UNIVERSITÉ DE MONTPELLIER

WINE TECHNOLOGY

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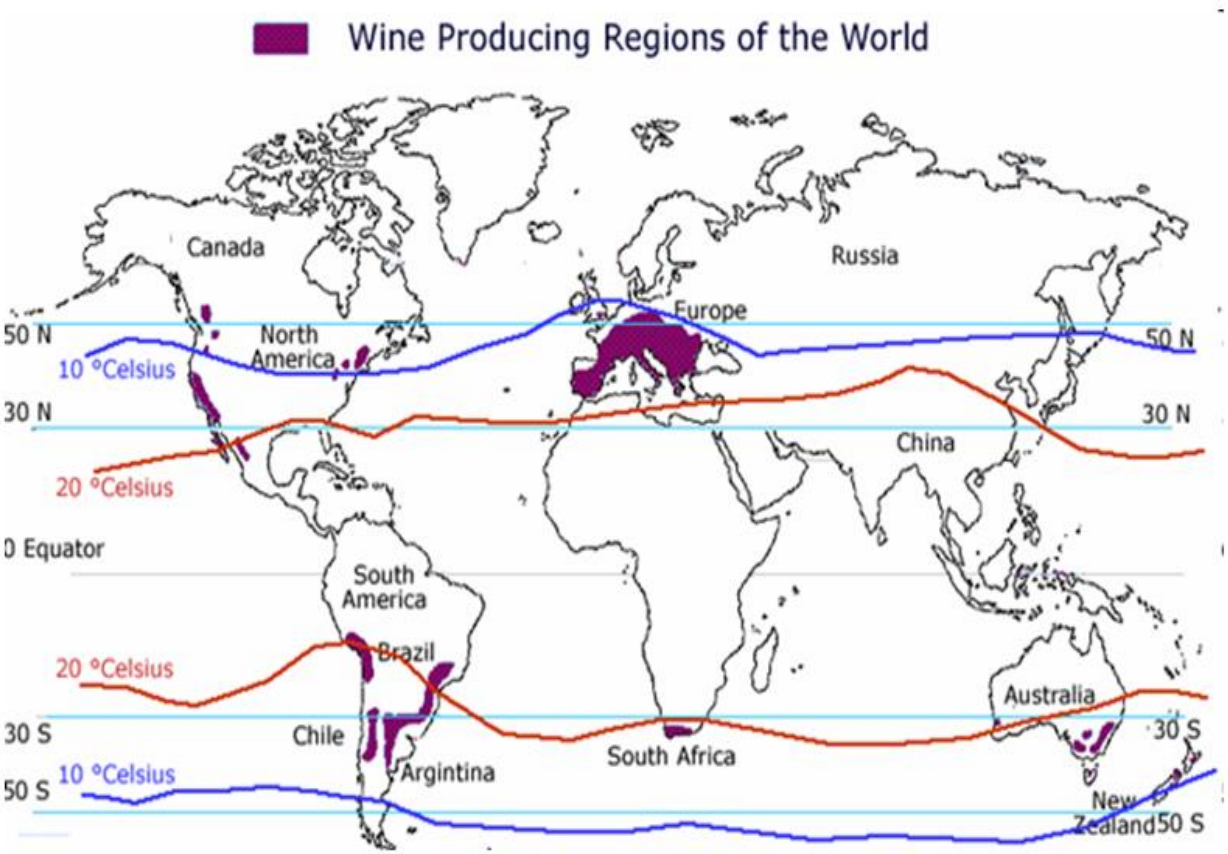
INTRODUCTION

Wine is the beverage resulting exclusively from the partial or complete alcoholic fermentation of fresh grapes, whether crushed or not, or of grape must.

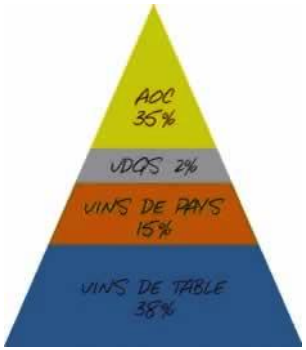


✓The world's wine regions are located between 30 and 50 degrees north latitude and 30 and 50 degrees south latitude

✓In 2013, the five largest producers of wine in the world were, in order, Italy,Spain, France, the United States and China . World wine produxtion 2013 : 27,864,100 liters (wineinstitute.org)

Classification of wines in France

- ✓ **APPELLATION d'ORIGINE CONTRÔLÉE is the French system of designating, controlling and protecting the terroir and wine quality**
- ✓ **It is often used as abbreviated (AOC)**
- ✓ **Possibility to blend several varieties often (Complexit**



AOC Grands Crus

AOC Crus

AOC Communales or Villages

AOC Régionales

Country Wines

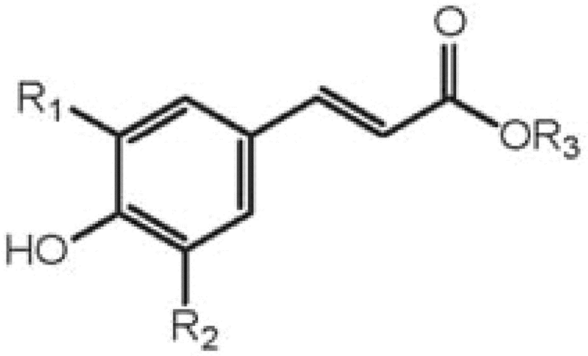
Table Wines

Wine consumption per capita 2013 : Vatican city state 50 liter,France 43 liter,Japan 2,7 liter

Composition (g/L) of grape juice and wine

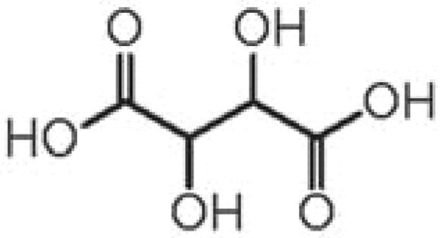
	Grape juice	Wine
Water	750-900	750-900
Ethyl alcohol	<3.5	70-100
Sugars	140-200	<2
Polysaccharides	2-4	2-4
Organic acids		
Tartric	1.5-3	1.5-3
Malic or lactic	1.5-4	1-4
Glycerol	<0.1	4-10
Mineral (K+)	0.9-1.6	0.7-1.6
Nitrogenous cpds	<1	<0.5
Phenolic cpds	0.1-7	0.1-7
Volatile cpds	<0.1	0.3-2

PHENOLICS IN GRAPE : Hydoxycinnamic acid derivatives



Hydroxycinnamic Acid	R_1	R_2
p-coumaric	H	H
caffeic	OH	H
ferulic	OCH_3	H
sinapic	OCH_3	OCH_3

R_3 esterification



tartaric acid

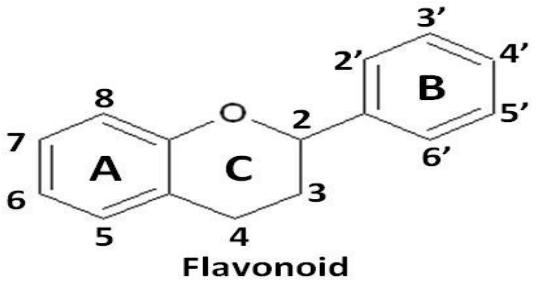
Kennedy et al., 2006

✓Hydroxycinnamic acids occur mainly in esterified from (tartrate) in grape

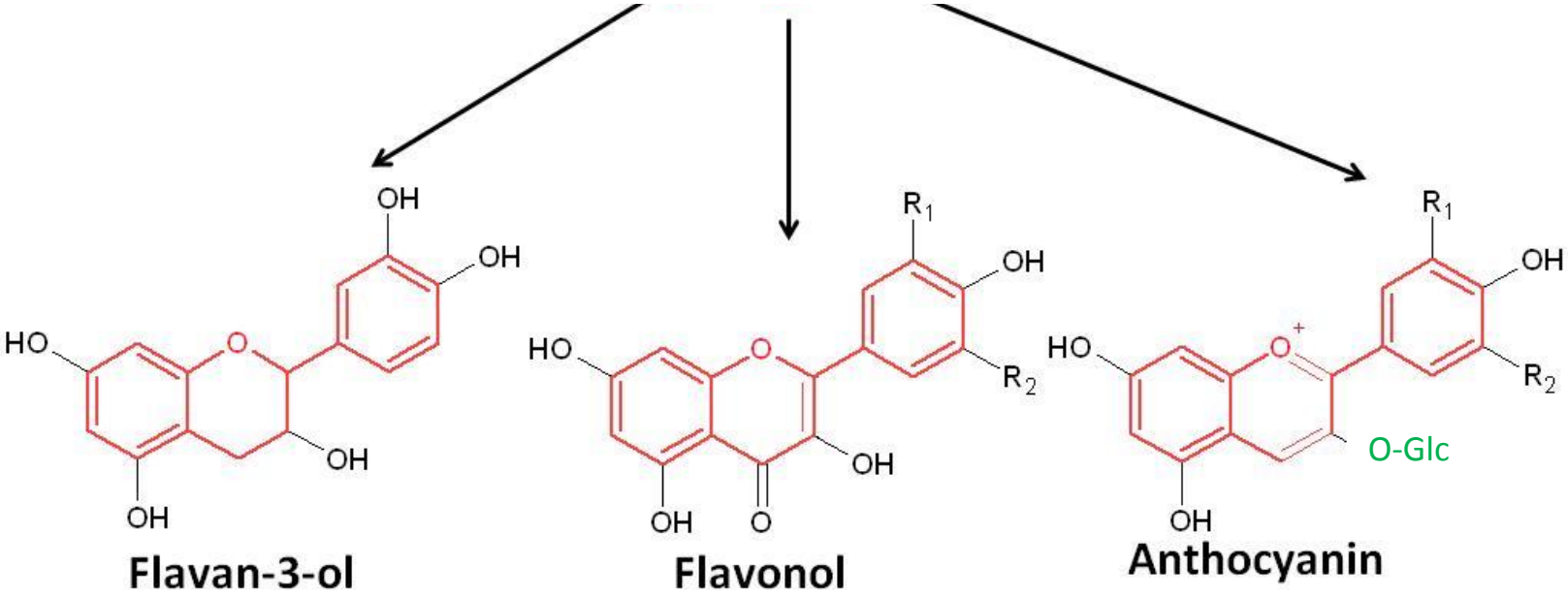
✓They are among the best substrates of grape polyphenol oxydase and laccase from Botrytis cinerea that infect berries. Their enzymaticoxydation leads to the browning of white grape juices and wines

