TONG

— ABOUT WINE —

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OAK

FROM TREE TO BAR- REL

BY DOMINIQUE DE BEAUREGARD / FRANCE

It's an interesting experience to taste the same wine aged in oak and in stainless steel. The difference can be enormous! Richness, body and complexity for the barrel sample… if the barrel is of top quality and the ageing methods have been applied with skill and experience.

Wine and oak marriages come in all shapes and sizes. They can be intimate, harmonious, effusive or low-key and in a variety of shades. Is there such a thing as the perfect wine-oak combination? No, there isn't, but we oenologists can repeatedly describe and analyse what works.

An oenologist based in Bordeaux, Dominique de Beauregard was a winemaker for châteaux Rausan-Ségla and Smith-Haut-Lafite. He also worked on organic farming procedures and was a consultant for estates in Bordeaux, Bergerac and Algeria. He is now in charge of the Research and Development Centre of the Chêne & Cie group, an organisation of French, Hungarian and American cooperages, including Cognac-based Tonnellerie Taransaud.

The art of cooperage starts in the forests with the selection, purchase and reception of trees and logs. The logs are then split into staves. Some cooperages buy ready-made staves from a stave mill. These are stacked outside for seasoning – for more than two years if the natural process is respected. During cooperage itself, the staves and heads are shortened, pared and jointed; the staves are then assembled to form the barrel and heating and toasting follows. The finishing includes leakage control, polishing, marking, quality control, packaging and finally shipment.

When selecting a barrel, a winemaker must consider its species and country of origin, the wood's seasoning and toasting methods.

BARREL BENEFITS

Spirits like cognac, whisky, calvados and brandy are aged in oak barrels. With wine, barrels are used during alcoholic fermentation, malolactic fermentation and ageing. In French, the word for ageing is "élevage", which means "raising" as in children or animals. In other words, barrel wine is encouraged to express its personality and full potential. Barrels used to be a way of transporting wine from one place to another. Today, they are more about bringing a wine from one state to another, with the final destination always an improvement on the departure point. Top-quality wines aged over many months or years in new oak barrels are not identified with a barrel taste,

but with a general impression of fruit, body and complexity. Barrel ageing is much more than adding oak flavours and oxygen.
A barrel's role is "to enrich the wine with new compounds", "to act as an interface between the wine and the environment", or "to allow specific physical reactions to occur". This can be partly analysed in a laboratory and described. But how barrels reveal the potential of great wines involves a process respectful of their nature.

Time, duration and seasons are key. Wine ageing cannot be accelerated or artificially shortened. It has to be done in respect of years and vintages.

The first benefit of barrel ageing is the production of a more complex and richer wine. Oak transfers many aromas and tannins dissolved in the water and alcohol. The wine structure will be softer, less astringent and bitter. The colour will be stabilised and eventually more intense than the original wine colour in the vat. Clarification is better and faster. If alcoholic fermentation occurs in barrels, this allows for better "integration", in other words a more intimate "marriage" of wine and oak sensations. New aromas will appear, and the fruit will be enhanced. Malolactic fermentation in barrels allows the wine to be more pleasant sooner (a technique often used in Bordeaux for Primeur tastings). Some of the oak compounds such as vanillin can be extracted from oak lignin thanks to the microorganisms involved in winemaking.

All mechanical, physical and chemical constraints that are applied to each stave of a barrel require almost perfect wood. This is why logs need straight, tight grain and no knots or pin knots. The colour has to be clear and homogenous.
This high-grade wood is usually found in a small amount of even-aged forests where trees are growing slowly. Only a small part of the volume produced can actually be used for barrel making; usually the first logs of the best trees meet such requirements.
In France, this represents 10% of harvested oak wood timber.
Later, during the various production stages (splitting, sawing, grading…), staves with defects are also eliminated.

As an interface between wine and the environment, the barrel is unique. It is like a membrane, with its characteristics of porosity, adsorption, and specific reactions on the surface. Oak is permeable. Wine, which is mainly made up by water and alcohol, slowly evaporates while air enters. The airflow is immediately absorbed and consumed by the wine. This is why after some weeks, a wine barrel hermetically sealed with a bung will slowly lose wine and endure negative pressure. Wine concentrates during ageing.

Oak and the environment both influence the quality of wine. The barrel is an element in a complex system. The human factor plays the leading role: frequency and methods of topping up and racking, adding sulphur, stirring the lees, bung on the side or on the top, etc. The cellar conditions must also be considered – cold or warm, fresh or dry, quiet or air-conditioned, non-renewed or constantly regenerated air, and so on.

All these aspects need to be considered when choosing a barrel. Not only are they air-porous vessels that provide aromas and tannins, but they do more than that: wine breathes, develops and matures. How the barrel is used is crucial. With the same tool, you can obtain very different results.

