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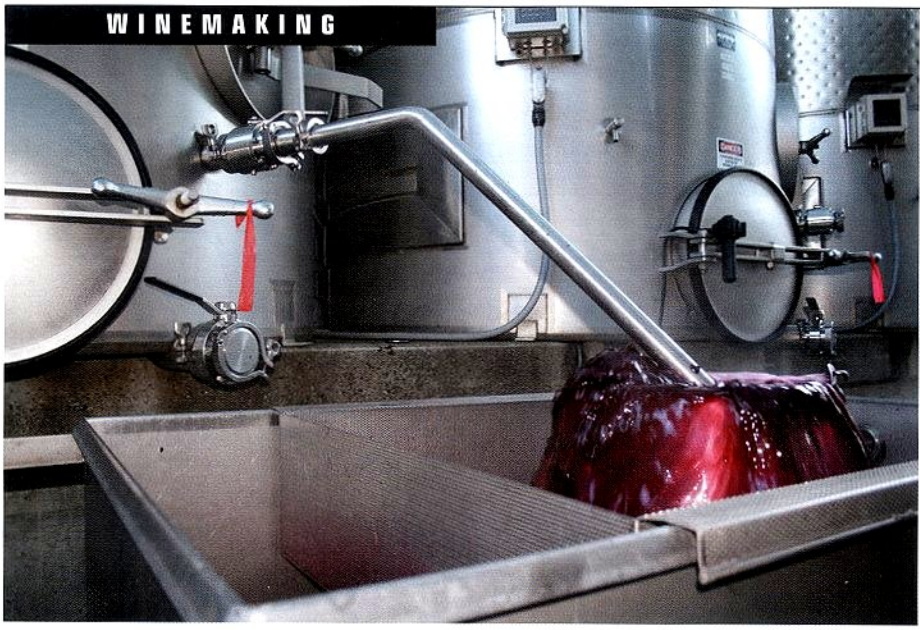


Aeration across a screen with seed removal during draining of the fermentor. Photo by Wendy Day, Vine Cliff Winery (Napa, CA).

MERLOT AND CABERNET SAUVIGNON WINES

Impact of délestage with partial seed removal

BY Bruce W. Zoecklein[1]*, Lisa M. Pélanne[2], Sandy S. Birkenmaier[3], Karen Reed[4]

Délestage (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).

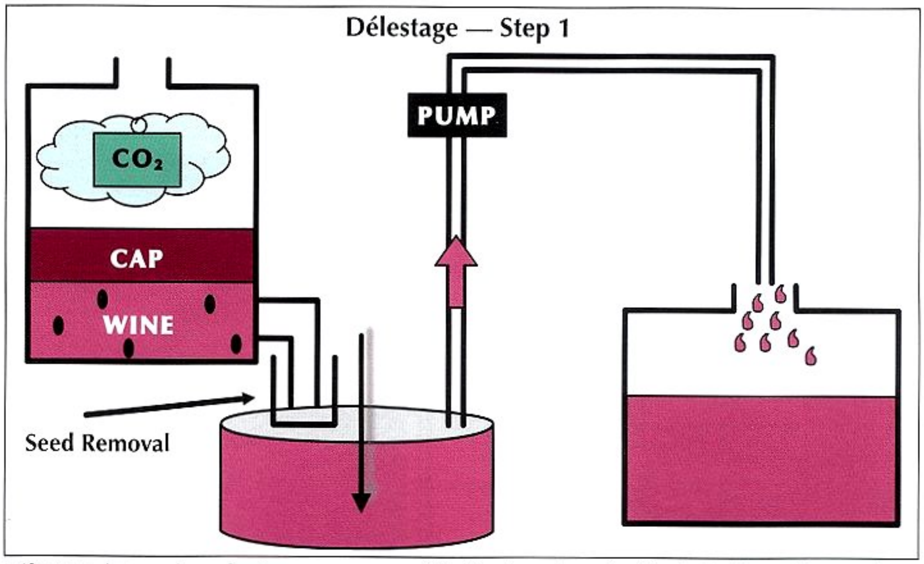
Fermentation reduced the color derived from monomeric pigments and increased polymeric pigment color for all treatments. Délestage wines generally had more large polymeric pigment color than cap-punched or pigeage wines. Total glycosides increased during cold soak and fermentation, and were in greater 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.[12,36]

The level of extraction depends on various factors, including fruit maturity, duration of skin contact, temperature, ethanol concentration,[20] and vinification practices, including cap management techniques.[7,16,22,31] 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,[30] being extracted from the skins and outer seed coat during fermentation.[38] 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.[8,35]



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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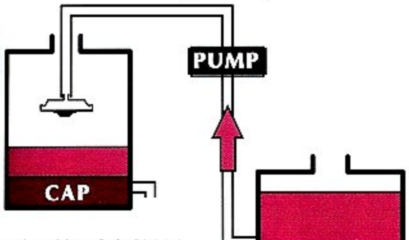
Délestage: Step 2



