GENCO's Winemaker's Handbook: 2023

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Introduction:

I started gathering technical information about winemaking more than 20 years ago in hopes of improving my winemaker. I thought by exploring a wide variety of technical resources defining procedures, offering explanations, and solutions to common winemaking problems, my wines would progressively get better, and they did, but I still needed more. This endeavor was more challenging that I first imagined. First, there was scant definitive information on-line, and most of it was geared to the begging home winemaker. Much of what I found was either incomplete, sketchy or contradictory. Fortunately, there is now more information available. Nonetheless, I began writing simple guidelines for GENCO winemakers. Since then, these guidelines have undergone several revisions, and comprehensiveness has increased. The original version was close to 20 pages. This draft has expanded significantly to keep pace with technology, flesh out standard procedures, include new procedures, approaches, theories, research data, and to discuss new products. This updated version is intended to help interested GENCO members advance their winemaking skills. Beginning winemakers may, though, find it overwhelming. But, like anything new, perseverance is the key. The two most critical subjects: managing SO_2 levels and acidity, are indeed complex. To grasp the concept of acidity in winemaking, you 'll need some understanding of chemistry. I've done my best to define acidity and discuss how it changes during winemaking, and I've provided guidance for making adjustments when needed, and how to deal with unusual acid conditions.

There is no single way to make wine, no rules—guidelines, yes, and some generally accepted practices that have been shown by experience, and research to work. What I've tried to do here is to present some of the basic, time-honored (empirical), as well as science-based information, and accepted practices used to make wines that are comparable to those made commercially. Wine can be made without using cultured yeast, SO_2, or any of the currently available fermentation aids (enzymes, tannins, fining agents, etc., or high-tech equipment—if that's what you want. But unless you really know what you are doing, the results may be disappointing. The learning curve can be long and steep if you are interested in making wines you can be proud of.

There are reasons for following accepted practices, at least loosely, and areas where you have greater flexibility to be creative, or to just let 'nature' do he' thing. All our technological advancements stem from trial and error, mistakes, failures, problemsolving, innovation, scientific research, and the desire to make a better wine. Some people would have you think that 'natural' wines are better, simply because they are natural, but that just isn't so. Well, at least, I'm not buying it. The use of stainless steel and electricity, as well as cross-flow filters, etc. are modern improvements that have proven quite useful for commercial winemakers and have resulted in better wines, in my opinion, and have made their lives easier and the results more predictable. Fining agents like egg whites, bentonite clay, milk protein, etc., have been used for hundreds of years to make wines more palatable, visually attractive, and stable.

I've compiled a lot of information from online sources, technical publications, product supply catalogs, handbooks, articles, publications, conversation with commercial winemakers, educational workshops, and classes I've attended. The inherent problem is that there is a wide range of opinions regarding nearly every aspect of winemaking. There are many perspectives to consider. Dosages for common winemaking products varies from source to source. Winemaking procedures vary from country-to-country and even within regions. There are many ways to make wine and achieve one's objectives, some better than others, and people keep pushing the envelope. There, are though, some age-old methods that seem reliable, but winemaking has vastly improved in the last 30 year, and wine quality has remarkably improved.

There have been many technological advances in vineyard management, farming practices, and winemaking. We can take advantage of some of latest winemaking practices and technology, for example: comprehensive juice and wine analysis, quick chill-down of grapes after stemming and crushing temperature control during fermentation, cold-soaking, temperature control and aeration and micro-oxidation to soften tannins during fermentation, gentle pump-overs punch-downs, improved racking systems, and new products to prevent or mitigate problems. Outcomes are not always predictable, and accepted protocols may fail to work. What works for one winemaker may not work for another. Maybe, that's why winemaking is so engaging.

Although the science and technology of winemaking has advanced greatly over the last 50 years, many aspects are well understood, new winemaking tools and fermentation products are being developed to make it easier to make wine. For me it's been a challenge trying to offer accurate and detailed cook-book like instructions that are reliable and produce desired results, because there are so many variables, complicating factors, and conflicting information out there.

Some thoughts on winemaking:

Not everyone likes wines—it's an acquired taste. However, once you've acquired that taste, you may be inspired to learn more about it, or even try your hand at making it. The motivation to make wine varies for everyone. Some of us find the idea a bit romantic because it is rich in history, lore, and tradition, and has its root, literally in the soil. Many find it intellectually challenging, for others it's a creative outlet. It can be socially rewarding because it involves meals shared with family and friends. Others stumble into it because they bought a home with a hobby vineyard, or someone offered them free grapes. I suspect the ability to transform grapes into wine has its own appeal. For some, the draw is its complexity, requiring a depth of knowledge, an analytical approach, and attention to detail, yet others are interested in making wine more simply using traditional, time-honored methods. Of course, there are winemakers who fall somewhere in between. Nonetheless, wine is endlessly fascinating, and when well-made, a pleasurable beverage for people to enjoy when they relax and converse, and, of course, dine.

Making wine is not particularly hard, making good wine that is both enjoyable and stable for more than a year or two, can be challenging. Regardless of your motivation, how good your wine will be, depends on many factors, such as, quality and condition of the grapes, how you stem, crush, and press, how well you manage the fermentation, get it through critical stages without spoilage or oxidization, and finally, prepare it for bottling. How well you did will be reflected in the wine's appearance, intensity of flavors and aromas, and more importantly, its balance of sugar, acidity, tannins, and alcohol. Really good red wines smell, well, really good, display varietal characteristics, moderate fruit and/or spice, have moderate body, are rich, round, supple, and balanced. Whites in general, should be reasonably crisp fruity and refreshing, dry, minerally, and complex, or soft, smooth, round, complex, a bit oily (viscosity), and quite fruity. Not everyone, though will like a particular wine, even though it may be well made, and is a good example of that variety. Some may find reds harsh, astringent, bitter or too dry, others dislike the tartness or overt fruitiness that characterize most whites. It's really more about whether the winemaker likes it—each to his/her own.

There are, of course, other more subtle and delightful characteristics that make wines so interesting, for example: the aromatics (fruity, floral, herbal, woodsy, and spicy, earthy, and minerality notes. And often, the pleasing notes of oak. e.g., mocha, toffee, sweet tobacco, cedar.

From grape juice to wine:

Grapes are comprised of water, organic acids, sugars, minerals, Nitrogen, pectins, aromatic precursors, as well as tannins and pigments (mostly in the skins and seeds. The composition and/or amount of each in the grapes at harvest greatly influence the balance and sensory appeal of the resulting wine.

Tannins play a particularly important role red wine, because they give red wine its body, which can range from harsh to smooth and complex, and is largely responsible for longevity. In nature, tannins are found in plants, seeds, bark, wood, leaves, and fruit skins. Tannins, by nature, are bitter, and astringent (harsh, mouth-drying, a puckering sensation on the palate). In wine, tannins bind with proteins that precipitate and settle out. When you drink harsh red wines, they bind with saliva in your mouth, forming compounds that lack the lubricating effect of saliva, thus, the sensation of roughness and dryness. In general, the higher the tannins, alcohol, and sugar content, the fuller-bodied the wine. *Fermentation* tannins, often added to wines before fermentation act as an antioxidant, and bind with unstable protein, preserving natural skin-tannins.

Grape tannins (polyphenolic compounds) are derived from the skins, seeds, stems, oak barrels, and tannin-containing additives. They inhibit oxidation, and combine with anthrocyanins (grape pigments, thereby stabilizing color. Unlike white and rose wines, red wines have more tannins because their juice remains in contact with skins, seeds, and bits of stems during fermentation. By comparison, the juice of white grapes and those used to make roses are typically pressed off their skins and seeds within a few hours of crushing.

The five elements of red wines:

- **Tannins** give red wines their body. The longer grapes macerate (gently break down, before, during and after fermentation, the greater the body of the resulting wine. With time, tannins soften and mellow and the wine becomes very drinkable.
- **Acidity** (tartness) makes the difference between a good wine and a mediocre one. Acidity of grapes and the resulting wine greatly influences wine stability, aromatics, expression of fruit characteristics, and balance. Red wines with higher acidity taste tart, seem drier, more tannic, and lighter in body. Those with moderate acidity seem more full-bodied and sweeter. When acidity is low, wines taste flat and uninteresting. Consequently, I've given a lot of emphasis to acidity, adjusting acidity, and some thorny grape acid conditions.
- **Alcohol** adds sweetness, body, and adds a warm sensation in the mouth. Too much alcohol makes a wine taste hot. Moderation is a good thing.
- **Sweetness**: the amount of residual sugar left in the wine after it's made, or the sensation of sweetness from fruitiness, newer oak, and/or alcohol. Sugar can help balance a wine and brings out fruitiness. By and large, unless the fermentation is interrupted before it finishes, the wines will ferment to dryness (nearly sugar-free). Residual sugar may also result when a fermentation sticks—trust me, you don't want that. Good reds are generally dry, not particularly fruity but may have a slight touch of sweetness. Overtly sweet reds, except for late harvest, and desert-style wines, are usually off-putting. A sensation of sweetness, though, can be desirable. Wines made from very ripe fruit and aged in newer oak barrels tend to taste sweeter.
- **Body** is the feel (weight or viscosity) of the wine in your mouth. In general, the higher the tannins, alcohol, and sugar content, the fuller-bodied the wine.
- Structure is the term that refers to the balance of acidity, tannins, sweetness (fruit), and alcohol.

The game plan:

It may be helpful at this point to give you some idea of where this discussion is headed. I begin by reviewing the basic winemaking process, then move on to winery sanitation, and then offer an overview of using sulfur dioxide in winemaking: its advantages and how to use it to protect your wine. Next, I summarize the considerations involved in the early steps of winemaking: sourcing grapes, harvesting, crushing, stemming, and pressing the juice and/or preparing it for fermentation, along with a discussion about juice quality (acidity, percent sugar, and other important factors, and how they influence the resulting wine. You will need to know when these elements are within an acceptable range, and then how to adjust a wine when needed. Otherwise, the wine may be unstable, imbalanced, or undrinkable. That's followed by guidelines to adjust acidity—up or down, and grape conditions that can stymy good winemakers. I've placed a lot emphasis on acidity because it is one of the key components in wine. It just has to be right. Fruity flavors can be overwhelmed when acidity is too high and the wine can seem dull and uninteresting when acid is too low. Getting it right makes a big difference. Yes, there will be some chemistry involved, it just helps to make sense of it all. After that, it's clear sailing-- back to pressing, racking, fermentation, yeast nutrition, managing fermentations, the fun stuff. Along the way, we'll talk about why wine can become really stinky, and how best to resolve that odious problem. From there we move on to malolactic conversion, aging white wine 'surlie' (on the dead yeast or lees), using various commercial products to fix problems or make a better wine. Other topics, along the way include aging and clarification, and finally bottling.

Winemaking: the basics:

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 on its own. Although alcohol is produced, it is not the endpoint. Once alcohol is produced, it can be oxidized if exposed to air (oxygen) during racking, aging in the barrel, and when you pull the bung for any reason, or bottle the wine. Thus, level of exposure is a key factor in to whether oxidation is good or bad.

Alcoholic fermentation is largely an <u>anaerobic</u> process involving a series of complex biochemical reactions, and unless you prevent excessive oxidation (exposure to oxygen), or use SO_2 (sulfites), particularly after fermentation, wines will begin to oxidize (go-off) or just age prematurely. Wines, regardless of how well they are made or stored, will oxidize and lose their youthful color, fruitiness, flavors, aromas, freshness and vitality. They ultimately, take on sherry-like or vinegary notes. Young, fresh whites have a pale yellow to yellow-green color. With time and oxidation, they progress to a rich golden-yellow color and then brown. Reds typically lose their vibrant red/blue /purple pigments and take on a brick-red color as they oxidize. So, it's what you do, both before and after fermentation, that keeps harmful bacteria in check, and mitigates the formation of acetaldehyde that forms when alcohol is exposed to air.

Oxygen, though, is a critical component in winemaking, the yeast can't function without some minimum level in the juice or must. Some exposure to Oxygen near the end of fermentation, shortly after fermentation, and during storage/aging is beneficial in small amounts. Too much, however, can lead to a wine's premature decline. The most common aromatic compound associated with chemical oxidization is a distinct aroma of green, bruised, or rotten apples, sherry, nuts, pumpkin-seeds and flesh, etc. Oxidative yeasts and bacteria can grow on the surface of wine that is improperly stored or neglected, forming a film. They produce what is known as VA (volatile acidity): acetic acid and ethyl acetate, that nail-polish remover smell.

Sulfur dioxide (SO_2) is a powerful antioxidant and antimicrobial agent, commonly used by winemakers. It protects grape must from browning and wine from oxidation. Moreover, it inhibits wild yeast, and kills bacterial that can cause spoilage.

Modern winemaking practices and fermentation ‘aids’ have been developed and fine-tuned to avoid spoilage and oxidation, and improve quality, longevity, and of course, taste and aroma. The most reliable way for home winemaker to ensure their wines are acceptably good, is to add SO_2 to their wines after crushing and maintain levels high enough to prevent oxidation and inhibit microorganisms throughout the entire process from harvest to bottling, and to minimize exposure to air. So, if you choose not to add sulfites to inhibit oxidation and kill common spoilage microorganisms, it’s best to rack the finished wine, into an air-tight tank, after it settles to minimize contact with air, and then consume it quickly. It may initially taste good, but that seldom lasts for very long, unless you really know what you’re doing. In most cases, you won’t be able to get it past your nose.

Although winemaking is a natural process, things don’t always go as planned. And unless you are aware of potential problems, how to prevent them, or how to respond when something goes haywire, you may be in for some disappointment. I hasten to add here, that it’s not just about winemaking practices, but also grape quality. In general, high-quality grapes make the best wines. While it’s true you can make unremarkable wine from exceptional grapes, you can’t make remarkable wine from mediocre grapes.

In France the best winemakers refer to themselves as vignerons or ‘winegrowers’ rather than winemakers. They emphasize cultivation of grapes and don’t make a distinction between growing grapes and making wine—the two are inextricably linked. Many wineries there still use time-honored methods, but take advantage of modern technology. In other wine-growing regions, like California, there are viticulturalists and enologists. Most commercial winemakers, though, are closely involved in the decision-making process with respect to farming practices, such as canopy management, limiting yields to improve quality, and when to harvest. Some home winemakers grow grapes for their own use, others buy what is available, and what they can afford. Growing and managing your own grapes, though, doesn’t necessarily guarantee you of getting high-quality grapes. That has more to do with the site, soil and environmental condition, the grape variety and suitability to the site, the clone(s) and root stock(s) used, trellising, vineyard practices, etc., attention to detail, and of course, when to pick. So, it’s just a matter of finding or growing what you’re looking for.

Some commercial winemakers strive to make wines as naturally as possible—minimal intervention. No question, some make very fine wines that are reasonably long-lived, complex, and often have that elusive sense of place— terroir. While other winemakers use the latest innovations to make big, bold, complex, well-structured, silky, and opulent wines; perhaps a bit heavy-handed for some, and such wines don’t appeal to all. Many commercial wine makers, though, are committed to using organic or sustainably farmed grapes, and making their wine as naturally as practical, and minimizing SO_2 use. Their goal is to make exceptional wines that are aromatically appealing, varietally correct, expressive, have good intensity, and that age well. Most will fine or filter their wines when needed to make a more appealing product. At the end of the day, they must sell their wines, and we as home winemakers have to drink the fruits of our labor—good or bad. So, it's really up to you to frame the style, and adjust your winemaking accordingly.

How red and white grapes differ and how they are vinified:

- The pH range for white grapes for still wines is from about 3.0 to 3.5. The range for reds is usually somewhere between 3.4 to about 3.9 (less acidic).
- The juice of both red and white grapes, with a few exceptions, is basically colorless. The pigments that characterize red wines are found in their skins. Most of the aromatics in grapes is in the skins as well.
- In general, white grapes and red grapes (those used to make rosés) are typically de-stemmed, crushed, chilled, and the juice pressed-off the skins. The relatively clear juice is removed (racked) after the heavy sediment has settled out **before** fermentation is initiated. White and red grapes used to make rosés are typically pressed within a few hours of crushing to minimize the extraction of tannins and pigments. Limited skin-contact enhances varietal extraction, but too much can result in a harsh finish, or a color darker than desired.
- If you are interested in the more traditional Provençal-style of rosés, which are very pale—from salmon to onion skin, one option is to press whole clusters or just whole berries to minimize skin contact. The yield will be less, but you'll get very little color. Crushing and pressing as you go, works reasonably well too. The remaining skins, which still contain some juice, can be added to another red wine fermentation, if reasonably compatible for greater extraction. This works best when you're making both a rosé and a red from the same grapes. You probably wouldn't want to add, for example, Zinfandel or Cabernet sauvignon grape skins to fermenting Pinot noir.
- The ideal temperature range for fermenting white and red grapes used for rosés is about 55 to 64°F, depending on grape variety and your objective. Some yeast cultures, though, are intolerant of temperatures lower than 60°F, so make your selection accordingly. White fermentations often last for several weeks or more
- Red grapes are typically de-stemmed, crushed, 'cold-soaked' (optional), and the wine pressed-off the skins and seeds **after** fermentation. Skin contact is lengthy, so color and tannins are more intense. Red grapes should remain in contact with the juice during much of the fermentation to ensure extraction of varietal fruit, aromas, red pigments, and tannins. The latter is important for developing body and protecting the wine during cellaring and in the bottle. Fermentation temperatures should range between range between 70° and 85°F or slightly more. Many red fermentations will reach 90°F or higher for a short period, unless the temperature is moderated. Be careful to keeping the fermentation within the range listed by the manufacturer of that particular yeast culture. Hot

fermentations can stress the yeast, causing the fermentation to 'stick, 'or cause make the wine taste cooked.

- Grapes for rosé wines are often harvested at 21.5 to about 23 for crisp, fresh, fruit-forward wines.
- The juice of white and red grapes used to make rosé is prone to oxidation, and therefore should be fermented in closed containers, e.g., stainless-steel or food-grade plastic tanks made of **PET** (polyethylene terephthalate)—the plastics used to make water bottles, carboys. and kept under an air-lock during fermentation. After that they will need an air-tight seal or silicon bung. Chardonnay, however, is occasionally fermented and aged in oak barrels.
- Red must (crushed grapes) and finished red wine, due to high levels of tannins from skin contact, are more resistant to oxidation than whites. Red grapes, after destemming and crushing, are generally fermented in open-top fermenters to allow the '**cap'** of grapes that rises to the surface during fermentation to be '**punched-down,'** back into contact with the fermenting juice below. Wineries often ferment red must in stainless steel tanks and gently pump the juice from the bottom over the skins (rack and return) to keep them wet.
- Relatively long, slow fermentations are thought to produce better red wines. In general, red grape fermentations typically takes from 7 to 14 days from inoculation to dryness.
- It's still important for most reds that the temperature naturally rises to close to the upper limit of the yeast for a short period to get good extraction. Variables include: yeast culture, ambient air temperature, temperature control, and how <u>often</u> you punch down.
- If the temperature exceeds the maximum range listed for the yeast culture during fermentation, it's prudent to cool fermenting must with frozen water-filled jugs or dry-ice.
- If the ambient temperature is cool and the fermentation is 'slow off the mark', you may want to warm the fermenting must to get things up and running. Fermenting grapes will generate their own metabolic-heat.
- White grapes are typically fermented at lower (cool) temperatures to preserve varietal fruit aromas, and can take up to 6 weeks or longer to finish, assuming the temperature is kept close to or below 60°F.
- Reds typically undergo a secondary (malolactic) fermentation (MLC) that reduces the wine's acidity. Except for Chardonnay, and perhaps Sauvignon Blanc, MLC for white grape is usually not desirable. Partial MLC may be done for other varieties to reduce acidity and add roundness.
- Whites may undergo spontaneous MLC in the storage containers or the bottle. One way to prevent this is to add 70 ppm of SO_2 following fermentation to inhibit the bacteria. Lysozyme or **Stab Micro** (Enartis) or **Bactiless**, a similar product from Scott Labs can be used to prevent MLC. Sterile filtration with a 0.45 microns (absolute) membrane filter is effective at preventing MLC in the bottle, as well bottling with a relatively high level of SO_2 helps to prevent MLC in the bottle, levels much above 50ppm free-SO2 are often detectable. We will pick up again from this point after a comprehensive discussion about sanitation and use of SO_2 (Sulfur Dioxide).

An overview—from vine to bottle:

- ***Harvesting*** the grapes
- ***Crushing* and *de-stemming*** (all grapes): grape clusters and individual grapes are crushed to break their skins, and destemmed to remove as much of the green stems as practical to avoid herbaceousness and bitter stem tannins.
- **Collecting the juice and fractured berries (must).** Although crushing immediately releases some of the juice, the must will need to be pressed to release the remaining juice (white and red grapes used to make rosé).
- ***Chilling*** helps to minimize oxidation and the development of microorganisms the juice and grape must, followed by:
- ***Sulfiting****,* once chilling begins Potassium Metabisulfite (SO_2 or sulfites) should be added to inhibit oxidation and bacterial spoilage, as well as spontaneous fermentation, unless that is your plan. Adding SO_2 is an ongoing process.
- ***Skin contact:*** helps to extract aroma and taste component, as well as pigments. Enzymes may be added following crush or pressing to help release aromatic components in the skin, break down the gel-like pulp, and help clarify the juice.
- ***Pre-fermentation pressing***: white and red grapes used to make rosé and are pressed immediately or within a few hours to 'squeeze' out the juice within the split grapes, as well as smaller intact berries. In this manner, the juice is fermented off the lees. Otherwise, the resulting wines would be more tannic, amber in colored, with atypical flavors and aromas, generally undesirable for white wines.
    - The pressure applied by the press, releases most of the juice and pulp within the skins, and crushes any remaining intact berries.
    - As the must is bucketed into the press, the juice runs that through quickly, and the juice released by pressing is collected in convenient containers such as carboys.
- ***Settling:*** the cloudy juice is then allowed to settle for 8 to 12 hours to allow the heavy solids to settle out.
- ***Racking*****:** the relatively clear juice is siphoned or pump off the heavy sediment (gross lees) to an air-tight fermenter.
- **Fermentation** can now be initiated.
- ***Clarification* and *stabilization*:** Clarification begins as soon as the wine has completed fermentation and has been racked (cleanly) to a holding tank. It's prudent to have a local wine lab run a **standard wine-panel** for the wine to accurately determine: pH, TA, Malic acid (when appropriate), alcohol, free- and total-SO_2, and VA. 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 lot of tasting experience.
- For **reds**, the step after stemming and crushing is sulfiting, and chilling, depending on their temperature. If the must (skins, seeds, and juice), is relatively cold, *fermentation* can be started.

- Another option is to chill the must to less than 50°F, and allow the grape skins to soak and 'macerate' for 2 to 4 days.
- ***Skin contact and 'maceration'*:** Maceration is the process of softening the skins, giving the wine its color and tannins (body), either during fermentation and/or optional *cold-soak*. Time on the skins influences color and flavor profile of reds. The longer reds spend on the skins, the greater the extraction of phenolic compounds, tannins, pigments (anthocyanins), and flavor compounds from the grape skins. It begins just after crushing, continues with chilling, cold-soaking—an optional step, fermenting, and extended maceration, if done.
- ***Cold-soaking:*** More color and fruit flavors are **extracted** in an aqueous environment than an alcoholic one. Furthermore, the heat and alcohol produced by fermentation, extracts polyphenolic compounds (tannins), best described as harsh, bitter, and astringent. Cold-soaking appears to be best suited for lighter bodied reds like Pinot Noir, Grenache, Barbera, and Zinfandel depending on style.
- ***Post-fermentation pressing***: reds are pressed after fermentation, the wine is allowed to settle for up to 24 hours, racked off the heavy lees, and placed in a tank or barrel for malolactic conversion (MLC).
- ***Malolactic conversion**,* sometimes referred to as secondary fermentation, follows fermentation without delay. Selected strains of Lactic acid bacteria (LAB) are added. They metabolize Malolactic acid, converting it to Lactic in the process. Malic acid is very tart, while Lactic acid is much less acidic. Nearly all red wines undergo this process because it makes them more palatable. Some white grapes like Chardonnay are inoculated with LAB.
- ***Clarification* and *stabilization*:** whites and reds are often racked after MLC and up to 3 more times before bottling. Racking is the process is removing (transferring) the clarified juice from one container to another, allowing the sediment to be flushed away.
- ***Racking*:** is done to remove insoluble matter suspended in the wine before bottling. The process involves racking (siphoning) the 'clear wine (white, pink, and red) off the sediment layer at the bottom to another clean container, leaving it behind. It also involves **fining** to remove unstable proteins (whites and rosés) and tartrates (all wines) that can settle out after the wine is bottled.
- ***Bulk storage/Aging:*** helps a wine become more harmonious as it clarifies, stabilized, and matures. Wines evolve after they are aged in the barrel or tank, and, and of course in the bottle—to a point. 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 agreeable. You can use this time to stabilize the wine, and make acid minor adjustments to improve body, balance, or mouth-feel by adding polysaccharides to further improve. You can balance sweetness by increasing acidity, or make a tart wine more palatable. Even though you may have added water to adjust °Brix before fermentation, you can add a little more water if a wine still tastes hot. The wine will be a little less extracted but more drinkable. You can minimize bitterness, subdue harsh tannins, strip away off notes, or even excess color in a rosé by fining. A thin wine can be made to feel more substantial, or a Various agents can be used to add a

sense of sweetness, heighten fruitiness heightened. Aging is the time to make small changes (tweaks) to improve overall quality and sensory appeal.

- ***Cold stabilization:*** the process of removing excessive **potassium bitartrate,** the naturally occurring salt of the grape's tartaric acid, which largely determines the wine's tartness. Th process involves chilling or exposing the wine to temperatures just below freezing for a couple of days, which causes excess acid in solution to precipitate out as crystals in the holding containers. if neglected or done inadequately, tartrate crystals will precipitate out of solution when the wine is chilled.
- ***Bottling*** involves filling your bottles in a sanitary manner, with as little exposure to air as possible, and adding just enough SO_2 beforehand to prevent excessive oxidation.

Sanitation—Keeping it clean:

Most home winemaker don't clean and sanitize their equipment the way they should, or as often as they should throughout the winemaking process. This oversight can lead to loss of the wine and sometimes the barrel it was stored in. Most of the time, it's several mis-steps that lead to disappointing results.

Commercial wineries take **cleaning** and **sanitation** very seriously. They have strict protocols for doing both with all their winemaking equipment at the start and end of each step, at the end of each harvest, and at the start of a new one. They know that a lapse in sanitation can have a significant impact on the quality and marketability of the final product. And they are usually fastidious about preventing accidental introduction of spoilage organisms during crush, cold-soaking of grapes, fermentation, extended maceration, MLC, or later during racking, topping-up, pumping, filtering, and bottling.

Cleaning involves the removal of both inorganic and organic substances from the surfaces on all winery equipment. Sanitation, on the other hand, is the reduction of microbes that can cause wine defects. It is not the same as sterilization and disinfection. Both of which are quite difficult to achieve.

Water quality can be an issue in winemaking. Most municipal water that has been properly treated to keep microorganism below harmful levels, is fine for rinsing. Well-water, however, may contain high levels or bacteria that could affect your wine unless properly treated. Water that has been softened, pH adjusted, UV treated, and filtered is generally fine for rinsing. Soft water, though, may leave a residue and is not good to use for diluting must or mixing with yeast and other wine additives, e.g., yeast nutrients, enzymes, tannins, bentonite, etc. It also has a higher sodium level. Bottled water that has been filtered and is chlorine-free is much better to use for dilution and mixing with yeast and wine-making additives.

Sanitation begins with keeping your cellar reasonably clean, free of debris, and working surfaces clean and regularly sanitized. Even floors should be vacuumed and mopped with a disinfectant, especially at the start of crush. Wild yeast and bacteria are all around us—in the air, on work surfaces, on our winemaking equipment, on our clothes, and even our hands. It's not necessary to remove or kill every bacterium or wild yeast cell that might cause spoilage. It is important, though, to keep their numbers low to minimize development and the production of metabolites that create off-aroma and flavors.

Anything that contacts harvested grapes, juice, must, and finished wine should be cleaned and sanitized, including your hands, which are a great source of microorganisms such as lactic acid bacteria. It's not practical or necessary to eliminate wild yeast and bacteria on grapes, but winemakers should pick into lugs or buckets that have been cleaned of surface debris, dirt and stains. From that point on, grapes should be transported in clean and sanitized containers. Stemmer crushers, presses and tanks, open-top fermenters, etc., should be thoroughly cleaned and sanitized. Collection buckets, funnels, strainers, car boys, stoppers, bungs, stir-rods, tools used to do punch downs, or stir the lees, etc., need to be clean and sanitized.

Simply rinsing winery equipment such as siphon hoses and carboys after use does not remove all the organic material, staining, and hard to see films associated with microorganisms. Alkaline cleaning agent (see below) are recommended to remove organic material, staining and biofilms (a slimy material containing microbes and sugar-like polysaccharides) that are typically not visible. Molds often grow in the residual rinse-water, containing a tiny amount of wine residue that remains after a quick rinse. It usually takes 4 rinses to remove the residue in carboys, fermenters, tanks, gallon jugs, etc. Unless removed, it may contaminate the next batch of wine. To prevent this, use a cleaning solution, followed by a sanitizer: **Star San**, **SaniClean** or Iodine-based sanitizers such as **Iodophor BMP** or **Io Star,** a 10% solution of **Potassium Metabisulfite (PMBS)** or **high proof ethanol**. Some cleaning agents can sanitize as well, after adequate contact time, but still need to be rinsed. Scrubbing may be needed to remove stubborn residue and deposits. Avoid abrasive scrubbing pads on plastic to prevent scratching. Scratched and roughened surfaces are more difficult to clean and sanitize. Cleaned and sanitized containers like carboys and beer kegs should be allowed to drain upside down until there is no visible water. Once dry, they can be stored with a paper cup inverted over the neck of the bottle, or a wadded paper towel placed in the bung hole. Other containers can be stored with the cover in place.

Recommended alkaline cleaning agents:

- **Sodium carbonate** (also called Soda ash): a good cleaning agent for many surfaces, but should not be used to clean barrels because it leaches key oak compounds.
- **Sodium percarbonate** (Sodium carbonate Peroxyhydrate): a bleaching agent sold as Proxycarb or PeroxyClean is made by combining Sodium carbonate and hydrogen peroxide. When added to water it releases hydrogen peroxide, resulting in a foaming action. More importantly, it dissolves the hard to remove tartrate deposits inside of barrels and storage tanks, and it neutralizes acetic acid (vinegar) in problem barrels.

- **OxyClean-Free** (no fragrances added!) Contains sodium carbonate and sodium percarbonate, Sodium Metasilicate, and a surfactant. Good winery cleaner and sanitizer.
- **One-Step-No Rinse (**contains sodium carbonate and sodium percarbonate). Cleans and sanitizes. Requires two minutes of contact time, and no rinsing required! Use 1 tablespoon per gallon of water.
- **Powdered Brewery Wash**, (**B-Bright**, **Straight A** (special formulations): contain sodium percarbonate, Sodium Metasilicate, and a surfactant. They are safer than caustic cleaners and outperform them. Use 1 ounce per gallon for winery equipment. Soak equipment overnight in a PBW solution, and rinse the following morning - no scrubbing required. PBW can effectively clean items that can't be reached with a brush or sponge, and is strong enough to remove thick, difficult, caked-on organic soils. These cleaners also work well to remove labels from commercial wine bottles.
- **Cleanskin-K** (Scott Labs): is an alkaline detergent. This potassium carbonate-based formulation also contains a proprietary percarbonate, chelating and sequestering agents for enhanced cleaning. Cleanskin-K efficiently removes wine tartrates, color, proteins, and organic deposits.
- **Destainex** (Scott Labs) a sodium percarbonate-based cleaning agent with sanitizing abilities, removes wine stains, protein stains, mold, mildew, and biofilms from surfaces that wine will contacts. Can be used on stainless steel, concrete, polyethylene, polypropylene, plastics, flexible hoses, glass, and other surfaces.
- **Oak Restorer-CW** (Scott Labs): a blend of buffered carbonate, bicarbonate and proprietary surfactants. It removes tartrate crystals, wine color, protein and organic soils from barrels using cool water (68-86°F).
- **TDC i**s a liquid acid cleaner for glass carboys and other glassware. It is unscented and comes in liquid form. Use at the rate of 1/2 tablespoon per 5 gallons of water and rinse thoroughly.
- **Do not soap**! You don't want a soapy, perfumed fragrance lingering in your wine.

Recommended sanitizers:

- **Star San** is a common 'no-rinse' sanitizer for winery use. It's made to foam, so it's ideal for most general sanitizing duties (ex: tanks and equipment, etc.)
- **SaniClean** is like **Star San**, but has been formulated to produce minimal foaming—ideal for sanitizing pumps, filters, and as a final acid rinse.
- Both the above are acid-based sanitizers and when used at their recommended concentrations are quick, odorless, tasteless, and safe for glass, stainless, and plastic materials. They also don't need to be rinsed. When using Star San and Sani Clean there are no fumes and intermittent skin contact is not an issue.
- **Ethanol**: is also a good sanitizer. You can purchase high-proof 'Everclear' or Diesel vodka to use as a surface sanitizer.
- **IO Star Iodine sanitizer:** a 'no rinse' product used at the rate of 1 ounce per 5 gallons of water (25 ppm). Allow 1 minute of contact time to effectively sanitize equipment. Although it has the same benefits as **Star San** and **SaniClean** there is a potential to stain vinyl tubing and plastic parts over time.

- **BTF Iodophor:** a ‘no rinse’ sanitizer for most equipment: buckets, kegs, tanks, vats, bottles and more. No residual taste or odor left behind, low foaming and gentle on hand. No-rinse concentrate requires only 1 tsp per 1.5 gallons of cool water (12.5ppm concentration) and 2 minutes of contact time to be effective.
- **Alpet D2:** Like Star San and SaniClean, Alpet D2 is a surface sanitizer. However, because Alpet D2 contains QUAT (a residual bacterial killer) it has the added benefit of keeping a surface sanitized even when dry. It’s ideal for sanitizing work areas where yeast and bacteria are handled and winemaking additions are weighed and made-up.

- **Warning:** Clorox bleach (Sodium hypochlorite), should never be used in the cellar or to clean or sanitize winemaking equipment. There is a real potential to cause a serious musty taint known as **TCA** in wine that contacts surfaces that have been cleaned with products containing Sodium hypochlorite. Don't use Clorox bleach where wine is made, aged in barrels, wine stored in case boxes, or areas where bags of corks or wine-making supplies are kept. There is a significant threat of taint from using a hypochlorite solution or its vapors that contact wood, wood pallets, paper, or cardboard, that could conceivably contact wine, wood pallets, case boxes, or equipment used in wine-making.

Cleaning and sanitizing oak barrels:

- Acidify a new barrel once it has been filled with water and no longer leaks. Change water daily until the swelling is complete, or add Potassium Metabisulfite to retard spoilage. Add about 35 ppm per gal of water (See **Using Sulphur Dioxide to ensure wine stability** below).
- Citric acid, because of its low pH, is an effective antimicrobial. There doesn’t appear to be a consistent dosage rate, but it seems that that **5g/gal** is adequate You only need about 2 gallons or 3 gal. of acidified water to slosh around in the barrel to lower pH. So, to make it simple, I’m recommending using 1 T Citric acid in 2.5 gal of water. That close to the 5 g/gal rate. There’s about 12 to 13 g Citric acid /T. Most municipality water and some wells contain chlorine or Chloroamines to act as a disinfectant. You can remove it by filtering it or adding about 0.5 ppm g Citric acid/gal of water. The reaction takes a few minutes. Drain the acidified barrel for a few hours or overnight and fill with wine after it has had time to drain (about 20 minutes).
- After racking a wine that will go back into the barrel: rinse the barrel thoroughly before refilling it.
- The best option to clean a recently emptied barrel that has been rinsed is to use hot water (close to 180°F). Fill the ⅓ to ½ full, rock the barrel back and forth, and side to side, intermittently, for about an hour.to loosen and dissolve the tartrate deposits, and then rinse and drain it. At that point it’s preferable to acidify it before refilling. If the barrel will not be refilled immediately, acidify it, and burn a 2- to 3-inch piece of sulfur wick inside the barrel in it to prevent the formation of

VA (volatile acidity; vinegar, or finger-nail polish/remover (see **Storing Barrel** below).

- If you don't have access to hot water, a solution of **Proxycarb**, at the rate of **7.5 g/gal** or 16 oz per 60-gal barrel, works well to remove tartrates. Fill the barrel part way and add the Proxycarb and then top up. Allow the solution to remain in the barrel for several hours.
- To use less water and Proxycarb fill the barrel a little over halfway with water and then reduce the amount of Proxycarb by half. Allow the solution to work for several hours before rotating to clean the remaining inner surface. Yes! A bung is required.
- Use up to 24 oz of Proxycarb for barrels that smell strongly of VA: vinegary an/or ethyl acetate—the solvent in nail polish remover or in airplane glue used in the past. Allow the cleaning solution to stand for 8 to 24 depending on severity of the problem.
- Evaluate the barrel after it has been rinsed and drained. You may need to repeat the process, Barrels with persistent odors should be re-purposed, because it may ruin the wine you put in it.
- After treatment, drain the barrel, rinse, and neutralize any remaining alkaline residues with a citric acid solution. To prepare the solution, dissolve 5 g of citric acid powder for each gallon of water, or 1T in 2.5 gal of water. Slosh the solution around the barrel. Drain and check for off odors. This will prevent mold and bacteria from growing inside for a while.
- If the barrel will not be filled within 24 hours, burn a sulfur wick or disc in it to generate some SO_2 gas, preventing bacterial spoilage.
- A citric acid slosh will also protect the barrel for a few days.
- Citric acid, if not rinsed away before refilling the barrel, can have a negative impact on wine
- To clean the exterior of mold-covered barrels: apply a solution of PMBS and citric acid in water (3T of each in 1 gal of water).
- Barrels that have a medicinal, band-aid, barnyard, horse-stable, sweaty-saddle, rancid, or smoky smell are probably infected by the wild yeast Brettanomyces. Such barrels should be discarded because they can't be cleaned easily, and are no longer suitable for holding wine. Barrels that smell moldy should also be discarded.
- Drain and **rinse** the cleaned barrel several times with water, followed by acid rinse to neutralize the Proxycarb, and discourage microbial growth. Citric acid, at the rate of **5 g** for each gal of acid solution, is recommended for that purpose. Used 2 to 3 gal of acidified water and slosh it around inside the barrel. Make sure you get the heads as well. Once that's done, allow the barrel to drain upside down over a dry towel to keep the bung area clean. If you don't intend to refill within a day or two, burn a 2- to 3-inch piece of sulfur stick (wick), or a 5-gram sulfur disc in the barrel. Burning the wick/disc releases SO_2 gas into the barrel. That should hold it for a week or two. Use a special sulfur 'cage' to prevent dropping the burning wick/disc, or splattering elemental sulfur inside the barrel (See: **Dry storage (short or long term below for more details**). Repeat if there is a delay in refilling the barrel.

Long term barrels storage:

Wine barrels can be stored either ‘wet’ or dry. Dry storage is usually the preferred way to store barrels for a couple of weeks of longer. This preserves the barrels tannins and oak flavors that would otherwise be leached out when filled with water or a solution of Citric acid and Potassium Metabisulfite (PMBS). The concern regarding dry storage is that barrels will dry out. Once they’re dry, though, they can be stored indefinitely. They will, of course, need to be rehydrated before they can be filled, otherwise they would leak profusely. I’ve stored barrels for many months with reasonably good results. In some cases, there is some seepage that may require using barrel wax to seal the leaky spots, usually around the head. Wet storage is most applicable for short period of time – one to two weeks. Longer storage can result in a significant loss of oak flavors and aromas.

Dry-storage (short and long term):

When a barrel has been cleaned and will not be refilled for a few weeks or an extended period, it can be stored ‘dry.’ Once it has been cleaned, rinsed, acidified (important) and drained upside down overnight, and treated by burning a sulfur wick or disc coated with or containing elemental sulfur. When doing so, it’s imperative to avoid dropping the burning sulfur wick/disc, pieces of it, or droplets (splatter) of sulfur from the burning sulfur inside the barrel. Any pieces of unburned sulfur that fall to the bottom will result in a H_2S problem during the next cycle, unless properly removed by cleaning before the barrel is refilled. To prevent this from happening, use a special sulfur ‘cage’ to prevent dropping the burning wick/disc, or splattering elemental sulfur inside the barrel. Burn a portion of a sulfur wick or disc every 2 to 3 weeks until the barrel is dry. This usually takes 4 to 6 weeks. The standard dosage of sulfur is roughly ⅓ of a sulfur wick per 60-gallon barrel - roughly a 1” wide x 2-3” long piece or a 5g disc (pastille). Avoid storing barrels outside or in open areas where boring beetles, such as the destructive lead cable borer can burrow into the wood. This is a very real issue!

Long term ‘wet’ storage:

Add 180g citric acid to a 60-gallon barrel to drop the pH to around 3.0), and then add 160g Potassium Metabisulfite (KMBS)—enough for about 400 ppm SO2). Procedure: fill the barrel half full with Chlorine-free water. Dissolve the Citric acid in a gallon of warm water to help dissolve it. Add this solution to the barrel and mix to disperse it in the water. Fill the barrel to about 75% of its capacity with chlorine-free water. Dissolve the KMBS in a gallon of water and add the solution to the barrel, and mix thoroughly. Be careful, as SO_2 gas is quickly released and volatile and rather caustic, particularly your lungs. Next, fill the barrel to capacity. Mix again and then insert the bung. Use an old bung or protect it with plastic wrap. The solution will degrade a silicon bung over time. Source: Enartis. Doesn’t seem very practical to me, become you lose oak flavors and tannins during storage. Be sure to rinse residual citric acid in barrels following wet storage.

