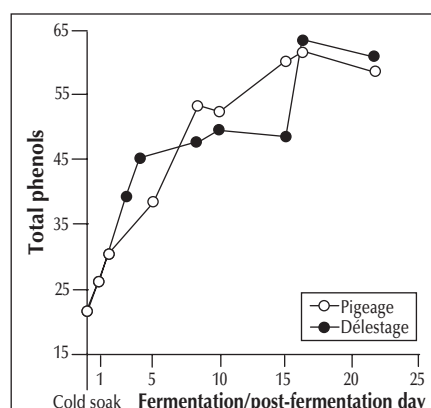
**Table III: Effect of manual cap punch (control) and délestage on total (TGG) and phenol-free (PFGG) Merlot glycosides for two seasons.**

Sample	TGG ( $\mu M$ )		PFGG ( $\mu M$ )		
	Control	Délestage	Control	Délestage	
Season 2	Post-Cold Soak	386b <sup>a</sup>	435a	157b	191a
	Day 2	1513a	1156b	180b	264a
	Dejuice	2068a	1866b	135b	194a
Season 3	Post-Cold Soak	360b	394a	144a	152a
	Day 2	1260a	1279a	141a	127a
	Dejuice	1583a	1433b	120b	134a

<sup>a</sup>Different letters within rows indicate significant difference ( $p \leq 0.05$ ) of treatment means;  $n = 3$ .



**Figure IV. Effect of pigeage and délestage on Cabernet Sauvignon — tannin concentration during cold soak, fermentation, and post-fermentation;  $n = 3$ .**

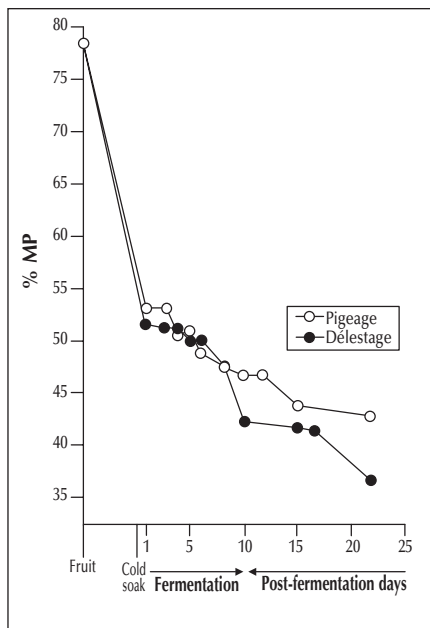


**Figure V. Effect of pigeage and délestage on Cabernet Sauvignon — total phenols during cold soak, fermentation, and post-fermentation;  $n = 3$ .**

**WINEMAKING****Table IV: Effect of pigeage and délestage on Cabernet Sauvignon wine chemistry, and average percentage of color derived from monomeric pigments (MP), small polymeric pigments (SPP), and large polymeric pigments (LPP).**

	Pigeage	Délestage
% Alcohol (v/v)	12.4a <sup>a</sup>	12.5a
TA (g/L)	5.19a	5.01a
Tartaric Acid (g/L)	1.36a	1.32a
Malic Acid (g/L)	0.52a	0.52a
Lactic Acid (g/L)	4.12a	3.72a
pH	3.96a	4.01a
Total Tannin (mg CE/L)	337.8a	294.5b
Total Phenols (AU <sup>280</sup> )	65.2a	58.0b
Total Anthocyanin (AU <sup>20</sup> -AU <sup>502</sup> )	2.65a	1.67b
AU <sup>420+520</sup>	0.616a	0.608b
AU <sup>420/520</sup>	0.77b	0.81a
Monomeric Pigment (%)	43.5	34.6
Small Polymeric Pigment (%)	49.6	53.8
Large Polymeric Pigment (%)	6.9	11.6

<sup>a</sup>Different letters within rows denote significant difference ( $p \leq 0.05$ ) of treatment means;  $n = 3$ .



**Figure VI. Effect of pigeage and délestage on Cabernet Sauvignon — monomeric pigments (MP) as a percentage of total color during cold soak, fermentation, and post-fermentation;  $n = 3$ .**

junction with délestage, to help improve red wine mouthfeel. Due to logistical limitations, including the necessity for replications, wines were not produced by délestage alone, without seed removal.

The majority of the seeds removed (average 25%) were removed in the first few days of fermentation, possibly contributing to the lower total tannin concentration frequently observed in délestage-produced wines. Tannin levels generally remained stable in the must until active fermentation, then increased significantly.