WOOD PROPERTIES

Oak wood is used to make barrels because it has so many favourable properties. Oak wood is resistant and can be bent without breaking. It is watertight but slightly porous, allowing slow oxidation. Its compounds interact with the wine.

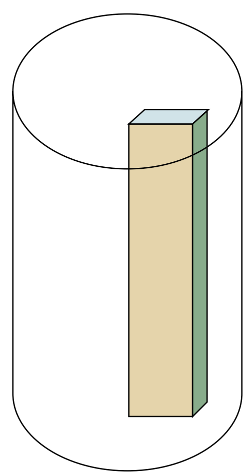

Diagram representing the shape of a future stave in a piece of log

THE FLA-VOUR OF OAK AND ITS IMPACT ON WINE

BY NICOLAS VIVAS / FRANCE

The use of wood for the maturation of fine wines is an ancestral practice, and one of the rare production criteria common to all exceptional wines. Oak, which is used for making barrels, has various properties that profoundly modify a wine's composition and quality.

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One of the most identifiable modifications is aroma; wood provides wine with complex and varied odorous substances, some of which have a preponderant organoleptic impact.

But oak maturation is more than just flavouring. Successful ageing in oak barrels produces discreet woody aromas that are well integrated into the wine. The final impression should be one of consistency and continuity, rather than an awareness of the different elements that compose it: grapes, wine and wood. This is the prime goal of a one-to-two year process, and the main focus of an oenologist's efforts.

Wood has a direct effect on the odour of wine, through its aromatic substances and those revealed during the natural drying process. The impact of these substances is modest, however, when seen within the wine's entire aromatic picture. It is during toasting – an indispensable stage in barrel making – that the wood's aromatic diversity and strength express themselves. Thus, when we speak of an oaky wine, we should speak instead of a wine marked by toasting flavours.

OAK FLAVOURS

Fresh oak has a faint fragrance evoking coconut and vanilla, sometimes with a hint of cloves. The chemical structures responsible for these aromas are represented in figure 1. The concentration of substances varies according to the species of oak and the speed at which it grew. The American *Quercus alba* is much more aromatic than the European species, among which *Quercus petraea* is richer in aromas than *Quercus robur* (table 1).

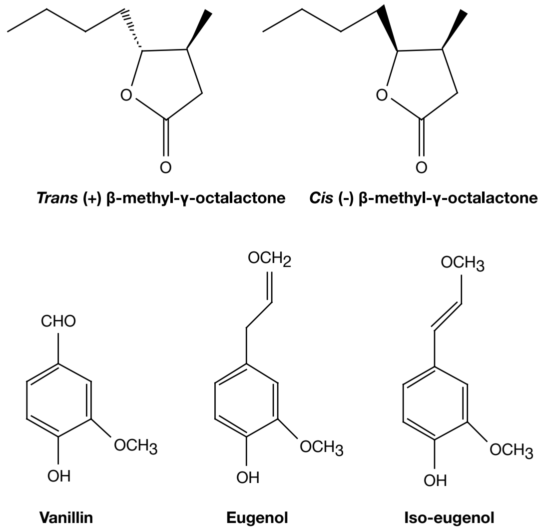

Fig. 1. The main compounds responsible for fresh oak aromas. Methyl-octalactone *cis* and *trans*: coconut, fresh oak; vanillin, vanilla; eugenol and i-eugenol, cloves.

	Q. petraea	*Q. robur*	*Q. alba*
β-methyl-γ-octalactone	80 ±12	5,5 ±3,1	228 ±63,8
Eugenol	11,5 ±3,4	1,1 ±0,6	17,5 ±6,2
Vanillin	9 ±4,3	7 ±3,6	17,5 ±6,2

Table 1. Comparison of aromatic content of the main oak species used for barrel making. *Q. petraea* and *Q. robur* from french forests and *Q. alba* from Missouri (USA) (Results represent the average of 180 samples for each species and are expressed in µg/g of dried wood).

Within this classification, we often observe that trees that grow slowly are richer in odorous substances than those that grow rapidly. The aroma of fresh oak is relatively simple; 60%-70% of its aromatic intensity coming from isomers of methyl-octalactone (wood flavour) and eugenol (cloves). Vanillin has a secondary impact. The *cis* isomer of methyl-octalactone has an aromatic capacity three to five times stronger than the *trans* isomer.

During the natural drying process wood apparently becomes more fragrant. It is amusing to observe that after one or two years of drying, wood has a fresh oak odour more intense than when the tree was felled or split for making staves. Natural drying acts as an aromatic enhancer. Analysis of wood samples explains this phenomenon (table 2). We see a more or less significant increase in the amount of eugenol and vanillin, but it is mainly the evolution of methyl-octalactone that explains the odorous intensification of the wood.

