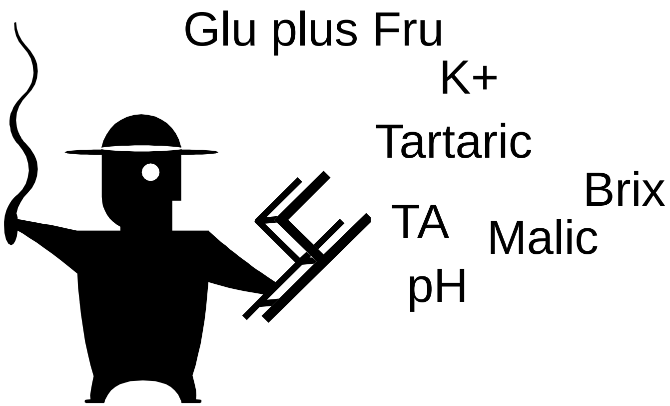
Understanding and Managing Sugar and Acid in Juices and Musts



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ETS Laboratories

Acid and Sugar in Juice and Must

ranges for relevant analytes

- Brix & Glucose +Fructose
  - 17-32 Brix
  - 180 to 300 g/L glu + fru

  ➢ Increases after veraison
- Tartaric acid
  - 0.5 to 10 g/L

  ➢ On per berry basis is steady from veraison to harvest
- Malic acid
  - 0.5 to 10 g/L

  ➢ On per berry basis will decrease veraison to harvest
- Potassium
  - 400 to 6000 mg/L

  ➢ Increases throughout ripening
- Titratable Acid and pH
  - 3.5 to 17 g/L as tartaric
  - 2.8 to 4.3 pH

  ➢ Complex relationship between the amount of acids, their ionic forms & potassium levels
- Buffer Capacity
  - 25 to 75 mM/pH unit

  ➢ Equivalents needed to change pH by one unit

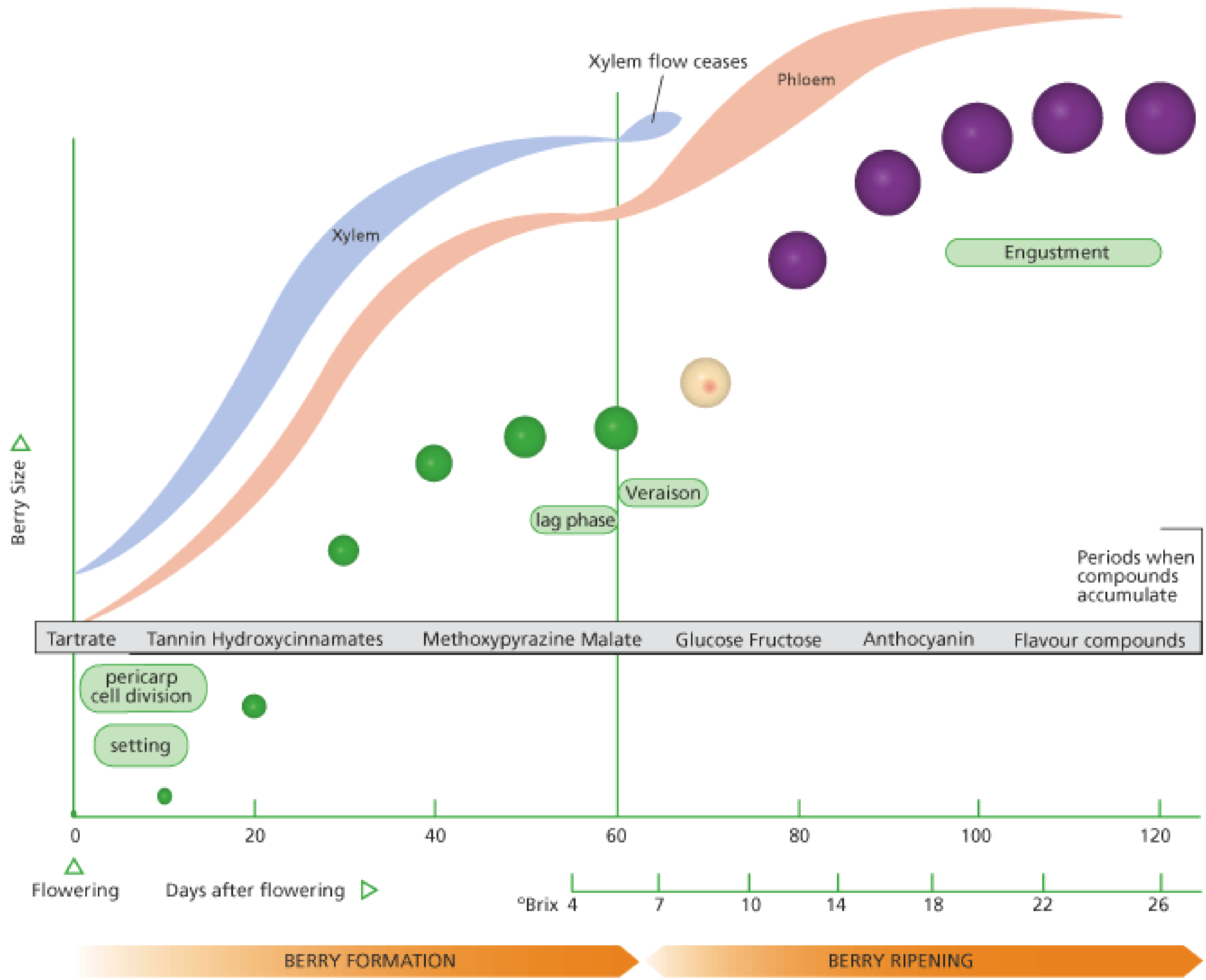
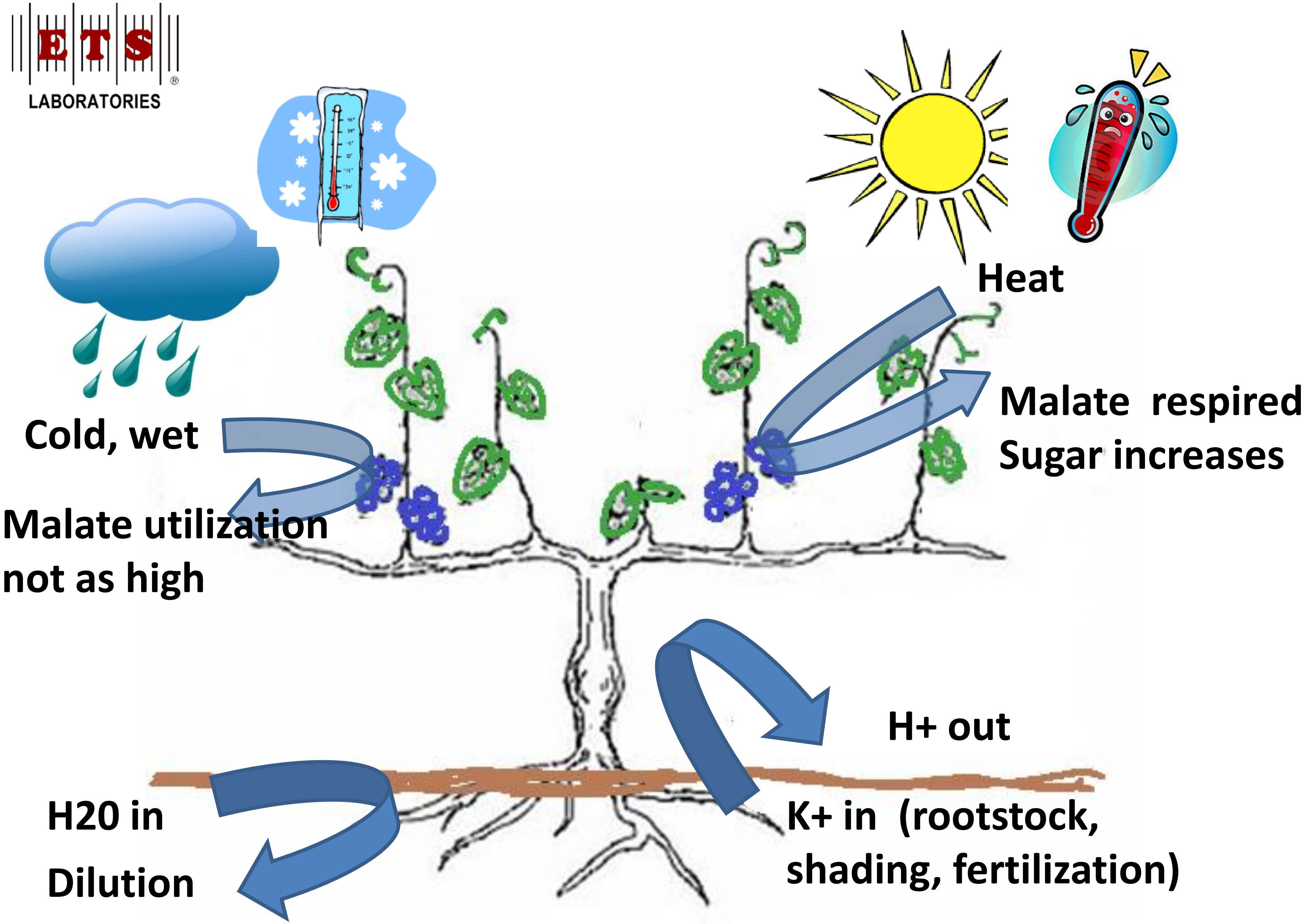


