Innovative Tools for Stave Selection and Toasting

Uncovering the impact of oak on wine style and composition

BY M.L. Badet-Murat, J.C. Vicard, A.A. Watrelot and J.A. Kennedy

While variation in oak barrels' contribution to wine is generally accepted by winemakers, this variation can have unintended impacts on wine composition and the economics of production. To reduce this variability, it is important to understand oak chemical composition (see "Oak Wood Composition" on this page).

Wood-extractable compounds can be directly transferred from oak to wine. They are extracted during winemaking and *élevage* in barrels, and the extraction rate can vary depending on wood and wine. Even if wood-extractable compounds represent a minor component of total oak chemistry, they play an important role in wine style.

In this group there are ellagitannins (representing the majority of oak-extractable compounds) and a pool of aromatic compounds present in untoasted wood (native aromatic compounds) that are responsible for oaky aromas.

For example, whisky lactones are responsible for coconut and fresh wood notes but also contribute to wine freshness and fruitiness. Non-extractable compounds, while not extractable as such, are precursors of volatile compounds produced during the toasting process.

The degradation of hemicelluloses during barrel toasting generates compounds responsible for toasted/roasted aromas, whereas lignins generate compounds responsible for vanilla/pastry nuances and spicy and smoky notes. The amount produced during toasting varies according to time, temperature and wood humidity. Toasting also degrades ellagitannins and can increase or decrease oaky notes (whisky lactones) depending on temperature.

Ellagitannins, while a small percent of oak chemical compounds, are highly extractable and play an essential role in winemaking.

The toasting system has an inner cone covering the flame and an outer dome that eliminates environmental fluctuations.

Thus, the contribution of these different compounds to wines at the end of *élevage* can vary depending on initial oak composition and toasting management but also winemaking and aging protocols.

To understand and potentially control variation, Jean-Charles Vicard founded a research and development company, Esprit de Dryades, in 2009. Their research has shown that the primary sources of variation occur at three stages: raw material selection, bending and toasting.

Focusing initially on bending and toasting, Esprit de Dryades developed a fully automated, computer-controlled system that eliminates the variability introduced by traditional methods of bending, open-pot wood-toasting with direct flame contact, human interaction and impact from the outside environment.

The patented system has a steam chamber that bends the staves into a barrel shape in four minutes without changing the chemical composition of the wood and a separate closed, radiant-heat toasting chamber controlled by computer within +/- 3° C. The system, which required a large investment and two years to optimize, was installed for the 2011 vintage as the standard toasting system for all barrels made by Groupe Vicard.

Variation in the chemical composition of raw oak wood has been well documented by the scientific community. [1,2,3,4,5,6,7,8] While the selection criteria traditionally used by cooperages to reduce variability (e.g., width of growth rings and silvicultural practice) provides some consistency, these criteria do not relate to the heterogeneity of oak chemical composition.[5] To achieve compositional homogeneity, the chemical analysis of every stave is necessary. Near-infrared spectroscopy (NIRS) was utilized to accomplish this while maintaining throughput.

Several hundred staves were analyzed by NIRS, and the results

indicate that a large variation in ellagitannin content exists (both inter-individual and according to the location of the wood within the tree). This variation was not related to practices that cooperages have traditionally utilized for stave segregation.

Esprit de Dryades identified three classes of tannin potential (TP) corresponding to distinct ellagitannin content in untoasted wood: low TP (LTP) containing less than 4,000 ellagic acid equivalent (μg ellagitannin per gram of dry wood), medium TP (MTP) containing 4,000 to 6,000 and high TP (HTP) containing more than 6,000.

