Oak Chemistry & Applications in Wine

Barrel Aging: Knock on Wood!

ASBC Annual Conference – Pre-Meeting Workshop

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Oak aging is common in red (and some white) wines

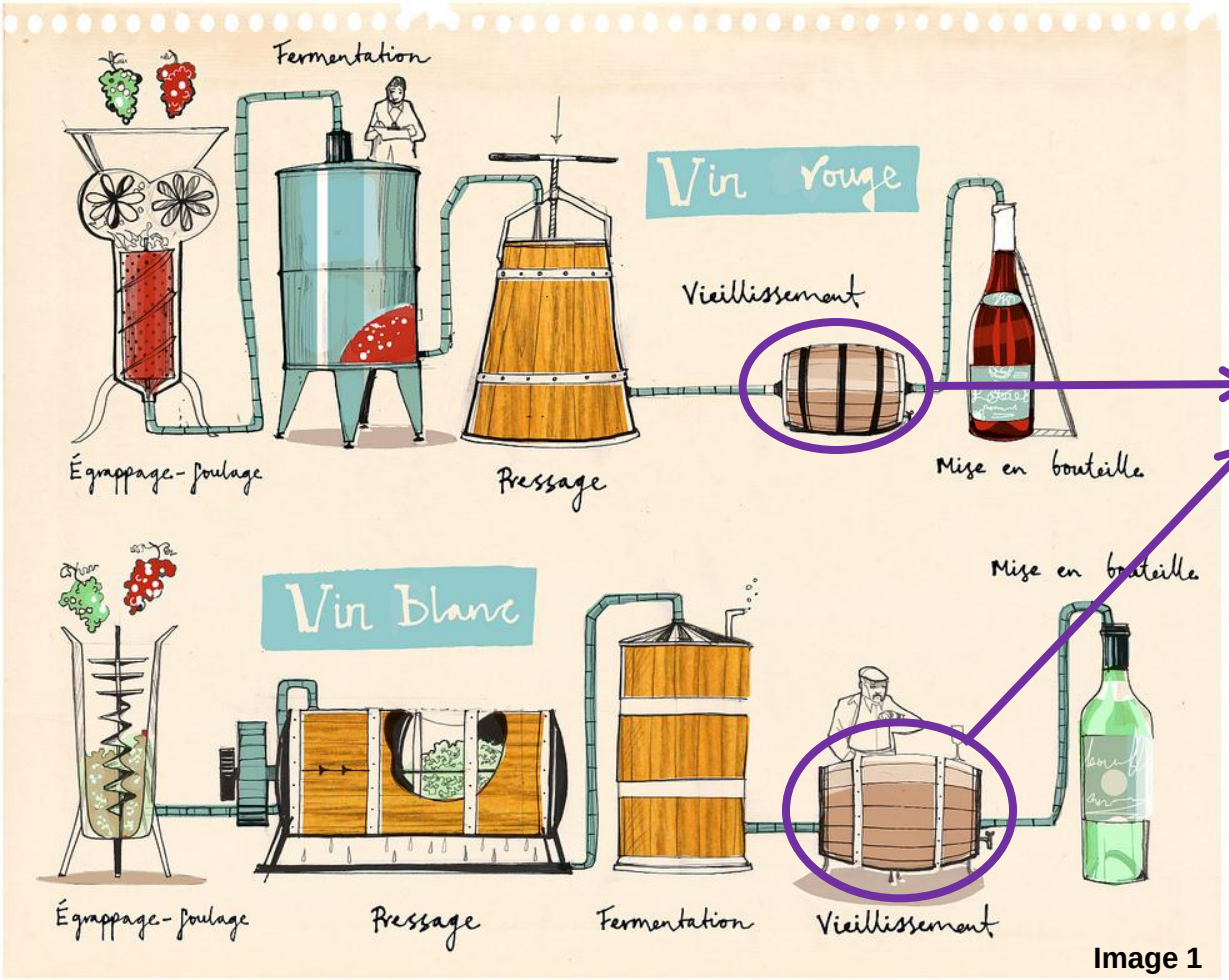
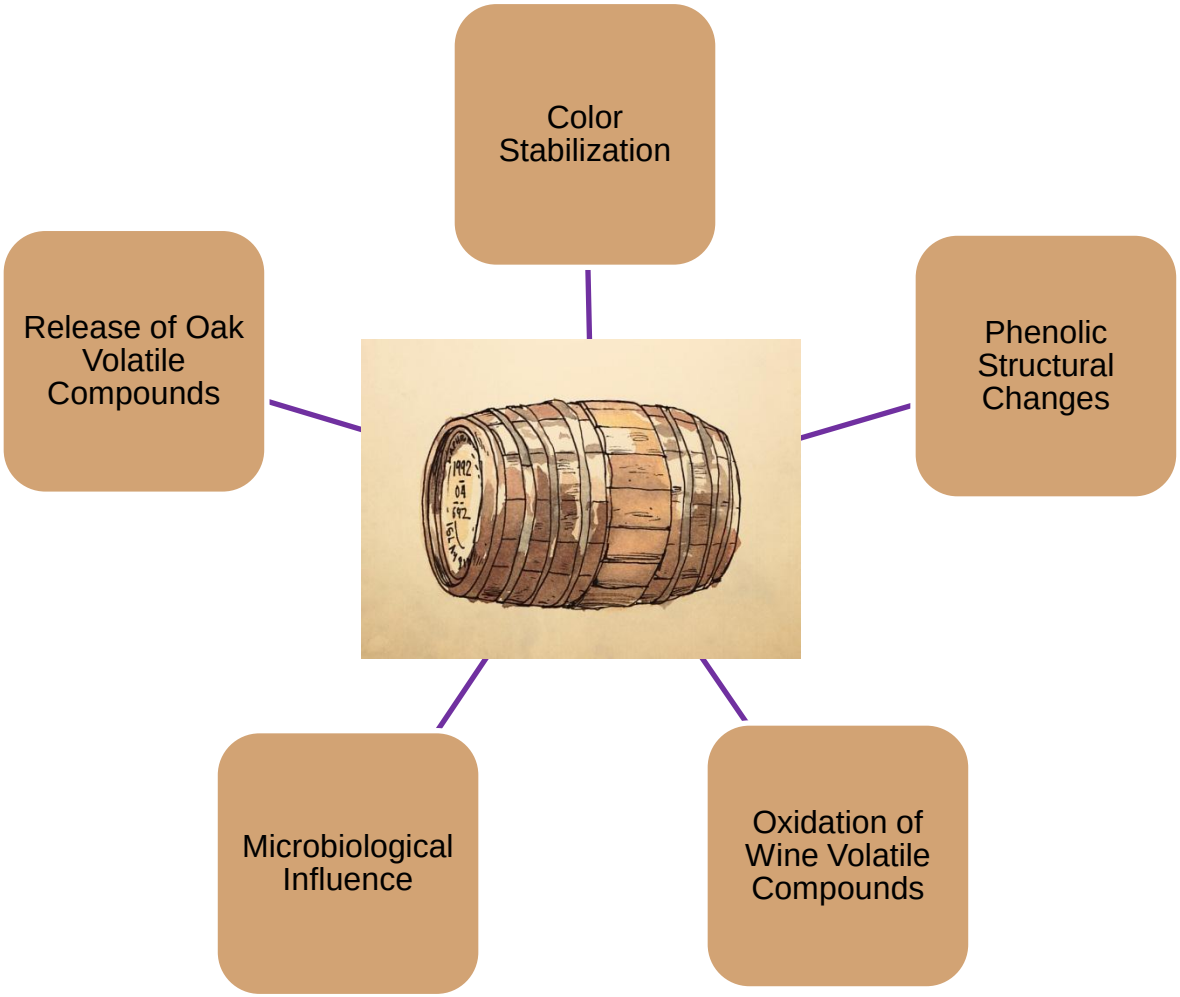