✓They do not participate to the taste of the wine. BUT decarboxylation of p-coumaric acid and ferulic acid by the yeast and bacteria during fermentation leads to flavor compounds

PHENOLICS IN GRAPE : Flavonoids



Flavonoid

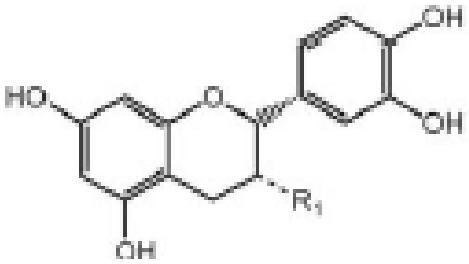


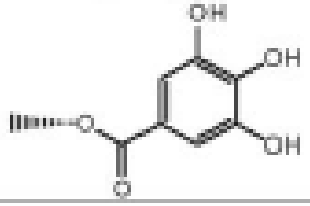
Flavan-3-ol

Flavonol

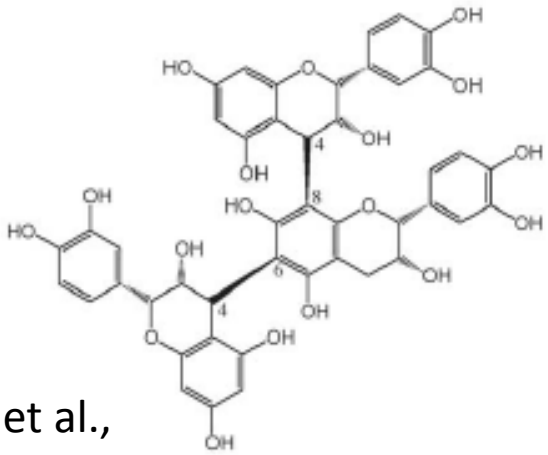
Anthocyanin

PART I PHENOLICS IN GRAPE : Flavan-3-ol



Flavan-3-ol Monomer	R_1
(+)-catechin	
(-)-epicatechin	
(-)-epicatechin-3-O-gallate	

Structures of flavan-3-ol monomers and proanthocyanidins subunits



Kennedy et al., 2006

Proanthocyanidin structure (tannins)

✓Tannins (polymers of flavan-3-ol) contribute to red wine character, astringency (most significantly) and bitterness. They bound with salivary proline-rich proteins. This gives a sense of roughness and dryness.

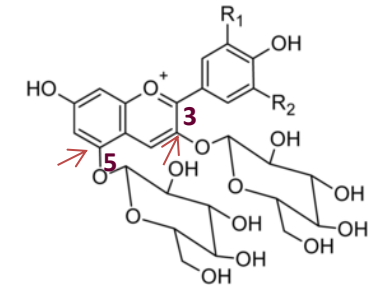
✓The astringency of tannins usually increases with degree of polymerization (dp).

✓Astringency ➡ dp12>dp8>dp5>dp3.
Grape seed tannins are more polymerized than skin tannins.

PART I

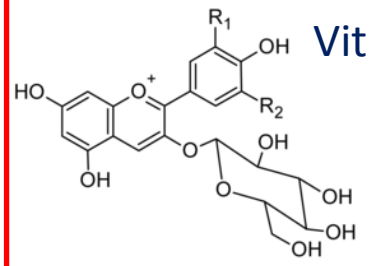
PHENOLICS IN GRAPE :

Anthocyanins in grape cultivars from Vitis vinifera, V. rupestris, V.riparia, V.Labrusca and V.lincecumii

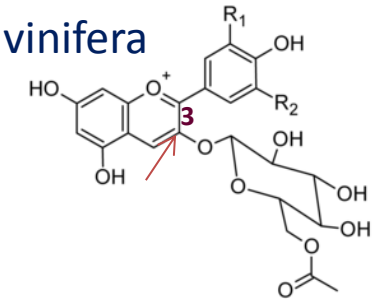


delphinidin (Dp) 3,5-*O*-diglucoside	R_1=OH; R_2=OH
cyanidin (Cy) 3,5-*O*-diglucoside	R_1=H; R_2=OH
petunidin (Pt) 3,5-*O*-diglucoside	R_1=OCH_3; R_2=OH
peonidin (Pn) 3,5-*O*-diglucoside	R_1=OCH_3; R_2=H
malvidin (Mv) 3,5-*O*-diglucoside	R_1=OCH_3; R_2=OCH

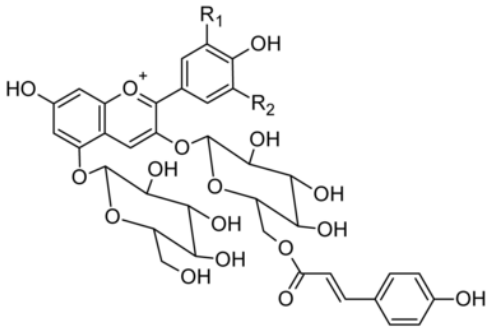
Vitis vinifera



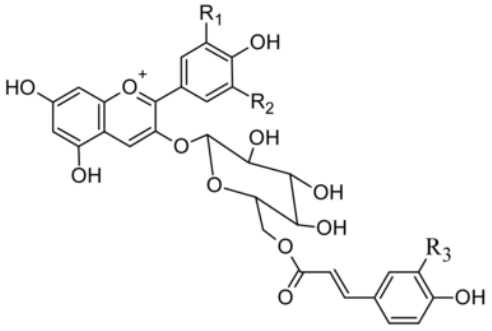
Dp-3-*O*-monoglucoside	R_1=OH; R_2=OH
Cy-3-*O*-monoglucoside	R_1=H; R_2=OH
Pt-3-*O*-monoglucoside	R_1=OCH_3; R_2=OH
Pn-3-*O*-monoglucoside	R_1=OCH_3; R_2=H
Mv-3-*O*-monoglucoside	R_1=OCH_3; R_2=OCH_3



Dp-3-*O*-(6-*O*-acetyl)monoglucoside	R_1=OH; R_2=OH
Cy-3-*O*-(6-*O*-acetyl)monoglucoside	R_1=H; R_2=OH
Pt-3-*O*-(6-*O*-acetyl)monoglucoside	R_1=OCH_3; R_2=OH
Pn-3-*O*-(6-*O*-acetyl)monoglucoside	R_1=OCH_3; R_2=H
Mv-3-*O*-(6-*O*-acetyl)monoglucoside	R_1=OCH_3; R_2=OCH_3



Dp-3-*O*-(6-*O*-*p*-coumaroyl)-5-*O*-diglucoside	R_1=OH; R_2=OH
Cy-3-*O*-(6-*O*-*p*-coumaroyl)-5-*O*-diglucoside	R_1=H; R_2=OH
Pt-3-*O*-(6-*O*-*p*-coumaroyl)-5-*O*-diglucoside	R_1=OCH_3; R_2=OH
Mv-3-*O*-(6-*O*-*p*-coumaroyl)-5-*O*-diglucoside	R_1=OCH_3; R_2=OCH_3



Dp-3-*O*-(6-*O*-*p*-coumaroyl)monoglucoside	R_1=OH; R_2=OH; R_3=H
Cy-3-*O*-(6-*O*-*p*-coumaroyl)monoglucoside	R_1=H; R_2=OH; R_3=H
Pt-3-*O*-(6-*O*-*p*-coumaroyl)monoglucoside	R_1=OCH_3; R_2=OH; R_3=H
Pn-3-*O*-(6-*O*-*p*-coumaroyl)monoglucoside	R_1=OCH_3; R_2=H; R_3=H
Mv-3-*O*-(6-*O*-*p*-coumaroyl)monoglucoside	R_1=OCH_3; R_2=OCH_3; R_3=H
Mv-3-*O*-(6-*O*-caffeoyl)monoglucoside	R_1=OCH_3; R_2=OCH_3; R_3=OH

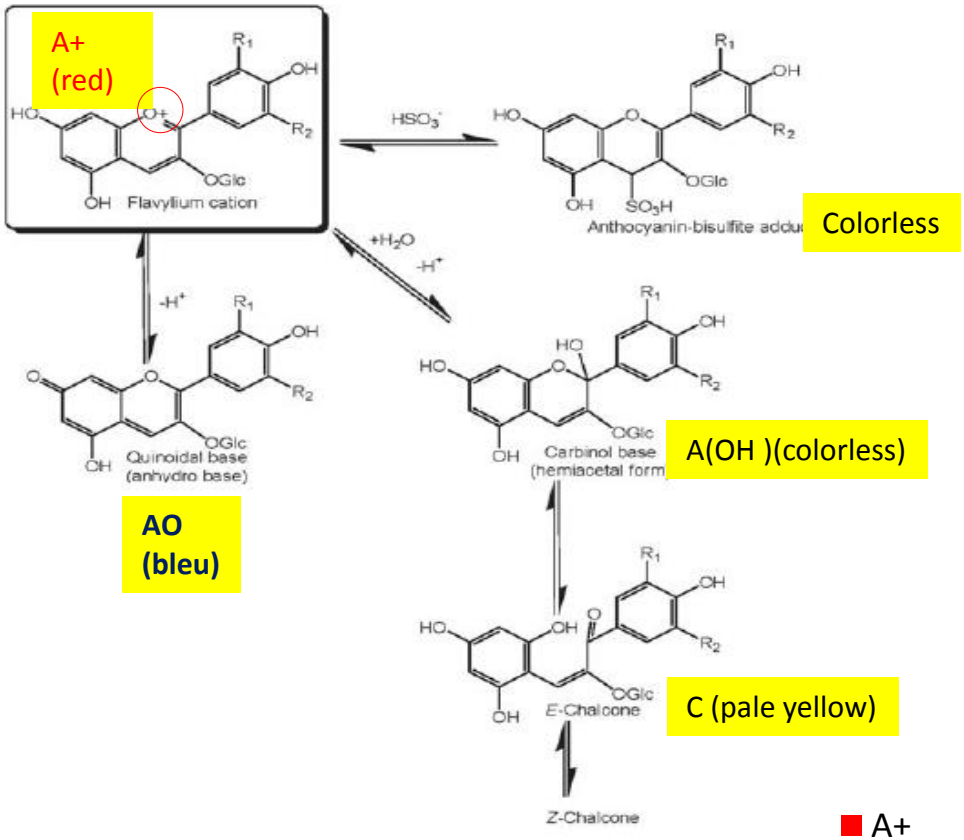
Diglycosides are practically absent in *V. vinifera grapes,* and their presence in a wine is an indication of fraud with non-V.vinifera grapes

