Winemaking for Grape Growers

Newsom Grape Day
April, 2021

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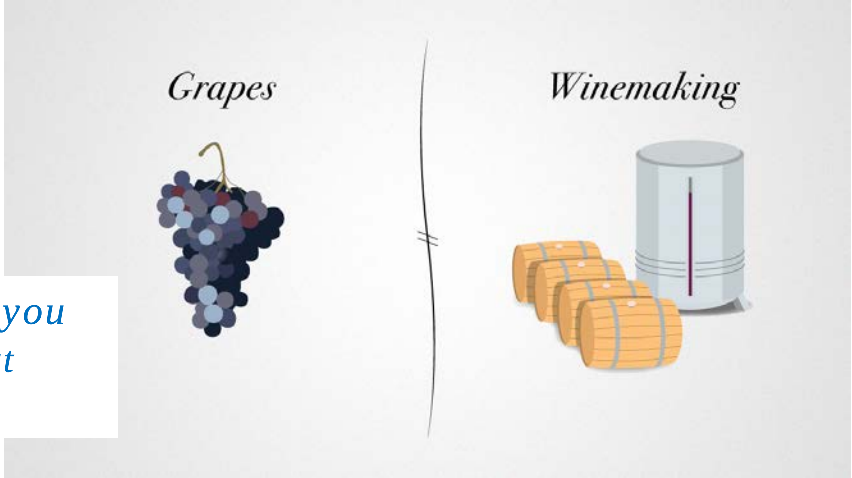
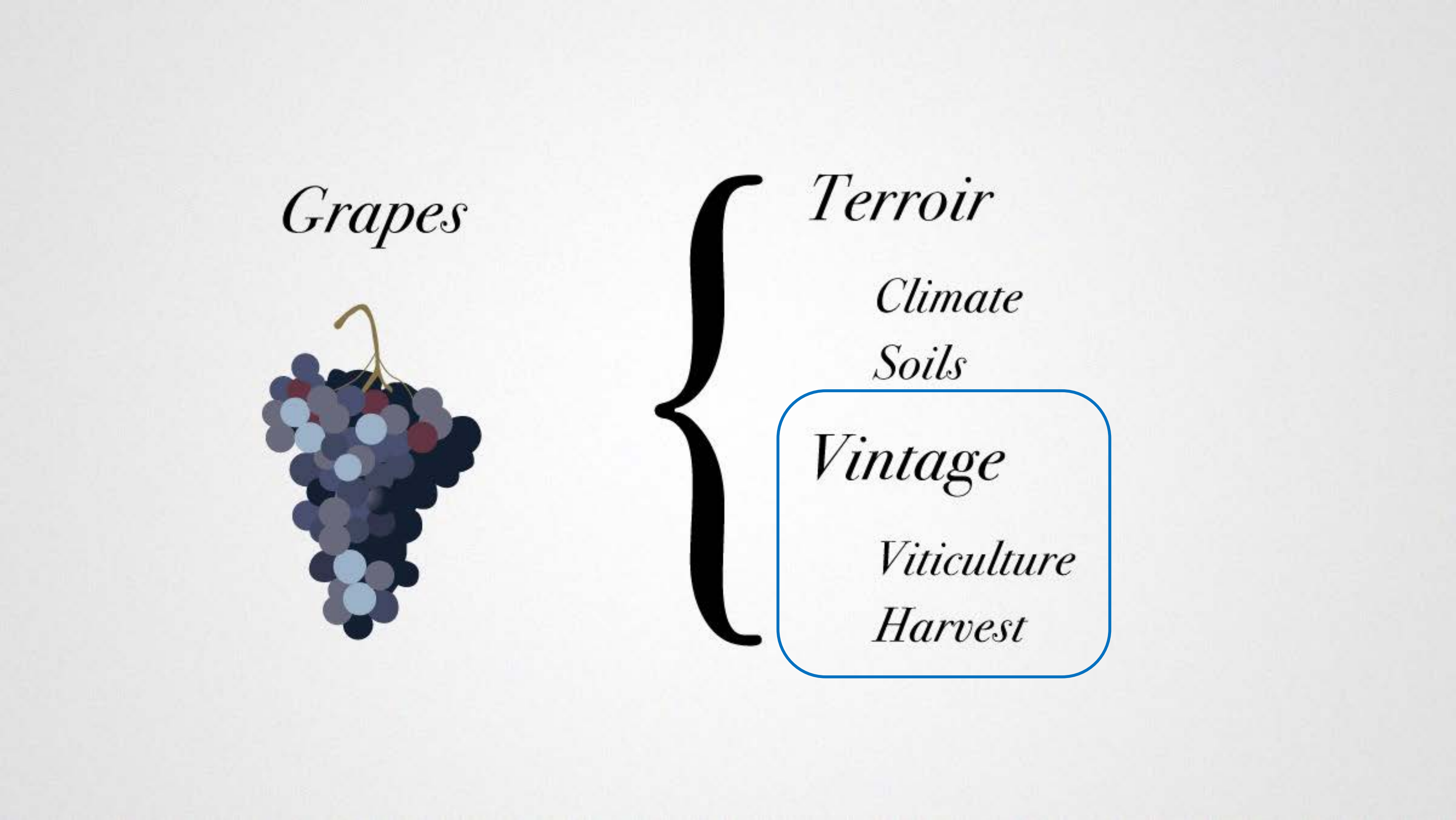
Grape and Wine Quality

- Wine quality is extremely dependent on grape quality!
- Winemaking starts at harvest
- Continues in the winery