Image 1

Oak aging typically occurs after fermentation and pressing

Several changes occur in wine during the barrel aging process



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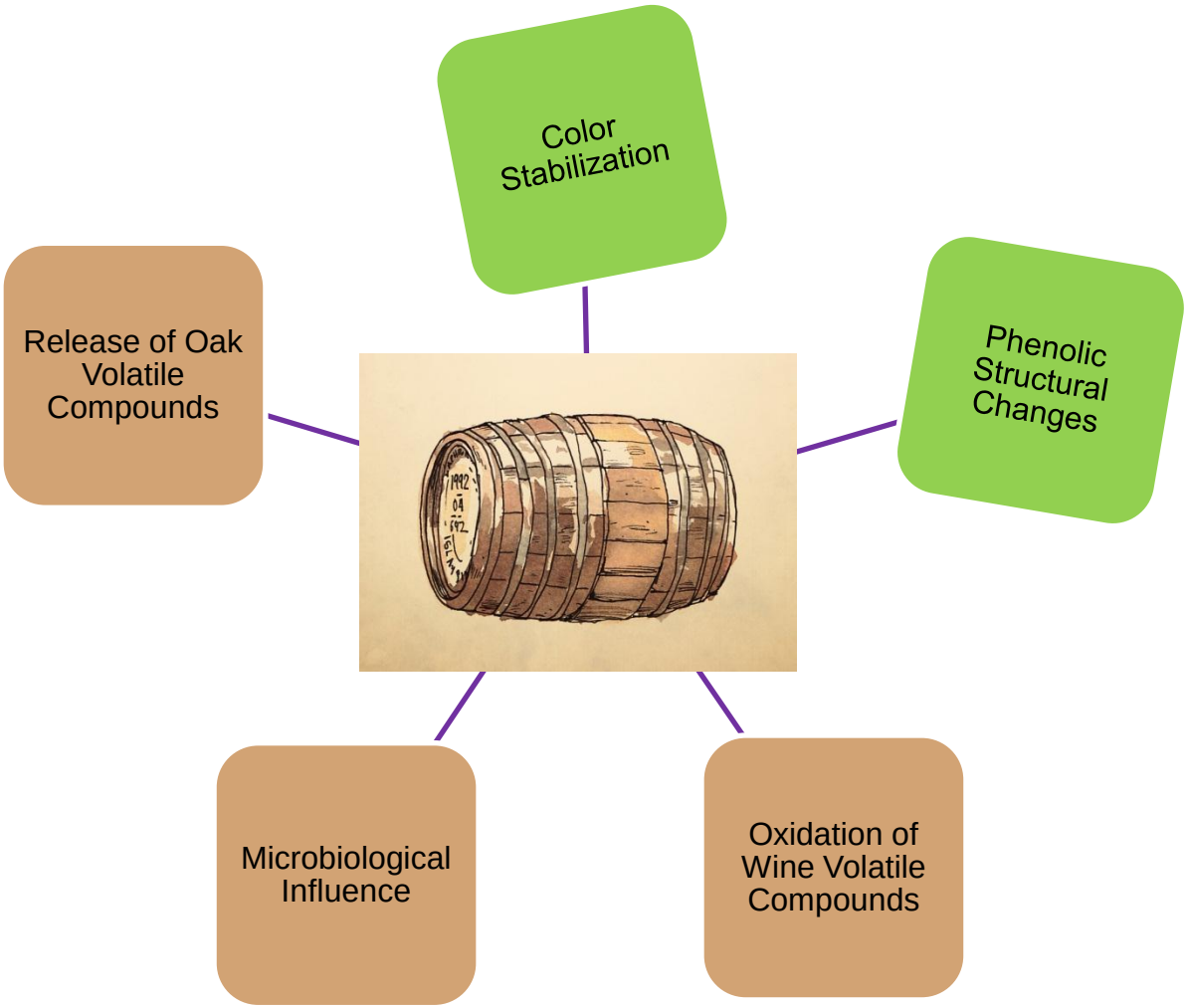
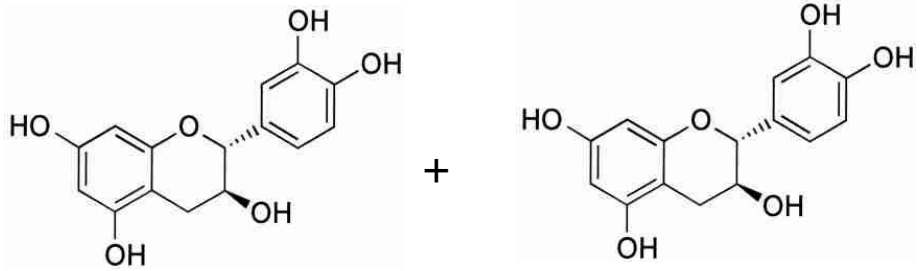
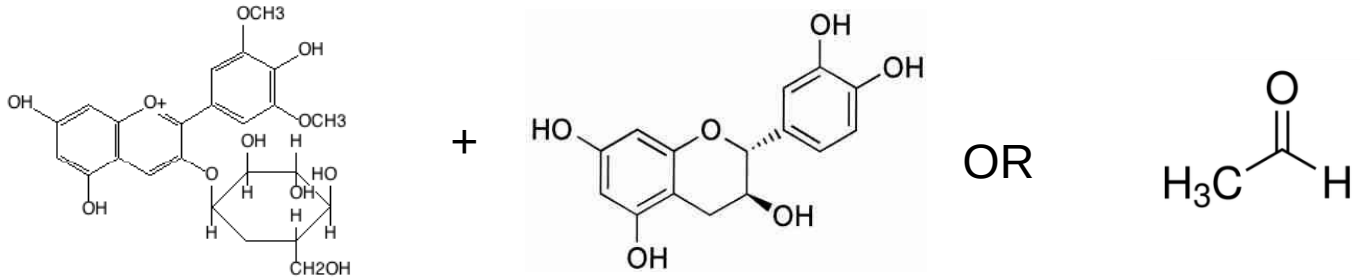


Small amounts of oxidation in barrels can stabilize color by polymerization reactions

- Tannins polymerize – change in mouthfeel, increase in brown color



- Anthocyanins react with aldehydes and tannins to form "pigmented polymers" – more stable over time



