
Research News from Cornell's Viticulture and Enology Program Research Focus 2015-3

# RESEARCH FOCUS

## Know how to hold 'em: New insights on hybrid tannin retention

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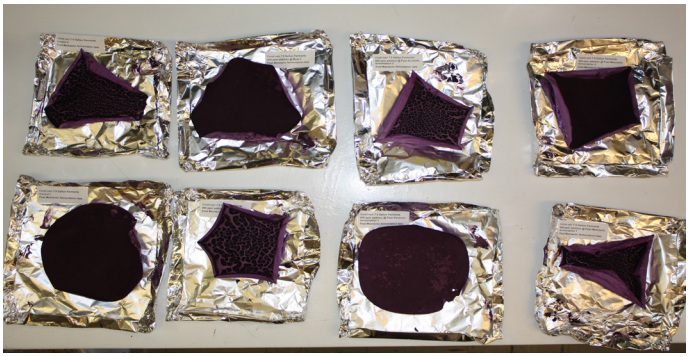
*Anna Katharine Mansfield harvesting Corot noir grapes.*
*Photo by Chris Gerling.*

Tannin is essential to red wine quality, but is generally low in wines made from hybrid grapes. To improve tannin extraction and retention, the Cornell Enology Extension Lab (CEEL) assessed the efficacy of processing methods on hybrid tannin retention. When preliminary work suggested that exogenous tannin addition was the only sure means of increasing wine tannin, we followed up with additional trials on additive timing and concentration. Concurrently, Lindsay Springer and Gavin Sacks set up trials to identify the must component responsible for limiting tannin extraction and retention. Results suggest that proteins occurring in higher concentrations in hybrid grapes are responsible for binding and removing wine tannins, both those derived from the grape and those added during processing (Springer and Sacks, 2014). Ongoing work explores the best means of timing tannin additions to increase hybrid red wine structure and quality.

### KEY CONCEPTS

- Wines made from red hybrid grapes have lower tannin concentration than the average wine made from a red *Vitis vinifera* cultivar.
- Traditional wine production methods that enhance tannin concentration in *V. vinifera* wines have little or no impact on red hybrid wines.
- Protein content in grapes is correlated to binding and precipitation of tannins, and is generally much higher in red hybrid cultivars.
- Exogenous tannin additions may be used to increase tannin concentration in hybrid red wines, but very large additions may be required.
- Means of removing or otherwise inactivating tanning-binding proteins in wine are under investigation.



*Filtered and freeze-dried lees are used to analyze tannins lost during fermentation.*
*Photo by Alex Fredrickson.*

**Grape breeding for survival, not structure**: Winemakers have struggled for years to make a 'big' red from hybrid grapes–they search for the Cabernet Sauvignon of cold climates; the perfect marriage of disease resistance, high yield, and structured mouthfeel. The cultivar that will yield this mythical wine, however, has proven elusive. To be fair, early breeders didn't have tannin concentration in mind when they set out to solve the *phylloxera* root louse problem that was ravaging European vineyards. Instead, their most pressing need was to incorporate the *phylloxera* resistance of native American *Vitis* species in hybrid varieties with more favorable sensory attributes for wine production. Since the mid 20th century, wine grape breeding has broadened to include the development of cultivars suited for a range of climates, pests, and diseases that challenge more fragile *V. vinifera*, allowing viticulture to expand well beyond its traditional borders.

**The case of the missing tannins**: As regions that rely on hybrid winegrape cultivars matured, the goal of most industries moved from "make something drinkable with the grapes that will grow here" to "produce high quality, regionally-driven wines." Because tannin amount and type are key to red wine quality, red hybrids have come under heightened scrutiny. In a 2010 poll, winemakers in five midwestern and northeastern states indicated that 'low tannin' was their biggest concern in red hybrid winemaking. In the same survey, we asked winemakers what processing methods they used to try to increase tannin concentration, and got responses that ran the gamut from extended maceration to enzyme addition - but no one agreed on the best way, or even a really good way, to get more tannin from the fruit.

The first step in getting more tannin into wine is figuring out why concentrations are low in the first place. To tackle that problem, we had to consider three possible options:

1. Hybrid cultivars are lower in tannins than *V. vinifera*.

2. Hybrid cultivars have as much tannin as *V. vinifera*, but the tannin cannot be extracted.

3. Hybrid cultivars have as much tannin as *V. vinifera*, but the tannin is lost for some reason during the winemaking process.

….Or some combination of the above.

