Wine/Enology

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BARRELS, BARREL ADJUNCTS, AND ALTERNATIVES

Learning Outcomes: *After reviewing this chapter, the reader will understand the multiple functions of oak in wine. The reader will review the impacts of oak as a structural agent, and its role in the textural and aromatic features of wines. The effect of oak as a red wine color cofactor, as an antioxidant, and as a framing tool will be reviewed. The influences of the many variables, including source, seasoning, and toasting, as well as when and how oak is used, will be discussed. Novice winemakers frequently make the mistake at looking at wood first and foremost as a flavoring agent. Oak should be like cosmetics for wine, that is, in the best case you can't tell it is being worn. Oak to provide structural framing should be carefully selected to match the needs and the wine varietal. For example, some wines, such as Barbera, Merlot, and Grenache, have a strong fruit core, but may lack some structural elements. Other wines, such as Cabernet franc and Mourvèdre, may have some framing, but lack fruit.*

Chapter Outline

Section 1.

Oak Barrel Components

Oak has a number of purposes or functions in wines. These including co-extraction and color enhancement in reds, as a component impacting wine texture, as an antioxidant and as an aroma enhancer.

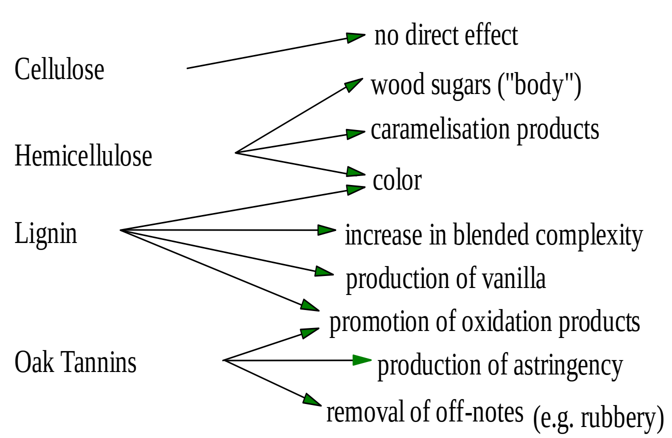
Fermentation and/or storage in oak involves the interaction of air, wine, wood and, possibly, microorganisms. Today, it is possible to relate some sensory properties of wine to specific oak components or compound groups, and to relate the component levels to practices such as seasoning condition, toasting levels, and fermentation conditions.

The major components of oak include the following:

• cellulose	45 – 50%
• hemicellulose	20 – 25%
• lignin	25 – 35%
• tannin	5 – 10%
• minor constituents	0.1 – 0.5%

Some of the influences of oak wood on wine components are shown in Figure 1.

Figure 1. The Influence of Oak Wood on Barrel Maturation

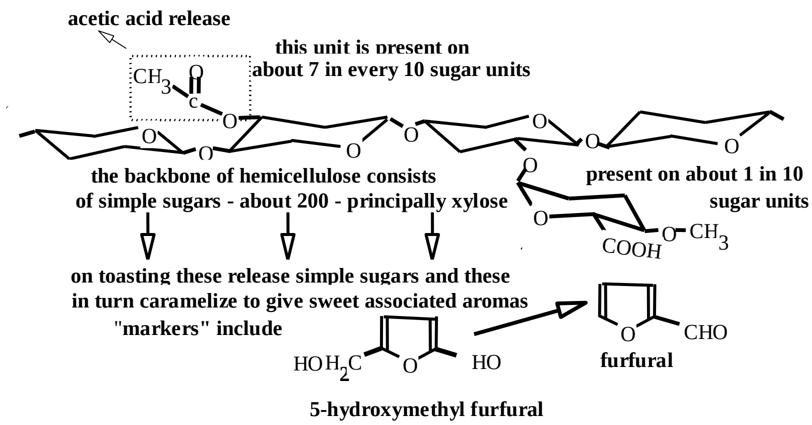


Wood Composition

Cellulose and Hemicellulose

Hemicellulose is composed mainly of 5-carbon sugars such as xylose and arabinose, with a limited amount of the 6-carbon sugars mannose and galactose. Products of hemicellulose brought about by heat treatment (e.g., toasting) include furfural, maltol, cyclotene, and ethoxylactone (Figure 2).