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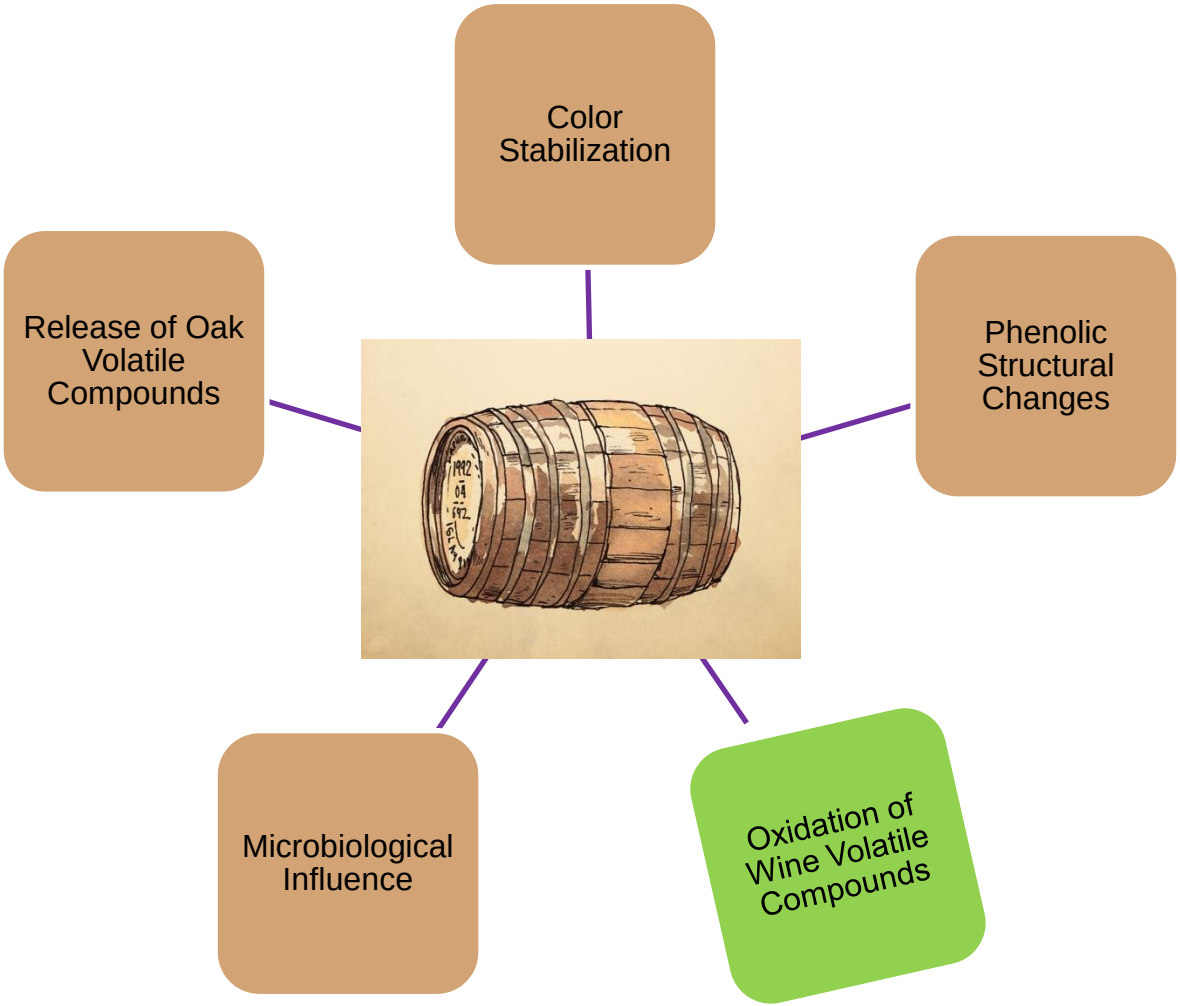
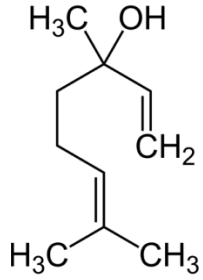
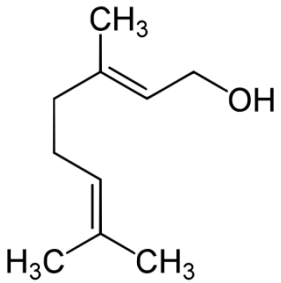


Some volatile compounds are lost due to oxidation during barrel aging

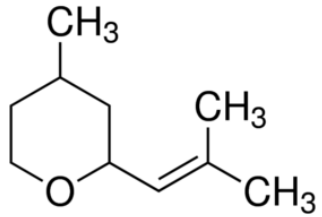
- Oxidation and hydrolysis of terpenes



Linalool

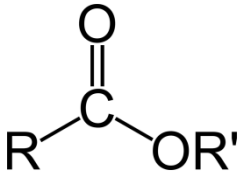


Geraniol

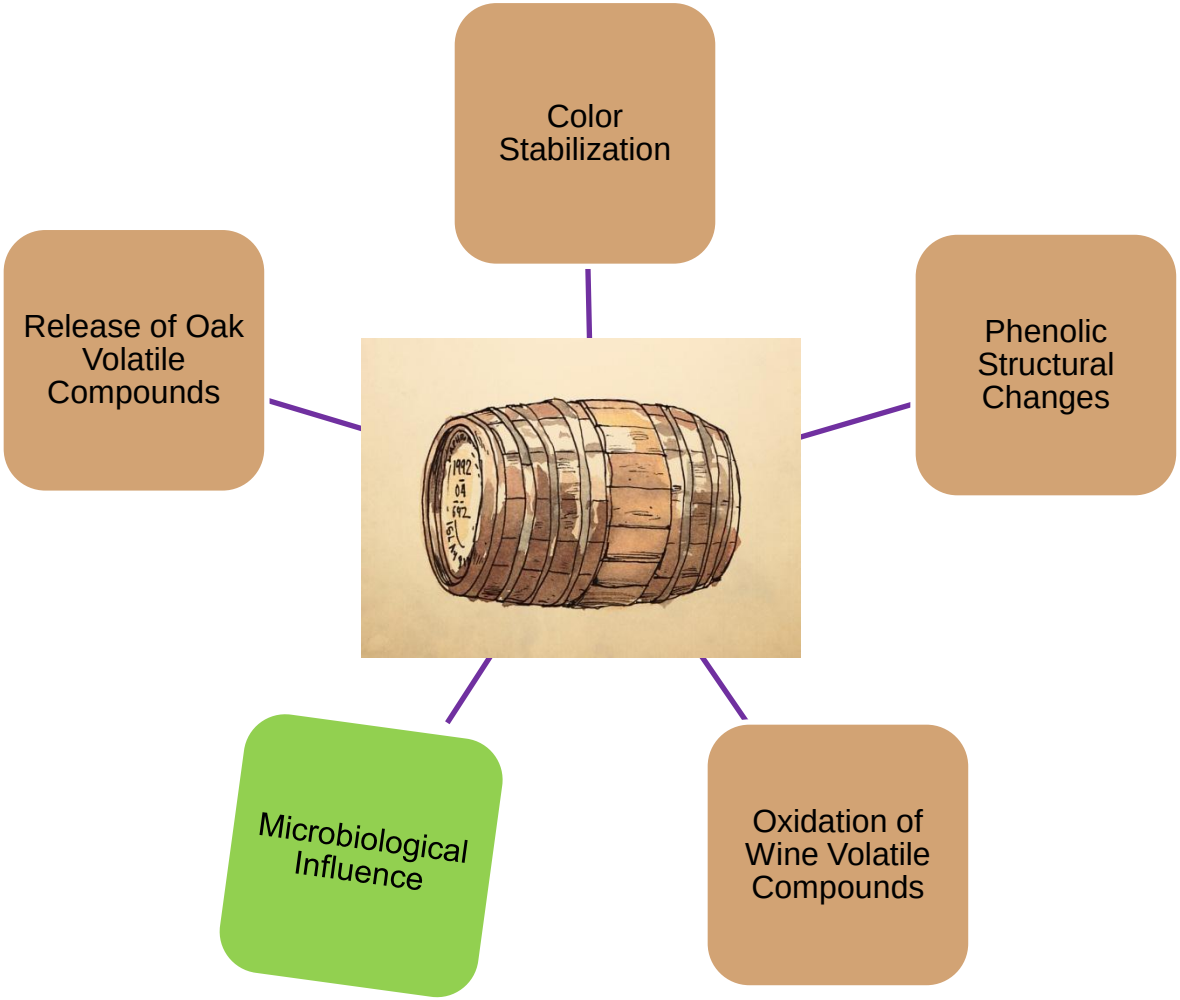


cis-Rose Oxide

- Hydrolysis of esters



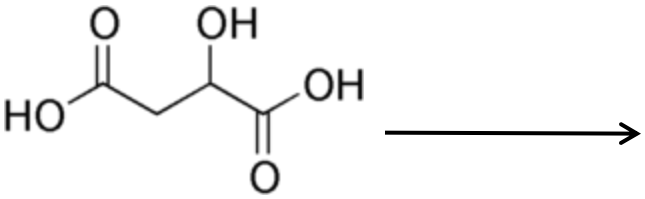
Several changes occur in wine during the barrel aging process