**Hypothesis 1: Hybrid grapes have lower tannins**. Traditional wisdom holds that hybrids don't produce the same concentration of condensed tannins, the polyphenolic compounds found in skins and seeds, as their *V. vinifera* cousins. Though tannin concentrations may vary somewhat by region and year, cultivar appears to exert the greatest influence. In the Sacks lab, a comparison of per-berry tannin composition among 12 winegrape cultivars showed that six *V. vinifera* grapes had higher concentrations than the four French-American hybrids tested, with means of 1.27 mg/g compared to 0.71 mg/g, respectively (Figure 1B) (Springer and Sacks, 2014). These *V. vinifera* tannin amounts are similar to those found in an earlier

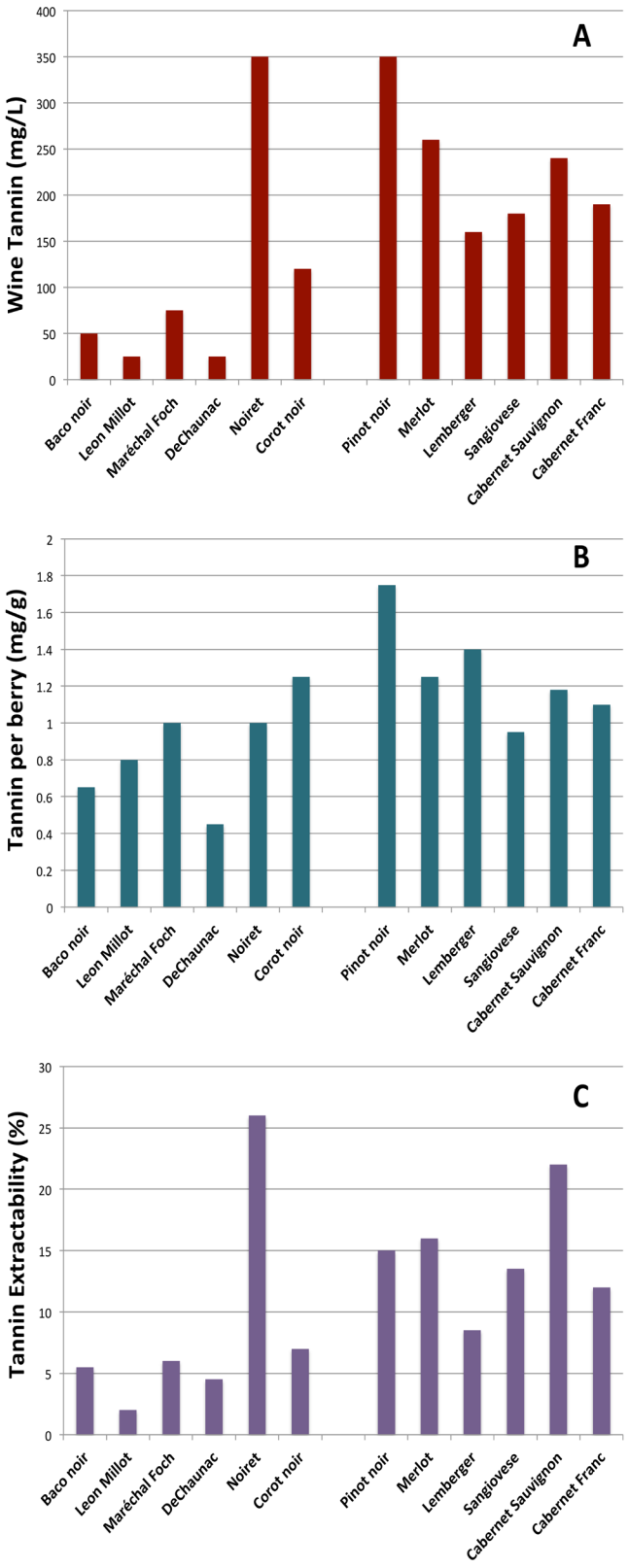



**Figure 1**: (A) Wine tannin by cultivar (n=4 per cultivar). (B) Tannin per gram berries by cultivar. (C) Tannin extractability by cultivar. [*Modified from Springer and Sacks, 2014.*]

work reporting per-berry concentrations ranging from 0.99 to 1.44 mg/g (Harbertson et al., 2002).

Not all hybrids are created equal, however. In the same study, Springer and Sacks observed that Noiret and Corot noir, two 21st century cultivars released from the Cornell Grape Breeding Program, had some of the highest per-berry tannin concentrations among the hybrid cultivars surveyed (Figure 1B), with Corot noir concentrations topping those of several *V. vinifera* grapes.

Comparing berry and wine tannin (Figure 1A), however, it becomes obvious that the correlation is weak, at best. In fact, when Springer and Sacks compared skin, seed, and total grape tannin (where total tannin=skin + seed), skin tannin predicted final wine tannin ($r^2$=0.73) better than total tannin ($r^2$=0.44) or seed tannin ($r^2$=0.01). While this confirms previous reports that skin tannin is extracted more rapidly than seed tannin, and that only a portion of total tannins in the fruit moves into wine, the lack of correlation is still puzzling. As shown in figures 1A and 1B, a greater percentage of tannins in *V. vinifera* grapes show up in final wines, and even hybrids with relatively high fruit tannin average less than 50 mg/L in wine. So where's the rest of the tannin?