(Adapted from Delteil (1998))

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/procedur/delestage.htm or www.vtwines.info/enologynotes/onlinepublications)

Grape seeds differ from skins in that seed proanthocyanidins contain greater levels of monomeric flavan-3-ols, and those esterified to gallic acid.[3,25,32] Additionally, seed proanthocyanidins generally have a lower dp (degree of polymerization) than those found in skins, and no trihydroxylation of the B-ring.[9] 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.[38] 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.[36] These pigments are believed to be formed by condensation products of malvidin-3-glucoside and various procyanidins created through acetyl bridges.[9,26] Anthocyanin-tannin complexes can be produced by binding between the C-4 of the flavylium salt and the C-8 of catechin.[21,27]

D.O. Adams *et al.* reported extractable seed tannins in Syrah grapes

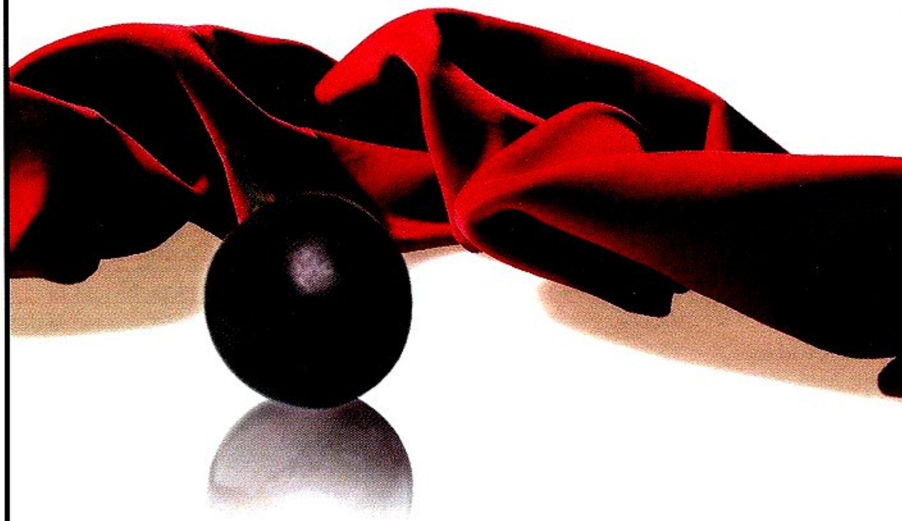


Table I: Effect of manual cap punching (control) and délestage on Merlot wine chemistry for three seasons.

	Season 1		Season 2		Season 3	
	Control	Délestage	Control	Délestage	Control	Délestage
Alcohol % (v/v)	12.8a[a]	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^{280})	59.8a	58.3a	43.1a	37.6b	40.1a	37.0b
Total Anthocyanin (AU^{20}–AU^{SO_2})	ND[b]	ND	3.89a	3.04b	2.37a	2.21b
$AU^{420+520}$	8.23a	6.92b	8.21a	7.82a	8.87a	7.64a
$AU^{420/520}$	0.793a	0.780a	0.794a	0.789b	0.575b	0.585a

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

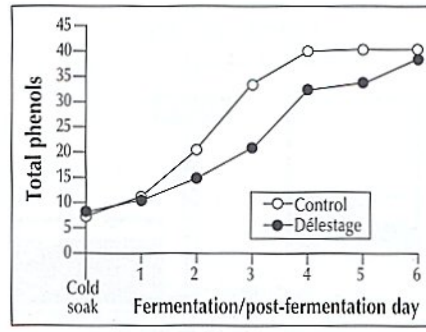


Figure I. Effect of cold soak, fermentation, and post-fermentation on total phenols of control (cap punched) and délestage-produced Merlot wines in season 3; n = 3.

declined by about half from véraison to harvest, and were about three times greater than skin tannin concentrations.[2] Grape skin phenols are more easily extracted during fermentation than those of seeds and stems.[18]

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

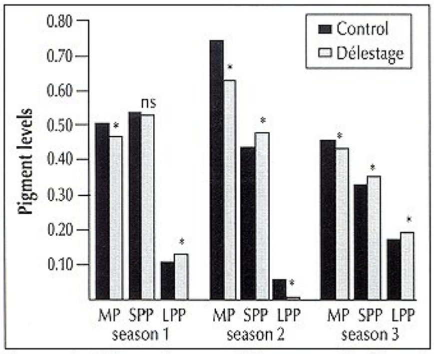


Figure II. Effect of control (cap punched) and délestage on Merlot — percent color derived from monomeric pigments (MP), small polymeric pigments (SPP), and large polymeric pigments (LPP) for three seasons; n = 3.