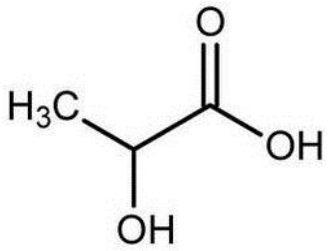
Microorganisms can produce volatile compounds during barrel aging

- Barrel Fermentation
  - Common in white wines to reduce oxidation
  - Reduce aldehydes to alcohols to ethyl esters (↓ green)
  - Adsorption of some volatile components by lees

- Malolactic Fermentation



Malic Acid



Lactic Acid

Aromatic Byproducts

Microorganisms can produce volatile compounds during barrel aging

- Hydroxycinnamic acids (present in grapes) are converted to volatile phenols by exogenous yeast (*Brettanomyces*)

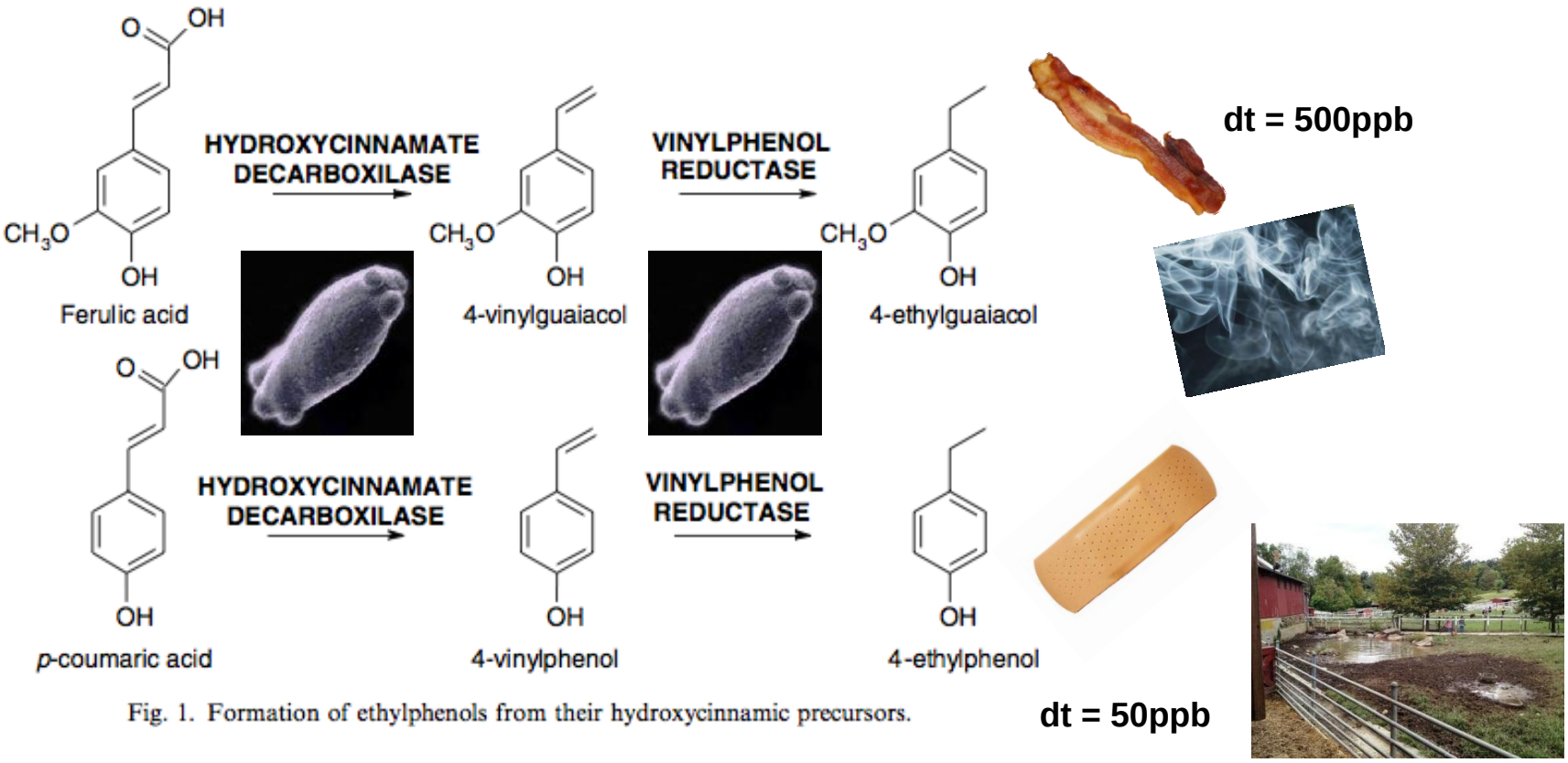
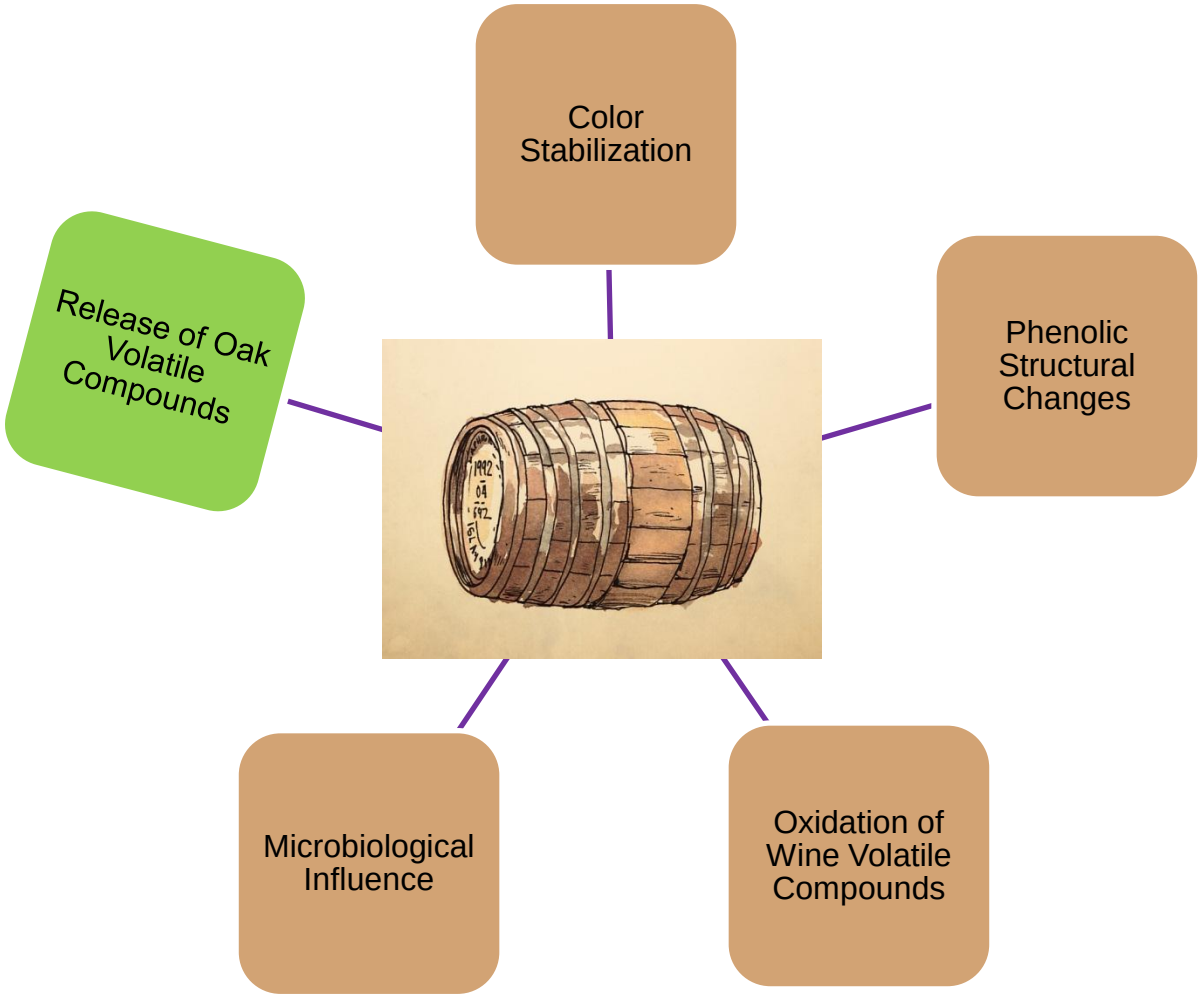
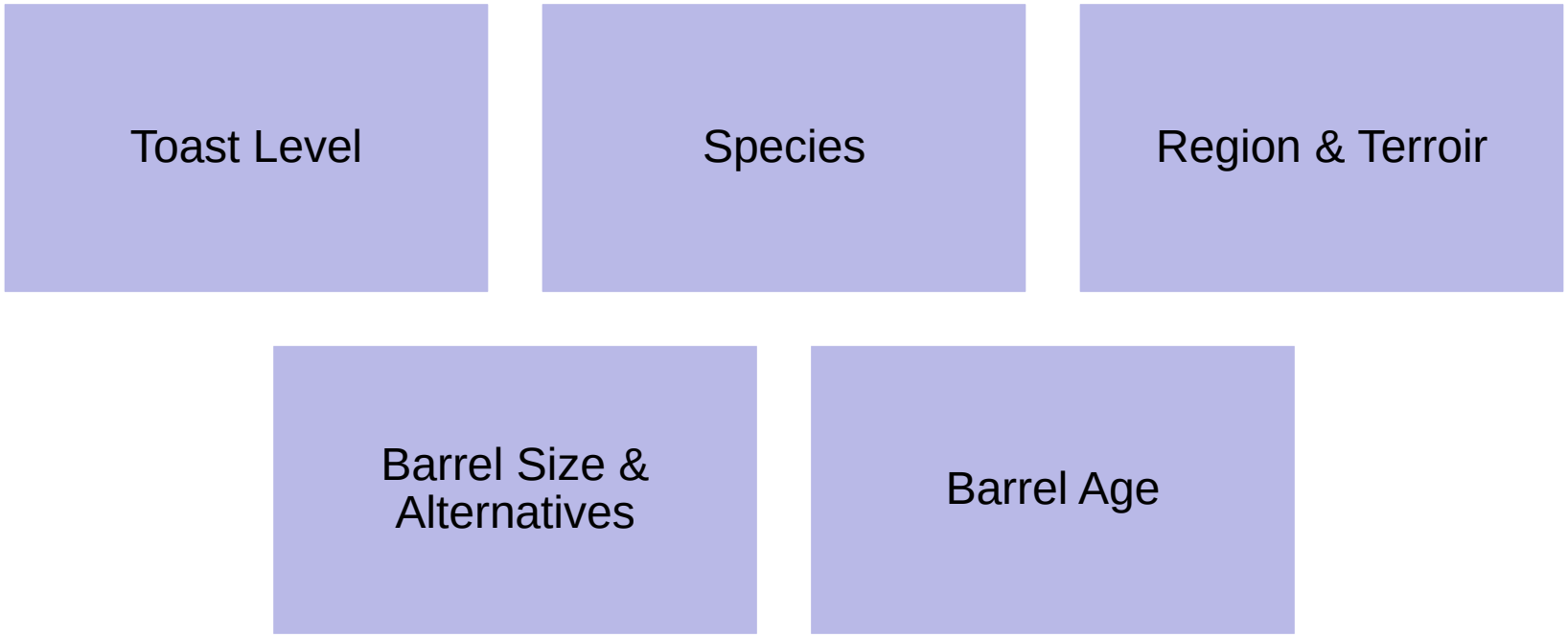


