Red winemaking: a synopsis

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v.2.26.2024

Winemaking involves natural fermentation—the conversion of sugar by yeast cells to alcohol. You don't need to add anything to make wine—it will happen all by itself. It's what you do after afterward that makes all the difference. You really don't need to do much more than rack it once it settles into a holding-container, bottle it and drink it before it starts to go off, unless you really know what you're doing. There is a good chance that you won't be able to get it past your nose. So, if you like natural wine––and have developed a fondness for 'earthiness' and often atypical aromas and flavors, much of the following will be of little interest to you.

Modern winemaking practices and fermentation 'additives' has been fine-tuned to avoid spoilage and oxidation, and improve quality, longevity, and of course, taste and palatability. The most reliable way for amateur winemaker to ensure that their wines are at least drinkable, is to add and maintain sufficient SO_2 (Sulfites) to their wines. There are many other non-essential wine additives that can improve palatability, body, and mouth-feel, as well as other sensory characteristics. It's up to you to frame the style of wine you want to make.

Red grapes are fermented on their skins and seeds in open-top fermenters to extract tannins, pigment, and flavor compounds that make red wines unique. Open tanks are used to allow the skins that rise during fermentation to be pushed back into contact with the juice. Phenolic compounds (tannins, pigments, and aroma/flavor components that characterize red wines are contained in the skins, and can only be extracted when they are in contact with the juice. The CO_2 produced during fermentation protects red grapes from oxidations. Oxygen is, though, an important factor in fermentation and greatly influences quality and palatability.

Process: An overview—from vine to bottle:

Harvesting:

- Harvest grapes when the fruit flavors seem right. Other indicators include uniform color, sweetness, brown stems, and seeds.
- °Brix° is not always a good indicator of ripeness.
- The concept of "physiological" ripeness in grapes is relatively new–it's the stage when tannins and other phenolic compounds that contribute to tannic structure, color, flavors, and aromas have reached optimal ripeness.
- Ripeness, though, may vary depending on the intended style of wine being made and the winemaker's objectives.
- Weather is an overriding factor: unseasonably cold weather, cloudy skies, fog, unseasonable rain, etc., can delay or even prevent ripening. Prolonged hot weather and extreme heat spikes desiccate grapes, which drives sugar levels up, and increase Malic acid respiration leading to reduced grape acidity. Furthermore, extreme heat can slow sugar accumulation, and damage grapes.

- The trick is to pick as soon as the grapes are ripe, not just sweet. The °Brix at that point is usually about 23.5 to 24°B, Acid levels are still ideal, and nutrients (needed by the yeast) begin to drop sharply above 24°B.

Sorting and loading the hopper: Take the time to sort through the clusters and pick out stray leaves, incidental debris, earwigs, spiders, and discard unripe clusters, those with lots of raisins, mold, rot, or bird damage, or cut away the affected areas when loading the hopper.

Crushing and de-stemming: Add clusters gradually to the far-end, allowing them to move forward to the crushing rollers individually or in small groups. Avoid the common mistake of dump whole buckets over the rollers. That can strain the motor, and crush seeds in the process. Make sure to remove the stems that exit to the rear of the hopper. They often back up and wrap around the rotating shaft with paddles. I use a long plastic wine-thief to sweep through to facilitate their removal. If you use your hands, be very cautious, as the paddle are within an inch or two of your fingers. If the stems become entangles around the paddles, which is quite common for certain varieties, or if don't stay on top of stem removal. Stop, and **unplug** the crusher, before you remove or disentangle stems.

Some winemakers prefer to ferment whole clusters, rather than crushing and de-stemming them. Seems unorthodox, but it does work. Occasionally, winemakers will simply destem the grapes without crushing them. The intact grapes are then fermented. This can be done by increasing the distance between the rollers, or by using a specialized de-stemmer. The stems, though, are still removed. In this manner, the fermentation will occur within intact berries. The juice in the largest berries that may be split or crushed will ferment normally. Each grape acts as its own fermenter and the resulting wine is fruitier and less tannic, because there is less 'maceration'. Also, the fermentation takes longer. Whole-cluster fermentation is mostly used for Pinot grapes and chardonnay.

Collecting crushed grapes and juice (must): Grape clusters and individual grapes are crushed to break the skins and release the juice. Most of the green stems are removed in the process to avoid green herbaceous flavors and bitterness. You can collect the grapes as they are crushed and destemmed in 32-gal food-grade bins or half-ton macrobins, which ever you prefer. The smaller bins, when secured to wheeled-dollies, can be moved under and away from the stemmer/crusher quickly. Otherwise, you can suspend the crusher/de-stemmer above a macrobin on a platform of 2 x 4 studs, spanning the sides of bin. Bear in mind the consequences of hasty construction or poor design…

Chilling: minimizes oxidation and inhibits the development of microorganisms in the grape must that can lead to spoilage. Keep the must cool (about 55 to g 57°F) until you are ready to start the fermentation. If the must, is relatively cold, fermentation can be started without delay.

Sulfiting: Pre-fermentation: The standard dose is 50 ppm based on the total volume of the must. Once chilling begins, add SO_2 (Sulfite). SO_2 acts as an antimicrobial and an antioxidant, critical for inhibiting microbes that cause spoilage. Furthermore, it prevents enzymatic browning, and binds with aldehydes—precursors of oxidation (vinegar and ethyl acetate, which smells like finger nail polish/solvent). It also accelerates the extraction of phenolic and color compounds contained in grape skins.

- The standard **application rate** for sulfiting is 50 ppm SO_2.
- When stemmed and crushed, 1000 lbs. of grapes yield about 90 gal of must. Actual volume depends on size of individual grapes (ratio of juice to skin surface area) size of clusters, ripeness, thickness of skin, and number of stems in the must.
- You can add Potassium Metabisulfite powder directly to the must:
  - PMBS, when added to water, juice, must, or wine, is measured in milligrams (mg) of SO_2 per Liter (L) of the liquid. There are 1000 milligrams (mg) in a gram of SO_2 and 1000 milliliters (mL) in a liter of water. This makes it possible to express the SO_2 addition as parts per million (ppm) — parts of SO_2 per million parts of juice or wine. One ppm is equivalent to 1 milligram (mg) (.001 g) in 1L of water, juice, must, or wine. To convert gallons of juice, must, or wine to liters, multiply the volume by 3.79. There are 25 gal (about 1hL) of must in a 32-gallon fermenting bin filled to the inner ring about 6 inches below the top.
  - The volume in European presses is typically marked off in hectoliters (hL). One hL = 100 liters), that's about to 26 gal. Using hLs of must can be is a bit tricky, but after crushing, 1000 lbs. of grapes yield about 90 gal, that's about 3.5 hL of <u>must.</u>
  - Hectoliters (h/L) are a common Metric unit used by commercial wineries for making additions. The Metric system is just easier to work with. Additions of PMBS are based on a ton, 1/2-ton, or hLs of grape must.
  - An addition of 8.9 g of must of PMBS Powder (Winy) will provide 50ppm per hL of must. (See Table below)
  - To calculate the dose for a macrobin, holding ~3.5 hL of must, multiply the rate: 8.9 g/hL X 3.5 =~ **31** g.
  - **0.326 g/gal** of must will also provide 50ppm.
  - 32-gal food-grade fermenter holds about 1hL filled to the ring near the top. They are convenient for fermentation because they hold about 1hL of must when filled to the inner ring, about 6 inches below the top. That makes dosing them a bit easier –just add 9 g (KMBS).
  - Using the 32-gal food-grade plastic bins make punch-downs easier, heat buildup and retention is less than in larger fermenters, and they can be moved around as needed on their optional wheeled-dollies. More importantly, they hold about a hectoliter (hL) (about 26) of must when filled to the inner ring, about 6 inches below the top.
  - To calculate grams of PMBS to add to must:

<u>(ppm Total SO_2 desired) x (Liters of must) = grams of PMBS (Winy (Enartis)</u>
(0.56 x1000

Potassium metabisulfite addition guidelines (winy: Enartis)

SO_2 (mg/L)	g/hL	g/barrel	g/1,000 gal	lbs./1,000 gal
5	0.9	2	33	0.07
10	1.8	4	65	0.14
30	5.4	12	196	0.43
50	8.9	20	326	0.72
60	10.7	23	392	0.86

Note: Dosage rates for additions of various winemaking products to juice or wine, are given as g (grams)/hL of juice or wine. For example, when adjusting °Brix by adding water to dilute the must, the amount of water should be calculated based on expected yield of juice from the must in gallons. The "conversion factor" home winemakers can use is 0.6 to 0.7. Thus, the yield after fermentation and pressing from 100 lbs. of grapes is 6 to 7 gallons of wine after pressing. So, if you harvest 1,000 of grapes, base your calculation a yield of 60 to 70 gallons, depending on berry size, pressing efficiency, and ability to salvage most of the juice/wine from the sediment.