Figure 2: Diagram showing relative size and color of berries at 10-day intervals after flowering, passing through major developmental events (rounded boxes). Also shown are the periods when compounds accumulate, the levels of juice °brix, and an indication of the rate of inflow of xylem and phloem vascular saps into the berry. Illustration by Jordan Koutroumanidis, Winetitles.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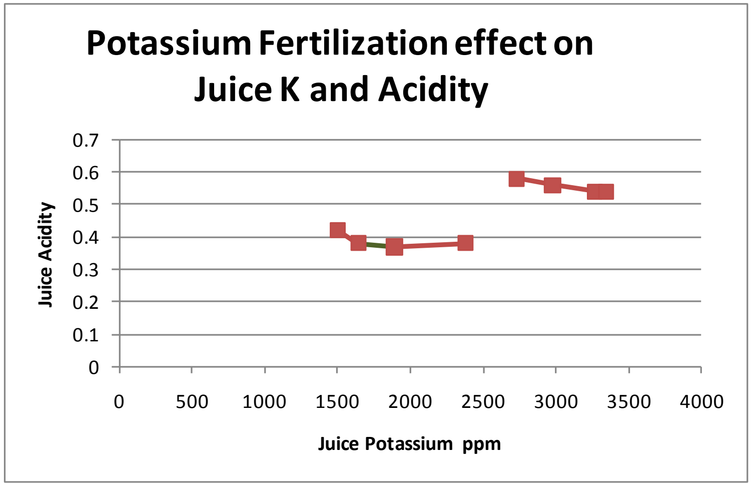
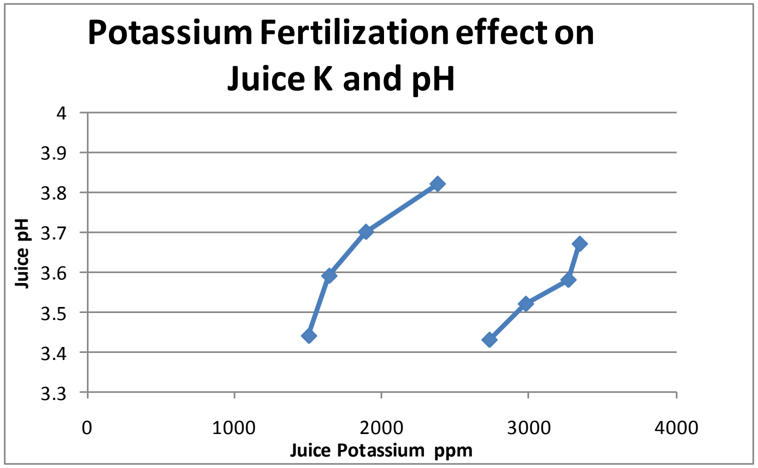
Heat
Malate respired
Sugar increases
Cold, wet
Malate utilization
not as high
H+ out
H20 in
Dilution
K+ in (rootstock,
shading, fertilization)

Increased K to grape plant

Effects of potassium fertilization and storage on the quality and changes of grape juice *(after Morris et al, Am. J. Enol. Vitic., Vol. 34, No. 1, 1983)*			
Potassium fertilization (g/plant)	Juice K (ppm)	pH	Acidity (% tartaric)
0	2730	3.43	0.58
3	2977	3.52	0.56
6	3266	3.58	0.54
12	3343	3.67	0.54
0	1504	3.44	0.42
3	1642	3.59	0.38
6	1891	3.7	0.37
12	2378	3.82	0.38





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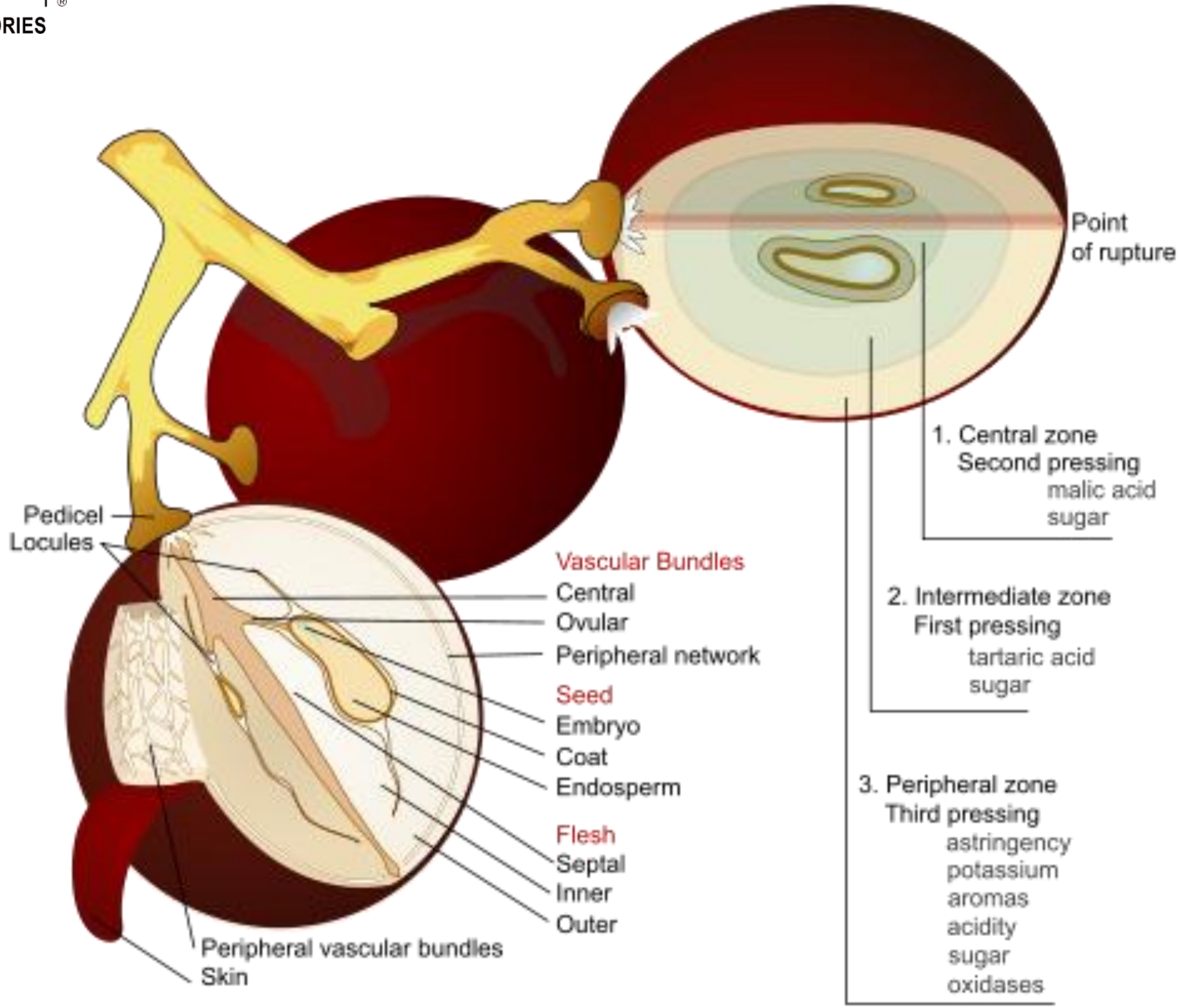