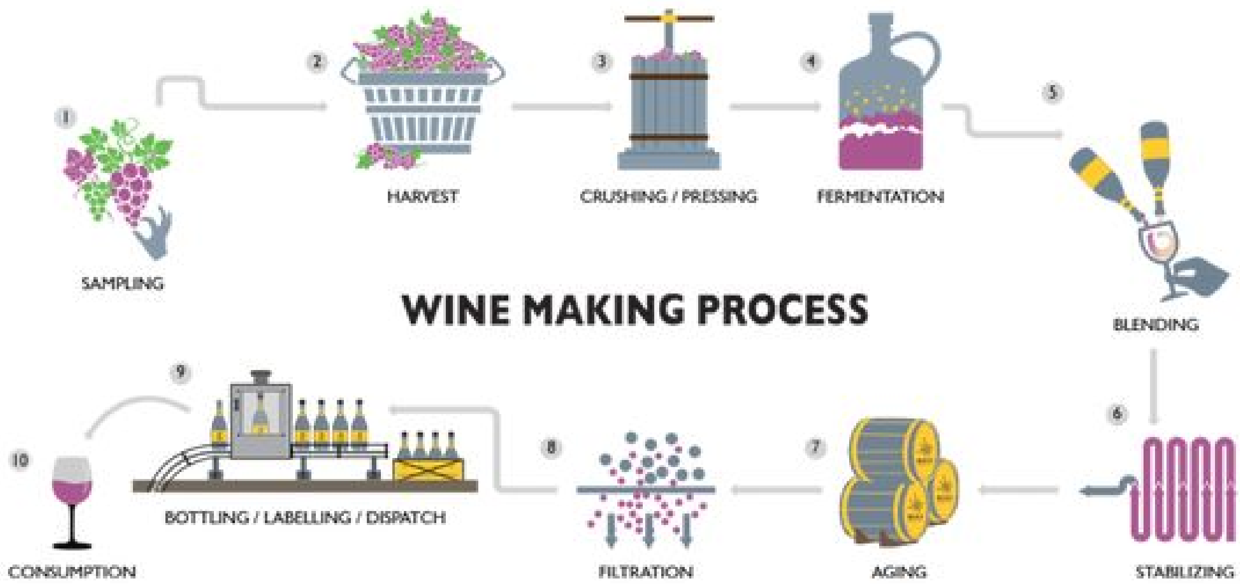
"You can make bad wine with great grapes but you can't make great wine with bad grapes." -Robert Mondavi

Grape quality



Winemaking process

- General steps :
  - Harvest/Sorting
  - Crushing/destemming
  - Fermenting/pressing
  - Maceration for red wine
  - Conditioning (racking, filtering, stabilizing, blending)
  - Aging
  - Bottling



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Harvest and Sorting

- Important because they impact everything downstream
- **Harvest timing** and **quality of grapes** will influence fermentation and parameters of wines

HERE IS WHY

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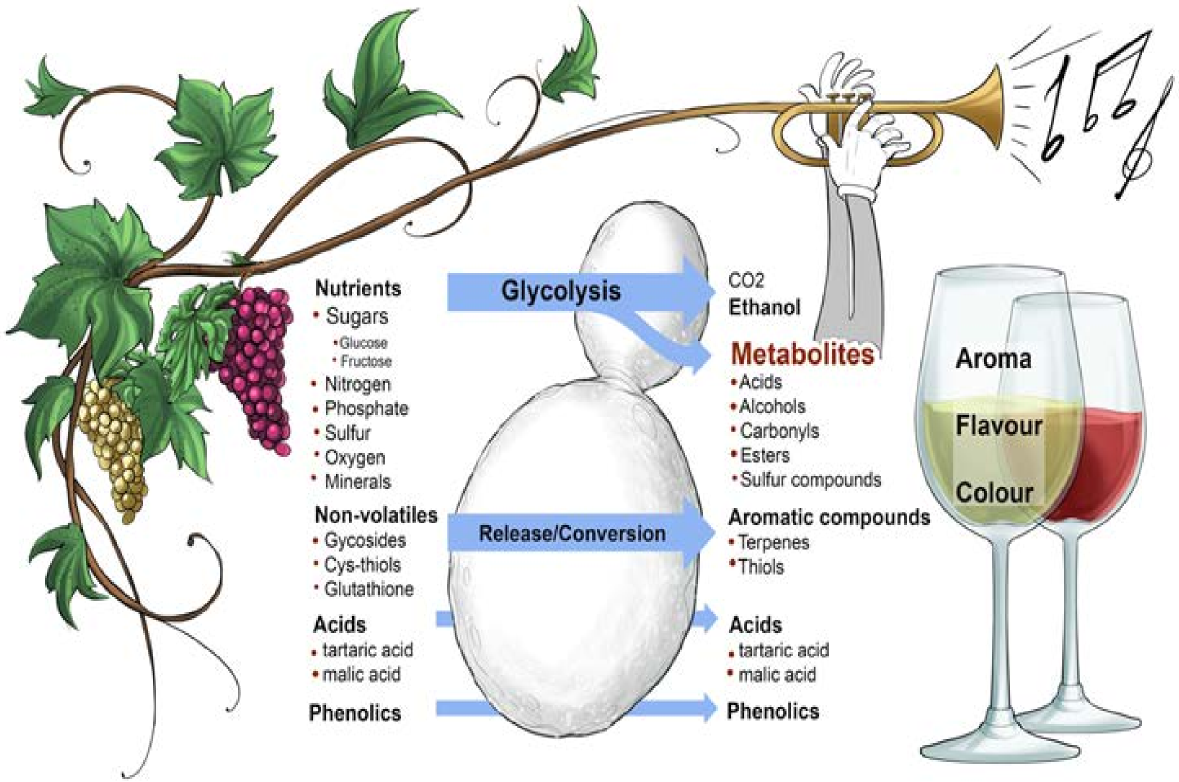
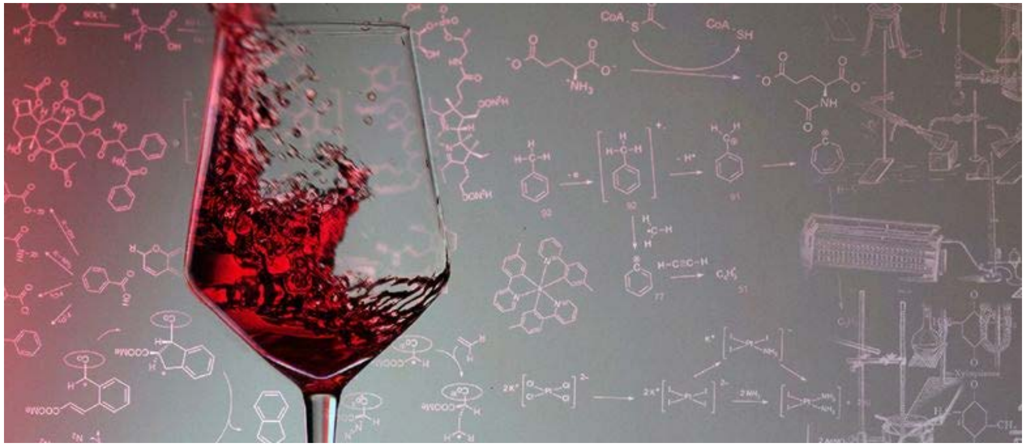
Fermentation

