Managing Wine Aroma

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Evaluation of wine: Visual, ***aroma (bouquet)***, taste and ***flavors***, texture / mouthfeel, and finish (combination).

Aroma compounds in grapes are responsible for determining the varietal character or ***typicity*** of wine.

Like other animals, aromas trigger responses in humans of ‘like’ and ‘dislike’. Often difficult to describe due to many factors; vast exposure to aromas and aromas that are familiar but not experienced often.

Winemakers goal is to produce a *clean wine*, with *varietal distinction* (when applicable). Generally focus on maximizing aroma intensity and complexity while minimizing aromas that may dominate, inhibit, or produce a negative perception (faults).

As plants and animals have evolved they have taken advantage of volatile compounds as a means of interacting from a distance.

This eliminates the requirement for physical proximity for interactions.

Taste	Substance	Threshold
Salty	NaCl	(280 ppm)
Sour	HCl	(16.2 ppm)
Sweet	Sucrose	(3.4 *ppt*)
Bitter	Quinine	(2.6 ppm)
Umami	Glutamate	(103 ppm)

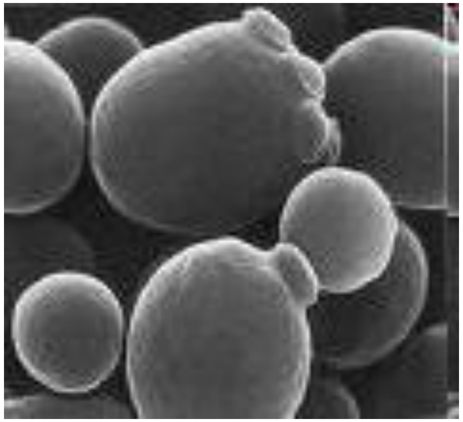
Aroma	Substance	Threshold
Cabbage	methanethiol	~.002 ppm
Onion	Ethanethiol	~.002 ppm
Clove, spicy	Eugenol	.1-.006 ppm
Vanilla, sweet	Vanillin	~.004 ppm
Violet, fruity	β-ionone	10^{-6} - 0.2 ppm

Wine Production- Players, Factors and Influences

1° Grapes - Variety, age, season, climate, H2O, integrity, nutrition, yield, micro-organisms / flora, cultural practices…

2° Yeast and Bacteria (*enzymes*) – Species, population, growth conditions (pH, temp., O_2 etc.), substrates, time…

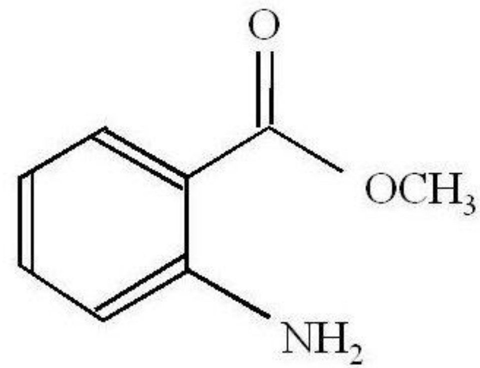
3° Aging – Time and conditions, oxygen, wood / aging vessel, yeast and bacteria, substrates (*1° Aroma*)…



Grapes Contribute Aroma

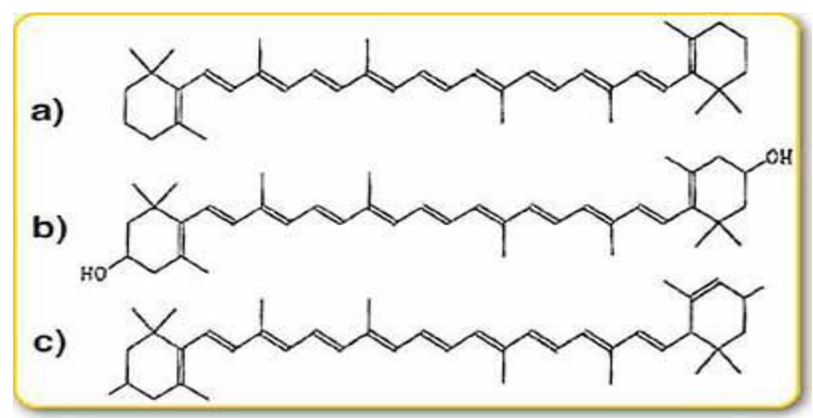
Volatile compounds-

Synthesized and/or modified intracellular; active aroma compounds.



