Impact of Oak Tannin on Red Wines

Trial at first-growth château examines effects of geographic origin, grain and tannin on sensory profile

By Marie-Laure Badet-Murat, Fréderic Desamais and Jean-Charles Vicard

For many years, the cooperage industry developed tools to select and classify oak with the goal of ensuring quality, precision and reproducibility in their barrels. Selection on the basis of geographic origin dates back to the early 19th century.[1,2]

Selection according to morphological criteria such as the width of growth rings (grain), closely linked to forestry management methods and botanical species, was first applied about 50 years ago.[3,4,5,6] In recent years, the market for fine-grain oak has grown dramatically. Some forests are so sought after that sourcing has become difficult, which in the long term could lead to the total depletion of large-diameter (60-80 cm) fine-grain wood resources.

The challenge for winemakers is to obtain barrels of known, homogeneous, reproducible quality. Therefore, it is necessary for cooperages to control the concentration of extractable compounds in oak.

Recent extensive research in the variability of the chemical composition of oak has highlighted an alternative selection criterion. Indeed, while selection by forest and/or grain is useful for controlling barrel quality, it does not reflect the tremendous variations in composition, both on an inter-[7,8,9,10,11,12] and intra-individual level.[11,13,14,15]

Barrel quality control and reproducibility are key concerns for winemakers, as barrel aging forms an integral part of each wine's distinctive signature, and the choice of barrels can result in significant changes in a wine's sensory profile. For example, one experiment on four lots of 10 barrels revealed that a single barrel was capable of inducing a 50% variation in concentrations of major volatile compounds from oak in the final blend.[16]

Given this new data, the challenge for winemakers is to obtain barrels of known, homogeneous, reproducible quality. Therefore, it is necessary for the cooperages to control the concentration of extractable compounds in oak. In 2009, Groupe Vicard launched a research program aimed at controlling variability factors during barrel making.

This research led to the development of a specific range (Vicard Generation 7) based on wood selected according to its ellagitannin content.[12] Ellagitannins represent the majority of extractable compounds and contribute significantly to variations in composition and quality during *élevage*.[17,18,19,20] Analysis using near-infrared spectrometry identified three main classes of tannin potential corresponding to distinct ellagitannin contents in untoasted wood.

This analytical approach to wood selection was accompanied by other innovations aimed at controlling the factors responsible for variability in cooperage: scarification of the staves (blister-free process consisting of micro-slits to allow water locked in the wood to escape naturally during the toasting process), short, automated steam-bending, and a unique process for toasting not previously used in cooperage. Toasting using radiant heat in a fully automated and computer-controlled, closed system guarantees homogeneity, reproducibility and precision.[12]

This system also makes it possible to adjust toasting according to the tannin level of the oak. Because thermal degradation of ellagitannins varies according to toasting time and temperature,[9,21] it is necessary to adapt toasting parameters to different tannin potentials. This is a fundamental aspect of this approach, because without complete control of the toasting process, the upstream classification of oak on the basis of its tannin content would be meaningless.

Combining this new oak selection and classification criterion with the toasting system described above produces barrels with known, homogeneous, reproducible tannin levels and has opened up avenues for further research.

What follows are the results of an experiment made from a single estate in two different vintages, with the objective to study the impact of geographic origin within French oak forests as well as grain width and potential tannin level of oak used in barrel making on the sensory profiles of red wines.

The results indicated for barrels with the same geographic origin and grain width, a considerable variation of major oak aromatic compounds was attributable to the tannin potential of the wood, which in turn had a significant impact on the sensory profile. With this new analytical method of oak stave selection and classification, winemakers are assured greater consistency and uniformity. However, this selection criterion must be combined with an automated toasting process capable of controlling thermal degradation of the oak tannin to achieve consistent and reproducible results.

