

Oak Wood Composition*

By Dr. Murli Dharmadhikari

Significant variation occurs in the composition of oak heartwood. There are many factors that contribute to this variation. These include: differences within a tree, age of the tree, rate of growth, soil and climate of the region, and more importantly, the genetic differences between various species.

Variation Within a Tree

Within a given tree, variation in the heartwood composition can be considerable. For example, heartwood close to the sapwood is richer in tannin than the heartwood close to the pith. Higher tannin levels are found in the base of the tree than near the crown. The tannin content increases as the tree gets older. Soil, climate, and other environmental conditions also affect growth and composition of heartwood. Although significant differences in composition can be found within a tree, as well as among the trees, these differences are minimized during the process of barrel making. A 50-gallon barrel is made out of 30 plus staves. The staves in a given barrel may come from different segments of the same tree or from several trees grown in a given area.

Variation Due to Rate of Growth

The rate of growth also affects the heartwood composition. A slower rate of growth is characterized by a greater proportion of spring wood and a smaller proportion of summer wood. The spring growth consists of large vessels; whereas in summer growth, the pores are relatively small. In a slow growing tree, due to the higher proportion of spring growth, the heartwood is less dense, softer, and accumulates more phenolic extractives. It should be noted that less dense wood would be easier to work, and therefore would be preferred by the cooper. Heartwood from a fast growing tree would be more dense, harder to work, and would be lower in extractives. Data regarding wood density and extractable phenols in spring and summer growth of American and European oak is shown in Table 1.

Table 1. Average Composition of Summer and Spring Oakwood for Staves

Source	Growth mm/Year	Density Air Dry gram/cm ³	Density Air Dry gram/cm ³	Extractable Phenols Oven Dry gram GAE*/100 grams	Extractable Phenols Oven Dry gram GAE*/100 grams
		Spring	Summer	Spring	Summer
European	2.7	0.49	0.73	7.3	4.8
American	3.3	0.60	0.84	1.9	1.5

*Gallic Acid Equivalent

Source: Adapted from Singleton (1974)

Several important points are apparent from the figures given in Table 1.

1. Summer wood is invariably more dense than spring wood.
2. The faster growing tree has less extractable phenols than the slower growing tree.
3. On the average, European oak has a higher amount of extractable phenols.

Variation Due to Genetic Differences

Botanically, oak belongs to the genus *Quercus*. There are many species in this genus; however, only a small number of them are used in barrel making. From a winemaker's point of view, there are two major groups of oak: North American oak and European oak.

These two groups exhibit considerable differences in heartwood composition. American oak contains higher amounts of odorous compounds such as vanillin and oak lactones than the European oak. On the other hand, European oak contains more total extractables, and particularly twice the amount of extractable phenols than American Oak. A wine stored in American oak is likely to have a more pronounced "oaky" aroma and less tannic character. As the barrels are reused, the differences in wine stored in the American oak and European oak become less obvious and difficult to detect. There is no consensus among winemaker's preferences, the style of wine, and the economic considerations.

Sources of Oak and Their Significance

Oak is widely distributed throughout the temperate regions of the Northern Hemisphere and in certain parts of the subtropical and tropical regions of the world. Oak used in barrelmaking belongs to the genus *Quercus*

which includes over 300 species. Of this large number of species, relatively few are used for cooperage.

American Oak

The American white oak grows over a wide area of the Eastern United States. The oak forest extends from the Canadian border to the north and the Gulf of Mexico to the south; from midwestern states such as Iowa, Missouri, and Arkansas to the west, and to the Atlantic Coast to the east. The main species of oak in the U.S. is *Q. alba*, and it constitutes about 45% of the standing timber. Other species that may be used in barrel production include *Q. prinus*, *Q. bicolor*, *Q. mueh. lenbergi*, *Q. stellata*, *Q. macrocarpa*, *Q. lyrata*, and *Q. durandii*. *Q. alba* is widely distributed over the area mentioned previously and is best suited for making barrels.

Other species are not as widely distributed as *Q. alba*. For example, oak wood obtained from Missouri, Kentucky, and from the northern part of the U.S. is more likely to include *Q. bicolor* and *Q. macrocarpa*; and the staves obtained from Arkansas and the South are likely to have come from *Q. prinus* and *Q. lyrata*. Staves made from *Q. alba* and other species are difficult to distinguish. It is more realistic to assume that American oak barrels are made from largely *Q. alba* and to some extent, other species. Since the influence of American oak barrels, as a group, on the sensory attributes of wine is fairly consistent, it is safe to assume that the chemical and physical properties of oak wood from other species is similar to *Q. alba*.