A ‘pickling’ solution:

Another option involves making a 'pickling' solution of about 10% of the barrel's volume, containing Citric acid and PMBS (Potassium Metabisulfite) in chlorine-free water. The citric acid lowers pH to around 3.0 and the PMBS acts as a powerful antioxidant and antimicrobial agent. Add 5 g/L (19 g/gal) of Citric acid, and .5g/L (1.9 g/gal) PMBS. To treat a 60-gal barrel add 4 gal of water to the barrel. Next, dissolve **115 g of Citric** in 1 gal of warm water, and then add to the water in the barrel after mixing. Then dissolve ~115 g of **PMBS** in another 1 gal of water and, after mixing it thoroughly, add to the barrel. **Warning**: Concentrated Citric acid and PMBS will react violently if combined in the barrel. They must be first be dissolved (separately) in water and then added and mixed, one at a time, to the water in the barrel. Do not combine concentrated acid and KPBS together. This 'pickling' solution releases SO_2 gas that prevents microorganisms from growing, and the humidity inside is adequate to keep the barrel hydrated. Source: The Australian Wine Research Institute. Label barrels containing a pickling solution, and be careful when opening and avoid inhaling the gas that can be very caustic if inhaled. The pickling solution will need to be replenished to the original 10% volume every 4-6 weeks, because the volume will decrease due to evaporate and some will soak into the wood. The dosage from Enartis for their 'pickling solution' is significantly different: add 10-gal water to barrel 160 g citric acid (added separately) + 180g KMBS + and then bung tightly, replace every 3 to 6 months.

Barrel rehydration:

Turn the barrel on end, fill the depression on top of the barrel, and then begin to fill the barrel slowly, allowing water to trickle in. This will gradually rehydrate the heads, and stave ends. You can minimize water use by soaking the barrel on-end in a wide tub—such as a stock tank. After about 4 hours, turn the barrel over and repeat. Once the ends no longer leak, turn the barrel on its side and begin filling slowly. It may take a while to fill the barrel because it may lose water nearly as fast as it is added. But within a couple of hours, it should retain most of the water. Typically, most leakage stops within about 8 hrs. More persistent leaks may take as long as 48 hours to stop. I've been able to stop most leaks using barrel (bees') wax. I usually apply the wax to the leaky area(s), melt it using a propane torch, allowing it flow into leaky areas. Mark the leaks with a felt-tip pen and allow the barrel to dry in the sun for 12 to 24 hours. You can use a hair-dryer or paint-remover to expedite drying and then seal the leak with wax. When nothing seems to work, have the barrel repaired as needed by a cooperage company, for example, ReCoop (a barrel repair and reconditioning shop in Sebastopol). Continued leaking may be the result of small 'bore' holes made by lead cable borers (beetles), usually in the groove where the head and staves meet, or at the edge of the metal hoops. You can use a wood matchstick or round toothpick to plug the hole, or obtain a 'spiel' (special plug) from the Beverage People or ReCoop. It's a good idea to add 35 ppm PMBS to the barrel while it is filled with water for more than 24 hours to discourage spoilage bacteria.

Practices that help prevent microbial spoilage:

- Pick grapes into clean picking lugs, buckets, or macrobins.

- Do your best to clean your cellar and sanitize work-surfaces.
- Clean and sanitize all winemaking equipment used in the winemaking process.
- You can make up a sulfite cleaning solution or high proof alcohol ('Everclear') and put it in a squirt bottle to clean equipment and items that contact the juice, must, or wine.
- Use the recommended rate of SO_2 (35 to 50ppm) after stemming/crushing reds or pressing whites. SO_2 is a strong antimicrobial agent that kills or greatly inhibits most bacteria and that may cause spoilage.
- Rinse your punch-down tool after each use and sanitize it before use if it not properly stored.
- Add winemaking products using a freshly sanitized transfer spoon and/or container (beaker) when making a solution.
- I use 3-oz 'Dixie' cups when weighing dry products like yeast, Go Ferm, Bentonite, etc., and then discard them after transferring the content to sanitized mixing beaker.
- Use bottled (filtered) water to solubilize winemaking products and dilute must.
- Use yeast nutrients to ensure that your fermentation progresses to dryness, and does not become sluggish or stick (stop before all the fermentable sugar is gone). Wines that are sluggish or that stick are prone to oxidation and spoilage organisms due to low SO_2 levels.
- When doing a cold-soak, make sure the temperature of the must is reduced to less than 50°F preferably 45°F as quickly as possible by using dry-ice or frozen water-filled plastic jugs. Yes, you must clean and sanitize the plastic jugs.
- Maintaining adequate levels of SO_2 throughout the entire process will usually ensure a defect-free wine.
- Adjusting pH levels of finished reds to somewhere near 3.65 to 3.7 and to no higher than 3.4 for finished whites, help to ensure stability.
- Keep open-top fermenters covered during fermentation to exclude fruit flies. They carry acetobacter bacteria.
- 'Top' (fill up) barrels at the very least every 3 to 4 weeks and use an inert gas (preferably, Argon) to purge air above the wine. Fill storage containers to near capacity to minimize head-space, but allow a little space for expansion if the temperature increases.
- Excess headspace increases the loss of SO_2 (volatilization) into the headspace and out of the barrel as soon as the bung is removed. Vinegar-forming (Acetobacter) bacteria and white surface 'film' yeast are likely to develop when there is ample head-space, the SO_2 levels are low, and when oxygen can enter through a poorly seated bung, or leaks in the barrel. Yeast and other microorganisms can oxidize ethanol to acetaldehyde under oxidative conditions. Barrel and tanks when low levels of wine are more subject to surface-yeast infection that produce high levels of acetaldehyde and high levels of acetic acid and ethyl acetate (VA). The smell of acetaldehyde is like bruised apple, sort of nutty or sherry-like. Ethanol is the primary source of carbon in aerobic film-yeast. Wines with excess head-space lose SO_2 more rapidly, and are more subject to oxidation.

- Wine in containers with large voids are prone to developing a white film of wild film-yeast or other organisms on the surface of wine. The film, comprised of a wild yeast, thrive when oxygen is present. The condition is often referred to as **mycoderma** (*Candida mycoderma*), a common problem in neglected or infrequently topped wine. The wine, unless quick action is taken, (topping-up and adding 60 to 70 ppm SO_2, will spoil.
- Make sure barrels are tightly bunged. You should hear a 'woosh' sound when you remove the bung, breaking the vacuum that forms as wine evaporates from the barrel.
- If you have a few gallons of wine left over after filling a barrel, bottle it for topping, assuming it has gone through MLC and been racked. You could also use an older vintage of the same variety of wine of top with. This will prevent having to break down smaller containers. If you need a bottle to top with and have extra wine in a 5- gal carboy, rather than breaking it down to smaller containers, use something else to top with. Once you start moving wine to multiple smaller containers, the likelihood of oxidation increases. It would be better to leave the carboy intact, and blend it with the wine in the barrel or the main storage container well before you bottle.
- For best results, store wines at 60°F or less, because spoilage organisms are less likely to develop. If you can't do this, make sure that your SO_2 levels are adequate and you test for free-SO_2 regularly, and adjust as needed to maintain a level high enough to prevent oxidation and inhibit spoilage bacteria.
- When cleaning stainless steel barrel or tanks after fermentation, pay particular attention to the inner, upper surface of the tank because it can be difficult to remove the residue from the previous fermentation. Use a bent carboy 'bottle brush' to make sure any fermentation-residue is loosened and then rinsed away. You can also turn the sealed drum/tank on-end, so the cleaning solution (Proxycarb) remains in contact with the residue for 8 to 24 hrs. to ensure adequate cleaning. Variable capacity tanks are much easier to clean.
- Check your SO_2 level following each racking. You'll probably lose 10 to 15 ppm of free-SO_2 during racking, so you will need to add more SO_2 to compensate for the amount lost to volatilization, and to bind up with metabolites that form when the wine is exposed to air. Better yet add 10 to 15 ppm prior to racking and test a few days later to see how the wine responded.
- Contrary to conventional thinking, wines with a pH greater than 3.6 up to about 3.8 only need about 30 ppm for stability. Use the *standard molecular* SO_2 levels for wines with a pH of 3.6 and below. (per. comm. Clark Smith)
- It's prudent, though, to maintain the SO_2 levels at around 45 ppm to provide a bit of a cushion, until you're ready to bottle, and then bottle at the level you feel comfortable with.
- Clean and sanitize your bottle filler before using, and make sure your siphon hose has been sanitized.
- Sanitize the cork-compression and insertion mechanism to prevent contaminating the corks and the wine. Spray with a solution of Star-San, a 10% PMBS sol or high-proof alcohol, etc. If you drop a cork on the floor, be sure to sanitize it before inserting it into a bottle.

- Keep your corks in sealed plastic bags and avoid handling them with your bare hands. Use disposable food-service or surgical-type gloves. At the very least, wash your hands thoroughly and refrain from touching your face or other parts to avoid contaminating them with *Lactobacillus* bacteria, commonly found on your skin. It may be good for cheese-making but not wine!
- Before using a transfer pump, flush it first with a solution of Sani Clean and then chlorine-free water, and then circulate a solution of a sanitizing agent like Sani-Clean or Star-San. Flush it again with water and drain it the best you can. Run the pump dry to remove addition water inside the pump-head.
- After use, flush the pump with water for about 30 seconds and then run a solution of Proxycarb through it. Flush it again and run a disinfectant solution through it. Drain it the best you can, and then store it away.
- A pressure washer is very effective at cleaning large equipment, such as open-top fermenters, macrobins, stemmer crushers and presses, press screens, etc.

Ensuring wine stability—Using SO_2 (Sulfur Dioxide):

Before we get much further into the process of winemaking, I want to introduce the somewhat controversial use of SO_2 in winemaking. Some home winemakers are concerned about or opposed to using SO_2 because they either react to it, or because they have heard that it can causes headaches. Yes, a few people do react to sulfites, and they should avoid it, but for most people, it's not a concern. There is no compelling research linking its use to health issues at the levels people encounter in wine. Let's face it, if you drink too liberally, you are likely to get headache. Is it the alcohol or the sulfite? If you are concerned, do some research, but keep an open-mined. It's good to be skeptical. Nonetheless, it will be difficult to make good wine that holds up for more than a few months, without using a minimal amount of SO_2. Some 'natural' wines may taste OK initially, but most are undermined by oxidation or funky-earthy aromas. Both conditions are considered defects. Furthermore, the wines are typically short-lived.

The following discussion about SO_2 (**Sulfites**) for wine stability is intended for serious-minded winemakers. Sulfi<u>t</u>es smell like a freshly burnt match, while sulfi<u>d</u>es are stinky. For most amateurs, the use of SO_2 is fundamental to successful winemaking. Since the 18th century, SO_2 has been a widely used additive because of its antimicrobial and anti-oxidative properties. When used properly and in moderation, SO_2 is an effective means to inhibit oxidation and microbial spoilage. Although a few wineries can make reasonably good wines with little or no added SO_2, it's unlikely for amateurs to do so successfully, without expert guidance. The shelf-life of most wine made without sulfite is relatively short, so if that's your goal—drink up!

Winemaking is straightforward, once you understand what SO_2 does, how much is needed, when to add it, and how to keep levels just high enough to protect your wine. Periodic testing determines when more is needed. There are several local wine analysis labs that can test for SO_2, and other factors. If you are a serious winemaker, consider buying test equipment (Vinmetrica) so you can test for SO_2 and other important factors at home. You'll save money in the long run, and are likely to test more frequently. SO_2 can be added by using Potassium Metabisulfite (PMBS) in the powder form, in a water-based solution, or as convenient effervescent granules or tablets. Avoid the use of Sodium metabisulfite.

The value of SO_2:

- Sulfur dioxide is one of the most effective tools winemakers have to slow deterioration.
- When added to juice, must, or finished wine, SO_2, inhibits microbial spoilage, inactivates enzymes that cause browning of the juice, prevents oxidative browning and it binds with acetaldehydes that form in the presence of alcohol when the wine is exposed to oxygen, thereby increasing shelf-life. Aldehydes have a bruised apple, or sherry-like aroma, and are the precursors to volatile acidity (VA) – ethyl acetate (airplane glue or nail-polish or nail polish remover), vinegar, and other off-odors.
- SO_2, when present in sufficient amounts, binds with aldehydes produced during fermentation and aging, masking the oxidized aromas. Furthermore, it reacts with Oxygen (O_2) to prevent the formation of hydrogen peroxide, which in turn reacts with alcohol, forming acetaldehyde. Aldehydes, when bound with SO_2, are not noticeable.
- Every time you open a container of wine to add something, smell or taste it, rack, or top up, you expose the wine to oxygen. If the level of SO_2 in the wine is too low, aldehydes that form will remain unbound and off-aromas will develop. If nothing is done to bind the aldehydes, the wine may be ruined.
- Wines in oak barrels are exposed to minute amounts of oxygen because the wood is slightly porous. This, of course, is how red wines mature, and their harsh tannins soften.
- Bacteria (Acetobacter) that produce VA (volatile acidity) vinegar and ethyl acetate (solvent used in finger nail polish) are favored by high levels of oxygen in the wine. Air enters a wine when it is racked, pumped, filtered, or something is added. Just removing the bung and failure to top up every time the wine level is down, exposed the wine to oxygen. Leaky bungs or oak barrels are others ways oxygen can get in. Filling containers to near-capacity, and keeping barrels consistently topped up, and maintaining proper levels of SO_2 prevents these bacteria from developing.
- Wines with little or no SO_2 typically:
  - tend to oxidize quickly —whites become more golden to brown, and reds turn brick-red to brown.
  - lose flavor and aromas (‘flatten’)
  - develop a sherry-like aroma (acetaldehyde) or notes of vinegar or ethyl acetate.
  - are more susceptible to wine-spoilage organisms, e.g., *Acetobacter*, *Lactobacillus*, *Brettanomyces*, *Pediococcus,* film yeasts, and others that can impart disagreeable odors and tastes, e.g., sherry, vinegar, nail-polish remover, leathery, earthy, barnyard, medicinal, band aid, rancidity, horse-sweat, mousey, dirty sweat-socks, cheesy, sauerkraut, earthy, ‘tanky’, mousey, etc.

Forms of SO2 (free, bound, and total):

- A portion of the SO_2 added to grape juice, must, or wine quickly binds with various grape components, and is, thus, referred to as '**bound'** SO_2. The remaining '**free'** portion is available to perform its important work. SO_2 testing measures free-SO_2. It can also determine **Total'** (free + bound) SO_2)
- Bound SO_2 includes sulfites attached to either sugars, acetaldehyde, or phenolic compounds.
- Total SO_2 measured in a wine is less than what has been added from start to finish. Some SO_2 is lost to the environment as SO_2 gas, and some binds with the materials that settle out in the lees, and is removed by racking. 'Total,' therefore, is the sum of the free and bound SO_2 in a wine that has finished primary fermentation and MLC (if initiated), during aging, or just before bottling.
- In general, home winemakers need only be concerned about free-SO_2 in their wines. The trick is to add as little SO_2 as possible, while still protecting the wine, as oxidation or bacterial spoilage are likely to occur if too little is added, and if you add too much, you will probably be able to smell it in the wine.

Why you need to continue adding SO2 during the wine-making process.

- As previously stated, SO_2 exists in both the active (free) and inactive (bound) forms. Once bound, though, SO_2 is generally inactive and can no longer protect your wine – its work is basically done. Some of it, though, may become free later and bind with acetaldehyde, the precursor to volatile acidity (VA).
- Every time wine is exposed to air, for example, racking, pulling the bung to smell or taste the wine or add something to it, some of the free SO_2 will become bound.
- Wine in oak barrels is continually exposed to very low levels of air, so free-SO_2 is constantly being lost as it bind with aldehydes, formed in response to exposure to low levels of oxygen. Unless more free-SO_2 is added, periodically, will level will drop to zero, and the wine will eventually oxidize and/or spoil.

The chemistry of SO_2:

- When added to water, grape juice, or wine, Potassium metabisulfite (**PMBS**), a white powder with a pungent odor, dissolves and <u>disassociates</u> into 3 distinct forms: $\mathbf{SO_2}$, the gas or molecular form), (**bisulfite** ions ($\mathbf{HSO^{3-}}$)**,** and **sulfite** ions ($\mathbf{SO_3^{2-}}$). The reaction is as follows:

  $\mathbf{K_2S_2O_5}$ (PMBS) + $\mathbf{H_2O}$ (juice/wine) → **2** $\mathbf{K^+}$ + **2** $\mathbf{HSO_3^-}$ (bisulfite ion)

  $\mathbf{HSO_3^-}$ + $\mathbf{H^+}$ ↔ $\mathbf{SO_2}$ (molecular, gaseous form) + $\mathbf{H_2O}$ ↔ $\mathbf{2H^+}$ + $\mathbf{SO_3^{2-}}$ (sulfite ion).

- The red double-pointed arrows indicate that the reaction is in equilibrium, and the relative amount of each form is determined by the juice's/wine's pH.
- At normal wine pH (3.0 to 4.0), Bisulfite (HSO_3^-) ions predominate. There is a small amount of dissolved SO_2 (gas) in solution), and an even a smaller amount of Sulfite (SO_3^{2-}) ions
- Note in the Table below, the lower the pH, the higher the percentage of molecular SO_2. The level, however, decreases sharply with increasing pH.

- Between the pH of 3 to 4, there is a 10-fold decrease in the concentration of molecular SO_2, thus, low pH wines need less free SO_2.

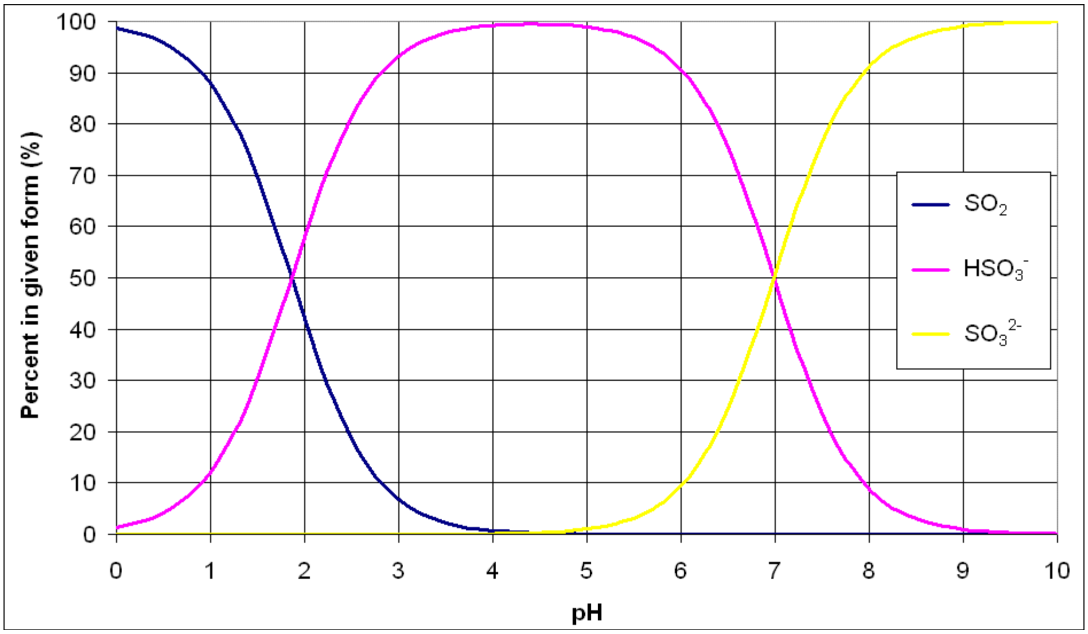

Figure 1. Shows how the amount of bisulfite, SO_2, and sulfite present in a solution as pH changes. At pH of 3.0, Bisulfite ions predominate and there is a small amount of Sulfite ions. At pH 4.0 there is a very little SO_2 in solution.

- **Bisulfite (HSO_3^-)** Most of the SO_2 added to juice or wine exists as Bisulfite ions. Unfortunately, they do not prevent oxidation. Nonetheless, they are still very important because they bind with acetaldehyde (the precursor of VA (Ethyl Acetate, the solvent commonly used in finger-nail polish, and vinegar (Acetic acid) that forms when alcohol in wine is exposed to air, adversely affecting wine quality.

- **SO_2** — the molecular (undissociated) form is, by far, the most important fraction of SO_2. It is the volatile (gaseous) form, so it can be smelled. It dissolves in water, much like Carbon Dioxide (CO_2) does. The level can be as high as 6% for a wine with a pH of 3.0 and as little as 0.5 percent for a wine with a pH of 4.0. It has powerful antimicrobial properties, that inhibit bacteria, wild yeasts, malolactic bacteria, and others spoilage microbes.

- **Sulfite** (SO_3^{2-}) The amount in wine is extremely small, except at high pH. But sulfite is important even in minute amounts, because it can deactivate enzymes that cause browning, and remove free-oxygen (O_2) from wine. In this reaction, O_2 reacts with phenolic compounds, and then is converted to hydrogen peroxide (H_2O_2). The Hydrogen Peroxide then reacts with alcohol, forming acetaldehyde. If free sulfur dioxide is present, the hydrogen peroxide reacts with the sulfite, resulting in the formation of Sulfate (which is innocuous) and water:

$\mathbf{SO_3^{2-}}$ + $\mathbf{H_2O_2} \rightarrow \mathbf{SO_4^{2-}}$ (Sulfate ion) + $\mathbf{H_2O}$.

- When wine oxidizes, in the presence of adequate SO_2 levels, during aging the production of H^+ causes the pH to <u>decrease</u> and the titratable acidity to increase, as sulfite ions are used up. This effect is small but it can be significant factor in high pH wines. A reduction of as much as 0.1 pH is often observed when high pH red wines are aged in barrels for a year or more.

- Equilibrium shifts from left to right or right to left, depending on what component is being bound up. For example, if Bisulfite (HSO_3^-) binds up with Potassium ions, some of the molecular bSO_2 present will shift Bisulfite ions, and some of the sulfite (SO_3^{2-}) converts back to Bisulfite until equilibrium is reestablished.

How much is enough?

- The level of free SO_2 in wine is measured in parts per million (ppm). However, only a portion of it is '**active'**— in the **molecular** (dissolved gaseous state. To protect a wine against oxidation, unless have to target a specific free-SO_2 level to ensure there is enough of the molecular SO_2 to do the job. That determination, however, is dependent on pH of the juice, must, or wine.
- The recommended molecular level reflects the amount of free-SO_2 needed to protect juice, must, or wine with a specific pH.
- White grapes need a higher molecular level of SO_2 than reds. Research has demonstrated that a level of **0.8 ppm** (mg/L) of the molecular SO_2 will adequately protect white wines during winemaking, storage, and later in the bottle. Reds, on the other hand, contain more tannins (natural antioxidants), so they need only **0.5 ppm** of SO_2.

pH	**0.8 ppm**	**0.5 ppm**
	White Wine	**Red Wine**
2.9	11 ppm	7 ppm
3.0	13	8
3.1	16	10
3.2	21	13
3.3	26	16
3.4	32	20
3.5	40	25
3.6	50	31*
3.7	63	39*
3.8	79	49*

- The table above, still commonly used, indicates the level of free-SO_2 needed to keep a red wine from oxidizing. Notice that the number goes up with pH. So, it generally takes more SO_2 to keep a higher pH wine safe from oxidation and bacterial spoilage than a lower pH wine.

- As a rule of thumb, target a free-SO_2 level listed in the table above for the type of wine (red or white) and its pH. Most wineries deviate from this rule and add less SO_2 than listed in the charts for reds with a pH of 3.6 or greater (marked with an asterix above). The new thinking is that red wines with a pH greater than 3.6 only need about 20 to 30 ppm for stability. To be on the safe side, though, home winemakers should consider using 35 to 40 ppm for wines with a pH of 3.6 or higher during aging.
- It's also a good idea to lower red wine pH to 3.7 or less
- If you are looking to minimize the use of sulfites, something to consider: wines with low pH, and the high alcohol, need less SO_2.
- Natural cork is commonly used to as a closure because it allows the entry of minute amounts of oxygen and gaseous exchange. Therefore, SO_2 in bottled wine, slows oxidization and keeps it fresh longer.

Molecular SO_2 (ppm) needed for wine stability:

- It's critical to maintain an adequate free-SO_2 level to prevent antioxidation and microbial spoilage throughout the winemaking process This is why we routinely test for free-SO_2.
- As previously stated, how much we need toad depends on the wine's pH. The higher the pH, the less molecular SO_2 will be available, therefore the level of free-SO_2 is greater.
- So, we are mostly interested in free-SO_2.
- Because free-SO_2 gradually dissipates, it must be replenished periodically throughout the winemaking process:
    - after crushing,
    - again, after fermentation for white and rosé wines, and after Malolactic Conversion (MLC) for reds,
    - during cellaring
    - and just before bottling.

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- Periodic testing allows you to determine the free-SO_2 level in a wine of a wine and if it's at risk of oxidation. Most, if not all the SO_2 added prior to fermentation is used up (bound), or lost to the atmosphere during fermentation. Wine stored in oak barrels, which are pervious, are continually exposed wine to low levels of O_2. Thus, SO_2 is continually used up, protecting the wine. SO_2 depletion is less in wine stored in impervious tanks and glass carboys.

Determining free-SO2 for white and rosé wines:

- The goal is to maintain a 0.8 ml/L of molecular SO_2 throughout the winemaking process, except for wines you want to undergo MLC. That will determine the correct **free-SO_2** level. See the table above and the one below. One way to use less SO_2, is to keep the pH below 3.5, preferably 3.2 to 3.3, depending on variety. For example, to ensure that there is 0.8 ppm of molecular SO_2 in a white wine with a pH of 3.4, add 32ppm of SO_2. If it was 3.5, you would need to add 40 ppm

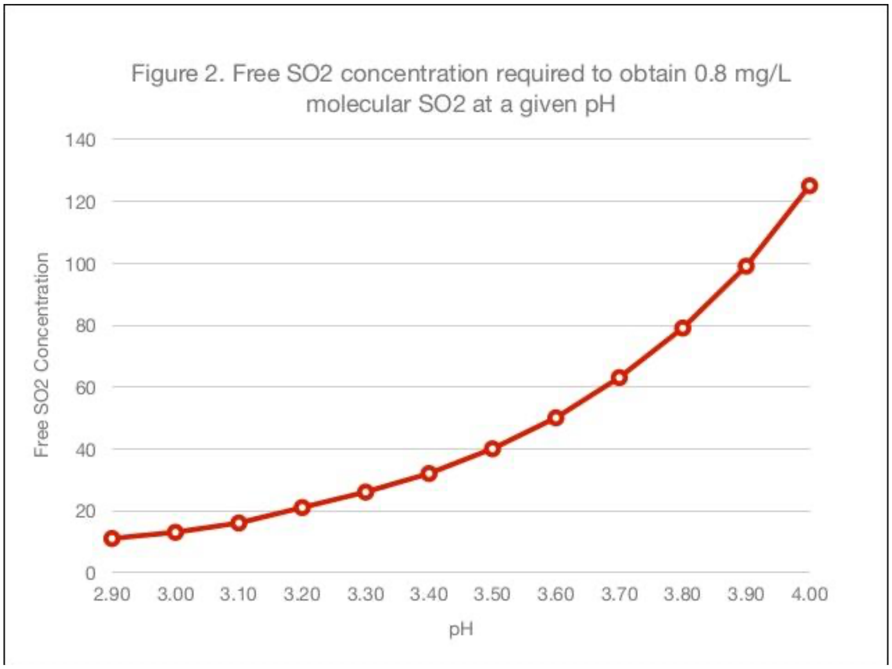


Figure 2. Free SO2 concentration required to obtain 0.8 mg/L molecular SO2 at a given pH

Minimum free-SO_2 needed for a 0.8ppm molecular level (white and rosé wine)

- Contrary to older charts, red wines with pH above 3.6 need less free-SO_2 than previously though (Clark Smith (Vinovation, and WineSmith. Personal communication). Above 3.6 SO_2 binds with H_2O_2 (hydrogen peroxide), a precursor to acetaldehyde (has a sherry-like smell), forming H_2SO_4 (sulfuric acid) which increases acidity (lowers pH). Why less SO_2 is needed as pH increases above 3.6 is not fully understood.

- However, red wines above 3.85 are likely to be unstable and should be adjusted to pH 3.7 or less. pH and TA are best adjusted before fermentation (See: **Testing and adjusting the must** below). Strains of *Lactobacillus* and *Pediococcus* (spoilage bacteria can readily grow If the pH is 3.8 or higher.

Current minimum free-SO2 for a 0.5ppm and 0.8 ppm molecular addition:

Wine type	**pH**	**Concentration mg/L (ppm)**
White table wines	pH 3.00 to 3.20	10 to 20 mg/L free SO_2
	pH 3.21 to 3.40	20 to 30 mg/L free SO_2
	pH 3.41 to 3.50	30 to 50 mg/L free SO_2
	pH > 3.50	50 plus mg/L free SO_2

Red table wines	pH 3.40 to 3.60	10 to 20 mg/L 'apparent[1]' free SO_2 or 50 to 150 mg/L total SO_2
	pH > 3.60	> 20 mg/L 'apparent' free SO_2 or > 150 mg/L total SO_2

Source: **The Australian Wine Research Institute, in their publication *Revisiting Sulfur Dioxide Use,* based on research by Rankine, 1989.** (Note: mg/L is the same as ppm).

Important SO_2 considerations:

- If the wine is intended for medium to long-term aging, it will require a greater free-SO_2 than a wine intended for early consumption.
- If a wine is still hazy, free-SO_2 in the wine is likely to bind up quickly, leaving the wine susceptible to oxidation and microbial growth.
- The concentration of dissolved oxygen in wines increases during racking and bottling.
- Wines commonly lose 10 to 15 ppm during racking and a similar amount during bottling. So, it's prudent to add an additional 10 to 15 ppm of free-SO_2 before racking, and then again before bottling, typically done at another time. Allowing the level to drop significantly below the recommended level between additions is inviting trouble. If the level is already high, you could, of course, skip the addition.
- I think it's best to increase the <u>minimum</u> free-SO_2 level toa minimum of 30 ppm at 3.6 to 3.8, and adjust high pH wines to less than 3.7 or less.

Other points:

- Many commercial winemakers use less SO_2 than recommended. They can do so because they can measure dissolved oxygen in a wine, routinely sterile-filter their wines, and have greater control over the wine-making process than most home winemakers.
- Lower-pH wines are inherently more stable because they need less SO_2 for protection, and provide a less favorable environment for spoilage organisms.
- The sensory threshold for SO_2 (a sulfury, pungent smell, like that of a burning match) in wine, is determined by pH. At 3.0 ppm a modest dose can be overwhelming, yet at 4.0 it's undetectable.
- You should test every 4 to 6 weeks and try to maintain a free-SO_2 level for reds at about around 35 ppm throughout the process to give you a 'cushion' and ensure that the level does not drop to close to zero. That happens more often than you think. Your only option at that point is to add a very large dose: maybe 60 to 70ppm. Much of it will bind up, as it reacts with aldehydes that typically form when SO_2 have been allowed to drop precipitously. Stages of winemaking: SO_2 needs:

Stages of winemaking and SO_2 additions:

- **After crush:** Make the initial SO_2 addition (red, white, and rosé wines) after crushing, or just following pressing, and several before yeast inoculation. In general, the recommended amount after crushing is 50 ppm (parts per million): about 2 grams of Potassium Metabisulfite per five gallons of juice/must. You could probably get by with 30 to 35 ppm.
- To reduce the amount of SO_2 used in whites, some winemakers add the SO_2 after the fermentation is done (see: **To sulfite or not to sulfite?** below).
- **Fermentation:** once the initial dose of SO_2 has been made, do not any until after fermentation or MLC (malolactic conversion), for most reds and perhaps Chardonnay.
- **Post-fermentation:** Most white and rosé wines, having completed their primary (alcoholic) fermentation, should receive a second timely addition of SO_2. Most reds and a few whites like Chardonnay, however, are allowed to undergo malolactic conversion. Adding more SO_2 after primary fermentation will inhibit malolactic bacteria. Therefore, a second SO_2 addition is required after MLC has finished.
- Before you make the second SO_2 addition, wait a couple of weeks before adding it because any remaining viable yeast in the wine can convert the SO_2 to H_2S.
- The recommended SO_2 rate for reds is 60 ppm after MLC, and 70ppm for white and rosé wines after fermentation.
- **During settling, after racking, and aging**: SO_2 levels will continue to drop throughout the winemaking process. Every time you rack or open the container to smell, taste, or to add something, you expose the wine to air (O_2), and some SO_2 dissipates. Barrel aging also exposes the wine to small amounts of air.
- Frequent monitoring (preferably monthly) is needed to ensure that free-SO_2 levels remain high enough to prevent oxidation and inhibit bacterial spoilage. The concept is to prevent free-SO_2 from falling too far below the targeted value.
- Avoiding air-space in barrels is particularly critical. They lose quite a bit of wine due to evaporation.
- Fill stainless steel, food-grade plastic and glass containers to near-capacity, and use Argon gas to displace O_2 after you 'fiddled' with the wine, the best approach is to increase the targeted level by 10 ppm to act as a cushion.
- At some point, the wine, if not disturbed much, will stabilize, and the drop in the SO_2 level will decrease significantly. The loss of free-SO_2 is much lower in glass, and stainless-steel containers. Most plastic container designed for wine have some degree of permeability to air, but there is no loss of water due to evaporation.
- **Bottling:** Check the free-SO_2 level after racking just prior to bottling, and adjust as needed. Wines, even those that taste and smell fine, can go off quickly if bottled with insufficient SO_2. Something to remember is that you should add an extra 5 to 15 ppm, depending on bottling system, to account for the additional uptake of O_2. during bottling. The proper level will ensure that the wine will remain sound longer. (See the section: **Pre-bottling, SO2 addition,** toward the end of the document).

Adding SO_2 (Potassium Metabisulfite):

- Potassium Metabisulfite (PMBS), a concentrated powder, is commonly used to add SO_2 to juice, must, or wine, but you will need an accurate scale. It can be added directly as a powder, or in a 'stock' water-based solution in the quantities needed. The powder contains 57.6% SO_2 (Winy, an Enartis product contains 56%). You can use Sodium Bisulfite (**$NaHSO_3$**) can be used to make a sanitizing solution for winery equipment, but avoid using it in your wine.

Measuring SO_2:

- 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 a 1000 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 about 25 gal (about 1hL) of must in a 32-gallon fermenting bin filled to the inner ring about 6 inches below the top. So, an addition of about 8.5 g PMBS will provide ~50ppm SO_2. Hectoliters (h/L) are a common unit for used by wineries for making additions. They may use tons or h/L.

Ways to add SO_2:

- **10 percent" stock solution** — An inexpensive and convenient way to add SO_2 is to make a '10-percent' stock solution. Add 100 g PMBS to a liter bottle filled to about 3/4th it's capacity with water, and then add enough water to bring the volume of water to the liter mark or about 34 ounces), or 75 g PMBS to a 750 mL bottle partially filled with water, and then add enough water to reach the standard fill level. The actual percentage of PMBS is lower because the product is formulated with less active material. The level typically ranges from 56% to 57.6%. Therefore, the respective solutions contain either 5.6% PMBS or 5.76%. Make sure you check the label. Use the following amounts of the stock solution to add the desired ppm of SO_2:

  - When using a standard 10% solution containing 5.76% SO_2, add 3.32 mL to each 5 gal to raise the SO_2 level to 10 ppm,
  - When using a standard 10% solution containing 5.6% SO2, add 3.38 mL to each 5 gal to raise the SO_2 level to 10 ppm,
  - **0.654** mL of a standard 10% (**5.76**%) PMBS solution adds 10 ppm SO_2 to **1gal** of must.
  - **0.676** mL of a standard 10% (**5.6%**) PMBS solution adds 10 ppm SO_2 to **1gal** of must (slightly more).
  - Winebusiness: Wine Calculator: SO_2 Additions Calculators SO2/Additions as Liquid Solution (winebusiness.com)
  - Use a pipette with a bulb for safety and to make more precise additions.

- Use the table below to determine how much of the stock solution to add for the volume of juice/must or wine when using a 5.6% solution.

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.

- Remember to stir the juice, grape must, or wine thoroughly after making an addition to disperse the SO_2. Unless you stir it, the SO_2 will largely remain at the bottom where it can't protect the juice, wine.

- **Direct powder (Potassium metabisulfite) addition:**
  - Use an electric scale that weighs to the 2nd decimal place, e.g., 5.35, to weigh material. Using measuring-spoons does not cut it.
  - To add **10ppm** to 5 gal., use 0.33g PMBS juice/must (dissolved in water)
  - To add **30ppm** to 5 gal., use 1.0g PMBS
  - To add **40ppm** to 5 gal., use 1.30g PMBS
  - To add **50ppm** to 5 gal., use 1.65g PMBS
  - To add **50ppm** to 25gal of must in a 32 gal. bin use 8.3g

- **Foil pouches containing powdered (effervescent) SO_2:**
  - Offer a convenient, but more expensive way to adjust SO_2. One advantage is that you don't need to stir the wine, as with other means of adding SO_2.
  - Pouches or tablets containing **2**-g or **5**-g of PMBS are available. The effervescent mixture helps to distribute SO_2 in the wine.
  - Foil pouches are only useful if you make 30 gal of wine or more, because a 2-g packet will provide 528 ppm of SO_2 per gallon of juice or must—yes, way too much SO_2. If, however, you want to treat 25 gal of must/juice divide 528 (the amount of SO_2/gal in each packet) by 25. Therefore, the packet will add 21 ppm of SO_2 to 25 gal of juice or wine. Two 2-g packets will add 42 ppm. That's fine to start fermenting most reds or whites. For 10 gal of must a 2-g packet will add 52.8ppm. So, that workable, at least initially.
  - Use a 10% stock solution to make smaller additions.

- One 2-g pkg of (**Efferbarrique** or **Inodose** granules or tablets) will raise the free SO_2 level of a 59-gal barrel ~ **9 ppm,** at least temporarily, a 30-gal container ~ **18 ppm** and a 15-gal container **36 ppm**.
- A 2-g packet/tab will add about **21ppm** to 25 gal (about 1hL) of must just below the inner ring, about 6 inches below the top edge of a 32-gallon food-grade fermenting bin. This is helpful if you use 32-gal food-grade bins to ferment in). So, two, 2-g packets per 25 gal of must will provide roughly 42 ppm of SO_2.
- If you divide a packet, remember there is 5 grams of material (SO_2 plus the effervescent agent) in a 2g-packet. So, 2.5 g of the granules will provide 1g of SO_2, enough to add 10.5 ppm to 25 gal.
- A 5-g-packet of **Effergran** or a 5-g **Inodose** Tablet will raise the free SO_2 level in a 59-gal barrel to **23 ppm**.

Factors affecting how much SO_2 is needed:

- type of wine: white, rosé, or red? More for whites and rosés.
- tannin level: heavy bodied reds can get by with less SO_2.
- condition of grapes: more is needed for moldy, bird-pecked, bee or yellow-jacket damaged grapes.
- temperature of grapes upon arrival to the winery
- cellar temperature
- the higher the pH, the higher the dose.
- sanitation practices
- handling (number of rackings, topping practices, and how often you expose the wine to air.
- number and types of additions
- use of oak chips, cubes, etc., because they introduce a lot of air, resulting in faster SO_2 depletion.
- aging on the lees (sur-lie). The lees bind with free O2 in the wine. So you can get by using less SO_2, initially.
- type of storage container used, oak barrels and plastic carboys and tanks are semi-porous and the wine stored in them need more
- how often a barrel is topped.
- whether or not you use inert gas to displace O_2 from containers.
- bottling system

Calculating how much SO_2 to add:

- You can use the formula listed below to calculate how much PMBS to add, or the easy to use calculator: http://www.winebusiness.com/tools/?go=winemaking.calc&cid=1 (make sure you enter 5.6% or 5.76 when using a stock "10%" solution) or you can use: http://winemakermag.com/1301-sulfite-calculator

Formula for PMBS addition:

gal. of wine x 3.785 x desired ppm = grams of PMBS to add
1000 x 0.56 or 5.70

- 3.785 converts gal to liters
- 0.56 is the fraction of SO_2 in PMBS
- 1000 converts mg/L ppm to g/L
- A simplified version is: gal of wine x desired ppm x .0066 = g of PMBS

The winemaking process:

Sourcing grapes:

- There is a strong correlation between grape quality and price per pound. In general, you should be prepared to pay market value when buying commercial grapes. There are several resources including the GENCO Website, and The Fermenter's Warehouse, that list grapes available and the asking price. It's best to look at the vineyard to see if it seems well managed, and to sample the grapes before committing. Sometimes, you can fine real bargains by shopping around. Occasionally, you may find a grower offering fruit at an attractive price because he/she has extra fruit, or just lost their buyer. Sometimes you can get a deal because the grapes are fully ripe and need to harvested ASAP. You may find grapes from a small, hobby vineyard for free, provided you give the owner a case or two, depending on how much finished wine finished wine you get
- You can buy your grapes from growers, or other sources in areas known for producing the variety and quality you want. Look further afield for hard to get Italian or Rhone varieties. You're more likely to find them in Amador, El Dorado, and Mendocino Counties. Lake County has some excellent and attractively priced Cab and Sauvignon Blanc grapes. Lodi is a good source for high-test zinfandels. Clarksburg is known for producing great Chenin Blancs and Chardonnay. Mendocino Vineyards also offer a wide range of varieties and attractive prices. Rather than making a cab, try Merlot. Well-made Merlots rival, Cabs, and typically are more elegant and drinkable. Consider vineyard practices and look at the quality of the fruit. Check to see if the vines appear healthy and properly managed. Negotiate for grapes picked in the morning, if that's part of the deal. Second-crop (the small, under-ripe clusters that are usually passed over during picking) can seem attractive because they're free, but picking is painfully slow, and the quality is not the best, unless you can wait until they are fully ripe. Letthe birds have them. f you want to save money, look for the deals, check the adds.