Two-year trials in a Bordeaux first-growth château

The trial was conducted using Bordeaux barrels at a first-growth chateau in France's Pauillac appellation during the 2013 and 2014 vintages of the estate's flagship wine (majority Cabernet Sauvignon). For both years, the same wine was put into different trial barrels after malolactic fermentation (January after the harvest), and each trial was duplicated. The experiment included 16 barrels (3,600 liters) in 2013 and 32 barrels (7,200 liters) in 2014. *Élevage* was conducted according to the château's usual procedure, including racking and returning to the same barrel every three months.

Wine from each barrel was analyzed after 15 months of *élevage*, following fining with egg white and removal of sediment. Wines from duplicate barrels were blended in equal quantities for sensory analysis.

GEOGRAPHIC ORIGIN OF OAK STAVES USED

2013 Trial: Fontainbleau, Loches, Tronçais and Orléans forests

2014 Trial: Bercé, Darney, Loches and Tronçais forests

Geographic origin of the wood and experimental parameters

The Vicard Group's wood buyer was responsible for ensuring traceability. The trees were felled in winter, when the sap level was low. Stave wood for barrel production was selected after 30 months of natural seasoning at the Vicard Cooperage woodlot in Cognac.

The 2014 trial involved logs from the Bercé forest.

Every barrel in each protocol was built by assembling wood from 30 trees, using one stave per tree for the body. The two heads were built from 14 pieces, each taken from a different tree from among the 30 sourced for the staves.

For the 2013 vintage trial, a ranking by tannin potential (TP) was performed for six geographic origins. For the 2014 vintage trial, the barrels were initially sorted by grain and then ranked by TP.

Sorting by grain and tannin

Two types of grain were selected: fine grain (f) and medium grain (m), corresponding to growth rings less than 2 mm wide and between 2 and 3 mm, respectively. The oak was sorted by grain prior to TP analysis.

After machining, the untoasted staves were analyzed by near-infrared spectrometry using an acousto-optic tunable filter crystal detection system. Only two TP levels were selected for the experiment: low TP (LTP), or less than 4,000 μg/g, and high TP (HTP), between 6,000 and 8,000 μg/g (values expressed in μg ellagic acid equivalent/g dry wood).

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Oak toasting method: concept of molecular cooking

The patented Vicard toasting system has a steam chamber to bend the staves into a barrel shape in four minutes without changing the chemical composition of the staves, plus a separate closed, radiant-heat toasting chamber controlled by computer to within +/- 3° C. An infra-red probe measures the temperature on the inside of the barrel during toasting (see "Innovative Tools for Stave Selection and Toasting" in the February 2016 issue of *Wines & Vines*).

In addition to its precision and total reproducibility, this technology made it possible to develop innovative toasting profiles including gradual toasting, in which the temperature is gradually increased in four stages. This unique profile modulates the temperatures that affect the formation, development and degradation of various aromatic compounds in the oak.

All barrels used for both vintages in this research had exactly the same toasting profile (gradual toasting).

Chemical and sensory analysis of the wines

The major aromatic compounds extracted from oak in each type of barrel used in both trials were assayed by stir bar absorption extraction/gas chromatography/mass spectrometry and liquid chromatography/mass spectrometry.

The château's technical personnel conducted a blind sensory analysis of the 2014 vintage wines. The panel evaluated the following criteria on a six-point scale (from 0 = absent to 5 = maximum intensity), with olfactory: overall aromatic intensity and descriptors related to the contribution of the oak; flavor: balance, tannin quality and length, and an overall quality assessment. Analysis of variance was used to detect any significant differences that emerged from the sensory analysis.

Impact of geographic origin, grain and tannin levels on chemical composition of wines

For both vintages, when the concentrations of major oak aromatic compounds found in the wines after *élevage* were grouped according to wood origin, no statistically significant difference was

detected between six geographic origins, while there were tremendous variations within each forest. Only wines aged in barrels from Darney forest (vintage 2014) contained noticeably higher concentrations of furanic aldehydes and guaiacol, but lower concentrations of *cis*-whisky lactone.

Grouping concentrations of major aromatic compounds from oak according to grain only produced a small effect. Once again, variation within both types of grain was higher compared to variation between the two grain widths.