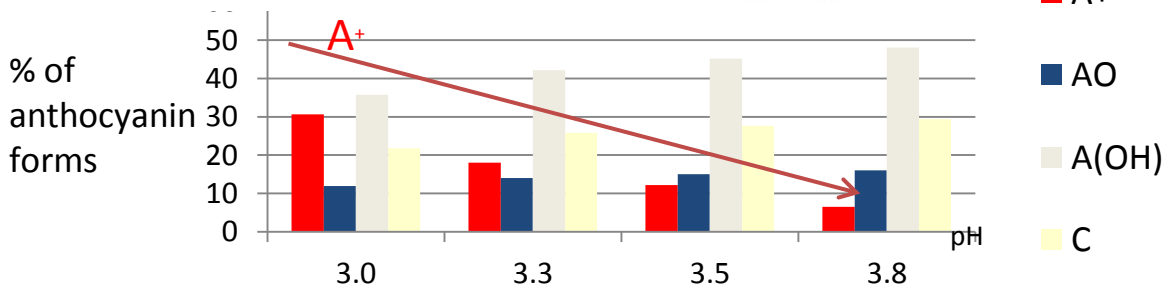
Flamini et al., 2013

PART I

PHENOLICS IN GRAPE :

The pH-dependant equilibrium among the various structural forms of anthocyanins in red wines

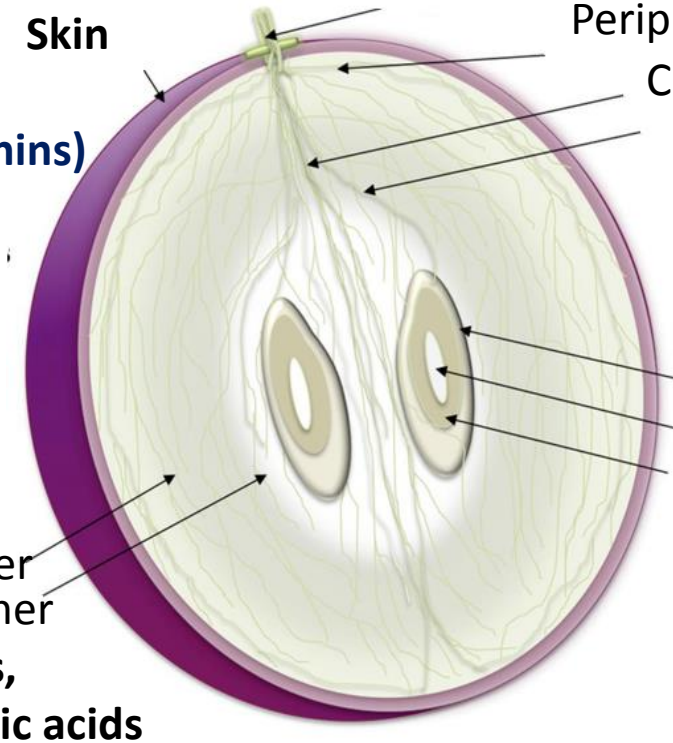




Anthocyanins are responsible for the color of wines

Glories,1984

Grape cell and localization of components



Rich in
Anthocyanins,
flavonols, flavanols (tanins)
flavor cpds, lipids,
potassium

Rich in
hydroxycinnamic acids,
sugars, tartric and malic acids

Rich in
Flavanols (tanins),
hydroxycinnamic acids
stilbenes (resveratrol),
lipids

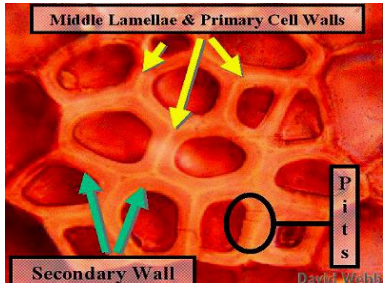
Flesh only in "teinturier "varieties contain anthocyanins

Adapted from Teixeira et al., 2013

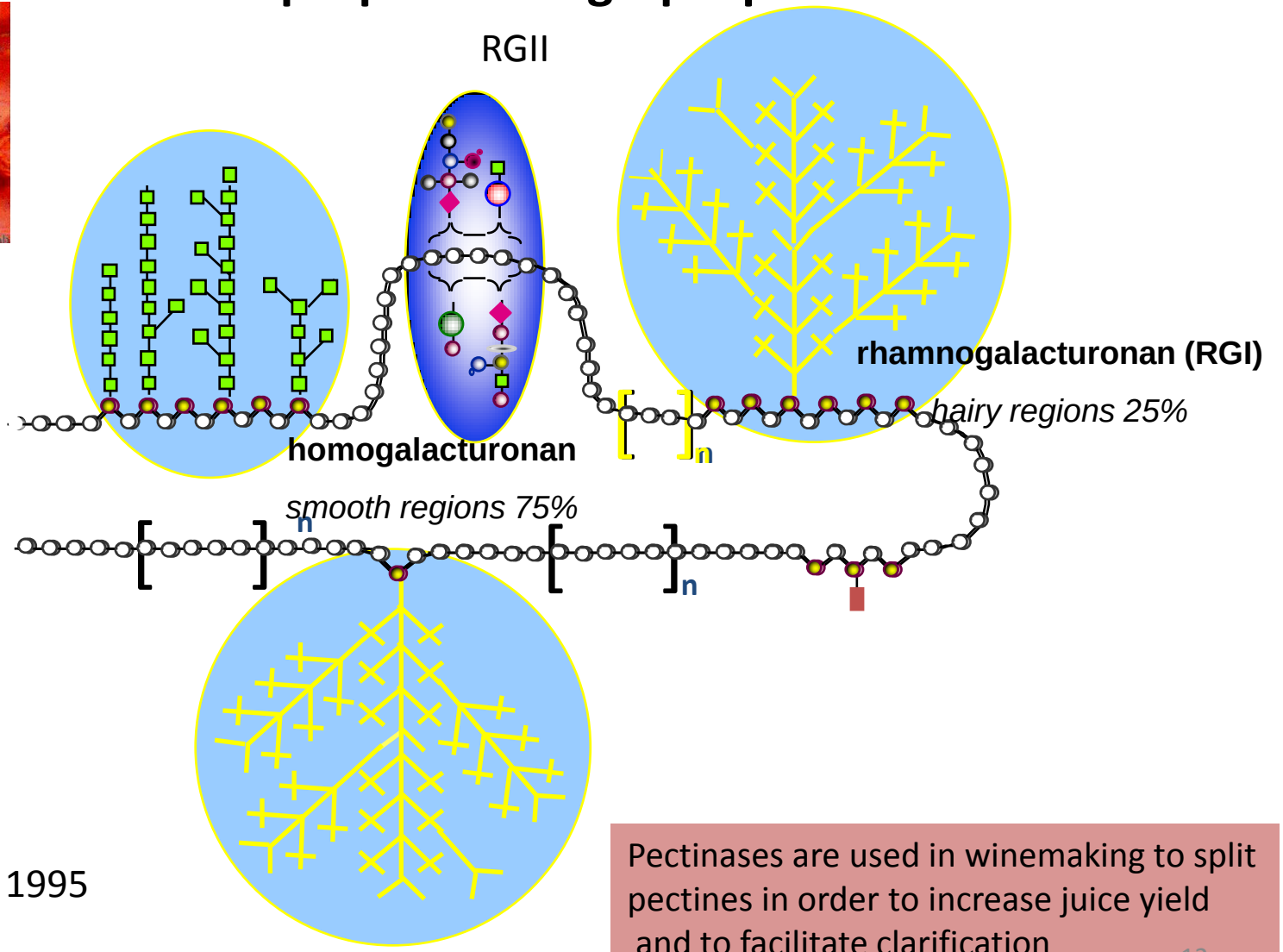
PART I

PECTINES

Cell localisation of pectines



Model proposed for grape pectines



Doco et al., 1995

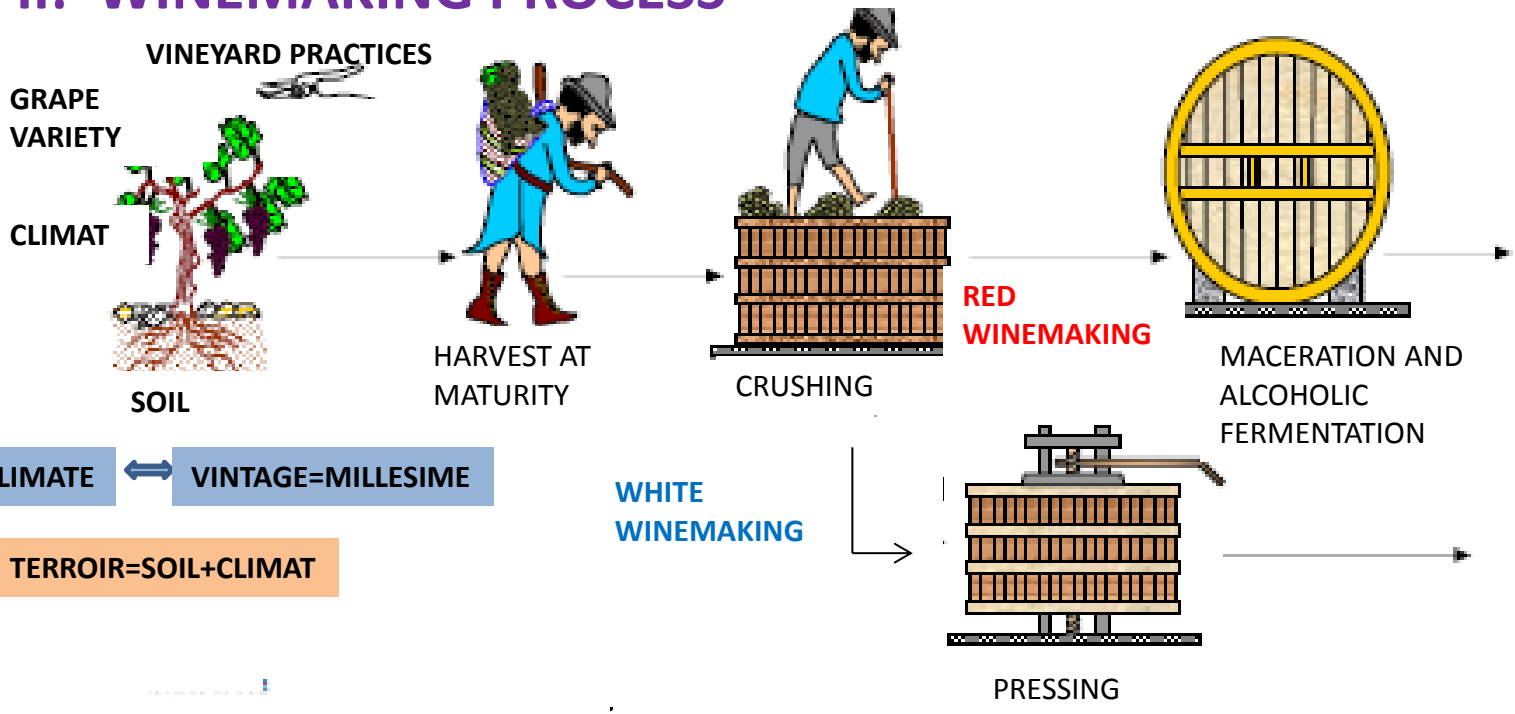
Pectinases are used in winemaking to split pectines in order to increase juice yield and to facilitate clarification