Fig. 1. Formation of ethylphenols from their hydroxycinnamic precursors.

Several changes occur in wine during the barrel aging process



Different oak characteristics influence the release of oak volatile compounds



Different oak characteristics influence the release of oak volatile compounds

Toast Level

Species

Region & Terroir

Barrel Size & Alternatives

Barrel Age

Only oak heartwood is used to make barrels

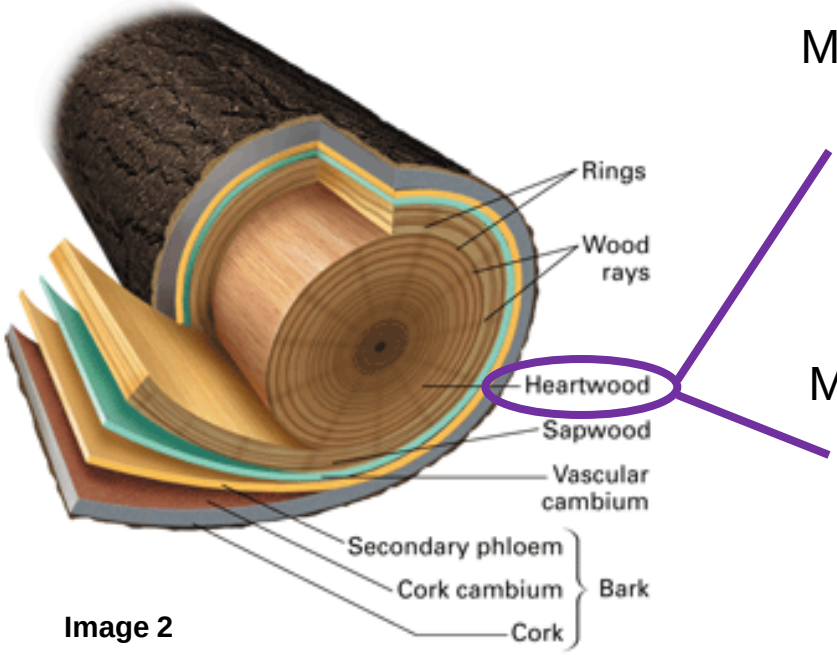


Image 2

Macro-components in heartwood:

- Cellulose (50%)
- Hemicellulose (20%)
- Lignin (30%)

Micro-components in heartwood:

- Acids
- Sugars
- Steroids
- Phenols
- Terpenes
- Lactones

Cooperage process influences oak aroma compounds

1. Start with raw wood.
2. Dry “season” the wood (air or kiln).

3.Split the wood. Hollow inside of staves.