Non-Volatile Precursors –

Fatty acids/amino acids, carbohydrates, phenolics, various hydrocarbons (terpenoids, acids, esters, aldehydes etc.) that are modified extracellular (enzymatic, chemical, and combinations) to yield ***active*** aroma compounds.



Berry Physiology and Compartmentalization

Aroma compounds and precursors are primarily synthesized within the exocarp or skin, although some are produced in the leaves.

Some compounds can be found in the mesocarp or flesh and following loss of cellular integrity.

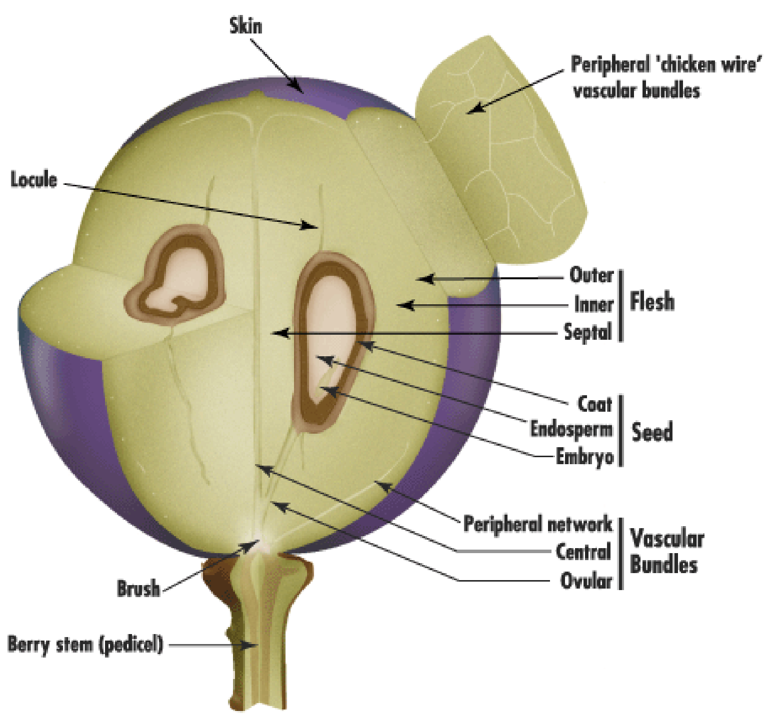


Figure I: Structure of a ripe grape berry partially sectioned on the long and central axis to show internal parts. Illustration by Jordan Koutroumanidis, Winetitles.

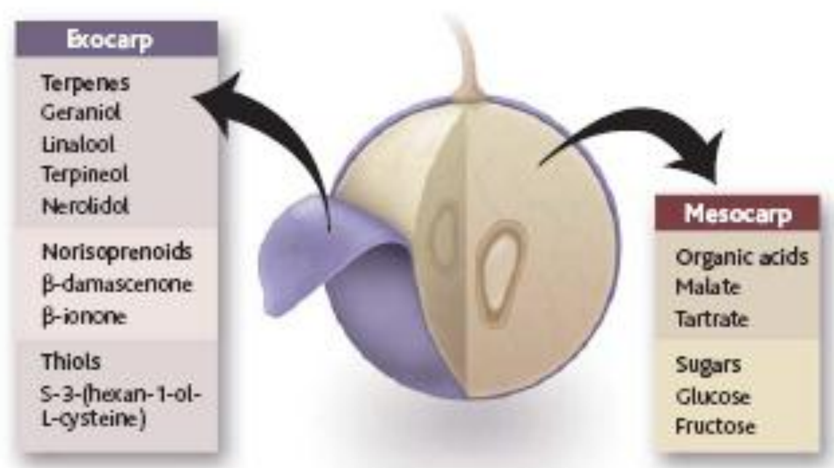


Fig. 1. Major chemical determinants of flavor and wine quality in grape berries are predominantly localized to mesocarp (flesh) or exocarp (skin) tissues. Only a small number of the dozens of known grape compounds important for flavor are represented here. Potentially volatile compounds such as terpenes, norisoprenoids, and thiol precursors are stored as sugar or amino acid conjugates in vacuoles of exocarp cells. The compounds are volatilized through physical crushing and subsequent cleavage by grape, yeast, and/or industrial enzymes (glycosidases and peptidases) during the winemaking process.

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Berry Development

Grape berry development follows are multi-phase progression.