- Fermentation is a very complex process
- Simply put, yeast transform sugars into alcohols.
- Other metabolites are also formed



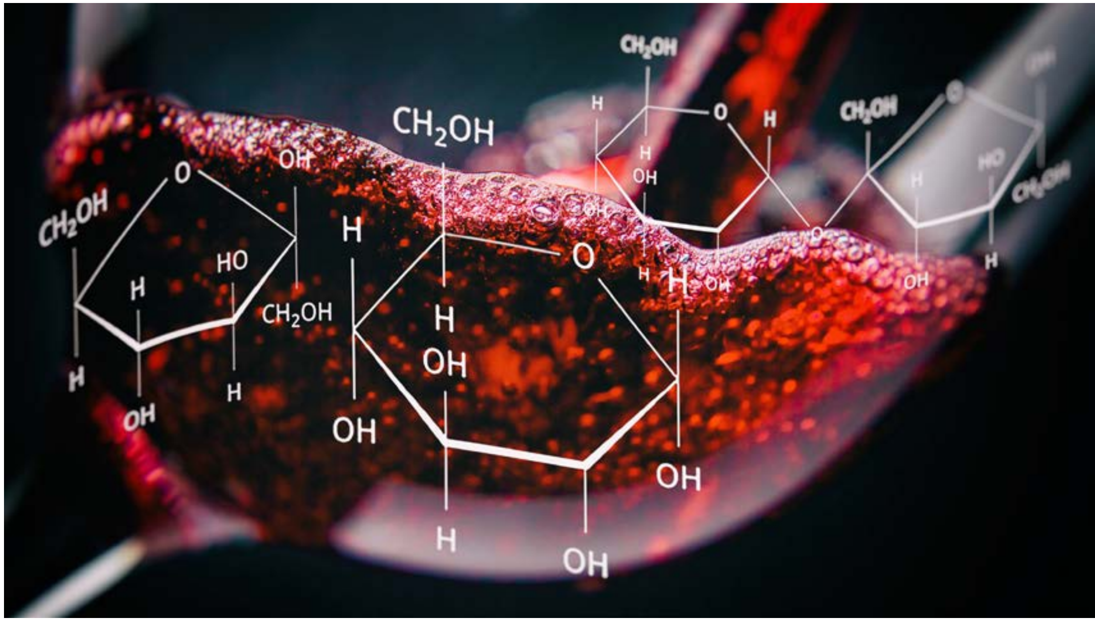
Grape composition

- As grape growers, you need to make sure all the necessary arsenal is present
  - Sugars
  - Acids
  - Tannins & other phenolics
  - Color compounds
  - Aroma compounds and precursors



Sugars

- The amount of sugar in the grapes directly influences how much alcohol the wine can potentially have
- The higher the sugar, the higher the alcohol
- In North America we measure sugar in degrees Brix
- 1 degree Brix is 10 grams of sugar per kg juice
- Very generally speaking 17-18 grams of sugar will generate 1 % alcohol
- So, if we have 22 degrees Brix, potential alcohol is between 12 and 13% alcohol



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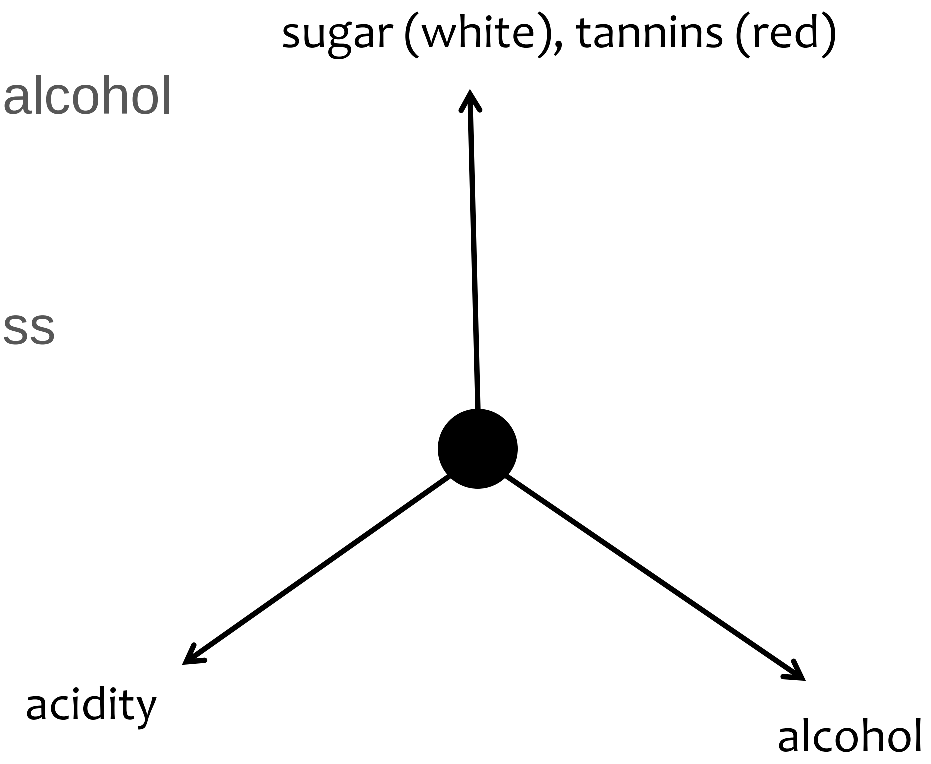
Acids in Grapes and Wine

- Acids balances sugar and alcohol
- Perceived as tart or sour
- Freshness, crispness
- Increase perceived fruitiness

Balance of Components in Wine



Major Acids in Grapes & Wine

Acid	Concentration (g/L)	Origin
Tartaric	2-6 g/L in grapes	Grapes
Malic	>25 g/L in unripe grapes 2-7 g/L in ripe grapes	Grapes
Lactic	0-3 g/L in wine	Fermentation
Citric	0.2 -1.0 g/L in grapes 0-0.7 g/L in wine	Grapes, Fermentation
Succinnic	1.0 g/L in wine	Fermentation
Acetic	0.1-1.0 g/L in wine	Fermentation