Grape ripeness:

- Optimal grape ripeness will depend on the style of wine you want to make, as well as the objectives of the grower. The style of wine is usually dictated by the relative ripeness and balance between sugar and acidity.

- Enologists use the term physiological ripeness to determine when to pick. It is a combination of factors indicating ripeness: skin, seed, and stem color, skin elasticity, °Brix (°B), acidity, and, ‘ripe’ (soft, smooth) skin tannins, and of course, ideal flavors.
- The following changes occur as grapes ripen:
    - skin color of colored cultivars changes from green to red, blue, or black.
    - berries begin to soften, with white cultivars becoming more translucent.
    - sugars (measured as °Brix begins to increase.
    - TA decreases and pH increases
- What to look for—the convergence of grape ripeness (sugars and acids) and ripeness (maturity) of phenolic compound (pigments and tannins). It’s not unusual for grape sugar levels to peak before phenolic ripeness is reached, particularly during extended heat waves near the end of the season. Growers typically allow their grapes to hang longer to achieve phenolic ripeness, risking high sugar concentrations, low acid levels, and often juice with insufficient nutrient content to support a healthy fermentation. To compensate for this imbalance, diluting the juice with water, and increasing acidity, and supplementing nutrients levels are an important consideration when degerming the need for adjustments, and how best to handle the fermentation.
- Sugar levels can be easily adjusted by adding water (‘watering-back’) to ensure a reasonable alcohol level. In most cases, acidity can be elevated as needed, and complex nutrient blends are available to ensure the fermentation is trouble free. Bear in mind that these adjustments are largely unnecessary when grapes are harvested below 24°B.
- Grape color is also a useful indicator of ripeness. White grapes begin to turn yellow when they ripen, and turn golden-yellow (assuming they have some exposure to direct sunlight) when reaching their peak. With reds a uniform dark ruby red to a red blue, to dusty ripe blueberry, indicate ripeness is close
- Most commercial growers and winemakers rely on tactile and taste sensations when they taste/chew on grapes: skins, seeds, and stems, looking for the ideal balance. For comparison, chew on an unripe grape including the seeds and bits of stem to sense the tartness, puckery, mouth-drying feel, and bitterness. Then chew on ripe grapes with brown stems and seeds. The difference is night and day. Unripe grapes or clusters with too many unripe red grapes make thin, harsh, astringent, and bitter wines, often with herbaceous notes from unripe or ‘green’ tannins. Seeds contribute a substantial amount of tannin to red wines and, if they are unripe and green, they can adversely affect the wine.
- If you grow your own grapes it helps to manage the canopy carefully, thin heavy crops to ensure even ripening, drop fruit that is slow to ripen, or is damaged in some manner. It’s also a good idea to untangle clusters at the same time to speed picking when you finally get to it.

Determining when to harvest:

- Knowing when to harvest is key to making good wine. Underripe grapes produce tart, thin, herbaceous, bitter, astringent, and low alcohol wines—not what you had in mind? Unless adequately adjusted, overripe grapes will produce a wine with excess alcohol and low acidity.

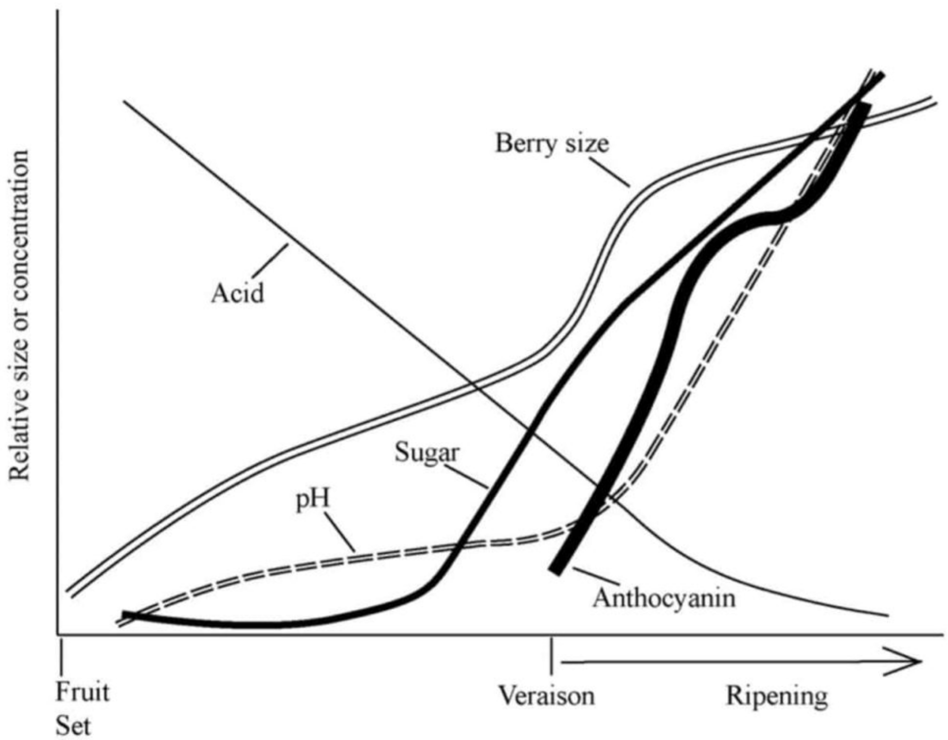
- The goal is to have enough sugar and flavor in the grapes to make the wine more appealing.
- Ensuring that a wine's basic elements, e.g., sweetness, acidity, tannins, and potential alcohol are in harmony (perhaps the term **balanced** is more appropriate) should be factored when you decide when to pick.
- Ideally, grapes should be picked when they are ripe. Ripeness is usually expressed as percent sugar or °B (Brix). In California grapes are typically picked when the sugar levels are from about 23 to 26 °B, 17.5 to 19°B for sparkling, 21.5 to 22.5°B for 'crisp' and more austere whites, 21.5 to 23°B for rosés, and 24-25°B for richer whites. Most reds are picked closer to 25°B or a tad higher. Many wineries pick at a higher level and then water-back, because it gives them extra wine they didn't have to pay for. A refractometer is typically used to check grape sugar in the field.
- Targeting a specific °B level is **not** the best way to ensure ripeness. Grapes can have high °B but may not be fully ripe, and grapes can be fully ripe, even though their sugar level is seemingly low — say 22.5. There are many variables that influence ripeness, so relying solely on °B can be a misleading.
- Key considerations:
    - Color and taste are better indicators of ripeness.
    - Some winemakers rely solely on taste: sweetness and flavor.
    - Berries should be soft and slightly dehydrated (skins a bit slack). The texture of the pulp softens as grapes ripen. When red grapes are fully ripe, the berries feel a little soft, and the skin becomes slightly slack, but not wrinkled like a raisin.
    - Each grape variety has a characteristic combination (and range) of aromas and flavors, including tannin, and sugar and acids levels.
    - Ripe fruit flavors: in general, look for the smell/taste of sweet black berries, black cherries, black currants, rather than red cherry, cranberry, and pomegranate. For white grapes look for sweetness, floral and spicy notes, apple or pear, sweet citrus, sweet stone-fruit.
    - Underripe fruit has a green, herbaceous smell, and may have a smell/taste like that of bell peppers. Over-ripe fruit is more reminiscent of dried fruit, prunes, or raisins.
    - Most of the stems as well as the seeds should be brown. Seeds should also be easily separated from the pulp, and should also be crunchy and have a nutty flavor. The color of grape seeds changes from green to brown as the berries ripen. Many experts feel 80 – 90% of the seeds should be brown before harvest.
    - When grapes are fully ripe, they should be relatively easy to pull away from the pedicel—small stem that attaches the grape to the cluster.

- Most red grapes, when ripe, are dark Navy-blue, like ripe blueberries, and taste sweet, but with some remaining tartness, and have deep, complex fruity flavors. Clusters that have a reddish (cranberry) cast, rather than blueberry, should be avoided. Reddish grapes are not ripe and will skew flavors and acid levels. If in doubt, taste the grapes. Select cluster where all the grapes look like ripe blueberries.

- For whites, depending on variety, look for a greenish-yellow to yellow, or in some cases, yellow-gold, rather than dark green. Grapes should be sweet, with typical fruit aromas and flavors, and good acidity.
- Ripe grapes should appear healthy and be free of mold, rot, sunburn, or other physical damage. Clusters with those issues should be ignored. Avoid clusters with lots of small, green, unripe 'shot-berries, as well as those that are over-ripe—wrinkled skin or extensive raisining.
- **Sampling**: When grapes in a vineyard or block appear nearly ripe, collect a sample of individual grapes or clusters to determine the sugar content of the combined juice. Depending on weather, you may need to sample daily to see how the grapes are progressing.
- If you buy grapes, the grower will do the sampling, and let you know when the they are ripe, or expected to be ripe.
- Generally, a 200-berry sample is enough to give an accurate representation for +/- 1 °Brix, or a 500-berry sample can be taken for +/- 0.5 °Brix. Sample the grapes in the morning, collecting grapes from individual vines and clusters that are most representative of the vineyard or block. Avoid end-row vines and outside rows. For berry sampling, pick two berries one from either side of the cluster, near the top. Pick two berries from the middle of the cluster, but at a right angle to those taken at the top, and finally a single berry at the tip of the cluster.
- Do the same with a cluster from the opposite side of the vine. Try to collect clusters as randomly as possible, for example, focus on a leaf in the fruit-zone and pick from the nearest cluster. Try to pick grapes those that are average in size. Make sure you sample grapes from both sides of the trellis for vertical canopies, and select clusters with varying degrees of sun exposure. Place them in a zip-lock bag, and crush to release the juice for testing. Allow the juice to settle for an hour or two. Use the relatively clear juice to measure °B using either a hydrometer or a refractometer.
- The larger the sample size, the more accurate the results. For greater accuracy, select whole clusters from different parts of the vineyard and from different sides of the rows, say one cluster per every 10th vine. You may want to sample more cluster in very small vineyards. Select clusters that are shaded as well as some that receive ample sunlight. After testing, the bags with the remaining skins, seeds and juice can be frozen and added to the fermenting juice after you've harvested—waste not, want not.
- Factors that influence ripening include weather, particularly temperature and duration, heat spikes, irrigation practices, grape variety, aspect (exposure), topography, trellising system, canopy management, etc. Ideal ripeness is determined by variety, type of wine being made, desired brix and acidity levels, and the winemaker's objectives.
- Although, some winemakers pick when the °B level reaches a specific level. Taste and appearance are the most reliable way to know when to pick. Many winemakers also consider pH, and try to pick when pH is close to 3.5 for reds.

Otherwise, they just adjust acidity accordingly. As grapes ripen, the sugar content increases, while acidity decreases—pH goes up, and TA goes down.

- Grapes are often left to hang after they are obviously ripe, in hopes of increasing fruitiness and pigment content. It can be challenging for home winemakers to make a balanced wine from such grapes because the sugar levels are high, nutrient levels are often low, and the acid levels are typically low (moderate to high pH and moderately low TA) as well. Acid adjustments and watering-back (diluting) the juice to keep alcohol levels reasonable, are important in such cases.



Graphic generalization of changes in grape chemistry through development and ripening. From Watson, 2003

- Tartaric acid (see **Adjusting Acid** below) is typically used to increase acidity in juice when TA is too low and pH too high.
- Adding water to high °B juice will reduce sugar content and lower the resulting alcohol level. Too much alcohol can make a wine taste ‘hot’ (a sense of burning in the mouth). Furthermore, the fermentation may stick unless you use an alcohol-tolerant yeast. Stuck wines are often overly sweet and subject to bacterial spoilage while you try to get the fermentation restarted. Something to keep in mind:
- Grapes harvested much above 25 B° should be diluted to keep the resulting alcohol level moderate (see **Adjusting °Brix** below).

- The percent alcohol produced will depend on the yeast strain, fermentation temperature, yeast nutrition, and can vary from harvest to harvest.
- To estimate potential alcohol, multiply the °B by 0.59 (current conversion factor). For example: 26°B x 0.59 = 15.34%. -- very hot! But if you dilute it to 24°B, the alcohol will be close to 14.16%—quite acceptable. If you don't dilute the grape-must, select a yeast that tolerates high alcohol to minimize the chance of the fermentation sticking. Overly-ripe grapes are notoriously low in nutrients, essential to maintain yeast health and development.
- Unless adequate yeast nutrients are added during fermentation, the yeast may struggle, causing the fermentation to founder and come to a screeching halt, before all the sugar has been metabolized. Not a good thing! And unless you act quickly and follow a complex set of procedures involving a special yeast, some nutrients and a detoxifying yeast-based product, and something to inhibit bacteria, your chances of getting the fermentation back on track are slim.
- °Brix correlates to the potential alcohol content of a dry wine. Assuming the wines ferment to dryness, the starting °B to resulting alcohol chart is as follows.

Sugar to Potential Alcohol Chart

Brix	Baumé	°Oechsle	Specific Gravity	Potential Alcohol
14	7.8		1.0568	7.6
15	8.3		1.0611	8.2
16	8.9	65	1.0654	8.8
17	9.4	69.8	1.0698	9.5
18	10.0	74.1	1.0741	10.1
19	10.6	78.5	1.0785	10.8
20	11.1	83	1.0830	11.5
21	11.7	87.4	1.0875	12.2
22	12.2	91.9	1.0920	12.9
23	12.8	96.5	1.0965	13.6
24	13.3	101	1.1011	14.4
25	13.9	105.6	1.1057	15.1
26	14.4	110.3	1.1103	15.9
27	15	114.9	1.1150	16.7
28	15.6	119.6	1.1197	17.5

*Alcohol content in the chart above is determined using an alcohol conversion factor of 0.59 and rounded to the nearest tenth. Common conversions factors range from 0.55 – 0.65, depending on grape variety, yeast used, and data collection error.

Determining how many pounds of grapes to buy: 'Rule of thumb':

- First, determine how many gallons of wine you want to make. Remember, you will need extra for topping and to account for loss during racking, or because you didn't press particularly hard or decided not to use the hard-press wine because it bitter and astringent. Let's say you're making a red wine and plan aging it in a 30-gal barrel. To do so, you'll need about 500 pounds of grapes. In general, divide the weight of the fruit by 15. Varieties with larger grapes produce more juice. White grapes typically yield maybe 20 percent less juice than reds, because it's hard to extract most of the liquid faction contained within the gel-like pulp around the seeds, that remains largely intact after pressing. The gel is comprised of gum-like pectins. Pectolytic enzymes help by breaking down (liquifying) the pectins, increasing the yield, but that takes at least 2 to 3 hours of skin time after stemming/crushing. In reds, these gels are broken down during fermentation, thus, yield is greater.

- Yield from 500 pounds of red grapes after pressing, is roughly 30 to 35 gal., depending on grape variety, and how hard you press. Yield ranges from 30 to 37.5 gal. The rule of thumb is that one hundred pounds of red grapes typically yields anywhere from 6 to 7.5 gal of juice.

- One ton of red grapes yields upward to 180 gal (commercially), but about 150 gal using a small basket press. Large grapes (higher juice to skin and seeds ratios) may yield up to 160 gal. To fill a 60-gal barrel you'll need approximately 1000 pounds. Typically, that will yield from 5 to 15 gal. of extra wine. The point is to get enough grapes, plus some extra for topping. You can age the excess wine in one or more containers, e.g., a carboy, or 5, 7.5, or 15-gal stainless-steel 'beer' kegs. It's also a good idea to bottle a case or two for topping – a case holds about 2.5 gal. Fill containers of extra wine to near capacity. For beginners, using a variable-capacity tank, makes good sense until you get a feel for how much fruit to buy and how best to store it. Make sure to include all containers when you add Sulfites. If you are using a barrel to hold the bulk of wine you can run the extra wine through the barrel several time to ensure the entire lot benefits from oak aging.

Cellar sanitation:

- Successful winemaking starts with good sanitation practices. All winemaking equipment—anything that the grapes, juice, or wine will come in contact with, should be cleaned and sanitized, throughout the entire winemaking process. It's easy to see and remove debris, dirt, dust, or wine residue and staining, but it hard to see and remove bacterial films. This is where sanitating chemical agents can be useful. For more information regarding cleaning and sterilization, see the discussion on **Sanitation** section above.

Harvesting grapes:

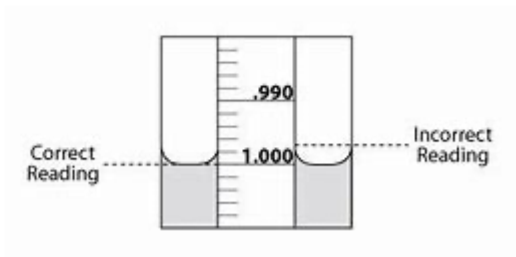
- t's best to pick early in the morning when the grapes are cold. I've found it convenient to pick directly into 5-gal buckets. These can be dumped into 40 lb-picking lugs, 32-gal, or smaller, white, food-grade bins, or a ½-ton macro-bin for transit. Keep the grapes cool by using dry-ice pellets or frozen water-filled jugs in the transport bins. Cover the grapes with a tarp or use the lids that come with the trash bins to avoid exposed to grapes to direct sunlight during transit, particularly if you have a long way to go, or are forced to pick later in the day. To prevent the covers from blowing off, use a tarp as well. Picking-lugs and buckets can be easily emptied into the 'stemmer'/crusher. Larger trash bins are best emptied by hand (wear Nitrile gloves to prevent bee or yellow-jacket stings. I've found that macrobins can be emptied more efficiently using a shortened pitchfork with dull tines.

Temperature control:

- Warm grapes are prone to microbial spoilage, particularly during the **cold-soak** phase (see **Cold Soak** below). Try to pick early in the morning, so the grapes are cold when starting a cold-soak.
- Warm-grapes should be cooled to <50°F using dry ice, or 2 to 3 1-gal sized frozen water-filled jugs. These need to be replaced daily as the ice melts
- Early SO_2 additions will also help minimize microbial spoilage.
- To maximize freshness and fruitiness, ferment the juice for whites and rosés at <60°F. You'll need to devise a way to keep the fermentation near that temperature (see **Managing fermentations (white grapes and those used for rosé**: **Keeping the fermentation cool**, below:
- The upper limit for maintaining some fruit and freshness is about 65°F.
- Red wines are allowed to ferment at room temperature, and temperature control may be needed to cool a particularly warm fermentation, or warm the juice /must when the temperature is low. If the temperature is getting too high, do your best to cool the fermentation, otherwise the yeast may suffer. Check both the upper and lower temperature range of the for the yeasts you plan to use, and try to keep the temperature within the stated range during peak activity.

Testing and adjusting grape juice or must:

- Use a hydrometer to test sugar content (°B) of grape juice: The instrument consists of a sealed weighted glass tube that floats when placed in a tall, narrow plastic cylinder filled with grape juice, it floats higher or lower, depending on the density (concentration of solids, such as sugars, in a liquid such as grape juice. The higher the instrument rises in the juice, the higher its °B. The bottom of the hydrometer is wider and weighted. A 'graduated' paper scale within the hollow stem of the instrument, indicates either the relative density of the solution, or the. percent sugar (°Brix). Once the instrument comes to rest, note the numerical reading on the hydrometer scale closest to the level of the liquid's surface. Liquids cling to many surfaces and move upward slightly on the inner surface of the cylinder wall, as well the outer surface of the hydrometer, forming a curved meniscus, giving an inaccurate reading.



- Knowing the specific gravity of the juice provides a measure of the alcohol that is likely to result. It can be used to indicate how the fermentation is progressing, and how much fermentable sugar is remaining when fermentation activity is slowing or appears to have stopped.
- The °B for a number red varieties, particularly Zinfandel, often increase within a day or two of crushing. Readings taken after 1 to 2 days of skin contact, can be 2 to 3 °Brix higher than a reading taken at crush. This can make a big difference in the final alcohol level. Without knowing the actual °B, you can't make the decision to dilute the juice to keep the alcohol within a desirable range. Additional time allows the sugar in the pulp, and small uncrushed berries to leach into the surrounding juice. °B level will also increase when there is a significant number of raisins in the cluster that will release additional sugar as they ferment. So why the concern? Grapes with high sugar levels >25°B produce high alcohol levels that make a wine taste hot—a burning sensation.
- With red grapes, you want to determine pH accurately. The problem is that pH increases with skin contact. So, it important to wait 24 to 48 hours after skin contact. Potassium ions in the juice will combine with Tartaric acid and precipitate as Potassium bitartrate. This will drive pH up. Use an accurate pH meter and calibrate it before use.
- White grapes, as well as those used to make rosés, can be tested immediately after pressing (no skins to raise pH.
- Collect a sample for a wine-panel test, from a pooled source of juice of white grapes, and those used to make rosés that has settled (about 8 hours), and 24 to 48 hours after crushing and chilling red grapes. This will provide a more accurate assessment of pH, TA. Most of the potassium ions will have leached out of the skins, increasing pH.
- Refrigerate the sample juice and allow it to settle overnight. The sample you submit to a wine lab for analysis should be relatively clear.
- It is both convenient and prudent to have a commercial wine lab run a complete **juice panel** test (°B, TA, pH, Malic acid g/L, YAN (nutrient availability). There are at least several options for home winemakers: Home Wine Lab, Gusmer Lab Services, and My Enologist.
- Knowing the YAN of your grapes will allow you to add the right amount of yeast nutrients. When the YAN is high, most yeast will generally ferment to dryness

with no problems. When it's relatively low or moderately low, many yeast strains will struggle and the fermentation will become sluggish, or stop altogether (stick), or they will produce stinky hydrogen sulfide (H_2S), a problem that must be dealt with.

- You can also do your own testing using the Vinmetric system. There is a bit of a learning curve involved running the tests, but the results are good.

Adjusting Brix (°B):

- **°Brix** is a measure of the dissolved solids, mostly **sugars**, in grape juice. It measures the specific gravity of a solution, relative to that of water. The common symbol for it is **°B**. 1°B is about the same as one percent sugar (wt./vol.), or 1 gram of sugar in 100 mL of water. It's also a measure of the potential alcohol content in a wine made from those grapes. To measure °Brix use an accurate hydrometer. You may need to compensate for temperature to get an accurate reading. The -1.5 to -0.2 °B mark (Brix/Balling scale) on a hydrometer indicates virtually no remaining fermentable sugar in the finished wine.

Raising °B

- This is seldom necessary in California), however, if you are forced to pick early, due to rain, conditions that favor bunch rot, or unusually cold weather, and the sugar levels are too low to make a reasonably good wine, adding sugar will help by increasing the alcohol level. This will improve taste and mouthfeel. However, because acidity will be higher than normal, and fruit flavors and skin color will be less developed, making a good wine is unlikely. Adding about **60g** of sugar per gal of juice will raise °Brix by 1°B.
- The amount of sugar needed should be based on amount of juice you have or the expected yield of juice from the grape-must. Dividing the weight of the fruit by 15 will give you an approximation of juice yield in gallons. One hundred pounds of red grapes typically yields anywhere from 6 to 7.5 gal, depending on grape size. On average, 60 to 70 percent of grape must is juice. Use 60% for smaller grapes and 70% for larger grapes, like Zin.

Lowering °B

- The reason for lowering °B is to keep alcohol levels under 15%. In general shoot for about 14.5 for reds and from about 13 to 14 for whites and rosés. As sugar levels exceed 25°B, the likelihood that the alcohol will exceed 15%. When grapes toward the end of their development, they can do so very quickly, particular during prolonged hot weather, common later in the season. It's not unusual for grape sugars to peak within a day or two. Much of the increase, though, is due to water loss from the grapes.
- Sometimes you're forced to pick late due to factors beyond your control. The longer you wait, to pick ripe grapes, the less likely you are to make a balanced wine, unless you adjust the juice, or do some blending.
- The up-side of high-brix grapes is intense fruit flavors, and less bitter, green tannins. The down-side, though, is higher alcohol levels in the finished wine that

will detract from the wine's sensory appeal. Alcohol level increase with sugar content (B°), so the only practical solution is to dilute the grape juice by adding bottled water.

- Adding water is a common practice throughout the industry to keep alcohol levels in check. Water, as you would expect, dilutes the concentration of sugar, reducing the amount of alcohol in the finished wine. Conceptionally, '**watering back**' replaces the water lost to dehydration during hot, dry weather. (On line calculator: (www. Vinolab.hr) enter brix and gallons.
- Except for port and late harvest wines, alcohol level in table wines should <u>not</u> exceed 15 °B. Admittedly, flavors are diminished somewhat depending on the volume of water added. But when done with restraint, the wines taste better.
- The ideal range for Brix is 23.5 to about 24.5°B, depending on variety and actual ripeness (not sugar). Grapes above 25°B should be watered-back to 24 to 24.5 using bottled water to dilute the must. Greater than 14 percent alcohol is generally considered moderately high. Above that it is thought to be excessively high.
- Alcohol is an important element in wine, because it greatly influences a wine's sensory appeal, by adding a touch of sweetness, and enhancing the wine aromatics, because it carries aroma molecules. Furthermore, it increases viscosity (weight on the tongue), and ramps up body.
- A significant increase in °B is common during 'cold-soak' of grapes that are known to ripen unevenly, such as Zinfandel, Pinot Noir, Sangiovese, and Malbec. You may also need to do some additional dilution later. It's a good idea to test the alcohol level after fermentation, even if you've watered-back, so you can readjust it if the wine still hot.
- Wine quality may suffer if you lower the °B by much more than 3 points. So, if °B is 29 you could lower it to 26. One option is to blend the wine with another with a lower alcohol wine. Another issue with high brix grapes is that fruit flavors become jammy and more like dried-fruit, even prune-like or raisiny.
- Another option for dealing with high-Brix grapes, provided you have enough grapes to fill your barrel or aging container(s), is to drain off a portion of <u>juice</u>, equal to the amount of water needed to dilute the must to the desired level. This process compensates for diluting the juice or must by increasing the skin-to-juice ratio. You'll end up with the same ratio as you had before water addition. The net effect is that the resulting wine will have better balance, and the juice that is 'bled' off can be used to make a decent rosé. Of course, you will have to make some adjustments in B° and acidity.
- Diluting high B° grape with water lowers (discussed in defining acidity), but <u>**not**</u> pH due to the buffering capacity (resistance to change) of the juice. In most cases, you'll want to add acid if TA is <u>low</u>, particularly for high B° grapes. In cases with <u>high</u> TA, adding acid will just increase it. So, when warranted, add 23 g of Tartaric acid per gallon of water to account for the drop in TA.
- When TA is higher than normal, just adding water will modestly lower the TA. If the TA is less than normal, add the acid.
- **Rule of thumb**, to lower the B° of a juice by 1 unit, add 150 mL of bottled water for each gal. of juice in the must. Ten gallons of grape-must contain between 6 to

8 gallons of juice, depending on the size of the grapes. On average 60 to 70 percent of the must is juice. Knowing this, you can calculate the amount of water to use:

Calculating how much water to add:

Estimate the expected yield of wine in gallons from the harvested grapes. One hundred pounds of grapes typically yields anywhere from 6 to 7.5 gal, depending on grape size. Varieties with larger grapes produce more juice. Multiply that amount by 3.79 to convert to liters. Next, measure the Brix as accurately as possible after the grapes have cold soaked for a couple of days or longer. You can always make another water addition if the alcohol becomes too great after fermentation. If the wine tastes balanced after fermentation and MLC, you're probably OK. If is not, or you aren't sure, have the wine tested for % alcohol. You can do that when you test for competition of ML.

To calculate how much water to add to a specific volume of wine to dilute it to the desired °B level use the following formula

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

V^l = volume (in liters) of undiluted juice (whites and rosés) or volume of juice in the must (reds)
SB = starting °B
DB = desired °B
V^2 = volume (in liters) of the diluted must
X = volume (liters) of water needed to dilute the must to the desired °B

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

Conversion factor: 1hL (hectoliter) contains 100 liters (L) or about 26 gal (100 ÷ 3.79)

Defining wine acidity:

Acidity is one of the four fundamental traits in wine, along with tannin, alcohol, and sweetness. Wine acidity is critical in winemaking because it influences a wine's balance, sensory appeal, and its microbial and chemical stability. It can make one wine taste tart and another flat and dull. Excessive acidity in reds accentuates astringency and bitterness. To make wines that taste reasonably good, are balanced, and stable, requires some familiarity with the fundamentals of chemistry. Most home winemakers, though, find the subject confusing or of little interest, so they tend to ignore it until they run into problems. That just makes it harder to avoid or resolve predictable complications that often arise. So, let's see if we can change that. To begin with, wine acidity is characterized by just 2 factors: **pH** and **TA** (titratable acidity). Both are discussed below.

Natural acidity in grapes decreases throughout the season as they mature. Influences include climate, weather, soil characteristics, topography, drainage, exposure to sunlight, and farming practices, like trellising, canopy management, irrigation, etc. And of course, the longer you wait to pick, the lower the acidity. Acid levels vary widely from year-to-year, within the same vineyard, and even the same vines. So, it's hard to predict what the acidity will be when you harvest. The bottom-line is that acid levels can be too high or too low to make a balanced, stable wine. So, knowing how and when to adjust acidity is critical. California's warm climate and prolonged heat spells, and unpredictable heat spikes toward the end the season, tend to result in over-ripening, driving acid levels downward.

If your only academic exposure to chemistry was in high school, or you somehow managed to avoid it altogether, your understanding of chemistry may be rather limited, so, this may be a slog for some readers, but take heart, you're not alone.

Chemistry involves the composition, structure, properties, behavior, and changes that substances (atoms and molecules) undergo when combined with other substances, and the ways in which they interact with other atoms, ions, or molecules to form new substances. Nevertheless, a little 'homework' and some diligence can give you a leg up, when it comes to understanding key concepts. Let's start at the most basic level of wine chemistry:

- A **molecule** is a group of two or more atoms held together by attractive forces known as chemical bonds. Depending on context, the term may include ions. Molecules may separate into charged **ions** that can react with other ions.
- An **acid,** for this discussion, is a molecule that separates (**dissociates**) or **ionizes** in a water-based solution, such as grape juice, releasing one or more positively charged hydrogen ions (H^+), commonly known **cations**, and a negatively charged ion (known as an **anion** or 'conjugate base'), for example, CL^- or SO_4^{2-}. The result is a 'sour' solution, containing hydrogen (H^+) ions, with a pH (discussed below) of less than 7. Cations have a plus ($^+$) charge, while anions have a negative ($^-$) charge. The presence of H^+ ion(s) inn solution makes it **acidic**.
    - When **Tartaric acid,** the primary acid in grape juice and wine (represented by the simplified chemical formula: **H_2Ta**), is added to water, juice, or wine, some, depending on the starting pH of the solution, will dissociate into **Bitartrate** ions (HTa^-) +1 H^+, and **Tartrate** ions (**Ta^{2-}**) + 2 H^+, while some of the acid (**H_2Ta**), remains undissociated.
    - The proportion of each of these two ions is pH-dependent.

- pH is determined by the number (concentration) of H^+ ions released into a solution. The higher the concentration, the lower the pH (stronger, more acidic).

- A **base** is a molecule, like NaOH (lye) that when added to water, separates into 2 charged ions—Na+ (the cation) and OH^- (the anion)**.** The OH^- ion makes the solution **basic**—the opposite of acidic. Other bases, for example, Potassium Carbonate ($KHCO_3$), used to adjust acidity, does not release OH^-, but forms a chemical bond with H+ ions, essentially removing them from solution, thereby increasing pH (making the solution <u>less</u> acidic).
- A **salt** is a molecule produced when an acid reacts with a base in a water-based solution. For example, when Hydrochloric acid (**HCL**) and **Sodium hydroxide** (NaOH), a base, are combined, they react to form a salt: in this case, **NaCl** (table salt) and water (H_2O), from the H^+ and the OH^- ions released into the solution when the chemicals dissociated. Salts do not carry a net electric charge.
- Soluble salts in solution consist of a positively charged ion (cation), and a negatively charged ion (anion) often referred to as the **conjugate base.**
- The term **pH** is a measure of the concentration of H^+ ions or OH^+ ions in solution. (See **Acidity in grape juice and wine below**).
- Solutions below pH 7, are said to be **acidic** because they contain more H^+ ions than OH^- ions. By comparison, solutions with a pH greater than 7 are said to be **basic** or alkaline, because they contain more OH^- ions than H^+ ions.
- If an acid, for example, Tartaric Acid is added to grape juice or wine, acidity will increase—good to know. If instead, you add a base, such as Potassium Bicarbonate, acidity will decrease because some of the acid will be neutralized—this provides the means to adjust acidity up or down.
- The best way to <u>increase</u> acidity in grape juice or wine (lower pH and raise TA) is to add **Tartaric acid**, a natural grape acid. To <u>reduce</u> acidity (raise pH and lower TA), add **Potassium Bicarbonate** or **Potassium Carbonate.** Both are harmless bases. It’s as simple as that. You will, however, need to calculate the amount to add.

Acidity in grape juice and wine:

- The principal acids in wines are Tartaric, Malic, and to a lesser extent Citric. Tartaric acid is the most abundant, followed by Malic acid, much of which is lost during ripening in warmer climates, and levels in very ripe grapes tend to be significantly lower than Tartaric acid.
- Acidity can be measured in 2 ways: **TA** or **pH**.
- **TA** (**titratable acidity**) is the acid content of grape juice or wine that gives wine it’s characteristic tartness. It is also a measure of the total concentration of H+ ions (dissociated and undissociated) in juice or wine, as determined by titration—gradually adding NaOH, a strong base, to neutralize all of H+ ions, to a specified end point. TA is expressed as g/L of Tartaric acid equivalents, or as a percent concentration.
- **pH** (a chemistry term used to measure the strength of an acid or a basic solution. It is measured using a specialized meter to determine the concentration in g/L of H^+ ions <u>currently</u> in a solution, such as grape juice or wine, and is expressed

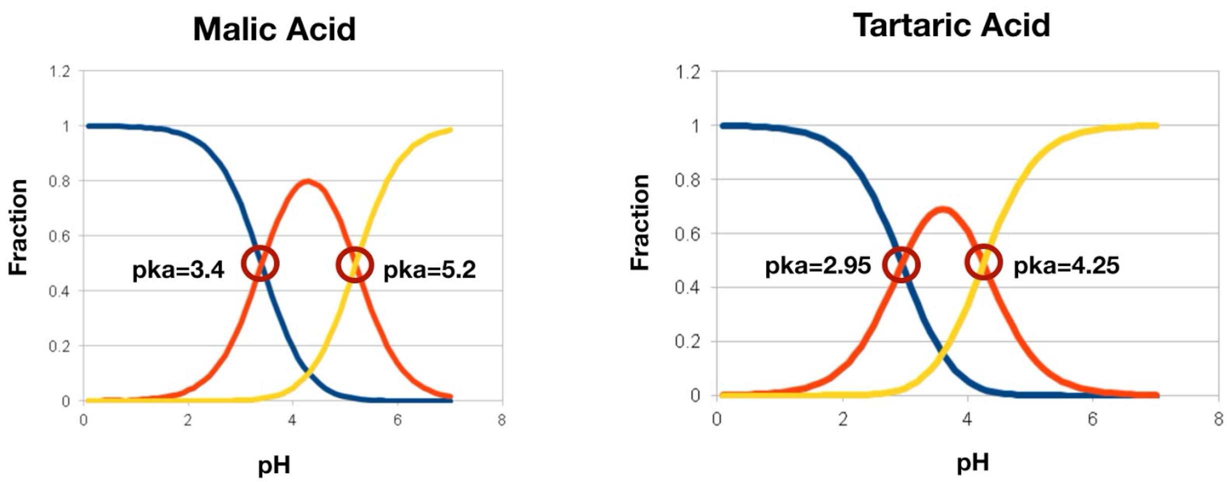
using a logarithmic scale from 0 (the greatest) to 14 (the lowest). Acidity decreases 10-fold for each whole number on the scale of 0 to 14. For example, a pH of 3 is 10 times more acidic than pH of 4, and a 100-times greater than a pH of 5. A sparkling wine with a pH under 3.0 is significantly more acidic than a red wine with a pH close to 3.8. A pH of 7—close to that of water, is considered neutral, neither acidic nor basic.

- Solutions below pH 7 are acid, and those above pH 7 are alkaline (basic).
- The thing to remember about pH is that the higher the pH, the lower the acidity of the juice or wine, and the lower the pH, the higher the acidity. Yes, it's confusing.
- High acidity wines are characterized by high TA, and low pH values.
- Low acidity wines are characterized by low TA and high pH values.
- **Important concept**: pH is usually proportional to the amount of acid in grape juice or wine. How it changes when Tartaric is added, depends on how much is added.
- Grape pH typically ranges from as low as 2.9 (very acidic) for grapes picked for sparkling wines, to a little over 4.0 (low acidity) for example, red grapes grown in hot regions or harvested late in warm areas.
- pH of grape juice or must ranges from a little under 3.0, to a little over 4.0
- TA for grapes grown in Northern California ranges from about 5 to 9 g/L, depending on variety, when they're picked, canopy management, local climate (Sonoma Coast or Alexander Valley), and weather, etc.
- Acidity decreases (TA goes down and pH goes up) as grapes ripen. The decrease in TA is largely the result of dilution with water as the grapes expand. It also declines due to respiration (breakdown) of malic acid. This occurs more rapidly in warm regions and seasons, than in cool regions and seasons.
- Warmer climates and seasons generally produce grapes with high sugar and lower acid levels, whereas cooler climates produce grapes with less sugar and more acid.
- High pH in grapes is often associated with high Potassium or malic acid levels.

Acid strength:

- Some acids are 'weak,' others are 'strong.' Strong acids are those that totally or mostly ionize (dissociate) when placed in water.
- Ions, for this discussion, involve atoms, groups of atoms or molecules that acquire a negative or positive charge by gaining or losing electrons, ex. H^+ (loss of 1 electron) and OH^- (gain of one electron, often in conjunction with other chemical changes. Sulfuric acid, a strong acid, ionizes nearly completely in solution. Weaker acids like Tartaric acid are only partially ionized in solution, and the degree of 'ionization' is pH-dependent:
- Solutions of strong acids have lower pHs. Although Tartaric acid is considered a weak acid, it is significantly stronger than Malic acid, so the ratio of Tartaric to Malic acids is an important factor in determining pH in juice and wine.
- Tartaric acid is the strongest acid in wine, because it is well-dissociated at normal wine pH (3.0 to 4.0), and because of that, it's good at lowering pH by increasing the levels of H^+ ions in solution. Malic acid is next in strength, but significantly weaker (much less ionized at normal wine pH than Tartaric acid.

- Tartaric acid is about 50% dissociated at pH 3.0, nearly 70% dissociated at pH 3.65, and all but fully dissociated at pH 4.25. See the tables below depicting pH and ionization of acids in juice and wine.
- Malic acid is only 50% percent dissociated at pH 3.4, and nearly fully dissociated at pH 5.2.



The figure above demonstrates the degree of ionization of Malic compared to that of Tartaric acid in relation to the pH of the solution. Malic acid is 50% at pH 3.4, by comparison Tartaric acid is 50% dissociated at pH of ~3, so it is a stronger acid. The pKa of an acid is the pH value when 50% of the acid is disassociated or ionized. The red line indicates the ration of Bimalate or Bitartrate ions, respectively, and the yellow line indicate the Malate or Tartrate ions relative to pH (discussed below).

- Malic acid tastes more sour than Tartaric acid. The reason is that un-dissociated acids taste tarter than those that are more dissociated. And for that reason, Malolactic Conversion (MLC)—the consumption of Malic acid by bacteria, makes red wines taste less tart.
- Grape juice or wine with high pH typically have a high Malic to Tartaric acid ratio and potentially a big problem for winemakers. Fortunately, for us it’s not that common in Northern California.
- Grapes grown in cooler climates or seasons have <u>higher</u> overall acidity, and higher Malic acid levels, than those grown in warmer climates and seasons. This can make adjusting pH and/or TA to a suitable range, challenging.
- MLC is usually desirable, particularly because it converts Malic acid to Lactic acid (a weaker, less tart acid). In this manner, the wine’s acidity is reduced: TA goes down and pH goes up. This is particularly desirable for reds, but not for most whites and rosés where higher acidity is more suitable.
- Acidity is determined by grape variety, ripeness when picked, where they are grown, climate, soil characteristics, viticultural practices, yield, etc. For example, grapes grown in soils rich in potassium tend to have lower TAs and higher pHs.
- Grapes grown in cooler areas or harvested early, tend to have lower pH values and higher TA values. Grapes harvested with high Brix° tend to have higher pH values and lower TA values.