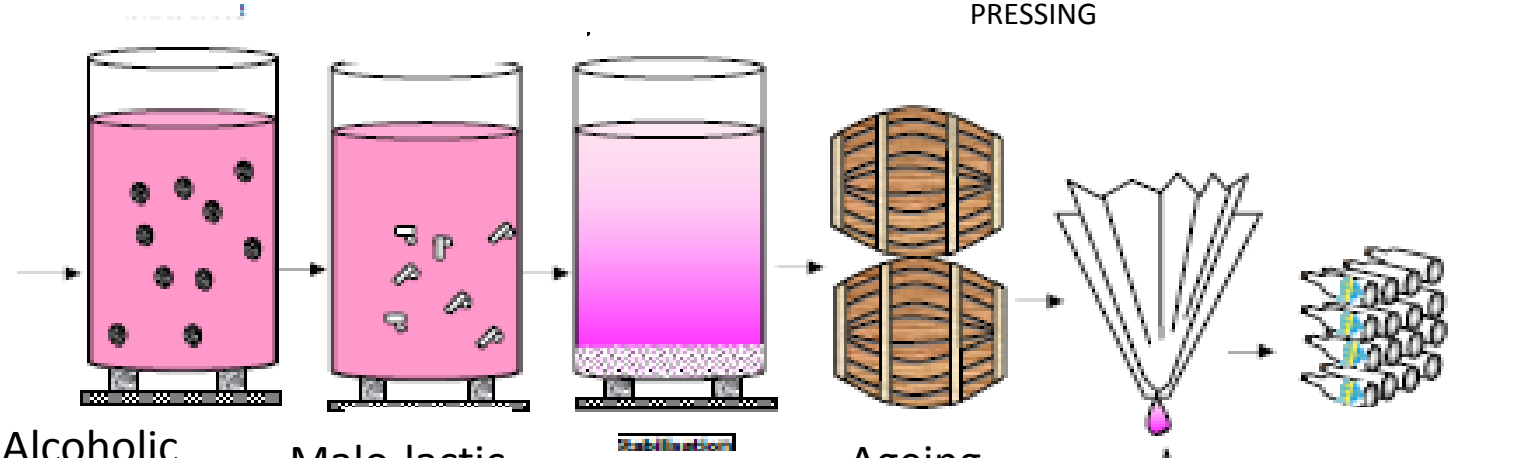
PART II: WINEMAKING PROCESS

WINEMAKING IS AN OLD HISTORY

Tomb Nakht, Egyptian dynastie 1505-1405 BC

PART II: WINEMAKING PROCESS

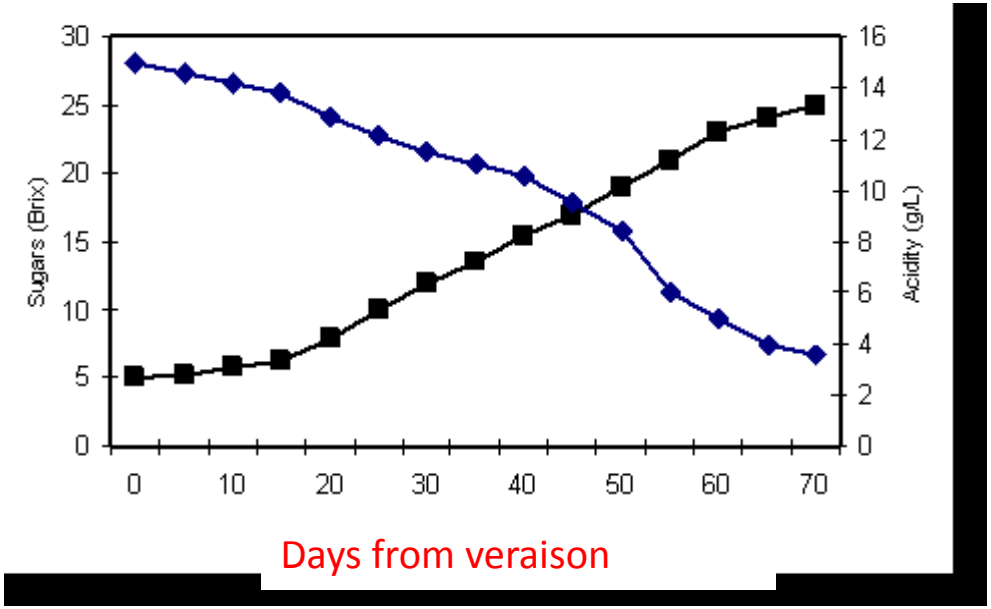




Adapted from Enofylz wine

PART II

HARVEST TIME

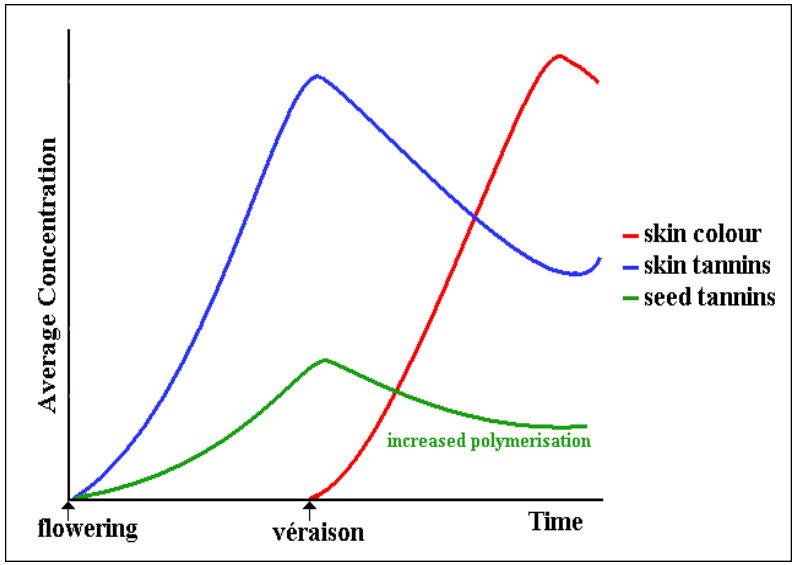


Changes in sugars and acidity during grape berry ripening

Brix determination

Veraison

https://en.wikipedia.org/wiki/



Decision for the optimum moment of Harvest depends on :

- a good balance of sugar and acid (17g/L sugar =1° alcohol (1% alcohol, v/v)
- flavor potential
- phenolics (colour,tannins) potential
- wine type

Changes in tanins and color during grape berry ripening (Ben Rotter 2004)

PART II

HARVESTING

Grape-pickers usullay receive free of charge 2 liters of wine per day in France

Blog de Binbin

PART II

Grape berries contaminated by fungus, usually by Botrytis cinerea : Grey rot /Noble rot

Berries presenting grey rot

Botrytis cinerea on Semillon grapes (in Sauternes area, France) (Noble rot)

Grey rot occurs when weather stays humid.
Grape quality is highly degraded : oxidation of phenolic cpds by laccase, degradation of flavor cpds, anthocyanins

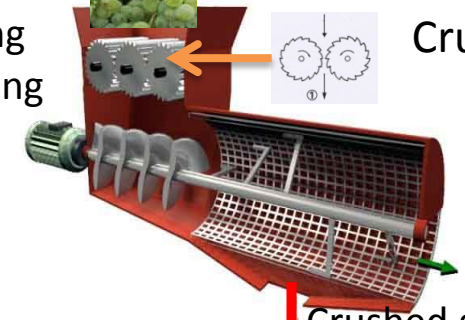
Noble rot develops in some "**Terroir**" where air humidity followed by dry air conditions allows increasing in sugar concentration.
Famous sweet wines, Sauterne, Tokaji (Hungray),Trockenbeerenauslese(Germany) were obtained from noble rotten grapes.

PART II White winemaking : crushing,sulfiting and pressing

For white wine : the pressing operation should be done quickly following crushing to minimize the contacts with grape skins and oxydation as well.