V. Singleton and P. Draper demonstrated that fermentation for 90 hours resulted in extraction of 65% of the available seed tannins, while 180 hours resulted in the extraction of 70%.<sup>28</sup> Seed tannins comprise approximately 60% of the total phenols in conventionally-produced red wines,<sup>28</sup> with nearly half of the extractable catechins and oligomeric proanthocyanidins in grape seeds transferred into wine.<sup>37</sup>

V. Kovac *et al.* added seeds during fermentation (6% of the weight of the fruit) and noted a doubling in the concentration of catechins and proanthocyanidins in the fermented wine.<sup>15</sup> For the Merlot wines, about 1.1% of the weight of the fruit was removed as seeds during délestage. A. Bosso *et al.* compared pump over with délestage, using Montepulciano d'Abruzzo, and found that pump over produced wines higher in anthocyanins, polymeric pigments, and tannins.<sup>3</sup>

In the current study, délestage wines contained a lower tannin concentration than controls (manual cap punch down or pigeage), possibly due to limited extraction and seed removal in délestage treatments. However, HPLC analysis of aged wines did not demonstrate statistical differences in selected phenols, including those associated with seeds, such as catechin and epicatechin.

Phenol extraction from seeds is dependent, in part, on the degree of seed oxidation or maturity.<sup>9</sup> Délestage can allow fermenting juice to percolate through the cap, providing an exchange that may minimize particulate extraction from the cap (Dominique Delteil, 2003, personal communication).

Although not measured in this study, it is possible that délestage

reduced the concentration of non-soluble solids, thereby aiding in reduction of total phenols, including skin tannins. Total anthocyanins were frequently in greater concentrations in conventional- and pigeage-produced wines, compared to délestage, possibly suggesting greater extraction.

The higher concentration of total glycosides noted in manual cap-punched Merlot wines may also indicate increased extraction, although there were no differences in total glycosides in the Cabernet Sauvignon produced by pigeage and délestage.

Formation of polymeric pigments is important due to their contribution to color stability. It has been demonstrated that, after only a few years of ageing, the vast majority of color is due to polymeric pigments, with a small concentration of monomeric anthocyanins remaining.<sup>33</sup>

Analysis of the fruit demonstrated a relatively high percentage of color from monomeric pigments compared to LPP, consistent with D. Adams *et al.*,<sup>2</sup> and J. Harbertson *et al.*<sup>11</sup>

In the second and third years, the Merlot fruit LPP averaged 9.8% of the color, while corresponding wines averaged 18.5% color from LPP. The increase in percentage of wine color from LPP, compared to the fruit, appeared to parallel a decrease in the percentage of color from monomeric anthocyanins in the wine.

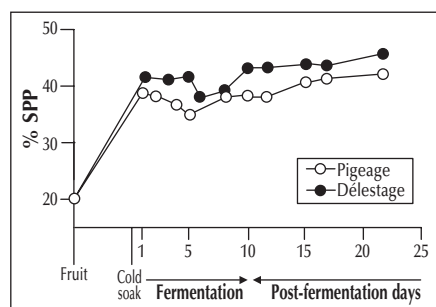
It is generally assumed that formation of polymeric pigments is the result of relatively slow, post-fermentation reactions.<sup>34</sup> J. Eglinton *et al.* however, demonstrated that fermenting yeast cells and their metabolites are actively involved in condensation reactions with tannins and anthocyanins, suggesting polymeric pigment formation during fermentation.<sup>6</sup>

In this study, it must be noted that the analyses of the percentage of color from MP, SPP, and LPP are estimations. For example, while not impacted by the phenolic matrix,<sup>11</sup> monomeric anthocyanins at the pH of the assay are largely in the leuco- or colorless form.

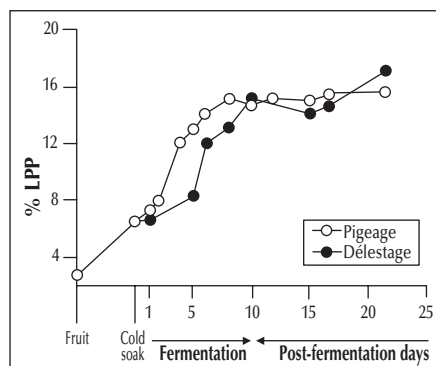
The percentage of Cabernet Sauvignon color from monomeric pigments declined during fermentation for both treatments, by an average of 25%. A. Zimman and A. Waterhouse demonstrated that a significant per-

centage of the loss of monomeric pigments could be due to association with grape solids.<sup>42</sup> Therefore, it is possible that a cap management technique that impacts the non-soluble solids level could impact monomeric anthocyanins.