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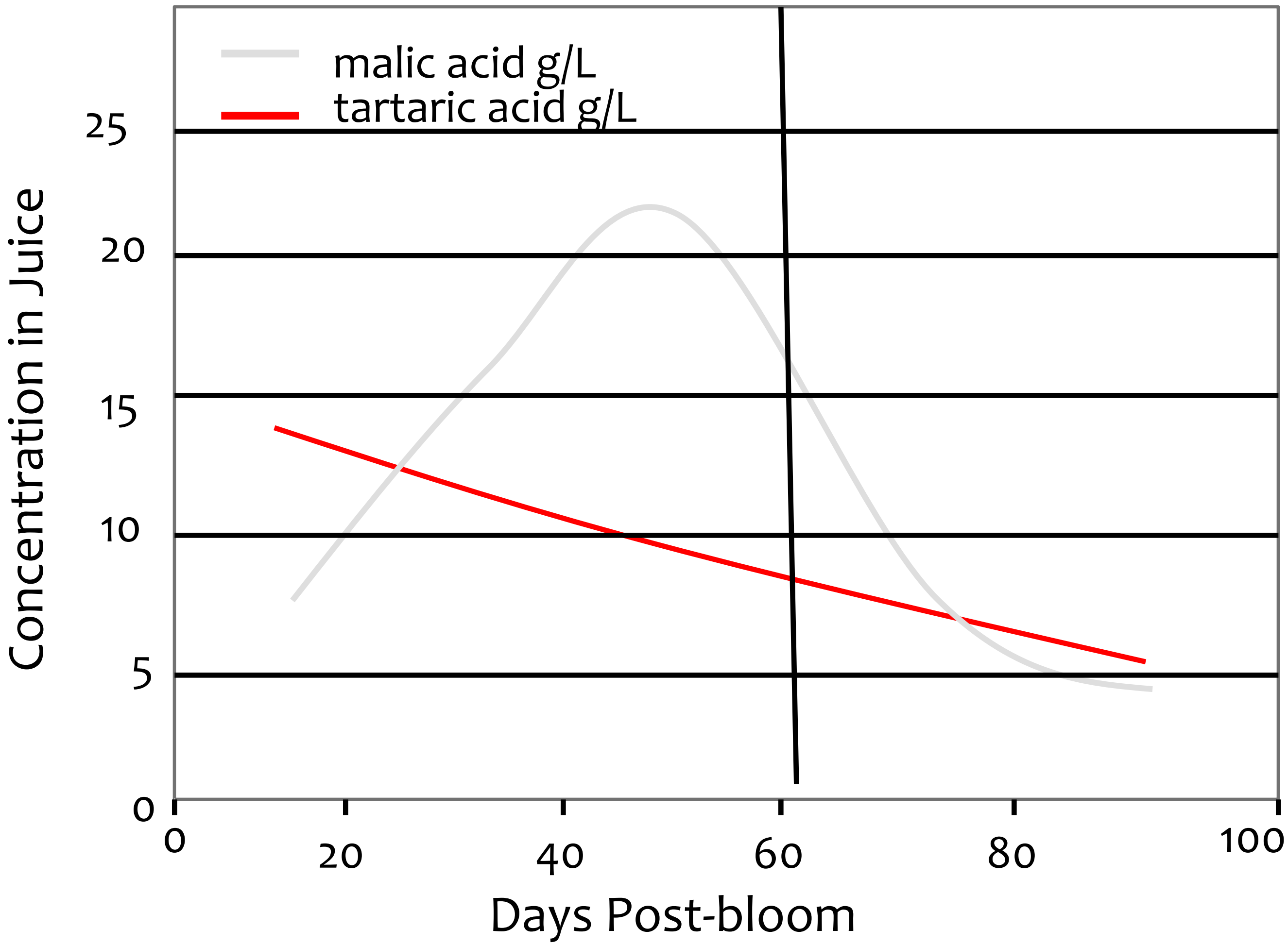
Organic Acids During Berry Development



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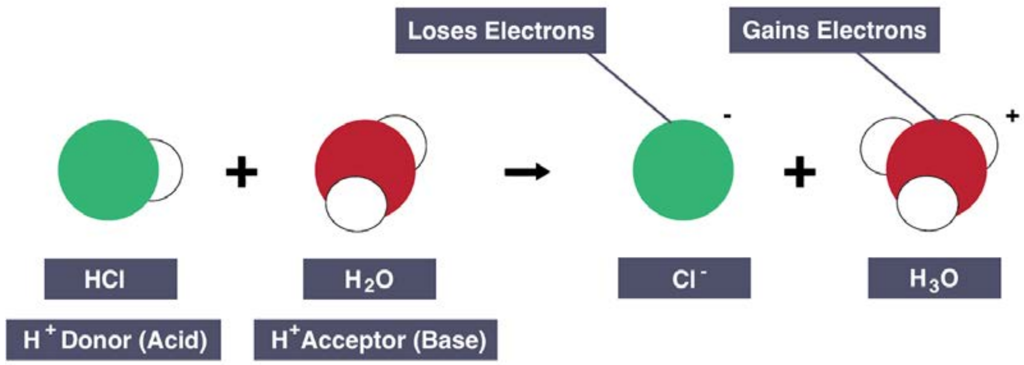
What is an acid?

A proton donor

$$HA \longrightarrow H^+ + A^-$$

any acid — proton — conjugate base or acid anion

A real example:



hydrochloric acid — water — chloride ion — hydronium ion

Acid Dissociation ($HA \longleftrightarrow A^- + H^+$)

- Strong acid – dissociates more or less completely when it dissolves in water (very good donor of H^+)

- Weak acid – dissociates only slightly in water (poor donor of H^+)

pH is a measure of the H+ concentration in a solution.