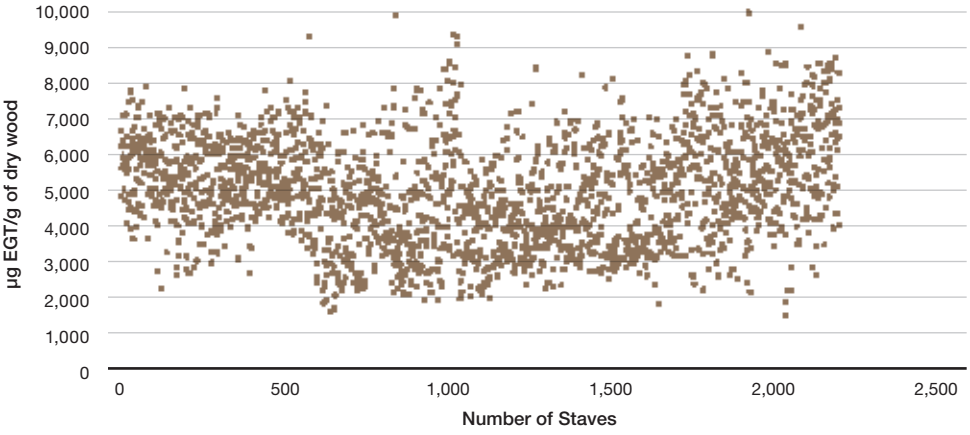
Because oak wood undergoes significant compositional change during toasting (e.g., formation of volatile compounds and partial degradation of ellagitannins), traditional methods of toasting and the associated variations in human management of the toasting process would negate the upstream wood classification by NIRS. Therefore, it was essential to incorporate automated toasting to achieve consistent and reproducible results.

With the NIRS classification and automated toasting systems in place, Esprit de Dryades launched the new Vicard Generation 7 cooperage in 2011 to offer clients increased precision. Winery trials began in Italy and France, and the results indicated that predictable and consistent flavor profiles were achievable.

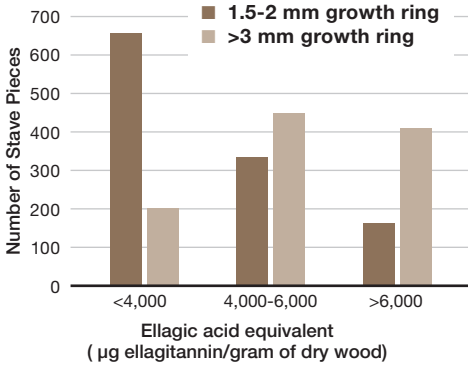
With positive response from many winery clients, the cooperage expanded production in 2013 to make several thousand barrels to sell each year in Bordeaux, Burgundy, the United States and the southern hemisphere.

Esprit de Dryades is continuing research to learn the potential im-

VARIABILITY OF ELLAGITANNIN CONTENT IN OAK STAVES



DISTRIBUTION OF ELLAGITANNIN ACCORDING TO GRAIN SIZE



The Vicard toasting room has 60 individual toasting units, each controlled independently by computer.

pact of tannin on wine style. For the 2015 vintage, Marie-Laure Badet conducted full-scale scientific collaborations for red wines with California State University, Fresno's Aude Watrelot and James Kennedy (now of Constellation Brands) and for white wines with Regis Gougeon and Maria Nikolantonaki of the University of Dijon (Burgundy, France).

Materials and methods

The wood used in this study came from Vicard Group's stocks (French forests and neighboring countries) with 30 months of natural maturation.

Wood classification according to ellagitannin content, as described above, was performed using NIRS with a detection technique based on the use of an acousto-optic tunable filter.

Each barrel was placed on a rotating plate with a toasting pot under a hole in the center of the plate. Agglomerated oak pellet material (made from waste at the stave mill) was augured into the toasting pot. For optimal combustion, air was blown into the pot using a fan. A computer controls the auger and fan. A barrel-shaped cone (inside the outer dome) covered the fire, creating radiant heat, and a smokestack vacuumed smoke from the chamber when the unit was closed. When the outer dome was shut, all environmental fluctuations of temperature or humidity were eliminated.

A toasting profile was entered into the computer prior to toasting. An infrared thermometer, aimed inside at the mid-point of the barrel, provided temperature readings as the barrel turned on the rotating plate. Readings were continually sent to the computer to adjust the temperature by speeding or slowing the auger and/or the fan to maintain the requested toasting profile or maintain a specific temperature.

In our study, all barrels underwent a gradual toasting, and various initial temperatures were compared for: Merlot (G150) for estate A; Cabernet Sauvignon 160° C and 170° C (G160 and G170) for estate D, and 180° C (G180) for estate B; Chardonnay Ivory (160°/170° C) for estate C. The gradual toast profile was designed to slowly increase the temperature

NATURE AND ORIGIN OF WINES

Origin	Vintage	Grape variety	Toasting process	Tannin potential (TP)	TPI
INFLUENCE OF TP					
Estate A Saint Emilion	2014	Merlot	G150	LTP / MTP / HTP	84/83/86
Estate B Napa Valley	2013	Cabernet Sauvignon	G180	LTP / HTP	70/78
Estate C Burgundy	2014	Chardonnay	Ivory	LTP / HTP	nc
INFLUENCE OF TOASTING LEVEL					
Estate D Sonoma County	2013	Cabernet Sauvignon	G160/170	LTP	58/59

LTP=low tannin potential; MTP=medium tannin potential; HTP=high tannin potential; nc=not concerned

for 90 minutes. (See the wines and experimental setup in the table "Nature and Origin of Wines.")