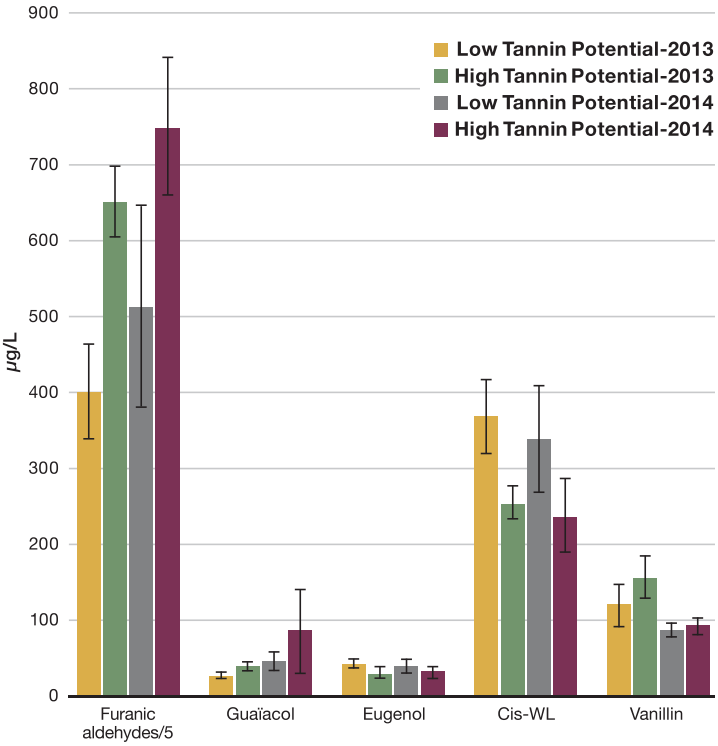
The only factor that clearly discriminated among concentrations of certain major aromatic compounds in wine was the TP of oak (see "Impact of Tannin Potential" below). For both vintages studied, wines aged in HTP (high tannin potential) barrels contained significantly higher concentrations of furanic aldehydes, while the wines aged in LTP (low tannin potential) barrels had a higher *cis*-whisky lactone content. Other differences identified were not consistent in both vintages: higher guaiacol concentrations for 2014 wines aged in HTP barrels; higher vanillin for 2013 wines aged in HTP barrels.

A wine aged in wood from the same forest with the same grain may have a different aromatic content, depending on the tannin level of the oak. It is important to note that the differences observed cannot be attributed to toasting levels because under the experimental conditions, all barrels were toasted using the Vicard system, which produced an identical toasting profile for all barrels (+/-3° C for an initial temperature of 170° C).