In the United States, barrel production was geared towards the needs of the whisky industry. The so-called bourbon barrel, when used by the wine industry, did not give satisfactory results. Nowadays, many coopers are making wine barrels from American oak by using traditional French coopering techniques. These include air drying the wood, bending staves using wood fires, and wood fire toasting slowly over a relatively long period, to achieve deeper penetration of heat into the wood. French-style American oak barrels have yielded very encouraging results and more winemakers are using them for maturing their premium wines. Some winemakers are also experimenting with American oak barrels, using much thinner staves and using wood obtained from specific locations, such as Minnesota or Missouri. These experiments will yield some information that can be used in selecting and buying barrels. However, a lot more research needs to be done in order to assist the winemaker in making the proper selection of barrels that would be suitable for maturation of various styles of premium wines.

European Oak

The oak wood preferred in Europe to make barrels is derived from two species *viz* *Q. robur* and *Q. sessilis*. These two species are known to grow in most of the European forest. *Q. robur* is reported to be more widely distributed than

Q. sessilis. In many regions they grow side-by-side and easily hybridize. *Q. robur* seems to grow well in heavy and more moist soils. The wood is generally denser than in *Q. sessilis*, and the branching of the trunk occurs at a lower level. *Q. sessilis*, on the other hand, tends to grow in shallower soils and the tree trunk is tall and slender, with fewer low branches. For this reason it is preferred for reforestation in France.

French Oak

About 14 million hectares of land area in France is forest and about one third of this forest (about 4.5 million hectares) is in oak. The predominant species of oak are *Q. robur* and *Q. sessilis*. Other oak species of lesser significance include: *Q. afares*, *Q. macranthera*, *Q. longipes*, *Q. imeretina*, *Q. iberica*, *Q. pedunculiflora*, *Q. lamugnosa*, *Q. farnetto*, and *Q. mirbeckii*.

There are four principal oak growing regions which supply the wood for making wine barrels.

Center of France - This region includes the departments of Nièvre and Allier, and a specific forest in Allier known as Tronçais. The oak from this region is sometimes sold under the name of Nevers, Allier, and Tronçais. The wood is tight grained and the species of oak grown in this region is mostly *Q. sessilis*.

Limousin

Limousin oak comes from the southwest area of France near the city of Limoges. It is close to the cognac region. The predominant species is *Q. robur*. The wood is wide or open-grained and more porous. It is richer in tannin than the wood from the center of France and is popularly used by brandy producers.

Vosges

This region is west of Alsace and northeast of Burgundy. The wood is tight-grained and relatively less dense, and close in character to the wood produced in the Nièvre and Allier regions. The barrels made of oak from the Vosges region are popular with Burgundy producers.

Bourgogne

This area consists of the forest east of Burgundy. The wood is somewhat similar to the oak produced in the center of France. Traditionally, the wood is used by the Burgundy producers.

There are other areas in France that supply oak wood. It is important to realize that the oak forest regions are not well defined and the origin should be considered as broad, general areas. In addition to origin, the French coopers and many winemakers also consider the grain of the oak wood as an important criterion in making a buying decision. For example, wide-grained vs. tight-grained wood should be considered. The grain reflects the growing conditions of the tree. A slower growth of the tree will result in tighter grain. The genetic makeup of the tree will also determine the grain of the wood. For example, *Q. robur* usually produces a wider-grained wood than *Q. sessilis*. There are several other conditions such as soil, climate, age of the tree, rate of growth, and location of tree in the forest that affect the grain. Even in the same tree, staves made from the bottom or top portion of the wood show differences in grain.

Although the source (origin) of the wood and the grain are important considerations in buying barrels, one needs to realize that they may not be the most crucial factors to consider. Species of oak, method of seasoning the wood, and barrel manufacturing techniques are more important factors that would affect the quality of wood, and consequently, the wood's impact on the quality of the wine.

American versus European Oak

The question as to which oak is ideally suited for aging a given wine is a debatable point. Winemakers do not always agree on using a certain kind of oak for a particular type of wine. The choice of oak wood, in many cases, is a matter of preference.

In order to make an intelligent choice between American versus European oak barrels, it is important to understand the differences in the composition of the two woods. Generally, the American oak has a higher concentration of odorous compounds such as vanillin and oak lactone (trans- B-methyl-y-octalactone) than European oak. On the other hand, European oak contains one and one-half times more extractable solids and twice the amount of extractable phenols than American oak.

Reference

Singleton V.L. 1974. Some aspects of wooden container as a factor in wine maturation. Chemistry of Winemaking. A.D. Webb, editor. p. 265.

*Previously published in Vineyard & Vintage View, Mountain Grove, MO.