**Hypothesis 2: Hybrid tannin is hard to extract**. Prior to Springer and Sacks' work, one working hypothesis was that hybrid reds were being processed differently than *V. vinifera*, and that different tannin concentrations may have been the result. After all, hybrid wines often command lower prices than *vinifera*, so producers may feel that the time and money required to coddle them into higher tannin extraction is simply a waste of resources. Further, many of the methods with the potential to enhance tannin extraction can also lead to the development of herbaceous or other 'hybrid' off notes, prompting producers to limit high-extraction methods.

To see if production methods would change tannin extraction, we performed a study in 2011 comparing the impact of the three most popular winemaking treatments in our 2010 winemaker poll (cold soak, enzyme addition, and tannin additions), as well as hot press, on the tannin extraction and retention of Maréchal Foch and Corot noir (Manns et al., 2013). All of these treatments have, at various times, been cited as effective in increasing tannin concentration in red *vinifera* wines, but their use in hybrid red winemaking is largely anecdotal. To our surprise, we found little difference among treatments, and the small increases seen in tannin concentration of wines at bottling were insufficient to affect sensory characteristics (Table 1). Further, it's notable that the impact of each treatment varies by cultivar; hot press, for example, results in lower tannin concentrations in Corot noir but higher in Maréchal Foch. The only similarity was found in exogenous tannin additions, which resulted in the highest final tannin concentration among treatments for each cultivar.

At this point, the outline of the puzzle is at least visible. Hybrid reds generally have lower initial tannins than *vinifera*, and the tannin available is difficult to extract. Further, extraction methods that work with vinifera don't seem to reliably or regularly work in hybrid tannins. Altogether, this suggests that there's something other than just extraction that influences tannin concentration- and that whatever it is isn't as prevalent in traditional wine grapes.

**Table 1**. Condensed tannin concentration (mg/L) in Corot noir and Maréchal Foch wines.

| Treatment | Corot noir | Maréchal Foch |
|---|---|---|
| Control | 132.9a | 76.3a |
| Enzyme Addition | 149.9ab | 87.7a |
| Tannin Addition | 156.9ab | 115.5b |
| Cold Soak | 145.7ab | 86.8a |
| Hot Press | 72.0c | 103.9b |

*Values followed by a letter indicate a statistically significant difference between treatments ($a < 0.05$).*
*Values are listed as mean (ppm) ± standard deviation of replicates, $n = 3$.*

**Hypothesis 3: Hybrid tannin is lost during winemaking**. The notion of 'sacrificial tannins,' that is, the large percentage of an exogenous tannin addition lost during fermentation, is well known to hybrid winemakers that use the products. Vendors and winemakers alike have observed that tannin additions to hybrid wines needs to be larger than the standard recommendations made for vinifera wines, with some suggesting rates as high as two to four times that of the manufacturer's recommendation. The question, though, is what these tannins are being sacrificed to. Are they simply not soluble enough, and fall to the bottom of the vat? Are they binding with grape solids or yeast lees? Or are they reacting with each other and falling out of solution?

The notion that tannin additions are lost in hybrid wines, coupled with the poor correlation between tannin concentrations in hybrid grapes and finished wines, led to Springer and Sacks' big breakthrough. They observed that tannin extractability- defined as [(wine tannin ÷ fruit tannin)X100] – was lower in hybrid cultivars than in *vinifera*, and that extractability lined up nicely with wine

tannin concentration (Figures 1C & 1A.) The concept of tannin extractability takes into account the fact that not all of the tannin available moves into the liquid portion of the must, but rather that other components in the must may absorb or bind with the tannin, removing it from solution.

To investigate the potential for tannin binding, Springer and Sacks isolated skin and flesh components from grapes, and tested their ability to react with a BioTan, a grape-derived commercial product with a relatively high condensed tannin concentration. They found that cell wall material of French American hybrids had, on average, a 2.7-fold greater affinity for the tannin additive than did *vinifera*, providing strong evidence that some component in hybrid grapes was capable of binding and precipitating both grape-derived and exogenous tannins. While there has been some previous evidence that grape pectins are capable of binding tannins, Springer and Sacks found that the concentration of protein in grape flesh was more strongly correlated with tannin binding. In short, grapes that had the highest measureable amount of protein by weight showed the strongest tannin binding capability- and these grapes were, for the most part, hybrid cultivars.

**Practical applications: What we know.** The discovery that hybrid cultivars contain proteins that not only prevent the grape's own tannin from being extracted but can also pull added tannin from solution raises some important questions for winemakers. Most winemakers add tannins at crush in an effort to better 'integrate' the product into wine, but if grape components are pulling that tannin right back out, early additions might not be the best plan. Our winemaking trials addressed two questions about exogenous tannin: First, would adding tannins later in the winemaking process enhance retention? Second, how large of an addition is needed to overcome binding activity?