For red wines, an international panel of trained tasters (17 for the 2013 Cabernet Sauvignon and 10 for the 2014 Merlot) from the National School of Agricultural Sciences of Bordeaux (Bordeaux Sciences Agro) participated in the blind sensory analysis. For white wines, a panel of 10 trained tasters participated.

For each series, there were two stages of sensory analysis: a triangle test followed by a descriptive analysis in pairs (Chardonnay and Cabernet Sauvignon estate D) and trio (Merlot). Tasters were asked to rate the wines from zero to five on criteria related to the perception of oak in wine and wood-wine harmony. The results were subjected to statistical analyses to highlight the significant differences between wines: X^2 test for the triangular test and two-factor Anova without repetition for descriptive analysis. The significant differences (see "Sensorial Analysis of Cabernet Sauvignon-Estate D" on page 52) by ** (significance at 5 %).

The impact on tannin reactivity was evaluated by measuring an index of salivary protein (SPI).[9,10]

The assay of wood aromatic compounds was performed on wines by Stir Bar Sorptive Extraction/gas chromatogram/mass spectrophotometry and liquid chromatography/mass spectrophotometry, which are internal methods at the Sarco laboratory in Bordeaux.

Grape-based tannin composition and concentration were determined using analytical methods capable of differentiating grape tannins from oak tannins.[11]

Results and discussion

Measuring tannin potential on a sample of more than 2,000 staves of various origins and grain width confirmed the variability of wood ellagitannin concentration.

The relationship between tannin potential and grain was investigated for two grain widths: growth ring width between 1.5 and 2 mm (FI) and more than 3 mm (GR). In accordance with data literature,[12] ellagitannin content increased with the grain width. However, this correlation was weak; therefore, grain width was determined not to be a strong predictor of stave ellagitannin content.

Triangle tests: For a 2014 Chardonnay tasted after 12 months of *élevage*, the triangle test clearly discriminated the two samples with 95% confidence. For a 2014 Merlot tasted after 12 months of *élevage*, two triangle tests have been performed: MTP compared to LTP, and MTP compared to HTP. The panel clearly discriminated the samples, the differences being more significant for the set MTP/HTP (99% confidence) compared to LTP/MTP (99.9% confidence).

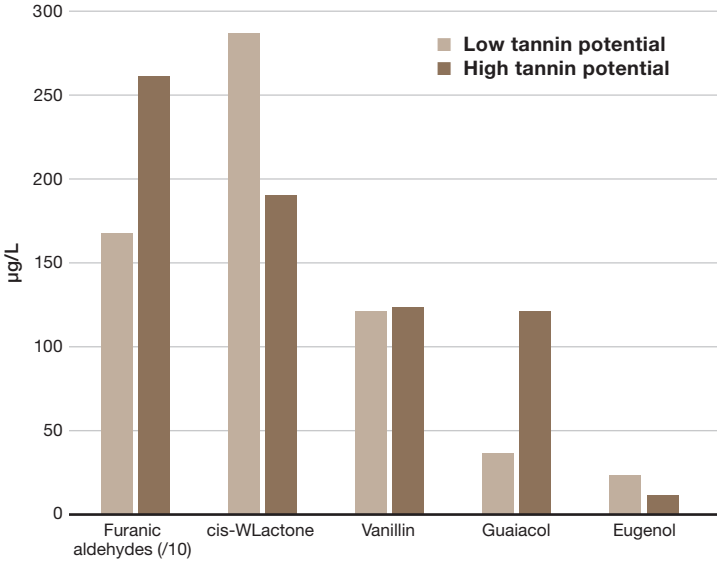
The references for this article are available online at winesandvines.com

Mouthfeel perception: For the Chardonnay, the wine aged in HTP barrels exhibited significantly more pronounced roundness and length, but the descriptive analysis could not discriminate the two samples on the balance criteria: LTP gives more freshness and HTP more roundness, the two modalities being complementary.