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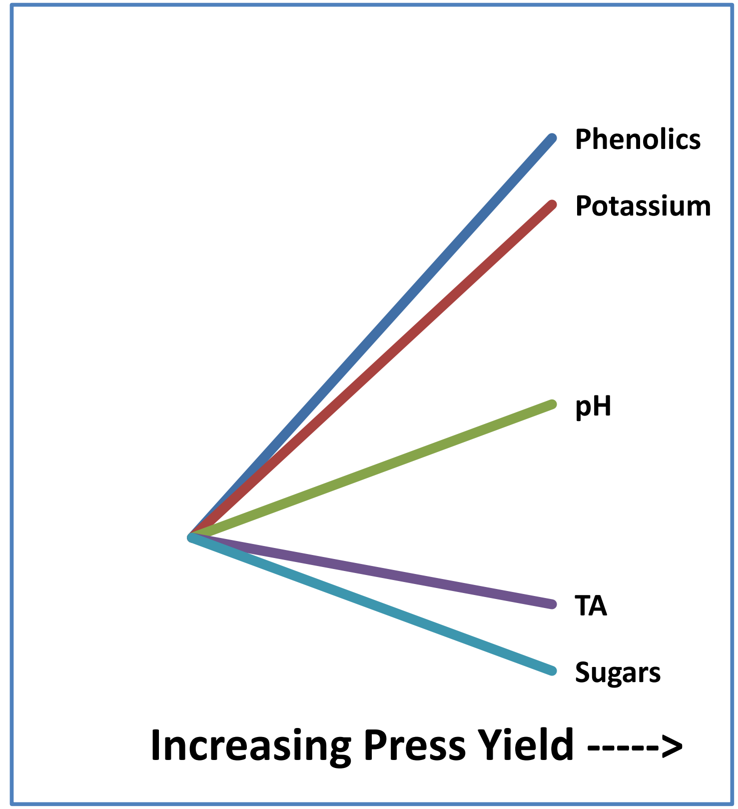
Sampling White Juices

- A representative sample from the tank is better than a sample from the press.
- Tank samples can be stratified. How will you ensure a representative sample?



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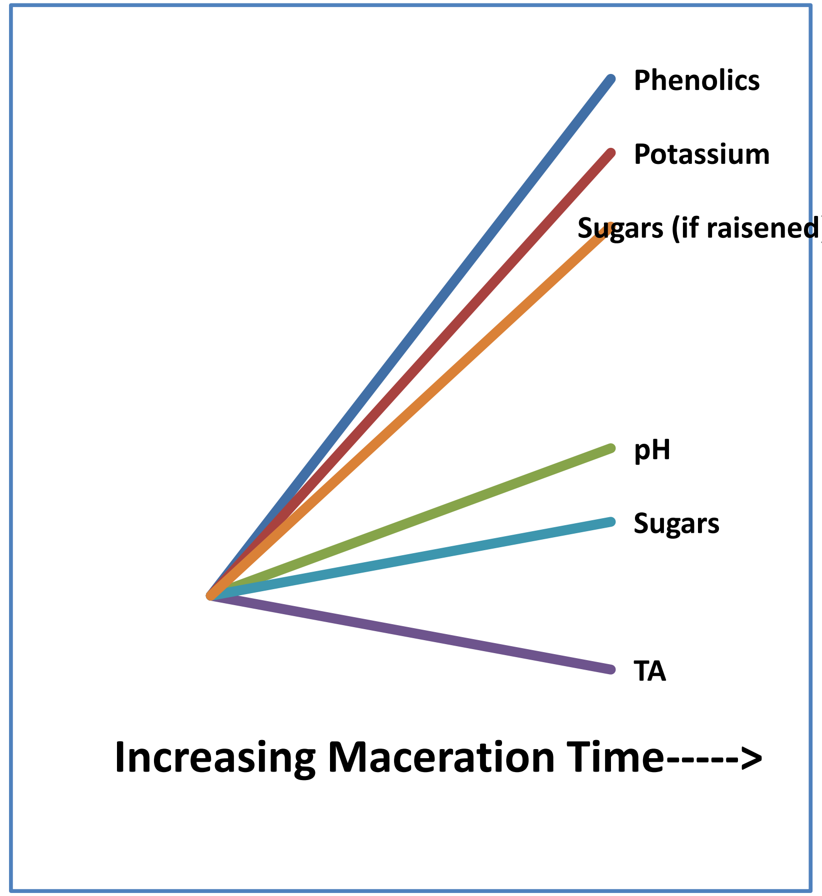
Sampling Red Musts

- Analyte extraction rates will vary with temperature, grape variety, crushing method, use of enzymes, and any movement of the must (pumpovers etc)
- Tank samples can be stratified; how will you ensure a representative sample?



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Managing Sugar

- Acceptability of sugar levels is usually related to desired final alcohol.
- Conversion of sugar to ethanol is affected by temperature, yeast strain, container size and shape, and other factors.

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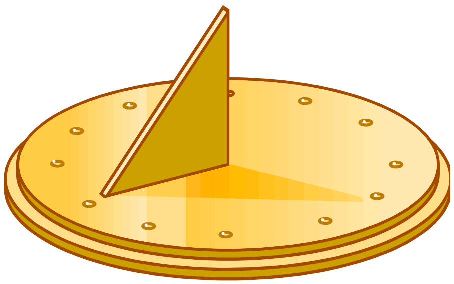
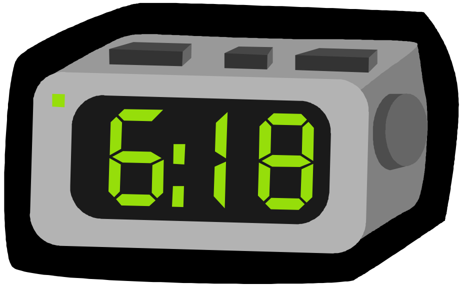
Potential Alcohol

- Brix is an estimate of the actual sugars in the sample and is really a measure of soluble solids by refractometry or density. Using Brix as a predictor of final alcohol has given “conversion factors” ranging from 0.52 to 0.64 %alc/Brix.
- Glucose and Fructose is a more direct indicator of the potential alcohol. The European Union uses this conversion formula:

$$\frac{\text{Glu+Fru (g/L)}}{16.83} = \text{potential alcohol \%}$$



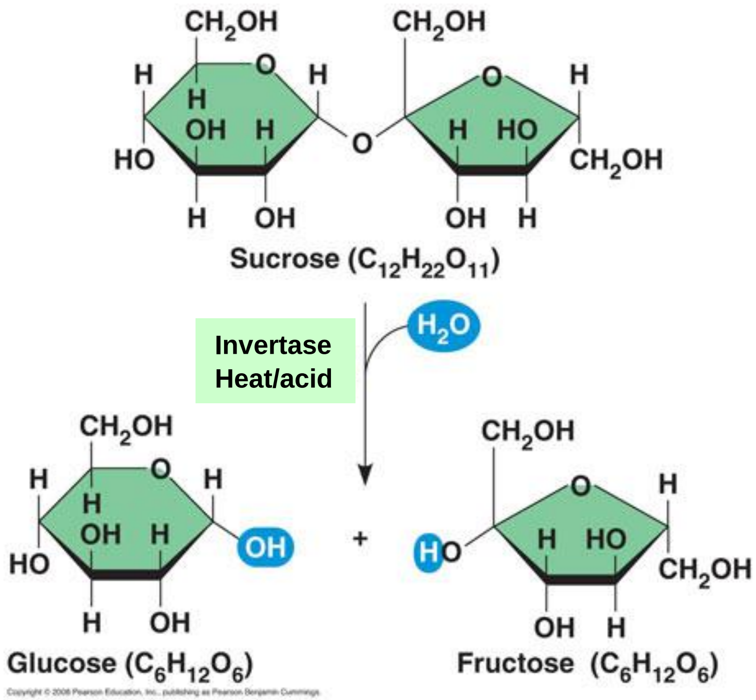


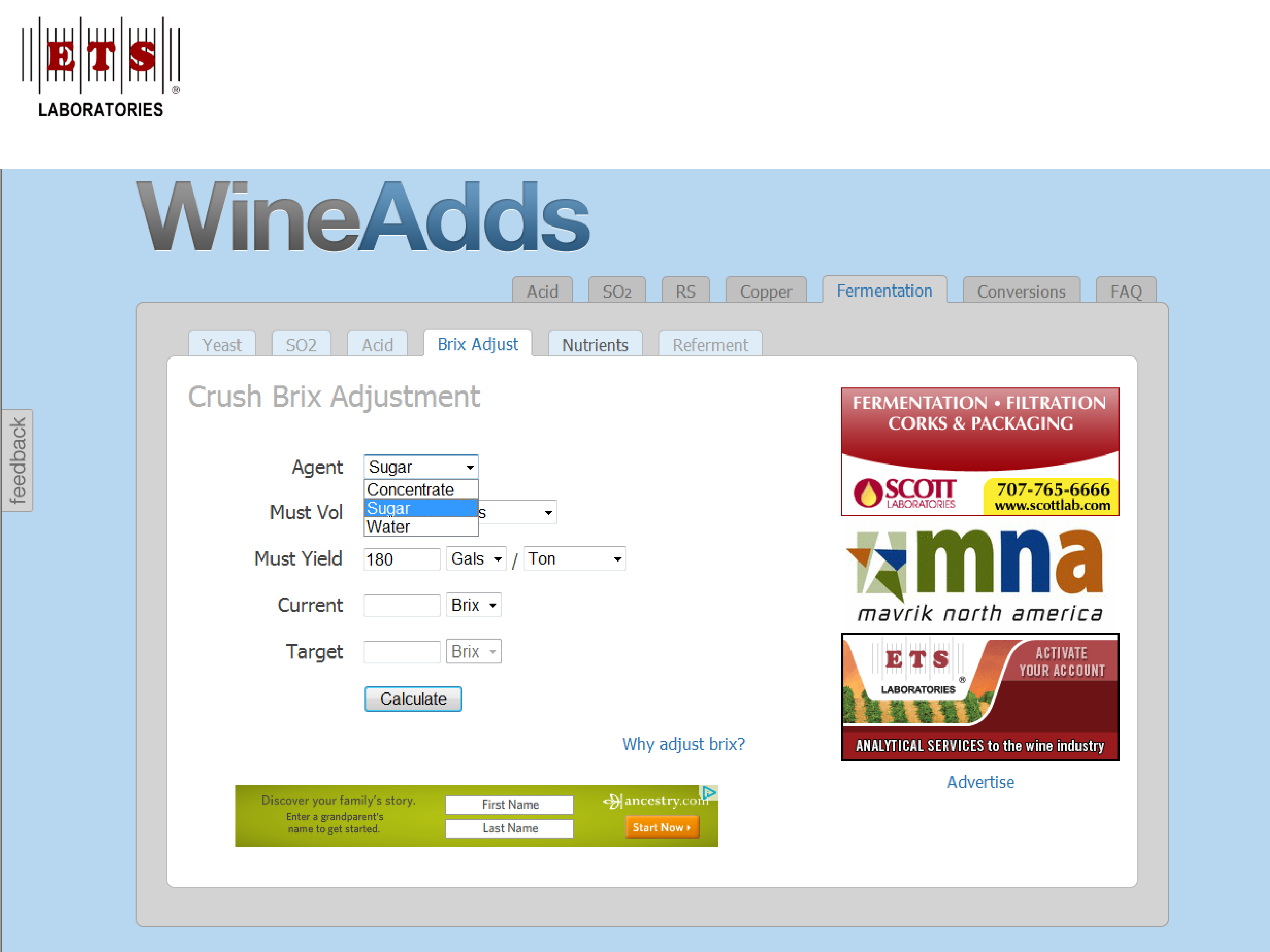
Terminology

- *Chaptalization (Brix adjustment)*
  - The addition of sugar or concentrated juice of the same kind of fruit to juice before or during fermentation to develop alcohol by fermentation.
- *Amelioration*
  - The addition to juice or natural wine before, during, or after fermentation, of either water or pure dry sugar, or a combination of water and sugar to adjust the acid level.
- *Sweetening*
  - The addition of juice, concentrated juice or sugar to wine after the completion of fermentation and before taxpayment.

Analytical Considerations

- Sugar additions can be in many forms:
  - Table sugar, cane sugar, bottlers sugar, etc (Sucrose)
  - Invert Sugar (Sucrose inverted to Glucose and Fructose)
  - Grape concentrate (Glucose and Fructose)
  - Liquid Sugar (Sucrose)





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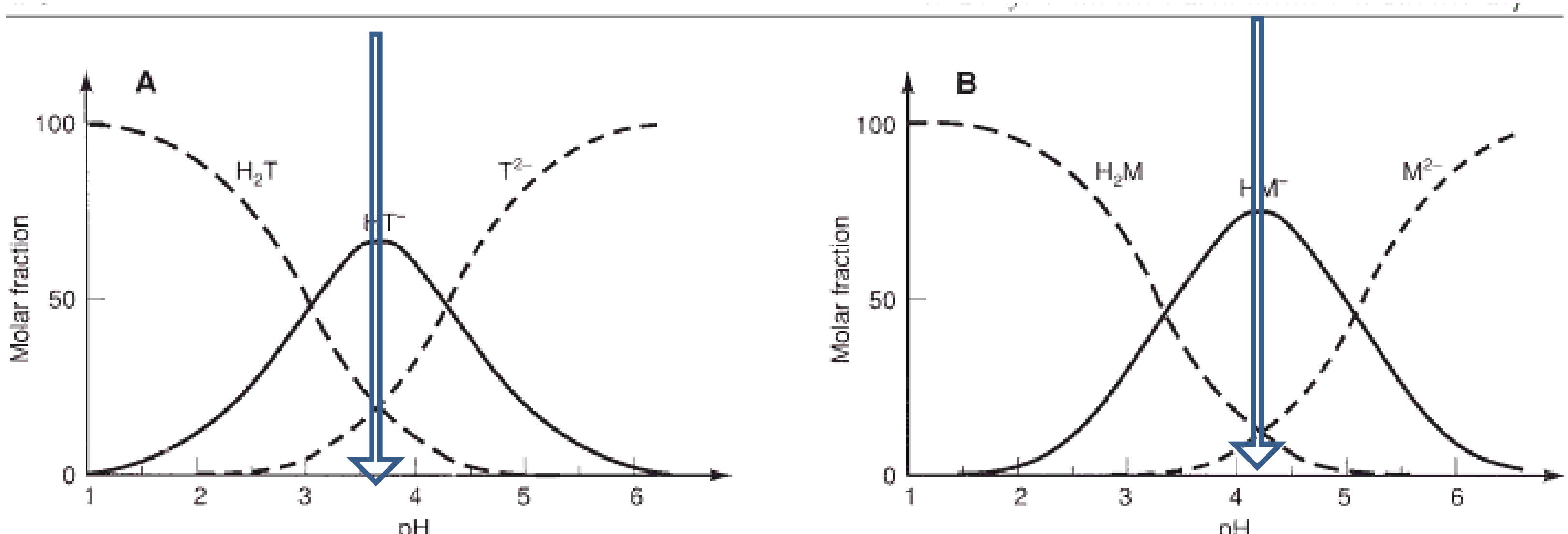
Acidity in Juice: Tartaric and Malic Acid



- The forms are in equilibrium with each other:

$$\mathbf{H_2Ta \Leftrightarrow H^+ + HTa^- \Leftrightarrow H^+ + Ta^=}$$

$$\mathbf{H_2Ma \Leftrightarrow H^+ + HMa^- \Leftrightarrow H^+ + Ma^=}$$

- The proportion of forms depends on pH.
- The total amount of the acids is dependent on viticultural, climatic, and processing conditions.