- The lower the pH, the higher the number of H+
- The lower the pH, the more acidic the solution

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Metrics for Acidity

pH reflects molar concentration of **free** protons

- pH = -log [H^+] (e.g., a wine with a pH of 3 has 10x more free protons than a wine with pH of 4)

Titratable acidity (TA) reflects total concentration of titratable H^+

(both **free** and **undissociated** H^+ that are part of –COOH groups)

Titratable Acidity

- TA reflects mostly in the flavor profile of wines
- It imparts freshness, brightness, crispness to wines.
- Low TA leads to flat and unexciting wines

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Wine pH

- pH is much more important, as it affects first and foremost microbial stability.
- Normally, wine pH falls within the 3-4 interval, with **optimum values falling between 3.2 and 3.7.**
- High pH wines (over 3.7) are much less stable than lower pH wines.
- At a **pH of 4 or above microbiological instability is guaranteed**, leading to spoilage (Brettanomyces, mousy taint, lactic referments) and little ability to age

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Wine pH

- pH also affects color, particularly in red wines. Lower pH wines tend to have red hues, while high pH turn either bluish or brownish

- High pH is less protective against oxidation, affects protein stability and tartaric stability – all important wine quality issues

- **In conclusion, high pH is not desirable and close attention should be paid by the grapegrower to the correct balance of brix vs acidity and pH.**

Sugar Acid Balance

- Sugar and acidity tend to have an inverse relationship, particularly after veraison.
- The higher the sugar, the lower the acids and higher the pH, as acids, particularly malic acid, quickly degrade during ripening
- The current focus on Brix needs to be reevaluated, especially in a hot climate such as Texas

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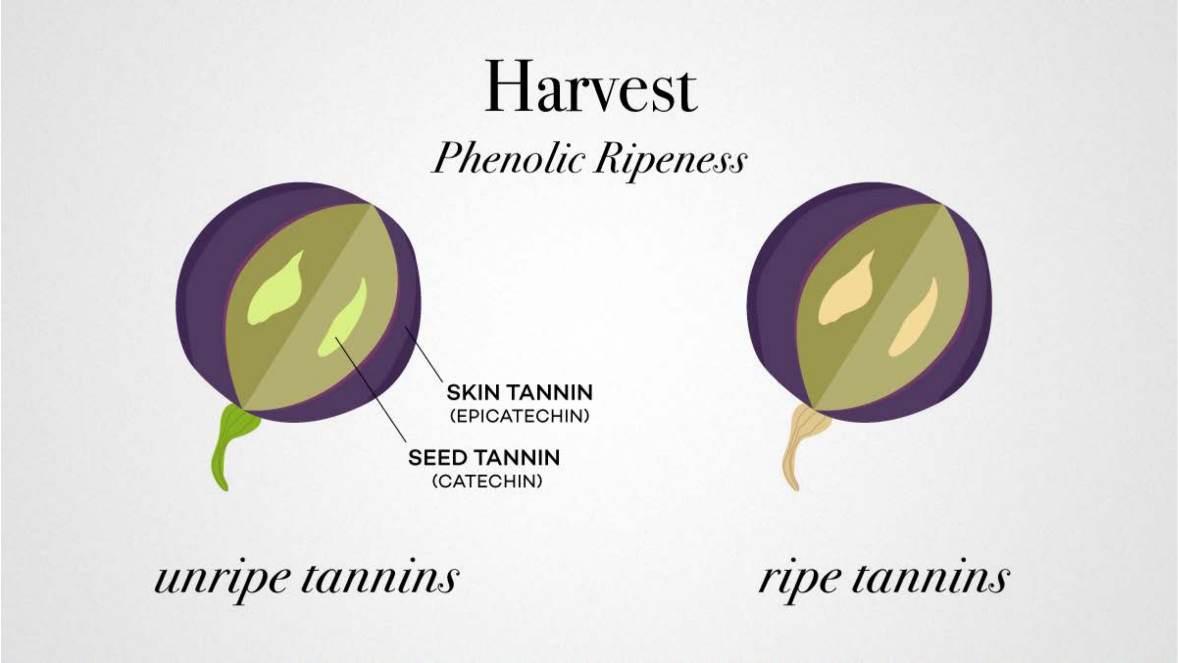
Grape Phenolics

- Grape phenolics play an important role in wine quality, particularly in red wines

- Generally speaking we have
    - **seed phenolics** (cathechin and epicathechin) and
    - **skin phenolics** (tannins and color compounds)



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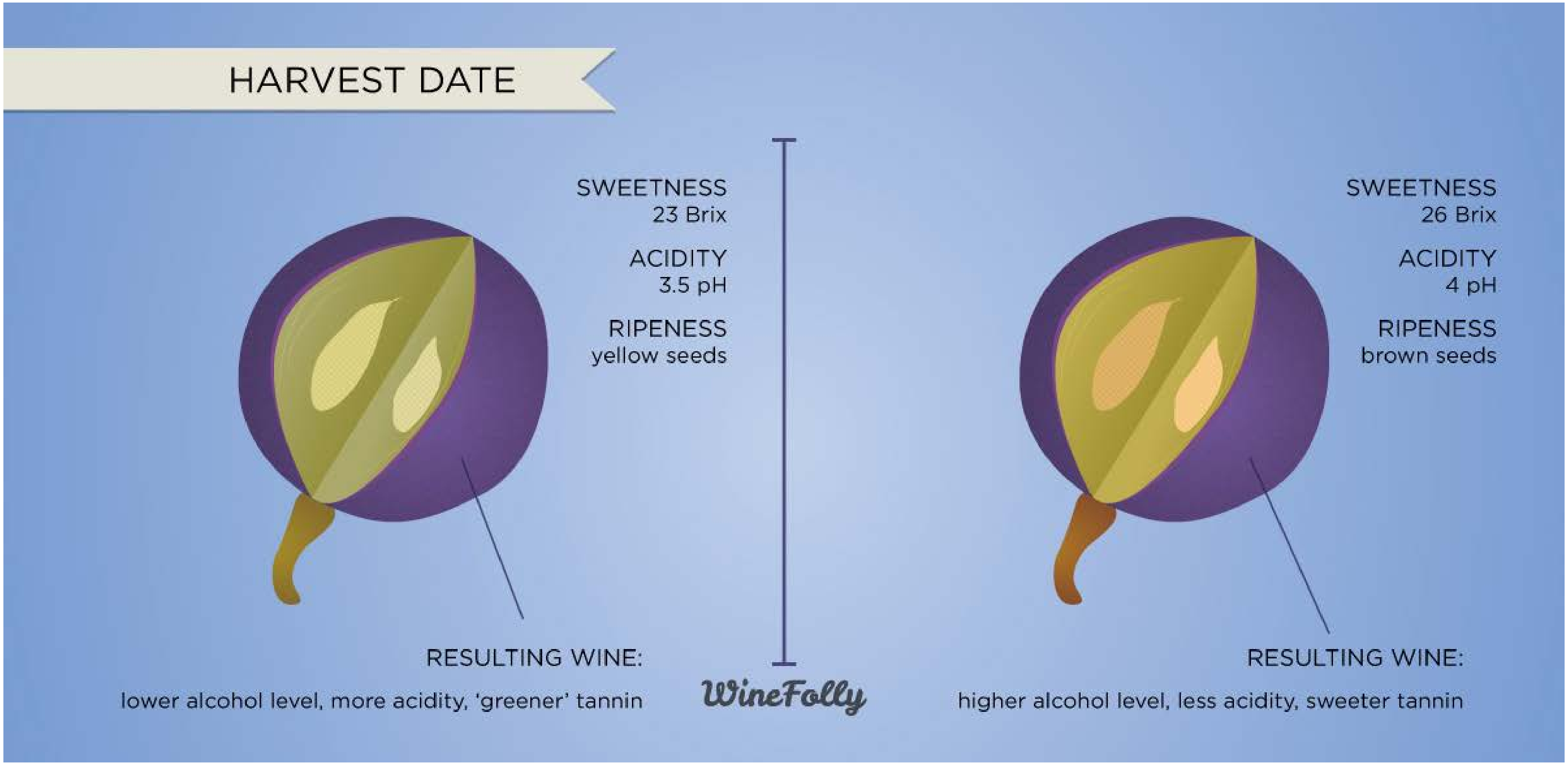
Grape phenolics