For the Merlot, the descriptive analysis clearly discriminated the wines on length and fruity retronasal criteria: Length increased along with TP, while fruitiness decreased. No significant differences were found between the three samples on the criteria of tannin intensity and quality. Tannin reactivity measured by an index of salivary protein was very close (respectively 45%, 49% and 51% for LTP, MTP and HTP).

During *élevage*, the ellagitannin concentration is known to increase during the first months and then decrease slowly due to ellagitannin oxidation and/or condensation with the wine con-

WOOD AROMATIC COMPOUNDS IN CHARDONNAY



stituents.[5] It is also established that the ellagitannin concentration in wine tends to decrease with the toasting temperature, as thermolytic degradation occurs during the toasting process and are converted into less astringent products.[13] This could explain the absence of significant differences in terms of tannin perception at the end of *élevage* in our study.

Olfactory perception: Beyond its impact on wine structure, wood sorting according to tannin potential seemed to have a significant influence on wine aromas. (See "Wood Aromatic Compounds in Chardonnay," above, and "Wood Aromatic Compounds in Merlot" on page 51).

For the Chardonnay, LTP modality was considered significantly more fruity than HTP. That same LTP modality presented more intense fresh wood notes and conversely less toasted notes compared to the HTP modality.

For Merlot, three criteria were impacted: fruity, spicy and vanilla notes. Fruity and spicy notes decreased along with TP, while the MTP modality exhibited the higher intensity for vanilla notes.

For both trials, chemical analysis provided a molecular interpretation of these sensory differences.

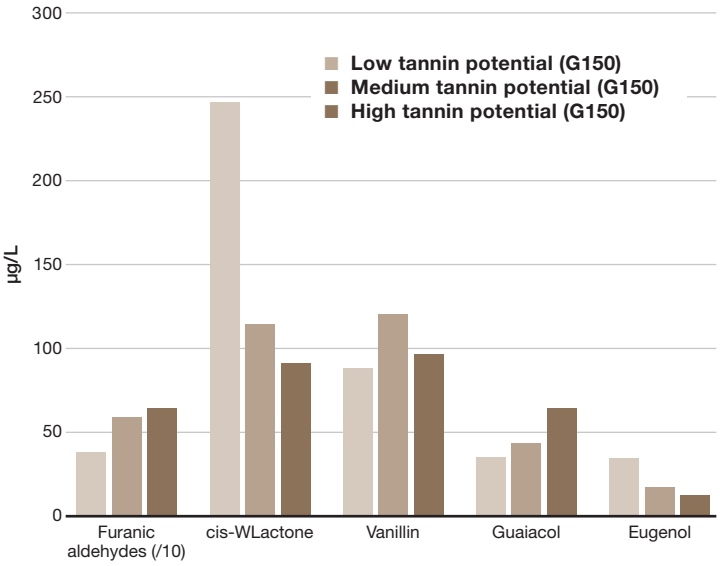
According to recent research,[5] levels of furanic compounds in wines associated with toasted notes increases along with wood tannin potential. For whisky lactones, aging under a lower TP resulted in a richer wine.

Differences in fruity perception between the different TP classes could also be explained by their respective chemical compositions. A greater concentration of furanic aldehydes and guaiacol reduces wine fruitiness,[14] while whisky lactones can enhance it.[15,16,17]

Thus, the tannin level of wood seems to be a determining factor for the levels of extractible compounds. HTP barrels conferred the greatest concentration of compounds responsible for toasted notes. Given their lower whisky

High-tannin staves (HTP) will darken more than low-tannin staves when subjected to the same toast. Many coopers use a visual clue to decide when to stop toasting barrels, but much of the color is due to tannin rather than toasting.