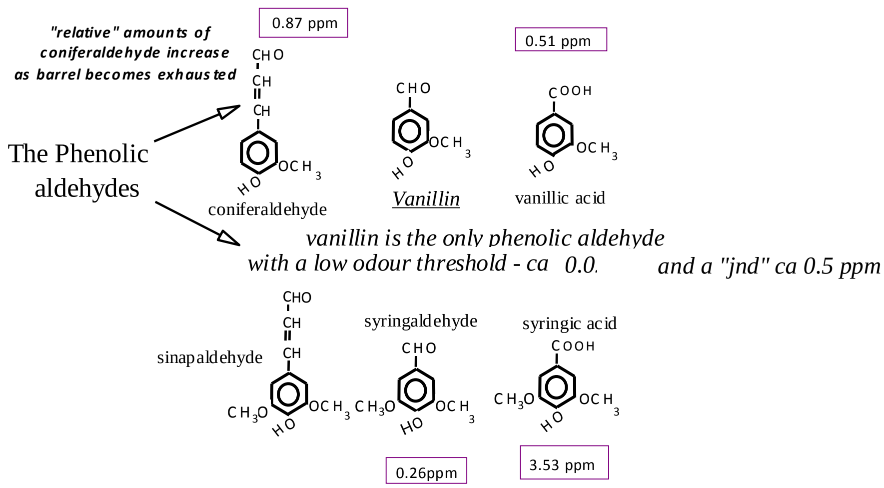
Figure 2. The Building Blocks of Oak: Hemicellulose (about 22%)



Lignin

Oak lignin is a complex polymer composed mainly of coniferyl and syringyl alcohols, which can generate a variety of volatile phenols based on the guaiacyl and syringyl nucleus. The most abundant of these are vanillin, syringaldehyde, coniferaldehyde, and sinapaldehyde (Sefton et al. 1990). See Figure 3.

Figure 3. The Building Blocks of Oak: Lignin (about 25%)

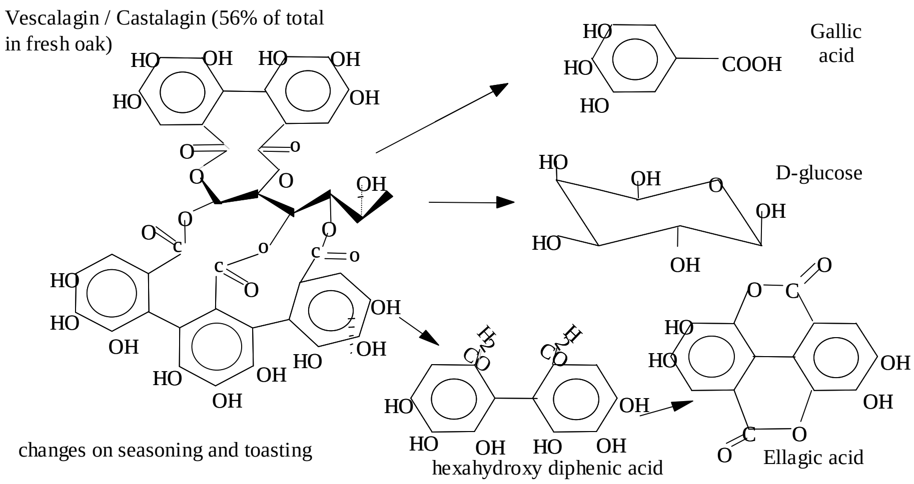


Tannins

Hydrolyzable tannins (those that can be broken up into other compounds through reaction with water) make up approximately 5-10% of the dry weight of oak wood. These are a complex mixture of oligomers of gallic acid and glucose, bonded by oxidatively-coupled and ester linkages. They are chemically different from the condensed tannins of grapes and wines (Quinn and Singleton, 1985).

The hydrolyzable tannins are unstable (hence the term *hydrolyzable*) at wine pH and break down, generating gallic acid and, predominantly, ellagic acid. During the normal course of barrel maturation of wine, ellagic acid precipitation takes place in the barrel. However, precipitation in the bottle can take place when wines have been treated with oak chips shortly before bottling (Pocock et al., 1984) (Figure 4).

Figure 4. The Building Blocks of Oak: Tannins (0.8-10%)



The sensory impact of oak extraction is not strongly correlated to the total phenolics extracted from the wood. It is possible that phenolic extracts of different oak types with different seasoning histories have different sensory thresholds.

Wine Processing Considerations

During oak storage, controlled oxidation can result in decreased astringency and increased red wine color stability due to the combination between anthocyanin and tannin molecules (Pontallier, 1987). Color stability is promoted by the presence of acetaldehyde produced by ethanol oxidation. This is facilitated by an oxidation catalyst, such as gallic acid, present in large quantities in oak wood.