Other ways to add SO_2:

- Make a 10% stock solution by adding 100g Potassium Metabisulfite (PMBS) powder in 1liter (1000 ml) of water or 75g in 750ml water. Mix thoroughly
- For each 5 gal of must, add 17ml of the solution to add 50ppm

SO_2 addition: 10% (5.6%) solution (Winy: Enartis)

	5gal	10 gal	15 gal	30 gal	60 gal
10 ppm	3.38	6.76	10.14	20.28	40.56
15ppm	5.07	10.14	15.21	30.42	60.84
20 ppm	6.76	13.52	20.58	40.56	81.12
25 ppm	8.45	16.9	25.35	50.76	101.39
30 ppm	10.41	20.28	30.42	60.84	121.67
35 ppm	11.83	23.66	35.49	70.98	141.95
50 ppm	16.9	33.8	50.7	104.39	202.79

Example: to add 30 ppm of SO_2 to 15 gal of wine, using a standard '10%' solution, use ~30 mL of the stock solution.

- Adding SO_2 is an ongoing process.

Maceration (skin contact): Maceration is the process of softening the skins during contact with the juice, allowing for the release of the polyphenols and flavor components, giving red wines their characteristic color, tannins, and body, prior to and during fermentation. Time on the skins greatly influences the color, flavor profile, tannin structure, and mouth-feel. The longer reds spend on the skins, the greater the extraction of phenolic compounds, tannins, pigments (anthocyanins), and aroma and flavor compounds from the grape skins**.** It begins with crushing, continues with chilling, cold-soaking–an optional step, fermentation, and extended maceration–also optional, but mostly for experienced winemakers.

Macerating enzymes: can be used to gently break down the skin, maximizing pigment and tannin extraction, stabilizing color, and intensifying aroma/flavor precursors.

- Examples: Enartis Zym Color Plus, Scott's labs Lallzyme EX, Lallazyme EX-V, or Scottzyme Color Pro.
- Dosage rate is based on weight of grapes, grams/hl.
- Important: Add SO_2 before enzymes and mix thoroughly before adding them.
- Allow 6 to 8 hours for enzymes to do their work, before adding fermenting tannins.

Cold-soaking: another form of maceration, is the non-alcoholic extraction of pigments and tannins from the grape must (crushed grapes). The time frame is usually 2 to 3 days, but up to 5. More color and fruit flavors are **extracted** in an aqueous environment than an alcoholic one. By comparison, the heat produced by the yeast during fermentation and the increasing level of alcohol, tend to extract phenolic compounds (tannins), best described as harsh, bitter, and astringent. One local winemaker remarked that cold-soaking allowed her to 'frontload' her Pinots, and use a softer touch during fermentation and post-fermentation when alcohol, a more powerful solvent, is high. She added that she keeps her fermentations on the cooler side. Cold-soaking appears to be more suited to lighter bodied reds like Pinot Noir, Grenache, Barbera, and Zinfandel, depending on style. Big reds like Cab, Syrah, Petite Sirah, don't seem to benefit as much, etc.

- There is some risk of bacterial problems if the temp is not cold enough.
- Juice must be chilled quickly to <50°F.
- Temperature should be maintained at 45°F or less the entire time.

Fermentation tannins: are used to minimize oxidation, preserve natural skin tannins, stabilize color, and add body. Some options: Tan Rouge or Fermcolor (Enartis), Tan Rouge Soft (Scott). Tannins, if used, should be added 6 to 8 hours <u>after</u> enzymes have been added, otherwise the tannins will deactivate them. <u>Untoasted</u> oak chips, a natural source of tannins can also be used to enhance fruit, soften structure, add volume, and sweetness during cold soaking. Rate: 8 to 12 g/gal

Testing the must: Knowing the basic chemistry of your grapes: °Brix (% sugar), pH, TA and YAN (nutrient availability), before you start fermentation, allows you to make corrections early, avoiding predictable problems, and ensures a better outcome. Even the best grapes often lack the ideal balance of acids, pH, and °Brix, necessary to create a harmonious wine, or have enough nutrients to support yeast growth and function. When one or more of above factors are too low, too high, or deficient, the quality of the wine will suffer, or the fermentation may falter. Most of these issues can be easily addressed before fermentation, and the resulting wines will be better.

Some winemakers do their own testing, while others submit samples to a local testing facility. Sugar and acid levels vary widely depending on how and when the sample is taken. So, the accuracy of the sample you collect and test or submit for testing depends on how and when you collect the sample. Samples should be collected from a pooled source of grape-must, 24 hours after stemming and crushing, and before yeast inoculation. If you plan to cold-soak, take the sample after a day or two after of soaking. The reasoning is that pH goes up as potassium ions leach from the grape skins into the juice, affecting pH. If you collect a sample during crushing, the sample is not a good representation of the entire lot of grapes. Thus, your numbers are skewed. An accurate assessment of pH, TA °Brix and YAN is important to make a balanced wine with good color, flavors, and aromas.

- Local labs: Gusmer, Home Wine Lab, and My Enologist (Juice panel, B, TA, pH, YAN)
- You can also do your own testing using the Vinmetrica system.

Adjusting °Brix: Adding water to high °Brix must is a common practice to keep the alcohol level within an desirable range. Water simply dilutes the concentration of sugar in the must, thereby reducing the wine's' subsequent alcohol content. Too much alcohol, can make wines taste hot. The practice of '**watering back,**' can be thought of as replacing some of the water lost to dehydration during hot weather that typically occurs at the end of the season. Use bottled water for this purpose, because it lacks chlorine and chlorine-based chemicals. Except for port and late harvest wines, alcohol level in wine should typically not exceed 15% alcohol. The ideal range for Brix is about 23.5 to about 24.5°B, depending on variety and actual ripeness. Grapes much above 25°B should be watered-back to 24.5. A word to the wise, a significant increase in °Brix is common during cold soak of grape varieties like Zinfandel that ripen unevenly, particularly if there are more than a few raisins. Consequently, you may need to do some additional dilution later. When you add water, you also dilute the TA, so you may, want to add Tartaric acid (23 g/gal) to account for water you're adding, particularly if the TA is lower than you would prefer. pH, however, remains unchanged following dilution (it has to do with natural buffering or resistance to change. Base the addition on the expected wine yield: 100 lbs. of fruit contain between 6 to 7 gallons of juice. On average, 60 to 70 percent (occasionally more) of the must is juice, depending on grape size. The Rule of thumb to lower the B° 1 unit, is to add 150 mL of <u>distilled</u> water for each gal. of juice in the must (that's about 2.5 gallons of water for a 59-gallon barrel of wine).

Determining how much water to add:

Equation 1: $(V^1 \times SB) / DB = V^2$

Equation 2: $V^2 - V^1 = X$

V^l = volume (in liters) of undiluted must*

SB = starting °Brix (°B)

DB = desired °Brix V^2 = volume (in liters) of the diluted must

X = volume (liters) of water needed to dilute the must to the desired °Brix

*To convert gallons to liters, multiply by 3.79

For example, if you had 60 gal (228L) of must at 27°B and you want to dilute it to 25°B, you would need to add 18.24L of water:

228L x 27 = 6156 / 25 = ~246

246L – 228L = 18.24 L of water
To convert to gallons, *divide* 18.24 L by 3.79 (L per gal.) = ~4.75 gal

Adjusting grape acidity: Acidity decreases throughout the season as grapes ripen. The longer you wait to pick, the lower the acidity. In California, grapes are commonly picked at 25 to 26°B, –sometimes even higher. So, low acidity grape-must is a concern. When acidity is either too low or too high, adjustments should be made, preferably before fermentation. This helps to ensure that the finished wines will be balanced and stable. So, knowing when and how to adjust acidity is important.

Wine acidity is a critical factor for winemakers, and one of the five taste and sensory components in wine: acidity, sweetness/dryness, tannins, alcohol, body (texture, weight). Acidity influences color, balance, and taste of the wine, as well as the fermenting yeast, and resistance to harmful bacteria.

Defining acidity:

- Acidity involves both TA and pH.
- TA (titratable acidity) is a measure of the total amount of acids in solution. It measures the sum of free H+ ions, and those that remain bound in undissociated acids in a solution, like grape juice. The test involves 'titration' (gradually neutralizing the acids in the solution using a base like Sodium Hydroxide (NaOH) to calculate the amount of acids present). Simply put, TA is a measure of tartness of grapes or wine.
- Acids like Tartaric which are largely dissociated at normal red wine pH, taste less tart than acids like Malic acid that are only partially dissociated at the same pH range. Both are the principal acids in wine—the reason Malolactic conversion makes red wine more palatable.
- The higher the TA, the tarter the wine. Low TA wines taste flat, and high TA in reds accentuates astringency and bitterness.
- TA is expressed as g/L (grams per Liter), or as a percent, for example 6 g/L, or a concentration of 0.6%.
- Acidity varies by grape variety, climate, weather, soil type, viticultural practices, yield, and Brix° at harvest.
- Acidity determines if a wine is tart, crisp, soft, or flat and uninteresting.
- Grapes grown in cooler climates have higher overall acidity and higher levels of Malic acid which has a very tart flavor, than those grown in warmer climates. This can make it more difficult to adjust pH and/or TA to a suitable range.
- **pH:** a critical component of acidity, is a measure of the concentration of H^+ ions from the disassociation of acids in solution. It is expressed as g/L of H^+ ions, based on a logarithmic scale. Acidity increases 10-fold for each <u>whole number</u> on a scale of 14 to 0. For example, an acidity of pH 3 is 10 times greater than pH 4, and a 100-times greater than a pH of 5. A sparkling wine with a pH under 3 is significantly more acidic than a red wine with a pH close to 3.8. A pH of 7 is considered neutral, neither acidic nor basic.
- Generally, the <u>lower</u> the pH, the <u>higher</u> the acidity in the wine, and the higher the pH, the lower the acidity. Yes, damn confusing.