- Warm, sunny days elevate sugar production sugar production, enhance color, flavor, and tannin development, while lowering acid levels in grapes. Direct exposure of the grapes to sunlight increases berry temperature, and chemical reactions. Grapes exposed to sunlight may be 10 to 15 °F higher than shaded grapes. Acid levels in fully exposed clusters are lower than those within the canopy. Hence, sunlight and berry temperature largely determine the quality of wine grapes.
- Making a balanced and stable wine is largely dependent on grape ripeness, and acidity (pH and TA). So, submitting a juice sample to a wine lab for analysis will provide vital information to determine if adjustments are warranted. Otherwise, the wine may not meet your expectations.
- Samples taken just after crushing may give misleading test results because acidity will decrease as Potassium ions leach from the skins and combine with Bitartrate ions in the juice, resulting in the loss of Tartaric acid. Consequently, TA is lower than you may think and higher pH.
- When making white and rosé wines, take samples after the juice has been allowed to settle.
- Collect samples from red grapes after they have been crushed, chilled, and allowed to soak for 12 to 24 hours. Most of the Potassium ions in the skins, will have leached out into the juice, after a day or two of skin contact.
- Grape acidity is not always ideal or balanced, so you should measure both pH and TA, and adjust as needed.
- Ideally, adjustments should be made before fermentation.
- Monitor changes in acidity after fermentation, MLC, and cold-stabilization, and make further minor adjustments as needed.
- Bear in mind, that pH goes up and TA comes down during cold-soak (skin contact (maceration), fermentation, MLC, and cold-stabilization.
- Keeping pH and TA within an acceptable range ensures that a wine is neither too tart nor too flat, and that the wine will likely be stable.

Favorable acidity range for white grapes/wine:

  - **Grapes**: TA 5 to 9 g/L, pH of 3.1 to 3.4
  - **Wines**: TA 6 to 7 g/L, pH of 3.3 to 3.5

Favorable acidity range for red grapes/wine:

  - **Grapes:** TA of 5 to 8 g/L, pH 3.3 to 3.5
  - **Wines:** TA of 6 to 7 g/L., pH 3.5 to 3.75

TA and is importance:

- TA is responsible for how tart grape juice or wine tastes. The higher the TA, the tarter it is. pH can do so as well, but to a lesser extent.
- Juice or wine with low TA values taste flat and uninteresting. Those with values at the high-end, taste tart.

- Excessive acidity in reds accentuates astringency, and bitterness. But that's something you can usually fix or prevent.

What makes pH so freaking important?

- If you recall, pH is a measure the concentration of H^+ ions in grape juice or wine. It has less to do with the sensation of acidity, than the concentration of acids. Thus, a low pH wine will taste tart owing to a high concentration of acids. By comparison, a high pH wine taste flat due to its low concentration of acids.
- pH influences wine chemistry, and in the ideal range, inhibits harmful microorganisms that can cause spoilage, and prevents oxidation. TA has no bearing on those traits.
- pH also influences the relative levels (equilibrium) of Tartaric acid and its two ions Biatartrate and Tartrate in grape juice and wine, as well as the formation and precipitation of Tartrate salts during fermentation, and later during cold-stabilization.
- Furthermore, pH influences how Potassium Metabisulfite dissociates in juice and wine. Between the pH range of wine from 3 to 4, there is a change 10-fold decrease in the concentration of molecular SO_2, which is a critical antimicrobial agent. Thus, low pH wines need <u>less</u> free SO_2. The molecular form is a powerful antimicrobial agent. My point here is that the molecular form decreases as pH increases.
- At normal wine pH (3.0 to 4.0), Bisulfite (HSO_3^-) ions predominate. There is a small amount of molecular SO_2 (gas in solution), and an even a smaller amount of Sulfite (SO_3^{2-}) ions.
    - Although Bisulfite ions do <u>not</u> prevent oxidation, they do bind with acetaldehyde (the precursor of acetic acid) that forms when alcohol in wine is exposed to air.
    - SO_3^{2-} usually exists in minute amounts, but is important because it deactivates enzymes that cause browning, and removes free-oxygen (O_2) from wine.
- More to the point, pH plays a critical role in wine stability by determining the amount (ppm) of free-SO_2 needed to keep a wine from oxidizing or undergoing bacterial spoilage. The higher the pH — the more free-SO_2 is needed! It does this by influencing how much molecular (un-dissociated) SO_2 gas is dissolved in the juice or wine. The lower the pH, the greater the level of free (molecular) SO_2 gas dissolved in juice or wine
- Wines made from grapes with moderately low pH will taste fresher and fruitier, and the color will be better than if the pH was significantly higher. The favorable range is 3.3 to 3.5 for red wines, and 3.2 to 3.3 for whites and rosés.
- Grape juice or wine with a TA, of let's say 6 (a little low), and a pH of 3.5, will taste more acidic (tarter) than one with the same TA, but a higher pH.
- White wines above pH 3.5 and red wines above pH 3.85 are inherently unstable.
- **Key concept:** the starting pH of juice or wine influences how pH changes (goes up or down) as acid adjustments are made. If pH, when Tartaric Acid is added, is 3.65 or less, pH will <u>drop</u>. If, however, pH is greater than 3 65, pH will rise—damn! I know that just doesn't make sense, but that's how it works. It has to do

with the formation of Tartrates (Potassium Bitartrate). Below 3.65, H^+ ions are released, so pH goes down. Above 3.65 H^+ ions are lost (neutralized), so pH goes up. For more details see **How pH influences acidity** below.

Testing for pH:

- Testing lets you know if juice/wine acidity is within a reasonable range to make a balanced wine. Of course, the style of wine must be taken into consideration.
- Use an accurate pH-meter—one that measures pH to the second decimal place.
- You may find it more convenient, however, to submit a juice sample to one of the local wine labs to provide the important information.
- Frequent calibration using pH standard-solutions (Fermenter's Warehouse) is important for accuracy.
- For greater accuracy, collect juice samples just prior to yeast inoculation (whites and roses) and 1 to 2 days after crushing for reds. This allows Potassium ions in grape skins to leach into the juice, raising pH. Most of the Potassium in red grapes is leached from the skins after a day or two of skin contact (cold-soak).
- When acidity is either too <u>high</u> (low pH and high TA), or <u>too</u> low (high pH and low TA), adjust acidity to ensure balance and stability.
- Adjusting pH of red grapes to 3.5 or a bit less, before fermentation, will make for a better wine, and prevent pH from exceeding 3.8 by the end MLC (Malolactic conversion).
- The pH for whites should be less than 3.4 before fermentation.

Potassium and its role:

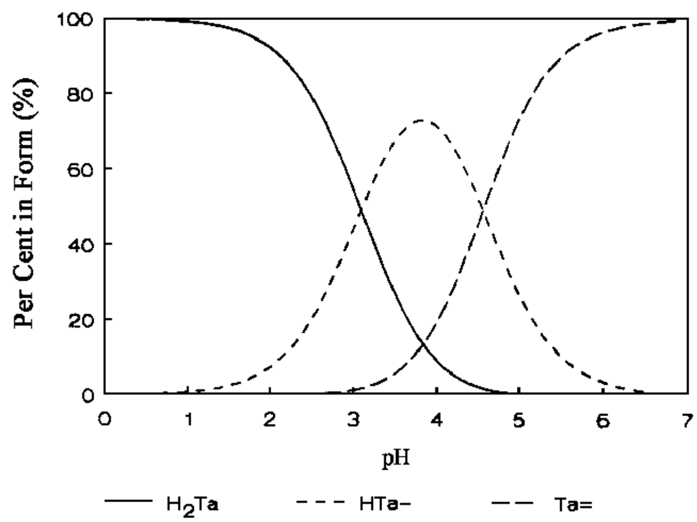
- Potassium (K^+ ions) in the soil are transported from the roots to the grapes, and exchanged for H^+ ions.
- The more Potassium available to the vine, the higher the pH, due to a lower concentration of H^+ ions in the grapes.
- Potassium uptake is greater in shaded fruit, and in warmer areas. It's also higher when there is heavy rainfall near harvest.
- Potassium affects acid additions to juice and wine. When Tartaric acid is added, some binds with Potassium ions in solution to form Potassium Bitartrate (KHTa). When KHTa reaches saturation, it begins to precipitate out of the juice/wine. This process, largely occurs during fermentation and cold-stabilization, essentially removing Tartrate salts, otherwise they are likely to form in the bottle. When KHTa precipitation is at its peak at pH3.65. pH goes **down** when the existing pH is 3.65 or less, but goes **up** when pH is greater than 3.65.
- The overall effect of acid addition may change during aging as KHTa precipitates in cold cellars over the winter. It's likely some of the Tartaric acid you may have added during adjustment will precipitate and TA will decrease. So, in some cases, you may need to add more acid to reach your target. Once the available Potassium has been removed from solution, acidity will become more <u>stable</u>.

Key points:

- Simply put: pH is a way to express the concentration of free or dissociated H^+ ion in a solution. The lower the pH, the greater the concentration, and the higher the pH, the lower the concentration pH and TA are interrelated. You can't change one without affecting the other.
- How pH changes with respect to TA is not always predictable, but depends on the pH of the juice, must or wine at the time an acid adjustment is made.
- The same TA can be measured in different juice samples with either low or high pH.
- What's important is that pH determines the level of free SO_2 required to prevent oxidation and protect a wine from microbial spoilage. It also influences the extraction of pigments and some aroma and flavor components. Furthermore, pH influences the relative levels (equilibrium) of Tartaric acid and its two ions in grape juice and wine, as well as the formation and precipitation of Tartrate salts during fermentation, and later during cold-stabilization (see **Acids and pKa values** below.
- Generally, the higher the Brix, the lower the acidity (higher pH and lower TA. Unless adjusted, the wine will taste flat, be more susceptible to bacterial spoilage, and will have a shorter shelf-life.
- Very ripe red grapes range from pH 3.7 to 4.0, occasionally higher.
- It can be very challenging to adjust pH adequately without causing the TA to increase precipitously. Thankfully, that doesn't happen much Northern California if it does happen, priority should be given to adjusting pH, particularly with red musts. TA will generally take care of itself in time (see: **Problem grapes** below).
- At the very least, try and get the pH of the must in the recommended range before fermentation.
- pH adjustment **before** fermentation is done to ensure wine stability, and improve aroma, taste, and color.
- Small acid corrections (around 1 g/L) can be made after fermentation or MLC.
- Acidity naturally decreases during the winemaking process.
- The upper limit of pH for red grapes prior to fermentation should be 3.5, so the finished wine will not exceed pH 3.8. Ideally, TA should be <7.5.
- pH generally increases about 0.2 pH units by the end of cold soak, fermentation, MLC, and cold-stabilization.
- The ideal pH range for many finished lighter reds is about 3.5 to 3.6. For big reds, pH should be less than closer to 3.65.
- After MLC (reds), pH should be less than 3.65. This will ensure rapid tartrate precipitation, resulting in a slight lowering of pH, rather than an increase.
- Minor pH adjustments can be made later, as finished red wines like Cab, Merlot, Syrah, Petite Sirah, Tempranillo, etc., often taste better when pH is closer to 3.7. High pH reds (>3.85) may taste good, but are relatively short-lived.
- Lower pH wines taste better when the TA is a bit lower, and higher pH wines taste better when the TA is a bit higher.
- Although, high pH wines tend to taste fine when TA is high, but are still unstable.
- Trust your palate when it comes to the determining the right acidity level.

pH and ionization of acids in juice and wine:

- Tartaric acid has two acid (-COOH) groups, each of which can lose a hydrogen ion (H^+) in solution, depending on current pH. For this reason, it has 2 dissociation equilibria (**pKa's**). Stay with me here, because it's a key winemaking concept that helps make sense of acid adjustment.
- You may recall that pH is influenced by the concentration of acids in solution. The pKa of an acid is the pH value (determined by using a pH meter) at which **50%** of the acid is disassociated or ionized. Chemists use this concept to indicate an acid's strength. Thus, an acid's pKa value(s) is the degree to which it ionizes at a specific pH. Some acids have only one pKa value, while others have two, or more. The higher the pKa of an acid, the less ionized it is at typical wine pH values—3.0 to 4.0. Tartaric acid has 2 pKa equilibria values, the first occurs at about pH **3.0**, and second at about pH **4.25**.



- Dissociation and equilibrium reactions of acids are often simplified and generalized in the form **of HA → H^+ + A^-**, where HA represents an acid, H+, the Hydrogen ion or **cation**, and **A^-**, the '**anion** or conjugate base. In the equation below, Tartaric acid has the following dissociation equilibria:

H_2Ta (Tartaric acid*) ↔ **H^+ + HTa** (Bitartrate) ↔ **$2H^+$ + Ta^2** (Tartrate)
* Simplified formula for Tartaric acid

*The double-pointed (↔) arrows in the equilibrium equation above, indicate the reaction can move left or right, depending on pH.

Equation 1. The first pKa occurs at about pH **3.0.**
H_2Ta → **H^+ + HTa^-** ↓ (Bitartrate ions)

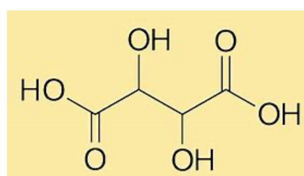
The Bitartrate curve (blue line in the '**Dissociation curves'** graph below) peaks at 3.65, and is rather low at pH 4.0. From about 3.4 to about 3.65 Bitartrate ions are most abundant. Note that in above reaction, 1 H+ ion is released into the solution, making it more acid (lower pH). OK, you're getting it. The downward-pointed arrow indicates that Bitartrate ions combine with Potassium ions in wine or juice, forming Potassium Bitartrate, an insoluble salt that precipitates out of solution. As Bitartrate ions precipitate out of solution, the reaction shifts left to replenish them. In doing so, more H+ ions are released into solution, lowering pH.

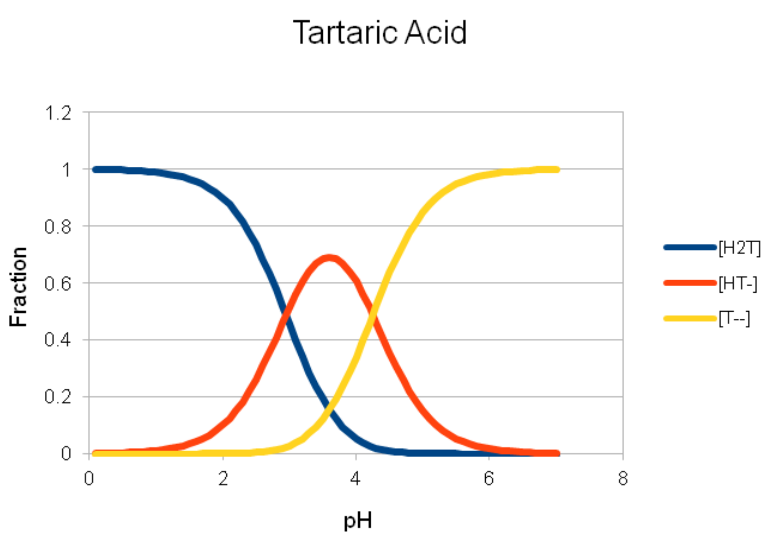
Equation 2. The second pKa occurs at pH **4.25**. The numbers of Tartrate and Bitartrate ions are about equal at pH 4.25, but Tartrate ions quickly predominate as pH above 3.65 increases.

H+ HTa^{-}↓ ← **$2H^{+}$ + Ta^{2-}** (Tartrate ions)

Above pH 3.65 the concentration of Bitartrate ions begin to decline and Tartrate ions begin to increase. The downward-pointed arrow indicates that as Bitartrate ions combine with Potassium ions in wine or juice, forming Potassium Bitartrate, an insoluble salt precipitates out of solution. As Bitartrate ions precipitate out of solution, the reaction shifts right to replenish them. But in doing so, H+ ions are removed from the solution, raising pH.

* For simplicity, Tartaric acid is represented as either **H_2Ta or H_2T**. The actual formula for Tartaric acid is more complex:





A dissociation curves showing the relative proportion of Tartaric acid and its 2 ions (Bitratrate and Tartrate) as pH increases. Dale Ims. The blue line represents un-ionized

Tartaric acid, the red: Bitartrate, and the yellow: Tartrate. Note: HT used here is the same as HTa, HT- is the same as HTa^- (Bitartrate) and T^{--} is the same as Ta^{-2} (Tartrate ion).

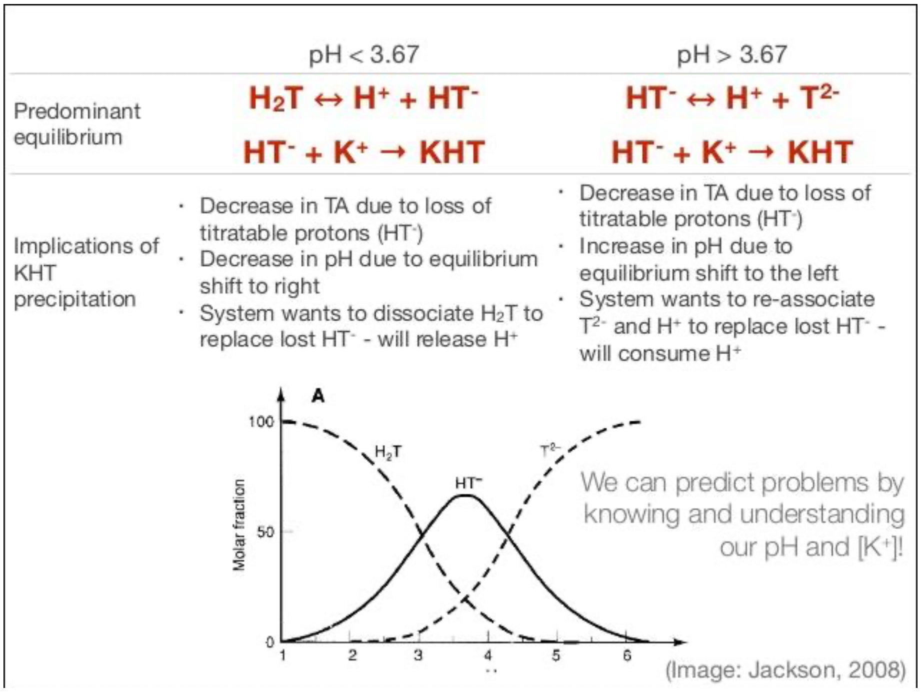
The figure above shows that the first pKa for Tartaric acid occurs where the red and blue lines intersect —around pH 3.0. The ratio of un-ionized Tartaric acid (**H_2Ta**) to Bitartrate ions (**HTa^-**) is 50:50. Maximum Bitartrate concentration occurs midway between pKa of 3.0 and 4.25. The Bitartrate fraction peaks at about 70% at pH **3.65**, thereafter it declines. The second pKa occurs at 4.25, where the red and yellow lines intersect. At this point, the ratio of ions of HTa^- (Bitartrate ions to **Ta^{2-}** (Tartrate) ions is 50:50. At pH 7.0, the acid is fully ionized and only Tartrate ions are present. Note also that when pH is close to 4, there is very little Tartaric acid in solution.

Notice that between pH 1 and 2, Tartaric acid exists primarily in the un-ionized (**H_2Ta**) state in solution, but between pH 3.0 and 3.65, the two pKa values, Bitartrate predominates. At pH levels much above the second pKa at pH 4.25, most of the acid is in the 'Tartrate' state (**TA^{2-}**). Thus, at typical wine pH levels (about 3.4 to 3.7) most of the Tartaric acid is in the Bitrate form, but there is some un-ionized Tartaric acid (**H_2Ta**) and Tartrate ions (**Ta^{-2}**) present. The level of **HTa^-** (Bitartrate ion) and the un-ionized Tartaric acid are about the same at pH 3.0. while the levels of **HTa^-** and **Ta^{2-}** are about equal at pH 4.25.

The point of all this is that pH 3.65 is of great important consideration when making acid adjustments. This has a major influence on how to fix problem grapes with both high pH and high TA.

So, what's the big deal?

- When Tartaric Acid ionizes, Bitartrate ions are released. Some of which bind with K^+ (potassium ions), forming **Potassium Bitartrate** crystals that settle (precipitate) out of solution. This removes acid from the wine—generally a good thing.
- The higher the concentration of Bitartrate ions, the greater the effect. Peak concentration of Bitartrate is at pH 3.65 or there about (the image below uses 3.67), but it quickly drops as pH increases. This is the 'Great Divide,' so to speak.



How precipitation of Potassium Bitartrate influences acidity:

- It always lowers TA, but how pH ultimately changes will depend on whether pH is lowered to pH 3.65 or less.
- The higher the concentration of Bitartrate ions, the greater the reaction, and the peak concentration of Bitartrate is at pH 3.65.
- When pH is less than 3.65, pH goes down, typically advantageous! That's because the reaction shifts to the right (red arrow, below) to maintain equilibrium. Note that one H^+ is released into solution, decreasing pH.

H_2Ta (tartaric acid) → HTa^- (Bitartrate ion) + H^+ + K^+ (in solution) ↔ **KHTa ↓ (Potassium Bitartrate) + H^+**

- When pH is greater than 3.65, precipitation of Potassium Bitartrate still occurs, but proceeds more slowly. What's weird, though, is that pH increases. Why is that? At high pH, most of the existing ions in solution exist as (**Ta^-**) Tartrate, so precipitation of KHTa shifts the equilibrium reaction **left** to replenish the HTa- lost to precipitation. This increases pH by neutralizing $1H^+$.

$HTa^{-} + H^+$ ← $Ta^{2-} + 2H^+$ (a net loss of 1H+)

Acidification (lowering pH and raising TA):

- Acid adjustment should be done as early in the winemaking process as possible, preferably before fermentation.

- Minor adjustments (less than 1 g/L) can be done after primary fermentation or MLC, however, it may result in tartrate instability if cold-stabilization has already occurred.
- Lower pH wines are generally brighter, crisper, lighter in body, and drier to the taste. Sweetness decreases acidity on the palate, for example Italian Proseccos. By comparison, higher pH wines are softer, smoother, but sometimes a bit flat. Wines like Riesling, Gewurztraminer, Sauvignon Blanc, Albariño, and other light-bodied whites, tend to have higher acidity than other varieties. For red wines, a final pH of 3.7 or 3.8 is OK. It really depends on the grape variety, and your preferences. It's a good idea to do trials to see how the wine tastes at different pH levels.
- When making acid adjustments, consider the current pH, tartness, cold-stability, and microbial stability of the juice or wine.
- The standard treatment to acidify high pH and low TA juice or wine is to add g of **Tartaric acid.** For each 3.8 g of tartaric acid, TA will increase by 1g/gal and pH will drop by roughly 0.1 unit, occasionally more. It's seldom a 'one-to-one' reaction. TA goes up because acidity is increased., and pH decreases because there is more H+ in solution. pH, however may not go down as much as anticipated because high levels of potassium and or Malic acid resist pH change (buffering).
- When pH and TA are both high, it can be challenging to lower the pH sufficiently without driving pH up even higher. Faced with this problem, what do you do? Throw up their hands and admit defeat? No, may be a fix. Yes, the solution seems counter-intuitive, but your best bet is to continue to add acid until the pH drops to 3.65 or less. Remember much of the excess TA will precipitate as Potassium Bitartrate, particularly during fermentation and cold-stabilization.
- When adjusting red must, consider that 60 to 70% of it is juice, when calculating how much Tartaric acid to add.
- For wines with <u>low</u> **TA** and <u>high</u> **pH,** simply add **Tartaric acid**. TA will increase, and pH may go down as well, but sometimes less than desired.
- When adjusting **pH** or **TA**, change may be unpredictable when pH is much greater than 3.8.
- The addition of a given amount of acid may **not** reduce the pH as much as you want, particularly when TA and/or pH is unusually high, due to the wine's high buffering capacity (discussed later).
- When buffer capacity is high, a larger addition is usually needed to get the change in pH you want.
- Juice or wines above about a **TA** of 9 g/L are more likely to resist pH change.
- Do bench trials to see if you can lower pH the desired level. Acid adjustments made close to bottling can create tartrate instability.
- To avoid excess acidification, make Tartaric acid additions incrementally. After each addition, mix thoroughly, and allow it to stand for an hour or more before testing Always taste it to see how it changed. Determine if more acid is likely to improve or diminish taste.
- **Bench trials**: You can also do bench trials to determine how much Tartaric to add by preparing a 10% solution (10g Tartaric acid in 100 mL of distilled water.

Set up 3 to 4 glasses, each containing 100mL of juice. Reserve one glass for a control. Mark the glass in numerical order and 'C' for control. Depending on acidity, add 1, 2, and 3 ml, if needed, of the 10% Tartaric acid solution to the glasses, and then taste and measure the TA and or pH change. The amount of the 10% solution used is equivalent to the g/L (grams per liter) of acid needed to make the best adjustment. This is because one mL of the solution equals one.

- Rely on your palate when adjusting acidity. If a wine tastes fine after making a partial addition, more is unlikely to improve the results. If you like the taste, you're done.
- Grams of acid /liter. By using a 10% solution, testing is a quick way to determine how much acid is necessary to balance your juice.

Some consideration for acidification:

- Tartaric acid, when added to juice or wine, dissociates primarily into negatively charged Bitartrate ions (**HTa^-**), and some negatively charged Tartrate ions (**Ta^{2-}**), as well as positively charged **H^+** ions, depending on the pH of the juice or wine.
- The relative amount of Tartaric acid and its ions (Bitartrate (HTa^-) and Tartrate (**Ta^{2-}**), are in **equilibrium**—a dynamic process that seeks to correct an imbalance when a change occurs, such as the formation and precipitation of Potassium Bitartrate.
- The **dissociation equilibrium** for Tartaric acid is depicted for reference below:

$$\mathbf{H_2Ta}\text{ (Tartaric acid*) } \longleftrightarrow \mathbf{H^+ + HTa}\text{ (Bitartrate) } \longleftrightarrow \mathbf{2H^+ + Ta^2}\text{ (Tartrate)}$$

- If you **add** or **remove** acid, equilibrium in the solution will change and the reaction will shift either right or left, as KHTa precipitates. The direction, however, depends on whether **pH** is above or below 3.65, which determines the relative proportions of **HTa^-** to **Ta^{2-}** Remember that at pH 3.65, HTa^- is at its peak, but above pH 3.65, the proportion of **Ta^{2-}** to **HTa^-** increases rapidly.

Resistance to pH change (Buffer capacity)—a complicating factor:

- Difficulties arise when both **TA** and **pH** are either low or high. This is relatively rare in Northern California. If it does occur, it's best to seek professional advice.
- Adjusting acidity can get sticky when both TA and pH are high (TA >10g/L, (pH >3.65). The issue is caused by **buffering**—the resistance to pH change. Adding Tartaric acid is unlikely to reduce pH enough, without causing the TA to skyrocket
- A wine's resistance to pH change, known as **buffer capacity**, is associated with high TA and high pH values. Elevated Potassium levels also play a major role. Potassium (K^+) ions in solution from salts such as Potassium Bitartrate, as well as Bitartrate ions (HTa-) ions. The effect is to remove H^+ from solution, causing pH to go up when existing pH is high.
- High levels of salts in solution interfere with lowering pH to a desired, or expected level. The addition of Tartaric acid effectively reduces TA, but without a comparable change in pH.

- For wines with high **pH** and low **TA**, (high buffering capacity), adding acid will increase TA to a desired value, while pH remains high. Although, it may seem counter-intuitive, the **solution** is to continue adding Tartaric acid until the **pH** is closer to 3.65. This may cause the **TA** to become excessive, but as **pH** nears 3.65, the ratio of Bitartrate to Tartrate ions increases. Because more Bitartrate ions are available, the formation of Potassium Bitartrate (KHTa) lowers **TA.** But in the process, H+ ions are released into the juice/wine, lowering pH as well. Yes!
- If you **don't** add enough acid to get the pH down to 3.65, pH will go up and TA will remain too high—not what you had in mind. It does works! Another reason why you need to have an accurate pH meter, and to calibrate it before use.
- Why it works: once you reach a pH of 3.65 or less, **TA** will begin to drop to an acceptable level as the KHTa precipitates out of solution, some immediately and some later during fermentation and cold-stabilization. The reason is that the maximum availability of Bitartrate ions is at pH 3.65. Above 3.65 availability drops precipitously.

Deacidification (raising pH and lowering TA):

- High acidity grape juice and wine are those with **low pH** and **high TA**, and unless both are properly adjusted, the finished wine will be imbalanced. Bear in mind that acidity will drop somewhat 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. This is where having a basic understanding of wine chemistry is helpful.
- If TA is above 10—not likely, consult a wine lab e.g., ETS Wine Lab, Home Wine Lab, Gusmer, or Scott Labs, etc., for advice. You may have an excess of Malic acid. The treatment is beyond the scope of this handbook.
- The worst-case scenario: is very low pH and very high TA, complicated by high Potassium levels (rare in California).
- **Deacidification** is commonly done by adding **Potassium Bicarbonate** ($KHCO_3$) or **Potassium Carbonate** (K_2CO_3), both are commonly used to 'deacidify' grape juice or wine with high TA, and low pH. Both will remove Tartaric acid and lower overall acidity (TA↓ and pH↑).
- How it works: The **Carbonate** ion (CO_3^{2-}) reacts with H^+ ions in the juice/wine, forming **Bicarbonate** ions (HCO_3^-), which in turn reacts to form Carbonic acid (H_2CO_3), which quickly breaks down to Carbon Dioxide (bubbles) and water (H_2O). It is the formation of water that results in the neutralization of 2 H^+ ions from the solution. So, pH goes up, as you would expect.
- Next, Potassium ions from the addition of $KHCO_3$ begins to bind with **HTa^-** in the juice/wine forming KHTa. As it precipitates out of solution, **TA** begins to drop.
    - If pH is <3.65, when precipitation begins. As the reaction proceeds and uses up available HTa^-, equilibrium shifts right: ($\mathbf{H_2Ta \rightarrow H^+ + HTa^-}$. Note that the reaction releases 1 H^+ ion into solution, causing the pH to decline.
    - If pH is >3.65, the loss of HTa^- shifts equilibrium to the left to produce more HTa- but consumes H^+ when doing so. $\mathbf{HTa^- + H^+ \leftarrow Ta^{2-} + 2H^+}$ This neutralizes one of the 2 H^+ ions, therefore pH goes down.

- The schematic chemical reaction for adding Potassium Bicarbonate to juice or wine is:

  $KHCO_3$ + H_2Ta → $KHTa$↓ + H_2CO_3 → CO_3^{-2} H^+ → HCO_3^- + H^+ → H_2CO_3 → CO_2 (bubbles) + **H_2O** (2 H^+ are neutralized, so pH goes up)

- **Dosage:** to lower TA by about 1g/L or 0.1%, add 3.4 g/gal of Potassium Bicarbonate (the preferred material for home winemakers), or Potassium Carbonate at the rate of 3.55 g/gal when pH is above 3.45, but 1.75g/gal when pH is below 3.45). Reference: Enartis (Vinquiry).
- An online calculator: Winemaker.Plus - Winemaker.Plus https://winemaker.plus/deacidification or www.winebusiness.com/calculator/ Rule of thumb: pH can go up to 0.2 pH units for each 1g/L drop of TA.
- Add $KHCO_3$ directly to the juice or wine, or dilute with a little water, and stir to disperse it throughout the container after it's added. Wait for about 15 to 20 minutes to test or taste the results.
- How pH changes will depend on the wine's buffering capacity, acid concentration (TA) and the Tartaric to Malic acid-ratio, as well as the Potassium level of the juice or wine. However, if a wine has a TA in the range 8–10 g/L, then a general rule of thumb is that 3.4 g/gal of $KHCO_3$ will reduce TA by 1 g/L.
- It's best to add the $KHCO_3$ gradually, say one third the calculated amount, and then see how the juice/wine responds. In this manner, you're less likely to overshoot your target. By the way, check your math several times.
- Calcium carbonate also works to lower acidity, but won't cause Bitartrate ions to precipitate. **Ca^{2-}** ions bind with **Ta^{2-}** ions instead. The precipitate does not remove Malic acid, because **CaMa** is soluble. **CaTa**, as you would expect, reduces TA, and pH goes up because there is no release of H+ ion. Recommended for large acid adjustments of 2g/L and higher (TA above 9 g/L). The addition of .62g/L of calcium carbonate theoretically will yield a reduction in TA of 1 g/L.

$$H_2Ta + CaCO_3 \rightarrow CaTa(\downarrow) + H_2CO_3 \rightarrow CO_2(\uparrow) + H_2O \text{ (TA}\downarrow\text{, pH}\uparrow\text{)}$$

- Downside: CaTa crystals are slow to form and may take two months or longer to precipitate.

Natural changes in pH during winemaking:

- Acidity changes during the winemaking as Bitartrate ions combine with Potassium ions and precipitate out of solution, lowering TA. The change in pH will depend on the pH of the solution.
- Acidity change in reds is greater than that for whites, because more Potassium ions are extracted from prolonged skin contact during and fermentation.
- pH may go up.0.1 to 0.2 units during skin-contact, but no change in TA.
- pH may go up 0.1 unit during fermentation. TA decreases about 1 g/L during fermentation

- MLC deacidifies wine by converting Malic acid with to Lactic acid with only one proton ion to donate. TA will decrease by about 1 g/L and pH increases by about 0.2 units.
- Slight reduction in pH during cold-stabilization, and further decline in TA.

Problem grapes—When things don't measure up:

- Over-ripe grapes are more likely to have **high** pHs and **lower** TAs. Cool growing seasons can produce high pHs—close to 4 and above. The culprit may be high Malic acid content. This condition is relatively rare in California. Seek technical advice for adjusting high pH and high TA grapes.

The four acidity conditions in grape-juice/wine:

- **Low**: low TA <6g/L, and high pH >3.5. mostly hot regions, and very ripe grapes.
- **Moderate**: TA 6-9g/L, and pH 3.0-3.5. For many finished red wines, a pH of up to 3.8 is stable.
- **High**: high TA >9g/L, and low pH <3.0. Cool areas and seasons.
- **Problematic**: high TA >9g/L, and high pH >3.5. Can be hard to adjust by adding or removing acid. Often the result of high Malic acid—relatively rare in California. It may be the result of excess Potassium ions. Such wines may resist adjustment and you may need to seek technical advice: ETS Wine Lab, Home Wine Lab, Gusmer, or Scott Labs, etc. TA greater than 10.5 is usually the result of too much Malic acid.

Managing the common acid conditions in grape juice or wine:

Adjusting pH and TA in wines—Source: Vinmetrica

	TA g/L→	≤5	6-9	>10
pH↓	<2.9	low pH/TA (**trouble***)	deacidify	reduce acidity a lot
	2.9-3.4	add acid	OK	reduce acidity
	3.4 -3.9	add acid	OK	reduce acidity
	≥4.0	adds lots of acid	acidify	high pH/TA (**trouble***)

***Trouble:** Difficulties are encountered when adjusting high pH/high TA or low pH/low TA (the latter is rare) wines. Adding acid or carbonates, typically don't work.**

Another look at adjusting acidity:

	Must/Juice Acidity		**Treatment**	**Result**	
Acidity	**pH**	**TA**		**pH**	**TA**
Low	High (>3.5)	Low (<6g/L)	Tartaric acid, cold-stabilization	↓	↑

Mod. to high	Low (<3.0-3.5)	High (6 -9g/L)	Potassium Bicarbonate (chill to ppt. KHTa)	↕	↓
	Low (but <3.5)	High (>9g/L)	Potassium Bicarbonate (chill to ppt. KHTa)	↓	↓
	High (but >3.5)	High (>9g/L)	Potassium Bicarbonate (chill to ppt. KHTa)	↕	↓

Some useful considerations:

- You should be able to taste when the acid is too low or too high, but testing will provide you with the actual level of acidity.
- Typically, there is an inverse relationship between pH and TA: lower pHs indicate higher TAs, and vice versa. However, the two do not track in a predictable way, and unfortunately there are times when both pH and TA are high in grape juice or wine.
- The amount of each, and the ratio of Tartaric to Malic acid are largely responsible for different pHs at the same TA.
- Warm nights help to metabolize (breakdown) Malic acid that contributes to high pH and TA in grapes.
- TA values above 10.5 are usually the result of excess Malic acid. MLC, though, will ultimately help to reduce pH. When Tartaric acid predominates (low Malic acid level), adjusting to a moderate TA and pH is relatively straight forward.
- A solution consisting solely of Tartaric acid has a much lower pH (higher free H+) than a Malic acid solution of the same concentration, thus, the higher the Tartrate level, the lower the pH. The higher the concentration of Malic acid in juice or wine, the higher the pH.
- Hot weather that can cause grapes to shrivel (lose water) during, can drive up TA, by concentrating the acids
- Although rare in California, high pH, compounded by high Potassium or Malic acid, is a big problem, typically requiring professional advice.
- High Potassium concentrations in juice, increase pHs at a given TA.
- When pH and TA are both high, and Potassium is low, high Malic acid is the culprit. You can test for these problems. Early budbreak and early ripening, leaves too little time for normal metabolism of Malic acid. Low soil moisture during the winter and early spring can also cause elevated Malic acid levels.
- Wine is a buffer—a solution of weak acids and their ions (conjugate-bases), as well as acid salts that form when there is plenty of Potassium available, such as Potassium Bitartrate or Potassium Bimalate (KHMa).
- High levels of salts in solution interfere with lowering pH to a desired, or expected level. The addition of Tartaric acid effectively reduces TA, but without a comparable change in pH.
- Adjusting acidity can get sticky when both TA and pH are high (TA >10g/L, (pH >3.65). Adding Tartaric acid is unlikely to reduce pH enough, without causing the **TA** to skyrocket.
- For many reds a pH of 3.7 to 3.8 is fine.

- In general, as TA increases, pH decreases, and vice versa. An old rule of thumb is that the **pH** drops 0.1 unit for every 1 g/L of tartaric acid added, but under extreme conditions ("high pH trouble" in the table above: **Adjusting pH and TA in wines** this relationship falters.
- **Potassium Bicarbonate** effectively removes excess Tartaric acid by causing Bitartrate ions in solution to form an insoluble salt (KHTa). Change in **pH** depends on the pH value when KHTa begins to precipitate.
- Maximum precipitation of KHTa during aging and cold-stabilization occurs at or below pH 3.65. **Above 3.65**, KHTA still occurs, but precipitation of KHTa removes a H+ ion from solution—**pH goes up**. However, **below 3.65**, precipitation of KHTa releases an H+ ion into solution—**pH goes down**.
- In general, pH values for red grapes should be between 3.3 to 3.5 range. For red wines pH values should range from 3.5–3.8, and the TA from about 6.0–7.0 g/L
- For white grapes, pH values should be between 3.1 to 3.3, and TA values should be somewhere between 6 to 9 g/L at harvest. The pH range for white wines is ~3.2 to 3.5, and the TA range between 6 to 7. Winemaker's will need to raise the acidity level for sparkling and dessert-style wines, or for a particular style of wine, will need to be higher.

The winemaking process (continued):

Stemming/crushing and processing red and white grapes:

- Keep grapes as cold as possible during transport.
- One way to do so, is to add 1 to 2 frozen, water-filled jugs to each of the 32-gal bins of grapes or 6 or more jugs to a macrobin during transport. Keep the grapes covered and out of the sun as much as practical.
- You can also use dry-ice, or dry-ice pellets for cooling, or store in a refrigerated room, depending on your setup.
- Warm grapes are prone to microbial spoilage and fermentation may start spontaneously. It's best to chill the grapes to slow down the fermentation. Longer, slower fermentations are thought to produce better wines.
- Dry-ice is good way to cool because it releases CO_2, displacing air and preventing oxidation.
- Stem and or crush the grapes without delay.
- Grapes can be destemmed and crushed, destemmed only (whole berries), or whole clusters can be pressed directly (whites and rosés), or fermented directly (usually reds). Yes, it does work. For whole berries, adjust the distance between the rollers to avoid crushing most grapes, or buy a de-stemmer designed for that purpose. Winemakers do this is to minimize maceration of the skins, so the resulting wine is less tannic. In this manner, fermentation occurs primarily within the grape skin (carbonic maceration), resulting in a lighter, fruiter, and less tannic wine. A good example of this is in Beaujolais wines. Additionally, fermentations take longer, resulting in better wines, depending on your objective or perspective.

Pressing whole clusters:

- To minimize stem and skin contact, clusters are loaded directly into the press for de-juicing. Commercial winemakers use this technique to make more delicate and less astringent white and rosé wines.

Sorting grapes: Take your time sorting through the grapes and discard leaves extraneous debris, inferior grapes (sunburned, moldy, mildewed, bird-pecked, under-ripe, rasined, etc.

Loading the hopper:

- Add clusters gradually to the far-end, allowing them to move forward, individually to the crushing rollers or in small groups. Avoid the common mistake of dumping a whole bucket over the rollers. That strains the motor, increase maceration, and can crush seeds in the process. Make sure to remove the stems that tend to collect at the rear continually. I use a long plastic wine-thief to sweep through to facilitate stem removal. If you use your hands, be very cautious, as the paddles are within an inch or two of your fingers. If you try to go too fast, the stems can back up and begin to wrap around the far end of the shaft and rotating paddles, straining the motor, or resulting in more bits of stem in the must. If the motor sounds like it's laboring, switch it off immediately. And before you try to clear the tangled stems. unplug the motor! You may have to remove the screen under and paddles to disentangle the mess before you can return to crushing.