Wood Variations

There are physical and chemical variations between American white oak (*Quercus alba*), and the European species *Q. robur* and *Q. sessilis*. Variations in wood composition also occur due to climate, environment, seasoning, and barrel processing. The sensory features of wines stored in oak are dependent on factors influencing wood composition, and include the following:

- origin
- barrel age and size
- seasoning: method of wood drying
- grain tightness
- seasoning: geographic location
- cooperage techniques
- stave width
- degree of toasting

The type of oak affects the phenolic content of barrel-aged wines. The main phenols of both European and American oak are ellagitannins, the total content being higher in European oak (Quinn and Singleton, 1985). Singleton et al. (1971) reported that new wines aged for one year in 200-L (53 gallon) French oak barrels contribute 250 mg/L phenols (gallic acid equivalents, GAE). By comparison, wines stored in American white oak contributed approximately one-half that level. Francis et al. (1992) found that the differences among French woods were not as great as those between French and American wood, with the latter perceived to have less-intense aromatic properties.

American oak has gained popularity in the United States due, in part, to economics. Both American and French wood contribute tannin and aroma. The differences can be generalized as follows:

- American oak is more aggressive, has immediate taste and aroma, and contains more vanillin, contributing to vanilla aroma.
- French oak contains more tannins, yet has less obvious “oaky” flavors and aromas.

During wood fermentation, two factors help to influence the structural integration of the wood into the wine. Mannoproteins are released by the yeast, which help to bind phenols. Additionally, yeast absorb about one-third of the ellagic tannins, lowering the perception of harsh astringency.

The “woody” character is generally less intense when the alcoholic fermentation takes place in oak. This phenomenon is linked to biochemical transformations of some aromatic components, caused by yeast and malolactic fermentation, when present. Some components are altered and become less aromatic, and some are absorbed into yeast cells (Chatonnet, 1993). Yeast can also act directly on oak components. One example is the conversion of ferulic acid to vinyl-4-guaiacol, which results in development of “clove-like” properties. Addition of the fining agent PVPP can have a dramatic influence on the conversion.

Fermentation of white wines in oak slows down the extraction of volatile phenols from the wood by the wine (Boidron et al., 1988). It is generally believed that the woody character is less pronounced and better integrated if newly-fermented wine remains in contact with the lees for some time. Yeast resuspended by stirring (*batonage*) are capable of fixing some of the volatile substances released from oak barrels. Additionally, enzymatic activity that starts during alcoholic fermentation reduces aromatic potential of vanillin and furanic aldehyde during lees contact (Chatonnet, 1993). Almost one-third of the tannins released by the wood are adsorbed onto the yeast cell walls and half combine with the colloids in the wine, resulting in a natural fining (Chatonnet, 1993).

Lindblom (1993) proposed a hedonic scale for the evaluation of oak aromas and flavor. Descriptors applied to oak include coconut, vanilla, roasted, resinous/varnish, sweet, toasty, smoky, and spicy.

Forest Variations and Wood Grain

The different aroma/flavor coming from barrels made from different forests stems mainly from differences associated with grain tightness. There is no universally accepted rating of grain tightness. Grain tightness is mainly due to the amount of moisture that the soil can retain, which enables the tree to grow. Forest-derived factors that affect flavor include grain tightness of the oak, oak species, and tree age.

Forest-derived factors that can impact aroma/flavor by impacting grain tightness include the following:

- soil moisture
- soil nutrients
- the straightness of the tree

The possible benefits of fine-grained oak include the following:

- Rich, easily extractable source of vanillin.
- Tannins are easily extractable.
- Cask-driven oxidation is enhanced.
- Spectrum of volatile acids that can increase “fruit” production.
- Compounds, such as caryophyllene, that add “spicy” character.