- There is no direct connection between TA and pH
- Wines are encouraged to undergo Malolactic fermentation (MLC) because it converts malic acid to Lactic acid, a softer tasting acid.
- Bear in mind, that pH will naturally go up and TA will go down during cold-soak, fermentation, MLC, and cold stabilization.
- That's why you want to start with grape must with a favorable pH range–3.3 to 3.5

pH and its importance:

- pH plays a critical role in wine stability by determining how much free-SO_2 is needed to keep a wine from oxidizing and safe from spoilage organisms. The lower the pH—the less free-SO_2 is needed! It does this by influencing how much molecular (un-dissociated) SO_2 gas is present. The lower the pH, the greater the level of molecular SO_2.
- The molecular form of SO_2 is a powerful antimicrobial, preventing wine bacteria and wild yeasts from spoiling the wine. In the low to moderate range, it inhibits bacterial and at the high range, kills them.
- pH also influences wine aroma/taste, color, and balance.
- Changes in pH should be monitored after fermentation and maturation to determine if adjustment if needed, particularly after MLC, and/or cold stabilization.
- To test pH, use a calibrated pH-meter – the more accurate, the better, so don't scrimp! You will need to calibrate frequently using pH standards solutions.
- Many amateur winemakers test their juice immediately after crushing, and their measurements are invariably inaccurate. Potassium (ions), leaching from the skins, raises pH, but that takes some time, so, test acidity after at least 24 hours of skin contact. For greatest accuracy, measure pH again at the start of fermentation because of the additional maceration time.
- It's not practical to measure pH, once fermentation becomes active.
- The pH of juice also influences how it changes (goes up or down) as Tartrates precipitate during winemaking and cold stabilization. Above pH 3.65 pH goes up as Potassium Bitartrate precipitates from solution, and below 3.65 it goes down. This is a key point to bear in mind when making acid adjustment.

Making acid adjustments: Favorable acidity for red grapes is: **pH** between about 3.4 to 3.5, and a **TA** of about 6 to 7 g/L.

- The resulting color and taste of a wine is better when the pH is adjusted to about 3.5 before fermentation.
- When juice acidity it is low (pH is >3.6 and TA is < 6), add tartaric acid to increase it.
- When juice acidity is high (pH <3.3) and TA is >8), add Potassium Bicarbonate to lower acidity (raise pH and lower TA).
- Bear in mind that the lower the pH, the greater it's acidity.
- Remember that acidity will decrease during the wine-making process–pH goes up and TA comes down, however it may not be enough for the finished wine to taste balanced.
- Red grapes are typically harvested around 24.5 to 26°B and often as high as 28°B, so acid levels are often too low to make balanced wine. They taste flat and uninteresting, and are unstable and likely to oxidize early.

- Wines made from under-ripe grapes have high acidity (low pH and high TA), and, thus, taste sharp or tart. Although, quite stable they are not particularly enjoyable.
- When all the elements of a wine: alcohol, sweetness, tannins, and acidity are in harmony, the wine is said to be balanced.
- Acidity naturally decreases during fermentation, particularly after Malolactic conversion. TA also decreases during cold-stabilization, and how pH changed depends on the pH of the wine as Tartrate crystals begin to form during cold stabilization. It will go down if pH is <3.65, and up if pH is >3.65 (the 'great divide')
- Correcting most acidity problems is straight forward, but, in a few cases, generally rare, (high pH and TA, and low pH and TA, it can be very difficult, and professional advice may be needed. Read the discussion on wine acidy in the GENCO Handbook for more insight.
- When adjusting acidity for red grape, consider that 60 to 70% of the must is juice when calculating how much Tartaric acid to add.
- To <u>increase</u> acidity (**TA**) by 1g/L (for example 6.0 to 7.0 g/L): add **3.8** g/gal (1 g/L) of **Tartaric acid**. This, however, will lower **pH**, because you're adding a relatively strong acid that will increase the level of Hydrogen ions (**H+**) in the solution. pH will drop by roughly 0.1 unit (for example 3.8 to 3.7), but occasionally as much as 0.2 units. So, add the acid gradually in 3 to 4 additions, and measure the pH after each partial addition. If you don't have a pH meter, get one, and get a reasonably good one.
    - To <u>decrease</u> acidity (**TA**) by 1g/L: add **3.4 g**/gal of **Potassium Bicarbonate** ($KHCO_3$). Potassium ions (K^+) from the addition of $KHCO_3$ bind with Bitartrate ions **HTa^-** in the juice/wine, forming potassium Bitartrate (KHTa). As it precipitates out of solution, **TA** begins to drop. Above pH 3.65 the reaction neutralizes 1 H^+ thus pH increases, but below 3.65 it releases 1 H^+ ions, therefore pH decreases. It's tricky!
- According to Enartis (Vinquiry), when using Potassium carbonate: If the pH ≥ 3.45, use 0.92 g/L (3.5g/gal.), or if the pH ≤ 3.45, use 0.46 g/L. Note: Some people simply use 0.62 g/L (2.34G/gal) regardless of pH. This will increase pH as well, so make additions gradually and check pH after each addition.

- **Pre-fermentation prep:** Allow the must to warm to about 55°F before inoculating with yeast. If you decide to do an uninoculated fermentations using only the yeast on the grapes, and whatever resident yeasts lurking in your cellar. Once the temperature warms >60°F, activity will increase and a 'cap' of skins will begin to rise. If you don't see activity after 3 days, be ready to inoculate with a cultured yeast, otherwise spoilage bacteria will proliferate. True uninoculated fermentations use no yeast additions at the onset of fermentation, although it may be needed later.
- One novel, approach to ensure that natural ('uninoculated') fermentations get off to a rapid start is create a 'natural' culture. This is done by harvesting 5 to 10 pounds of the grapes about 4 to 5 days prior to the anticipated harvest of the block or vineyard. Place them in a large Ziplock bag or small food-grade container with lid and air lock. Crush the berries to release the juice, allowing the yeast on their skins to build up and start fermenting the juice. You can add additional grapes to keep the fermentation going or to increase inoculum level. It's much the same as using a sourdough starter to make

bread. The French refer to this as '**Pied de cuve**.' As the fermentation starts, due to yeast on the skins, you'll need to leave a slight opening or open the bags occasionally to release the pressure from the buildup of CO_2, otherwise the bags will burst. Store them in a relatively cool room until used. If the ferment smells good, you can use the fermenting juice as a starter for the grapes once harvested and crushed. In this manner, you are more likely to ensure that the yeast cells on the skins can ferment the grapes to dryness.

Yeast selection:

- Yeast (cultured, wild (native (indigenous) or feral) are responsible for converting sugars into carbon dioxide and ethanol; they also contribute to a wine's sensory characteristics and quality.
- Yeasts vary widely in their attributes, tolerances, and nuances they impart to wine.
- Select one recommended for the grape variety and style you are looking for, but <u>first</u> consider their critical attributes, i.e., optimum temperature range, alcohol tolerance, nutrient requirements, rate of fermentation, particular aromas and flavor profiles, and propensity to produce H_2S, etc.
- Managing temperature and nutrient availability greatly increases the probability of trouble-free ferments.
- Unless you know the nutrient availability (YAN) of your grapes by testing them, the best you can do is to make an educated guess as to whether their YAN is deficient, low, moderate, or high, and how much if any additional is needed to ensure a trouble-free fermentation. Adding too much or too little can be problematic. Some winemakers add a moderate amount of nutrients and hope for the best, or add nutrients when they encounter fermentation problems. Sometimes it works, sometimes not.
- It generally costs about $50 to have a 'grape-panel test run by one of the local labs, providing that and other useful information.

Yeast rehydration:

- There are some new yeasts that have been cultured/processed in a specific manner, allowing them to be used without rehydration. This, of course, saves time, but they do cost a bit more and, currently there are few to choose from.
- In most cases, use 1 to 1.5g of yeast per gal of must, mixed into 10 times its weight in water (1g of a powder is roughly equivalent to 1ml of a liquid), ex. For 10 grams of yeast, use 100 mls of <u>bottled water.</u>
- Some yeast manufacturers recommend heating the water to 104°F. They caution that temperatures above 104 can stress or kill the yeast. Others recommend 100°F. All things considered, it seems prudent to heat to or allow it to cool 100 to 102°F before adding the yeast.
- Microwaving works well to heat the water. To save time, heat the water gradually to avoid over-heating the water and having to wait for it to cool. Use an accurate instant-read thermometer to check temperature. OXO brand (kitchen tools) makes an economical and easy to use insta read thermometer for under $30.
- Add the yeast to the warm water and allow them to rehydrate and become active.