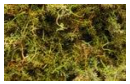
Whole cluster grape

Gentle crushing and destemming



Crusher-destemmer

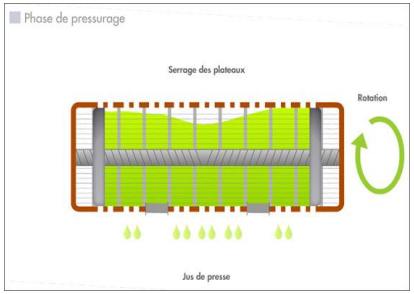
Stems



Crushed grapes

Sulfiting →

For grape cultivars rich in flavor cpds (Muscat, Sauvignon) several hours of maceration at 8-15 °C prior to pressing

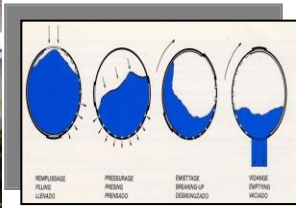


Horizontal press

Whole cluster (ex :Champagne)

Pneumatic press

Membrane



Sulfiting →

Juice poor in flavor, phenolics and suspended solids

Grape juice

Grape juice

Fractionation of the juice extraction by several press cycles (regulations in Champagne volume juice/kg) → **Must settling**

PART II White winemaking : must settling

Must settling allows :

- To discard solid parts (skins, stems..) giving harsh,herbaceous notes
- To improve sensorial quality of wine :off-flavors avoided and synthesis of esters by yeast is improved
- BUT if the must becomes very clear, a good alcoholic fermentation may be hindered

TWO TECHNIQUES :

I. Static mode (in vats, overnight, tempertature <15°C followed by racking (recovery of upper juice phase) (use of pectinases possible)

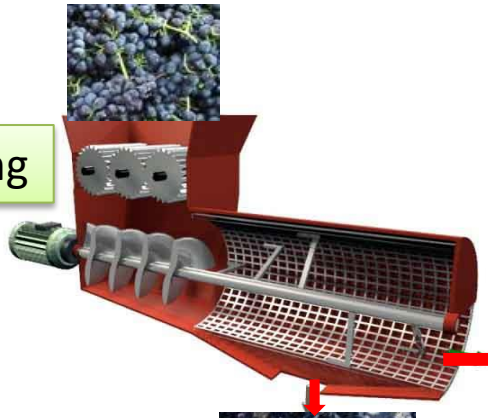
II. Dynamic mode : by centrifugation or filtration

Settled down juice

ALCOHOLIC FERMENTATION (15-18°C, 7-10 days)
(with native yeasts or inoculated yeasts)

PART II Red winemaking : crushing, maceration and fermentation

Crushing and destemming



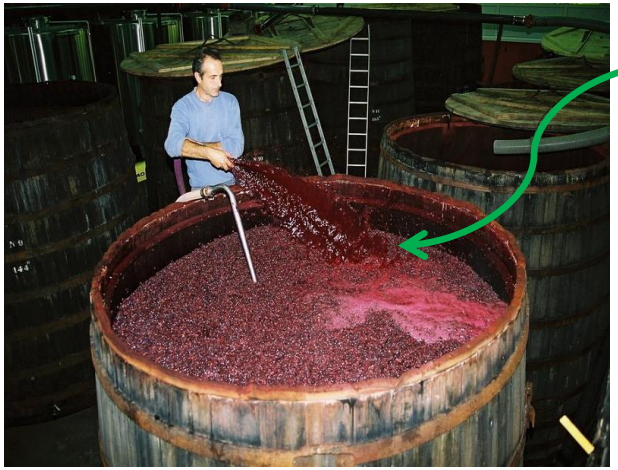
Stems

Sulfiting

Crushed grape berries

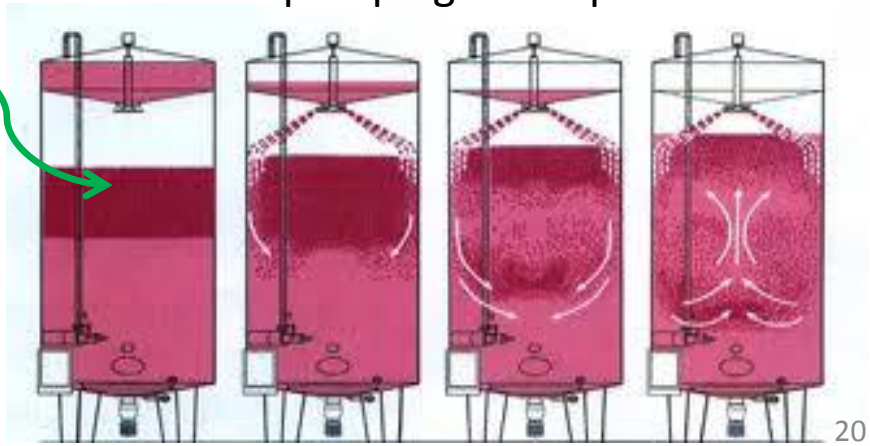
MACERATION ET FERMENTATION WITH NATIVE OR INOCULATED YEASTS (24-28°C, 7 to 28 days)

Opened oak barrel : manual pumping over



Cap
(grape skins)

Automated pumping over : process Gimar

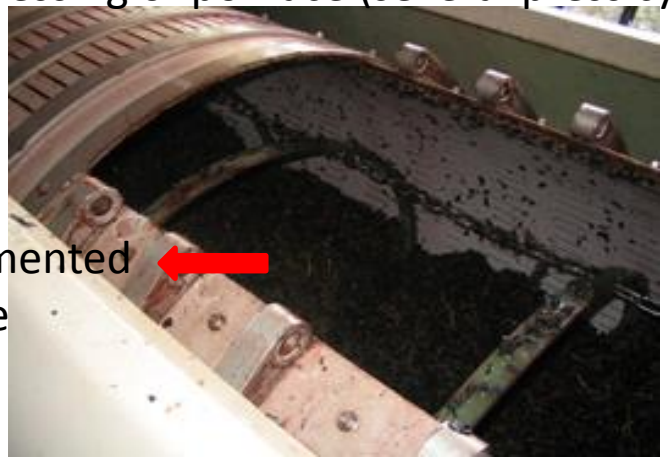


PART II Red winemaking : running off, de-vatting and pressing

Running of (when >80%sugar fermented)

De-vatting

Pressing of pomace (several press cycles)



Fermented juice

Fermented juice (free run)

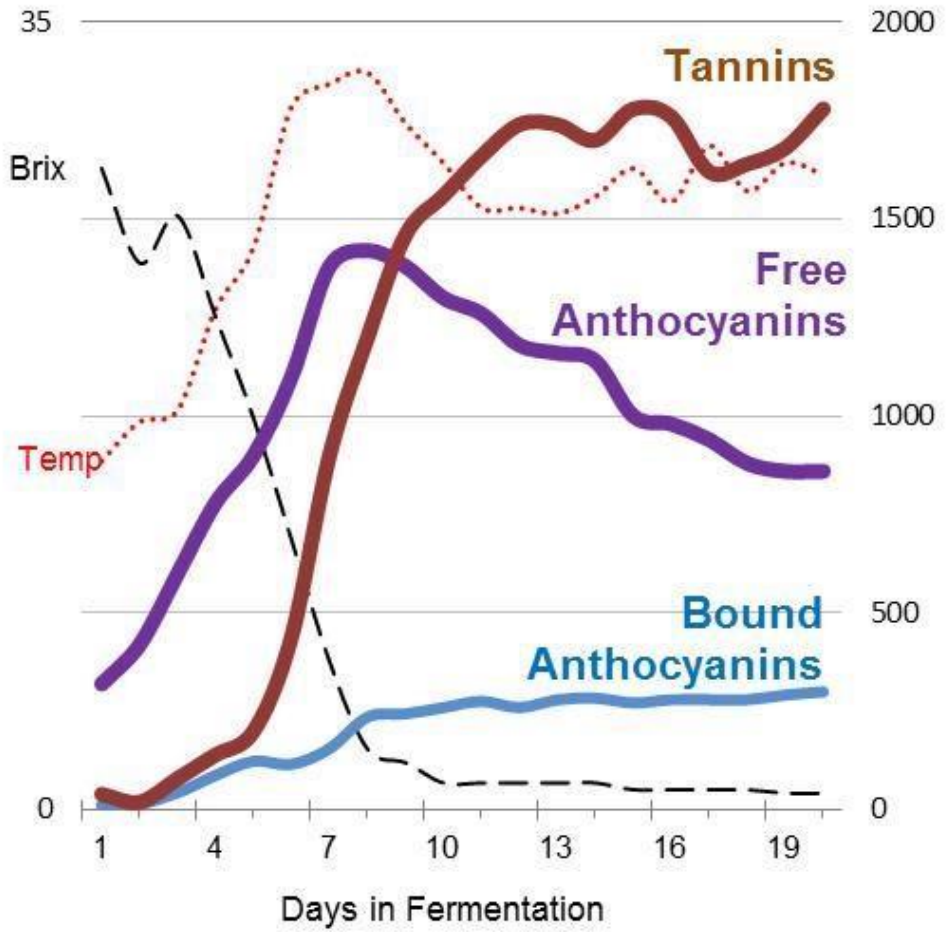
Continuing alcoholic fermentation (in barrels or vats), usually juices from last press cycles fermented separatly

Ageing of wines in oak barrels

➢extraction of oak flavors, vanilla, lactones..and oak tanins from barrels, wine become more complex

PART II

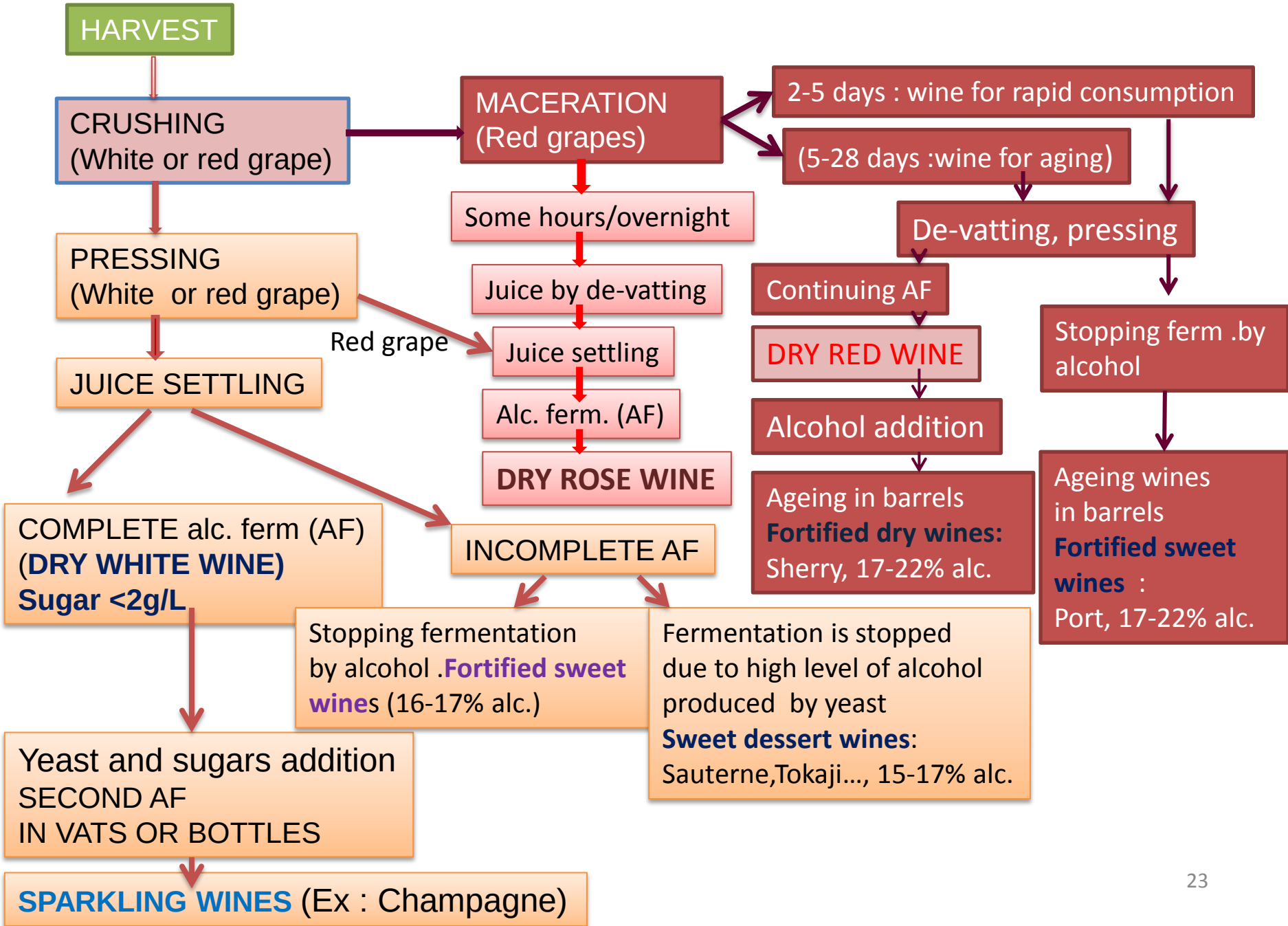
Extraction of tannins and anthocyanins into the juice during fermentation