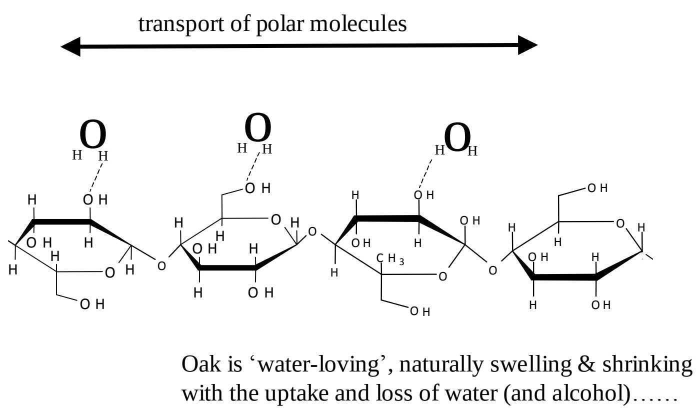
Oak Seasoning

Oak tannins are different from grape tannins. The tannins in oak are hydrolyzable: their chemical structure can be broken down to simpler tannins. Freshly-cut oak is about 60% moisture, and oak has about 18% moisture when coopered into barrels. At about 25% moisture, there is no more free water within the cells, and all that remains is fixed to the fibers.

Oak Toasting

During the toasting process, chemical bonds between the three polymeric building block groups, cellulose (Figure 5), hemicellulose, and lignin are disrupted. Hemicellulose and lignin are notably degraded. In addition, changes occur in the structure of oak tannins.

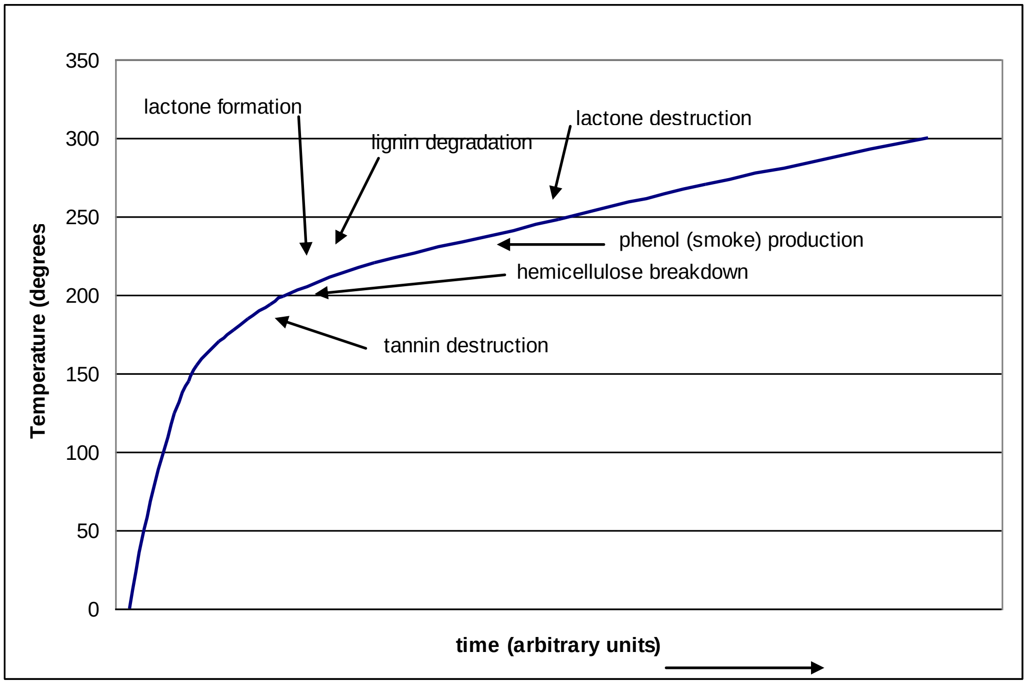
Figure 5. The Building Blocks of Oak: Cellulose (about 45%)



The industry has attempted to standardize the previously-used terms of light, medium, and heavy toast. Changes in the wood occur as a result of time and temperature, as illustrated in Figure 6. Generally, heat penetration is greater in American oak than in French, as a result of American oak’s being more dense.

Tannins in the first several layers of wood are substantially destroyed by heat. Sugars are caramelized in the top layers of both American and French oak, while the creation of vanillin results from greater heat. Hemicellulose is rapidly decomposed by heating, while lignin breakdown occurs more slowly, releasing volatile compounds.

Figure 6. The Effect of Heating Time and Temperature (°C) on Oak Components



Volatile Compounds in Oak

During stave heating, or toasting, wood is subjected to relatively high temperatures, giving rise to chemical changes. Some volatile compounds, such as methyloctalactone, initially present in the wood, and ellagitannins, disappear quickly. On the whole, the "woody" aromas are lessened as the degree of toasting increases. Some substances develop as a result of heat deterioration of wood. These include furaldehydes, phenolic aldehydes, and volatile phenols. Francis et al. (1992) found that heat was the most important barrel production parameter, regarding influence on the sensory characteristics of oak wood extracts.