- After 15 to 20 min., add some of the relatively cold must (about 10% of the volume of the hydrating yeast/water slurry, to acclimate the little buggers to the significantly colder environment, and to provide an immediate source of energy (sugar) and essential nutrients needed by the yeast to proliferate.
- A **rehydrating nutrient** is often recommended.
- If you're using Scott's nutrients like Fermaid K or Fermaid 0, follow their protocol and rehydrate the yeast in a warm nutrient solution containing Go Ferm or GoFerm Protect Evolution. You can view their instructions online in Scott Labs product catalogue. Add the free-dried yeast to the warm nutrient solution and allow the yeast/nutrient mixture to stand for 15 minutes.
- Begin adding a small amount of the must (about 10 to 20% by volume) to the yeast mixture to provide some sugar for the yeast to consume, and to start cooling it.
- After 15 to 20 minutes add more must to the yeast mixture. Continue to do this every 15 to 20 minutes for about an hour and the original volume of the yeast mixture has nearly doubled.
- Allow rehydrated yeast/juice mixtures to cool to about 70°F before adding to the must.
- A temperature difference of more than 10°F may be detrimental to the yeast.
- Once the yeast nutrient mixture has cooled sufficiently cooled add it to the must and stir it in. Voilà!
- **A game changer**: Lallemand's GoFerm Sterol Flash, recently marketed by Scott Labs is a real time-saver, because it eliminates the need to acclimate the yeast. Furthermore, it can be added to room-temperature water (greater then 60°F) and the freeze-dried yeast added immediately to the solution. The yeast/nutrient mix can then be added to the grape-must 20 minutes later. Voila! Go have a beer!

Starting the fermentation:

- Red must, berries, or clusters are fermented in open-topped containers, e.g., variable-capacity tanks, macrobins, 32-gal food-grade containers, and open-top plastic tanks. This allows for the floating cap of grape skins that quickly rises to the surface, to be broken up and re-submerged in the developing wine to insure adequate maceration: extract of skin polyphenols: pigments, tannins, aromatic and flavor precursors.
- You'll need to allow plenty of headspace, (about 8 inches), to accommodate the cap as it rises without over-topping the fermenter. The last thing you want to do late at night is to mop the floor because you failed to allow enough head-space.
- Cover fermenters during fermentation to exclude fruit flies. The lids don't keep them out. They are persistent and resourceful little devils, and can exploit the tiniest openings. I've found that draping a beach towel over 32 or 44-gal food-grade plastic bins work well. Make sure there are no wrinkles that can create openings for fruit flies to gain entry. You can buy fitted fine-mesh covers for macrobins.

Wine fermentation involves: yeast, either inoculated or those present on grape skin, utilizing the sugars for energy, and Nitrogen and other nutrients in grape juice for and metabolism, convert the sugar to Ethanol and Carbon Dioxide (a by-product). Important considerations include the yeast strain used, the temperature and speed of fermentation, availability of nutrient, and levels of oxygen present in the must at the start of the fermentation.

Yeast nutrition: the fine art of feeding your yeast

- Fermenting yeast use grape sugar (primarily fructose and glucose) as an energy source, but rely on abundant source of nitrogen-based nutrients to proliferate quickly, and prevail over a multitude of competing microorganisms present in grape juice.
- Nutrient deficiencies (primarily Nitrogen-based compounds) are quite common in commercial grapes, particularly high °Brix grapes. Unless you test for nutrient availability, you have no clue.
- So, nutrient supplementation is a means of ensuring a healthy fermentation that will consume all the fermentable sugar in the juice.
- Fermenting yeast will struggle when nutrients are in short supply, or fail to complete the fermentation, leaving the wine sweet and prone to bacterial spoilage.
- Struggling yeast cells are also likely to produce H_2S that will need to be resolved as soon as possible.
- Unless you act quickly to make conditions more favorable by adding nutrients or products that remove toxic substances in the wine, the fermentation stick (come to a complete standstill. At that point, your only hope is to restart the fermentation using special yeast and carefully following specific protocols. It's tough, but usually doable
- Nutrient availability is determined by testing. It is reported as **YAN** (Yeast Assimilable Nitrogen YAN). It is the amount of Nitrogen in the grape-must that yeast can take up (assimilate). It is expressed as mg (milligrams) of Nitrogen (N) per liter (L) of juice. The range is from less than 100 mg N/L to over 350. It is a critical consideration for managing fermentations.
- When test results indicate a deficiency, supplementation of nutrients will help ensure that the yeast thrive.
- Unless you know the YAN, you can't manage yeast nutrition well. It's like a shot in the dark. Many amateurs 'wing it,' and often, things go south on them, and they're left scrambling to fix the mess.
- A YAN of <130 mg N/L is deficient, a YAN of 130 to 150 is low, a YAN >151 to 200 is moderately low), a YAN of 201 to 225 is moderately high, and a YAN >250 mg N/L is considered reasonably high.
- Nonetheless, when determining how much YAN will be needed, you must factor in °Brix, nutrient-requirements of the yeast, and fermentation temperature. The higher the °Brix, and the warmer the fermentation, the greater the demand for nutrients! It's a sliding scale. So, what would be sufficient for a °Brix of 23 and a relatively cool fermentation, will not work if the °Brix was instead, 25 and the fermentation is relatively warm.

So how much YAN is enough?

- The required YAN or amount of extra YAN needed by the yeast will depend on the yeasts' nutrient-demand (low, medium, or high) and °Brix. This is specified by the manufacturer.

- From the table below (Scott Labs), determine how much extra YAN will be needed: 0-50, 51-100, 101-150 ppm.
- Notice that the required rate goes up with °Brix and nutrient-demand.
- Select a yeast strain after considering °Brix, and one that can tolerate the resulting alcohol, fermentation temperature range, and the YAN level reported in your test results. It the reported YAN is low to moderate, it's prudent to select a yeast with a low nutrient demand.
- For example: Let's say your grapes are at °25 Brix, and the YAN is a scant 100 ppm, the yeast strain you're using has a low nutrient need, hence you will need at least 100 ppm of additional YAN.
- Timing is important: Start by rehydrating the yeast with a nutrient (Go FERM, Go-FERM Protect Evolution, or Go-FERM Sterol Flash). For Scott Labs' products, make your first nutrient addition at a drop of 2 to 3 °Brix, and the second at 1/3 sugar depletion. For Enartis' products, a third addition of **Nutriferm No-Stop** is made at the half-way point. For dosage rate, follow the instructions outlined in Scott Lab's or Enartis' product catalogues and online for managing nutrient availability.

Table 1: *Measurable yeast assimilable nitrogen (YAN) needs of yeast at different starting sugars*

	YAN Required for Fermentation (ppm N)		
°Brix	Low N need	Medium N need	High N need
20	150	180	250
22	165	200	275
24	180	220	300
26	195	240	325
28	210	260	350
30	225	280	375

The downside of ignoring nutrient availability or mis-managing nutrient additions:

- Not adding the right nutrient (products), the right amount of them, and/or at the right time, can result in the production of hydrogen sulfide—the smell of boiled eggs, a sluggish fermentation, or one that sticks (the yeast (collectively) throw in the towel, leaving the wine sweet and open to bacterial spoilage.
- The critical stages in nutrient management are: at or near inoculation, ⅓ sugar depletion, and at after the half-way point—the long haul!

- There are many commercial nutrient options, most are blends of amino acids and other critical nutrients, some are combined with DAP (Diammonium Phosphate), a non-organic form of N that releases readily available ammonium ions.
- Products containing DAP are typically added at 1/3 sugar depletion, and no earlier than 12 hours after inoculation. DAP can be useful when nutrient demand is the greatest: the peak of yeast numbers and activity.
- Remember, dosage rates for yeast nutrients are based volume of fruit, either 1000 gallons of must or hLs. For the most part, 1000 lbs. of grapes after stemming and crushing yield about 90 gal of must. That's equal to about 3.5 hL (1hL equals about 26gal). For reference: a 1000 pounds of red grapes usually yields about 90 gallons of must, and after pressing: 60 to 70 gal of juice. The range, depending on grape size, but can be as low as 55 gal and as high as 75 gal.

Other yeast-based 'nutrients': these products release **polysaccharides** and **mannoproteins** that can significantly improve mouth-feel (roundness) and structure.

- Fermentation tannins are added soon after fermentation starts. Examples: Scott's: Opti-Red and Enartis: Pro Tinto.
- Noblesse (Scott) is another option added at the start of fermentation, can reduce the production of sulfides, while reducing the perception of alcohol in the resulting wine, and impart a perception of sweetness.