- Seed phenolics can lead to bitterness in wines if grapes are not completely ripe
- Skin phenolics play role in color (anthocyanins) and body as well as ageability (tannins).
- As grapes ripen, seed phenolics go down while skin phenolics go up.
- **Monitoring the ratio of seed phenolics to skin tannins helps inform harvest decisions**



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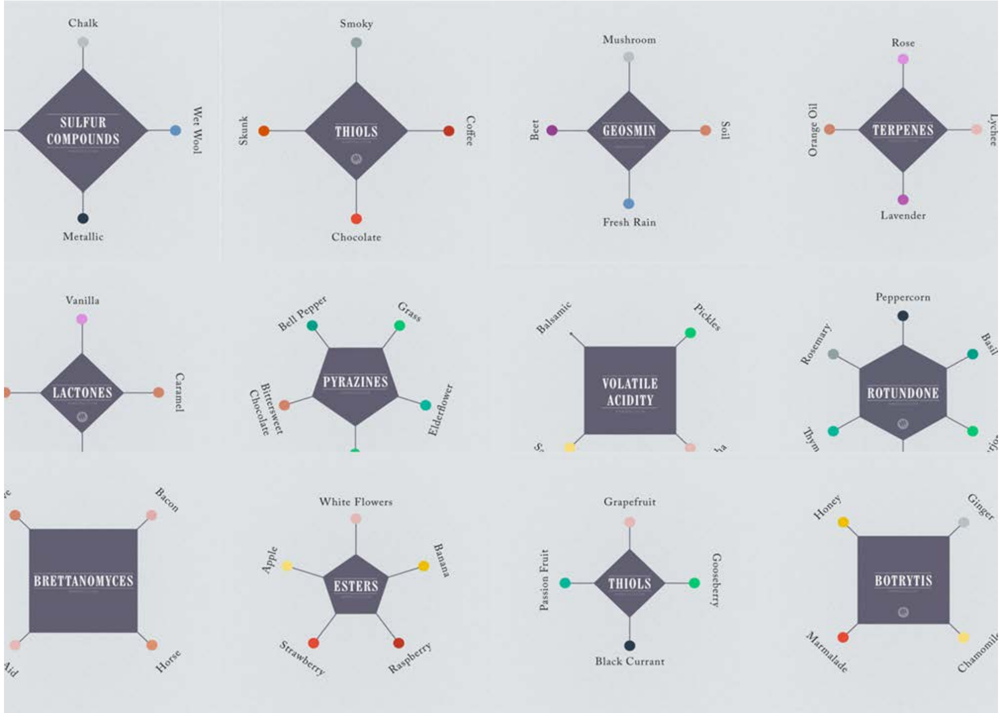
Aroma compounds in grapes

- There are many classes of aroma compounds that accumulate in grapes
- A few of them are volatile
- Most of them are found in the form of precursors that get liberated through microbial metabolism, such as yeast fermentation



Aroma compounds in grapes

- The main classes of aroma compounds found in grapes and wines are pyrazines, terpenes, esters, thiols, lactones some phenols and alcohols

- These compounds contribute to wine quality and tipicity

- It is important that care is taken in the vineyard that optimal conditions are created for the accumulation of desirable compounds or degradation of undesirable ones.

Vineyard practices and wine quality

- **Managing sugar/acid balance**
  - Crop thinning, shoot thinning, shading and water management can all affect sugar and acid accumulation
  - Careful monitoring of sugar and acids is recommended throughout the ripening stages
  - The ideal situation for a grape grower or winemaker is to have the **sugar, acidity and pH levels to be perfectly balanced** at the time of harvesting

Sugar/acid balance

- There are several formulas that viticulturists and winemakers can use that utilize the various measurements of sugar, acid and pH level.
- One method (developed by researchers at the University of California-Davis) is the **Brix:TA ratio**
- For example, a wine with **22° Bx** and **7.5 TA** will have almost a **3:1 Brix:TA ratio**.
- According to the Davis researchers, **the most balanced table wines tend to have a Brix to TA ratio between 3:1 – 3,5:1.**

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Managing acidity in the vineyard

Factors affecting acidity

- Variety
- Temperature (esp. during ripening)
- Shade/exposure
- Crop level/balance
- Plant nutrition/soil fertility/soil moisture