	Q. petraea			*Q. alba*		
	F[1]	SN[2]	SA[3]	F[1]	SN[2]	SA[3]
β-methyl-γ-octalactone						
cis	12	93	33	2	16	3
trans	78	21	62	4	7	7
cis + trans	90	114	95	6	23	5
cis/trans ratio	0.15	4.42	0.53	0.5	2.28	0.42
Eugenol	8	15	7	0,6	2,4	1
Vanillin	6	47	11	2	34	7

[1] immediate analysis; [2] analysis after 24 months; [3] analysis after 6 months.

Table 2. Influence of natural air drying, kiln drying and fresh wood on the main flavor components of *Q. petraea* an *Q. robur* wood *(F, Fresh wood; SN & SA, Natural and kiln drying).*

Even if the amounts of methyl-octalactone don't increase, the proportion of *trans* isomers slowly evolves towards a higher proportion of *cis* isomers in the wood. The *cis/trans* ratio goes from a value of less than 1 (0.1 to 0.5), on fresh or artificially dried wood, to a ratio well above 1 (2 to 4.5) after natural drying. As a result, the fresh oak aroma intensifies.

It is not surprising that oak has woody aromas, but it is that it has fruity or floral ones. During a study of the aromatic profiles of wood samples from Eastern Europe, we were surprised to note some samples with fruity or vegetal nuances (tea and tobacco odours) that aren't usually used to describe oak wood essence. The experiment was repeated on French oak samples and revealed, again on a few of the samples, the same olfactory characteristics. In addition, these fruity/vegetal notes were produced when the wood was pinkish in colour. Indeed, the colour of the duramen in oak is essentially linked to lignins (binding material that keeps cellulose together) and oxidised, polymerised forms of ellagitannins (wood tannins). The colour is yellow/brown.

Occasionally the wood has clear pink chromatic hues, and we discovered that these pinkish coloured oak samples contain the same carotenoids as those in ripe grape skins: b-carotene and lutein. We know that these substances are broken down by oxidation, heat or light resulting in substances with a fruity fragrance, namely norisoprenoids (figure 2). It is in this way that suitably selected oak is likely to intensify fruity nuances in wine.

WINE IN THE BARREL

BY WESSEL DU TOIT / SOUTH AFRICA

Winemaking has long been considered an art. Now new technological developments are enabling scientists to understand the science behind the art. This is also true about ageing in oak barrels.

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Oak and oak barrels are a subject as diverse and complex as viticulture and oenology, and they play an integral part in how wines mature. This article looks at how a wine's stability, colour, flavour and taste are affected by contact with the barrel.

My main focus isn't oak, but how wines ferment, mature and develop in oak barrels. In order to understand this, we need to know about the basic composition of oak. Flavours in wines matured or fermented in oak barrels frequently evoke vanilla, coconut and caramel; they can be spicy, woody, smoky or savoury. An oak's species and origin, how long its staves were seasoned, how the cooper did his toasting, all these factors affect the oak and the wine's composition (see Dominique de Beauregard's article).

In general, toasting increases the volatile compounds in wood and wine. American oak is assumed to have more flavour compounds than French oak, although the opposite is also argued. French oak tends to contain more tannins. Oak volatile composition can be very complex, with some compounds playing more important roles than others. Lactones in oak give a typical woody, coconut or vanilla character, while vanillin gives a vanilla flavour. Eugenol is partly responsible for the spicy, clove-like aroma of some wines, while guaiacol and 4-methyl-guaiacol can impart smoky, toasty notes. Caramel-like flavours are thought to be mostly caused by furfural, cycloten and maltol, while a coffee and chocolate character is often due to furfuralthiol (see Nicolas Vivas' article).

Barrels or oak wood can sometimes give a wine less pleasant aromas, like the plank-like or dusty aroma caused by 2-nonenal, as well as medicinal and horse sweat flavours. The latter aren't directly caused by the oak, but by the spoilage yeast *Brettanomyces*, which can produce volatile phenols in oak barrels that haven't been properly cleaned.

Oak barrels have long been used to store wine. They're strong, durable and easy to roll; the spherical shape offers the largest volume-to-surface ratio. Wine can be fermented and/or matured in oak barrels, although alcoholic fermentation is rarely done with red wines because the bunghole is usually too small, thereby limiting access. During red wine fermentation, the skins must be mixed at regular intervals with the must to extract colour and tannins, something difficult to achieve with the 225- and 300-litre barrels often used in wineries. In the case of some wines, the barrelhead is removed to place the barrel upright, thus allowing easier access to the skins and must. Other larger barrels are used for fermentation; the barrelhead is removed, replaced and the barrel put on a stand that allows it to rotate so the skins and must can be mixed regularly. Barrels of a few thousand litres are sometimes used to ferment red wine, but it can be difficult to clean them of leftover grape skins and potassium bitartrate crystals. In some countries, red wines are fermented with oak staves to produce strong aromas of coffee and chocolate. These wines are popular in certain markets, although the flavours can mask the wine's natural fruit. Oak barrels are an integral part of ageing red wines, but I'll address this issue further on.