Collecting crushed grapes:

- you can collect the grapes as they are crushed and destemmed in 20-, 32- or 44-gal. size, food-grade plastic bins. Bins, when secured to special dollies, can wheeled under and away from the stemmer/crusher quickly. Punch-downs during red grape fermentations are relatively easy and the bins can easily be covered to exclude fruit flies. The solid plastic lids don't provide a good seal against fruit flies, so you can use old beach towels to exclude fruit-flies and allow CO_2 and water vapor to escape.
- Various winemaking additives such as SO_2, enzymes, fermentation tannins, etc., can easily be added and mixed during skin contact.
- Another consideration is that they can be moved around the work area as needed.
- Four 32-gal food-grade plastic bins will handle about 1000 lbs of fruit.
- Crushed grapes can also be transferred to variable-capacity tanks (reds).
- Another option for red grapes is to place stemmer/crusher directly above a macrobin, suspended on a platform of 2 x 4 studs, spanning the sides of bin. Bear in mind, though, the consequences of hasty construction and poor design. I cringe at the thought of the crusher sinking slowly into the murky liquid. That kind of thing can ruin your day. And think of the ridicule you'll have to tolerate from your spouse and friends, who watched, mesmerized as the event unfolded. Just a thought ...

- Add SO_2 to the must in the holding or fermenting container(s) immediately after crushing. (See: SO_2: Pre-fermentation addition below).

Skin contact (maceration) for grapes (white and rosé wines):

- Limited skin-contact (2 to 8 hours) is thought to enhance varietal character of white and rosé wines, but more than that is likely to increase harshness, astringency, and bitterness, and may result in slight browning.
- Skin contact is more applicable for aromatic white grape varieties: Gewürztraminer, Riesling, Muscat, Viognier, Chenin Blanc, Sauvignon Blanc
- In general, allow an hour or two of contact for a fresh, fruity wine with varietal character. Four hours is probably the max for home winemakers.
- Green or herbaceous notes may result if the grapes are not fully ripe.
- Chardonnay does not seem to benefit much from skin contact.
- French-style rosés with just a blush of color are usually pressed within an hour or less after destemming and crushing.
- If you are interested in the more traditional Provençal-style of rosés, which are very pale—from onion skin to light salmon to a lovely light pink 'blush', press within an hour of crushing. You can also try pressing whole clusters for the faintest, hint of pink. The yield is significantly less, but you get very little color, if that's your objective. Hopefully, you can use the skins which still contain juice in another red wine fermentation. The extra skin will provide greater extract.
- Skin contact increases the likelihood of microbes on the skins getting a start in the wine, so adequate SO_2 is critical.
- For best results, keep the must chilled (under 50°F) during skin-contact. To prevent oxidation of the must during skin-contact, blanket it with argon or use dry ice pellets (they release CO_2 gas), then cover the fermenter with a tight-fitting lid.
- Red pigments in grapes like Pinot Gris and Gewürztraminer may bleed a little, imparting a pinkish or bronzy color to the wine.
- Another consideration is that skin-contact results in the extraction of potassium ions which increases wine pH.
- Pectolytic enzymes used to enhance aromas and aid in clarification will speed up the effects of skin contact. They need at least 2 to 3 hours to have much of an affect.
- A **clarifying enzyme** like RS(P) can be used after pressing to speed settling and increase juice yield. (See: **Enzymes** below)

SO_2: Pre-fermentation addition (both red and white grapes):

- The standard SO_2 addition is 50 ppm added immediately after crushing to minimize microbial problems and oxidative browning.
- Even though grape-must contains skins and seeds, which will be removed during pressing, calculate the addition on the basis of total volume (gal) of must for both red and white grapes. This will ensure you add enough SO_2 to protect the juice/ wine before, and during fermentation, become some will bind with the skins and other grape components. You should be able to estimate the volume in your

fermenters, for example, a 32-gal food-grade plastic bin holds about 25 gal of must when filled to the top of the inner ring where it flairs out a bit.

- You could use as little as 35 ppm if the grapes are in good condition and relatively cold. Higher SO_2 levels up to 60ppm are recommended for warm grapes and those with bird damage and rot. Levels much above 50 ppm at fermentation are likely to inhibit Malolactic Conversion (MLC), see **MLC** below).
- If the intent is to make a fresh, fruity, and crisp white, you can add up to 75 ppm SO_2 to effectively inhibit MLC
- Add the SO_2 and vigorously stir to disperse it throughout the must or juice.
- The standard 10% (5.7%) PMBS solution will add the following ppm for each 5 gal of must:
    - 10.0 mL adds ~30 ppm
    - 11.6 mL adds ~35 ppm
    - 13.4 mL adds ~40 ppm
    - 16.5 mL adds ~50 ppm
    - 25.0 mL adds ~75 ppm
- To add 50ppm to a 32-gal food-grade plastic bin filled to the upper-ring about 5 inches below the top edge, add 82.5 ml of a '10%' SO_2 solution.
- If you use powdered PMBS, you'll need to add 0.33 grams to provide 50ppm of SO_2 for each gallon or 1.65g/5gal.
- Mix well to disperse, particularly before adding enzymes (optional). Concentrated pockets of SO2 can will render the enzymes ineffective.
- Some professional winemakers use as less SO_2 than recommended before fermentation. Home winemakers, however, would do well to use a higher rate because they generally lack the experience, technical know-how, temperature control, and access to testing equipment. Commercial winemakers also have greater control over grape quality and harvest temperature.
- If you are trying to avoid SO_2 and unable to chill the grapes sufficiently to protect them from spoilage bacteria, e.g., *Lactobacillus*, *Pediococcus, Bretannomyces, etc*.), you can use Lysozyme or Enartis Stab Micro M (expensive. Scott Lab's **Bactiless** is effective against a wide array of wine bacteria, including Acetobacter, and Lactobacillus bacteria. If you add Lysozyme you will need to fine the resulting wine with Bentonite to prevent a protein haze from forming.
- **Note**: not all the SO_2 you add will remain in the finished wine, some will bind up with solids that settle out. In reds, some of the SO_2 is lost to the atmosphere during 'open-top' fermentation and later during racking. By the end of fermentation, little, if any, remains to do its work.

To sulfite or not to sulfite? Two options for whites and rosés:

Option 1: Add the SO_2 (say 35 to 50 ppm) immediately after crushing to prevent oxidative browning and inhibit microorganisms. The benefit is that there will be less browning and acetaldehyde formation in the wine. The drawback is that the wine will need more (50 to 75ppm) of SO_2 after fermentation because virtually all of it will have bound up or lost to the atmosphere during fermentation.

Option 2: If you're looking to minimize SO_2 in a wine, withhold the SO_2 until after fermentation. You will also want to press and start fermentation without much delay. The juice will turn brown (enzymatic browning). Most of the browning, however, will drop out after fermentation. The upside is that there will be less total SO_2 at bottling. The downside may be a slightly higher VA (volatile acidity). However, it's usually not detectable. Harvesting and crushing the grapes when they are still cool, and attention to sanitation will help minimize the formation of VA. There is also some risk of bacterial spoilage if grape quality is poor, temperature control is lacking, you have no means of blanketing the must/juice with argon or CO_2, or the fermentation is sluggish or sticks. It's best to use a commercial yeast and add sufficient yeast-nutrient to promote a healthy fermentation. This method is most successful when the condition of the fruit is good and temperature can be maintained below 60°F, and the grapes are not overripe. Wines made in this manner may lose some fruitiness but may gain in complexity. Your choice…but there is some risk involved.

Making additions: calculating how much to add:

Most products added directly to must (yeast nutrients), with the exception is the SO_2 are intended to be added to the volume of juice rather than entire volume of grape must. The calculation is based on the volume of wine rather than the volume of must, for example: based on the type of press, and other equipment, such as filters, as well grape varietal, etc. The "conversion factor" home winemakers can use is 0.6 to 0.7. For example, the yield after pressing 100 lbs. of grapes is 6 to 7 gallons of wine after pressing. Commercial yield for most red varieties is higher—about 150 to 160 gallons per ton (2000 lbs.). That's 7.5 to 8 lbs./100 lbs. That can easily be converted to hectoliters. So, if you harvest 1,000 of grapes, calculations should be based on the 75 to 80 gallons/1000, more or less, depending on berry size and pressing efficiency, and ability to salvage most of the juice/wine from the sediment.

When making acid adjustments or raising/lowering Brix, use the volume of juice in the must, rather than the volume of must. This is particularly important for pH and TA (Titratable Acidity) adjustments. Multiply the volume of must by 0.6 for varieties with smaller berries) or 0.7 for varieties with larger berries to estimate juice yield once the skins, seeds, stems, and heavy sediment are removed by pressing. The dosage rate for products intended to be added to juice are based on gallons or liters, and usually given as g/hL. A hectoliter (hL) is 100 L. Dividing that by 3.79 (number of L./gal. to get the number of gallons. A hL is roughly 26 gal. Now, divide the given dosage rate by 26, and multiply that by the number of gallons you want to treat. Let's say the dosage rate for the **Reduless** (a product to treat H_2S) is 15 g/h, but you have 30 gallons to treat. Divide the rate — 15g/hL by 26. That comes out to 0.577g/gal. You have 30 gallons to treat, so you multiply that by 30. That works out to an addition of 17.3 g of Reduless for the 30 gallons of juice—nothing to it!

Enzymes for making white or rosé wines:

- Enzymes are commonly added during skin-contact to release aromatic compounds, help clarify the juice, and increase yield.

- **Macerating enzymes** can increase aromatic extraction in aromatic grapes by breaking down the skins, for example, **ZYM AROM MP** (best for rosés), **ZYM CHARACTÉR** (Enartis). **Cuvee Blanc** or **Color Pro** (Scott Labs) also work well. Furthermore, they increase press yield, speed clarification, and improve protein stability. Recommended contact time is 4 to 6 hours, although 2 to 3 works reasonably well.
- For some grapes, like chardonnay, settling occurs rapidly and without the need for enzymes or other additions. Difficult to clarify juice like Sauvignon blanc can benefit from clarifying enzymes.
    - **Clarifying enzymes,** for example **ZYM RS(P**) (Enartis) provides **rapid** clarification particularly for white varieties that can be difficult to clarify, e.g., Sauvignon blanc, Pinot gris, Gewurztraminer, and some others. It can be added after pressing to improve clarification. Allow juice to settle for 6 to 8 hrs., or longer if can keep the juice chilled. **Lallzyme C-Max** (Scott Labs) is also very good for clarification for most whites.
    - You can use more than one enzyme to perform different functions.

Pre-fermentation pressing (white and red grapes for rosé):

- Press juice from skins and seeds after the desired period of skin contact.
- Red grapes for rosés should be pressed within minutes of crushing, if you want just a hint of color: pale peach. The most practical way is to add the crushed grapes directly to the press, and then begin as soon as it’s full. Keep the darker hard-press wine separate. You may want to use a special carbon black product such as **Enoblack-Perlage** (Enartis) to lightly strip excess pigment. The impact on quality is minimal.
- Rosés can also be made in the traditional method by draining off a portion of pink juice immediately after crushing red grapes, and then fermenting the juice separately from the rest. The pressed skins and seeds (the’ cake’) is fermented along with the red must. The object of removing some of the juice is to increase the skin-to-juice ratio of the remaining portion, so that the resulting red wine will have more intense aromas, flavor, pigments, and tannins. The French call this traditional method: **saignée** (to bleed). Rosés can be a useful byproduct of red winemaking, or done expressly for that style of wine.
- The juice that flows out of the press before any pressure has been applied, and the juice that flows under relatively low pressure is called ‘free-run’. Some people prefer to keep the juice produced under moderately high pressure separate from the free-run juice, because it can be more astringent and darker in color. The color of the juice darkens with pressing time due to oxidation and release of pigments from the skins. The color may turn dark-brown toward the end of pressing. This is of no real concern, as the brown color will settle out in time. Astringency levels, however, can be become an issue. Specific fining-agents can be used to remove astringency.
- Bladder presses apply less pressure and there is little or no difference between the juice that flows early-on and the juice that flows later. It’s not until the flow is significantly diminished, or you start repacking the cake to get extra juice.

- ‘Hard press’ juice can be treated with **Hydroclar 45** (Enartis) or **Colle Perle** (Scott Labs) to remove harshness and astringency due to seed tannins.
- Take your time when using a basket press and avoid extreme pressure. Fill your basket press about 80% full.
- Bladder presses should be filled-to-capacity—but don’t pack the grapes, even if there is only a small amount left. These can be added 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 it until the grapes just fill the void. It’s not a good idea to run the bladder press unless the basket is filled. The bladder is more likely to fail it’s inflated uniformly.
- Bladder pressing is gentler than basket pressing—it generally results in wines that are less harsh and bitter.
- Most small bladder presses operate using water-pressure. Some winemakers, though, convert their presses from using water to compressed air to do the work. This requires a few pipe fittings, and a small, portable air compressor with an accurate pressure regulator to prevent damaging the bladder and screen. Using too much pressure can break the welds in the metal basket, burst the bladder, resulting in the loss of wine or juice, or potentially causing serious personal injury. Nonetheless, there is a purge valve built into the press that should prevent failure – famous last words. Users must be cognizant of the risks involved and pay close attention to maintaining safe pressures when using the modified presses. Also, avoid the urge to crank up the pressure.to get that extra gallon of juice. Low and slow works best!
- You don’t need much air pressure to press the grapes using a bladder press — 8 to 12 psi (pounds per square inch) is very effective. Monitor the pressure gauge supplying the bladder press. Make sure the pressure is within the recommended range. The safety limit for the press is 2 bars ~29 psi limit. Read the instructions for your bladder press and operate the press within their safety margin. Don’t allow anyone else to operate it or loan it to a friend unless you supervise or have provided a ‘stern’ warning and detailed instruction. **Failure could result in significant expense to replace the screen, or much worse—personal injury**
- Using a basket press can be tedious and labor intensive. Although quite expensive, bladder presses are well worth the cost in terms of convenience, reduced labor and time involved. If you are serious about making wine, put one on your wish list, and then figure out how to pay for it. You could also buy some lottery tickets, if you’re feeling lucky. I recommend going in with several other winemakers to purchase one. It you got the water, use it to operate the press rather than converting it.
- Once you start pressing with a bladder press, be prepared to shut off the pressure valve (water source or pressure hose from the compressor) at the press when the juice or wine starts flowing freely, it can easily overflow the reservoir, or you won’t be able to transfer the juice fast enough to avoid spilling. You will need some assistance for this, otherwise there will be a lot of ‘floor tax’. Have at least 2 additional buckets in reserve to hold the juice, when things back up. Figuring out how to rotate the buckets in and out with minimal spillage will take a little practice.

- You also want to use a large hemispherical kitchen-strainer that spans the bucket to catch odd bits and bobs that makes their way through, such as spiders, earwigs, grape seeds, crushed grapes, or an occasional yellow jacket—it happens. Pour the wine from the bucket into the carboy using a large funnel fitted withs a back-up strainer.
- When pressing reds, you'll need to rinse out the screens frequently due to the heavy sediment and gel-like substance, probably pectins.

Settling (clarifying) the pressed juice for white and rosé wines:

- Transfer the freshly pressed juice using a large funnel into glass or preferably clear, food-grade plastic carboys to allow the heavy sediment to settle. It also facilitates racking the relatively clear juice into the fermenter. You can use the older glass carboys, but they are heavy, and ever so fragile! Be very careful when you move them around. I discontinued using glass carboys after I broke one too many carboys and lost the juice. I've heard of carboys breaking while being carries resulting in serious injury. The older ones are more prone to fail because they are scratched
- Initially the juice is very cloudy (looks like pea soup) because it contains a lot of extraneous solids. It takes 6 to 12 hours for the solids to settle, depending on variety.
- Using a clarifying enzyme, like RS(P) Enartis or Lallzyme C-Max (Scott Labs) will facilitate rapid settling.
- Store the juice while settling in a cool room <64°F, or immerse the carboys in cold water or cover each with a wet tee-shirt that is moistened periodically. The loss of water due to evaporation naturally cools the containers.
- Once most of the solids have settled to the bottom and the juice is reasonably clear, typically, about 8 hours, rack (transfer) the clear juice to another clean carboy, or to the intended air-tight fermenter, leaving the solids behind.
- Unless removed, the sediment is likely to contribute harshness, astringency, and herbaceous notes, and the resulting wine may develop stinky or sulfury (reduced) notes.

Racking:

- Racking is the transfer of clarified juice into a sanitized fermenter or holding vessel, e.g., carboy, beer-keg, or larger stainless or plastic tank approved for fermentation.
- Use a ½ inch siphon hose with a baffle attached to the end placed in the juice. The baffle prevents the uptake of sediment when the siphon is suspended just above sediment layer. As the level drops, tilt the bottle toward you to raise the level of juice above the baffle to prevent loss of siphon. Taking up a little of the light sediment near the upper surface of the sediment.is not a problem. Discard the remaining sediment.
- Allow about 10 percent head-space in the fermenter(s) to accommodate the foam generated by the yeast during an active fermentation. Some yeasts produce a lot, while others—very little. If you overfill your fermenter the foam

may blow off the air-lock or escape through it, creating a ‘bloody’ mess. I’ve had to clean yeast residue off the floor, ceiling, and walls late at night and was not amused. I had failed to leave adequate head-space. Just so you know…

- The juice from Sauvignon blanc does not settle well, unless you use the right enzyme, and after racking the clear portion, there is still a lot of juice mixed in with the sediment. Rather than discarding this turbid juice, you can reserve it and ferment it separately. And in my experience, the results have generally been good, or at least acceptable. You will want to rack it off the lees as soon as the solids begin to settle, usually toward the end of fermentation. Because the heavy lees often contain some elemental sulfur from the surface of the grapes, you may get the formation of H_2S (rotten-egg smell). If the wine is stinky, rack the wine to allow the odor to escape. If the odor persists, you can use a product like **Revelarom** (Enartis) or **Reduless** (Scott Labs); both are yeast-based materials infused with copper (see **Responding to ‘reduced’ odors during fermentation** below).
- Depending on aroma and taste, this wine can be bottled separately, blended into the rest of the wine, used to make a white blend, or discarded, if need be. I’ve found that certain fining agents, such as **Hydroclar-45** (Enartis), or **Colle Perle** (Scott Labs) can significantly improve the wine.

Fermentation tannins (whites and rosés):

- Why? Fermenting tannins are used to reduce oxidation, enhance aromatics, improve mouth-feel, <u>remove unstable proteins</u>, and bind with anthocyanins (pigments) in reds to create more stable color.
- If you’re using an enzyme, allow 6 to 8 hours for it to work, before adding tannins. Tannins, however, can be added to must treated with ZYM RS(P) within 30 min.
- So, you can add fermentation tannins after racking and before or at the start of fermentation.
- Recommended rate varies by product and are usually given as a range, for example: 3 to 10 g/per hL (26 gal) of juice (whites and rosés or grape must.
- Some choices for whites:
    - (Enartis: **Tan Blanc** (whites and rosés), **Tan Clar** (good for Sauvignon blanc, Pinot gris and Gewürztraminer), **Tan Arom** for aroma enhancement), **Tan Elegance** (also enhances flora notes and improves mouth feel).
    - Scott Lab’s: **FT Blanc Soft** or **FT Blanc** (also good for moldy or high protein grapes, e.g., Sauvignon blanc, Pinot gris, and Gewürztraminer).

Red grapes: after stemming/crushing:

- After crushing, add 50 ppm of SO_2 to the must to prevent oxidation, and microbial spoilage, particularly during cold soak.
- Make the addition based on the volume of grape must.
- You can either start fermentation without delay, **or** begin chilling the must in preparation of doing what is known as a cold-soak or (skin-maceration). This

involves allowing the must to 'soak' for 2 to 4 days in a covered, open-top container large enough to hold the crushed grapes or divided up among multiple fermenting containers. The length of time will depend on the grape variety and your objective.

- Cold-soaking is the practice of allowing the must to soak after crushing and chilling for a prescribed length of time, to increase the extraction of anthocyanins (pigments) and aroma precursors from the skins before any alcohol is present, potentially enhancing the resulting wine. The use of a fermentation enzyme during cold soak increases the rate of skin maceration (breakdown), maximizing extraction of skin components
- One obvious drawback is that the must is exposes to bacterial spoilage unless carefully managed.
- You also have to consider the condition of the fruit because microbial spoilage is more likely if the fruit is affected by mold (rot and mildew) or has appreciable damage.
- Keeping the must chilled is critical to prevent natural fermentation and/or spoilage. Use dry-ice, or frozen, water-filled jugs. For smaller containers, an ice-water bath in a large tub works well. Replace frozen water jugs twice a day to prevent complete thawing and add more dry ice as temperature rises.
- Keep the temperature less than 50°F, preferably 45°F until you have finished cold-soaking.
- For this to work, you must continue to add dry ice and or replace the thawed water-filled jugs — it's ongoing!
- You'll need lots of dry ice or numerous frozen water-filled jugs and a freezer or two dedicated for that purpose.
- Cold-soaking is widely used throughout the industry and thought to improve the color and aromas. There is, though, debate about the overall benefits of the practice. It may be more applicable for Pinot Noir, Grenache, Zin and other light to moderately light reds.
- After cold-soak, allow the must to warm up to at least 55°F and then inoculate with the yeast of your choice, or juice or allow the natural yeast on the grape skins or the natural flora in your cellar to ferment the juice.
- To help the yeast get off to a good start, rehydrate the freeze-dried yeast, rather than just 'pitching' them into the grape must
- Most yeast cultures are intended to be rehydrated in warm water (~104 °F). They start out in a warm environment one favorable to their development and population buildup. Adding the warm yeast to cold juice is stressful and can result in significant mortality. Thus, it is recommended that they be gradually acclimated to a much cooler environment, before you' throw them to the 'wolves', so to speak (See **Acclimating the yeast mixture before adding to the must below**).
- 'Natural or spontaneous fermentations', may be a bit slow to start (several days), and bacterial spoilage may begin if you haven't added enough SO_2, or the temperature wasn't low enough. If all else fails, inoculate with an appropriate commercial yeast, rather than letting things deteriorate.

- I've found that natural fermentation following cold-soaking and warm up, ramped up without much of a delay and completed the fermentation. I've used a number of different commercial yeasts in my cellar, so there is a rich flora in the room.
- Natural fermentations are started by the yeast on the grape skins, or one or more of the yeast cultures residing in your cellar. Fermentations typically involve different yeast strains.

Optional additions:

- **Fermentation enzymes**: Winemakers often add a fermentation or more than one. They do so to facilitate rapid clarification, release pigments, aromas and their precursors through maceration (softening and breakdown) of the skins, as well increase as juice yield.

- Various enzymes have been developed to meet the needs of commercial winemakers to perform specific functions.
- Enzymes are natural protein catalysts that increase the rate of chemical reactions, facilitating the breakdown of the skins and pulp. Some break down the cellulose, others degrade the pectins (gels), or various cell wall or cellular components, releasing pigments, as well as desirable aromas. In general, enzymes should be added shortly after crushing, SO_2 has been added, and has been thoroughly incorporated.
- Recommended enzymes:
  - **Color Pro**, **Lallzyme EX**, or **EX-V** (Scott Labs)
  - **Zym Color**, **Zym Color Plus** (Enartis)
- Other ways to improve grape extraction: use of a fermentation tannin, cold-soaking, saignée, punch down mor often and energetically, encourage a warmer fermentation, without exceeding the yeasts upper temperature limit.

Fermentation tannins:

- Benefits: act in a sacrificial manner to preserve more of the softer skin tannins, reduce oxidation, enhance aromatics, improve mouth-feel, and they bind with anthocyanins (pigments) to create a more stable color. They also bind with unstable proteins, and preserve more of the softer skin tannins.
- Tannins are best added early in the winemaking process, particularly during cold soaking, or at the onset of fermentation. Add the tannin 6 to 8 hours after an enzyme has been added, otherwise it will denature the enzyme.
- Some fermentations tannins for reds:
  - Tan FP, Tan Color, Tan Fermcolor, Tan Rouge (Enartis).
  - FT Rouge or Rouge Soft (Scott Labs).

Websites: www.Scottlab.com/products; www.enartisvinquiry.com

Preparing for fermentation (reds and whites):

- Both white and red grapes are typically crushed and destemmed before fermentation.
- Collectively, the crushed grapes, juice, seeds, and skins are referred to as grape **must**.
- While white grapes and those used to make rosés are pressed **before** fermentation, red grapes, are pressed after fermentation.
- Keep juice and grape must cool: <60°F is preferable until you are ready to start the fermentation.
- The juice of white grapes and those used to make rosés is settled and cleanly racked off the gross lees before fermentation.
- Fermentation temperatures are typically kept below 60°F to retain fruity flavors and aromas.
- Whites and rosés are nearly always fermented in air-tight fermenters, such as carboys, beer kegs, stainless-steel tanks, variable-capacity fermenters, food-grade plastic tanks (Speidel and Flextank) oak barrels (chardonnay primarily). to limit exposure to air.
- Red grapes are traditionally fermented in open-top fermenters: 32- or 44-gal food-grade plastic bins, food-grade plastic tanks (Speidel or Flex-Tank) variable-capacity stainless-steel tanks, and macrobins when fermenting a 1000 pounds or more of grapes.
- For reds, allow plenty of head-space, at least 5 inches, preferably six, to accommodate the rising cap of skins, and avoid the contents overflowing the fermenter. Very messy!
- Keep fermenters covered after 'crushing' and during fermentation to exclude fruit flies. Beach towels are ideal for the 32 gal, or larger food-grade plastic bins. Drape them over the tops of the containers, and make sure there are no wrinkles that will allow fruit flies to enter. You can buy fitted fine-mesh covers for macrobins.
- For whites and rosés, allow about 10% head-space to accommodate the foam produced by the fermenting yeast. Otherwise, it can easily blow out the airlock (volcano-like) and overflow onto the floor. Sometimes, rather spectacularly.
- If you choose to do a barrel ferment, say a Chardonnay, use an older (neutral) oak barrel, otherwise the oak may dominate the fruity aromas and flavors. Transfer wine made in a new barrel to stainless steel or food-grade plastic, once the desired level of oak has been extracted. MLC is likely to start on its own in most used commercial barrels as they typically contain LAB that can't be easily removed.
- If you want to barrel ferment or barrel age a white or rosé, but don't want it to go through MLC, use Lysozyme to inhibit MLC bacteria. Bactiless (Scott Labs) inhibits ML bacteria and a range of wine bacteria. Stab Micro (Enartis) is effective against a range of wine bacteria by binding with them and settling out in sediment where they can be removed by racking or filtering. Sterile filtering is another effective approach. This involves using an absolute 0.45μ (micron) membrane filter cartridge, after clarification and fining. They are

pricey and can become plugged unless the wine is very clear to begin with. They need to be back flushed after use and can be reused. They can be stored in the freezer or in high proof alcohol. After treatment, store the wine in stainless-steel, glass or food-grade plastic containers. Avoid contaminating the wine with residue from red wines where LAB may remain viable.

- **Fermentation tannins** can be added to white and red grapes used to make roses wines at the start of fermentation or a little later to protect the juice and developing wine from oxidizing, for example: Scott Labs: **FT Blanc** or **FT Blanc Soft,** or Enartis' **Tan, Tan AROM, Tan BLANC,** or **Tan CLAR.**

Natural, 'wild' or spontaneous ferments:

- Natural ('spontaneous') fermentations involve indigenous 'native' yeasts) or 'feral' yeast that start without the addition (inoculation) of a selected, cultured yeast. Such fermentations are commonly initiated by non-*Saccharomyces* yeast species that numerically dominate the must.
- Fermentation will, in most cases, start spontaneously due to yeasts on their skins, including those present in the winery.
- Many wild yeasts belong to different genera (types) of yeast. Most, though, are classified as *Saccharomyces cerevisiae* —the species that includes many strains that ferment grape juice or sugary liquids (honey, fruit, etc.) or carbohydrates (wheat flour, etc.).
- Often, however, the yeast that complete a natural fermentation are <u>not</u> those that were on the grapes.
- Saccharomyces cerevisiae will, in most cases, dominate the later stages of the fermentation, and complete the process in natural ferments. They may have been present on the skins or those present in the cellar.
- Whether you inoculate with a particular yeast culture, fermentation involves a complex of yeast strains, some that work well early on, others become dominant midway through, while others take over near the end when conditions are least unfavorable. It's very dynamic.
- Nevertheless, non-Saccharomyces species usually contribute to the character and quality of the wine.
- Natural fermentations, are not necessarily desirable or better than using cultured yeast. They may just add complexity.
- Many experienced winemakers, however, allow their wines to ferment using the yeast on the grape skins, mostly with good results. Some admit that they have to be ready to inoculate with a proven strain if the fermentation fails to get rolling or begins to produce funky notes. It doesn't work as planned.
- Problems are more likely to occur during wild fermentations than conventional ones, because there are far fewer indigenous yeast cells on grapes than the numbers added in a standard dose of a commercial strain—usually 1g/gal. It just takes longer for wild yeast to colonize the juice, and there may be some bad-actors in the group.
- Natural fermentations, do not include the customary addition of sulfites that kill bacteria, and retard most wild yeasts, leaving the grapes open to spoilage

organisms, and oxidation. The trick is to get the fermentation going quickly before the other microbes become active. Keeping SO_2 levels to about 20 ppm will encourage the yeast, yet still inhibit wine bacteria.

- It takes a little longer to get natural fermentations up and running.
- Keeping the temperature under 60°F and the juice or must will help prevent oxidation and discourage wine bacteria until the yeast population buildups.
- Some winemakers, allow a natural fermentation to start and then inoculate with a selected yeast to finish the fermentation. In this manner, they can get some of nuances that native yeasts can provide.
- Because indigenous yeasts are slow to develop, the juice is more subject to spoilage and oxidation, particularly if sulfites have not been added, and/the temperature is not low enough. Sometimes, the wine is ruined, or the fermentation sticks. So, it is important to monitor the fermentation and take corrective action as needed.
- The use of wild yeasts carries both potential benefits and risk, and care must be exercised to achieve the desired results.
- In most cases, either a commercial strain or an indigenous species of *S. cerevisiae*, is unintentionally introduced at the winery during the winemaking process, and completes the fermentation.
- Wineries that favor native yeast fermentations have experience, and closely monitor their fermentations, and are ready to inoculate if necessary, so that the resulting wines have the desired characteristics. They also know what to expect from the wild yeast in their vineyards.
- Another option is to use a commercially available non-saccharomyces yeast early on, and then inoculate later. Some of the cultures act as bio-protectants, while other impart unique characteristics
- Often near the end of cold-soaking you can see tiny bubbles on the surface of the juice—an indication that natural yeast cells are active and building up. You can inoculate if you like once the juice temp is close to 60 °F, or you can add nothing more than moderate amounts yeast nutrients, and let her rip!
- If thing get out of hand, be ready to inoculate with 2g yeast per gal to move things along.
- One novel, approach is to harvest 5 to 10 pounds of the grapes about 4 to 5 days prior to the anticipated harvest date. Place them in a large Ziplock bag. Crush the berries to release the juice, allowing the yeast on their skins to build up and start fermenting the juice. The French refer to this as ‘Pied de cuve.’ As the fermentation starts, due to yeast on the skins, you’ll need to open the bags occasionally to release the pressure from the buildup of CO2, otherwise the bags will burst. You could also use a large-mouth clear plastic food-grade container with an air lock. If the ferment smells good, you can use the fermenting juice as a starter for the rest of the juice or grape must. In this manner, you are more likely to ensure that the yeast cells on the skins can ferment the grape to finish. Store them in a relatively cool room until used.

Conventional fermentation (Selecting & preparing yeast for inoculation):

- Conventional fermentations are convenient, predictable, consistent, and reliable if you make a well-informed selection. You also have a wide array of yeast with different attributes and characteristics to choose from. There is value in knowing what your yeast can and can't do. Yeast selection is very important so that the culture you select will be up for the job. Even if you make a good selection and you don't manage the fermentation well an allow conditions for the yeast to become unfavorable, all bets are off.
- Once the juice (white grapes and those used to make rosé) has settled and been racked off the heavy lees into one or more fermenting containers, **or** the grape-must has been placed in open-top fermenters and the temperature at or above 55°F, you're ready to start the fermentation.
- Select a yeast strain that has an affinity for the grape variety you're planning to ferment, and one that produces the sensory characteristics you're looking for, and desired traits, such as low nutrient demand, etc.
- Consider the strain's fermentation speed, recommended temperature range, alcohol tolerance, nutritional needs, and potential to produce H_2S or acetic acid.
- Some yeasts may struggle or die if the fermentations become too warm, or if the if it's too cold.
- When making white and rosé wines the ability to ferment at low temperature is an important factor.
- When fermenting very ripe red grapes, you'll need to select a yeast strain tolerant of high alcohol levels. Many are intolerant of levels in excess of 15% alcohol.
- Yeast Nitrogen demand ranges from low to very high. So, if you select one with a high nutrient demand, and your juice is nutrient deficient, the yeast will languish and the fermentation may stick before all the sugar is consumed. That can take all of the fun out of winemaking.
- When specific nutrients are deficient, the yeast may resort to producing stinky sulfur compounds that will require remediation.
- Some yeasts are known to enhance varietal flavors in grapes such as Sauvignon blanc Gewürztraminer, Riesling, Muscat or Pinot noir, others produce fruity, spicy, or floral notes.so, give your yeast selection some thought.
- Using a yeast that is poorly-suited to the variety may produce a wine that lacks varietal aromatics, color, and body.
- Commercial yeast strains are popular because they are reliable, convenient, and predictable. Nearly all the commercially available yeast strains have been cultured from natural ferments because they had some very desirable attributes.
- Most yeast cultures are freeze-dried and intended to be **rehydrated** rather than added directly to the fermenter. Adding or 'pitching' the yeast without rehydration can result in high yeast mortality, which can delay fermentation. The freeze-drying process damages the cell membrane that controls what enters or leaves individual yeast cells. It takes a little time for their cell walls to function properly again.
- There are some new yeasts (Enartis) that are processed differently and can be used directly without rehydration, saving time and effort. However, they may not meet your criteria.

Preparing the yeast for inoculation (rehydration):

- The standard recommended rate of yeast for most fermentation is 1 g per gal. The more you add, the sooner the fermentation becomes active and finishes. In general, slower fermentation are thought to make better wines.
- Adding yeast directly (pitching) to the juice or grape-must is discouraged, as it can cause high yeast mortality.
- Follow instructions on the package. Rehydrate the yeast in 10 to 20 times its volume in chlorine-free bottled water, but not distilled water. The distillation process eliminates minerals in the water necessary for yeast development. Heat the water to 102 to 104°F, add the yeast, wait 5 minutes, and then mix. Temperatures much above 104°F can stress or kill the little buggers. Insta-read electronic thermometer (about $25) will make this easier, faster, and more accurate. Cover the mixture and allow it to stand for no more than 20 minutes. Once the little guys are active, they're hungry and need to eat! Just add a little juice to keep everyone happy.
- You may want to use a rehydrating nutrient like **Go-Ferm Protect Evolution** (Scott Labs) to make sure the yeast cells get off to a good start. (See **Yeast Nutrients** below). Yeast nutrients are a good bet to keep your yeast happy and off to a good start. This can avoid H_2S issues or a sluggish fermentation.

Warming the chilled the juice/must before inoculation:

- Allow the chilled juice for whites and rosés and red must, particularly those that were cooled for cold soaking to warm to at least 70°F (preferably 65°F) before you inoculate.

Acclimating the yeast mixture before inoculating the juice/must:

- 20 minutes after adding the freeze-dried yeast to the warm water, add a small amount of the juice/must (about 10% by volume) to the yeast mixture to provide some sugar for the yeast to consume, and to start cooling it.
- Live yeast populations begin to decline after 30 minutes deprived of a food source.
- Over the next 20 minutes gradually add more of the juice/must to the yeast until the original volume of the yeast mixture is doubled
- Once the yeast mix is close to 70°F or less, you may be able add it to the juice/must. A temperature differential of 16°F is detrimental to the yeast.
- Once the yeast mixture is sufficiently cool, and the temperature of the juice/must is close to 60°F, add the yeast it to the juice/must. Voilà!
- You can stir it in or allow it to rest on the surface. It seems to work either way.

Yeast and their nutritional needs:

- Yeast use sugar for energy, but Nitrogen availability is critical for normal cellular build up, and it sustains their metabolic function, allowing them convert all but a small fraction of the sugar to alcohol.

- Yeast cells require Nitrogen, amino acids, vitamins, and other nutrients, for cell growth, regeneration, metabolism, and a successful fermentation. Often, grapes lack sufficient nutrients to ferment a wine to dryness.
- Failure to address this important consideration, can be an unpleasant learning experience—a stuck fermentation.
- Unless we provide yeast the right amount of nutrients at the right time in the life cycle, producing clean, well-made wines, is unlikely.
- YAN (yeast assimilable Nitrogen) — the amount of Nitrogen (N) in the must or juice that the yeast can assimilate. It is expressed as mg (milligrams) per liter (L).
- Test results may be reported as YAN or separately as alpha amino acid-N and ammonia-N. Just combine these numbers to get the YAN
- In general, the higher the sugar content of the grapes, the lower their YAN, and the higher the fermentation temperature the greater their need.
- YAN commonly ranges from less than 110 mg N/L to well over 300 (see YAN table below: **Testing for and managing nutrient levels**.
- For totals below 225 ppm, supplementation may be necessary for a particular lot of grapes, the yeast selected, and the temperature range of the fermentation. It is also recommended to increase YAN for grapes with higher Brix.
- Brix is an important factor as more nutrients are consumed required as Brix levels increases.
- Hotter fermentations tend to require higher nutrient levels than cooler ones. So, even though the YAN level for your grapes may seem high enough, you may experience a sluggish or stuck fermentation unless you manage your fermentation carefully. This is where many home winemakers fail to plan and act accordingly.
- Yeast selection is a major consideration because nutrient demand varies widely among the those you can choose from. Some have a moderate demand, while other have a low or high demand. Thus, yeast selection can be critical if you YAN is low or even moderate.
- Unless you know the YAN, you can't manage yeast nutrition well.
- Many amateurs 'wing it,' with mixed results.
- Lack of available Nitrogen often results in the production of off-aromas such as H_2S (boiled egg smell, or worse), and a sluggish or 'stuck' fermentation.
- As available Nitrogen is depleted, fermentations become sluggish or stop all together. That can result in a sweet, oxidized wine, undermined by the smell of vinegar, unless you act quickly to restart the fermentation. Thankfully, there are special yeasts and protocols to get things going again. The point is that you should add yeast nutrients, and carefully monitoring the fermentation for indicators of H_2S.
- Even when nutrient level are high, additional specific nutrients may be needed to complete the fermentation without the yeast becoming stressed, and producing H_2S.
- Although **DAP** (Diammonium Phosphate), an *inorganic* form of Nitrogen (N), can provide Nitrogen (ammonium ions), it doesn't provide balanced nutrition.

- DAP is taken up quickly, and may result in rapid yeast buildup and a larger population. The larger the yeast population, the greater the demand for YAN. The downside is that YAN is consumes more quickly than if the population had been allowed to build up more gradually. The remaining YAN may not be enough to sustain the yeast and the fermentation may founder.
- Alternatively, when Nitrogen is supplied in the form of amino acids, the fermentation profile is very different. Ferments do not get as hot, the yeast population is controlled, and the cells are healthier. Interestingly, both aroma and mouthfeel are also improved when DAP is avoided (Scott Labs). Products containing DAP are though appropriate at the 1/3 sugar depletion stage.
- Most commercial wineries favor *organic* formations of Nitrogen. DAP is best used when the Nitrogen level of the grapes is very low. When needed, 10 g of DAP will add 20 mg/L of N per hL (26 gal of must). So, if your YAN is 110 mg/L you will need to bring it up to 150 with DAP 24 hours after inoculation, or use an increased rate of a DAP-free nutrient formulation at a 2 to 3 drop in sugar. At the 1/3rd point you can use then add nutrient formulated with DAP. Furthermore, you should also be using a <u>low</u> nutrient demand yeast to help avoid issues.
- For the most part, fermentation temperatures should moderate (74 to 78° F) because higher temperatures stimulate yeast activity, increasing their need for Nitrogen.

Avoiding sluggish or stuck fermentations:

- Make your life easier and test your juice for YAN before you begin fermenting it. Select a yeast with moderate, or better yet, low nutrient needs, and make sure that the it will tolerate the alcohol likely to result, when you ferment the juice/must, particularly if you haven't adjusted for high Brix.
- Many yeast are unable to tolerate the high alcohol levels produced when high-brix grapes are fermented. Consequently, the fermentation become sluggish and the stops.
- While you checking the yeast's characteristics, see what its optimal fermentation temperature range is. Because if you let the temperature run up past its upper limit overnight, the fermentation may go south on you.
- Use 'balanced yeast nutrients and follow the protocol outlined by the manufacture. If you use Scott Labs's Lallemand products, go online to get their catalogue for instructions. High temperatures can lead to problems.
- Do not rely on DAP alone.
- Aerating the fermenting must starting at about ⅓ to ½ sugar depletion will to increase the level of dissolved O_2 needed by the yeast to synthesize fatty-acids and sterols. An inexpensive aquarium air pump seems to do the job quite well.
- You definitely want to avoid having to restart a stuck fermentation because your grapes were nutrient deficient. It's an unpleasant and time-consuming ordeal …
- H_2S production during fermentation is the first indicator that something is amiss—the yeast struggle, usually because nutrients are in short supply, there in insufficient O_2 to keep the yeast healthy, or the temperature is too high.
- This is the time to be proactive: add more nutrients!