WOOD AROMATIC COMPOUNDS IN MERLOT



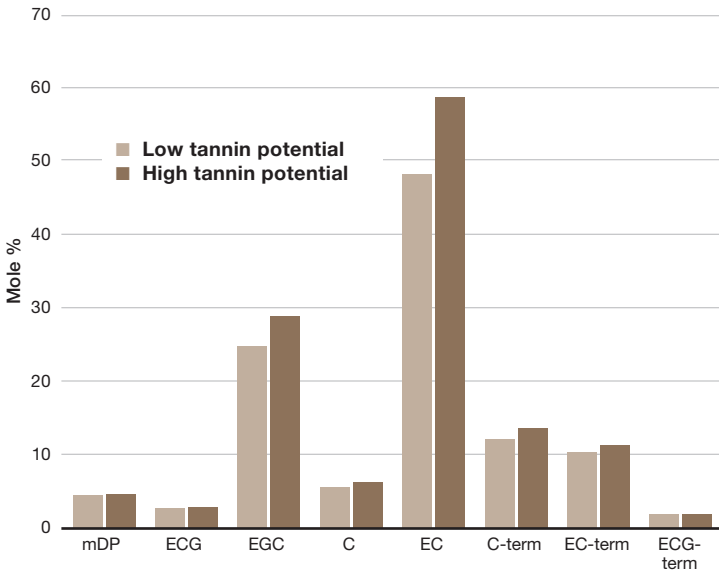
lactone concentration, this suggests that ellagitannin content may reflect other variations in wood composition such as lactones and hemicelluloses.

Regarding vanillin, no significant differences were found in Chardonnay between LTP and HTP, whereas the MTP modality exhibited a higher level in Merlot. This corroborates some previous observations made in other trials with that same TP.

Beyond its impact on wine structure and aromas, wood sorting according to tannin potential seemed to have a significant influence on preservation of grape-based tannins. (See "Tannin Composition and Concentration in Cabernet Sauvignon-Estate B" below.)

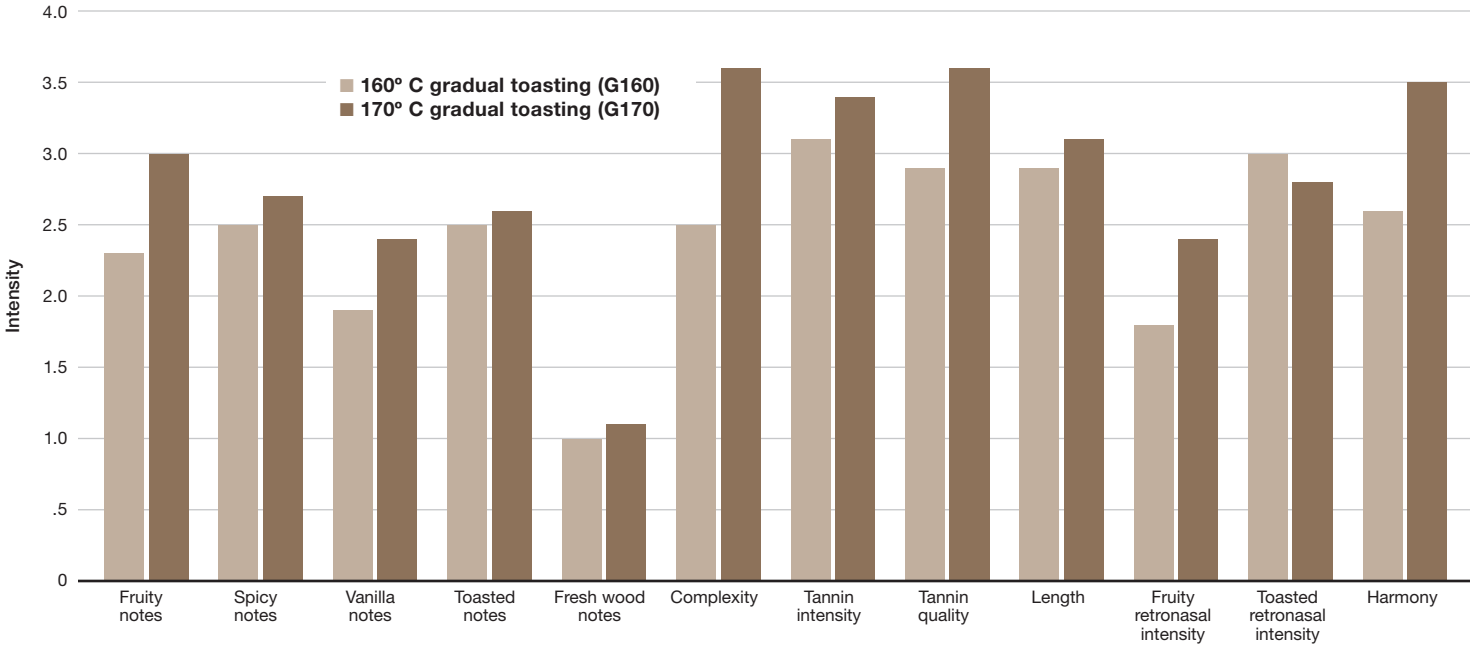
After 12 months of *élevage*, the condensed tannin concentration increased in Cabernet Sauvignon-Estate B according to tannin potential from 184.4 mg/L (LTP) to 215.3 mg/L (HTP). The mean degree of polymerization (mDP) was similar between LTP and HTP. However, the extension subunit percentage such as (-)-epigallocatechin