This is generally broken down into a stage of **cell division**, a **lag phase** and a **cell enlargement** phase.

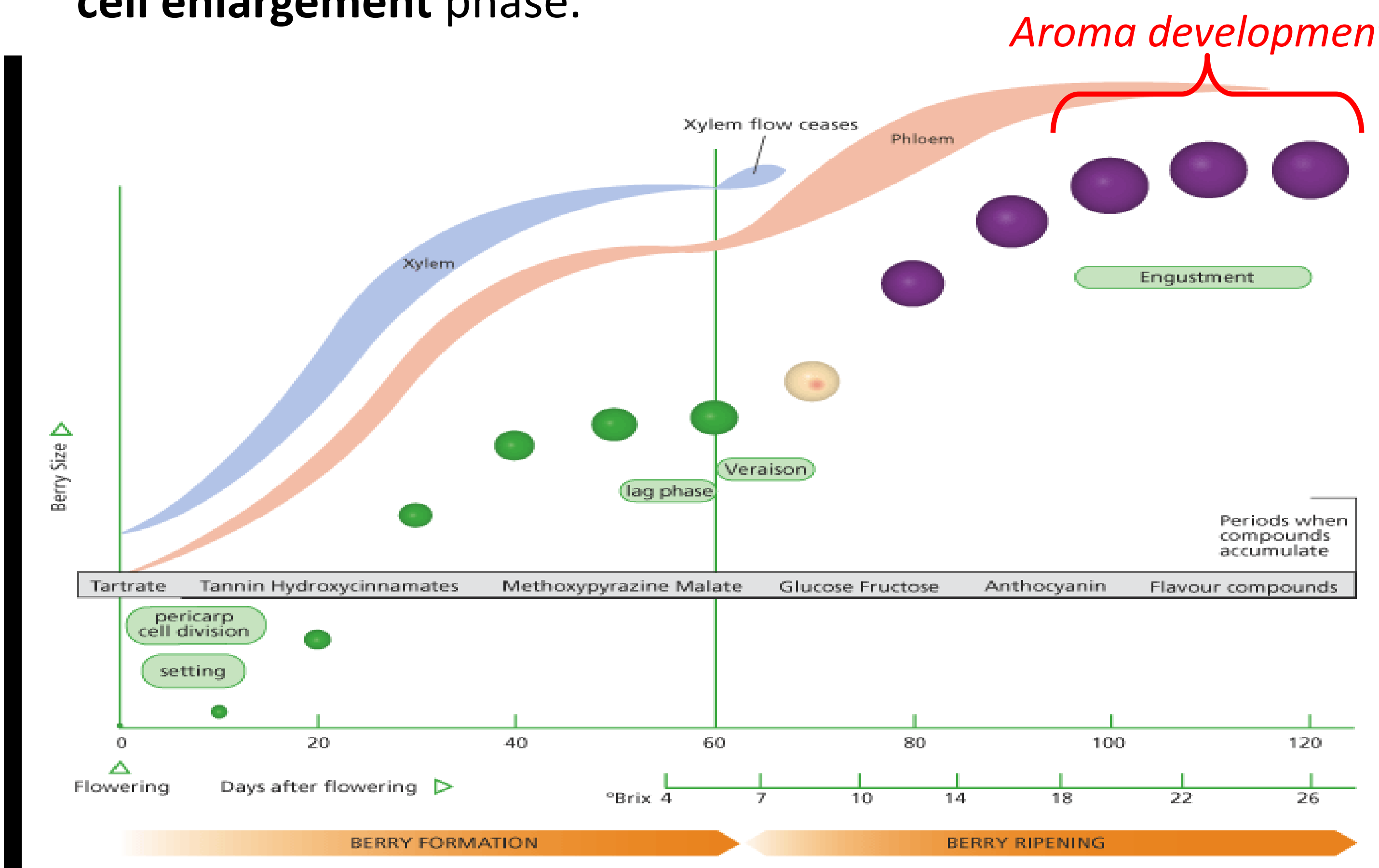


Figure 2: Diagram showing relative size and color of berries at 10-day intervals after flowering, passing through major developmental events (rounded boxes). Also shown are the periods when compounds accumulate, the levels of juice °brix, and an indication of the rate of inflow of xylem and phloem vascular saps into the berry. Illustration by Jordan Koutroumanidis, Winetitles.