4. Assemble staves. Fasten with hoop.

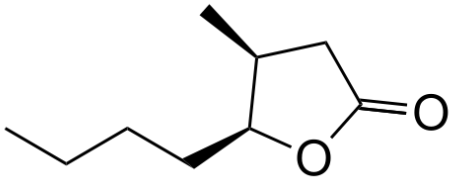
5. Toast partially-assembled barrel.

6. Arch staves and secure with hoop.
7. Fit staves into notches on heads.

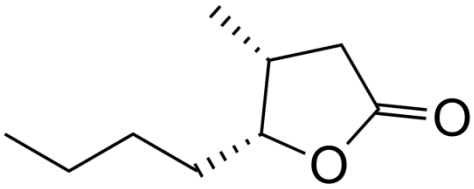
Images 3, 4, 5, 6

Volatile compounds form during drying and toasting steps

- Lactones are released from their corresponding glucoside precursor.



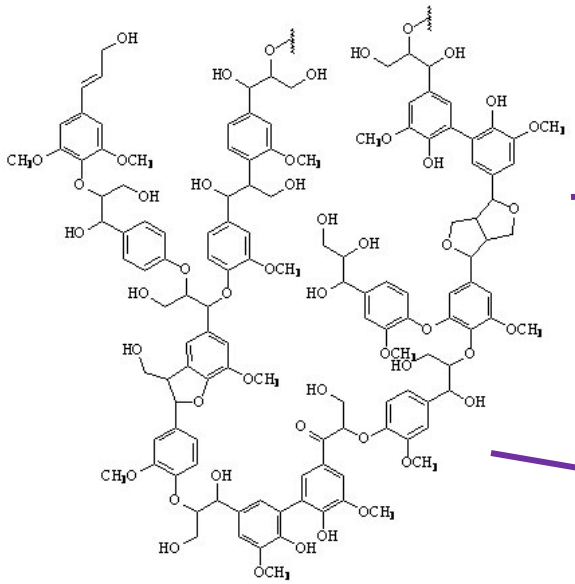
***cis*-Oak Lactone**
Aroma: coconut, vanilla
dt: 92 ppb, white wine



***trans*-Oak Lactone**
Aroma: spice, coconut
dt: 460 ppb, white wine

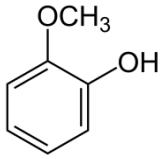
Volatile compounds form during drying and toasting steps

- Lignin degrades to form aldehydes and phenols.

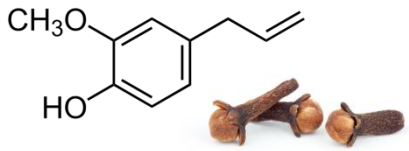


Lignin
(polymer of aromatic alcohols)

Phenols

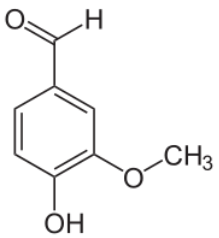


Guaiacol
(dt: 95 ppb, red wine)

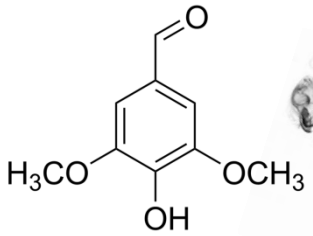


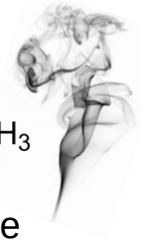
Eugenol
(dt: 500 ppb, red wine)

Phenolic Aldehydes



Vanillin
(dt: 320 ppb, red wine)

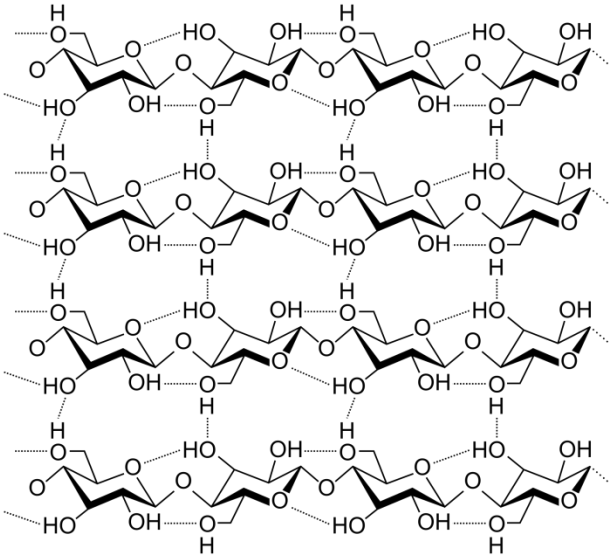




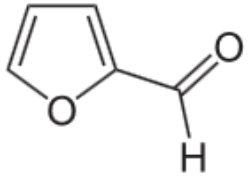
Syringaldehyde
(dt: 50,000 ppb, H_2O)

Volatile compounds form during drying and toasting steps

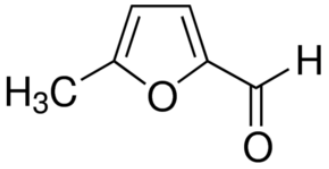
- Cellulose and hemicellulose break down to form aromatic aldehydes.



Cellulose
(polysaccharide of β-linked glucose)



Furfural
(dt: 20,000 ppb, red wine)

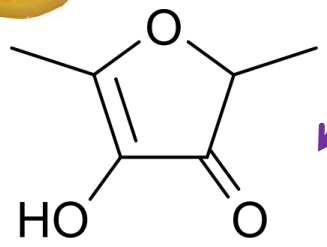


5-Methyl Furfural
(dt: 45,000 ppb, red wine)

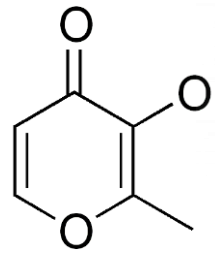
Volatile compounds form during drying and toasting steps

- Maillard reactions occur to form various aromatic molecules.

Reducing Sugar + Amine = Melanoidins



Furaneol
(dt: 20,000 ppb, red wine)



Maltol
(dt: 5,000 ppb, model wine)