Source : http://chateauhetsakais.com/phenolics/

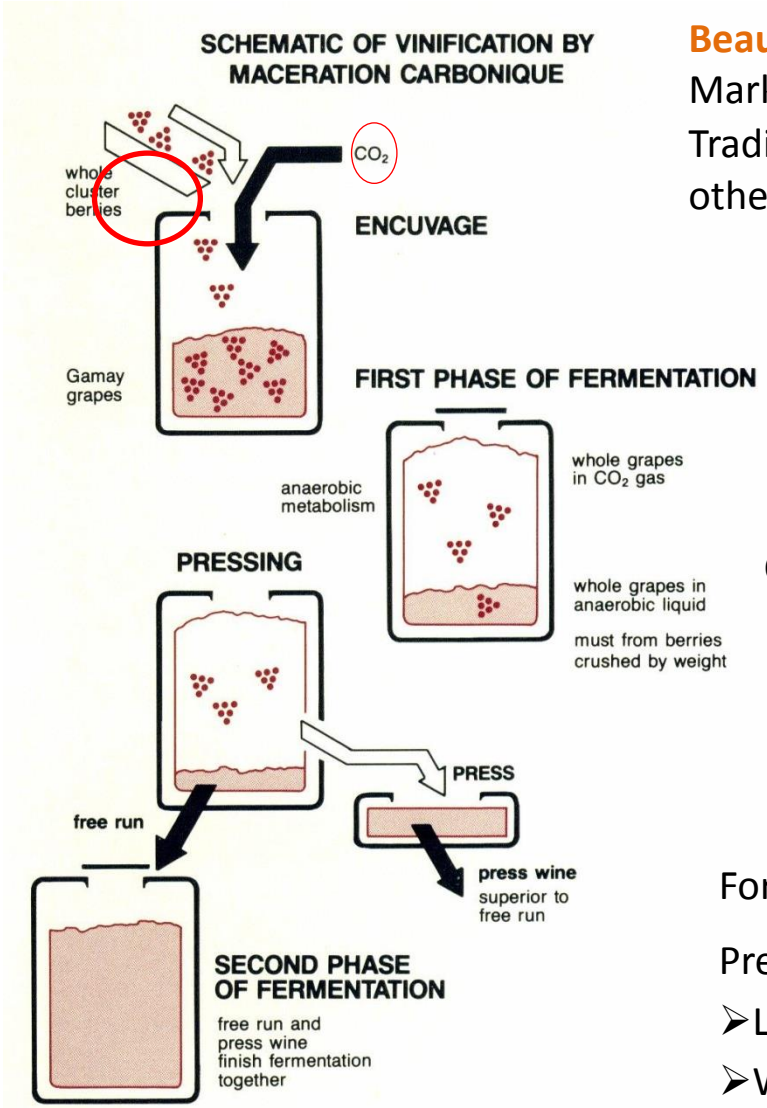
PART II

Summary table of winemaking process



PART II SOME SPECIAL WINEMAKING TECHNIQUES

VINIFICATION BY MACERATION CARBONIC



Source picture : Bedrcok wine co.

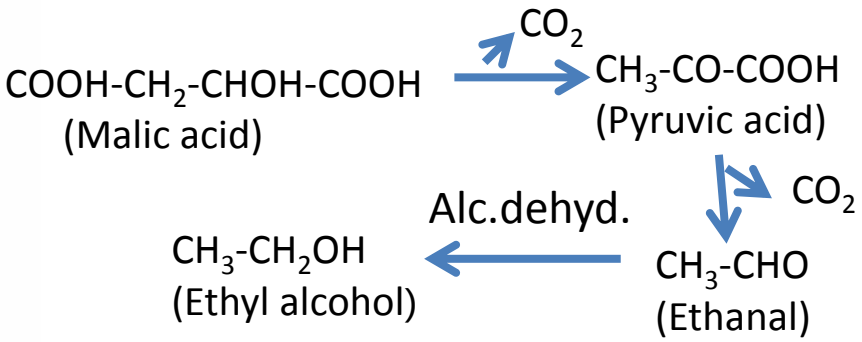
Beaujolais nouveau or Beaujolais primeur production

Marketing the 3th thusday of the novembre

Traditionally Gamay cultivar (red) is used but nowadays other cultivars in France

First phase of fermentation : 25-30°C, 8 to 20 days under CO2

Degradation of 15-30 % of malic acid :



Formation of 1.5-2.5% alcohol following mac. carbonic

Press wine has better sensory quality than free run wine

- Light, fresh, fruity (banana) wines for rapid consumption
- Wines for ageing are also produced by this technique

PART II SOME SPECIAL WINEMAKING TECHNIQUES

BURGUNDY WINE : FERMENTATION IN OAK BARRELS BY BATONNAGE (LEES STIRRING) (ELEVAGE SUR LIE / MATURATION ON LEES)

Pressing

Juice settling

Alcoholic fermentation (7-10 days)

The wine is racked

Clear wine is kept in oak barrels (228 liters) several months. Yeast lees are put in suspension by stirring (batonnage) every 10 days about

✓In particular for white wine production (initially with Chardonnay but now applied for other cultivars as well overall word)

➢At the end of fermentation yeast autolysis starts. The autloysis is a slow process. It leads to the release of mannoproteins, peptides, amino acids from the yeast cell into the wine

➢Mannoproteins stabilize wine against the precipitation of tartaric acid salt (Patent pending)

➢ Lees stirring increases the enrichment of wine in yeast components

➢Wine becomes more complexe in taste,flavor,and presents a creamy body, length in mouth

➢Softening of harsh tannins extracted from oak into wine

CHAMPAGNE PRODUCTION (1/3)

The name of “Champagne” is legally protected, a sparkling wine produced from the Champagne region in France

HARVEST → Grape cultivars : Chardonnay, Pinot noir,Pinot meunier

PRESSING → Whole cluster, gentle press, Only 2,550 litres of juice can be extracted from every 4,000 kg of grapes

The first pressing is named the *cuvee* and gives the best juice for Champagne. It is separately fermented from subsequent pressings

Traditional vertical press

Pneumatic press

JUICE SETTLING (12-24 h, 8-12°C)

ALC. FERM (18-20°C) AND (MALO-LACTIC FERM.) in stainless steel thanks

BASE WINE

PART II

CHAMPAGNE PRODUCTION (2/3)

BASE WINE (Blending is possible except vintage)

Addition of sugars and yeast

Bottles sealed with crown caps

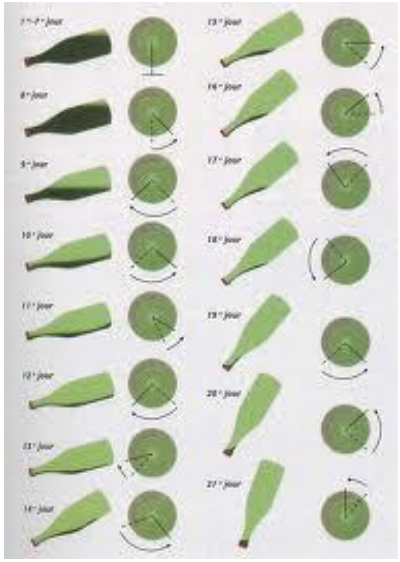
SECOND ALC. FERM.IN BOTTLES AND AGEING

Pression ca. 4 to 6 bar
Ageing in the cellar
Ageing at least 1 year
For vintages>5 years
Yeast autolysis occurs

REMUAGE (RIDDLING)

Manual

Automatic



The bottles are put in rack and turned daily to bring yeast lees after about 21 days into the bottle neck directed towards floor

Yeast lees

CHAMPAGNE PRODUCTION (3/3)

DISGORGEMENT(DEGORGEMENT) is to remove yeast lees from the bottle

The bottleneck is plunged into freezing liquid

The crown cap is carefully removed and the ice expels the yeast lees.