Testing for nutrient availability:

- Beginning winemakers are often unaware that yeast require at least a minimum level of nutrients to completely ferment wine to dryness and avoid other issues. Experienced winemakers.
- To determine YAN, submit a sample of juice to a wine lab for analysis. Labs typically include YAN in the juice profile test. There are a number commercial labs that will run a ‘juice’ panel of tests, such as Brix, TA, pH, and YAN for around $50. This information can be used to adjust the juice or wine when numbers don’t measure up. Making adjustment will ensure balance and stability in the finished wine. Knowing the nutrient status of your grapes allows you to manage the fermentation and minimize problems that might develop.
- If you buy grapes from a grower, you may be able to get this information from one of the wineries he/she sells to.
- Even though you’ve made wine from a particular vineyard before without issues, Nitrogen levels can vary year-to-year, and with grape ripeness.
- N levels tend to be significantly lower in grapes above about 24.5 °B. Environmental stress, and environmental stress may influence Nitrogen content as well. Both Enartis and Scott Labs has easy-to-use **Yeast Nutrient Guidelines**. The use of this information, though, is dependent on testing to determine the actual YAN. If you just don’t want to spend the money to have the juice analyzed, assume that the YAN is low to moderate, depending on °B, and then use a yeast with low nutrient requirements. Then, use a moderate amount of balanced nutrients at key points during the fermentation as sugar is depleted. Then monitor the fermentation for H_2S or sluggish and then add more nutrients (about half of what you added at 1/3 sugar depletion. In this manner, you are more likely to provide enough nutrients to avoid problems.

- YAN commonly ranges from less than 110 mg N/L to well over 300.
  - YAN <130 mg N/L is considered: **LOW** or deficient
  - YAN >130 to 200 is considered: **MODERATE**
  - YAN > 200 but <250 is generally considered **MODERATELY HIGH.**
  - YAN > 250 mg N/L is considered **HIGH** (ample)**.** Addition of nutrients are generally not needed, nonetheless, I may be prudent, depending on factors described above, to add a moderate amount of nutrient and to monitor for sluggishness and H_2S.
  - Above 300 you are typically, but not necessarily, ‘out of the woods’
    Note: The YAN numbers used above may vary, depending on source.

Managing the nutritional needs of the yeast:

- Measuring and maintaining proper nutrition, selecting the right yeast (nutritional needs, ethanol tolerance, upper and lower temperature limit, etc.), adding enough nutrients at the right time, and maintaining the temperature within the ideal range can help prevent stuck fermentations.
- Yeast like most other living organisms need nitrogen to grow, function and survive.

- Much of the Nitrogen they need is derived from the pool of amino acids, and ammonium ions, to a lesser degree released by the grapes following crushing. Other essential nutrients include fatty acids, sterols, vitamins, and trace minerals.
- Amino acids, the building blocks of protein, literally found in every living organism, are the precursors for aromatics and flavors in wine.
- Therefore, it's best to use a balanced, complex, organic (yeast-derived) formulations, containing mostly amino acids and peptides (short chains of amino acids) to supplement YAN.
- DAP (Diammonium Phosphate) releases Nitrogen in the form of ammonium ions, which are readily metabolized, promoting a rapid population buildup and higher fermentation temperatures—not necessarily a good thing.
- Don't rely <u>solely</u> on DAP to supplement YAN,
- **Timing** is important: Make additions early: at inoculation when using Enartis nutrients, or after a drop of 2 to 3°B (Scott Lab's Lallemand products. Lallemand recommends using a rehydrating nutrients Go-Ferm, Go-Ferm Protect Evolution, to sustain the yeast until the first nutrient addition is made.
- Enartis recommends making the first addition (**Nutriferm Energy**) following inoculation. However, when is YAN is very low, they recommend adding DAP 12 hours after inoculation to raise YAN to 150 mg./L (10 g of DAP/hL (~26 gal) of must will provide 20 mg N/hL,
- Both recommend another addition at 1/3 sugar depletion (about 14 to 16°B)
- Enartis recommend using **Nutriferm Advance** at 1/3 depletion when YAN is moderate or low
- Enartis also recommends the addition of specific nutrients formulated at the ½ way point for all YAN levels to keep the yeast healthy
- Scott Labs recommends <u>not</u> using **Fermaid K** at 1/3 depletion unless YAN is below 150.
- Nutrients added after ½ to ⅔ sugar depletion (that's ~12 °B) are usually of little value.
- Follow the manufacture's protocols.
- When you know the YAN for your juice/must, refer to the two options outlined below to help with additions. That information can also be useful when you don't know the YAN.

Option 1: Using Scott Lab's Lallemand products Excerpted from Scott Lab's protocol for managing YAN (Scott Lab's product catalog):

- For yeast inoculation: In general, use <u>one gram of yeast per gal of juice/must</u> <u>or</u> expected yield of juice. For example, 1000 pounds of red grapes usually yields about from 60 to 75 gal of juice (depending on grape size. Larger grapes produce more juice than smaller ones).
- Rehydrate yeast for <u>all</u> YAN levels with **Go-Ferm Protect Evolution** or see the bullet point regarding Scott Lab's new product below: add 30 g/hL (1.2 g/gal). So, for every 1 gram of yeast, add 1.2 grams Go-Ferm Protect Evolution mixed into 25 mL chlorine-free water, don't use distilled. To function, yeast cells need the minerals that distillation removes.
- To convert mL to ounces, divide by 29.6

- Heat the Go-Ferm solution to 104, any higher may kill or stress the yeast. Wait for the water to cool down, if you over-shoot the target. Once the temperature is 104, add the dry yeast and allow them to rehydrate for about 20 minutes. Stir it after about 5 minutes.
- After 20 minutes, start acclimating the warm yeast to a cooler environment by adding some juice/must. The temperature differential at that point is often close to 40°F—way too much for the little buggers—they are quite sensitive. To reduce the temperature of the yeast mixture, gradually (every 15 to 20 minutes) add cold juice/must until the temperature of the yeast mixture is approximately 70°F.
- If the temperature of the juice/must is close to 60°F, add the yeast. A temperature differential of 10°F is acceptable, greater than that, however, can be detrimental. For details, see **Acclimating the yeast** above).
- Scott Labs recently releases a labor-saving product: **Go-Ferm Sterol Flash**, a rehydration nutrient, to rehydrate the yeast in only 15 minutes in water at room temperature, and eliminates the need to acclimate the yeast before adding the mix to the cold must. What will they think next? This really simplifies getting the fermentation off to a good start.

Simplified nutrient guidelines for Scott Lab's Lallemand products based on YAN:

- **After a drop of 2 to 3 Brix:** add 40 g/hL (1.5g/gal.) **Fermaid 0** to low YAN juice/must.
- **At 1/3 sugar depletion** (8 to 10°F drop in Brix),
- **Low** YAN: add 40g/hL (1.5 g/gal) **Fermaid K**
- **Moderate** YAN**:** add 20g/hL (0.75g/gal) **Fermaid 0** after a 2 to 3 drop in Brix, and another 20g/hL (0.75g/gal) **Fermaid 0** at 1/3 sugar depletion.
- **High** YAN**:** add 30 g/hL or (1.2 g/gal) **Fermaid 0** at 1/3-sugar depletion.

- Aerate 4 to 6 hrs. for 3 to 4 days.

- **Fermaid 0** added at 1/3 sugar depletion, supplies critical nutrients to help the yeast avoid stressful conditions or sticking. **Note**: if hydrogen sulfide develops, add 10 g of DAP/hL (~26 gal) of must. It will provide 20 mg N/hL, thus 1g of **DAP**/hL provides 2mg N/hL, while, 1g DAP per gal will add ~52mg N/L per gal of juice or must. If things go awry, an addition of **Reskue** (Scott Labs) or **Nutrient Vit End** (Lallemand) can help sluggish fermentations finish without producing H_2S, and **Nutriferm No Stop** (Enartis) does much the same.

Option 2: Simplified nutrient addition guidelines for Enartis nutrients based on YAN. See protocol for Enartis products in their catalogue and online.

- Rehydrate yeast in warm water, following manufacturer's recommendations.
- **At inoculation**:
  - **Low** YAN < 130 mg/L**:** 15 g/hL **Nutriferm Energy** or 30g/hL **Nutriferm Arom**
  - **Moderate** YAN 130 to 200mg/L**:** 15 g/hL **Nutriferm Energy** or 25g/hL **Nutriferm Arom**

- **High** (moderately) YAN >200 mg/L): add 10 g/hL **Nutriferm Energy** or 20g/hL **Nutriferm Arom**

- When Yan is <130, wait 12 hours after inoculation, and then add enough **DAP** to raise YAN to 150. Rate: 10 g of DAP/hL (~26 gal) of juice/ must will provide 20 mg N/hL

- **At ⅓ sugar depletion** (8-10° drop in Brix), add **Nutriferm Advance** (contains DAP)
  - **Low** YAN <130 mg/L, add 40 g/hL.
  - **Moderate** YAN 130 to <200 mg/L YAN, add 30 g/hL
  - **Moderately High** YAN >200mg/L, add 20g/hL

- Aerate 4 to 6 hrs. for 3 to 4 days.

- At ½ sugar depletion add 15 **Nutrifern No Stop** to all YAN levels

Additional points:

- Avoid the use of DAP for the first 12 hours after inoculation. High levels of YAN stimulate yeast development, and when yeast populations are high, they may need additional vitamins, minerals, and lipids.
- Products like **Go-Ferm Protect Evolution,** and **Go-Ferm Sterol Flash** (convenient and less work are useful. In the past I used both GO-Ferm and Go-Ferm Protect Evolution before adding products. I switched to Go-Ferm Sterol Flash during the 2023 vintage.
- You may have to deal with hydrogen sulfide (H_2S) produced by the yeast near the end of fermentation. Sometimes aeration helps, and punching down allows much of the odor to dissipate. **Reduless** (Scott Labs), can clean up the problem. Copper sulfate should be thought of as a last resort. (See **Responding to 'reduced' smells during fermentation**, below.

Other useful yeast-based 'nutrients':

Other 'nutritional' products increase the levels of polysaccharides (sugar-like substances that yeast can't ferment). Those included here are added at the start of fermentation. The intent is to improve aroma and balance mouth-feel, reduce astringency and bitterness stabilize color, and reduce oxidation and the perception of dryness and alcohol. Most can be added later:

- For whites and rosés Scott Lab's **OPTI-White)**. Enartis': **Pro Arom**, **Pro R, Pro Blanco**, and **Pro Round** (OK for reds).
- For reds: Scott Lab's: **Booster rouge** or **Opti-Red**, or **OPTI-MUM Red** at start of fermentation: Enartis: **Pro R**, **Pro Tinto** (OK for whites), **Pro Blanco**, or **Pro Round**.
- **Noblesse** (Scott Labs) can reduce the production of sulfides in white, rosé and red juice, reduce the perception of alcohol in the resulting wine, and impart a perception of sweetness.
- **Ultra Soft (Enartis)**

Fermenting white grapes and those used for rosé:

- Because the juice for white and rose wines is prone to oxidation and loss of aromatics, fermentations are primarily done in **closed container**s using an air lock to keep air out, while allowing the CO_2 produced by the yeast to escape.
- Despite what you may have heard about, it's fine to expose white wines to a bit of air. Stir the inoculated juice every day or two to keep yeast in suspension until the fermentation is visibly active—12 to 24 hrs. The formation of bubbles indicate that the fermentation is underway. The generated CO_2 prevents much air from entering the fermenter.
- Once fermentation starts, the evolving CO_2 protects the wine from oxidation.
- Try to keep temperatures below 65°F. Less than 60°F is preferable to retain fruitiness and freshness, if that's your objective.
- Household air conditioners can be used to cool a garage or small cellar. This helps to reduce the fermentation temperature. Most air conditioners, however, don't cool below 64F. So, it's necessary to use a specialized electronic device (*CoolBot*) to override the air conditioner's thermostat. The device can be set to maintain the desired room temperature. There may be other similar devices available.
- Evaporative cooling can be used to significantly lower fermentation temperature during fermentation in warm garages. Cover carboys and beer kegs, with wet cotton T-shirts: children's' small for carboys and adult XL for beer kegs. Keep them moist. Larger stainless-steel tanks can be wrapped in fabric. Water evaporation from the wet fabric dissipates the heat generated by the fermenting juice, lowering its temperature. Cooling can be enhanced by using a fan to increase evaporative water loss. The cooling effect is less for larger containers due to the smaller surface area to volume ratio. Smaller fermenters can be placed in low, flat tubs or trays, like those used under plants to catch excess water and act as a reservoir, allowing water to partially wick-up the fabric.
- Another option to keep the fermentation cool is to immerse carboys and beer-kegs in large water-filled plastic or metal livestock tanks. To lower the water's temperature, add ice or frozen water-filled jugs. A small chest freezer will allow you to freeze multiple jugs to maintain the desired temperature. Bear in mind that it may several days to completely freeze the jugs. Avoid filling the jugs to capacity, allow about 10% head-space to prevent rupturing the jugs when the ice expands

Removing unstable proteins and protecting the juice (white and rosés) from oxidation:

- White varieties and those used to make rosés contain variable amounts of unstable proteins that can settle out in the bottle with time, particularly with exposure to warm temperatures. So, the sooner you remove them, the better.
- To test for protein stability in the finished wine, fill a wine-sample vial with a funnel-shaped bottom, with the wine, and then heat it with the cap loosely in

place, by placing it a measuring cup filed with very hot water for 20 to 30 minutes. Allow the vial to cool for 4-hours or overnight in a refrigerator before checking. Unstable proteins will coagulate and settle to the bottom of the inverted cone. Turn the vial slowly on its side to see if a whitish plug slides out.

- **Bentonite**, a common fining-agent, is traditionally used to bind with the protein, causing it to precipitate from solution. Once the bentonite-protein particles settle (several weeks), the clear wine is then be racked-off the sediment, leaving it behind. Red wines, because of the high tannin levels are free of unstable proteins.
- Tannins are useful when fermenting whites and rosé to minimize oxidation, and bind with some of the unstable protein, Tannins in oak barrels do much the same.
- Examples of fermentation tannins: Scott Lab's **FT Blanc** or **FT Blanc Soft,** or Enartis' **Tan Enartis, tan AROM or Enartis tan BLANC** can also be added at the start of fermentation.

Early removal ('preemptive' fining) of unstable proteins:

- Is done early during fermentation rather than later.
- Fining is defined as the addition of various agents, for example, Bentonite, to remove something undesirable in the juice, must, or wine. Bentonite or blends containing Bentonite, a purified clay is useful. Some blends like **Claril SP** (Enartis) effectively remove unstable proteins, oxidation, browning, and bitterness in whites and rosés. The sediment produced is removed at the end of fermentation, along with the heavy lees.
- Bentonite or one of the Bentonite-containing products are typically added to the juice of white, and red varieties used to make rosé wines and added shortly after the start of fermentation.
- Bentonite works because the microscopic clay particles are highly charged and attract oppositely charged substances like proteins, causing both to settle to the bottom of the fermenter. In this manner, the proteins along with the Bentonite can be removed by racking.
- Early fining results in significantly less stripping of aroma and flavor, and greatly reduces the amount used if needed if done later.
- Protein levels are largely dependent on the varieties, vineyard location, and practices, the vintage, and how the grapes are handled during pressing and crushing. The longer the juice is exposed to the skins, and the more the skins are manipulated, the greater the protein content of the wine.
- Bentonite treatment should be done once fermentation is visibly active or at least 8 hours after inoculation to allow fermentation tannins and enzymes, if used, to work because Bentonite will denature both.
- The use of fermentation tannins during fermentation can also greatly reduce the level of unstable proteins in white and rosé juice without stripping aromas or flavor components.
- Unstable proteins are generally not a problem for whites aged in oak barrels because the oak tannins cause them to settle out.
- Common agents used to remove unstable proteins include:

- **Bentolact S** (Scott Labs) Bentonite plus Potassium Caseinate—removes proteins and reduces astringency and bitterness by binding with excess phenolic compounds. It also mitigates oxidization. **Rate**: 20-100 g/hL
- **Claril SP** (Enartis)—a blend of four fining agents: Bentonite, PVPP, casein, and silica gel. It settles solids, reduces bitterness, harshness, oxidative browning, improves aging potential and aromas, and minimizes oxidation. It can greatly improve the quality of 'hard-press' juice. **Rate**: 50 to 150 g/hL.
- **Bentonite**—widely recommended to remove proteins (heat-stabilization) that can precipitate in the bottle during storage, particularly when the wine is warmed. Bentonite (Calcium- or Sodium-based). Silica gel, a counter-fining agent, can be used to increase the rate of settling the finer particles that are slow to settle. Rate: 20 to 100 ml/hL
    - Scott Labs markets several Bentonite products. Check with your local fermentation shop to see what they recommend.
    - **Pluxcompact** (Enartis)—contains calcium-based Bentonite and Sodium-based Bentonite. It removes protein well and is good for clarification. **Rate**: 20 to 120 g/hL in 20 times its weight in cold water
    - **Pluxcompact N** (Enartis) — a sodium-based bentonite. **Rate**: 20 to 120 g/hL in 20 times its weight in cold water
- **Chitosan** —for clarification and removal of unstable proteins for wine after fermentation (available on line). Use with Silica dioxide (SiO_2): Gelocolle (Scott Labs), Sil Floc (Enartis), aka Kieselsol.

Fermenting red grape:

- Make the pre-fermentation SO_2 addition shortly after stemming and crushing. The standard SO_2 dose is 50 ppm. You could get by with 35 if that's an issue.
- Warm grapes should be chilled after crushing, otherwise the fermentation will take off quickly. Ideally, you want the fermentation to start slowly and ramp up gradually. Long, slow fermentations are thought to produce better wines.
- Allowing the fermentation to warm gradually helps to extract more water-soluble anthrocyanin pigments contained in the skins, and provides more time for the extraction of flavor components and desirable tannins, improving the final wine.
- Allow must that is still cold from an early morning pick, or that has been cold-soak, to warm to at least 55°F, preferably 60°F before adding the yeast.
- If the ambient temperature is cold, use a room heater or an electric blanket to try and warm the grape-must, so the yeast to 60°F or a bit warmer can get started.
- If you don't see signs of bubbling within a day or two, it could be that the yeast were not viable, particularly if you it not from a fresh batch.
- Bubbling indicates that the fermentation is becoming active, and soon thereafter, the skins will rise to the surface, carried by the CO_2 gas released by the yeast, forming a '**cap'** of skins floating on the juice.
- Keep the fermentation temperature from exceeding its upper limit for the selected yeast.

Fermentation tannins:

- There are many useful tannins products. Some are designed to act sacrificially during fermentation to preserve natural skin tannins, stabilize color, and improve aromas by masking green or herbaceous notes. Others are used as antioxidants, and to improve protein stability. Some impart desirable oak flavors, improve body, or reduce astringency.
- Examples of 'sacrificial' tannins for use during fermentation: Scott Lab's **FT Rouge**, or **FT Rouge Soft**, or Enartis' **Tan Rouge** or **Fermcolor.** The addition should be made after the fermentation becomes active about ⅓ sugar-depletion.

Aerating fermenting red must: something new for home winemakers:

- Fermentation is largely an ***anaerobic process,*** yet yeast cells need some dissolved oxygen in the juice or must to function, and to synthesize sterols and fatty-acids.
- CO_2 released by yeast during fermentation effectively prevents air from entering the fermenter.
- Research (Australian Wine Research Institute) has shown that oxygen or just air addition during fermentation can have significant beneficial effects. Interestingly, the benefits are not the same for red and white winemaking. In white winemaking, oxygen addition during fermentation can improve yeast health and decrease fermentation times. In red wine fermentations, the most notable effect was improved aromas, flavors, and mouthfeel. Reference: Day, M.P., Nandorfy, D.E., Bekker, M.Z., Bindon, K.A., Solomon, M., Smith, P.A., Schmidt, S.A. 2021. Aeration of Vitis vinifera Shiraz fermentation and its effect on wine chemical composition and sensory attributes. Aust. J. Grape. Wine Res. 27: 360–377
- Cumulative oxygen exposure over the entire fermentation, rather than a single or several aeration events is primary consideration Adding air starting early (day 2 and 3) during fermentation helps yeast survive when alcohol levels rise. Enartis instructs winemakers to infuse fermenting wine with O_2 each day for 3 to 4 days. Air, however contains 21% oxygen, so it is unlikely home winemakers would exceed that recommended limit.
- Aeration by bubbling air directly into the must using a moderate size aquarium air pump displaces some CO_2 and introduces a little O_2, much like lengthy pump-overs that promote oxidation of tannins and polymerization. More effective aeration of the fermenting must can be done by using an and bubbling.
- 'Bucket' splashing from one container to another appears to be largely ineffective. The best option for home winemakers is to bubble air, using one or more mid-size capacity aquarium pumps.
- To reiterate, aeration minimizes stress on yeast, potential for reduction, and typically improves aromas, flavors, and mouth-feel.

- At any rate, the commercial uses the technique involves monitoring the levels to maintain optimum levels of oxygen during fermentation.
- Aeration is an economical and useful technique for home 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 is absorbed by the yeast or driven out quickly by the CO_2.

Punch downs:

- Extraction of pigments, fruit aromas, and skin tannins is dependent on adequate skin and juice contact. Therefore, it's helpful to break up and resubmerge the cap by pushing ('punching') it down into the developing wine throughout the entire fermentation. This is commonly called punching-down. The French coined the term **Pigéage** for this step**.** A commercial grade potato masher, available from restaurant supplies or your local fermentation supplier, works quite well to do 'punch-downs' They are also easy to clean.
- How often you punch and how vigorous you are, will influence the amount and type of tannins (skin or seed) extracted from the fermenting must, as well as the resulting style of the finished wine.
- Furthermore, the extraction of very bitter seed/stem condensed tannins, or skin (hydrolysable) tannins, increase with the level of alcohol. So, the greater the alcohol of the wine, the greater the extraction of tannins.
- Warmer fermentation (>80 °F), frequent and energetic punch downs, extended maceration, and use of enzymes, all serve to increase tannin extraction.
- Blending hard-pressed wine with the free run will also increase overall tannin levels.
- The reason we destem grapes before fermentation is to minimize the extraction of herbaceous and bitter stem-tannins. To minimize tannins, use tannins additives sparingly and be more with those you do use punch gently and less frequently, keep fermentation moderate, not much greater than 80°F for a day. Pressing early at 3 to 5 Brix will also favor fruitier less tannic wines. The fermenting wine is then finish in a or tank
- Red grapes are typically fermented in open-top fermenters to allow the '**cap'** of grape skins that rises to the surface during fermentation to be '**punched-down,'** back into contact with the fermenting juice below. Wineries often ferment red must in stainless steel tanks and gently pump the juice from the bottom over the skins (rack and return) to keep them wet.
- Punching-down incorporates a little air in wine—a good thing, at least until CO_2 bubbles produced by the yeast prevents air from getting into the fermenting juice/must. It also serves to keep the yeast in suspension.
- More importantly, it facilitates the extraction of color, aroma, and tannins, and allows undesirable fermentations odors to dissipate. Furthermore, it allows to dissipate some of the heat generated by yeast metabolism, otherwise the fermentation could become too hot.

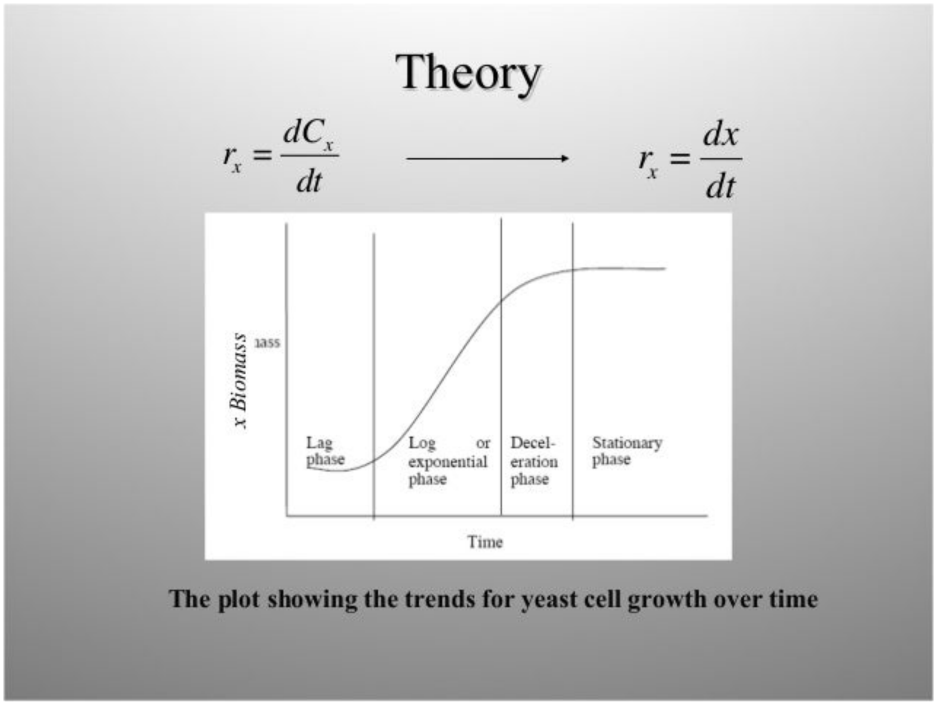
- More frequent punching-down has been shown to increase phenolic extraction during fermentation. This may be to your advantage or not.
- Punch-downs are typically done 1 to 3 times a day, depending on the winemaker's objective: more, or less tannin extraction. The more often the cap is punched, the greater the degree of maceration, and the extraction of aromatic and phenolic substances (tannins), and anthrocyanins (color pigments) from the skins. Cabernet sauvignon, on the other hand, is often pressed more frequently to increase the extraction of tannins to increase body.
- If you're trying to minimize skin maceration and tannin extraction when making a wine like Pinot noir, one punch-down a day or two very gentle punch downs work best. Some wineries go so far to ferment in small vats and use their gloved arms to gently break up and resubmerge the cap.
- Less punching can be used for big reds like Petite Sirah, Syrah, Malbec, etc., punching-down once per day to minimize astringency—the tactile sense of mouth-drying, roughness, or a puckering sensation.
- Avoid mashing the seeds that collect on the bottom when punching. This will release astringent tannins.
- Because it is not possible to physically break up the cap and remix and skins when the fermentation occurs in closed tanks or large ones, some commercial wineries pulse large bubbles of inert gas from the bottom to break up the cap, others do **pump-overs** (recirculate the wine from the bottom of the tank, allowing the wine to flow under low pressure over the cap to keep it moist. The French use the term **Remontage**' for this method. The advantage is that at the commercial level, it is usually easier, and causes less maceration of the skins than doing punch-downs. It also extracts color and flavor well. Most wineries have discontinued the harsh 'fire-hose' method to break up the cap.
- Another method, **Délestage**, a French term meaning 'rack and return,' involves a laborious, two-step process of draining the wine from a tank, and then returning it by pumping it over the top of the cap. This is done daily, until the fermentation is finished. Once the tank is empty, the seeds remaining on the bottom are collected and discarded. The object is to eliminate the source of bitter tannins. Obviously, a lot of oxygen is incorporated in the process, ultimately softening astringent tannins. It also works to stabilize color.
- More frequent punch-downs, and rackings increases tannin extraction, while exposing the wine to air. This leads to increased tannin polymerization, the process of small molecules called monomers linking together, forming long chains with multiple side branches, collectively called polymers, which have unique properties and structures.
- When punching down, it's a good idea to mix the sediment that collects at the bottom of the fermenter by pulling up the punching tool. This creates an updraft that carries it to the top, helping to aerate the wine and release off-aromas.
- Micro-oxygenation, a relatively new technique, widely used by commercial winemakers, doses red wines nearing the end of fermentation and shortly after with specified amounts of oxygen. The technique has been shown to promote polymerization of tannins, stabilizing the wine's color, and making the tannins seem soft on the palate. Oxygen flow must be carefully metered and turned off

when a set threshold has been reached. Otherwise, oxidation will occur. There are some simple systems available for under $1000. They are controlled using a smart phone and special app. Winemakers, though can, use the concept and aerating their big reds toward the end of fermentation, and for a short time afterward to improve taste.

Managing temperature during fermentation:

- Generally, red wines are fermented for shorter periods and at higher temperatures than white wines.
- Once the fermentation is active, temperatures, depending on ambient conditions. Try to keep the wine warm ~70°F, but avoid it from getting too hot (greater than 85°F, and keep the wine close to 70 as things are winding down.
- If the fermentation becomes too hot— aromas are lost and more astringent tannins are extracted. If you ferment is too slow or too cool, extraction of tannins and colors may suffer. It's all about balance.
- High temperatures can stress the yeast, leading to a sluggish fermentation, or cause the fermentation to stop (**stick**).
- According to yeast producer Wyeast, red wines should be fermented between 70 and 85°F. Color and tannin extraction are better at the higher end of this range. Thus, temperature can be used to achieve the desired style.
- Check the fermentation temperature after punching down the cap. For the most part, temperature should remain around 75 to 78°F. In most case, the temperature should not exceed 85°F for more than a day. Temperatures can reach 90°F, particularly when the ambient air temperature is warm.
- Cool fermentations typically produce wines that are more complex than those made during hot fermentations. The object is to attain sufficient extraction of color and flavor precursors.
- The ideal fermentation temperature largely depends on the preferred style of wine being fermented.
- For high Brix grapes, keep peak fermentation temperature and thereafter from exceeding 80°F). High temperatures (>80°F) can stress the yeast in the stationary phase, when the environment is challenging, resulting in sulfides (See image below.
- High fermentation temperatures tend to drive off volatile aromatic compounds and increase alcohol concentration through evaporation. Alcohol inhibition on yeast growth has a greater effect at high temperatures. Lower fermentation temperatures tend to retain fruit aromas and other volatile aromatics, while maintaining a fuller mouthfeel.
- If your objective is maximum extraction allow temperature to rise, but do not exceed the upper limit of the fermenting yeast.
- Fermentation temperature can be effectively reduced by adding a frozen water-filled jug for a short time to lower the temperature to 80°F.
- The heat generated at this time is important for extraction of skin components.
- Additional punch downs can also be used to temper a rising temperature.
- Cap temperatures care typically warmer than the juice below.

- The hottest point of the fermentation in the wine, is directly below the center of the cap.
- Temperature management is an important consideration, especially during the yeast's stationary phase, typically 3 to 10 days after the yeast became active. At this point, yeast growth slows.



The plot showing the trends for yeast cell growth over time

- Yeast tolerance to high temperatures ranges from 80 to 90+°F. That's why you should be aware of the yeast's temperature tolerance-range.
- Fermentation temperature and cap management influence tannin (phenolic) extraction, and composition of wines phenolics during winemaking.
- The rate of extraction of some grape-derived phenolic compounds increases with increasing fermentation temperature, but the final concentrations appear relatively unaffected.
- In studies conducted by the Australian Wine Research Institute, both the rate of extraction, and final concentration of bitter seed-derived phenolics increased with increasing temperature.
- Longer, cooler fermentations are thought to produce better red wines, assuming the cap temperature reaches the optimal temperature of 85°F or close to that for a short period.
- The fermentation temperature will gradually drop after it peaks (in the mid-80s) for a short time. When a cellar is too cool, the yeast may become sluggish, increasing the chance that H_2S might develop.
- Monitor for off-odors and sluggishness.

- If you detect a rotten egg smell (Hydrogen sulfide or H_2S) early in the fermentation, it's probably due to a low nutrient level. If you already added nutrients, the quick solution is to increase the Nitrogen concentration by adding some DAP, Fermaid K, Fermaid 0 or Nutriferm Energy/Nutriferm Advance. Nutrients are ideally added before the °B level has dropped below 12 (see **Yeast Nutrient Additions** above).
- H_2S is also likely to form if the grapes have a residue of elemental sulfur from sulfuring too close to harvesting.
- Fermentation is usually done when the cap settles back into the wine on its own. But bear in mind, that the cap also sinks when the fermentation has stuck.
- A hydrometer Brix/Balling reading of -1.5 to -2°B 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.
- In general, red wine is pressed after it has completed fermentation.
- Some winemakers though, prefer to press more tannic varieties at around 3° to 5°B. and rack to a clean fermenter, or barrel, leaving the skins and seeds behind. This serves to minimize bitter seeds tannins, while introducing a bit of oxygen at an opportune time. The wine is then allowed to finish in a barrel or tank fitted with an airlock.
- During fermentation, the bulk of the seeds, settle to. Pour the remaining 2 to 3 inches of wine, loose seeds, and sediment at the bottom of the fermenter into a 5-gal. bucket through a large conical ('China'-cap). In this manner, you can salvage the remaining wine and fine sediment, and discard the bulk of the loose seeds. This minimizes the extraction of bitter tannins released during **hard-pressing**.
- If you press early, keep the barrel reasonably warm to avoid stressing the yeast. Yeast cells are sensitive to sudden changes in temperature. So, if you refill a barrel that has cooled significantly, the yeast may go on strike. You may need to warm the barrel by placing it in direct sunlight on a reasonably warm day, or using an electric blanket over night.
- Unless you choose to an extended maceration, allow the heavy sediment (lees) to settle for 12 to 24 hours and then rack the clear wine to a barrel or storage tank. The heavy (gross) lees should always be removed, because it can add vegetative notes or lead to reduced (stinky) odors (see Appendix: **Extended Maceration** below).
- Begin malolactic conversion as soon as the wine has been racked into a barrel or holding container (See **Malolactic Conversion** below).
- Off-aromas can develop in fermenting must:
  - Fermenting wines may develop disagreeable odors, particularly Hydrogen sulfide (H_2S). The most common factors associated with the formation of H_2S include: low nutrient available, and elemental sulfur residue on the grapes from vineyard spraying less than 50 days before harvest.
  - Insufficient Oxygen in the fermenting juice/must can stress the yeast, leading to H_2S.
  - H_2S commonly forms when rising alcohol levels cause the yeast to struggle, or fermentation temperatures are no longer favorable.

- Failure to remove the gross lees before fermentation (white and rosé wines).
- Using yeast strains that have a high nutrient-demand while the grapes have low YAN
- Using yeast strains that are prone to producing lots of H_2S.
- Extended maceration of reds on the lees following fermentation (unless carefully monitored) may result in H_2S production.

Unpleasant odors—the sign of a faltering fermentation:

- Stinky volatile sulfur compounds, such as hydrogen sulfide H_2S), Mercaptans, and Disulfides, can form when the fermenting juice/must is nutrients deficient, the yeast's upper temperature limit has been exceeded, or when oxygen concentration is too low. Wines with such odors are said to be **reduced**, and the process is called **reduction**.
- The presence of H_2S in a wine, leads to the formation of other smelly sulfides, such as Mercaptans and Disulfides, especially during aging.
- Mercaptans can smell like onions, garlic, skunk, rubber, etc. These compounds can combine with other chemicals and form **Disulfides** smell like cooked-cabbage, canned asparagus, burnt rubber, stagnant water, staleness, the chemical substance added to natural gas to give it its characteristic odor, etc.
- Removing Disulfides can be challenge.

Reduction—what are we talking about here?

- Reduction and oxidation are two separate chemical reactions that complement each other. Electrons are transferred during chemical reactions. **Oxidation** is the loss of electrons, and **reduction** is the gain of electrons. If one component is oxidized, another is reduced. In an oxygen-rich environment, like wine in a poorly sealed barrel or tank, various components of the wine will become oxidized (electrons are transferred from those components to oxygen).
- Oxidation, a serious flaw, happens when wine (alcohol) is exposed to air, triggering a series of chemical reactions that convert alcohol to acetaldehyde, which has a slight nutty, bruised-apple, cider-like, or sherry-like aroma. The color darkens while aromas and flavors, and freshness fades.
- Given enough time, acetaldehyde is converted to acetic acid (vinegar). In the absence of free-SO_2, and where there is appreciable head-space above the wine, oxidative yeasts and bacteria can grow at the wine's surface, forming a film. These organisms often produce acetic acid and ethyl acetate (nail-polish or nail polish remover), typically referred to as VA (volatile acidity).
- Wines low in oxygen are said to have a low 'redox' potential— a measure of how oxidative or reductive the wine is. If levels get too low, there is a danger that some components will become reduced. Exposure to oxygen through winemaking practices such as stirring, aerating, racking, topping, filtering, sulfiting, fining, adding oak alternatives, etc., increase the level of dissolved oxygen in a wine, raising redox potential. So, it's a balance—too little or too much exposure to oxygen, is a problem for wine.

- H_2S is the 'volatile' sulfur compound frequently found in fermenting wine. Volatile substances are those that evaporate at normal temperature and thus, are detectable by smell, for example, vinegar, and hydrogen sulfide, pungent chemical, are readily detectable. Under normal conditions, most of this H_2S is volatilized from the wine along with CO_2. When large amounts are produced, usually during fermentation, residual H_2S may pose a serious problem, because of its persistence, and potential to form other more serious volatile sulfur-based compounds that are quite noticeable, even at very low levels.
- Nitrogen or other nutrient deficiencies typically result in excessive production of H_2S, and if not corrected, may result in offensive odors in the finished wine.
- Hydrogen sulfide can form during fermentation when yeast cells are most active, later in the final stages when the yeast are struggling, or during extended lees contact. When critical nutrients are inadequate, yeast cells are forced to degrade sulfur-containing amino acids to obtain Nitrogen, resulting in the release of H_2S as a by-product. Grapes with a **YAN** below about 130 mg N/L are considered nutrient deficient (See **Yeast Nutrition** above). Furthermore, some yeast strains require high levels of nutrients, or are known to form more H_2S than others.
- The formation of volatile sulfides can largely be prevented by testing for YAN and adding the right amount of Nitrogen and other nutrients to nutrient-deficient grape juice/must at the right time. Unless you test for YAN, the best you can do is to assume your grapes have a <u>moderate</u> YAN, based on Brix. Then use a strain that tolerates low nutrient levels, and one that has a moderate to slow fermentation speed, and keep the fermentations warm not hot to minimize Nitrogen demand. If you're fermenting high-Brix grapes, assume their YAN is low, and make your additions accordingly. Furthermore, use a balanced nutrient formulation providing organic sources of Nitrogen (amino acids and peptides) rather than DAP at the start of fermentation, and then follow the manufacturer's protocols. DAP (Diammonium Phosphate) is an inorganic source of Nitrogen (ammonium ions) that are readily assimilated by yeast. DAP can also be used to supplement YAN, particularly when YAN is deficient. It. However, inhibits the development of yeast during the onset of fermentation. In addition, reliance on DAP can lead to an overly vigorous and hot fermentations. Avoid the use DAP for at least the first 12 hours of inoculation. If you know the YAN is quite low, say 120, you <u>can</u> use DAP after 12 hours or more to raise the YAN to150. Products containing DAP should typically be used at the 1/3 sugar depletion stage to avoid rapid yeast buildup. Be prepared, at the first indication of H_2S, to moderately increase nutrient levels. For more information see **Yeast Nutrition** above.

How to respond when reduction occurs:

- At the first indication of reduction, gently aerate the fermenting juice by punching down (reds only) more frequently and a bit more energetically to allow the sulfides to volatilize. Whites can be stirred or swirled with the air lock out to release any volatile Sulfur compounds that can escape though the bung opening. Don't overdo it, and purge the head space afterward with an inert gas.
- Aeration serves to incorporate a minute amount of air into the fermenting wine/must, improving conditions for the yeast.

- Consider using an aquarium air pump to aerate the wine and help dissipate the H_2S (reds). You could probably aerate whites briefly, maybe 5 t o10 minutes, with an air pump.
- Wines stored in air-tight containers (glass and stainless) are, by nature, more subject to reduction because the environment within is very reductive (low oxygen).
- If the sulfite odor subsides, you may be OK. If not, you're probably dealing with low YAN.
- If you smell sulfides early in the fermentation and haven't added any nutrients, now is the time! But unless you know the starting YAN, and can't rule out other possible causes, so your response may not resolve the problem.
    - Begin by adding (0.75g/gal.) of **Fermaid 0** or 1 g of **Fermaid K,** or 0.6 g of **Nutriferm Energy** (Enartis) for <u>each</u> gal of juice or <u>expected</u> juice yield from the must, for example, the yield from 500 pounds of red grapes after pressing, is roughly 35 gal., depending on grape variety and how hard you press.
    - You could instead, add 1g DAP/gal to the must, based on the expected yield and add about 50 mg N/L.
- If the odor started about 1/3rd competition:
    - add 0.75 g/gal (juice or expected wine yield of **Fermaid K**, and 48 hours later add 0.38 g/gal **Fermaid K,** or 0.75 g/gal **Nutriferm Advance**.
- If the problem started about mid-way (12 to 13 Brix):
    - add Scott Lab's **Nutrient Vit End** (20/hL) **or** Enartis **Nutriferm No Stop,** both designed to absorb toxins that may be inhibiting the yeast.
- If it occurred near the end of fermentation or after the wine was pressed early and returned to the barrel or holding-container:
    - adding a little nutrient **Fermaid K** (0.38g/gal), may help the yeast complete the fermentation and hopefully avoid further H_2S production
- Make sure to keep the wine warm.
- Scott Lab's **Reskew** and Enartis' Nutriferm **No Stop**, are designed to be added later than the recommended 12 to 13°B, to reinvigorate sluggish fermentations.
- Low levels of residual H_2S can be removed 48 hours after fermentation by adding Scott Lab's **Noblesse**. It the problem persists repeat the application. It may take several additions to eliminate the odor. Rack 24 to 48 hours later if the odor is no longer detectable, and proceed with MLC.