Different oak characteristics influence the release of oak volatile compounds

Toast Level

Species

Region & Terroir

Barrel Size & Alternatives

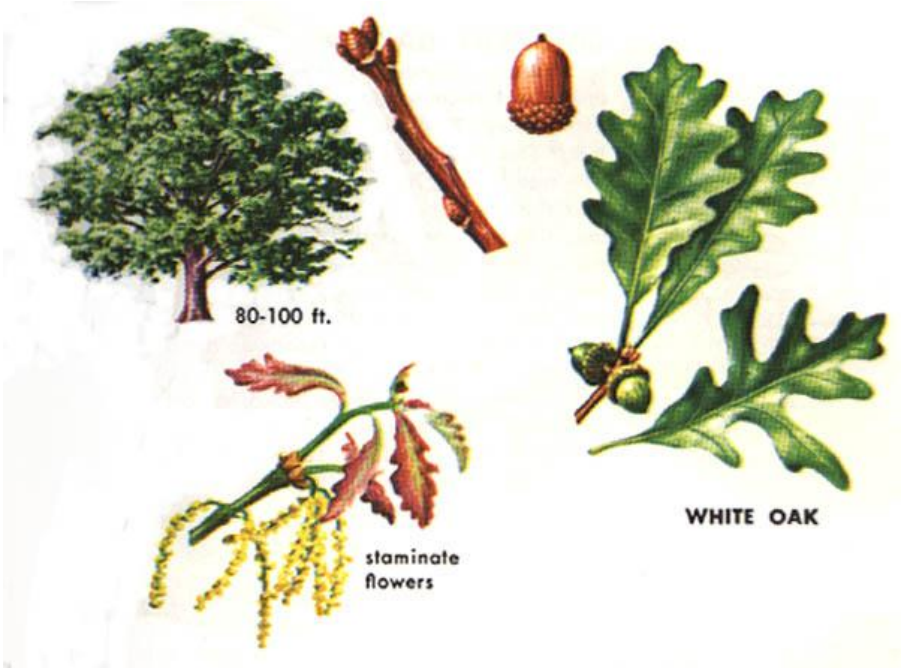
Barrel Age

Volatile compounds present in oak vary by species

French Oak

Quercus petraea, *Q. robur*

↑ **tannins**



American Oak

Quercus alba

↑ **lactones (esp. *cis*)**

↑ **terpenes**

↑ **norisoprenoids**

Images 7,8

Different oak characteristics influence the release of oak volatile compounds

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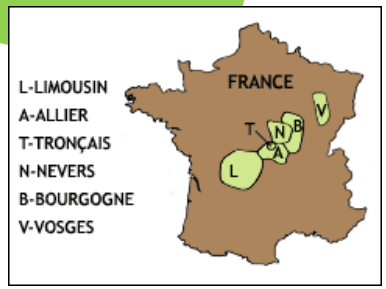
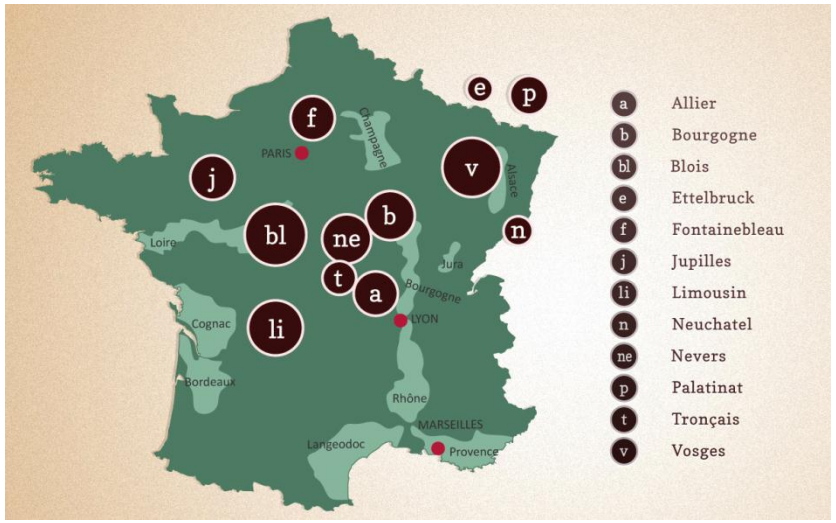
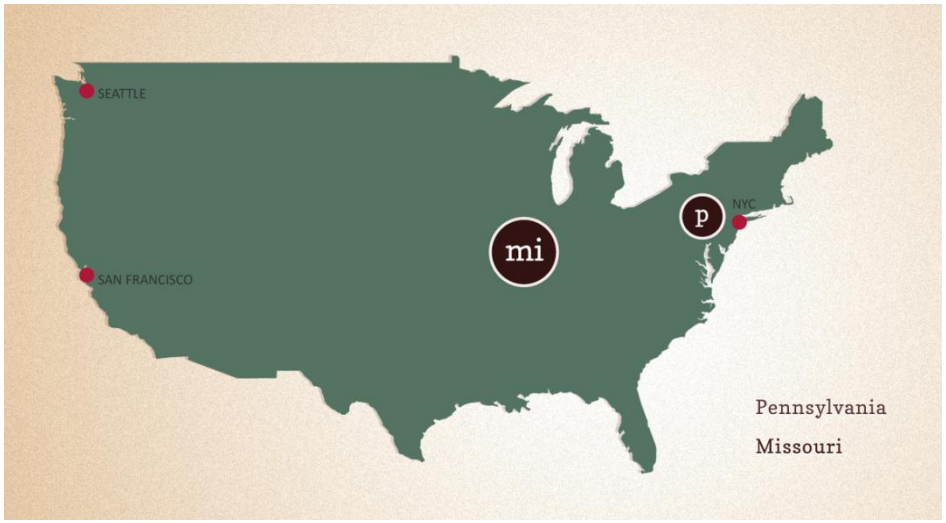


Barrel Size & Alternatives

Barrel Age

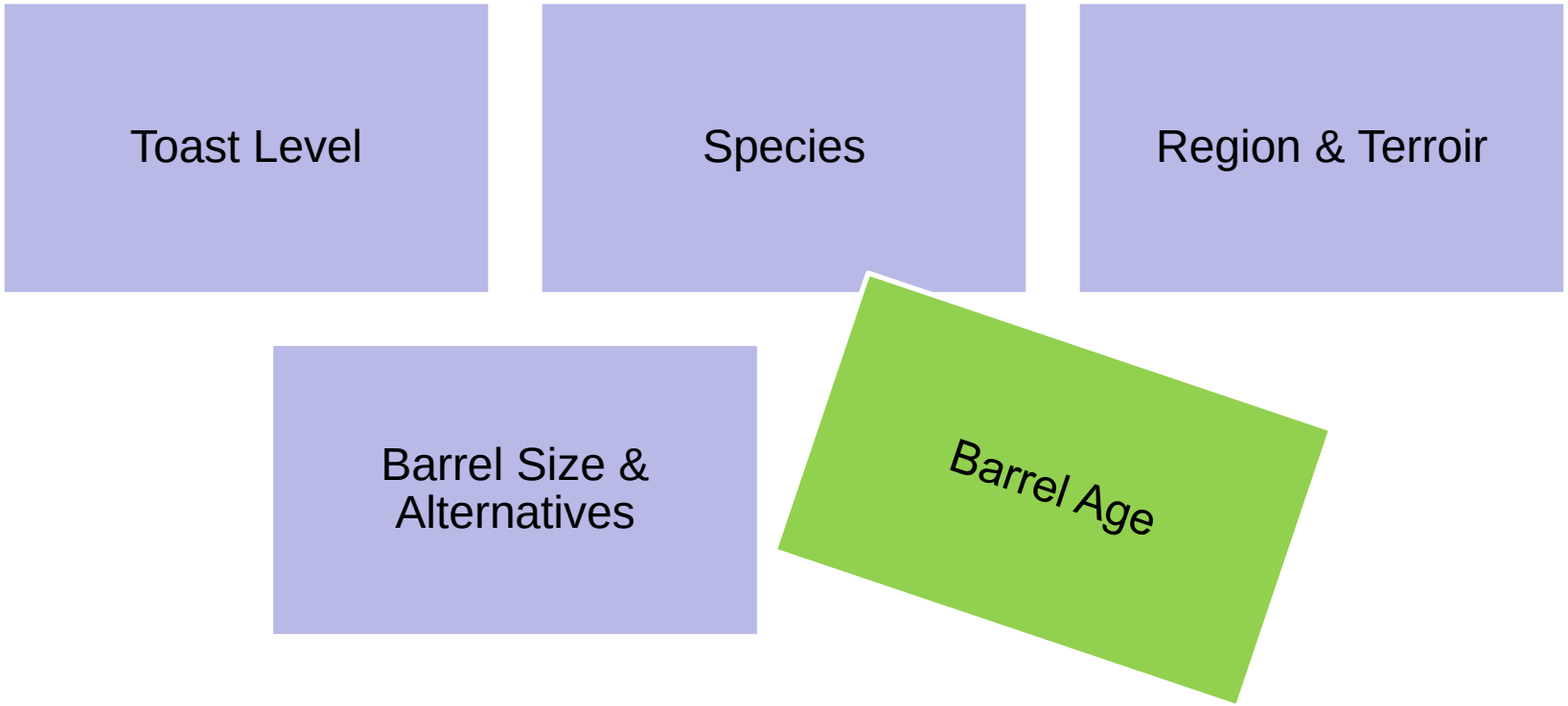
Growing region and climate also impact oak volatile composition