Reserve wines, sugar, and brandy is added to refill the bottles and give the desired flavor and sweetness (brut to sweet champagne, from 0 to more than 55 g/L sugar) and bottle is closed with special cork and secured with a wire muzzle

PART II

SULFITING with Sulphur Dioxide (SO_2) (1/2)

SO_2 is added both to must and wine for protection from oxidation and microbial spoilage. An aqueous solution is incorporated. SO_2 exists in must and wine in free and bound forms

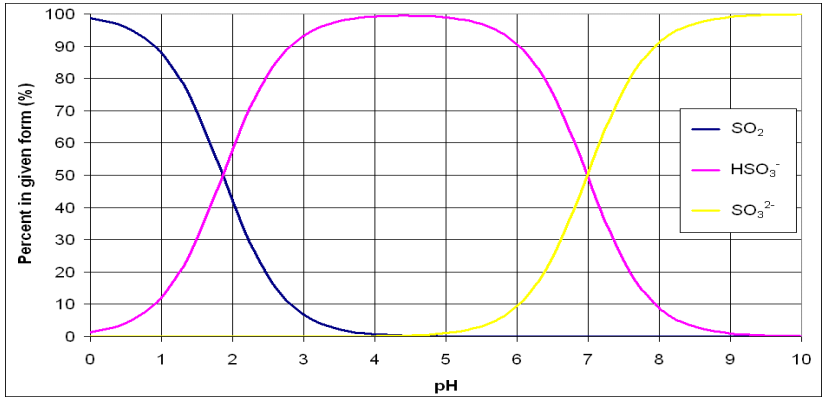
Free SO_2 :

$$H_2O + SO_2 \quad <===> \quad H^+ + (HSO_3)^- \quad <===> \quad 2H^+ + SO_3^{2-}$$

The proportion of different forms is dependent on pH

HSO_3- : low antimicrobial activity, inhibitor of enzymatic browning, improves anthocyanin extraction

SO_2 : high antimicrobial acitvity, antioxidant activity



Ben rotter 2001

Bound SO_2 : binding of SO_2 with carbonyl compounds, (ex : acetaldehyde, quinones…). Its anti-microbial activity is 5 to 10 fold weaker that that of free SO_2

$$R\text{-}CHO + HSO_3^- <==> CH_3\text{-}CHOH\text{-}SO_3^-$$

$$R\text{-}CO\text{-}R' + HSO_3^- <==> R\text{-}COHR'\text{-}SO3$$

Total SO_2 =free SO_2 +bound SO_2

PART II

SULFITING with Sulphur Dioxide (SO_2) (2/2)

Recommanded initial dosage
Sound grapes :
For white wine :60-800 mg/L
For red wine : 30-50 mg/L
Grey rotten grapes: 80-200 mg/L

Max. amount (total SO_2) permitted in Europe :
- White and rose wines : 210mg/l
- White and rose wines(sugars > 5g/L) :260mg/l
- Sweet wines : 300 mg/l
- Red wines : 160mg/l

✓For organic wines, the permitted amount is decreased by 35 %.

✓At bottling 25 mg/L free SO_2 is advised to protect wine against oxidation and microbial development

✓The label “Contains Sulfites” must be present on the wine bottles in several countries.

PART II

ALCOHOLIC FERMENTATION (1/5)

The main yeast : *Saccharomyces cerevisiae*

S. cerevisiae

Commercial dry yeast

Alcoholic fermentation is performed either with native yeasts already present on berries (spontaneous fermentation) or with the use of commercial dry yeasts (more than 100 available)

Advantageous of cultured yeast :

- Good achievement of fermentation
- Better control of sensorial quality of wines
- Possibility to choose yeast strain to better develop characteristic flavor of grape variety

Steel thanks for fermentation

PART II

ALCOHOLIC FERMENTATION (2/5)

Many metabolites are produced by yeast :

Flavor compounds, glycerol, amino acids, proteins, organic acids, fatty acids…

$C_6H_{12}O_6$+ 2 ADP + 2 H_3PO_4 => 2 CH_3-CH_2OH 2 CO_2 + 2 ATP + 2 H_2O + 25.4 Kcal

Theoretical yield sugar conversion to ethanol = 0.51 g ethanol/g sugar

In practice ethanol yield is 90 to 95% of theoretical yield.
17 g of sugar ⟹ 1% (v/v) ethanol

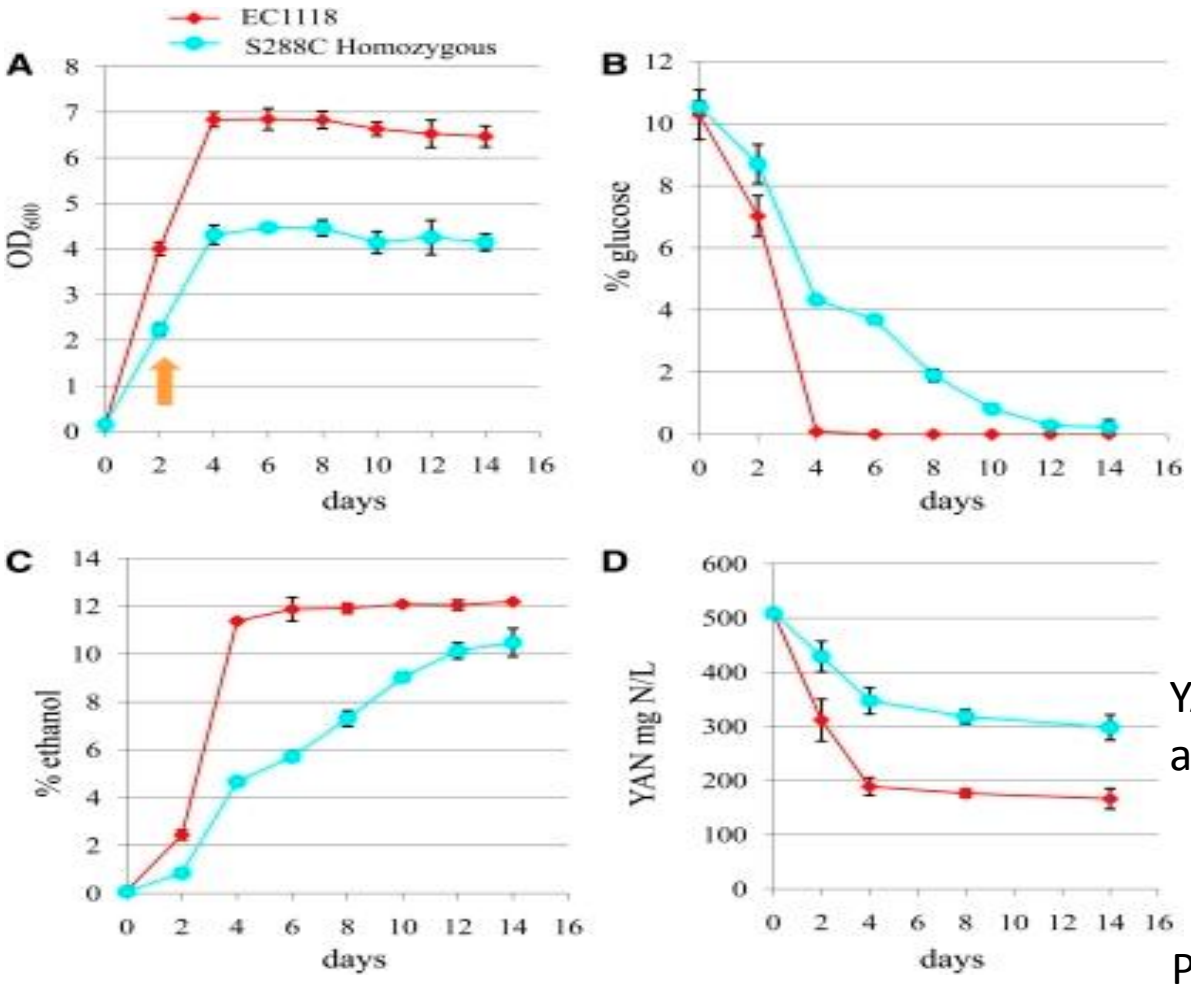
- Alcoholic fermentation is an exothermic reaction : 25.4 Kcal/mole de sucre
- Therefore increases of temperature during fermentation up to ca 35°C.
- The température must be ≤28°C for red wine production, ≤20°C for white wine production to obtain a wine of good sensorial quality.

➢ **COOLING OF WINE IS USULLAY PERFORMED DURING FERMENTATION TO CONTROL THE TEMPERATURE**

PART II

ALCOHOLIC FERMENTATION (3/5)

KINETCIS OF GRAPE JUICE FERMENATATION BY TWO YEASTS



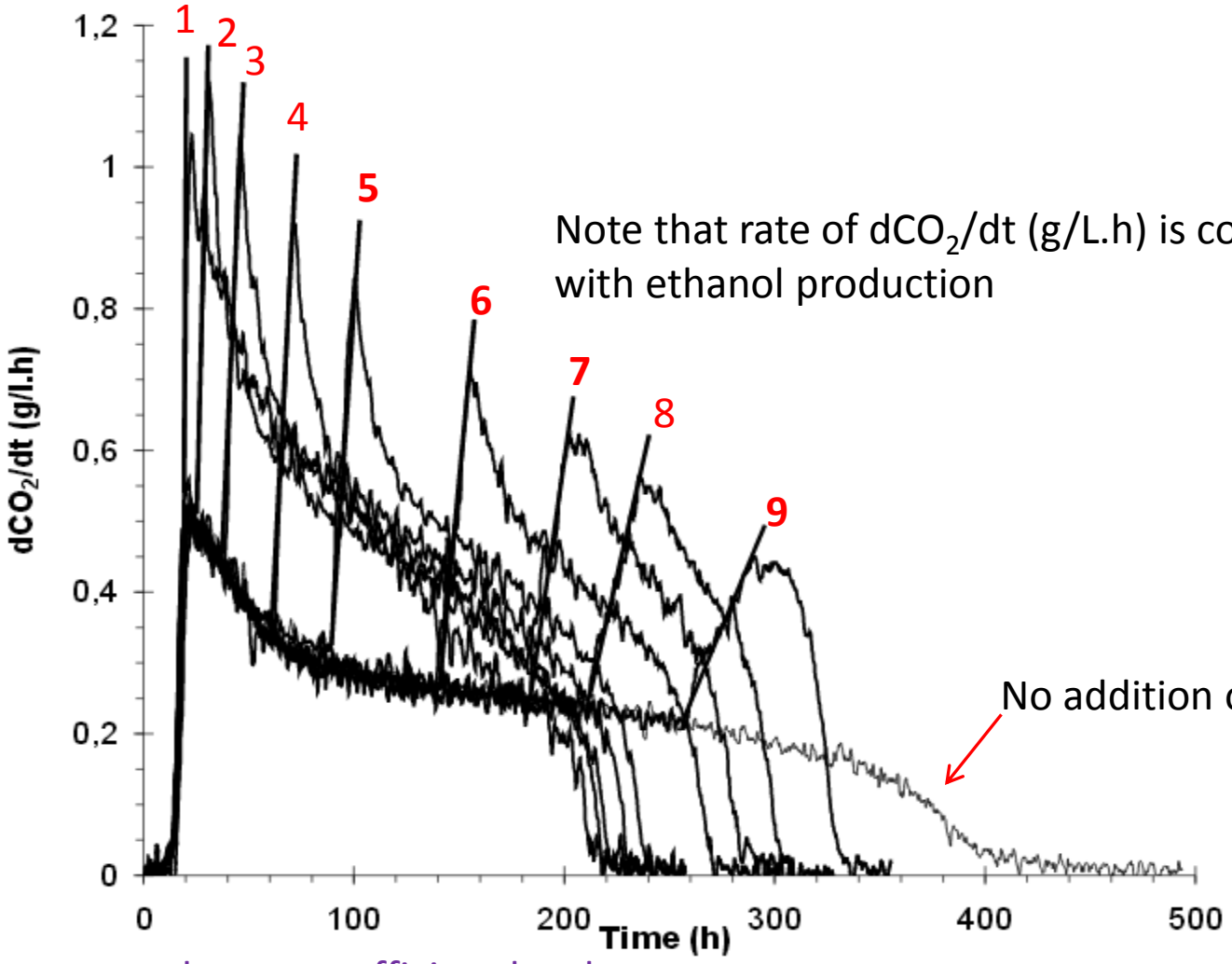
YAN : yeast assimilabe nitrogen

Piggott et al., 2011

- Turbidity of juice, oxygen, temperature, high alcohol level, nutrients can affect fermentation kinetic