Winemakers ferment white wines in oak barrels more frequently than reds, often to produce full-bodied Chardonnay and some Chenin Blanc, Viognier, Semillon, Sauvignon Blanc and Muscat wines. The grapes are crushed, the juice settles and is then pumped into barrels. Some winemakers like to start fermentation in the barrel, while others prefer to transfer it into the barrels once fermentation has started. New barrels are often used to ferment white wines; they are then used again for red wine maturation. During alcoholic fermentation, glucose and fructose – the two main types of sugar in grape must – are transformed into ethyl alcohol, carbon dioxide and heat (although yeast produces a myriad of other compounds as well). The carbon dioxide needs to escape and for this an airlock is used that also limits the amount of air that enters the wine. White wines are usually fermented at around 12-18°C, depending on how ripe the grapes are and what style of wine is wanted. In general at these temperatures, yeast produces esters that give white wines their fruity aromas. White fermentations need to be regularly cooled down, usually with cooling jackets in stainless steel tanks. This is harder to achieve with barrel fermentation. The barrels are usually stored in an air-conditioned room, and the yeast that is used is one that doesn't ferment too quick to give the winemaker some control over the process. There are special yeast strains on the market for white wine barrel fermentations.

White wines fermented in barrels and left on the yeast lees after alcoholic fermentation do not have the same intense oak-derived flavours as the same wine pumped into the barrel after fermentation. The reason for this is probably the microbial activity of the lees that transforms some oak-derived flavour compounds; vanillin, for instance, can be transformed into the less aromatic vanillic acid. White barrel wines are often left in contact with the yeast lees for periods ranging from a few weeks to 12 months. One reason for this is that yeast lees are an effective scavenger of oxygen, and thus reduce the risk of a wine's oxidation. This is an essential asset; winemakers don't want to add too much sulphur dioxide just after alcoholic fermentation, when the wine is susceptible to oxidation and doesn't yet have the anti-oxidative protection of carbon dioxide produced during malolactic fermentation. Adding too much sulphur dioxide just after alcoholic fermentation inhibits malolactic fermentation and can also lead to the formation of unwanted reductive sulphur compounds.

The yeast lees thus protect the wine, but they need to be mixed with the must regularly. This process, known as "batonnage", is performed with a tool that resembles a hockey stick; it is inserted through the bunghole to stir the lees. Another method is simply to roll the barrel (the winemaker must remember to close the bunghole tightly!).

TRICKS OF THE TRADE

BY ANDRÉ RAWYLER / SWITZERLAND

I'll be taking an unconventional approach in this article. I will consider the why rather than the how, in the hope that this will help practitioners and consumers better understand the different uses of oak wood formats in winemaking.

ANDRÉ RAWYLER

OAK CHIPS, STAVES AND POWDERS

André Rawyler obtained his Ph.D. in plant physiology in 1980. Among other subjects, he has worked on biological membranes in yeast. He now specialises in wood-wine interactions with barrels and oak alternatives and in wine polyphenols. A teacher of wine chemistry and laboratory practices, he coaches bachelor and master students at the Ecole d'Ingénieurs de Changins in Nyon, Switzerland.

Indeed, three recent articles by Pascal Chatonnet (See Sources 1-3) already provide excellent coverage of modern oak alternatives and their use in winemaking. I will consider the why rather than the how. Why write about wood in a wine publication?
The answer is obvious: wood is about packaging. The Bible tells us that wine was among the first discoveries of post-diluvian man. The first materials used in the manufacturing of bowls, jars and amphoras were stone and terra cotta. However, because of its abundance, workability and strength, wood soon became the material of choice for wine storage. The oldest wood barrels can be traced back to the Etruscans (5th century BC), but we owe to the Gauls the development of oak barrel manufacture and the first – perhaps the best – active packaging history (table 1)!
The many properties of oak barrels were discovered gradually. For a long time, they were simply used as containers, and if the wood was toasted (in addition to heat-induced stave bending), this was essentially to make it less permeable. The detailed impact of barrel toasting on the organoleptic characteristics of wine became an issue in the 19th century, but had to wait until the second half of the 20th century to be scientifically studied and become as predominant as it is today.
One usually thinks of oak chip treatment as an invention of modern winemaking technology, but this isn't quite true. Wine has always been "worked up" to dilute, mask or eliminate excessive acidity, fermentation defects and off-flavours. It was long commonplace to improve a wine's savour by adding water, honey, spices, aromatic herbs, pine resin… and even wooden chips! Thus, beech shavings, first water-boiled to remove bitterness and then air- or kiln-dried (with at most a light toast), have been used