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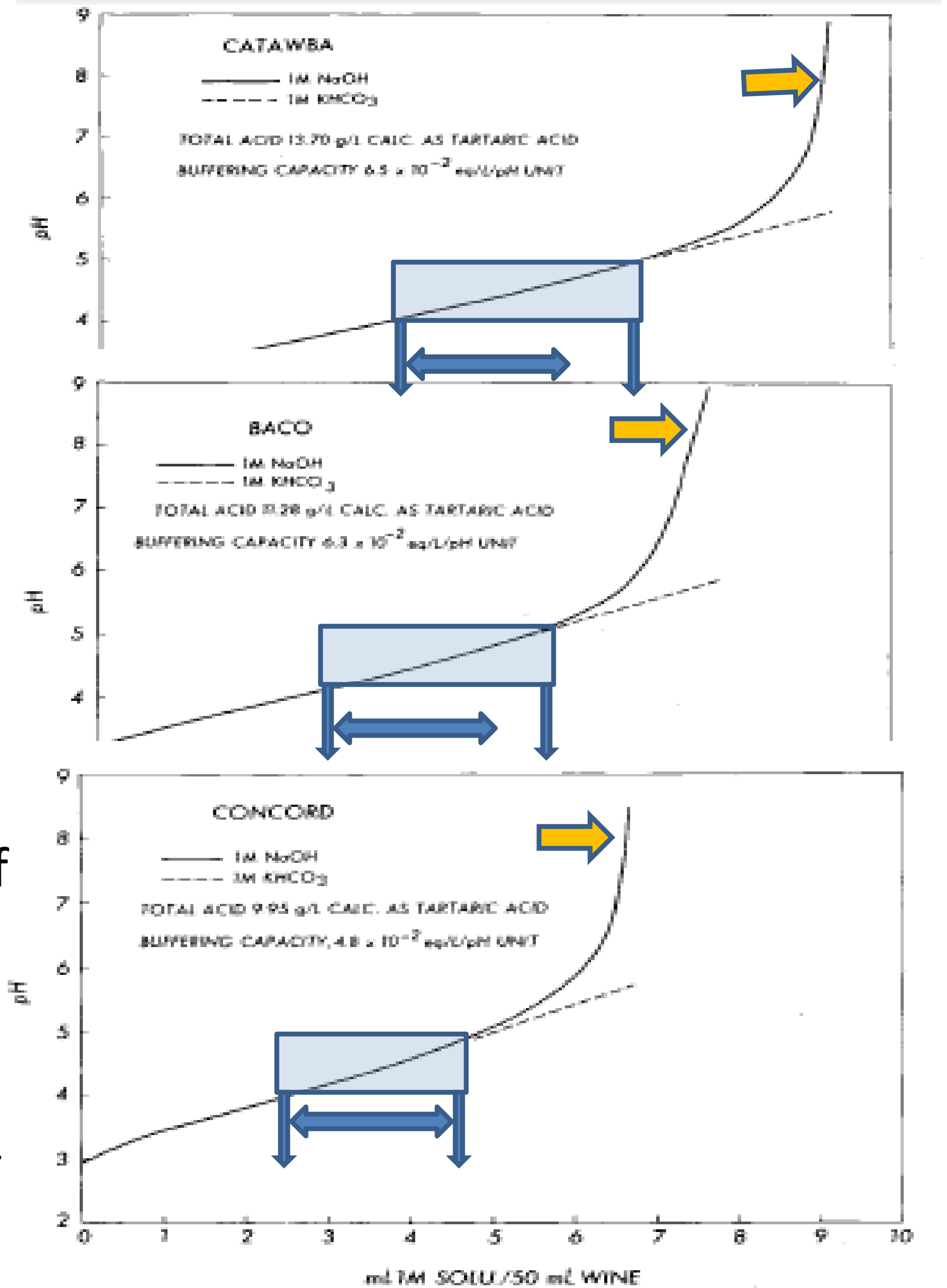
Titration Curves of Wines

- Note the slope of the curves. Buffer Capacity is the inverse of the slope, expressed in equivalents needed to change the pH by 1 unit.
- Note the inflection points
- Two important indicators of acidity : Titratable Acid and Buffer Capacity

LOWERING WINE ACIDITY WITH CARBONATES
Leonard R. Mattick, Robert A. Plane, and LaVerne D. Weirs
Am. J. Enol. Vitic., Vol. 31, No. 4, 1980



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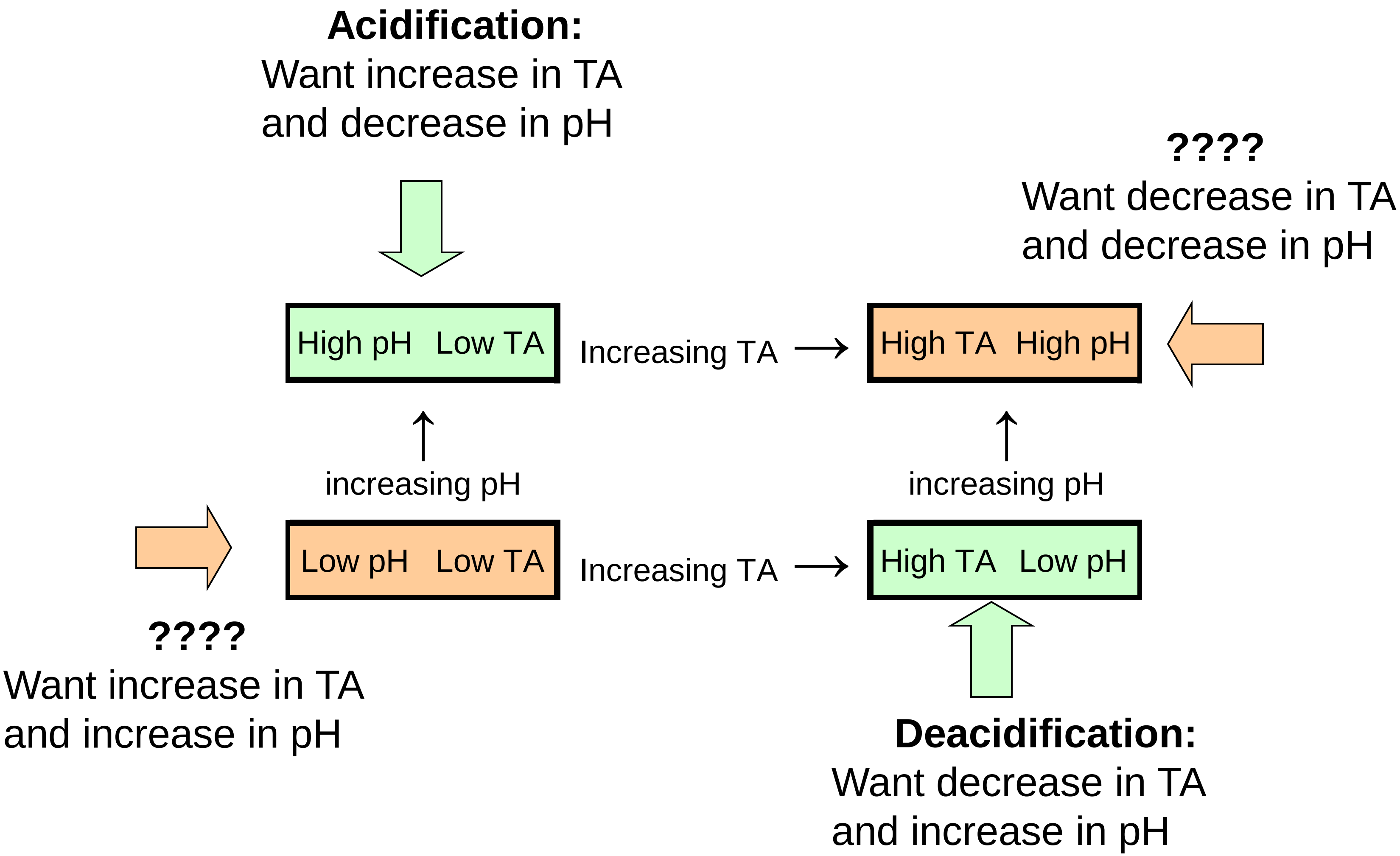
Four Acid Situations



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Acid Corrections: Acidification

- Relatively easy to estimate effect on TA, with knowledge of buffer capacity can also estimate effect on pH.
- Tartaric acid most commonly used on juices and musts, tartaric acid and citric acid most commonly used on wines. Fumaric, lactic, and malic also listed in 27 CFR 24.246
- Mineral acids (phosphoric, sulfuric, hydrochloric) not approved for use in wine.
- To understand the effect on TA and pH, need analysis on TA, pH, buffer capacity, potassium, tartaric, and malic values.