TANNIN COMPOSITION AND CONCENTRATION IN CABERNET SAUVIGNON-ESTATE B



mDP = mean degree of polymerization; ECG: epicatechin gallate; EGC: epigallocatechin; C: Catechin; EC: Epicatechin.

SENSORY ANALYSIS OF CABERNET SAUVIGNON-ESTATE D



and (-)-epicatechin was higher in red wine from HTP than LTP.

If it is assumed that ellagitannin in oak wood reacted with oxygen as it diffused into the wine, this could explain the observed results. Based on this hypothesis, grape-based tannins would mature more slowly in HTP barrels and barrels toasted at lower temperatures.

Impact of *élevage* with different toasting level and same TP

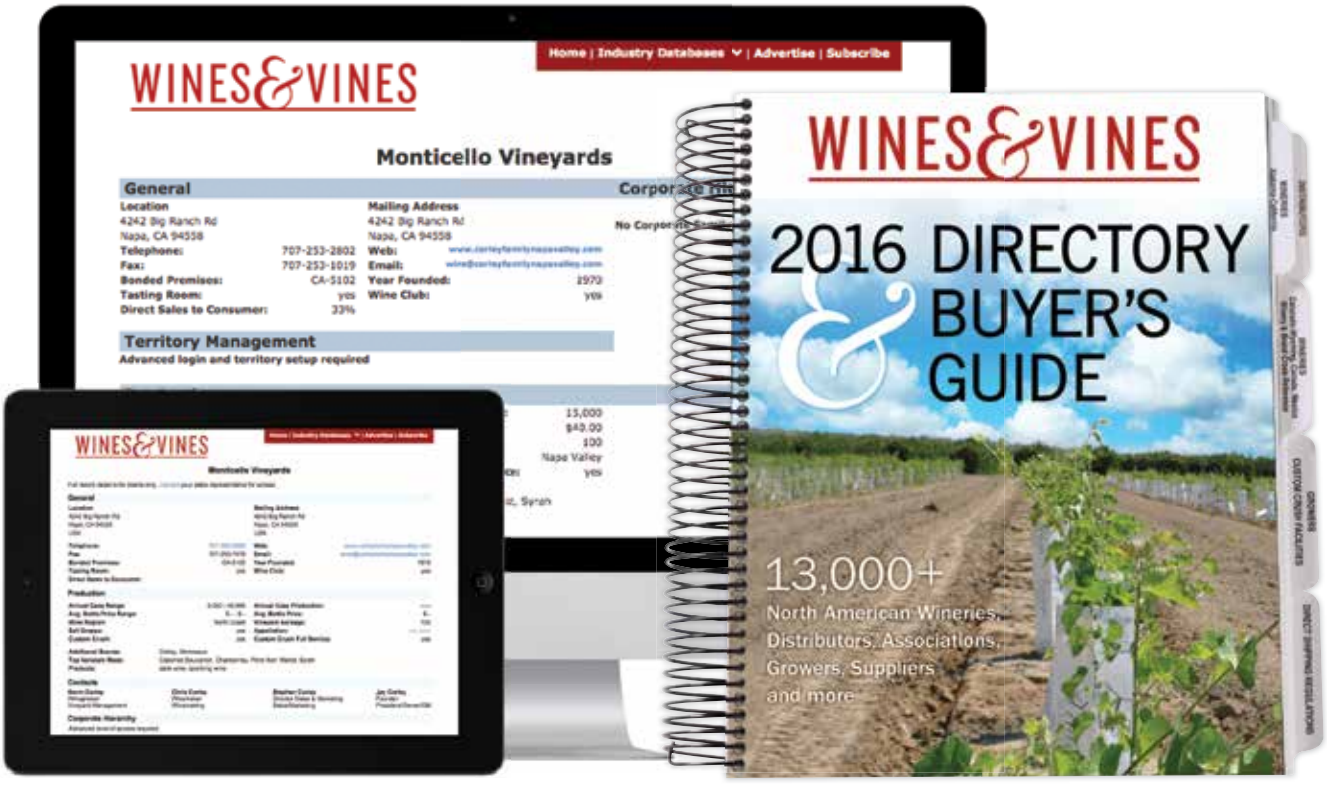
Sensory analysis after 10 months *élevage* clearly discriminated between the two samples from various criteria. (See "Sensory Analysis in Cabernet Sauvignon-Estate D on this page.)