More on Berry Development

Typical aroma descriptors of berries and juice during development:

Fruit Set to Veraison
**Minimal aroma*
Minty/Spicy
Vegetal
Green

→

Véraison to Full Color
Aroma develops
Minty/Spicy
Vegetal
Green
Some Floral
Some Fusel/Solvent
Herbaceous

→

Full Color to Seed Viability
Loss of Green
Some minty/spicy
Loss of Vegetal
More Floral
Development of Fruit Aroma
Varietal Character Develops
Some esters/alcohols

→

Berry Ripening (Engustment)
Varietal Character Strongest
Fruity Aromas/Esters
Floral
Earthy or Spicy
Loss of Vegetal*
Loss of Green
Tropical

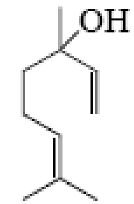
→

Late Harvest
Loss of Floral
Dried Fruit
Dark Fruit
Tropical
Spicy
Earthy, Musty

Major Classes of Aroma Compounds

-**Terpenoids**

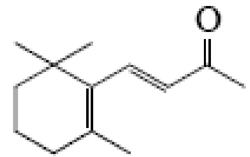
(Linalool)



Linalool

-**Norisoprenoids**

(β-Ionone)



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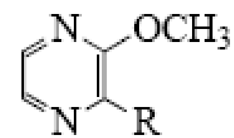
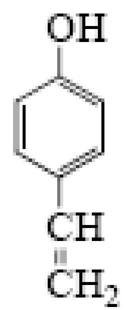
-**Pyrazines**

(i.e. 2-ethyl-3-methoxypyrazine)



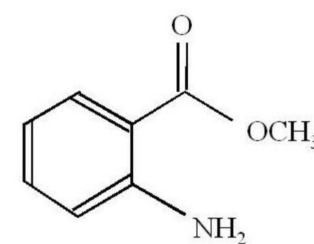
-**Phenols**

(4-vinyl-phenol)



-**Esters**

(methyl anthranilate)



-Other compounds (alcohols, aldehydes, acids via enzymatic or chemical modifications)

Terpenoids

Terpenoids one of the more abundant grape aroma compounds.

(linalool, geraniol, citronellol - floral and tropical aromas)

- Stored and transported as water soluble **glycosides** (*non-volatile*).
- Increase with ***moderate*** sun exposure; precursor to carotenoids

C13 Norisoprenoids

Structurally related to the terpenoids, **norisoprenoids** come from the degradation of carotenoids. (-ionone, -damascenone ; fruity and floral aromas)

- Generally produced after veraison (decline / degradation of cartenoids).
- Most compounds glycosylated (bound form).

Pyrazines

Pyrazines are **nitrogen** containing compounds often associated with herbaceous, vegetative or nutty aromas.

3-alkyl-2-methoxy = roasty/nutty *3-isobutyl-2-methoxy = bell pepper*

- Thought to degrade late in berry maturation due to light/thermal degradation.

Volatile Phenols

Volatile phenolics generally stem from the Shikimate pathway (*like tannins*).

- Some amino acids can be direct volatile precursors.
- Other phenolics can be precursors to aroma compounds (cinnamic acid, coumaric acid, benzoic acid).
- Hydrolysis and modification of phenols can lead to aromatics such as *ethyl-phenol* and *ethyl-quaiacol* (*Bretannomyces* spp*).*

Esters

Esterification between alcohol and carboxylic acids, generally fruity, "sweet" aromas.

- Although many are a result of fermentation some are produced in the plant.
- Methyl anthranilate (***Concord grapes***) results from reaction between MeOH and anthraniloyl CoA.

-Ester formation usually *accompanies fruit ripening*, when enzymes are active.

Metabolism of Fatty Acids

Fatty acid metabolism (e.g. linolenic, linoleic) responsible for many distinctive esters, alcohols, aldehydes, and lactones in fruit (*good and bad*).

- Several pathways active during ***berry ripening***
- Result in lactones (Tropical fruit)

Metabolism of Amino Acids

Amino acids can be direct precursors to volatile aroma compounds.

- Characteristic aroma of ***Sauvignon Blanc*** comes from several ***thiols*** (**S**);
    - 4-mercapto-4-methylpentan-1-ol (citrus zest)
    - 3-mercaptohexan-1-ol (grapefruit and passion fruit)
    - p-mentha-8-thiol-3-one (cat urine; *cat pee ketone*)

Released from **cysteine** precursors.