Oxygen—its role in winemaking:

- White and rosé wines are made in a 'reductive' (low oxygen) environment to preserve fruity notes and develop desirable aromas as they age—to a point. That's why we use SO_2, ferment whites and rosés in closed tanks, leave little or no head-space, purge O_2 with an inert gas, and keep barrels topped.
- By comparison, reds are fermented in open-top containers, allowing them to develop in a 'oxidative' environment.
- The yeast involved in fermentation needs some oxygen to function properly, and need sufficient oxygen throughout fermentation, particular reds, and more toward

the end of fermentation to help build structure and smooth tannins (this is what micro-oxygenation is about).

- Making wine in a reductive (low oxygen) environment, however, encourages the development of sulfides, as well as the more desirable fruity and/or minerally ones. So, the oxygen that enters a wine whenever you remove the bung or rack, helps prevent reduction, but too much of it can lead to oxidation.
- Adding SO_2 too soon after fermentation is done can result in the formation of H_2S. Yeast often remain viable for up to 2 weeks, producing enzymes that can form result in the formation of H_2S. Therefore, it's prudent to hold off for two weeks for the yeast to die and settle out. Not to worry! There is still a lot of CO_2 in the wine to protect it from oxidation. Nonetheless, avoid exposing the wine to oxygen unnecessarily. Hold off on racking as well, until you can make you post-fermentation addition.
- If a wine smells OK after racking, proceed with MLC, if that's your plan.

Mitigating reduction in finished wine:

- Take corrective action as soon as sulfides are detected.
- Stirring may help to dissipate the H_2S, but seldom fixes the problem.
- Bear in mind that H_2S is quickly converted to Mercaptans, and once Mercaptans have formed, aeration can lead to the formation of Disulfides that are even more difficult to resolve, so restraint is important.
- In the case of white wine still on their yeast lees, rack immediately and get rid of the probable source of the problem.
- If the odor in a wine is only slight, you can try adding Scott Lab's **Noblesse** (1 g/gal) and check 24 to 48 hours later to see if that helped. You can do this several times. Hopefully it will do the trick. If the odor is gone, you're good!. Rack the wine, after it has settled for 72 hours to eliminate bound volatile compounds and to dissipate any remaining sulfides. If the odor persists, the next best option is to add Scott Lab's **Reduless**.
- To determine if Disulfides have already formed, place 4 ounces of the wine in each of two glasses, and add one drop of a 1% solution (more than needed) to one of the glasses and mix. Add nothing to the other (control) glass. Cover both and wait for about 20 minutes. Smell the treated glass to see if it has changed, compared to the untreated glass. If the reduced smell in the treated glass is gone, Disulfides have not formed. So, your best option is to add Scott Lab's **Reduless** (10 to 30 g/hL) which contains Copper Sulfate binds that binds with the source of the odors: elemental sulfur, H_2S or Mercaptans with sulfides, forming an insoluble salt that settles out of solution, and is left behind by racking. The benefit of using **Reduless** is that it contains an agent that binds with residual copper that would otherwise remain in solution and affect quality. Treated wine should be racked within 2 to 3 days before MLC is started.
- Follow the manufacturers' recommendations for whatever product you use and use as little material as possible.
- Another option includes the use of ellagic tannins. They bind with H_2S and Mercaptans (if present). Some examples include: **Tan Elevage**, **Tan SLI**, **Tan Max Nature**, **Tan Coeur de Chene** (ideal for reds because of the toasted oak

aromas). It will, though, take some time to work. These tannins can mask Mercaptans, but not Disulfides. Once Disulfides have formed, the only recourse is to chemically convert the Disulfides back to Sulfides. This is discussed below. Disulfide compounds are very stinky and may smell like the odorant used in natural gas.

- The formation of Disulfides makes things a bit stickier to correct.
- The way forward is to convert the Disulfides back to Mercaptans by adding a small amount of **Ascorbic Acid.** Once the reaction is complete, **Reduless** can be added to bind with the Mercaptans.
- Dosage rate is 50 to 100 ppm (mg/L) or 0.22 to 0.44g/gal. I've used the high rate successfully. Furthermore, for the reaction to proceed, the free-SO_2 should be at least 35 ppm.
- One source recommended adding Ascorbic, and waiting 24 hours for the reaction to finish, before adding **Reduless**.
- Another source suggested it may take longer than 24 hours for the reaction to convert the Disulfides to Mercaptans, so they recommended two additions of at least 50 mg/L each. After the first addition, wait 24 hours, and then make the second addition, and wait another 24 hours before treating.
- After 48 hours have elapsed, add a copper-based compound to bind with the odious Mercaptans, rendering them odorless.
- Treatment may take a day or two to work. But once the problem abates, the wine will need to be racked off the sediment as cleanly as possible
- If Tannins are used in lieu of Reduless, they will need time to work, so be patient and monitor for changes. If you add tannins, you don't need to rack at this point.
- Professional winemakers have long used Copper Sulfate to remedy H_2S and Mercaptans, but they use a special fining agent to remove the Copper residue.
- The downside of using Copper Sulfate alone is that wine quality may suffer, because it can bind with varietal thiols and inactivate their associated aromas. For example, the herbal to grapefruit character in most Sauvignon blanc is due to thiols. Furthermore, copper, unless removed can reduce shelf-life, or cause a haze to form (cast)—not an issue for red wines.
- Proceed with MLC once the wine smells OK.
- You may have to start MLC even if you haven't fully resolved the issue. Once MLC is done, you can continue to work on it.

Responding to reduction that becomes noticeable during MLC:

- Stir the wine daily to keep the MLC bacteria and yeast lees if you are allowing the wine to remain on the lees during MLC in suspension, and gently aerate the wine in the barrel or tank, and allow any off-aromas to dissipate. Furthermore, as the lees in suspension settle, they form a compact layer minimizing ca the lees settle and form a cake.
- Volatile sulfides sometimes resolve themselves during aging in an oak barrel due to oak tannins.
- One of the recommended tannins can be used to bind with the volatile sulfides.
- It's probably best to wait until MLC is finished and you've added SO_2 to tackle a persistent volatile sulfide problem.

- It's also a good idea to rack the wine to remove the sediment (light lees), and aerate the wine a bit.

Sluggish or stalled (stuck) fermentations:

- Nearly every experienced winemaker had wrestled with this problem at least once. Stuck (dead in the water) fermentations are a challenge even for commercial winemakers, and unless quickly resolved, result in the loss of the wine or compromised quality.
- This condition is most likely to occur toward the end of fermentation. At issue here, is that conditions for the yeast have become unfavorable or even harmful, slowing or stopping the fermentation before all of the available sugars are converted into alcohol and carbon dioxide. The common causes include:
    - nutrient deficiencies; nutrient availability is critical for yeast metabolism and normal growth
    - inadequate aeration: yeast needs oxygen during the early stages of fermentation. Insufficient aeration can limit yeast growth and fermentation
    - unfavorable temperature
    - the level of alcohol exceeds the yeast's upper limit.
    - toxins substances (biproducts of fermentation) are inhibiting the yeast.

- Fermentations that are slow out of the gate may because not enough yeast was used, or yeast viability was low.
- If you notice that the cap is diminishing or doesn't resurface after punching and the wine is noticeably sweet, the fermentation has undoubtedly stuck—actually the yeast cells are on strike! Toxic by-products are often produced when fermentations become sluggish for various reasons.
- A fermentation is considered stuck if the Brix remains unchanged for more than 48 hours
- When the drop in Brix level seems painfully slow, stir the fermenting wine to resuspend the yeast and remaining nutrients, and provide a little aeration. Make sure the temperature is at least 70°F, if not, warm the fermenter.
- Options at this point include Scott Lab's **RESKUE™**, a proprietary yeast-hull product that removes toxic compounds in stuck <u>or</u> sluggish fermentations, allowing the yeast to function more efficiently. They also market Lallemand's **Nutrient Vit End** that does much the same. Enartis has a similar product: **Nutriferm No Stop.** Keep the wine warm until it reactivates and finishes. If there is no change, you may have to restart the fermentation with a special yeast and follow specific protocols.
- For a sluggish fermentation, try can also try adding a small amount of nutrient: **Fermaid K** (10g/hL), or Enartis **Nutriferm Energy** (10g/hL) to see if the fermentation perks up.
- If the °Brix hasn't changed after 36 hours, you will have to re-inoculate with a special yeast that tolerates high levels of alcohol. Consult the Fermenter's Warehouse to see what yeast they recommend and their protocols for resolving the issue.

- Use a yeast that is very aggressive and tolerates a range of adverse conditions, such as Uvaferm 43™ (Scott Labs). Consult the manufacturers procedures for restarting a stuck fermentation, e.g., Lallemand: The Wine Expert, *Stuck fermentation: Causes and Cures.* Enartis markets EZ Ferm 44 and has developed a procedure: *Restart and/or complete a stuck fermentation.* At any rate, be prepared to do your homework and determine the best approach and dosage rates.
- Once a fermentation sticks (stops), it can be difficult to restart it because the toxins will inhibit new yeast cells added to the batch. You must act quickly to restart the fermentation. The longer you wait the greater the probability that bacteria will proliferate. Essentially, they're opportunists and will consume the remaining sugar, but in doing so taint the wine. The most common wine bacteria include: *Acetobacter*, *Lactobacillus*, *Pediococcus*, *Brettanomyces*, etc.
- **Stab Micro M** (Enartis) and **Bactiless** (Scott Labs), can be used to manage stuck fermentations by preventing Lactobacillus bacterial spoilage, as well as Acetobacter (vinegar-forming bacteria) and *Brettanomyces* or 'Brett' — a horsey, leathery, barnyard, band-aid-like, or just a dirty smell.

End of primary fermentation (whites and rosés):

- Use a good quality hydrometer to check specific gravity and the Brix/Balling reading. Because the alcohol in the wine weighs more than water it distorts the reading. There is still some residual sugar in the wine with a reading of 0°Brix. So you are looking for is a (-) negative number. Thus, a Brix using reading of -1.5 to -2 indicates the wine is essentially dry and contains no fermentable sugar. Although there is still a small amount of sugar left, the yeast ae unable to metabolize it. If you're using a hydrometer with a specific gravity scale, a reading of 0.990 indicates dryness. At that point, the yeast have metaphorically 'throw in the towel'. Remember that you must adjust the reading based on the temperature of the wine. Check the literature that came with your hydrometer. Most hydrometer ae calibrated at 68°F.
- To minimize the production of H_2S in <u>non-MLC</u> wines, wait 2 weeks after the fermentation ends, before adding sulfites. Until the yeast cells have died, they can still produce enzymes that react with SO_2 to form H_2S or other sulfides. Note: I've ignored this recommendation for years and never experienced any issue, but maybe I've been lucky. When the fermentation is complete, the spent yeast (lees) settles to the bottom of the container. It may take several weeks, depending on temperature, for the fermentation to finish.
- **Clinitest test strips** or tablets can also be used to determine if a wine is dry or still contains fermentable sugar. They're inexpensive and readily available.
- The wine should smell fine at this point. If you detect an off-note, take corrective action. See the discussion on **Reduction** above: **Responding to 'reduced' odors during fermentation** above.
- For whites and rosés, you should submit another sample to a wine-lab to test for TA, pH, or run a complete wine-panel analysis. Who said home winemaking was inexpensive?

- Collect a sample of the finished wine for a 'wine' panel analysis (pH, TA, RS (residual sugar), etc. A wine panel test of residual sugar will tell you just how much sugar remains in the wine. A wine with 0.1% residual sugar contains one grams of sugar in a liter of wine. With information you can adjust pH and TA as needed. Small adjustments can also be made later after cold-stabilization.
- There will be some turbidity, but in time it will settle out, or you can hasten its removal by fining with a Bentonite product and/or Isinglass, or Sparkolloid (hot-mix).
- If you prefer crisp, fruity, refreshing whites and rosés, avoid malolactic conversion (MLC). Whites and rosés above pH 3.3 may undergo MLC on their own during storage, or later in the bottle if the SO_2 levels are too low to inhibit the bacteria.
- To prevent MLC, wines can be sterile-filtered or treated with **Lyso-Easy** (Scott Labs) or **Zym LYSO** (Enartis).
- Another option is **Chitosan** (Scott Lab's **Bactiless** or Enartis' **STAB Micro**.
- If Lysozyme is used, treat the wine with Bentonite or Chitosan to remove the unstable proteins that is releases.
- **Malolactic conversion:** can be useful for high acid wines (low pH, high TA). It improves palatability by reducing the tartness associated with Malic acid, and provides additional improvements like microbial stability, and enhanced aromas.
- MLC imparts creamy or buttery taste that gives both red and white wines a richer and creamier texture.
- In general, Chardonnay, Sauvignon Blanc, Riesling, and occasionally Pinot Gris are the only white wines may benefit from MLC. In some cases, only a portion of the wine is inoculated with LAB, and the resulting wine is combined with the original wine to moderate the effect of MLC. This is referred to as a partial-ML wine. The wine, though, must be sterile-filtered or treated a product like **Bactiless** added to inhibit the LAB. If you intend to do a MLC, now is the time to inoculate with a selected culture of freeze-dried LAB.
- MLC can be is initiated in the same fermenter at the end of fermentation along with the yeast lees. The wine is then racked after MLC is done. The problem with this option is that
- Some winemakers prefer to rack following **sur-lie** aging, before starting MLC (For more information see **Starting Malolactic Conversion (MLC): reds and complex whites** below). This gives them the option to rack whenever they are satisfied with the results.
- By the end of fermentation, little or no *free*-SO_2 remains, and the ***total*** is about ½ of the original addition. What remains is bound to various components, for example: acetaldehyde, pigments, solids, sugars, yeast/bacteria, etc. Some volatilizes and some precipitates out in the sediment.
- There is still plenty of CO_2 in the wine to prevent oxidation. But you'll want to refrain from exposing the wine to air as much as possible until you've made your second SO_2 addition.
- Two weeks after fermentation, and before racking, add 70 ppm (that's not a typo) of SO_2 to whites and rosé wines to protect against oxidation, minimize its effects, and prevent bacterial spoilage, as well as malolactic conversion.

- About half of the SO_2 added post-fermentation will bind with components in the wine and is, thus unavailable to do its work. So, if you started by adding 70 ppm, the level will soon be roughly 35ppm, still good, but not for long.
- SO_2 binds with aldehydes produced in wines exposed to too much oxygen. Aldehydes give wine that oxidized taste: flat, tired, bruised apple, or sherry-like aroma. Oxidized whites are yellow to gold in color, not a pale green yellow to pale yellow.
- Check a few days later and adjust to make sure the molecular SO_2 is suitable for the pH of your wine.
- About 70 to 75% of that addition will remain free.
- How much additional SO_2 is needed will depend on pH. In general, grapes in excess of 24 Brix usually have higher pH, and require higher levels of SO_2 than wines with lower pHs. It may be prudent to lower the pH to improve the wines stability.
- Racking to remove the gross-lees, following pressing and settling of white grapes and those used for rosés, minimizes the potential for the stinky sulfury odors to develop. Racking red wine off the gross lees after it has settled, does the same. Grape solids can impart undesirable flavors and aromas, such as herbaceousness, and add a note bitterness to the wine, and often are the source for reduced odors.
- The sulfited wine can be racked after most of the solids have settled (8 to 12 hours).
- The clear wine is racked off the lees by siphoning into a sanitized 'closed' storage container (carboy, beer-keg, or tank).
- Racking aerates the wine a bit and allows off-aromas to dissipate, so it's prudent to add 10 ppm to maintain the correct level of SO_2.
- Replace the air-lock with a solid silicon bung, or air-tight cap/closure.
- Some tanks are closed with a threaded cap, fitted with a rubber or silicon gaskets or 'O'-ring seal. For beer kegs use a 2-inch stainless steel cap with a specially designed 'Sankee' washer (St. Patrick's of Texas) www.stpats.com/index.htm, secured in place by a tri-clover clamp.
- Fill the container to near-capacity, leaving as little head-space as practical to retain aromatic components, and minimize loss of SO_2 to the void above the wine. A little head-space is needed to allow for expansion if the temperature increases. Displace the oxygen in the void with an inert gas such as Argon, Nitrogen, or even CO_2.
- You may choose to age a white or rosé on its lees (sur-lie) after fermentation, and sulfiting, assuming there are no off-odors. Surlie is done to add polysaccharides (unfermentable sugars) to the improve mouth-feel.
- At the end of fermentation, spent yeast cells settle to the bottom of the fermenter, are generally removed during racking. However, if the wine is not racked the gross lees begin to decompose, releasing small amounts of unfermentable sugars (polysaccharides), mannoproteins, and amino acids into the wine. These compounds add a sense of weight, roundness, viscosity, and complexity to the wine, and impart desirable tastes and aromas. Use an enzyme like Lallzyme (Scott Labs) or Enartis Zym Élevage to hasten autolysis (breakdown of the yeast)

and release of nutrients polysaccharides and mannoproteins. Other benefits include improved Tartrate and protein stability. The lees also absorb dissolved oxygen in the wine for several weeks. White, Rosé, and sparkling wines aged on their lees are often described as having a creamy, rich, full-bodied, yeasty, nutty, or toasty quality and have greater depth of character and complexity.

- Surlie (the aging of white wines on their lees) is done in the same fermenter after sulfiting the wine, and filling the container to near capacity to eliminate as much head-space as practical. Allow a little space for expansion that will occurs when the wine warms. Another approach is to add an additional 10 ppm SO_2, stir up the lees, and allow it to settle. Rack the cloudy wine within an hour or two and then transfer to the new aging container, leaving the heaviest sediment behind.
- Polysaccharides products mimic surlie aging and are a substitute for lees. Some winemakers use it when the lees in their wine smells dodgy.
- To elevate polysaccharide content of a wine by adding various products, such as Enartis: **Pro R** or **Pro Arom** (added during fermentation) or Scott Lab's: **Booster Blanc**, **Opti-White**, or **Noblesse** during fermentation.
- **Nobless** has other advantages such as imparting a sensation of sweetness, mitigating off-odors, and the sensation of dryness from tannins, and the hotness from too much alcohol in the final wine. Furthermore, Nobless can be added after fermentation to improve mouthfeel.
- Aging white wines on their lees has been shown to reduce oxidation, to improve wine stability, aroma, body (by increasing the level of Polysaccharides), and reducing astringency.
- Lees contact is commonly done for 2 to 8 weeks, or until the wine is racked prior to bottling. I routinely allow my whites to remain on their lees until February or even March, when I'm getting the wines ready for bottling. I've had some issues with long lees-contact with Rosés. Now I'm using an enzyme to hasten yeast autolysis.
- Enartis' **Surli Elevage**, **Surli Round**, and **Surli One** can be added during maturation to increase the level of polysaccharides. Surli Elevage works quickly and can be added several weeks before bottling.to soften a wine. It needs 48 hours to settle before racking or filtering.
- Stir the lees 3 to 4 times a week for the first month to prevent the help prevent the development of reduced odors (sulfides). The lees will absorb O_2 for about 6 weeks, reducing oxidation potential. Stir 1 to 2 times a week thereafter.
- When stirring, try to suspend the entire layer of sediment and yeast on the bottom. You can buy a special stirring tool used in France to do what they call 'battonage' to stir the lees, or find a tool that does much the same. Stirring also helps to make the wine less reductive.
- The length of time the wine spends on the lees will depend on the complexity desired. Commercial wines are commonly aged for 4 to 6 months or longer, particularly chardonnays.
- Smell and taste the wine at each stirring to make sure the wine is progressing as intended. If off-aromas develop rack immediately. If the odor has not dissipated after racking, you may need to treat the wine for reduction (see **Responding to 'reduced' odors during fermentation** above).

- Rack, if the wine develops off-aromas or the desired character is achieved.
- Maintain proper SO_2 levels throughout surlie aging, unless the wine is undergoing MLC.

Fining agents for whites and rosés after fermentation:

- **Bactiless**—a product manufactured by Scott Labs intended to prevent MLC in wines, also inhibits bacteria that form acetic acid, as well as other spoilage bacteria.
- **Bentonite**—the recognized treatment to remove unstable proteins in white and rosé wines that typically settle out later when the wine is warmed.
- **Chitosan**—use to remove unstable protein, inhibit spoilage bacteria, including MLC bacteria, and oxidation by targeting specific chemical compounds, binds with heavy metals such as copper and iron. Useful when treating wines with reduction (H2S, Mercaptans, and Disulfides. Effective in settling and clarification of juice and wine, and removal of oxidized polyphenols.
- **Isinglass**—an old standby, excellent for clarification, adding brilliance, reducing bitterness, and improving aromatics. The dosage rate is 1 to 4g/hL), You can add it with Bentonite and/or Silica dioxide (both act as counter-fining agents that speeds settling). Wait for 2 to 3 weeks for it to settle completely.
- **Potassium Caseinate**—this milk protein works well to reduce astringency and bitterness by binding with excess phenolic compounds. It is also used to treat oxidized (brown) must.
- **Non-fat milk**—reduces bitterness in white wines, and adds a touch of sweetness. Follow with Bentonite fining. Rack after 4 days, and do at least one month before bottling (20 to 50 ml/gal).
- **Whole milk**—reduces harshness, and absorbs aldehydes. Follow with Bentonite. Rack after 4 days, and do at least one month before bottling (20-50 ml/gal).
- **PVPP**—removes browning or bitterness in juice.
- **Stabyl MET** (Enartis)—removes copper, prevents copper haze following treatment with copper, and limits oxidation (pricey).
- **Silica gel** or Silica dioxide, aka Kieselsol (SiO_2) — a counter-fining agent, commonly used in conjunction with Bentonite, gelatins, Isinglass, and other organic fining agents to help compact the lees, and reduce risk of over-fining (25 to 100ml/hL).
- **Stab Micro**—a product manufactured by Enartis: can be used during fermentation or after as a fining agent to remove bacteria, particularly those that chemical compounds.
- **Tannins**—ex**.,** Tan Max Nature (Enartis) to mitigate herbaceous reductive notes, and add softness

End of primary fermentation for red wines:

- Other than the initial addition of SO_2 at the start of primary fermentation, do **not** add more SO_2 until after MLC has been initiated and finished.
- The next step is pressing.

- Another option is **extended maceration**
- Finished red wine can be left in contact with their skins and seeds for several weeks or longer to 'soften' the tannins and decrease bitterness. It seems counterintuitive, but the additional time on the skins, can soften the tannin structure of varieties that are typically tannic or astringent (Cab and Syrah, Petite Sirah, etc.).
- If you want to try this, inoculate the finished wine for MLC at this point.
- The process increases tannin levels, but is thought to cause them to lengthen (polymerize) by binding with other tannin molecules. This serves to create richer, more supple wines with less bitter tannin. Small tannin molecules are more bitter than those that are larger (polymerized). Blanket the finished wine with CO_2. Dry ice pellets (welding supply stores) and seal the container with plastic wrap. Keep the temperature warm — 68°F or higher—ideal for MLC (electric blanket).
- Bear in mind that LAB also release CO_2.
- One very respected commercial winemaker said that he smells and tastes the lees every day to check for reduction. He inserts a clean ½-inch diameter stainless steel tube to the bottom of the barrel, holding his thumb over the top of the tube, then removes his thumb and quickly replaces it. In this manner, some of the lees is forced by atmospheric pressure into the tube for sampling. Slick!
- If it starts to develop off-odors, press the wine to remove the problematic lees and allow MLC to finish.
- Knowing when to press can be tricky. When the tannin structure has improved perceptively, it's probably time to press. Depending on multiple factors, maceration time can range from 10 to 70 days, or even longer. More typically it's 2 weeks.
- This technique is best suited for more advanced home winemakers because problems are more likely to develop. It doesn't always result in a better wine. Some wines may not improve, and color may be slightly diminished. Do your homework before you give it a go.

Pressing reds:

- In most cases, red wines are pressed after completing primary fermentation.
- Reds may, however, be pressed early (around 3 to 5 °B) to make fruitier, lighter, less tannic wines. The fermenting wine is settled and racked to a barrel or an air-tight fermenter under an airlock to finish fermentation.
- Pressing red grapes is easier and faster than pressing whites because the pulp—the fleshy/juicy portion within fermented the grapes has been converted to wine, and the skins are soft and pliable.
- The process of pressing red grapes is much the same as that for white grapes (see **Pressing white and red grapes for rosé** above). Bladder pressing is gentler than a basket press—and generally results in wines that are less harsh and bitter.
- There is little difference between the wine that flows early with that that flows under light to moderate pressure. However, when the 'cake' (skins and seeds) becomes more hard-packed and flow dwindles to a narrow stream, the resulting wine may be somewhat astringent.

- Hard-press wine can be fined and later combined with the free-run if needed, without significantly diminishing quality. Fining agents: **Plantis AF-P or Plantis PQ** (Enartis) or **Colle Perle** (Scott Labs) are effective at reducing harshness and astringency. Allow the treated wine to settle, and then rack.
- Excess bitterness can be removed with **Claril SP**, **Combistab AF,** or **Protoclar** (Potassium caseinate) (Enartis). Isinglass with silica gel is also good for bitterness.
- When using a basket press, fill it to about 80% capacity, and take your time to avoid extreme pressure. Allow the 'cake,' hard-pressed skins, and seeds to 'rest' between cranking. Emptying the basket and repacking can often increase yield. It is a lot of work, though, but may be worth the effort if you really need an extra gallon or two.
- Bladder presses use an outward-expanding bladder to press grapes against a surrounding perforated stainless-steel screen. They typically operate using water pressure to inflate the bladder. They are gentler than basket presses, and are thought to produce wines that are less harsh and bitter.
- Bladder presses work well at low pressure, 8 to 12 PSI is sufficient. Avoid the temptation to crank it up.
- Bladder presses are designed to be filled-to-capacity, but don't pack the grapes, even if there is only a small amount left. These can be added after a brief period of pressing. You only need to create enough space to accommodate the amount that is remaining. If you have a lot of grapes you may need to fill the basket several times.
- When you don't have enough grapes to fill a bladder press completely, partially inflate the bladder to reduce space around it until the grapes will just fill the void without leaving much open space. It's not a good idea to inflate bladder unless the basket is filled. Otherwise, the bladder will not inflate uniformly, and is more likely to rupture.
- If you have enough wine to fill your barrel or storage container with free-run and light-press wine, keep the hard-press wines separate, allowing you to decide what to do with it later, such as mitigating any perceived astringency—usually by 'fining.'
- Some people press long and hard to maximize yield, but quality toward the end can suffer. Some use the hard-pressed wine (when you get down to a thin stream of wine, in blends, or even discard it — quelle dommage! Many people simply combine all but the last gallon or two of wine into one lot and make the most of it.
- I've found that when you have been pressing for a while, and are down to a narrow stream, that quality is not as good as when the flow is freer.
- Taste the wine as the flow diminishes. Wine that tastes perceptibly harsh should be kept separate, and then fined (treated) to make it more palatable.
- Remember, tannins are not necessarily the enemy; they are indispensable for developing supple structure in red wines. It's how you manage them later that makes all the difference.
- Filling the press: Bucket the finished wine from the fermenter directly into the press. When you reach the bottom of the fermenter, pour or scoop up the seeds

and remaining juice and pass it through a large sieve to separate the seeds from the wine. This is thought to minimize harsh seed tannins in the wine.

- It's convenient to collect the freshly pressed wine in 5-gal carboys, preferably food-grade plastic, for settling. So, you may need to invest in a dozen or more. They're manageable and can be elevated on a table-top or platform as needed to facilitate racking (siphoning).
- Collect the wine as it flows from the press in 2 to 2.5-gal buckets and transfer it to waiting carboys. Use a large funnel to fill the carboys. Have a couple back-up buckets handy, to avoid overflow when you can't transfer the wine fast-enough to a carboy, and things begin to back up quickly with disheartening consequences. I've seen buckets overflow while someone was preoccupied with poring the wine from a bucket slowly and methodically, so as to avoid spillage. So, you would do well to practice this essential and challenging task.
- Place a large kitchen wire-mesh sieve in the funnels to trap the seeds, skins, bits of stems, bees, yellowjackets, and other detritus for disposal. You can also use a larger sieve that straddles the receiving bucket.
- Fill the carboys to near capacity and close with a solid silicon bung.
- Allow the press-wine to settle for 8 to 12 hours.
- Elevate the wine-filled carboys to transfer (rack) the settled wine into a barrel or storage tank. Use a siphon wand or ½ inch ID clear plastic siphon-hose and insert a ½ barbed hose connector. Next, attach a siphon baffle to the end of the bark. A baffle is a devise designed to divert flow, in this case, it functions to draw wine from above, rather drawing it from directly above. In this manner you can avoid picking up much of the sediment.
- Suspend the baffle -end of the hose in 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 or pick up much sediment. This will maximize yield.
- If you transfer press-wine directly into the barrel without first removing the **gross lees**, you'll need to rack the wine within a few days. These solids, if left in the wine for more than a few days, are likely to impart harshness, bitterness, and vegetal notes, and the formation of smelly sulfur-based compounds.
- Fill barrels or other storage containers to near capacity, allowing only a small amount (an ounce or two at most) of head-space. Displace air from the head-space with inert gas like Argon.
- In preparation of MLC, use a silicone 'air-lock' bung for a barrel. One design allows them to be placed over the necks of carboys, as well as beer-keg. This type of bung is designed to allow CO_2 to exit, but prevents air from entering. Variable or fixed-capacity capacity tanks will need to be fitted with airlocks during fermentation and MLC.
- At this point, you're ready to start ML.

Starting Malolactic Conversion (mostly reds):

- Malolactic conversion (MLC) is typically done at the <u>end</u> of the fermentation in closed containers or barrels fitted with air-lock to minimize oxidation.

- Lactic acid bacteria (**LAB**) convert Malic acid to Lactic acid—a weaker acid, effectively lowering the wine's acidity. TA may drop by 1 to 3 g/L, and pH may go up as much as 0.3 pH units.
- LAB, in general, are intolerant of high alcohol, low pH, and SO_2 (free and bound), and are largely inactive below 60°F. Greater than 10ppm free-SO_2 (free-SO_2), and 50 ppm total will greatly inhibit them. This is seldom a problem when the initial SO_2 addition is less than 50ppm.
- Strains of *Lactobacillus* and *Pediococcus* can readily grow. When pH is 3.8 or higher.
- Bear in mind, that very little free SO_2 is present by the end of fermentation. So, even if you initially added 50 ppm SO_2, as is customary, the total is significantly less than 50 ppm. Unless you added 100 ppm or more SO_2, and residual free-SO_2 in excess of 10ppm is unlikely.
- By and large, nearly all reds and a few white varieties are inoculated with a freeze-dry culture of **Lactic acid bacteria** or allowed to start naturally at the end of 'primary' fermentation—the conversion of sugar to alcohol mediated by yeast. Malolactic Conversion is initiated by adding selected strains of LAB to metabolize Malic Acid to Lactic Acid, so it is not a fermentation, so to speak. It can, though, happen spontaneously after fermentation, while the wine is warm (>68°F), and SO_2 levels are low, or soon after a new wine is racked to a used barrel that had previously been used to for MLC. It may not start, though, until the following spring because the weather usually turns cold after red grape harvest.
- Some whites, like Chardonnay benefit from MLC. Most other white varieties like Sauvignon blanc, Riesling, Pinot Gris, Viognier, etc., lose their characteristic crispness and some of the varietal characteristics. The trade-off is a softer, more complex wine and a richer mouthfeel.
- White wines above pH 3.3 may undergo MLC on their own during storage, or later in the bottle if the SO_2 levels are insufficient to inhibit the bacteria.
- Lysozyme (**Lyso-Easy** (Scott Labs) or **Zym LYSO** (Enartis), **STAB Micro** (Enartis), or **Bactiless** (Scott Labs), can prevent ML fermentation, or stop it before it finishes for stylistic purposes.
- Whites and rosés can also be sterile-filtered to prevent MLC.
- A range of selected strains of the bacterium *Oenococcus oeni* are available., each its own specific attributes and tolerances.
- Indigenous LAB bacteria are typically present on grapes and may begin the process spontaneously. The reality, though, not all 'natural' LAB are reliable, or produce desirable results.
- Although MLC often starts spontaneously, most winemakers use commercial cultures because they have been selected for specific attributes, such as low pH tolerance, high alcohol and/or SO_2 tolerance. They are also convenient to use, start working quickly, dominate the fermentation, and complete the process within 3 to 4 weeks, after which the wine can be sulfited and racked if needed. They also take less time to finish than the native bacteria.
- Some wineries rely on whatever yeast and bacterial are on the skins of grapes delivered to the winery, or what is 'lurking' in the winery—seems to work for

them. But some winemakers have admitted that they had to intervene in some cases when things got dicey.

- Wines are usually inoculated (**sequentially**) with LAB bacteria added at the end of fermentation. In this manner, yeast cells don't have to compete with the LAB for nutrients. There is some concern that they can convert some of the sugar to volatile acidity (vinegar) during alcoholic fermentation, or more likely if the fermentation sticks.
- Some winemakers, however, prefer to add LAB shortly after inoculating with yeast. This is referred to as **simultaneous** or **co-inoculation.** In this manner, MLC is complete by the time primary fermentation finishes. The risk is that if the fermentation sticks, the bacteria may convert the residual sugar to vinegar. Not a welcome addition to wine.
- Another issue with simultaneous fermentation is that fermentation temperatures must be monitored and managed more carefully at various sugar levels, because LAB are sensitive to high temperature. Scott Labs's catalogue lists critical fermentations temperature at various stages of fermentation for their co-fermentation ML cultures.
- The optimal temperature range for LAB is 68 to 77°F. Below 60°F and above 77°F is stressful to them.
- The temperature range ML bacteria can withstand is highly influenced by alcohol concentration. The higher the alcohol in the wine, the lower the MLF temperature should be. The ideal temperature during sequential inoculations is 20°C (68°F). Not ideal for most reds.
- Specific LAB and yeast cultures are recommended for doing simultaneous fermentations. Protocols have also been developed to prevent the formation of Acetic acid.
- Advantages of co-inoculating (fermenting) include fresher, fruitier wines, with minimal buttery notes, and MLC finishes shortly after the alcoholic fermentation. Furthermore, the wine does not need to be kept warm and SO_2 can be added shortly after primary fermentation. There is also less potential for oxidation and bacterial spoilage, such as Brett. Sequential inoculation typically takes 3 to 4 weeks but up to 6 to finish. So, the time spent monitoring MLC and stirring the wine daily to keep the LAB in suspension, is saved.
- Co-inoculation should be done 24 to 48 hours after yeast inoculation, depending on the initial SO_2 addition. This gives the SO_2 added time to dissipate and bind up after crushing.
- A specific strain of LAB culture (Scott Lab's: **Beta Co-Inoc)** is recommended when doing co-inoculation.
- Grapes with low YAN levels, Brix above 25, and with a free SO_2 level greater than 60 at crush are <u>not</u> good candidates for co-inoculation.
- Some ML culture used for sequential inoculation, or naturally occurring strain on the grapes, may impart a buttery (lactic acid) quality, particularly in Chardonnay.
- Winemakers wanting to retain more natural acidity, stop the MLC by sterile-filtration, or treat with one of the products listed above, when the desired acidity level is achieved. This is referred to as a <u>partial</u> MLC.

- (MLC following fermentation known as **sequential inoculation,** enhances spiciness, texture and complex fruit notes, while minimizing the vegetative and herbaceous flavors.
- MLC proceeds typically slowly after fermentation due to the high alcohol content and low nutrient levels, that's why ML nutrients are strongly recommended.
- Commercial MLC cultures have been selected for their tolerance to high alcohol and SO_2 levels.
- Scott Labs makes several freeze-dried bacterial cultures for sequential inoculation of wine. **Alpha** works on wines up to 15.5% alcohol, and up to 50 ppm (total) SO_2. It also works at temperatures > 57°F. **Beta** work on wines up to 15% alcohol and up to 60 ppm total SO_2.
- All of the ML cultures currently on the market, must be kept frozen from the time of purchase till when they are hydrated and added to wine. Viability is affected, If they are allowed to warm up.
- Enartis offers two useful LAB cultures: **Enoferm ML Silver** (alcohol to 15+, pH >3.1, 45 total and 10 free SO_2) and **Enoferm ML One** (alcohol level to 14, pH >3.2, 40 total and 10 free SO_2).
- **Hydrating the LAB**: the freeze-dried bacteria, packaged in foil pouches must be rehydrated before adding to the wine. Follow the manufacturer 's procedures. Each packet contains 2.5g of LAB—enough to treat 66 gallons of wine. Add the content of the pouch to 50 ml of bottled (filtered) water, swirl or mix, and allow the bacteria to hydrate for 15 minutes.
- **Inoculation:** Scott Labs offers a rehydrating nutrient: **ACTI-ML** used to rehydrate the LAB bacteria, favor quick population buildup, and ensure that the MLC goes quickly and finishes. Use 10g per hL (~25 gal) of wine. Mix in 5 times its weight in bottled water at about 68°F, add bacteria, swirl, and wait 15 minutes before adding the bacteria solution to the wine. Enartis offers **Nutriferm Osmobacti**, an activator that improves bacterial survival and increases the speed of Malic acid conversion. Use it at the rate of 2 g per hL in the 100 ml of water. Combine the bacteria that has been rehydrated for 15 minutes. Wait 2 to 4 hours before adding the combined mixture to the wine.
- Enartis also offers **Nutriferm ML** (a LAB nutrient used at the rate of 20 to 30 g per hL of wine (0.77 to 1.14 g/gal). Add it to 20 times that weight of water, stir to mix, and add to the wine.
- Both the ACTI ML and the Nutriferm ML are very useful if you had a H_2S problem during the primary fermentation, or the grapes were very ripe.
- Once inoculated, and MLC nutrients have been added, stir the wine daily to keep the bacteria in suspension until MLC is done. If the wine is still on the lees (white wine), stirring will facilitate the release of nutrients in the dead yeast, needed by the ML bacteria. Otherwise, the lees will quickly settle to the bottom, forming a compact layer, which reduces nutrient availability. An enzyme (Scott Lab's **Lallemand MMX**) helps release the nutrients and other substances like polysaccharides and mannoproteins.
- Although nutrients contained in the light lees remaining at the end of the primary fermentation (reds, and whites racked off their yeast-lees, provide some nutrients for the developing bacteria.

- Ideally, the temperature of the wine during MLC should be 68 to about 75°F for a quick ML conversion. Anything above 77°F will stress the bacteria. You can use a small space-heater safe to use indoors to warm the room, but that's expensive. An old electric blanket is a good way to warm the wine, but they typically operate for 9 hours and then turn off automatically. So, you will have to turn in on at least every twice a day to keep the barrel/container warm. Some amateur winemakers use a small submersible aquarium-heater inserted through the bung hole. You'll have to find some way to keep air from entering around the wire attached to the unit. Perhaps you can use a silicon bung that has a longitudinal cut to the center hole in where you can insert the wire/cord ace around the wine—be creative.
- Once inoculated, and the MLC nutrients have been added
- CO_2 bubbles are released as Malic acid is metabolized. If you put your ear to the bung hole you can hear faint fizzing or crackling as gas bubbles break the surface and pop. While, the fermentation is active, the CO_2 gas being released will protect the wine from oxidizing. But when the reaction is winding down and the airlock is being removed frequently to check on progress, oxidation can occur.
- Keep barrels topped up and purge the air in the head-space in the tank or barrel with Argon, CO_2, or Nitrogen gas every time you remove the airlock to stir or check progress.
- When you can no longer hear the fizzing sound, test the wine to see if the MLC is done.
- It usually takes 3 to 4 weeks for MLC to finish, sometime as long as 6 weeks, depending on temperature and other factors. Factors affecting rate of MLC include:
    - SO_2, both free- and bound
    - concentration (percent) alcohol
    - pH
    - Temperature mg/L Malolactic acid in the wine; it can vary widely
    - ML culture
    - Nutrient availability
- Usually, the warmer it is, the faster the process.
- Unless you are using some means to warm the wine, MLC is unlikely to finish that year. You'll have to wait until the following spring when your cellar warms up again, assuming the wine isn't stored in a cool cellar.
- Test to make sure that the wine has completed MLC, before adding sulfites. If there is still residual Malic acid, you risk that MLC will restart after you've bottled, despite sulfiting. This will produce some carbonation. Probably not what you had in mind. You could of course sterile filter of use one of the Chitosan products to inhibit LLC after bottling.
- I've seen MLC restart again later while still in barrel the following year, despite a moderate level of sulfite. The resulting wine was quite good—go figure!
- An ML test reading of 30 ppm Malic acid or less, indicates completion.
- By the end of MLC, little or no *free*-SO_2 remains, the vast majority is in the bound form.

- Once MLC is done, add 60 ppm free-SO_2 for reds and 75ppm for whites. Replace the air lock with a solid silicon bund or use the air-tight screw-cap/lid included with your fermenting container.
- Red wines are typically, but not necessarily, racked after MLC.
- Racking after MLC, removes sediment, but also allows off-aromas to dissipate, and incorporates some oxygen needed to moderate tannins.
- Racking allows you to manage tannins to suit the style of wine you're making. If the object is to increase exposure to soften harsh tannins, rack the wine. after MLC, and one or more times before bottling. If tannins levels are low as with Pinot Noir, you can skip the post-ML racking and rack before bottling. For more information, see **Post-ML Racking** below.
- Fill the barrel to near the bottom edge of the bung hole. Leave a little space (the space occupied by maybe half an ounce, in tanks to compensate for expansion for changes in temperature. I've seen wine well up through the bung of a stainless-steel drum as I loosened the threaded cap. This occurred during a hot spell when the power in my cellar was out. Invariability as the temperature rose, the wine expanded, creating pressure within the tank.
- Wines retain more free-SO_2 and aromatic components when the void between the wine and bung or tank closure is as small as practical, and contact with air is minimal.
- For whites, rack after MLC to remove any sediment, particularly if the wine was being aged sur-lie.