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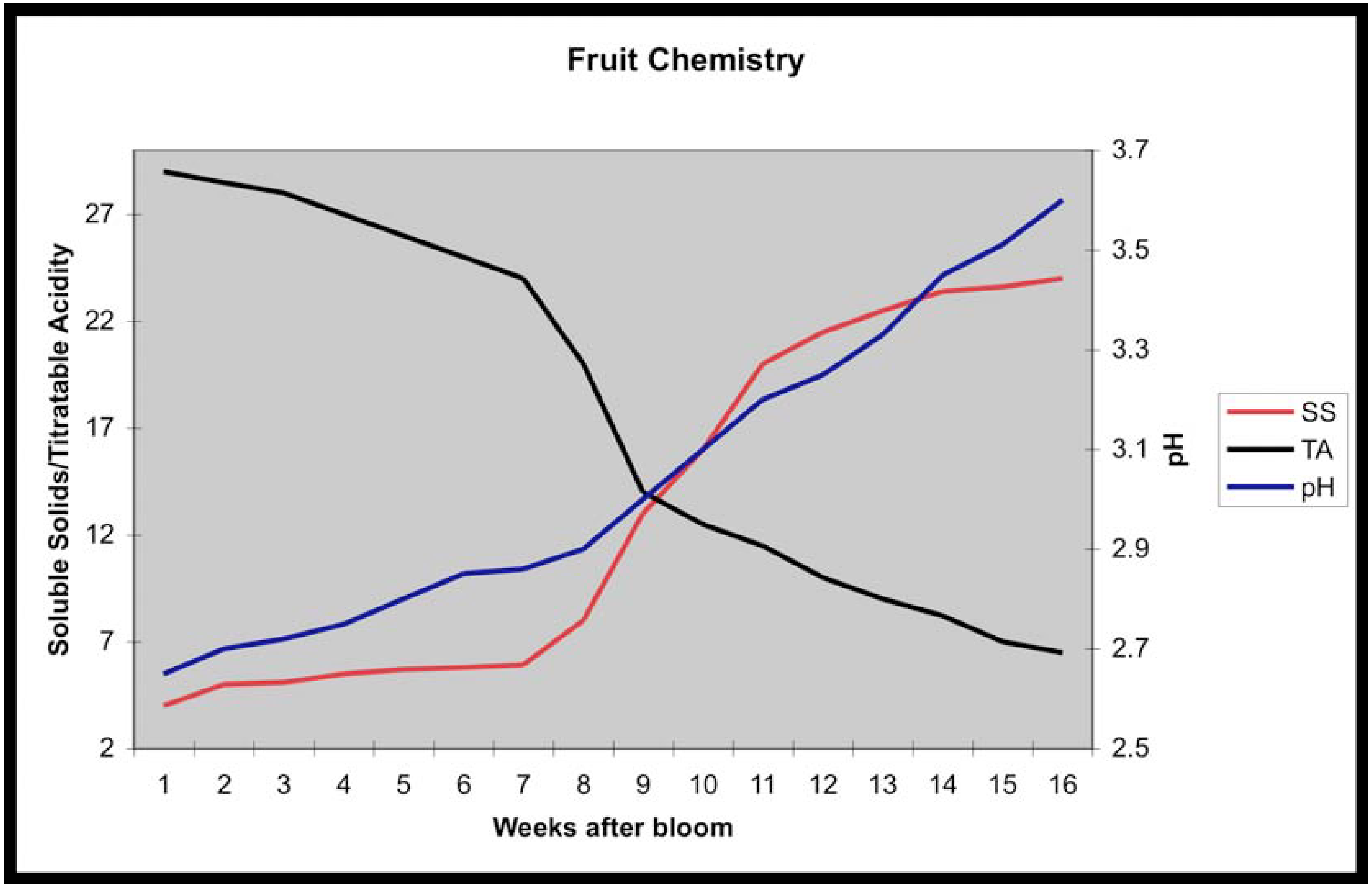
Factors affecting acidity



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Interaction of Variety Ripening Season and Temperature

- Some grape varieties are early ripening (Viognier, Tempranillo, Blanc DuBois) and some are late ripening (Cab Sauv, Mourvedre, Black Spanish)

- Early ripening grapes in a long season, hot area: Excess heat (especially night temps >60˚F)
  - High sugar, low acid, high pH, poor color, poor flavor & aroma

- Late ripening grapes in a short season, cool area: Insufficient heat (especially daytime temps <70˚F)
  - Low sugar, high acid, low pH, unripe herbaceous flavors

- Some varieties have a tendency for high pH and high TA
  - Black Spanish
  - Tempranillo

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Effect of Sun & Shade on Acidity

- TA
  - Excessive exposure of clusters leads to low TA
  - Shaded canopy leads to low TA
  - Shaded clusters leads to high TA
- pH
  - Shaded canopy (3+ leaf layers) leads to high pH
  - Well exposed canopy (1-2 layers) leads to low pH

Effect of Crop Load on Acidity

- TA
  - High crop load leads to high TA
  - Low crop load leads to low TA
- pH
  - High crop loads leads to low pH
  - Low crop loads leads to high pH

Soil and Plant Nutrition

- Soils deficient in K^+ lead to plant health problems (poor growth, reduced cold hardiness, increased disease susceptibility, etc)
- K^+ levels in soils are indirectly related to K^+ levels in plants
- Excess K^+ in soils will not lead to excess K^+ levels in plants
  - Active uptake, enzyme site saturation
- Large rootstock effect
  - *V. champinii* (Ramsey, Dogridge, Freedom, Harmony) increase K^+ up to 2x
- Soil pH can be important
  - K is less available at low soil pH
  - High K and high pH can lead to excess K and Mg deficiency.
- Soil moisture is important… K^+ must be in solution for uptake

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Managing aroma compounds

- Managing sunlight in order to have different percentages of exposure to sunlight on grape clusters.
  - Shading can be achieved using vines' own leaves or artificial shading materials such as shading cloth

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Managing aroma compounds

- For example – in Muscat cultivars the highest concentration of free terpenols was found in artificially semi shaded clusters. Linalool in particular (which imparts flowery or lavender or rose aromas) is very sensitive to sunlight exposure
- Muscat and Syrah bunches shaded to 90% had lower levels of monoterpenols and c13 norisoprenoids precursors
- TDN (an undesirable aroma compound) and acetal were both increased in Riesling grapes with sun exposure

Managing aroma compounds

- **Training and canopy management** can also influence aroma compounds concentration in grapes.
  - Alternate double cross-arm training of Riesling vines led to higher free volatile terpenes and their precursors
  - Viognier grapes had higher levels of free volatiles (linalool, α-terpineol, β-damascenone and n-hexanol) if subjected to Smart-Dyson training.
  - Levels of geraniol and other monoterpenes in Traminette juice were higher following vertical shoot-positioning training.