Starting the fermentation:

- Yeast inoculation can be initiated once the above concerns have been addressed.
- Once the must has been inoculated it undergoes a **lag phase** where yeast cells adapt to their new environment, and preparing for growth (replication) and active fermentation. It appears, though, that nothing is happening. To minimize the lag phase, make sure the yeast has been rehydrated with a rehydrating nutrient, or you already added a suitable nutrient to the must, and the fermentation temperature is within the yeast's optimal temperature range.

Managing the fermentation:

- After inoculation, the temperature will gradually increase for several days until it in the mid to higher 70s. At that point begin monitoring the temperature and sugar drop carefully. Check the temperature range of the yeast and keep it below the upper limit.
- Once the fermentation becomes active, the skins will rise to the surface, carried by the CO_2 gas released by the yeast as they metabolize sugar for energy. This causes the skins to form a 'cap' that floats on the juice.
- Extraction of pigments, fruit aromas, and tannins is dependent on adequate skin and juice contact. Therefore, it's necessary to break up and re-submerge the cap by 'punching down') to remix it with the developing wine 2 to 3 times a day throughout the entire fermentation. A commercial-grade potato masher, works quite well to do the job. Avoid mashing the seeds that collect on the bottom when punching. This will release those nasty, bitter and astringent tannins.

- **Aeration**: Fermentation is largely an ***anaerobic process,*** yet yeast cells need some dissolved oxygen in the must to function efficiently in an adverse environment like grape juice, e.g., high acid, and sugars. Once fermentation starts in earnest, the CO_2 released by the yeast, displaces what little O_2 is present, and prevents air from entering the fermenter. The CO_2 effectively blankets the fermenting wine, keeping air at bay.
- Research has shown that juice exposure to air/oxygen during fermentation produces wines with improved aromas, flavors, and mouthfeel. Cumulative exposure to air over the entire fermentation is important. A single exposure or several exposures are not as effective.
- So, exposing fermenting wine to air starting early (day 2 and 3) for 3 to 4 days during fermentation helps the yeast survive when alcohol levels rise and begin to inhibit the yeast.
- Commercial wineries regularly introduce air into fermenting red grapes for the sensory improvements. Amateur winemakers can do something similar by bubbling air directly into the fermenting must, with a small aquarium air-pump. This is like the lengthy pump-overs or 'drain and returns' that many commercial wineries do to promote oxidation of tannins and their polymerization (softer tannins).
- Aeration is an economical and useful technique for amateur winemakers to improve their red wines.
- The risk of oxidation from bubbling, either air or pure oxygen, using a range of techniques and infusion times has been shown to be of little concern (Australian Wine Research institute). Most of the air introduced is absorbed by the yeast or quickly driven out by the CO_2
- Although 'punching down' introduces little or no oxygen, it does maintain skin/juice contact, facilitating the extraction of color pigments, aroma and flavor precursors, and tannins. Furthermore, it keeps the yeast in suspension, and allows undesirable fermentations odors to dissipate.
- Punch downs are typically done 1 to 3 times a day, depending on the level of skin extraction the winemaker wants. Consideration should be given to grape variety, ex. Pinot noir vs. Malbec, and the desire for more-or-less extraction of polyphenol compounds (tannins and anthrocyanins from the skins, as well as bitter/astringent phenolic compounds from the seeds. If you're trying to minimize the extraction of these compounds in big reds like Petite Sirah, 1 to 2 punch downs per day and keeping fermentation temperature moderate will minimize astringency and bitterness. Pinot noir is often punched down gently once or twice a day to minimize skin maceration and the extraction of tannins.
- Fermentation enzymes enhance the extraction of color pigments (anthrocyanins), and tannins.
- Once the cap is broken up and mixed it back into the juice, re-suspend the sediment that collects at the bottom of the fermenter by pulling up the punching tool quickly, creating an updraft that carries it to the top, helping to release off-aromas.
- Measure the temperature after you punch down. The cap temperature will be higher.
- Keep the fermentation temperature below the yeast's upper limit. Higher temperatures may adversely affect them, or result in the loss of desirable aromas.

- Once the fermentation is active, temperatures generally should remain between 75 to 83, but may increase to 86°F or even higher if allowed.
- Cooler temperatures help preserve fruity aromas that would otherwise be driven off by higher temperatures, but color and tannin extraction are better at the higher end of the range.
- Punching down longer or more often helps to lower the temperature, but results in greater maceration.
- Heat is dissipation is also less if you leave the lid(s) in place. A porous fabric can be used to exclude fruit flies and other critters, while dissipating heat. Or, if need be, adding a frozen water-filled jug to the fermenting must for a minute or two will drop the temperature to a more favorable level.
- High temperatures can stress the yeast, leading to a sluggish fermentation, or causing the fermentation to stick. 💣
- Longer, cooler fermentations are thought to produce better red wines, provided the wine reaches the optimal temperature (80 to 83°F°) for a short period. In general, it's best to avoid exceeding 86°F. Some yeast, though, will tolerate higher temperatures.
- To minimize the extraction of bitter seed tannins, you can bucket the fermenting must to another similar container, at around 10°Brix. Scoop up or pour the wine, loose seeds, heavy sediment, near at the bottom of the fermenter, and pass through a large sieve to salvage the remaining wine, and then discard the seeds and other solids remaining in the sieve.
- Monitor for off-odors or sluggishness. If the cap begins to fall and the wine is perceptibly sweet, and there has been no further dops in °Brix for 4 to 48 hours, something is very likely amiss.
- Stinky volatile sulfur compounds, such as hydrogen sulfide (H_2S), Mercaptans can form when the fermenting juice/must is nutrients deficient, the yeast's upper temperature limit has been exceeded, or when the oxygen concentration is too low. Wines with such odors are said to be **reduced**, and the process is called **reduction**.
- The aromas generated by these sulfur compounds include: hard-boiled eggs, cooked, cabbage, asparagus, garlic, onions, rubbery, etc. In time, H_2S will form mercaptans (skunky), both, though are easy to fix with copper compounds like Reduless (Scott Labs). Ultimately, mercaptans form disulfides which are more difficult to fix.
- Off-odors detected early in the fermentation, typically indicate nutrient deficiency.
- Elemental sulfur on the grapes from sulfuring close to harvest is another cause of H_2S.
- If reduction is noted before the 1/3 sugar depletion point add about 30g/hL Fermaid K, or something similar like Nutriferm Advance and. If reduction is noted after one-third sugar depletion, and you have already added yeast nutrients, add another 20 g/hL Fermaid K.
- Fermentations will become sluggish and produce H_2S if the nutrient availability is deficient, the yeast strain's alcohol tolerance is too low, or the temperature got too hot for the yeast. Aeration can reduce or eliminate the concentration of volatile sulfur compounds.
- Exposing the wine to the air near the end of fermentation by bucketing from one container to another or just 'splashing' around in a macrobin, allows O_2 to bind with the

tannins and pigments, helping to build supple structure. Wine near the end of fermentation can absorb a lot of O_2 without oxidizing.

- Fermentation is usually finished when the cap settles back into the wine on its own. Check the °Brix level to determine if there is still some remaining fermentable sugar.
- A hydrometer Brix/Balling reading of -1.5 to - 2°B or a specific gravity of 0.990 to 0.996 indicates the wine is essentially dry. If it's above 0, when the cap starts to sink, you may have a problem because the wine still contains fermentable sugar.
- If there is any doubt about remaining fermentable sugar, use Clinitest reagent tablets to measure it.
- Some wine-makers, however, press at around 3°B after collecting and discarding the bulk of the loose seeds at the bottom of the fermenter. The wine is then allowed to finish in a barrel or fermenting container. The objective is to reduce astringency. Tannins can be augmented later if need be. At this point, an airlock is needed.

Post fermentation: Pressing, settling, and racking off the gross-lees

- Red wines, having completed primary fermentation, are typically 'pressed' to separate the wine from the skins, seeds, and heavy sediment (gross-lees). Allow the wine to settle for 4 to 6 hours, rack, and transfer the partially clarified wine to a tank or barrel for malolactic conversion (MLC). A little fine sediment helps the ML bacteria.
- Commercial winemakers sometimes do an extended-maceration, by allowing the finished wine to remain in contact with the gross-lees for several weeks. It takes know-how, attention to detail, smelling to detect off-odors, tasting, and occasionally stirring the wine to keep the lees in suspension. Experienced winemakers, however, use this approach to add complexity, improve mouth-feel, and enhance wine character, but they understand that there is some risk involved. They also know when to act and what to do if something seems off. Unless you know what you're doing, remove the gross-lees (sediment) that quickly settles to the bottom of the fermenter after pressing.
- When bucketing the finished wine and skins into the press, remove as many of the seeds that have settled to the bottom of the fermenter during fermentation. Scoop up the 'dregs' at the bottom and pour it through a large kitchen strainer/sieve and separate the seeds for disposal, and to collect the wine. This will minimize the extraction of bitter seed-tannins. Macrobins can be tipped so that the wine pools at one end or corner, allowing most of the remaining wine to be collected.
- If left in the wine, the gross-lees can result in off-aromas, particularly smelly sulfur-based compounds.
- Take your time when pressing and avoid hard cranking when using a basket press, and fill your basket press about 80% full, and when cranking become difficult, stop frequently to allow the pressure to decrease a bit, making it easier to press. And strive to keeping the pressure as low as possible. Although, this takes longer, the quality is better.
- Bladder presses use an outward-expanding rubber bladder to press grapes against a surrounding perforated metal screen. They typically operate using water pressure to do the work. They are gentler than basket presses, and are thought to produce wines that are less harsh and bitter.