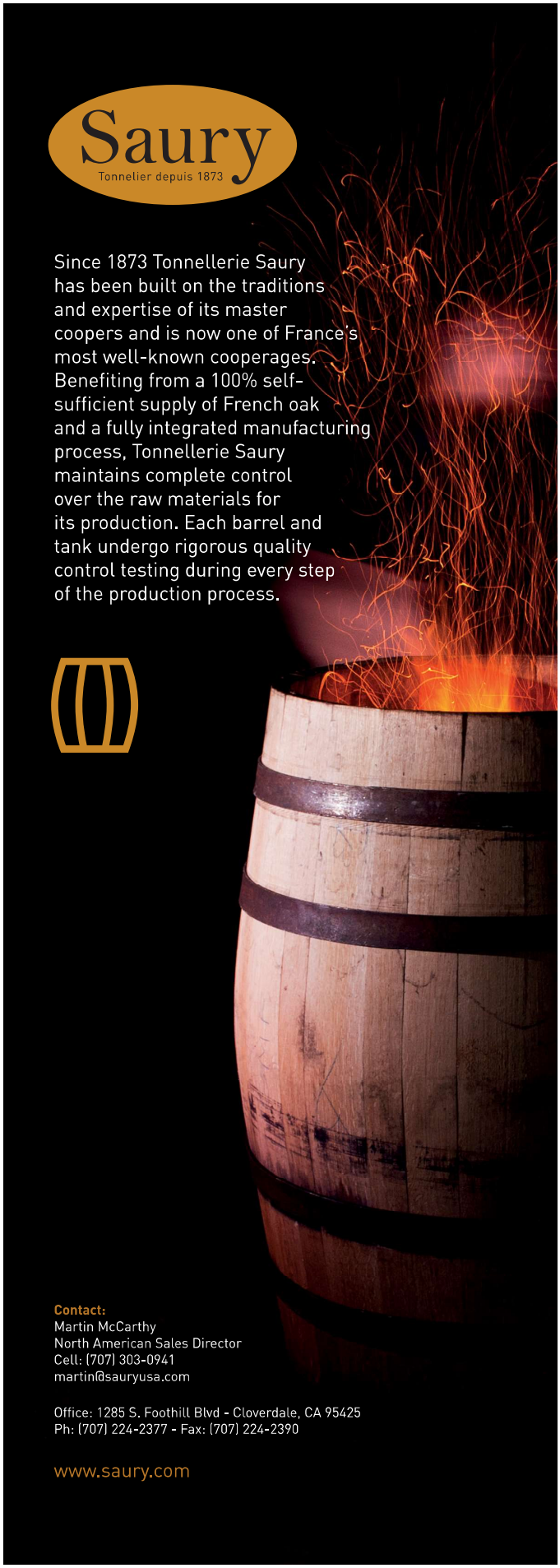
This confirmed the major aromatic impact of TP selection highlighted in recent research.[11,12] These results further revealed other variations in the oak's composition, which indicate the tannin levels correlated with the level of lactones, lignins and hemicelluloses. During the toasting process (thermal degradation), vanillin is released from lignins and furanic aldehydes from hemicelluloses. Both lignins and hemicelluloses are non-extractable compounds.

Geographic origin alone was not a discriminating factor, as already determined in previous

IMPACT OF TANNIN POTENTIAL



Concentrations of aromatic compounds varied based on what level of tannin potential the oak barrels had before being used to age wines.



DISTRIBUTION OF TANNIN POTENTIAL BY GRAIN SIZE

	Low TP	Medium TP	High TP
Fine grain	69%	17%	14%
Medium grain	17%	33%	50%

TP stands for tannin potential.

research.[7,11,15,22] By contrast, the absence of a significant "grain" effect was more surprising, and to understand this, it was necessary to examine the TP distribution in each type of grain. In "Distribution of Tannin Potential by Grain Size" (above), 14% of the fine-grain oak usually associated with LTP was actually HTP, while 17% of the medium-grain oak (usually associated with HTP) was LTP. Thus, under our research conditions, "atypical" wood (fine-grain with high tannin levels and medium-grain with low tannin levels) negated the differences between the two grain widths.

Impact of geographic origin, grain and tannin levels on sensory profile

Sensory analysis of the 2014 vintage trial wines clearly discriminated among the samples on the basis of aromatic criteria. Independent of the geographic origin and grain, wines aged in HTP barrels exhibited significantly more intense empyreumatic notes related to toasted register (toast, caramel, coffee and chocolate), nuances and correspondingly less marked fruity aromas.

However, aging in LTP barrels gave a more intensely fruity aromatic character with more discreet empyreumatic notes. (See "Sensory Analysis: Intensity of Empyreumatic and Fruity Notes" on page 47.) In other words, the sensory profiles of wine aged in oak from the same forest with the same grain differed significantly, depending on the tannin level of the oak.

For example, this was the case of the Tr-HTP-f protocol, which had one of the most markedly empyreumatic characters compared to Tr-LTP-f, which was radically different with more intense fruity aromas. These differences in fruity perception between the two TP levels were due to their chemical composition. The higher furanic aldehyde content of wines aged in HTP barrels diminished their fruity characters,[23] whereas the whisky lactones enhanced the fruity impression to varying extents, depending on the balance between the concentrations of these compounds and the molecules responsible for fruity aromas in the wine itself.[24,25,26]