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WineAdds

Acid | SO2 | RS | Copper | Fermentation | Conversions | FAQ

Adds | Deacidify | Solutions | Bench Trials

Acid Addition Details

Agent: Tartaric (Tartaric / Malic / Citric)

Wine Volume: Gals

Desired Δ TA: g / L

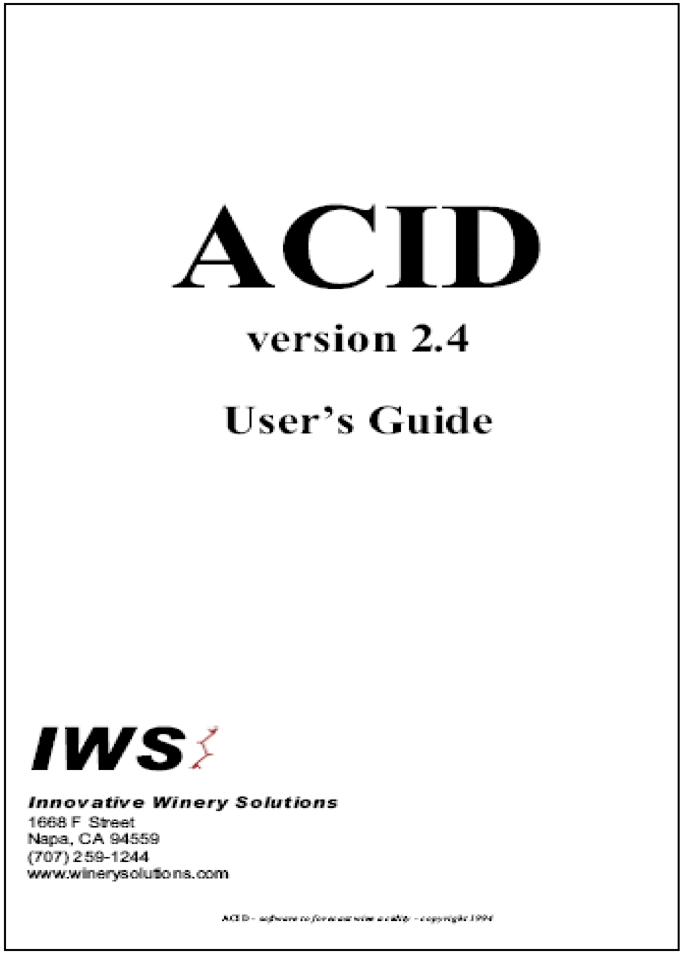
Calculate

Why adjust acid?

Advertise

feedback

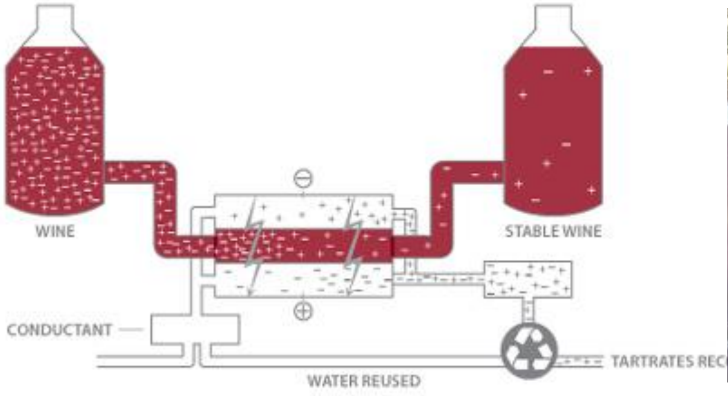
Acid Software



- Calculates acid addition and effects on both pH and TA.
- Predicts pH and TA after malo lactic fermentation.
- Inputs: TA, buffer capacity, K, pH, malic, tartaric, alcohol.
- Does not address carbonate deacidification.

Acid Corrections: Deacidification Processes

- Electrodialysis
  - Can be used specifically to remove the potassium and calcium cations and tartrate anions from wine.



Acid Corrections: Deacidification Processes

- Ion Exchange
  - The ion exchange treatment consists of passing the wine through a column containing resin in cationic or anionic form.

Acid Corrections: Deacidification with Microbial activity

- Deacidification using malo-lactic fermentation
  - Conversion of Malic acid to Lactic acid + CO_2 with loss of a proton.
  - Effect on pH and TA can be estimated if parameters are quantified (pH, buffer capacity, tartaric, malic, and TA)
  - Software is available to help
- De-acidification using Saccharomyces or other yeasts
  - Malic to Ethanol

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Acid Corrections: Deacidification with Carbonates

- Carbonate additions reduce TA and (usually) increase pH.
  - Foaming can be substantial, amount of precipitates of KHT and CaT vary, and residual K or Ca can be an issue.
- Changes in pH and TA using these methods can be estimated.
  - The anionic reactions are predictable, while the cationic reactions are dependent on the amount of precipitation. Analytical measures are needed for predictions, along with no fear of acid/base or crystallization chemistry.
  - A thorough chemical analysis before and after treatment enables better understanding of the state of the juice or wine.
  - Bench trials are recommended, but these may not duplicate cellar conditions.

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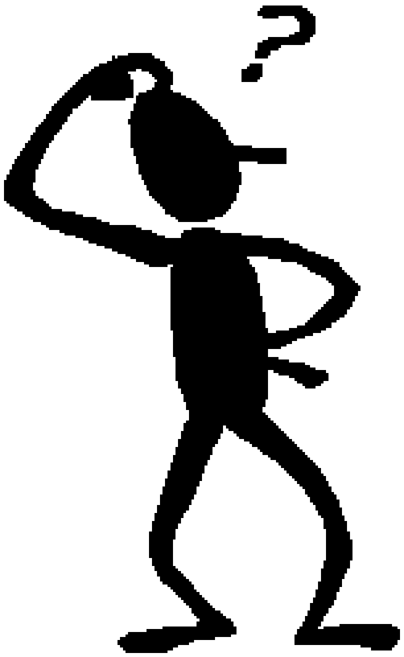
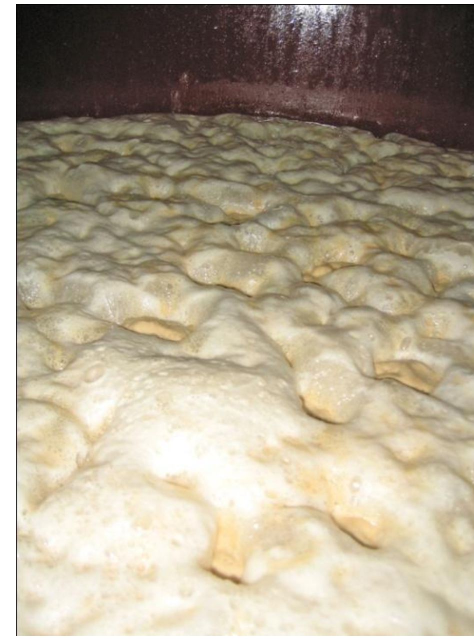


Anionic Reaction: TA down, pH up

$$CO_3^{=} + 2H^{+} \Rightarrow CO_2 + H_2O$$

$$HCO_3^{-} + H^{+} \Rightarrow CO_2 + H_2O$$



- Instantaneous reaction produces **foam!**
- TA ↓ and pH ↑due to the loss of H^{+}
  - 2 moles of H^{+} for each mole of CO3=
  - 1 mole of H^{+} for each mole $HCO3^{=}$
- Change in TA predictable and negative
- Change in pH predictable and positive

$$= \frac{\text{mM } H^{+} \text{ neutralized by anion reaction}}{\text{Buffer capacity of the liquid in mM/pH unit}}$$

Cation Reaction of K_2CO_3 and $KHCO_3$:

Precipitation and pH compensating dissociation

The Cationic reactions can produce tartrate precipitations if the pH, kinetics, and other conditions are favorable.

$$K^+ + HT^- \Rightarrow KHT$$

$$H^+ + K^+ + HT^- \Rightarrow KHT + H^+$$

$$Ca^{2+} + T^{2-} \Rightarrow CaT$$

$$H_2T \Leftrightarrow H^+ + HT^- \Leftrightarrow H^+ + T^=$$

$$HT^- + K^+ \downarrow KHT$$

$$H_2T \Leftrightarrow H^+ + HT^- \Leftrightarrow H^+ + T^=$$

$$T^= + Ca^{+2} \downarrow CaT$$

If these precipitations occur, an acid equilibrium shift can result in pH compensation reactions from the increase in free protons. Reactions are limited by crystallization kinetics and are dependent on the concentration of Potassium.