- Bladder presses work just fine at low pressure – 8 to 12 PSI works well. Don't be tempted to crank up the pressure.
- Fill bladder presses to capacity, but avoid packing the grapes, even if there is only a small amount of grape-must remaining. These can add later after an initial pressing creates the needed space. If you don't have enough grapes to fill a bladder press completely, partially inflate the bladder to reduce space around the bladder until the grapes just fill the void. It's not a good idea to press a partially filled bladder press. Unless inflated uniformly, the bladder is more likely to fail.
- The juice that flows freely from the press before any pressure has been applied, and the juice that flows when relatively low pressure is applied, is considered 'free-run.' 'Hard-press' refers to the juice collected after the flow is considerably reduced. At that point, pressing extracts more astringent and bitter tannins, particularly if there are still a lot of seeds in the press cake (compressed grapes). Some people prefer to keep the two separate.
- Quality does suffer when the 'cake' (skins and seeds) is relatively hard-packed and the press stream has significantly diminished.
- Keep the hard-press wines separate, and decide what to do with it, or how to resolve any excess astringency—usually by fining. Harshness and astringency can be removed with Clargel (Enartis) or Colle Perle (Scott) and others.
- Taste the wine as it's being pressed, and stop collecting when the wine tastes astringent. It often depends on the grape variety.
- Many people simply combine all the wine into one lot, and make the most of it.
- Remember, tannins are not necessarily the enemy, they are indispensable for developing supple structure in red wines. It's how you manage them that makes all the difference.
- Collect the wine as it flows from the press into a 2.5 to 3-gal. bucket fitted with a large kitchen strainer/sieve to trap seeds, skins, bees, etc. Have a couple of buckets in reserve for when the flow can be overwhelming. Transfer the juice, preferably to food-grade, alcohol-safe PET plastic carboys to allow the heavy sediment (lees) to settle for 4 to 6 hours before transferring (racking) the 'partially clarified' wine into a barrel or storage tank. Glass is heavy and easily broken. Carboys are ideal for settling and ease of handling, and because you can see when most of the sediment has settled out.
- Place the carboys on a raised surface, like a solid folding table, but don't over load it. From that height you can easily siphon the wine without having to lift the container and disturb the lees.
- From the carboys, transfer (rack) the settled wine into a barrel or storage tank. If using a barrel make sure that it is clean, smells good, has been rehydrated, and is tight (leak-free).
- Use a siphon wand or ½-inch clear plastic siphon hose fitted with a bright red baffle (easier to see in dark wine) at the tip, to draw wine from above, rather than directly from below, maximizing yield, and minimizing uptake of sediment. Suspend the tube into the wine and position the baffle just above the sediment. As the level drops, pull the carboy toward you to raise the level of wine above the baffle, so you don't lose the

siphon. Avoid picking up much of the solids as practical. You'll lose a bit a wine in the process.

- After filling the primary storage container, transfer any excess wine to smaller air-tight containers and fill to capacity for storage. Do not add any SO_2 until MLC is finished.
- Now, you are ready to inoculate for MLC.

Post fermentation: Malolactic Conversion (MLC)

- MLC is a natural process involving Lactic acid bacteria, naturally found on grape skins, they metabolize Malic acid, converting it to Lactic acid, a softer-tasting one, reducing the wine's acidity. Malic acid is very tart, while Lactic acid is not. Nearly all red wines undergo this process because it makes them more palatable.
- Initiate MLC without delay once the wine has been pressed, settled, and racked. By the end of fermentation little if any of the SO_2 added prior to fermentation remains, so ML bacteria can thrive. In general, ML bacteria are very sensitive to SO_2. Less than 10 ppm of free-SO_2 and more than 40 to 60ppm Total SO_2 can suppress them.
- ML bacteria, in general, are intolerant of high alcohol levels, low pH, and free-SO_2 greater than 10 ppm, and largely inactive below 60°F.
- Selected strains of Malolactic bacteria are available for varying levels of alcohol, pH, and free-SO_2 They are also easy to add.
- Although MLC may occur spontaneously, it's better to inoculate with a commercial culture. They've been selected for their attributes and reliability. The initial level of inoculum in a standard culture is much greater than that found on grapes skins, so the reaction starts without delay.
- The wine's potential alcohol level, and it's free-SO_2 must be considered when selecting a ML culture. For example, if you use an ML culture that is intolerant to alcohol greater than 14%, and the grapes have a °Brix of was 26, the alcohol level is likely to exceed 15%, consequently the ML bacteria will languish and die. So, no dice! You'll have to start over with a ML strain that is tolerant to alcohol. There is no way of knowing how the native ML bacteria will fare.
- MLC should be done in a closed container or barrel fitted with an air-lock to minimize oxidation. Make sure there is little or no head-space when you start, and during the conversion process.
- Oak barrels are ideal for MLC, aging and, storing red wines. You can, however, use stainless, or plastic tanks. Barrels stored empty will need to be rehydrated to prevent leakage.
- High SO_2 levels in recently sulfited barrels may retard the bacteria. So, rinse the barrel several times, drain for an hour or two, and then allow it to sit empty and upright for up to 8 hours, with just a wadded paper town stuffed in the bung hole. This should allow much of the residual gas to dissipate before filling it.
- Before adding ML bacteria, you'll need to rehydrate the freeze-dried cultures available in 2.5g foil pouches — enough to treat 66 gallons of wine. Follow the manufacturer's recommendations. There are some cultures that can be added directly without having to rehydrate them.

- Use an ML rehydration nutrient such as Acti-ML (Scott) or Osmobacti (Enartis) to rehydrate the bacteria.
- To ensure that the MLF goes quickly and finishes, use an ML-nutrient added to the wine 24-hrs. prior to inoculation or just prior to it. Enartis markets Nutriferm ML, and Scott has Acti-ML, ML Red Boost, and OptiMalo-Plus. Check the nutrient demand of the culture (Scott labs) and add enough nutrient to ensure adequate nutrition.
- Ideally, the temperature of the wine during MLC should remain above 68°F but below to 77°F for a quick ML conversion. Try to maintain a temperature of 72°F. This may require heating the room for several or more weeks (expensive), or using an electric blanket to keep the barrel/container warm (cheap). Some amateur winemakers use a small aquarium heater inserted into the wine. It's important that the wire attached to the unit can be securely sealed to prevent air intrusion.
- Stir the wine during MLF 1 to 2 times a week to keep the ML bacteria and any remaining dead yeast cells in suspension. If the spent yeast cells settle out, they will form a thin layer at the bottom, making their nutrients less available to the ML bacteria. The ML bacteria are also more active when kept in suspension.
- CO_2 bubbles rising to the surface indicate that the conversion process is active. If you put your ear to the bung hole, you can hear a faint fizzing or popping as the tiny bubbles break the surface. CO_2 gas is being released while the fermentation is active, this serves to protected the wine from oxidation. But when the reaction is slowing and the airlock is being removed frequently to check progress, and there is appreciable head-space.
- Film bacteria and yeast are likely to develop when barrel in the head space that occurs when the wine lost to evaporation through the wood is not replaced frequently enough. They produce perceptible volatile acidity (Vinegar and Ethyl Acetate, considered a serious flaw.
- Oak barrels gradually lose water through the wood to evaporation, and need to be topped regularly to eliminate the head-space that develops.
- Purge barrels and fermenters with Argon or Nitrogen gas every time you remove the airlock to stir the wine or check progress.
- It usually takes 4 to 6 weeks, sometimes longer, for MLF to complete, depending on temperature. The warmer it is, the faster the process, however, is the temperature reaches 78°F it may be 'curtains' for the yeast.☠
- When you can no longer hear bubbling/popping, test the wine to see if the MLF is done.
- If the MLF doesn't finish before winter, it will start again the following year when temperatures increase, assuming the wine is not stored in a cool cellar.
- A word to the wise: wines that have not undergone MLC, will generally restart in the bottle, resulting in a carbonated red wine. Yikes!
- A test reading of 30 ppm or 0.3g/L malic acid or less indicates completion.

Post MLF: SO_2 addition

- Once MLF is finished, top the barrel, leaving little or no head-space and use a solid silicon bung to prevent air contact.
- Now! It is time to make the second SO_2 addition to protect the wine form oxidation and bacterial spoilage.