Managing Grape Aroma

<u>Our ability to influence wine aroma in the vineyard…</u>

- Ripeness (Obviously easier said than done)
- Sun exposure (Moderate exposure vs. shade or open fruiting zone)
- Vine Nutrition
- Vine water status
- Vine vigor / crop load / canopy management
- Vine age / maturity
- Grape Variety
- Biotic Stress / Berry Integrity

Treatment of grapes in vineyard, during harvest, transport and crushing

Physical Stress, Temperature, SO_2, Oxygen, Storage Time

Keeping berries in-tact, undamaged, and at low temperatures is first line of defense.

Discourage / manage unwanted oxidation and enzymatic modifications in general.

Wine Secondary Aroma : Fermentation Bouquet

Once grapes are harvested and delivered to crush pad, assess condition of fruit to determine subsequent production steps.

The development of aromas from this point until aging is considered **2° aroma**.

The activity of yeast, bacteria, enzymes, and related chemical reactions during fermentations.

The starting point for all of this are the grape-based compounds (1° aroma).

How do we get what we want out of the grapes and what can the yeast / microbes contribute to wine aroma as well?

Assuming we have done what we can in the vineyard (in a given year)…
What tools do we have to make the absolute best of what we have at hand!

Skin Contact – Maximizing extraction of potential aroma components from fruit

White wines: Definitive aroma impacts, often followed by light fining (e.g. PVPP)

Rose: Similar process, care to not 'over-extract color', fining.

***Glutathione*:** Natural antioxidant (commercially available), aids in preserving aroma especially in conjunction in proper oxygen management. (*PVW, May/June, 2010*)

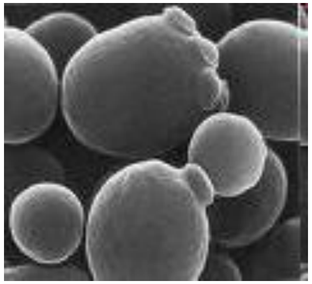
Reds: Not so much an issue- but Cold Soak? No definitive benefit per se (for aroma) – ***Whole Berry / Whole Cluster %***

Saignée: Common tool for managing **solid : juice** ratio (*both under- and over-ripe scenarios*)

Oxygen Management: Important *pre-fermentation* and *once primary AF is complete* – Proper use of $\mathbf{SO_2}$, enological tannins, and inert gases CO_2 (Dry Ice), N2, Ar

Enzymes: Typically ***cell-wall degrading enzymes***, improve extraction and potentially liberation of aroma compounds

During Fermentation



YEAST – Yeast selection may be one of the most influential decisions regarding aroma development post-harvest (2° aroma)

Development of a ***fermentation bouquet*** is one element that can provide a ***'unique' profile*** for your winery.

During yeast metabolism, enzymes are excreted to aid in increasing availability of nutrients etc.

Metabolism of amino acids, fatty acids, production of alcohols and esters

VERY Dependent upon **YAN** (*Yeast Available Nitrogen*)

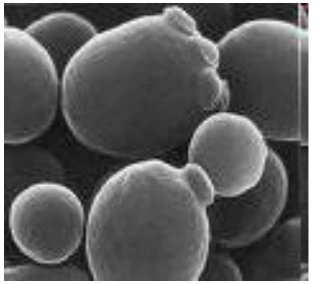
To OPTIMIZE yeast performance, we consider N as well as other yeast nutrients (vitamins, fatty acids, sterols); inactivated yeast products.

Without proper nutrition, we encounter **H_2S** production ("reduction", *rotten egg*).

Want a <u>stress-free fermentation</u> and <u>steady reproductive growth cycle</u>

Yeast search for sources of N for growth, can metabolize sulfur-containing amino acids (cysteine) liberating H_2S.

Temperature: Yeast *WILL work faster at higher temps*, but consequences are not ideal (except for biofuels).



Typically looking for moderate to low temps; 20C/68F, avoiding temps near 30C/85F).

1- Regulate yeast activity to reduce stress aromas
2- Avoid driving off volatile components
3- Time for production and stabilization of *positive* aroma compounds

Selection of Yeast is made much easier by the abundance of well-characterized commercially available yeasts (***native yeasts in your cellar***).

Pay specific attention to profiles: Temperature range, YAN requirements / H2S production, Ester production, ML compatible, suggesting grape varietal → **TRIALS!**

Breaking wines into lots and ***blending*** back is a useful way to build complexity from different yeasts.