At equal tannin potential, the

THE 2016 WINES & VINES DIRECTORY/BUYER'S GUIDE

NOW AVAILABLE IN PRINT.

Order the 2016 print directory for only $95* and you'll also get online access to the Wines & Vines Diretory/Buyer's Guide. Get the most current and comprehensive print and online guide to the wine and grape industry professionals, products and services in North America.



*Free shipping in the U.S. Rates for other countries apply.

ORDER TODAY!

winesandvines.com/order

FREE SHIPPING*

170° C gradual toasting is judged significantly more fruity and complex than the 160° C toasting. On the palate, it exhibited a better tannin quality (softness) and greater harmony.

It is important to remember there was a difference of only 10° C between the two samples. In respect of these first results, the effective management of the toasting process and selection of toasting level to each tannin potential, in order to provide homogenous and reproducible barrels, is essential.

Conclusion

The heterogeneity of oak wood composition, combined with irregular toasting protocols, can lead to substantial variation in wine perception after *élevage* to such an extent that the management of this variability constitutes a major challenge for the cooperage industry.

The originality of the Vicard Generation 7 production approach lies in the combination of a reliable sorting method based on the analysis of wood ellagitannin as well as an accurate, repro-

BARREL SUPPLIERS

Company	Phone	Website
Alain Fouquet French Cooperage Inc.	(707) 265-0996	alainfouquet.com
Artisan Barrels & Tanks Inc.	(510) 339-0170	artisanbarrels.com
Barrel Builders Inc.	(707) 963-9963	barrelbuilders.com
The Barrel Mill	(800) 201-7125	infusionspiral.com
Barrels Best The Vadai World Trade Enterprise Vadai Barrels Vadai Wine LLC	(626) 289-8250	vadaiwinebarrels.com
Barrels Unlimited Inc.	(562) 438-9901	barrelsunlimited.com
Bastos LLC	(707) 968-5008	bastosllc.com
Bayard Fox Selections	(707) 812-4554	bayardfoxselections.com
The Boswell Co.	(415) 457-3955	boswellcompany.com
Bouchard Cooperages	(707) 257-3582	bouchardcooperages.com
Brick Packaging Corp. Inc.	(866) 770-7600	brickpackaging.com
BSG Wine Division | Napa	(707) 252-2550	bsgwine.com
Canton Cooperage	(707) 836-9742	cantoncooperage.com
Carolina Wine Supply	(336) 677-6831	carolinawinesupply.com
CFP Winemakers	(412) 232-4507	cfpwinemakers.com
Charlois Cooperage USA	(707) 944-1330	charloiscooperageusa.com
Cooperages 1912 Napa	(707) 255-5900	cooperages1912.com
Demptos Napa Cooperage	(707) 257-2628	demptosusa.com
DRMre.Coop	(905) 380-4526	drmrecoop.com
East Coast Wood Barrels	(516) 430-5757	ecwbny.com
Ermitage-Berthomieu Tonnellerie	(707) 224-2377	berthomieu-ermitage.com
Flexcube – The New Cooperage	(707) 254-5418	flexcubegroup.com
GW Kent Inc.	(734) 572-1300	gwkent.com
H&A Financing and Services Corp.	(707) 523-1112	hafinancing.com
Heinrich Cooperage	(707) 738-8670	heinrich.com.au
Heritage Barrels LLC	(707) 598-3285	heritagebarrels.com
IDL Process Solutions Inc.	(604) 538-2713	idlconsulting.com
Kinnek	(800) 784-3151	kinnek.com
Laurence Cheftel Inc.	(707) 259-5344	tonnellerie-sylvain.fr
Leroi Tonnellerie	(707) 944-1330	leroibarrels.com
Louis Latour Inc.	(415) 479-4616	louislatour.com
Mel Knox Barrel Broker	(415) 751-6306	knoxbarrels.com
Mercier	(707) 321-9640	tonnellerie-mercier.com
Mio Vigneto Products	(415) 531-6450	miovigneto.com
Mistral Barrels (Chile)	(562) 460-0500	toneleria.com
miwinebarrel	(800) 727-6294	miwinebarrel.com
The Morlet Selection Inc.	(707) 967-8690	morletselection.com

ducible toasting tool matched to wood phenolic content.