- In general, the recommended practice for amateur wine-makers is to add 60 ppm free-SO_2 following MLC.
- Even though, you may have added 50 ppm of SO_2 before you started fermentation, little or none of it remains after fermentation and MLC. Bloody Hell! Where did it all go? Well, most volatilizes during fermentation, or is bound up with grape components, polyphenol, etc. and some winds up in the sediment. The bound SO_2 remains in the wine, but is largely unavailable to do its work.
- So, even if you do add 60 ppm, much of it will bind up, leaving perhaps 30 ppm, and then another 10 ppm will be lost dealing with oxidation following racking. That leaves you with a scant 20 ppm. That's hardly enough to keep the wine stable during aging.
- So, you'll need to retest the free-SO_2, within a week or two and add enough to bring the free-SO_2 level back to close to 50 ppm, that should hold for a while. Adding SO_2 is an ongoing process and you will need to check the level periodically.

Post MLC: **Testing the finished wine:**
Have a local wine lab do a standard 'wine-panel' analysis to accurately determine: pH, TA, remaining Malic acid, alcohol, free- and total-SO_2. This will tell you if adjustments for stability, or to improve sensory appeal are warranted. Otherwise, you'll have to trust your instincts, and make adjustment based on your taste preferences. That can be hard to do unless you have a lot of tasting experience.

The pH of finished wine should range from 3.50 to 3.75 and TA should be > 5.5g/L but less than 7 g/L. If pH is above 3.7, reduce it to around 3.6. This will help with tartrate precipitation, and lower both TA and pH. If it's closer to 3.7, TA will drop, but pH will increase — typically not what you want! So, it's critical to know what the pH is after fermentation. You can dial-in pH later during maturation to a level that is more desirable to your taste. In general, many reds taste better at around pH 3.7. Above about 3.85, they may taste quite good, but are not stable. You're skating on thin ice…

Post MLC: Racking and clarification and stabilization:
- There is no compelling reason to rack after MLC, assuming the wine smells fine. That can be done later.
- Racking is the removal (transfer) of the largely clarified wine from one container to another, allowing the sediment to be flushed away. It typically involves siphoning, pumping, or using pressurized inert gas to move the clear wine to another container, leaving the sediment behind.
- Racking serves to clarify the wine, eliminates sediment (light-lees), allows off-aromas to dissipate, and exposes the wine to a modest amount of air, ultimately 'softening' the tannins.
- Ideally, you would rack from one storage container to another with a similar capacity. If you have only one suitable holding tank, rack to carboys temporarily to remove the sediment, and then return the wine to the original container after the sediment has been flushed out.

- Some winemaker rack 4 or more times: once after pressing, once again after MLC, another about half-way through the maturation period, and finally just before bottling. Some skip the post-MLC racking and rack just once or twice before bottling. Some professional winemakers rack Pinots just twice during the winemaking process to minimize exposure to air and loss of fruity aromatics.
- Tannic wine typically benefits from more frequent racking to increase exposure to air, facilitating polymerization of tannins, making the wines softer and rounder. Remember that racking exposes the wine to oxidation, so don't over-do it. Therefore, careful racking and attention to free-SO_2 levels is important.
- Yeast, insoluble pigments, and other material will eventually settle out, leaving a clear red wine. It typically takes 12 months to adequately clarify most reds. When early bottling is desired, filtering will remove most of the remaining sediment If you want to bottle sooner.
- Sediment is likely to form in wines aged for less than a year, and red pigments are likely to coat the inside of the bottle. Medium to heavy-bodied reds aged for one year will likely 'throw' sediment. Most big reds aged for 2 years or more will drop some sediment after a couple of years or two in the bottle. It's not a bad thing, but if appearance is important, filtering is an option. It is widely done in the industry.
- Cloudiness in wine after several months may indicate bacterial problems that should be mitigated using a product such as Scott Lab's Bactiless, or Enartis' Stab Micro M designed to remove them.
- Wine in small containers can be easily transferred by siphoning, but that's harder to do for larger ones, unless you can lift the container by some mechanical means.
- The currently available wine pumps work just as well. I use a variable speed diaphragm transfer pump. Initially, there is some agitation (cavitation–bubbles) of dissolved gases forming in the wine exiting the pump, but that quickly subsides. After that, the wine moves smoothly and remains clear. If you see discrete bubbles, stop pumping, and check the fitting for leaks. If you do nothing, you'll just incorporate air into the wine–a bad thing! To minimize exposure to air. I purge the pump, and siphon hoses and racking cane with argon to displace the air trapped within before I start pumping.
- Perhaps the best way transfer wine is to use a barrel gas-transfer tool (Bulldog). It typically uses compressed CO_2 or Nitrogen to modestly increase pressure within the barrel to push the wine up through a stainless-steel tube, connected to a hose that runs to the receiving container. The tube is positioned just above the sediment using an adjustable screw. It's very efficient, and exposure to air is minimal.
- It's best to add 10 ppm of SO_2 before racking to compensate for the resulting exposure to air. Check the SO_2 in about a week and adjust free-SO_2 to the molecular SO_2 level suitable for the pH of your wine. (See the section on SO_2 in the GENCO Winemakers' Handbook for details). I think it's a good practice to maintain free-SO_2 at about 35 to 40 ppm as much as practical, until you are getting ready to bottle.

Bulk storage/maturation: This is the time to resolve issues regarding acidity, stability, disagreeable odors, etc., and improve the wine's overall sensory appeal, while getting the wine ready to bottle. You can minimize bitterness, subdue harsh tannins, strip away off-notes. A thin wine can be made to feel more substantial, or various agents can be used to add a sense of sweetness, add mouth-feel, or heighten fruitiness, or oaky flavors. Small changes (tweaks) can be made during aging to improve overall quality and sensory appeal.

Use this time to stabilize wines by making minor acid adjustments, particularly pH, to balance the wine, or use a finishing-tannins to add hints of oak, minimize oxidation, improve body/structure, soften mouth-feel, or mask off-aromas. Furthermore, there are several polysaccharide products that improve mouth-feel during maturation, ex., Scott Lab's Nobless and Enartis SurlieElevage. Various products containing mannoprotein which naturally occur in wines, for example Scott Lab's Ultima Soft, can create the sensation of roundness in wine.

Balancing acidity can make a tart wine more palatable and fruit-forward. And even though you may have added water to adjust °Brix before fermentation, you can add a little more if the wine still tastes hot. Do some trials and see if you can get to a point that the wine tastes reasonably balanced. Use distilled water, which contains little dissolved oxygen, to dilute the alcohol, making it less hot. The wine will be a little less extracted, but more palatable.

The objectives are to ensure the wine's sensory elements are balanced or in harmonious, and the wine is stable. Wines are dynamic and will continue to evolve after fermentation, MLC, and during storage and maturation, as well as in the bottle. For reds, time in-barrel is important for adequate exposure to air. Even small concentrations of air soften tannins, and improve mouth-feel, making the wine more appealing. This may include an extra racking with a follow-up addition of Sulfite.

Storage and aging:

- It's a good practice to keep wine barrels 'topped up, silicon bung is firmly seated.' Fill storage containers to near capacity in, as much as practical, and make bungs are firmly seated and secure, and that tank closure are tight.
- The term **head-space** refers to the void between the surface of wine and the top of the container or to the barrel's bung-hole. Fixed and variable-capacity tanks should be filled to near-capacity, allowing a little space to accommodate expansion as the cellar temperature changes. This will discourage the development of film yeast/bacteria that cause spoilage. Head-space in such tanks is usually relatively static, but does change with ambient air temperature. If you sample the wine a lot, or pour a few tastes for friends, make sure to replace. Loss of water to evaporation in air tight tanks is not an issue.
- By comparison, the head-space in oak barrels gradually increases as water evaporates through the porous wood. It's not unusual for the barrel to lose up from 375 to 750 ml of wine every month, depending on cellar humidity. When 'air-tight' barrels lose water, a vacuum develops in the void. Regular topping is important because any air that enters through a leaky bung, or if the upper barrel staves are no longer 'tight', favors the development of VA and film-yeast/bacteria that cause spoilage. Cellar temperature during storage in the summer should be under 60°F to minimize potential microbial issues, and limit expansion and contraction of the wine.
- Watch for leaks that may develop in barrels.

- Use a silicon bung to seal a barrel and make sure it is properly seated. If your barrels are '*tight,'* they will develop a strong vacuum as the wine evaporates. You can top less frequently because there is little exposure to air.
- Barrels that don't develop a vacuum, may be leaky. The upper staves on either side of the bung are prone to leaking, and leakage (staining) may not be perceptible, particularly if the wine level is low. Cracks that develop on either side of the bung are a potential issue as well. Leaks can sometimes be sealed with barrel wax without having to empty the barrel to allow the leaky area to dry. Push the wax into the crack and heat with a torch, hair dryer, or heat-gun, so the wax melts and penetrates the crack further.
- During the winter, temperatures in wine cellars often dip into the low 50s, occasionally lower, resulting in the precipitation of excess Tartrates (Potassium Bitartrate) from solution. If the temperature in you cellar during the summer is greater than 60°F, pay particular attention to maintaining an adequate free-SO_2 level. Most air conditioners cool to 64°F, so they can't do the job. There is at least one electronic device — the CoolBot, that can override the thermostat in most air conditioners, allowing them to refrigerate small rooms (a walled-off and insulated area in the garage, barn, shed, container unit designated for winemaking. I use it to keep my cellar at about 58°F in the summer. I have also used a swamp cooler in the past to keep temperatures in my garage below 64°F in the summer.