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$CaCO_3$ "Double Salt" Additions

- Acidex®, SIHADEX® (Begerow), Kalinat ® (Martin Vialatte), or Neoanticid® (Erbsloh) are CaCO3 with added seed crystals of the double salt Ca_2TM. The amount of to use and the subset volume of wine added to it is *critical*; the treated subsample must reach a pH of 4.5 or above for the double salt to form.
- Many researchers note that the concentration of malic to tartaric appears important; a 2:1 ratio is noted.
- Tables require measurement of TA prior to addition. To predict pH shifts need buffer capacity, tartaric, malic and pH. K can compete with formation of salt.
- Calcium instability is a potential serious and insidious downside; measure Ca before and after treatment.

Carbonate deacidifications: Summary of pH and TA effects

- **Anion reactions:** $CO_3^{=} + 2H^{+} \Rightarrow CO_2 + H_2O$
  - TA change is predictable and negative. $HCO_3^{-} + H^{+} \Rightarrow CO_2 + H_2O$
  - pH change is predictable and positive and is a function of the buffer capacity and the change in the TA.
- **Cation reactions**
  - TA change is zero from calcium.
  - TA change from potassium is dependent of the amount of precipitation of KHT and will be negative; it is a function of the pH and the concentration of K and Tartaric.
  - pH change for potassium or calcium reactions are dependent on the precipitation, the pH, and the buffer capacity.
  - pH changes from the cation reaction can be negative, positive, or zero.

$K^{+} + HT^{-} \Rightarrow KHT$

$H^{+} + K^{+} + HT^{-} \Rightarrow KHT + H^{+}$

$Ca^{2+\,+} + T^{2-} + M^{2-} \Rightarrow Ca_2TM$

$Ca^{2+} + T^{2-} \Rightarrow CaT$

Calcium Carbonate Addition Calculation

Email Print

Volume = 1.0 L

Desired Δ TA = 1.0 g/L

Adding Calcium Carbonate
0.667 g
0.001 Kg
0.001 lbs
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Carbonic Deacidifications: Predicting pH and TA changes

- TA changes based on the Anionic reaction are usually all the online calculators provide.
- pH changes are more complex and require additional data and comprehension of the acid chemistry.
- Buffer capacity, pH, malic and tartaric acid, and potassium values assist in understanding the pH shift from deacidification reactions.
- Crystallization kinetics and competition between cations can have significant hindering effects.
- Bench trials are advised although they may not match cellar conditions.

Understanding and Managing Sugar and Acid

- Know the acid and sugar parameters prior to any treatments.
  - Be aware of representative sampling methods
  - Will vary with vintage, variety, harvest conditions
  - Understanding how these parameters relate to vineyard and climate develops appreciation for differences
- If treatments are needed, follow up with additional analysis
  - Choose the treatment for your situation
  - Predictive models are complex and may not result in expected values; Bench trials may not duplicate cellar conditions; Additional actions may be needed
  - Post-treatment analysis allows for additional understanding downstream

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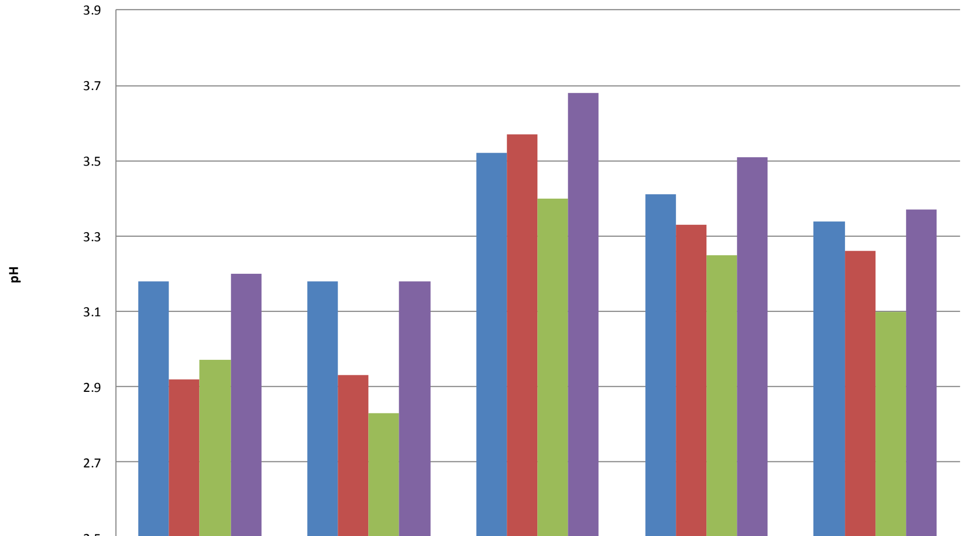
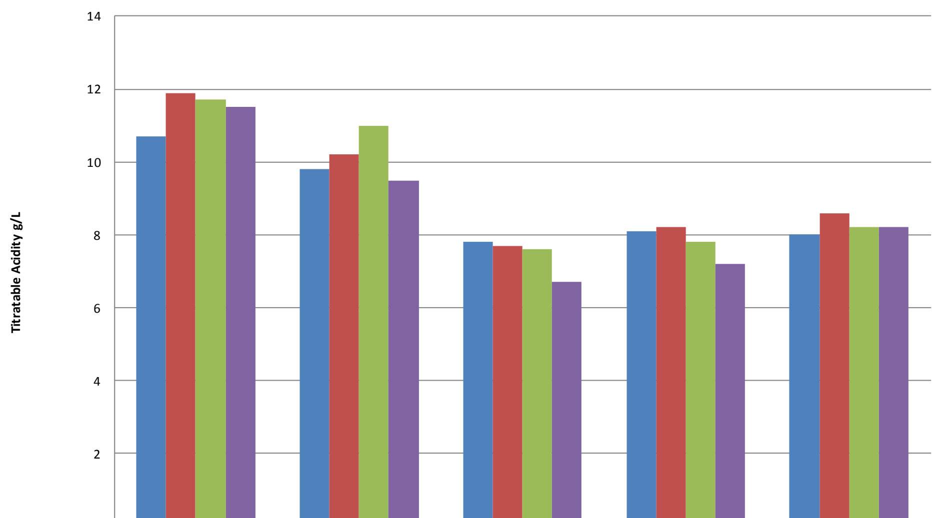
Effect of Deacidification on pH of Four Musts and Wines



	Juice/Must	No treatment	K2CO3 in wine	CaCO3 in wine	CaCO3 DS in must
Chard	3.18	3.18	3.52	3.41	3.34
Chenin blanc	2.92	2.93	3.57	3.33	3.26
White Riesling	2.97	2.83	3.4	3.25	3.1
Zinfandel	3.2	3.18	3.68	3.51	3.37

Effect of Deacidification on Titratable Acid of Four Musts and Wines



	Juice/Must	No treatment	K2CO3 in wine	CaCO3 in wine	CaCO3 DS in must
Chard	10.7	9.8	7.8	8.1	8
Chenin blanc	11.9	10.2	7.7	8.2	8.6
White Riesling	11.7	11	7.6	7.8	8.2
Zinfandel	11.5	9.5	6.7	7.2	8.2

Comparison of Methods of Deacidification of Musts and Wines, JR Munyon and CW Nagel. Am J. Enol. Vitic. Vol 28, No. 2 1977