The enological advantage of wood selection by tannin potential—combined with a computerized, precise toasting management—is evidenced both by sensory and chemical analysis. At exactly the same toasting level, the wine character changes according to tannin potential.

Beyond the enological interest of this innovative approach, we expect this rationalization of wood sorting will play a more important role as natural resources are more effectively utilized and the demand for a consistent product increases.

Marie-Laure Badet-Murat serves as research consultant at Œnologie by MLM in Saint-Médard-en-Jalles, France. Jean-Charles Vicard is the chairman and technical director of Vicard Generation 7 in Cognac, France. Aude Watrelot is a postdoctoral research scientist in the Department of Viticulture and Enology at California State University, Fresno, and James Kennedy is president of Polyphenolics and Concentrate, a division of Constellation Brands Inc. in Madera, Calif.

BARREL SUPPLIERS

Company	Phone	Website
Moxon Oak	(209) 224-5353	moxonoak.com
Nadalie USA	(707) 942-9301	nadalie.com
Napa Barrel Repair Shop	(707) 253-1182	napabarrelrepair.com
Napa Fermentation Supplies	(707) 255-6372	napafermentation.com
Napa Valley Barrels Inc.	(707) 246-5505	peterdunsmuir.com
Oregon Barrel Works	(503) 472-8883	oregonbarrelworks.com
Pacific Winemaking LLC	(503) 419-7942	pacificwinemaking.com
Pickering Winery Supply	(415) 474-1588	winerystuff.com
Premier Wine Cask	(800) 227-5625	premierwinecask.com
Presque Isle Wine Cellars	(814) 725-1314	piwine.com
Quality Wine Barrels Cooperage	(805) 481-4737	qualitybarrels.com
Rich Xiberta USA	(707) 795-1800	xiberta.com
Saury Tonnellerie	(707) 944-1330	saury.com
Seguin Moreau Napa Cooperage	(707) 252-3408	seguinmoreaunapa.com
StaVin Inc.	(415) 331-7849	stavin.com
Tonelería Nacional USA Inc.	(707) 996-5600	toneleria.com
Tonnellerie Bel Air	(707) 987-8905	tonnellerie-bel-air.fr
Tonnellerie Berger & Fils	(707) 266-8357	tonnellerie-berger.com
Tonnellerie Boutes	(510) 799-1518	boutes.com
Tonnellerie Cadus	33 3802 64949	tonnelleriecadus.com
Tonnellerie Garonnaise	(510) 799-1518	garonnaise.com
Tonnellerie Meyrieux	(707) 259-5344	tonnelleriemeyrieux.com
Tonnellerie Ô	(707) 752-6350	tonnellerieo.com
Tonnellerie Orion	33 0645 925458	tonnellerieorion.com
Tonnellerie Quintessence	(707) 935-3452	tonnelleriequintessence.fr
Tonnellerie Radoux USA	(707) 284-2888	radouxcooperage.com
Tonnellerie Remond	(707) 935-2176	
Tonnellerie Rousseau	33 0380 523028	tonnellerie-rousseau.com
Tonnellerie Saint Martin North American	(805) 226-5622	tonnelleriesaintmartin.com
Tonnellerie Sansaud USA	(707) 666-2946	sansaud-usa.com
Tonnellerie Sirugue	(310) 403-8398	sirugueusa.com
Tonnellerie Sylvain	(707) 259-5344	tonnellerie-sylvain.fr
Tonnellerie Taransaud	(415) 549-7333	taransaud.com
Trust International Corp.	(561) 540-4043	barrelmakers.com
TW Boswell	(707) 255-5900	twboswell.com
Vicard Generation 7	(707) 228-5982	vicardg7.com
World Cooperage	(707) 255-5900	worldcooperage.com

For more information about the suppliers listed above, visit winesandvines.com/buyersguide or see *Wines & Vines*' 2016 Buyer's Guide.