Acidity (final adjustments):

- final adjustments can round out wines that are too tart, or make a flat wine more interesting.
- Before making any acid adjustment, taste the wine and determine if it taste too tart, about right, or perhaps a bit flat. You can taste when a wine is out of balance. Do this several times before deciding what to do.
- For low acidity (high pH, low TA): use **Tartaric acid** to <u>lower</u> pH and <u>raise</u> TA
- For high acidity (low pH, high TA): use **Potassium Bicarbonate** to <u>raise</u> pH and <u>lower</u> TA.

SO_2 additions during storage and maturation:

- Add SO_2 periodically to protect your wine from oxidation and prevent bacterial spoilage. Refer to the recommended free-SO_2 levels based on the wine's pH listed in the table below: As a rule of thumb maintain 30 to 35 ppm, give or take, should be adequate during storage and maturation.
- Measure free-SO_2 every 2 to 3 weeks initially, and then monthly for a couple months. Once SO_2 levels appear to have stabilized, test every six weeks.
- If SO_2 levels are well below the recommended **molecular level** every time you test, you may not be adding enough SO_2, or you need to test and adjust more often.
- Add a little <u>extra</u> SO_2 to avoid levels falling significantly below the desired molecular level between tests. A little cushion will ensure that the wine is adequately protected between additions.

30pH	**0.5 ppm**
	Red

	Wine
2.9	7 ppm
3.0	8
3.1	10
3.2	13
3.3	16
3.4	20
3.5	25
3.6	31*
3.7	39*
3.8	49*

Updated free -SO_2 (Australian Wine Research Institute) needed to maintain a 0.5 ppm molecular level):

- pH 3.4 to 3.6: 10 to 20 ppm free SO_2 50 to 150 ppm Total SO2
- pH > 3.6: 20 ppm free-SO_2 and >150 ppm Total-SO2

Recommended ppm free-SO_2 to be safe

3.4 20
3.5 25
3.6 30 ppm
3.7 35 ppm
3.8—you're on thin ice!

Preventing oxidation during maturation

- Wines can easily lose 10 to 15 parts of SO_2 during racking, so it's important to add additional SO_2 preferably before racking.
- Check the free SO_2 level a few days afterward to see how the wine responded.
- Fill containers to near-capacity to eliminate as much head-space as practical.
- Wines in cellars with low humidity need to be topped more frequently due to evaporation.
- If your barrel is air tight, a strong vacuum will develop within, as wine evaporates.
- Because stainless-steel tanks are essentially air-tight, there is no evaporative water loss, and free-SO_2 levels decrease more slowly than in porous oak barrels, unless there is excessive head-space. **Never** leave a <u>large</u> void in a tank as SO_2 gas escapes into the head- space, and is lost when the tank is open. A white, waxy film produced by certain yeasts and bacteria is likely to develop on the surface of the wine when there is a lot of head-space, and free-$S0_2$ levels are low. This can result in spoilage☹
- The air that enters even small void, unless purged with an inert gas, may result in some oxidation.
- Add a little SO_2 (5-10ppm) every time you add a fining agents or other wine-making product, particularly oak chips, cubes, sticks, inserts, etc. These products add a lot of air to the wine.

- It's a good idea add more SO_2 than needed to create a cushion so that the level doesn't dip below what is required between testing and adjustments. Fewer, larger additions are better than many small ones.

Cold-stabilization: is the process of precipitating unstable Potassium Bitartrate in wine.

- Potassium ions contained in grape skins are released following crushing, particularly during the early stages of maceration. These ions bind with Tartaric acid forming Potassium Bitartrate, an unstable salt, that ultimately precipitates (crystalizes and settles out), especially when the wine is chilled.
- Because Potassium Bitartrate is less soluble in alcohol, some of it will precipitate (crystalize) out of solution, thus reducing the amount of Tartaric acid in the wine, this in-turn lowers TA, which is responsible for the perception of tartness.
- In general, red wines unlike whites and rosés, are not intentionally cold-stabilized, because most tartrates settle out during the winter in the cellars. Furthermore, reds are seldom refrigerated which would facilitate tartrate formation. Most of the tartrates that form in red wines adhere to the inside of the barrel or tank.
- A cold garage in the winter is usually sufficient to facilitate the process in larger containers.

Fining — an often-overlooked step: A simple way to reduce astringency and bitterness, remove an off-note, or make sensory improvement…

- Fining wines involves adding an agent, something like egg whites, casein (milk powder), gelatin, mannoprotein, activated carbon, etc., to solve a problem like astringency, bitterness, and stinky sulfides, herbaceousness through removal, masking, or mitigation, or, or improve roundness or aromatic intensity.
- In most cases, you need to rack to remove the unwanted substance and binding agent. Some products dissolve into the wine and need not be removed.
- Homemade reds often suffer from excessive tannins, and are bit harsh (astringent—mouth-drying) or a touch bitter; both detract from the wine's overall appeal, but can be mitigated. There are several agents that can minimize this problem, e.g., PVPP, milk protein (caseinate), albumin (egg white), animal or vegetable-based gelatins, and mannoproteins (Scott Labs offers several choices). It's best to use fining agents well before bottling as some agents may take several weeks to settle out.

Other useful additives:

- Oak cubes, chips, sticks, barrel-inserts, and toasted oak chips can be used to impart the desired level of oak in wine held in neutral barrels or other holding vessels.
- Cellaring or finishing-tannins such as Riche (Beverage people) can add a note of French oak, improve structure, add a sense of sweetness, or reduce the sensation of alcohol and dryness. Both Scott and Enartis have a number to tannins to choose from, unfortunately, they're not cheap! Start with the lowest recommended rate—a little goes a long way.
- You may want to use a polysaccharide product, like Surli Elevage (Enartis) or Noblesse (Scott) to improve structure, mouth-feel, and aging potential, lower the sensation of

alcohol, and add a sense of sweetness. I routinely use them early in the maturation period.

- Mannoproteins are also useful to smooth out excess tannins (astringency), allowing for improved fruit expression.
- Gum Arabic is widely used just before bottling to help to reduce astringency, add body, roundness, and lend a sense of sweetness.

Optimal aging period:

- For best results, age red wines in oak barrels. Oak, because it is porous to some extent, exposed the wine to very low levels of O_2 over time. This facilitates the polymerization — the binding together of tannin molecules (polyphenolic compounds) into long chains, significantly reducing their reactiveness and astringency. While rounding out the wine, it effectively prevents more harmful oxidative reactions. This process takes time.
- Many home-winemaker age their reds in oak for 8 to 12 months. That's really not long enough for most reds to adequately mature (soften). Time in the bottle can't do what time in the barrel does.
- Most premium reds are aged in barrels for 18 to 30 months
- Big reds are best after 18 to 24 months.
- Pinot noir needs 12 to 14 months in wood.

Pre-bottling SO_2 additions:

- Bottling involves filling new or sanitized recycled bottles in a reasonably sanitary manner, with as little exposure to air as practical, and adding just enough SO_2 beforehand to prevent excessive oxidation.
- It's imperative to bottled the wine with at least the minimum level of free-SO_2 to minimize oxidation for several or more years. Understanding that some reds mature more slowly than others, and will require at last a year of 'bottle time' before consumption. Rember, tannins, which may take several years to soften, are critical to the longevity of reds. Other factors are also involved.
- Test for free-SO_2 before bottling, and adjust to the free-SO_2 needed to maintain the minimum targeted level, for the pH of the wine. It is possible you could get by on less, but a free-SO_2 level 30 to 35 ppm is a safer option. Remember to account for depletion of SO_2 at bottling due to air exposure, depending on your bottler: 10 to 15 ppm for a standard 3 to 5-spigot bottlers, or 5ppm for an Enomatic filler.
- **But wait there's more**: you must also account for the immediate binding of the SO_2 after it is added to the wine. Only part of it will remain free–about 70 to 75% when added to a clean, dry red.
- Let's say you need to add 18 ppm to achieve the targeted free-SO_2 level. Some of it will bind up, so, you will need to add ~26 ppm to ensure that your wine is protected. $(18 \div 0.7 = \sim 26\text{ppm})$

Well, that just about sums up what you need to know about winemaking. I suspect that by now you're beginning to realize just how complex it can be–so many variables and approaches, endless decision-making, attention to detail, and problem solving. It not like following a recipe.

Although fermentation is a natural process, winemaking is not. Everything you do or don't do along the way influences the outcome. You, and, of course, nature: the grapes and their environment, the weather, length of growing season, timing of harvest, the yeast and bacteria, a multitude of simple and complex chemical and biochemical reactions, your handling of fermentation and MLC, and then how well clarified and stabilized the wine for bottling. Nothing to it! I guess that's the attraction of winemaking.

v.2.26.2024