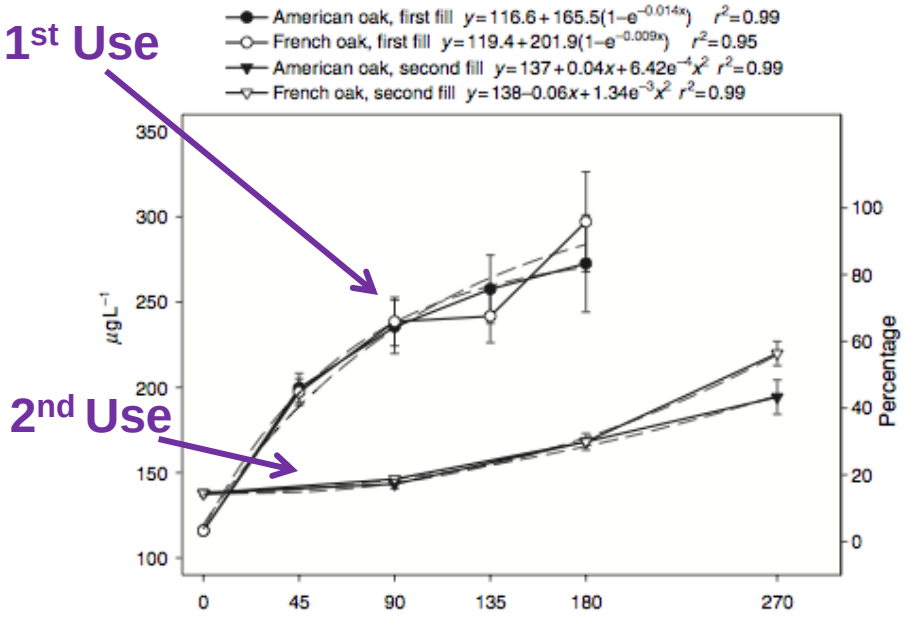
In France, species varies by region	Concentrations of some aroma compounds differ by region	Growth rate influences wood density
• *Q. petraea* • *Q. robur*	• Eugenol • Vanillin • 2-phenylethanol	• "Fine-grain" wood lower in tannins

Different oak characteristics influence the release of oak volatile compounds



Oak aroma extraction rate decreases with use

- Extraction rate significantly decreases after one year of aging.



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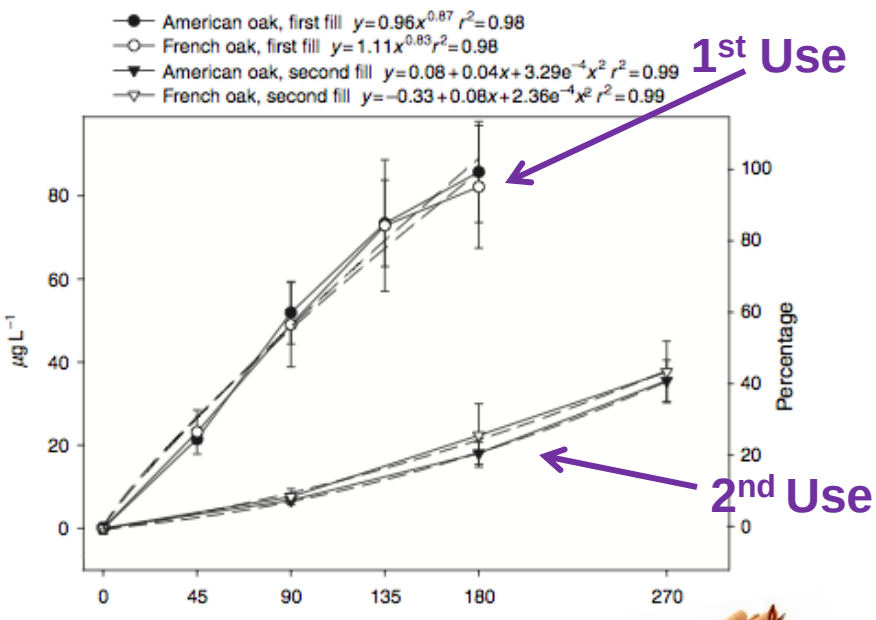
(dt: 320 ppb, red wine)



trans-Oak Lactone
(dt: 460 ppb, white wine)

Gómez-Plaza, et al. 2004

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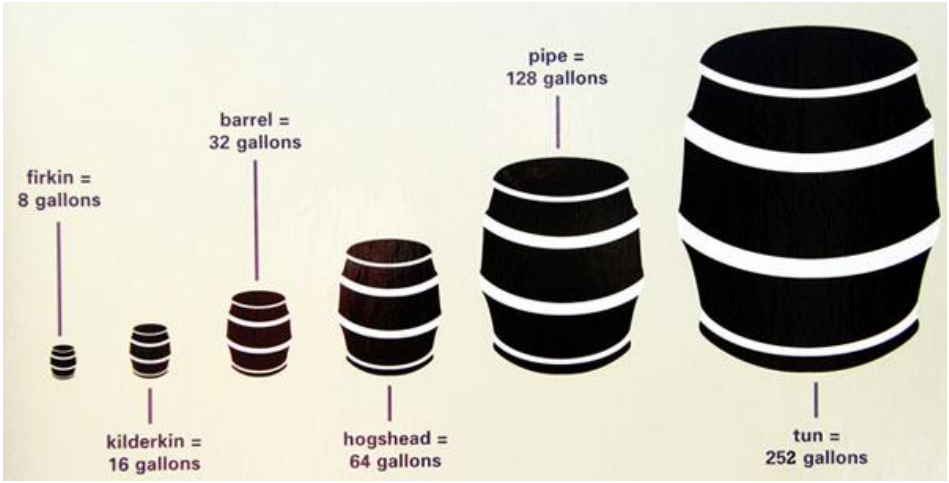
Barrel Size & Alternatives

Barrel Age

Barrel size and type influences aroma extraction and stabilization reactions



- Barrel size range: 5 – 8,000 gallons (typically 53)
- Size determines:
  - Surface/volume ratio
  - Wood contact, amount of extraction
  - Oxygen ingress and egress

Barrel size and type influences aroma extraction and stabilization reactions

- Oak alternatives were first used in white wines to minimize oxidation
- Short contact time, before or after fermentation

- **Use of oak alternatives can decrease loss of volatiles**
- **Increase extraction of phenolic compounds**
- **Easier to over extract oak compounds → could mask varietal character**

***Oak lactones increase even after removal of oak**

Thank you!

- Questions?

- Contact Information:

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