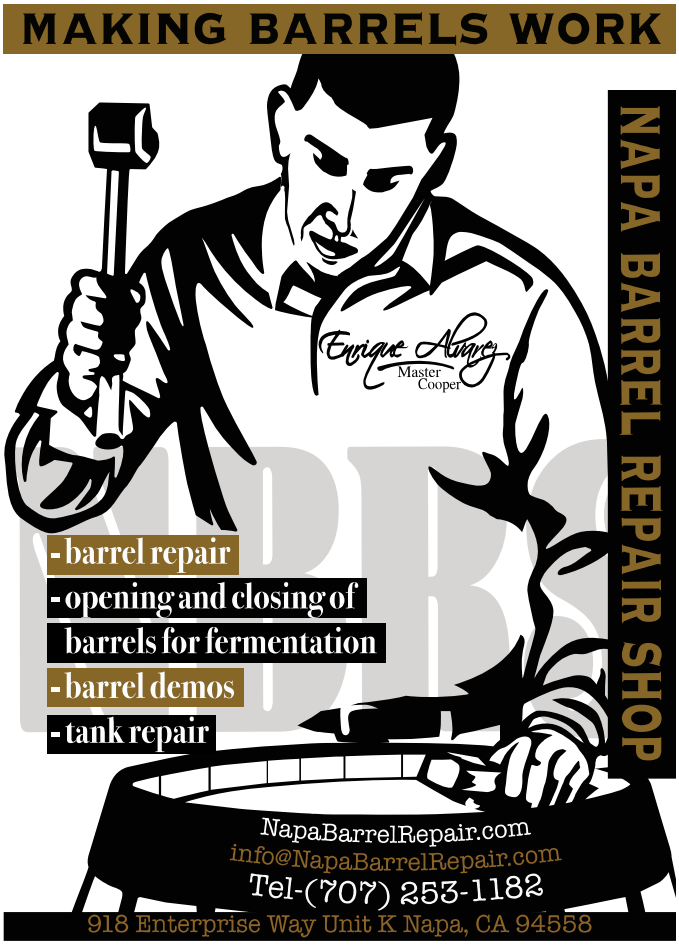
In agreement with the chemical analysis results, the tannin level of the oak was apparently a more discriminating factor for sensory qualities than simply geographic origin or grain.

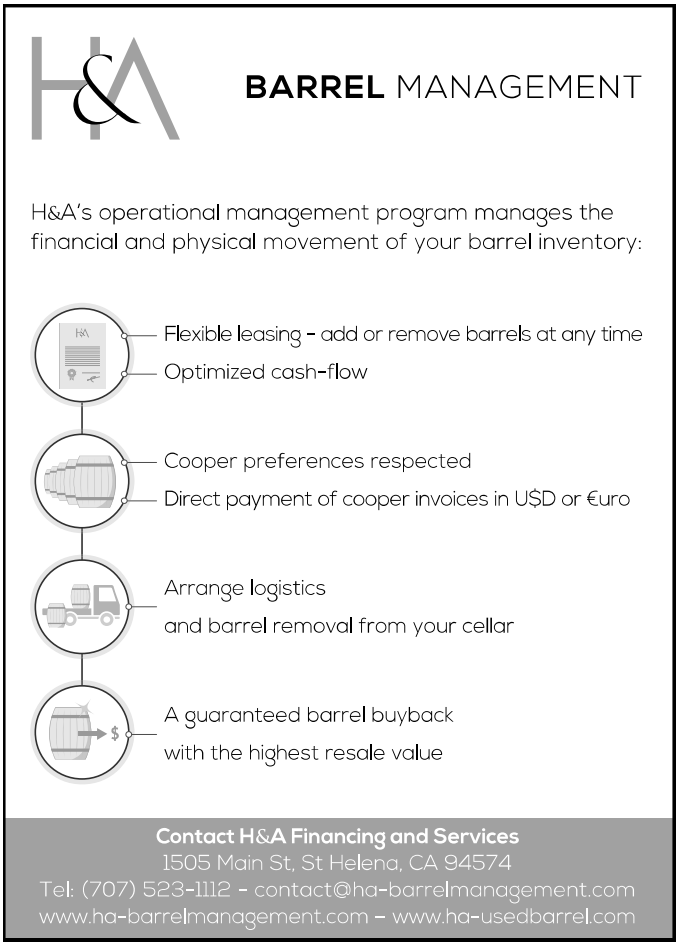
Among the other criteria assessed during the sensory analysis, only the overall assessment of the wines identified marked differences between the different series of barrels. However, these differences were not statistically significant. It is, nevertheless, interesting to note that the panel tended to prefer wines with less obvious empyreumatic character such as Be-LTP-f and Lo-LTP-m.