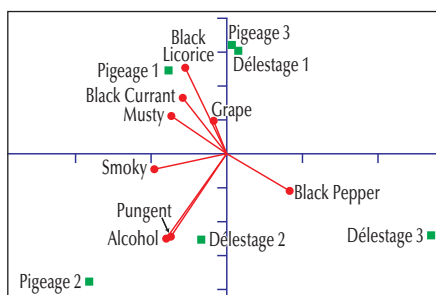
The higher percentage of color from monomeric pigments in pigeage wines at the end of fermentation may reflect increased fruit extraction. Cabernet Sauvignon color from SPP increased during cold soak, and appeared to



**Figure VII. Effect of pigeage and délestage on Cabernet Sauvignon — small polymeric pigments (SPP) as a percentage of total color during cold soak, fermentation, and post-fermentation; n = 3.**



**Figure VIII. Effect of pigeage and délestage on Cabernet Sauvignon — large polymeric pigments (LPP) as a percentage of total color during cold soak, fermentation, and post-fermentation; n = 3.**



**Figure IX. Projection of aroma attributes on principal components 1 and 2 for Cabernet Sauvignon pigeage- and délestage-produced wines; n=11.**

increase only slightly from the beginning of fermentation to dejuicing (average 7.8%). The percentage of color from LPP increased during fermentation by approximately 150%.

The Cabernet Sauvignon LPP-to-SPP ratio, as percent of color, ranged from 0.11 during cold soak to 0.37 at dejuicing. The SPP would be expected to contain pigment dimers and trimers formed by acetaldehyde crosslinking of anthocyanin and flavan-3-ols.<sup>28</sup> The LPP fraction likely contains anthocyanins that have reacted directly with polymeric flavan-3-ols, or by acetaldehyde crosslinks, to form polymeric pigments large enough to precipitate with BSA in the assay.

Phenol-free glycosides were in larger concentration in Merlot, but not Cabernet Sauvignon, délestage-produced wines. The analysis of phenol-free glycosides includes all but shikimic acid metabolites. This analysis may be a better approximation of the glycosidically-derived aroma/flavor pool than is the total glycosides assay.

Discrimination sensory analysis on pooled treatment replications indicated differences in aroma and flavor among

Merlot and Cabernet Sauvignon délestage and control wines. PCA analysis of Cabernet Sauvignon treatment replications demonstrated differences between délestage and pigeage wines, and among replications of the same treatment.

It is evident that délestage wine-1 and pigeage wine-3 have similar aroma and flavor profiles. While treatments were dejuiced each day at the same Brix, individual replicate variation occurred, possibly as a result of the degree of seed removal, pomace drain time, and/or oxygen exposure. With the exception of replicate-1, délestage wines were characterized by pungent black pepper aromas and pungent raspberry flavors.

### Conclusion

An important industry goal is to be able to customize maceration methods, predicated on fruit composition and desired outcome. This study evaluated the impact of a cap management technique in conjunction with seed removal.

Given the large variability in fruit composition, the response to a particular maceration technique may be variable. Délestage with partial seed removal appeared to slightly modify the percentage of color derived from monomeric and large polymeric pigments. The result of discriminatory sensory analysis generally suggested differences in aroma and flavor between délestage and control wines.

These differences were charted for the Cabernet Sauvignon, and were variable among replications. These differences may or may not justify the additional effort involved in the utilization of délestage with seed removal as a cap management strategy. ■

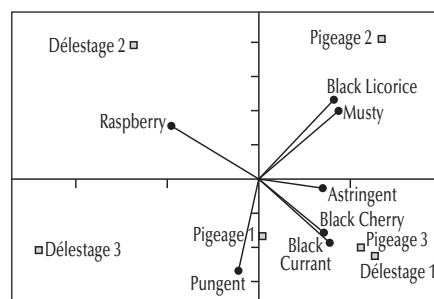
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**Table V: Effect of mechanical pigeage (P) and délestage (D) on total (TGG) and phenol-free (PFGG) Cabernet Sauvignon glycosides.**

Sample	TGG ( $\mu\text{M}$ )		PFGG ( $\mu\text{M}$ )	
	P	D	P	D
Post-Cold Soak	986a <sup>a</sup>	662b	189a	98b
Day 10	1441a	1505a	139b	154a
Dejuice	1470a	1470a	113a	94b

<sup>a</sup>Different letters within rows and assays indicate significant difference ( $p \leq 0.05$ ) of treatment means; n = 3.



**Figure X. Projection of flavor attributes on principal components 1 and 2 for Cabernet Sauvignon pigeage- and délestage-produced wines; n=11.**



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