**Addition timing**: To answer the first question, wines were made from Maréchal Foch, Corot noir, and Cabernet Franc (to compare *vinifera* activity with the two hybrids) and tannins were added either at crush, at the end of alcoholic fermentation (AF), or at the end of malolactic fermentation (MLF). In all cases, tannin retention increased with later additions, but the percent retention varied by cultivar. Cabernet Franc showed a relatively consistent increase in retention with additions later in the winemaking process, but in hybrid cultivars, the difference in retention in post-AF and post-MLF additions varied. We did not pursue sensory evaluation in these trials, so the impact on wine structure and aroma is unknown. Sensory impact will vary by tannin product, as the difficult extraction process results in all additives carrying a certain amount of odor-active plant extracts, so bench trials are necessary with each cultivar + tannin combination. If tannin retention is the goal, however, it's clear that the later the addition, the better.

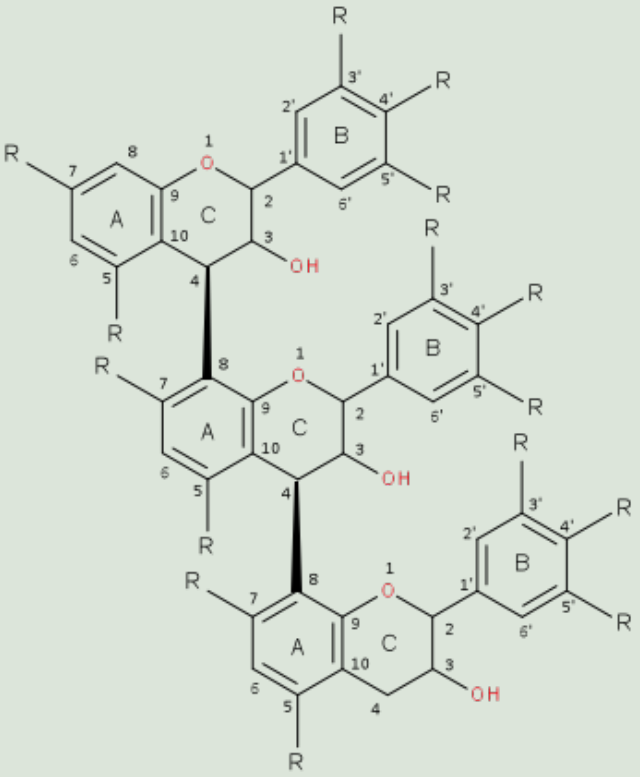
**Addition rate**: In a previous study, exogenous tannins added at the top of the recommended range (400ppm for the product in question) made little difference in final wine tannin concentrations. This made us curious- how large of an addition could we make? To compare hybrid and vinifera matrices, we made wine from Maréchal Foch, Corot noir, and Cabernet Franc, adding tannins at crush at 400, 800, and 1200ppm, as high as 3X the manufacturer-recommended addition rate. The results seemed to validate the work of Springer and Sacks. Maréchal Foch, which has fairly low tannin extractability, also had the lowest tannin retention at all addition levels. In contrast, Corot noir retained a larger portion as additions got larger, suggesting that the binding reaction reached a saturation point. Both retained less tannin than the *vinifera* cultivar Cabernet Franc. This leads us to believe that hybrid cultivars do need generally larger tannin additions, but that the optimal addition is dictated by the extractability of each cultivar. Further work is needed to fully understand what parameters influence this effect.

**And what we don't know…** When we discuss these findings with winemakers, the most common response is "Ok, so proteins are pulling out tannins...so is there any way I

**The anatomy of grape tannin.**

Condensed tannins are polymers of flavan-3-ol subunits, primarily catechin, epicatechin, and epigallocatechin, that are formed in the skin and seeds of grapes. Specific subunits, combinations, and ratios are found in wine, and differ from those found in other products like beer and tea. In wine, skin- and seed-derived tannins can be differentiated by the types of subunits that make up the polymer chain.

*Illustration courtesy David C. Manns, 2015*



can remove or deactivate the proteins early on, then make tannin additions later?" The short answer is: we don't know. It seems logical that removing proteins with bentonite fining, or denaturing them with a protease, should inhibit protein-tannin binding. Since we don't know a lot about the active protein, however, it's hard to know if these treatments will be effective. Research on protein removal is underway this fall, as are additional studies to assess the sensory impact of late and/or high-concentration tannin additions in specific wine types. Despite these uncertainties, understanding that wine proteins can interfere with tannin extraction and retention is a huge step forward, providing winemakers with a better understanding of timing and amount of exogenous tannin additions to optimize tannin content in red hybrid wines.

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