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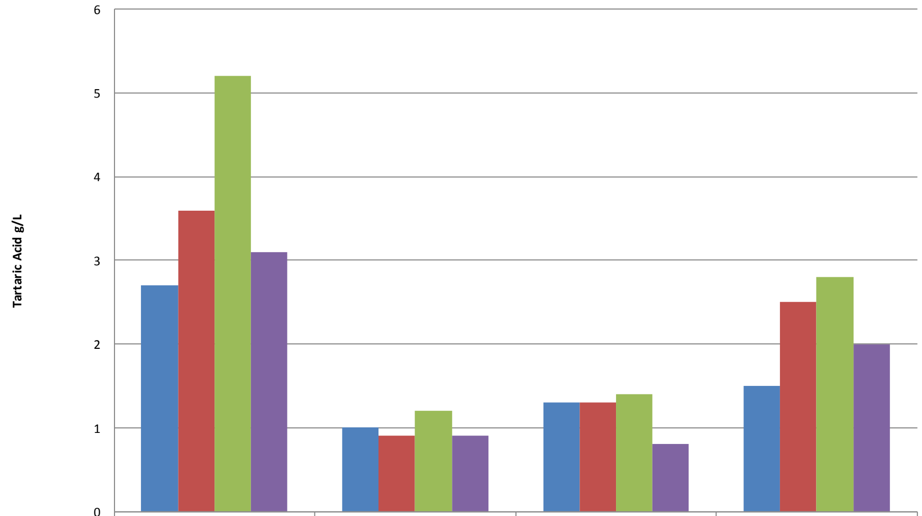
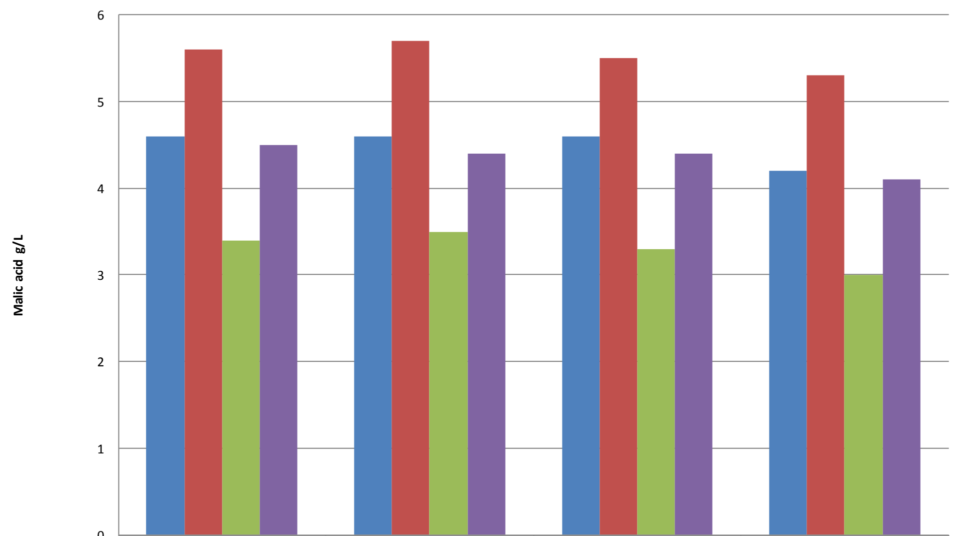
Effect of Deacidification on Tartaric Acid of Four Musts and Wines



	No treatment	K2CO3 in wine	CaCO3 in wine	CaCO3 DS in must
Chard	2.7	1	1.3	1.5
Chenin blanc	3.6	0.9	1.3	2.5
White Riesling	5.2	1.2	1.4	2.8
Zinfandel	3.1	0.9	0.8	2

Effect of Deacidification on Malic Acid of Four Musts and Wines



	No treatment	K2CO3 in wine	CaCO3 in wine	CaCO3 DS in must
Chard	4.6	4.6	4.6	4.2
Chenin blanc	5.6	5.7	5.5	5.3
White Riesling	3.4	3.5	3.3	3
Zinfandel	4.5	4.4	4.4	4.1

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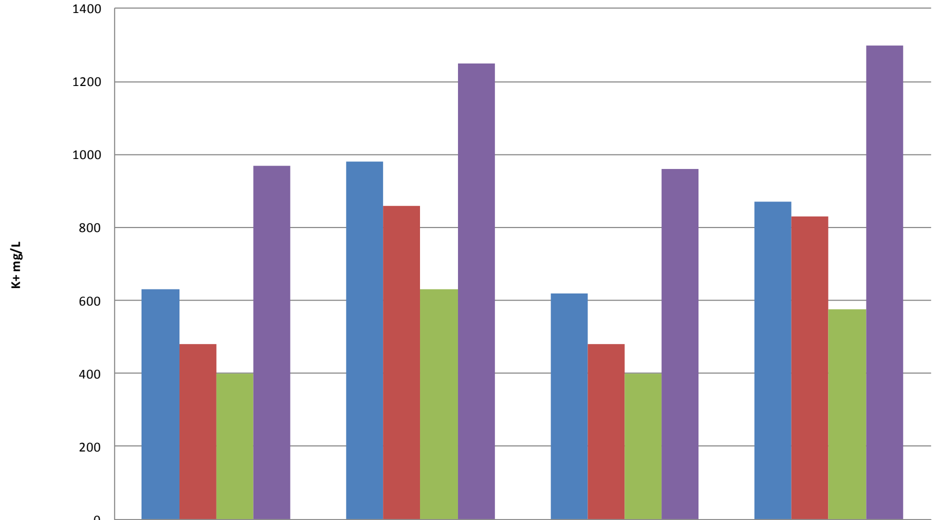
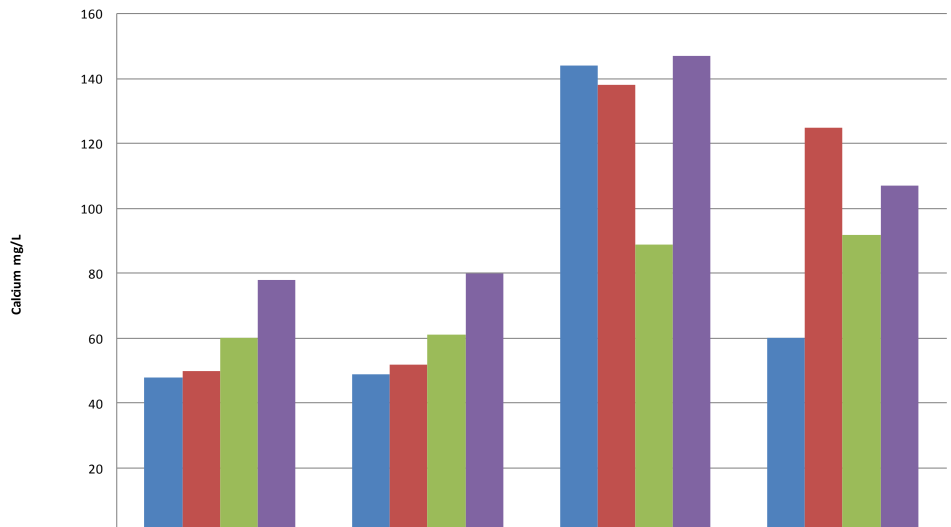
Effect of Deacidification on K+ of Four Musts and Wines



	No treatment	K2CO3 in wine	CaCO3 in wine	CaCO3 DS in must
Chard	630	980	620	870
Chenin blanc	480	860	480	830
White Riesling	400	630	400	575
Zinfandel	970	1250	960	1300

Effect of Deacidification on Calcium of Four Musts and Wines



	No treatment	K2CO3 in wine	CaCO3 in wine	CaCO3 DS in must
Chard	48	49	144	60
Chenin blanc	50	52	138	125
White Riesling	60	61	89	92
Zinfandel	78	80	147	107

Comparison of Methods of Deacidification of Musts and Wines, JR Munyon and CW Nagel. Am J. Enol. Vitic. Vol 28, No. 2 1977

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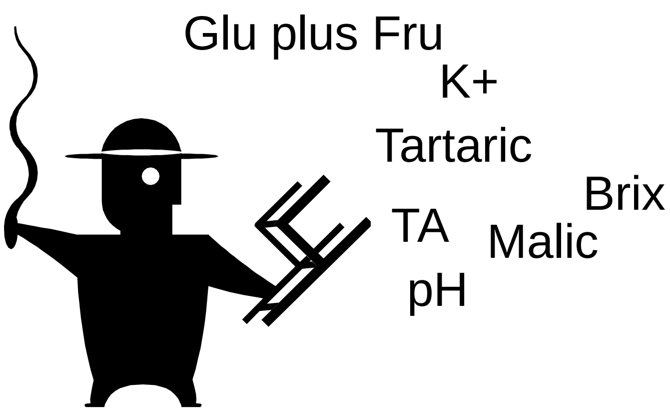
Understanding and Managing Sugar and Acid in Juices and Musts



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