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Managing aroma compounds

- **Basal leaf removal** tended to increase Free Volatile Terpenes (FVT) and Potential Volatile Terpenes (PVT) in Gewurztraminer vines
  - wines from the vines so treated were generally richer in muscat and floral aroma and flavor.
- FVT and PVT found to be higher in the berries of Chardonnay Musque vines following **cluster thinning** and **basal leaf removal**.
- There are many other examples available in the scientific literature.

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Managing aroma compounds

- Water and water stress can also play a major role in the final aroma potential of the grapes:
  - Cabernet Sauvignon made from **minimal irrigation** treatment were significantly **higher in red/blackberry aroma, jam/cooked berry aroma, dried fruit/raisin aroma**, and fruit by mouth than the wines from the irrigated treatments.

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Managing Aroma Compounds

- Grapes from Sauvignon Blanc vines subjected to **moderate water stress** also have **higher concentrations of aroma compound precursors t**han those with unlimited water supply.
- In Agiorgitiko vines **limited water availability** seems to **increase the levels of the precursors** of the main aromatic components.
- Wines from own-rooted Merlot vines that were supplied with only 35% of their estimated crop evapotranspiration requirement throughout the berry development had more vitispiranes, β-damascenone, guaiacol,4-methylguaiacol, 4-ethylguaiacol, and 4 vinylguaiacol than wine produced from well-watered vines

Managing aroma compounds

- In the case of **methoxypyrazines** – compounds that impart **greenness and vegetal like aromas** such as bell pepper, green beans or asparagus, **light exposure** and climate likely have the largest effect on both their synthesis and degradation

COMPOUND:	THRESHOLD:	CONCENTRATION:	AROMAS:	REFERENCE:
IBMP 	WHITE WINE: 1 ng/L RED WINE: 16 ng/L	WHITE WINE: 4.7 – 33 ng/L RED WINE: up to 56 ng/L	Bell pepper Vegetal Dead leaves Asparagus Canned green bean Fresh mushroom Musty Earthy	*Allen et al. 1995* *Botezatu & Pickering 2012* *Hjelmeland et al. 2016* *Sidhu et al. 2015*
IPMP 	.3 ng/L	WHITE WINE: 0 – 3 ng/L RED WINE: up to 27 ng/L	Peas Green/herbaceous Canned green bean Musty Earthy Peanuts Fresh mushroom Vegetal/dead leaves	*Allen et al. 1995* *Botezatu & Pickering 2012* *Boteza et al. 2013* *Hjelmeland et al. 2016*

GRAVITY

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Managing aroma compounds

- Exposing clusters to sunlight can result in reduced MP concentration in the berries, while high vine vigor leads to elevated levels
- The timing of leaf removal to improve light exposure appears particularly important, with earlier (after berry-set but pre-véraison) interventions most effective, leading to IBMP reductions of up to 60% in both white and red cultivars

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Managing quality through grape health

- Care must be also taken in regards to grape health. Grape diseases can have a big influence on wine quality.
  - Grapes affected by *Botrytis cinerea* can lead to an increase of gluconic acid concentrations in wines, which might have a detrimental effect
  - Botrytis in its noble form can, on the other hand, have a positive effect on wine aroma and flavor

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Table 1. Organisms Associated with Grape Bunch Rots, Trivial Names, and a Summary of Documented Impacts on Wine Quality and Selected References

organism	trivial name and appearance	reported impacts on wine quality	selected refs
Alternaria spp.	black mold	unknown	104, 209
Aspergillus spp.	black sooty mold	mycotoxin production (e.g., ochratoxin A (5) in some strains of *A. niger* and other *Apergillus* species)	150, 151, 210
Botrytis cinerea	gray mold/noble rot	loss of red wine color, earthy mushroom aromas	47, 115, 118, 134
Cladosporium spp.	dark green velvety mold	unknown	62
Colletotrichum spp.	orange sporulation – ripe rot	Hessian sack and musty off-flavors, higher VA, glycerol and gluconic acid	116, 211
Elsinoë ampelina	black spot	unknown (disease primarily affects table grape varieties)	68
	black spot or lesion on immature berry that becomes a black hardened scar on ripening		
Greeneria uvicola	bitter rot, black rings of sporulation around circumference of berry	bitter off-flavors	49, 78
Guignardia bidwellii	black rot	unknown	63, 64, 212
Penicillium spp.	blue-green mold	earthy, mushroom aromas. mycotoxin production (patulin) by some strains	118,163–165, 213–215
Rhizopus	black mold	unknown	118, 209
indigenous yeasts, bacteria, and filamentous fungi	sour rot	largely formation of ethyl acetate and acetic acid, but variable depending on the particular complex of organisms involved	50, 114, 170
	watery berries, smell of vinegar		

Table 2. Organisms Capable of Infecting Grape Berries That Are Normally Regarded as Pathogens of the Vegetative Tissues and Selected References

organism	trivial name and appearance on berries	vegetative tissue more commonly affected	reported impacts on wine quality	selected refs
Botryosphaeriaceae	macrophoma rot	trunk and other woody tissues	unknown	112
	bunch rot of mature berries			
Erysiphe necator	powdery mildew of preveraison berries	leaves	wine haze	135
			reduction in levels of 3-mercaptohexanol associated with Sauvignon varietals	175
Phomopsis viticlola	bunch rot of mature berries	leaves, green shoots, and lignified canes	unknown	109, 111
Plasmopara viticola	downy mildew on preveraison berries	leaves	unknown	106

Grapevine Bunch Rots: Impacts on Wine Composition, Quality, and Potential Procedures for the Removal of Wine Faults

Grape Health

- In the case of **Grapevine Leafroll Disease** differences in total soluble solid between grapes of symptomatic and non-symptomatic vines were more pronounced after the onset of *véraison*, with significantly lower concentrations of TSS in grapes from symptomatic vines throughout berry ripening until harvest.

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Grape Health

- Wines made from grapes of GLD - affected vines had significantly lower alcohol, polymeric pigments, and anthocyanins compared to corresponding wines from grapes of non-symptomatic vines.

- Sensory descriptive analysis of the wines indicated significant differences in color, aroma and astringency between wines made from grapes harvested from GLD-affected and unaffected vines.

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