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[a]	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

[a]n = 3

Several reports have suggested that seeds contribute significant concentrations of proanthocyanidins to wines,[15,29] while others have reported the seed contribution to be limited.[4,24,39] 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,[40] while fermentation temperature appears to be a primary factor influencing extraction from skins.[23]

Délestage, or rack and return, is a maceration technique designed to help optimize the exchange between the liquid and solid phase by emptying the

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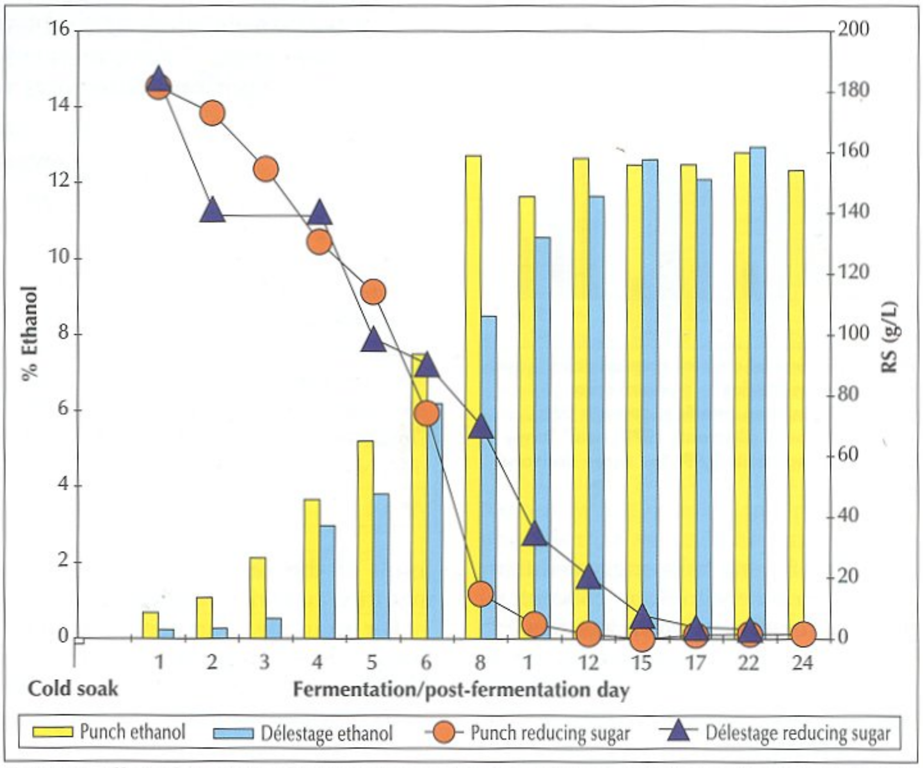

Figure III. Effect of mechanical punch (pigeage) and délestage on Cabernet Sauvignon ethanol production and reduced sugar decrease; n = 3.

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,[10] 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).

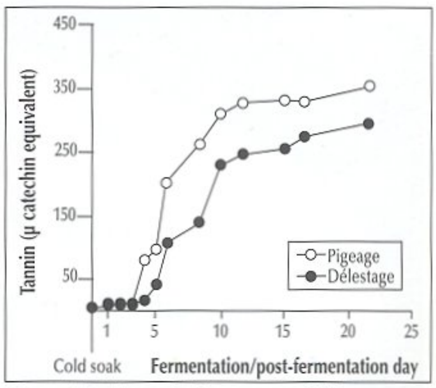

Figure IV. Effect of pigeage and délestage on Cabernet Sauvignon — tannin concentration during cold soak, fermentation, and post-fermentation; n = 3.

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

Sample		TGG (μM) Control	TGG (μM) Délestage	PFGG (μM) Control	PFGG (μM) Délestage
Season 2	Post-Cold Soak	386b[a]	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

[a]Different letters within rows indicate significant difference ($p \le 0.05$) of treatment means; n = 3.

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 dejuicing 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.

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[a]	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^{280})	65.2a	58.0b
Total Anthocyanin (AU^{20}–AU^{SO_2})	2.65a	1.67b
$AU^{420+520}$	0.616a	0.608b
$AU^{420/520}$	0.77b	0.81a
Monomeric Pigment (%)	43.5	34.6
Small Polymeric Pigment (%)	49.6	53.8
Large Polymeric Pigment (%)	6.9	11.6

[a]Different letters within rows denote significant difference ($p \le 0.05$) of treatment means; n = 3.

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 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.*[43]

HPLC analysis was conducted 18 months post-fermentation on selected phenols in finished aged wines described by Price *et al.*[19]

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,[1] and Harbertson *et al.*[11] The concentration of total glycosides was estimated by the analysis of glycosyl-glucose in thawed samples as described by P.J. Williams *et al.*,[41] and modified by R.S. Whiton and B.W. Zoecklein.[40] Analysis of phenol-free glycosides was conducted as described by B. Zoecklein *et al.*[44]

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

Sample	TGG (μM) P	TGG (μM) D	PFGG (μM) P	PFGG (μM) D
Post-Cold Soak	986a[a]	662b	189a	98b
Day 10	1441a	1505a	139b	154a
Dejuice	1470a	1470a	113a	94b

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

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.*[17] The wines were