PART II ALCOHOLIC FERMENTATION (4/5)

Effect of the timing of spiking (1 to 9) of the juice with diamonium phosphate (300 mg/L) during fermentation on fermentation kinetic

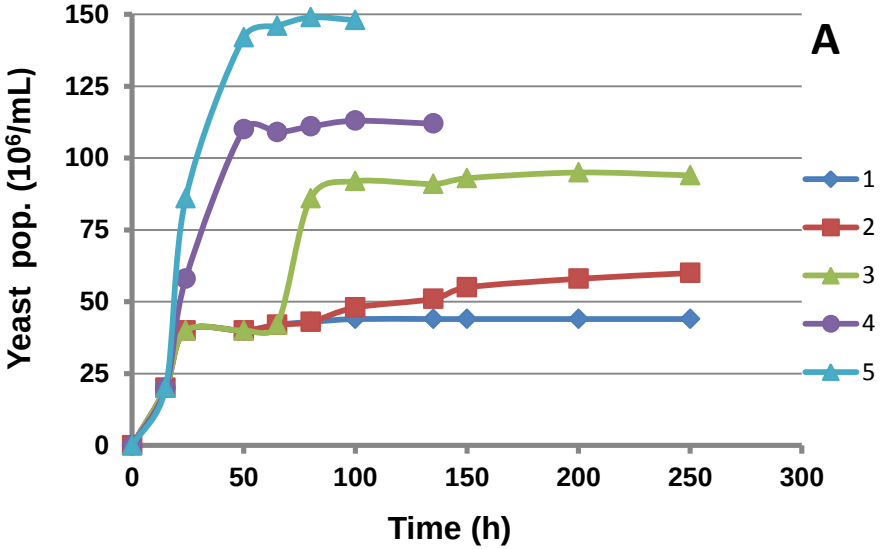


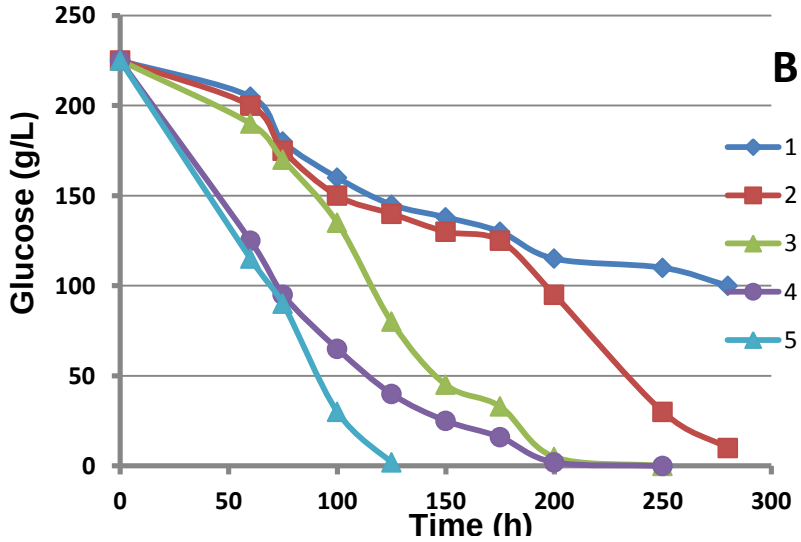
Assimilable nitrogen may be at unsufficient level in the must. $(NH_4)_2PO_4$ is an assimilable nitrogen source for yeast and used in fermentation

Sablayrolles and Salmon, INRA, FRANCE

ALCOHOLIC FERMENTATION (5/5)

Effect of timing of oxygen spiking (5mg/mL) on the yeast growth (A) and glucose metabolism (B) during grape juice fermentation





PART II

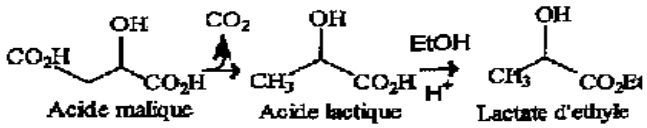
MALOLACTIC FERMENTATION (1/2)

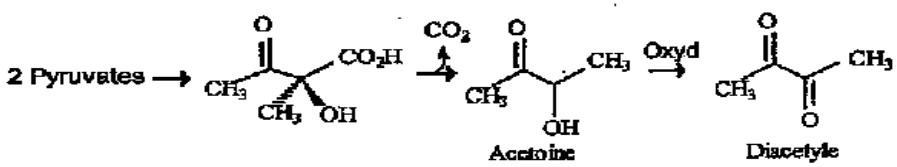
- Connversion of L-malic aci to L+lactic acid by bacteria (*Oenococcus oeni*)
- Occurs at the end of alcoholic fermentation, but can sometimes run concurrently with it.
- Inoculation of wine with selected bacteria allows better control of malolactic fermentation
- Free SO_2<10 ppm, 18-20°C and pH>3.1-3.2 are favorable to malolactic fermentation.
- Recommendable for most of red wines but only for some white wines (Champagne, Chardonnay…).

For white wines a good level of acidity is searched for maintaining fresh notes

O.oeni

Commercial *O.oeni*





MALOLACTIC FERMENTATION (2/2)

CONSEQUENCES

- Green apple taste of malic acid is replaced by buttery,softer tasting of lactic acid

- Higher perception of buttery taste due to the ethyl lactate up to 100 mg/L and to diacatyle

- The astringency and bitterness perception of red wines is reduced

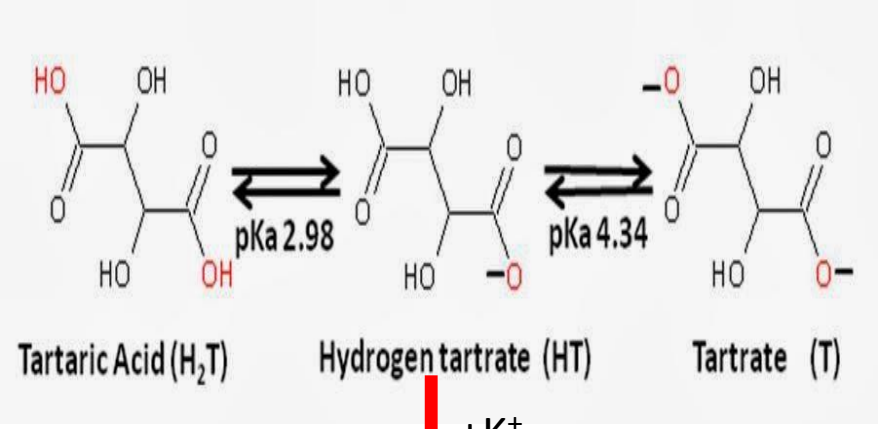
- Better microbiological stability of wine vs malic acid , a good substrate for bacteria (risk of off-flavor)

- Some decrease in red color of wines due to the increase of pH

PART III STABILIZATION OF WINE

Mainly two treatments : remove of tartaric acid salt and fining of wines

I. TARTARIC ACID SALT (KHT) Stability



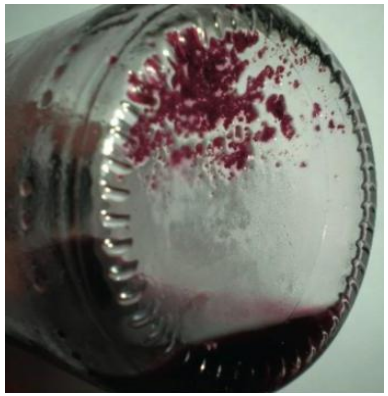
KHT (Potassium bitartrate)

KHT crystallizes in wine at low temparature and precipitate in casks and bottles.

Precipitation °C of KHT= $-(\frac{\%\ alcohol}{2} - 1)$

Ex: for a wine of 12% alc. prec.temp=-5°C

If not removed, tartrate crystals can be observed in bottles



Stabilization of wine vs KHT

- Addition of metatartic acid into wine
- Addition of yeast mannoproteins
- Chilling of wine (1 to 2 weeks)
- Electrodialysis

PART III STABILIZATION OF WINE

II.FININIG

Fining is the process where a substance (fining agent) is added to the wine to discard undesirable compounds through their adsorption on fining agents or the formation of suspensions amenable to the precipitation

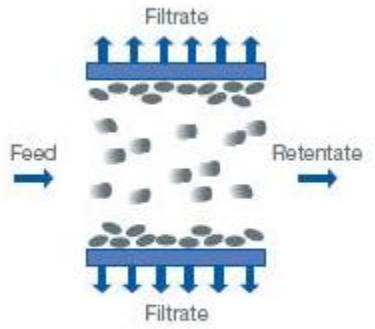
PURPOSE	FINING AGENT	MECANISM
Removal of browning (mainly white wines)	PVPP	Adsorption
Removal of undesirable flavor	Active charbone	Adsorption
Removal of protein causing hazes in white wines	Bentonite (volcanic gray)	Absorption Charge-interaction
Reduction of astringency, bitterness	Proteins : Egg white,gelatine caseine,isinglass	Interaction (hydrophobic, charge interaction) with proteins and tannins

PART III STABILIZATION OF WINE

MICROBIOLOGICAL STABILIZATION BY FILTRATION

Traditionnal filtration

Crossflow or tangential flow filtration



Wine bottling

In tangential flow filtration the medium to be filtered is forced with pressure through exactly defined pores of a membrane. The clogging of the pores is prevented by keeping the solids suspended. **Microbiological stabilization of wine is possible through the removal of microroganisms by selecting mebranes with pores <0.5 µ.**