The Control of Antioxidants in Red Wine by the Pump-Under Fermenter

(a comparison with punch down fermentation)

Lawrence Dawson
SRNRL

Of the multiple compounds extracted during skin-contact fermentation of red wines , some of the more important are the polyphenols also known as tannins. Science has identified them as having health advantages:

> *"Polyphenols are antioxidant compounds found in the skin and seeds of grapes. When wine is made from these grapes, the alcohol produced by the fermentation process dissolves the polyphenols contained in the skin and seeds. Red wine contains more polyphenols than white wine because the making of white wine requires the removal of the skins after the grapes are crushed.*[1]
>
> *Polyphenols have been found to have antioxidant properties. Antioxidants are substances that protect cells from oxidative damage caused by molecules called free radicals. These chemicals can damage important parts of cells, including proteins, membranes, and DNA. Cellular damage caused by free radicals has been implicated in the development of cancer. Research on the antioxidants found in red wine has shown that they may help inhibit the development of certain cancers*[2]*."*

However, not all tannins are created equal. Tannins which originate from the seeds (Catechins and Epicatechins) tend to add a bitter or astringent quality to the wine, a quality which sometimes requires long aging to eliminate. Non-seed tannins —primarily those from the skins— are softer and add complexity to the wine. Skin-born antioxidants may also have greater health advantages:

> *"Resveratrol is a type of [skin born] polyphenol called a phytoalexin, a class of compounds produced as part of a plant's defense system against disease. It is produced in the plant in response to an invading fungus, stress, injury, infection, or ultraviolet irradiation. Red wine contains high levels of resveratrol.*
>
> *Resveratrol has been shown to reduce tumor incidence in animals by affecting one or more stages of cancer development. It has been shown to inhibit growth of many types of cancer cells in culture. Evidence also exists that it can reduce inflammation. It also reduces activation of NF kappa B, a protein produced by the body's immune system when it is under attack. This protein affects cancer cell growth and metastasis. Resveratrol is also an antioxidant.*[3] *"*

A series of comparative fermentations between the pump-under fermenter developed by Pasco Poly, Inc. and the conventional punchdown method has revealed that the pump under fermenter significantly increases skin-born antioxidants (polyphenols) in red wines.

The tests were conducted over three years and over three different climates and over two different varieties of grape. The same comparative results were indicated in all cases. The results were not restricted by climate, season or even grape variety. Skin-born antioxidant

---

[1] The pump-under skin contact fermenter is now used on whites by the St. Regulus winery.

[2] *"Cancer Prevention and Red Wine"* ; MedicineNet.com

[3] Ibid.

polyphenols increased by an average of 47% across the board. The lowest increase in skin-born polyphenols was recorded at 33% and it occurred in the test of the grape with the highest number of natural antioxidants in the study.

These fermentation studies have determined conclusively that the pump under fermentation system, which keeps the skins in contact with the wine during the whole of the fermentation process, produces a significant increase in antioxidants in the wine. The pump under method is contrasted with the conventional "punch down" system which allows the grape-skin cap to rise out of the wine until it must again be "punched down" to renew contact with the wine.

However, it is not only better pump-under contact with the wine which explains these results. Better temperature control also seems to be a factor.

In the manufacture of wine, energy application is a function of the rate of fermentation. Energy is measured as the change in temperature over time (Joules or BTUs). A faster fermentation releases more heat over time and thus is a higher energy condition than a slower fermentation.

The pump under fermenter retains the skin-cap in the wine. By retaining the cap, precise and continuos temperature control is applied to the cap where the majority of fermentation takes place.

In contrast, "punch down" is realized by pushing the cap back into the cooler wine below. Rate of fermentation is known to be a function of heat. Higher temperatures produce faster fermentations and lower temperatures produce slower fermentations. "Punch down" therefore, periodically slows the rate of fermentation in comparison to the pump under fermenter. It is inferred that there is a difference in energy application between the two methods of fermentation.

The rate of increase in seed-born tannins between the "pump-under" versus the "punchdown" was much less than the rate of increase in skin-born antioxidant polyphenols. In fact, there was a very small overall average decrease in seed-born tannins for the pump-under system vs. "punchdown." This difference between the pump-under's rate of increase for skin-born antioxidants versus seed-born tannins approached statistical significance. It is concluded that the better maintenance of fermentation temperature by the pump-under increased skin-born antioxidants more than did that temperature consistency affect the less valuable seed-born polyphenols.

The Study

Four pairs of fermentations were conducted, each pair using the same grape from the same season and the same vineyard. Each grape was fermented in Pasco Poly's pump-under, temperature controlled fermenter and by the "punch down" method. Fermentations were conducted in the wineries which received the grapes. All were fermented to dryness. The comparison, therefore, is between methods of fermentation for each included grape in the study.

The grapes used were a 2006 Cabernet Sauvignon from California's Napa Valley, a 2007 Cabernet Sauvignon from California's Green Valley, a 2004 Cabernet Sauvignon from Idaho's Snake River appellation and a 2007 Pinot noir from Oregon. The fermentations were conducted on site.

Each finished fermentation was given a phenolic profile of twelve compounds from a well

qualified lab in St. Helena, California[4] . Included in this profile were measures for seed tannins as well as the total number of polymeric phenols (total polyphenols) in each sample. The number of skin-born polyphenols were calculated by subtracting seed tannins from total polyphenols.

The results were arrayed for a statistical "t test." A "t test" tests the statistical significance for the difference between matched pairs on a single variable. It is used for a small number of samples of such matched pairs. Its greatest application is in the field of medical science. The "t test" is biased against our samples since in assumes a normal distribution of a single population which is untrue in the present case. This fact makes the level of significance discovered all that more impressive.

Antioxidant-Polyphenols in Finished Wines

Punch Down Vs. Pump Under

PU=pump under; PD=punch down

Fermentation ***variety, locale and vintage***	**Non-seed PD** ***skin antioxidants*** mg/ L	**Total PD** mg/ L	**Non-seed PU** ***skin antioxidants*** mg/ L	**Total PU** mg/ L	**Change non-seed PU-PD** ***skin antioxidants*** mg/ L	**Change Total PU-PD** mg/ L
Cab. Sauv Napa Vly 06	475	514	708	738	+233	+224
Cab. Sauv. Green Vly 07	740	808	985	1052	+245	+249
Cab. Sauv. Idaho 04	243	353	415	549	+172	+196
Pinot noir Oregon 07	175	322	296	399	+121	+77
Mean	**408.25**	**499.25**	**601**	**684.5**	**+192.75**	**+186.5**

"t" test for significance of the mean difference between matched pairs.

$s^2 = \sum_{i=1}^{n} \frac{(d_i - \bar{d})^2}{n-1}$; s = variance ; d_i = difference pairs $\qquad t = \frac{\bar{x}_1 - \bar{x}_2}{s/\sqrt{n}}$

The mean difference between skin antioxidants for "pump under" vs. "punch down" is "+192.75" with the greater number being "pump under." This gives a "t" value of the following:
t= 6.700970746 > "t= 5.8408 for .01 level of confidence (3 degrees of freedom)." Experimental "t" value is greater than .01 level of statistical confidence.

The mean difference between total polyphenols between "pump under" vs. "punch down" is "+186.5" with the greater number being "pump under." This gives a "t" value of the following:
t= 4.866*< t= 5.8408; does not meet .01 significance level but greater than .05 confidence level; t =3.18 for .05 confidence level. This fall in significance for total polyphenols shows effect of the "reverse" seed variation on the total .*

[4] The compounds were reported as solution values of milligrams per liter (mg/L).