Wood selection by tannin potential has the strongest impact on wine sensory profile

The objective of this research was to assess the impact of geographic origin, grain and tannin levels of oak wood used in cooperage on the sensory profile of red wines. The results indicated that for barrels with the same geographic origin and grain width, a considerable variation of major oak aromatic compounds was attributable to the tannin potential of the wood.

This new analytical method of oak selection and classification offers the possibility of better exploiting the natural variability of oak and thus assuring precision and repeatability. This





is not the only decisive parameter: It must be combined with an automated toasting process capable of controlling the thermal degradation of oak tannin. The combination of these cutting-edge technologies constitutes a crucial tool for adapting *élevage* to the specificity of each wine and winemaker goals.

In addition to its implications for winemaking, this new approach will contribute to a more rational management of forestry resources in the future.

Thanks to the trial, the château has increased its knowledge regarding what barrel style contributes to a final blend. Trials continue at the château, especially those focused on how to match barrel style to grape ripeness.

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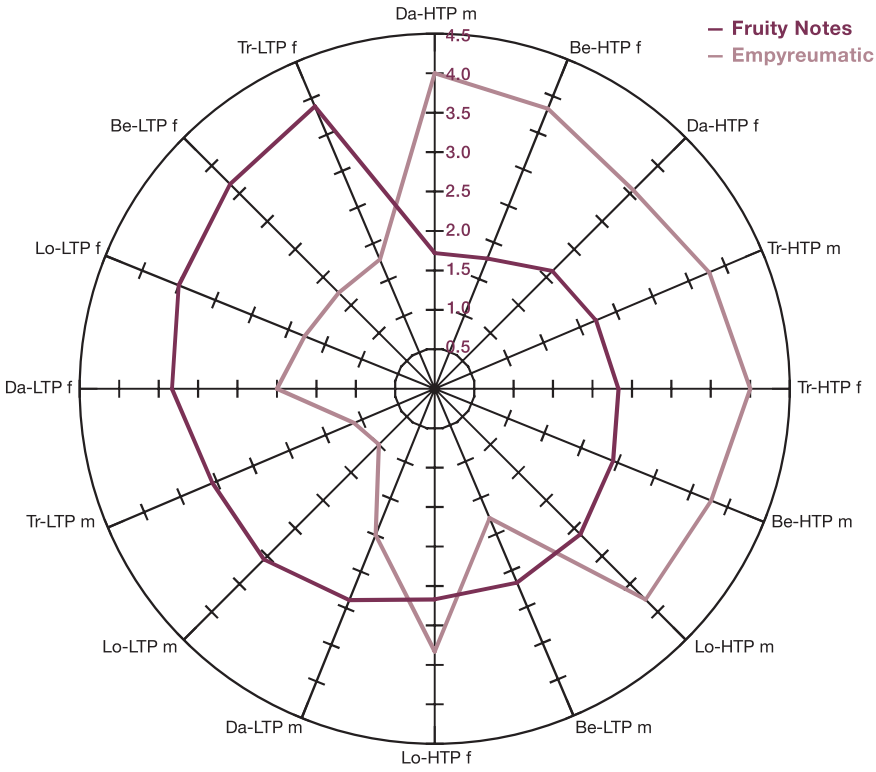
The references for this article are available online at winesandvines.com

SENSORY ANALYSIS: INTENSITY OF EMPYREUMATIC AND FRUITY NOTES



Tr: Tronçais; Be: Bercé; Lo: Loches; Da: Darney. HTP: high tannin potential; LTP: low tannin potential. m: medium grain; f: fine grain.