Several ***yeast hybrids and yeast blends*** on the market under proprietary names
Harmony, Alchemy, EZ Ferm

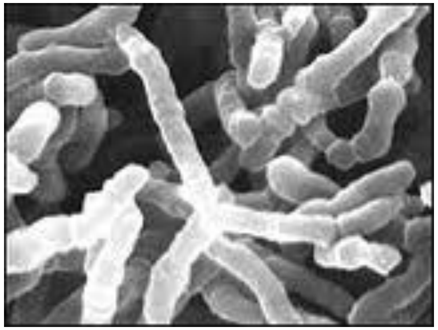
During Fermentation

Monitor fermentations constantly; 2x / day
Looking for **development of stinky aromas** (H_2S) indicating yeast stress
Easy to avoid with **oxygen incorporation** (during active ferment)
drain and return, pump-over, punch down
If adding N; try to ***get a handle on starting YAN*** (FAN, Ammonia ~ ***250ppm +***)
Plan additions of DAP + Nutrients, **avoid heavy DAP** additions at onset

All this said, remember that not every wine is looking for elevated fermentation bouquet, may want a neutral profile to accent varietal character

Pressing - Pressing time can also influence wine aroma
Pressing before dry (natural CO_2) versus ***extended maceration***.

At the end of AF, ***oxygen becomes an enemy*** in most cases.
Simply trying to ***avoid premature loss of fresh aroma*** among other damages due to oxidation.



Malo-lactic or secondary fermentation:
This is a decision based on ***style* *and* *stability***
Not too many choices for strain (*Oenococcus oeni)*
Determine **malic acid content** after AF, is it even an issue?

ML fermentation can result in notable '*buttery*' notes due to production of **diacetyl**.
Metabolism of ***Citric acid*** (Acetolactate decarboxylase : divert diacetyl pathway)

Use of ***lysozyme*** effective in inhibiting ML bacteria (**gram +**) as well as some other potential spoilage microbes.

Sur Lies aging: aside from MF/Tecture, yeast lees contribute to aroma of wine (*some ester / fruity aromas released*)

Continue secondary or aging in ***tank or barrel***?

Aging and Storage: Tank vs Barrel

Matter of **temperature control** (chilling)
Oxygen ingress
Oak flavor / aroma contributions

Bulk aging and storage will result in ***less variability*** when **blended** back at bottling.

Use of **barrels or smaller lots** allows for specific attention and differential treatment contributing to complexity – ***More Work, Risk Aversion?***

Aging and Development tools:

- ***Enzymes*** (liberate bound aroma compounds during aging / bottling)
- ***Tannins***
- Proper **SO_2 / O_2** management
- Vigilance during storage (**VA** and **oxidation** critical!)
- Time before bottling

Packaging

The **last step** (hopefully) between you and the consumer

The right tool for the job:

What style or type of aromas do you intend to deliver?

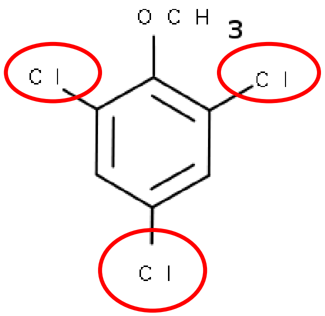
Young, aromatic (2° forward) wines may not need to mature in-bottle.

Natural cork will allow for a slow ingress of O_2 over time

Technical stoppers / screw caps have come very far in delivering the functionality of cork without the risk / costs associated

Cost SHOULD NOT BE AN ISSUE!!! (my 2 cents)

<u>Deliver the wine you intend to deliver</u> (intended age)



<u>Tri-chloroanisole</u> : ***One*** issue with cork

Changes in treatment / cleaning of cork has lowered incidence.

Avoid Cl^- at all times in the winery (not only from cork)

It is well accepted that ***not all wines benefit from the same Oxygen content*** at bottling (DO) or from the same ingress rate over time.

(*aroma profile, tannins/antioxidants/SO2*)

Progress is being made to characterize the changes in aroma relating to oxygen in solution.

Progress has also been made in producing technical stoppers that deliver oxygen at a prescribed rate.

DO measurements (accurate ones) are expensive and probably not realistic for small wineries.

Understand where **O_2 ingress** occurs (racking, transferring, ***bottling***).

The bottom line

Be aware of aroma genesis

Be aware of aroma faults (masking potential)