Post MLC sulfite addition: and adjust acidity as needed:

- Add 60 ppm SO_2 after MLC for reds, and 75 ppm for whites at the end of MLC, particularly those with a pH above 3.5. This may seem high, but about ½ of the SO_2 added post-fermentation will bind up with components in the wine and become unavailable to do its work. When later additions are made, more SO_2 (about 70 to 75%) remain free.
- Check the sulfite level after a few days and adjust to make sure the molecular SO_2 is suitable for the pH of your wine.
- How much additional SO_2 is needed will largely depend on pH as well as exposure to air depends.
- Wait a couple of weeks, check the SO_2 level and readjust, as needed to the targeted number.
- Home winemakers commonly don't add enough or as often as needed. Occasionally, they add too much, because they get the math wrong. So, always double check.
- After MLC, you should submit a sample for a complete wine panel analysis to see how pH, TA have changed, percent alcohol, residual sugar, level of VA, and remaining Malic acid.
- TA will have decreased by as much as 2 g/L and pH will have gone up as much as 0.3 pH units.
- If the pH is above 3.65, reduce it by adding Tartaric acid, so that is closer to 3.60. This will facilitate the precipitation of Bitartrates and lower the pH at the same time—sweet!

- Now check TA, because it will have increased by adding Tartaric acid.
- If should be about right, or perhaps a little higher than desired, but remember excess Tartaric Acid will drop out of solution over the winter, driving TA down.

Post-MLC: Racking:

- Racking reds again after MLC, allows off-aromas to dissipate and incorporates some oxygen needed to moderate tannins. If your objective is to expose the wine to oxygen to soften tannins, then rack after MLC, and perhaps once again prior to the final racking just prior to bottling. If tannins levels are low as with Pinot Noir, you can rack once just before bottling.
- Racking is the process of transferring a wine by siphoning, pumping, or using pressurized gas delivered through a special transfer tool, from one container to another, or back to the original container, allowing the sediment "lees" to be removed. It can be done post MLC or later during aging.
- How often winemakers rack, varies. In general, the more tannic a grape variety, vineyard, or vintage, the more the wine is likely to benefit I) from additional rackings.
- Most home winemakers rack their red wines 3 times:
  - **First:** is made post fermentation after the wine has been pressed and the sediment allowed to settle for 8 to 12 hours. The wine can then be racked, leaving behind the **gross lees**.
  - **Second:** just after MLC (following sulfite addition), to remove the **fine lees**, and the
  - **Third:** just before bottling to remove additional pigments and sediment.
  - Some winemakers prefer to rack just twice: once after pressing and settling a recently fermented red, and again just before bottling.
- Long contact with the fine lees may add complexity, and greater retention of tannins. The down-side is less exposure to relatively small amounts of air which soften tannins and increase body.
- Racking soon after MLC finishes, allows the sediment (fine lees), dead bacteria, and minor solids, to be removed.
- Racking introduces some oxygen, discouraging reduction, and allows reductive odors, <u>if</u> present, to dissipate, and softens tannins.
- Others winemakers prefer a 4th racking—after the second one and before the final racking prior to bottling.
- Initially, the tannins in young red wines consist of short chains of phenolic (bitter) substances. However, with time, these tannin molecules begin to link together in longer chains —a process called polymerization. One theory is that it reduces the tannins' reactive 'surface', thereby softening their mouth feel. Texture is useful to describe the sensation that tannins cause in the mouth, i.e., harsh, grippy, moth-drying, silky, plush, r velvety, etc.
- Wines in the Bordeaux that are typically more tannic than those in warmer regions, are often moved several or more times from barrel to barrel to soften harsh tannin, enhance aromatics, and provides a small amount of oxygen to help with the aging process.

- Racking, when carefully done, exposes the wine to small amounts of oxygen that can help soften tannins via polymerizations.
- One commercial winemaker stated that "If you're trying to create a wine that's more approachable, you might rack more, and if you're aiming for one that's more age-worthy, rack less."
- Commercial wineries may rack more often, but they can control exposure to oxygen much better than most home winemakers.
- Excessive racking is time-consuming, and may be counterproductive because it may over-expose the wine to air, particularly if your SO_2 levels are low, potentially leading to oxidation and loss of aromatics, or a wine that lack the desired tannin level.
- It's not always straight forward. Damn!

Bulk storage and aging:

- Sulfite considerations during wine storage and aging:
- Because white wines and rosés are more subject to oxidation, they require a higher level of SO_2 than reds.
- Research indicates that maintaining 0.8 mg/L of SO_2 ('molecular') throughout the aging process, and at bottling provides adequate resistance to oxidations. Red wine, with their protective tannins, need only 0.5 mg/L of SO_2 (molecular) to provide similar protection.
- The term '**molecular'** is simply SO_2 gas (the un-disassociated 'molecular' form of SO_2, when added to grape juice, must, or wine, rather than one of its ions: HSO_3^- (Bisulfite) or the SO_3^{2-} (sulfite).
- The table below shows the free-SO_2 levels for a range of pH levels values, that will ensure the correct molecular levels for whites and reds.

pH	**0.8 ppm**	**0.5 ppm**
	White Wine	**Red Wine**
2.9	11 ppm	7 ppm
3.0	13	8
3.1	16	10
3.2	21	13
3.3	26	16
3.4	32	20
3.5	40	25
3.6	50	31*
3.7	63	39*
3.8	79	49*

- **Red wines**: updated free -SO_2 needed to maintain a 0.5 ppm molecular level.
  pH SO2 ppm or mg/l
  3.4 20
  3.5 25
  3.6 **30 ppm.** At 3.6 and higher wine is protected by some other means*.
  3.7 ⇩

3.8—you're on thin ice!

- Determine the baseline molecular-SO_2 level and avoid deviating from it too much.
- 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 often enough. Another possibility is that the barrel, tank, or container may not be air tight.
- Keeping the SO_2 levels a little higher than what is recommended for the pH, will help avoid levels dipping significantly below the desired level between SO_2 tests. A little cushion will ensure that the wine is adequately protected between additions.
- Fewer, larger additions are better than many small ones. It shocks the bacteria more, and the free/total ratio is more favorable.
- Keep barrels topped-up and the head-space in barrels and other containers should be as little as practical.
- Low humidity in cellars increases evaporative water/wine loss from barrels, and the need for more frequent topping. You may need to top as often as every 2 to 3 weeks.
- If your barrels are 'tight' a strong vacuum will develop inside as the wine evaporates. It makes the bung more difficult to pull and makes a sucking or whooshing sound when the vacuum is broken. Tight barrels can go longer between toppings. Even tight barrels still allow some air to naturally enter through the porous wood.
- I've noted that the upper staves are prone to drying out, particularly if there is a lot of air space, allowing them to separate a bit. Consequently, air enters the barrel more readily. That's why topping is so important. Another potential issue is cracks that develop on either side of the bung. You can fill these with barrel wax. 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. This is best done when the barrels are dry. Another problem is that the silicon bung may not be firmly seated in the bung hole. And it's not uncommon for barrels to develop visible leaks. Barrels in cellars that are open to the outside or where the door is often left open are susceptible to *lead cable borers* (beetles) that burrow into the wood — usually the crevice where the curved staves meet the '*heads'* (flat surfaces at the ends of the barrel).
- The situation may arise when you don't have enough wine to completely fill the barrel or container you plan on using. You' may be tempted to fill it part way, leaving a large void. The problem is that aromatics and SO_2 escape into the head-space in partially-filled containers. Your best option is to buy a couple of smaller containers, for example a reconditioned 30-gal barrel if you can't fill a 60-gal tank. Who said this was going to be cheap? For example, you can buy a range of sizes of plastic food-grade fermenter/ tanks (Speidel: 30-, 15.9-, 7.9-, and 5.3-gals). You can also buy used beer-kegs in 15.5-gal and 7.5-gal, and 5-gal size. There is also a 10-gal stainless tank designed for beer the market. Another option is making a blend, if you have additional wine of another variety—

that is reasonably good. You can also buy a case (about 2.5 gal) of an inexpensive wine like '3-Buck Chuck' to use as a filler. It's actually not bad.

- Because stainless steel tanks are essentially air-tight, free-SO_2 levels decrease more slowly than in porous oak barrels, unless there is a lot of head-space, or the containers are opened frequently. Both FlexTanks and Speidel make fermenting containers composed of a special 'pervious' plastic which allows a minute amount of air to interact with the wine. Check the sulfite level of wine stored in such containers a little more frequently.
- I've noted that with Speidel 15.5 gal tanks you need to check that the removable lid makes an air-tight seal after tightening the compression strap. Pressurize the tank by blowing air into the open petcock at the base of the tank. You can see or feel the lid rise. Close the petcock quickly without allowing the air to escape. Listen for air leaks, and if the tank lid is still arched upward after 20 minutes or longer, the seal is good. You could also immerse the top of the container in water and look for bubbles
- 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 or immediately afterward.
- Check the free-SO_2 level a few days later to see how the wine responded.

Limiting the loss/use of SO_2 in storage:

- SO_2 is lost to the head-space above the wine in closed-containers, and ultimately, the atmosphere, every time a container is opened to taste or smell the wine, or add something, or stir the wine. It also binds with chemical components that form when the alcohol is exposed to air.
- Fill containers to near-capacity, but allow a little space to accommodate expansion if the wine is warmed.
- Make sure oak barrels don't leak, and also use a silicone bung to make an air-tight seal, and purge the headspace with inert gas, every time you open a barrel or tank.
- Add a little (5 to 10 ppm) SO_2 when you add wine-making products to your wine, particularly oak alternatives: oak chips, cubes, sticks, inserts, etc. The latter add a lot of air to the wine. They are porous, after all.
- Cellars should be cool. A temperature of 58°F is good ideal for whites and 59 to 63 is ideal for reds. Heat increases the rate at which wine oxidizes, so more sulfite will be needed sooner the warmer the room. More importantly, bacterial problems are more likely to develop.
- Air conditioners are go0d to keep temperatures low, but have a limited capacity to cool the room to less than 64° There is at least one electronic device, e.g.—the CoolBot that can override the thermostat in most air conditioners, allowing them to refrigerate small rooms to the ideal temperature.

Cold-stabilization:

- Tartaric acid, naturally present in grapes and finished wine, precipitates from solution during fermentation, and later during the winter when temperatures drop, or when the wine is intentionally chilled or refrigerated. Although wines typically lose much of their excess Tartaric acid during fermentation, they still contain unstable levels. Excess Tartaric acid, unless removed, will crystalize later during storage, and in bottles that are chilled. The 'tartrate' crystals on the inner surface of carboys, tanks, barrels, and sometimes at the end of a cork or bottom of the bottle are composed of Potassium Bitartrate — a salt, formed when K^+ ions and Bitartrate ions in the wine bond together. This will continue until the acid concentration reaches equilibrium.

- Chilling and the addition of materials such as Bentonite or cream of tartar (Potassium Bitartrate) or a pinch of bentonite can be used to 'seed' the reaction and hasten cold-stabilization. Also, the lower the pH and higher the TA, the greater the likelihood of crystallization. This is more of an aesthetic issue because tartaric acid crystals are harmless, but unsightly, and some people mistake them for glass.
- Unstable Tartaric acid can be removed by chilling a wine for an extended period. Allowing the temperature in the cellar to drop to 40°F for 2-3 weeks, or chilling to 32°F for at least 36 hrs. is effective. A spare refrigerator will do the job nicely for wine in carboys. A cold garage in the winter is usually sufficient to facilitate the process in larger containers.
- I typically roll all my whites in stainless kegs and drums and plastic tanks outside when the temperatures drop into the lower 30's or below. I may leave it outside tarped for 2 to 3 weeks. I figured that the wine remains close to 35°F. It would go down at night to 30°F or less and up maybe 5°F during the day. It takes a fair amount of heat to raise the temperature particularly if it's a cold, overcast day and the wine is in the shade.
- Chilling a wine to even 30 degrees for 36 hours greatly improves **Tartrate stability**, but it's not cold enough to completely stabilize a wine. Therefore, some wineries use Gum Arabic (**Citrigum** or **Cellogum**) to help stabilize the remaining excess tartrates. I use Gum Arabic in whites for this purpose, and the sensory effect it has on the wine. It's just an option …
- **Zenith Uno** (Potassium Polyaspartate) marketed under the Enartis label effectively stabilizes tartrates in whites and rosés. Rate: 100ml/hL. For reds, a product is labeled **Zenith Color** (200 ml/hL).

Clarification, part of the aging and polishing process:

- Once a finished wines has been placed in a barrel or tank and undergone MLC, have a local wine lab run a **standard wine-panel** to accurately determine: pH, TA, Malic acid (remaining), alcohol, free- and total-SO_2, and VA. This will tell you if adjustments for stability, or to improve sensory appeal is 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 lot of tasting experience.
- Wine acidity should be adjusted when either TA or pH or both fall outside the normal range. This is when small changes can make big contributions.
- Racking is indispensable for proper aging and clarification.

- The point of racking is to clarify a wine by allowing suspended particles, and materials, such as: dead yeast cells (lees), bacteria, excess tartrates, proteins, pectins, various tannins and other phenolic compounds, unstable pigments, etc. gradually settle and collect in the sediment. Over time, tannins soften and astringency declines, particularly in oak barrels because of the minute diffusion of oxygen into the wine. Aging also fosters the extraction of oak flavors and aromas.
- To reiterate: white and rosé juice is racked off the gross lees that settles after crushing and pressing, and again after fermentation to remove the lighter yeast lees.
- Red wine is racked off the skins, seeds, spent yeast cells, and other particles that settle to the bottom of the tank after fermentation and pressing.
- Whites and roses should, of course, have some color, but should be clear, and brilliant when bottled. Red should also be clear when held up to light.
- Racking: Most home winemakers rack their red wines 3 times: the **first** after primary fermentation to remove the *gross lees*. The **second**, just after MLC (following a sulfite addition, to remove the fine lees, and the **third**, just before bottling to remove additional pigments and sediment. For more information about racking (See **Post MLC racking** above and **Racking** below**)**.
- Some winemakers prefer to rack only twice, once after primary fermentation and again just before bottling.
- For whites, 3 to 4 racking is customary: the **first** to remove the heavy lees after crushing and pressing, the **second** to remove the yeast lees several weeks after fermentation, the **third** in the early spring 4 to 6 weeks before bottling, and the **fourth** just prior to bottling. You may want to filter the wine as you do the final racking, prior to bottling—two birds with one stone.
- Wines aged sur-lie may be racked after 2 to 6 weeks or longer to remove the lees.
- When racked into a holding container, finished wine should be clear, or better yet, brilliant, and free of unpleasant odors. Cloudiness and unresolved off-aromas detract from the wine's appeal. So, the sooner you resolve sensory or visual issues, the better.
- Red wines are best aged in oak barrels to allow small amounts of oxygen to infuse into the wine through the porous wood. The oxygen serves to mellow the wine's tannins. Furthermore, it imparts sweet, spicey, woody, toasty, or savory notes, e.g., vanilla, caramel, toffee, chocolate, coffee, coconut, clove, allspice, nutmeg or, cedar, cigar box, smoky, etc. New barrels add the most oak flavors, while used or 'neutral' barrels primarily enhance texture by softening and 'rounding out' the wine**.** You can though used oak products or barrel inserts or use finishing tannins that can add the essence of toasted oak.
- Most oak barrels hold 58 to 59-gal of wine. Enough to fill about 24 cases of bottles. Far more than most couples can reasonably drink within a few years or two. I suppose you could trade with other winemakers for other varieties. Another approach is to look for several partners, or interested friends to form a co-op, so you don't have more wine than you can deal with.

- Another option is to make less wine. Used 30-gal barrels are occasionally available for purchase, or you can order a reconditioned 30-gal barrel from the Beverage People, they're refurbished at ReCoop in Sebastopol. The problem with new and reconditioned barrels is that they can impart too much oak flavor in the wine, so it's best to transfer the wine to some other container, preferably a neutral barrel after or stainless or plastic tank after about 6 months to 8 months.
- Used barrels are readily available from local wineries after they bottle and rotate out their older ones. They're also relatively inexpensive. Some are cleaned and treated with SO_2 gas. Others may have simply been drained and rinsed. If they smell 'off —vinegary, or like fingernail polish or remover, you 'll have to treat them (See **Sanitation** above). If they really smell bad, look elsewhere.
- Barrels that have been cleaned, sanitized, sulfited, and properly stored, will need to be rehydrated before filling, and then flushed with a citric acid solution to kill any residual bacteria.
- Steam cleaning is the preferred way to prepare barrels that have been rehydrated for filling.
- Taste the wine during storage and aging to determine if minor adjustments in pH and TA will improve the balance.
- Toward the end of aging, make sure that no single component, e.g., acidity, sweetness, tannins, alcohol, dominates or detracts from the overall impression
- A wine is said to be balanced when these elements are well integrated. Balance or harmony is an elusive factor that defines well-made wines, and creates a favorable impression. For example, hotness from alcohol, excess dryness, bitterness, or astringency from excess or unresolved tannins, can be off-putting. If the wine is intended to be slightly sweet, you don't want it to be cloying, so increasing acidity is a way to balance the wine. Without acidity, wine can feel and taste flat and uninteresting, too much though, the wine tastes tart. Tannin astringency in wines can be diminished by adding egg white, selected gelatins, ex. **Colle Perle** (Scott Labs) and **Hydroclar** (Enartis), etc. Acidity, either too high or low is easy to correct.
- Keep barrels topped up, and purge the head-space in storage containers with argon gas or other inert gas every time you open one.
- Whites can be aged/stored in oak barrels to add complexity, or reduce acidity (full or partial MLC). To prevent MLC or to stop the process early, you can use: **Bactiless** (Scott Labs) or **Stab Micro** (Enartis). Lysozyme: **Lyso-Easy** (Scott Labs) or **Zym LYSO** (Enartis) will also do the job, but you will need to remove unstable proteins that are released by during the process.
- Using toasted oak chips, or oak inserts, is an effective and inexpensive means to add oak aromas and flavors to wines held in stainless-steel, plastic, glass carboys, or neutral (well-used) oak barrels. Follow the recommendations use them with restraint, as you can always add more. The rate for oak chips, depending on the type of wine is:
    - 0.5-1 g/L for most fresh whites (Sauvignon Blanc, Pinot Gris, Viognier, etc.
    - 1 -1.5 g/L for Chardonnay, Pinot Blanc, etc.
    - 1.5 to 2.5 g/L for fruity reds such as Pinot noir, Zin, Grenache, etc.,

  - 2 to 4 g/L for Cab, Petite Sirah, Syrah, etc.
- Other oak products (cubes, sticks, or larger barrel-inserts) are available to impart the desired level of oak in wine.
- **Optimal aging time**—fresh, fruity, and crisp whites are typically aged in stainless for 6 to 8 months before bottling. Barrel-aged Chardonnay is best after 10-12 months of barrel time. Big reds are best after 18 to 24 months. Pinot noirs and Zins typically need 12 to 14 months in wood. High-end reds like Cabernet Sauvignon are often aged three years.
- **Yeast-derived 'nutrients'** such as **Surli Elevage** (Enartis), and **Nobless** (Scott Labs) improve mouth-feel (viscosity and texture), like aging wines sur-lie. You can also do much the same with Scott Lab's **Claristar**, and **Ultima Soft.** Both, release mannoproteins and polysaccharides during aging, but are formulated with gum Arabica.
- **Gum Arabic** can be added just before bottling to enhance aromas, reduce bitterness and astringency, add body, roundness, and a sense of sweetness.
- **Cellaring tannins** are commonly used in the industry to improve structure and mouth-feel, reduce astringency, lower the sensation of alcohol, enhance aromas and expression of fruit, mask reduced and herbaceous notes, add a sense of sweetness, or touch of vanilla or toasty oak aging potential. Both Scott Labs and Enartis markets a range of tannins to choose from. Unfortunately, they're not cheap! Locally, Fermenters' Warehouse) carries a reasonably priced option. Use them sparingly. A little goes a long way.

Fining: is part of the clarification and stabilization process that involves adding a substance to the wine to remove something in the wine that detracts from its visual and other sensory attributes.

- Fining removes large molecules 'colloids', e.g., tannins, phenolics, unstable proteins polysaccharides, pectins, and oxidative browning, etc. They are removed to improve clarity and stability. If not removed, they can n negatively affect appearance cloudiness, haze, or form sediment.
- Fining agents bind to the unwanted molecules in the wine, increasing their size, making them easier to settle out or remove by filtering.
- Fining removes cloudiness, browning, or heat-unstable proteins (whites), astringency, bitterness, herbaceous unwanted color (rosés), odors, metal residues (ex. copper), oxidized components, potentially harmful bacteria. Fining should be done well before bottling (See: **Fining-agents** below, and **Fining Agents for white and rose wines after fermentation** above).
- It's a bit of a trade-off, depending on what, and how much you use. You may lose a bit of character to improve appearance or overall quality. In many cases, though, the wines are dramatically improved.

Fining-agents:

- There is a wide range of fining-agents to increase stability, improve clarity, remove undesirable characters (bitterness and astringency, unstable proteins,) and other components (metal ions like copper), and also reduce risk of spoilage. Doing bench trials is recommended to determine which agent works best, and the appropriate dose to achieve the objective. Listed below are some of the more useful fining agents:

- **Ascorbic Acid**: (Vitamin C): It is mainly used to scavenge oxygen in wine, particularly whites, before bottling or other operations where the wine will be subjected to temporary aeration. Add ascorbic acid at a rate of 2–3 g/hL just prior to bottling. For Ascorbic acid to work you must have significant fee-SO_2. It can also be used to convert disulfides in wine back to mercaptans, which can then be removed with copper-containing products, but only in the presence of higher levels of SO_2. This is the way out of an intractable reduction problem involved Disulfides.
- **Bactiless** (Scott Labs): a product intended to prevent MLC in wines, also inhibits bacteria that form acetic acid, as well as other spoilage bacteria.
- **Bentonite**: is an essential fining agent for the removal of unstable proteins in white and rosé wines that typically settle out later when the wine is warmed, or is being cellared after bottling. Unless removed, the protein loses it solubility and settle out as large white particles or snow-like flakes. Bentonite is commonly used in low levels for Chardonnay, but at higher levels for wines such as Sauvignon blanc, Pinot gris, Gewürztraminer, and a few others. The use of fermenting tannins, which binds with unstable proteins, minimizing the need for Bentonite.
    - Ideally, Bentonite is added to the juice/must at the start of fermentation. This is thought to result in less stripping of flavors than when added later during storage.
      Rate: 20 to 120 g/hL (26 gal.) See discussion on **Preemptive fining** in **Protecting the juice from oxidation and removing unstable proteins** above).
    - If you use Bentonite use a product that compacts the lees to avoid picking it up during racking. For example. **Pluxcompact** (Enartis)
    - Bentonite is first mixed in in water, and allowed to hydrate for 3 hrs. or longer, depending on the formulation. When added to wine, it binds with unstable proteins, and settles to the bottom of the container. Add the slurry slowly, while vigorously stirring. Make sure it's well mixed because Bentonite works on contact. The more evenly it's dispersed throughout the juice/wine, the more effective it is.
    - Add **Silica gel**, a counter-fining agent, immediately after the Bentonite is mixed to facilitate quick settling. It may take a week or more for the Bentonite and protein to completely settle out. Stir the treated wine the following day to keep the material in suspension and to increase contact time.
    - Red wines and those high in tannins are generally stable. White wines, and low tannin reds may have some protein instability issues. Wines fermented or stored in barrels have far less of a problem with protein stability compared to those held in stainless steel, glass, or food-grade plastic.

- **Claril SP** (Enartis): contains Bentonite, PVPP, Potassium Caseinate (milk protein), and Silica gel. Use for pre-emptive fining. Added at the start of fermentation. Rate: 50 to 150 g/hL.

- **Claril SMK** (Enartis)**:** a blend of carbon, pea protein, and chitosan. It mitigates the impacts of exposure to smoke.
- **Claril QY** (Enartis): yeast hulls and Chitosan. Reduces astringency, bitterness, and reductive and vegetal notes.
- **Colle Perle** (Scott Labs): This gelatin removes excessive astringency. Fine early in the cellaring process.
- **Copper sulfate**: when added to wine, the copper ions chemically bind with undesirable sulfides, e.g., H_2S, and mercaptans, which mostly settle to the bottom as a precipitate. The reaction occurs quickly and the deodorized wine can then be racked off the lees. The drawback is that it leaves a small residue of copper in the wine. That can affect flavor, clarity, and shelf-life.
- **Egg white**: used to remove excess tannins and reduce astringency. **Rate:** 1 to 4 eggs. Allow 2 weeks of settling before racking. Reducing acidity moderates the perception of tannins.
- **Fenol** (Enartis): an activated charcoal that can reduce the aroma of Brett or smoke taint.
- **Gum Arabic**: more of a stabilizing agent than a fining agent. It is used to reduce tartrate formation in refrigerated wines, prevent deposits from forming on the inside of the bottle (red wines), enhance mouth-feel, and impart a slightly sweet sensation.
- **Gelatins**: There are many to choose from, depending on objective. They are used to reduce astringency. Both Scott Labs and Enartis have a range of products to choose from.
- **Isinglass: Finecoll** (Enartis) or **Crystalline plus (**Scott Labs): gentle clarification agent that removes bitterness, oxidative and herbaceous notes. Takes several weeks to clarify the wine. Highly recommended. *Rate*: 1 to 4 g/hL (25 gal).
- **Milk** (Non-Fat): 20 to 50 ml/ gal for white wines, to reduce bitterness, add a slight sweetness. Follow with Bentonite fining. Rack after 4 days, do at least one month before bottling one month prior to bottling.
- **Milk** (whole): 20-50 ml/ gal. to reduce harshness, absorb aldehydes (oxidation). Follow with Bentonite. Rack after 4 days and do at least one month before bottling.
- **Potassium caseinate**: milk protein intended to remove bitterness, oxidation, slight off-flavors, or excess oak flavors. Fine early in the cellaring process.
- **PVPP**: Stabyl (Enartis), **Polycel** (Scott Labs): removes small tannins, minimizes bitterness and oxidized color. Reduce acidity when a wine is too tannic.
- **Reduless:** (Scott Labs: a copper-based additives to eliminate reduced odors (H_2S and mercaptans) It contains a component that removes the copper that the can adversely affect wine quality.
- **Silica gel**: Silca dioxide: **SilFloc** (Enartis, **Gelocolle** (Scott Labs) or **Kieselsol:** all are effective <u>counter-fining</u> agents used to speed the precipitation of gelatins, Isinglass, Bentonite, and other fining agents. It goes in immediately after the

other agent. Rate: 25 - 75 ml/hL. Rack off the sediment after several weeks or leave it until you are ready to rack.

- **Sparkolloid** (hot mix): Can be used to create brilliant white wines, however, it does not remove heat-unstable proteins. When used with moderation, It does not strip character. It can be combined with Bentonite as a counter-fining agent to help compact the lees or to remove haze left by other fining agents. It takes at least a week for a cloudy wine to become brilliant. Rate: Hot Mix (Scott Labs: 12-48 g/hL/ (26.4 gal) or 2.5-10g/5gal wine or 0.5g to 2g per gal.
- **StabMICRO** (Enartis): Removes spoilage organisms by binding with them, causing them to settle out of suspension. The bacteria can then be removed by racking, leaving them behind in the sediment. This can prevent MLC or remove bacteria that may lead to spoilage organism, such as ‘Brett’. One formulation can be used at the start of fermentation; the other is applied later during aging.
- **Tannins, egg whites, gelatin**, and **isinglass:** all have a strong affinity for proteins, can be used its remove from wines.

Racking:

- Racking is done to remove natural sediment or something that has settled out following the use of a fining agent.
- Racking involves pumping, siphoning, or use of pressurized gas to transfer the wine from one container to another. In this manner, the sediment including the residue from fining-agents, ex. Bentonite, egg whites, etc. can be flushed out when the barrel/container is cleaned for storage or refilling.
- Heavy sediment (gross lees)—spent yeast, grape solids, etc.) that collects following the fermentation and settling of red wine, should be removed and discarded. In general, the spent yeast that collects when white grapes are fermented, should, in most cases, be removed. Winemakers, however may choose to age their wines on the lees (sur-lie) to improve mouthfeel and add complexity. Rack whites aged sur-lie after the desired effect has been achieved.
- An additional racking will be needed after fining whites for clarity and protein stability—the addition of Bentonite, Isinglass, Sparkaloid, etc. to improve clarity. And, of course you will rack just prior to bottling.
- The light sediment that collects after MLC, fining during storage should also be removed to improve clarity, ensure aromatic appeal, and stability.
- **Bentonite**, **Chitinase**, **Isinglass,** and **Sparkloid** are commonly added to white and rosé wines lacking clarity or ‘brilliance.’ After ‘fining,’ the wines are allowed to settle for 3 to 4 weeks before racking, particularly if the intent is to sterile-filter.
- Most home winemakers rack their red wines 3 times: the **first,** follows primary fermentation to remove the *gross lees*. The **second**, is done just after MLC, and following SO_2 addition, to remove the *fine-lees*, and the **third**, just before bottling to remove any additional sediment, resulting from the use of fining agents toward the end of aging
- It is also possible to rack reds, like Pinot noir, only twice. Once, after primary fermentation, to remove gross lees, and again just before bottling, unless fining becomes necessary for other reasons.

- For whites, 3-4 racking is common: once to remove the *gross lees* after pressing and settling. The second is done in the early spring to remove the sediment from using Bentonite, or Isinglass, etc., well before bottling. Additional rackings may be required depending on fining for various issues. The final racking should be no later than later than 3 to 4 weeks before bottling. If the wine is clear, you may want to filter the wine as you do the final racking—killing two birds with one stone.
- Reds varieties, such as Tannat, Tempranillo, Petite Sirah, Cabernet, Malbec, Mourvèdre, Nebbiolo, Syrah, etc., may be racked 4 or more times to make the them more accessible (less tannic). Racking also aerates the wines, and allows off-odors to dissipate.
- You can rack from one container to another similar-size container, or to several holding-containers, such as carboys, or beer kegs, and then return the racked wine to the original container after it has been cleaned.
- Reds are commonly racked following MLC to remove the <u>fine-lees</u>, expose the wine to a little air, allow any off-aromas to dissipate and. Some winemakers prefer to skip this step.
- Too many rackings can lead to oxidizing the wine, particularly if the free-SO_2 level is below the targeted 'molecular level.
- Siphon the sediment-free wine through a flexible, clear, food-grade hose using gravity. Elevate the container to facilitate siphon flow. Of course, you'll have to start the siphon by sucking on the opposite end of the hose to draw the wine into it. Holding the hose above the wine, draw up enough wine to largely fill the hose, and then quickly place your thumb over the end to hold the wine in place. Now, lower the hose into the receiving container You can also use a self-priming electric pump to transfer the wine to another container(s).
- It's helpful to have several inexpensive racking wands to help siphon and transfer wine from different size containers. A better option is to buy several lengths of ½-inch OD stainless-steel tubing to do the same thing. You want to reach the bottom without it being too long.
- There are some very nice stainless-steel racking-wands designed for use when racking barrels. They have an adjustable screw that positions the intake opening above the sediment. There are 2 openings, one on either side of the capped tube to prevent direct uptake of sediment. Check with your local wine supplier. They will also work in beer-kegs, 15.5-gal and 30-gal plastic tanks, or variable capacity tanks.
- A clear-plastic siphoning hose (½-inch ID) work well when you can see the sediment layer. Be sure to use baffle (a flow-directing devise) on end of the hose, and lower it down to just above the sediment. The baffle prevents uptake of the sediment by drawing the wine from above it. In this manner, most of wine can be racked with little or no uptake of sediment.
- Make sure everything in the siphon system, including the pump, if used, has been cleaned and sanitized before use.
- Wine can also be racked/transferred from barrels and some tanks under pressure using a 'pressure-transfer tool' (Bulldog). You can pressurize the barrel

or tank using Argon, Nitrogen, or Carbon dioxide. The internal pressure causes the wine to flow out to the receiving vessel. Slick!

- Purge the air in the siphon-tube, hose, pump, and filter-housings (if used) with argon, CO_2, or NO_2. before transferring wine.
- Avoid splashing by placing the end of the siphon hose near the bottom of the container so that it will be quickly submerged by wine.
- Use Argon gas, if you have it, and deliver it through a ½- inch tube to the bottom of the container, rather than through the neck of the carboy, or tank opening. In this manner, the wine, under a blanket of inert gas, displaces air as it rises.
- When racking from a stainless-steel container or a barrel, and you can't see the sediment, position the siphon tube with baffle about an inch above the bottom. Push the racking wand to the bottom and pull it up at least about 1 inch. You'll need to devise some way to suspend the racking tube above the sediment layer. Another option is to clamp a narrow, but stiff rod to the siphon tube. I use a ½ hose barb to hold the black plastic baffle (Fermenters' Warehouse) in place. I then clamp (stainless steel hose clamps) that hold a narrow metal (nut-pick) that has been bent around the baffle. It can be adjusted up or down as needed by loosening the clamps. It's low tech, but it works. I soak the whole unit in high test alcohol before use.
- If the wine is cloudy when you start pumping or siphoning, stop and pull the tube up a bit until the wine is clear.
- Some of the wine remaining near the bottom of the container just above the sediment can be salvaged by siphoning or pumping the liquid portion along with some sediment into one, maybe two 1-gal jugs. You may be able to siphon most of the wine by tilting the tank so that most of the wine collects on one side. Stop siphoning or pumping as soon as the wine in the hose appears to be very cloudy or thick. Allow at least a week for the collected sediment to settle. Rack the relatively clear wine off the sediment. You can bottle this wine and use it for topping, or just drink it.
- If you are racking back to the original container, you will need to add some reserve 'topping' wine to fill the void left by the removal of the sediment, and any wine that couldn't be salvaged. Always fill the holding-tank to capacity after racking.
- When racking from carboys, tilt the bottle toward you as the wine level drops to raise the level above the siphon tip. This will increase yield. If there is too little wine above the baffle, air will be drawn in and the siphon lost. Not good!
- For gravity to work, the wine container must be higher than the receiving vessel. This may present a problem for containers larger than 5-gal carboys.
- Special lifting devices are available for beer kegs and even full barrels. Barrels on tall racks can be siphoned into carboys for bottling, which can then be elevated later for siphoning back into the barrel, once it has been cleaned.
- Electric pumps are a quick and efficient way to transfer wine. One concern though, is that unless you displace air in the siphon hoses, and pump and filter housing (if used) with an inert gas before pumping, some oxygen will be incorporated in the wine. Adding 10 to 15 ppm of SO_2 before racking will minimize this.

- It's important to make sure the hoses attached to the pump are tight-fitting and do not draw air from the outside. If you see bubbles in the line, starting at the point where a hose attaches to the siphon tubes and to the pump inlet, there is undoubtedly a leak, and you need to stop siphoning and add a hose clamp or tighten the hose clamp if there is one already, to make sure the siphon hose is tightly attached to the barbed-end of the pump inlet. Air will be drawn into the wine whenever hose fittings are loose. You may need a new length of hose that fits tightly, or try cutting off the loose-fitting end of the hose, and reattach the more snug-fitting hose over the barb.
- If you pump white wines shortly after fermentation, very fine bubbles may appear to form in the hoses, particularly in the line from the pump. These bubbles may be nothing more than CO_2 gas coming out of solution due to pump agitation and cavitation (loss of dissolved gasses in the wine).
- Even if there are no leaks, some aeration will occur because the hose, pump, and filter-cartridge, unless the air in the system is purged before you start pumping.
- Once the hose and pump are filled with wine, there should be no further aeration.
- It's important to immediately turn the pump off when the barrel empties and air is being drawn into the hose. If allowed to run, air will be pumped into in the receiving vessel. You can hear this when it occurs, and see air bubbling in the wine.
- Exposure to air during racking by gravity or pumping, results in loss of some free-SO2 as it binds with the aldehydes that form due to contact with air. That's why the addition of 10 to 15 ppm SO_2 prior to racking is so important. To be on the safe side, test for free-SO2 in about a week.

Barrel topping:

- The wood used to make oak barrels is porous and allows the infusion of air into the wine, and the loss of water and alcohol due to evaporation. The rate of loss, depends on the cellar's humidity—the dryer it is, the greater the loss of wine volume. A barrel can lose as much as a bottle's worth of wine each month. Under dry conditions, a barrel can lose as much as 14% of its volume in 3 years. Loss of wine due to evaporation leaves a void (head-space) where oxidation can occur, and vinegar-forming bacteria are more likely to develop. Consequently, barrels need to be topped up monthly. Excess head-space also increases the loss of SO_2 (volatilization) into the void. *Acetobacter* bacteria and film-yeast (a white, waxy coating on the surface of the wine) are more likely to develop when there is ample head-space, the SO_2 level is low, and when oxygen can enter through a poorly seated bung, or leaky barrels.
- Use a good quality wine to top with, preferably extra wine of the same variety. If you do have extra wine, bottle some of it, say a case or two, after it has gone through MLC and has been racked. You can use it for topping instead of having to break down containers as you need the wine. You can also use an older vintage or a compatible variety as long as it smells and tastes fine. Another option is to buy an acceptably good wine like '*three-Buck Chuck*.' I mean, how bad could it be?

- Never use a wine that smells or tastes bad.

Pre-bottling, SO_2 additions:

- By now, white wines should be clear. Ideally, they should have a brilliant or sparkling appearance. If not, you haven't fined the wine properly.
- You may also want to consider filtering to polish the wine or remove bacteria including those that could cause MLC to start.
- Prior to bottling, test free-SO_2, and adjust to the molecular level appropriate for the wine's pH.
- Remember that only part of the addition will remain 'free' — about 70 to 75%, when added to a clean, dry wine.
- Let's say you need to add 18 ppm to achieve the correct molecular level. Some of it will bind up. So, you will need to add ~26 ppm to ensure that your wine is protected. (18/0.7 = ~26ppm)
- Remember to account for depletion of SO_2 after bottling due to oxygen pickup during bottling, depending on how you bottle: under a vacuum or inert gas or exposed to air. In general, add an extra 5 ppm when using an *Enomatic* filler, and 10 to 15 ppm for standard bottlers.
- To be on the safe side, shoot for 45ppm as your target of free-SO_2 when you bottle reds with a pH greater than 3.7.
- Some people can detect SO_2 in the aroma when it is above 50ppm free.

Some commercial wineries bottle with as little as 25 to 30 ppm, but their sanitation practices, and ultra clean automated bottling systems are very good. In general, they have good control over most factors. They also sterile-filter their wines and bottle under inert gas. That's why your SO_2 levels must be high enough before and after bottling to prevent oxidation. That's the trick. Even when the SO_2 level is adequate, white wines begin to oxidize, usually within 1 to 2 years. That often happens for commercial wines as well. Few last much longer than that. Those that do are typically acidic (low pH levels: <3.3) and high TA.

Filtering:

- Filtering, mostly for whites, is done to help stabilize them, improve appearance, and shelf-life by removing bacteria could affect taste and aroma.
- Unless there is a bacterial problem, most reds don't need to be filtered. Commercial wineries, though, routinely filter their reds to remove bacteria, improve clarity and prevent sediment from forming in the bottle.
- Although, many commercial winemakers now filter their reds using the cross-flow technology, it is generally not needed for reds. Some would argue that filtering disturbs tannin structure that may take several months or longer to re-form. But it's hard to argue that point when they're winning gold metals … just saying. Filtering whites may be beneficial to improve clarity, add brilliance (sparkle) or.
- A standard 1-micron filters can be used to remove most particulates, a .45-micron filter can remove most bacteria and yeast, but not all of them. 'Nominal'

filters, those that remove most of the particles, equal to or greater than their 'micron' rating, are relatively inexpensive.

- **Absolute filters**, by comparison, use a membrane that removes all particles equal to and larger than the stated 'micron' rating. A micron is a unit a unit of length equal to one millionth of a meter. Yeah, small. Although, reliable, these absolute membrane filters are expensive. They are available in a cartridge form that fits in the standard filter housings used by many home winemakers. They can be reused several times after back-flushing (reversing the direction of the flow while pumping clean water. Between uses, I store my 0.45-micron filter in 80 proof grain alcohol to prevent bacterial buildup. You can also store them in a freezer, carefully sealed in a Ziplock bag.
- Sterile filtering can be used to remove spoilage bacteria and prevent MLC in the bottle, protect a wine with residual sugar, or just 'polish a wine. Stab-Micro (Enartis), Bactiless (Scott Labs) remove bacteria that adversely affect the wine, for example, Brettanomyces.
- Sterile filtering for reds may remove some of the polymerized particles that are important for structure and roundness.
- If you decide to filter for aesthetic reasons, 1-micron (nominal) filters will usually do the job, a 0.45-micron (nominal) filter will, though, remove bacteria, perhaps not all of it to be safe.
- Unless the wine has been racked at least twice to remove solids, small sediment will probably plug the membrane filter, requiring you to stop and back-flush—a real pain! So, it's a good idea to fine (clarify) and rack white and rosés 2 to 3 twice before filtering. If you have fined the juice (whites and rosés with Bentonite (Claril SP) during fermentation, it will settle to the bottom of the fermenter along with the natural lees after fermentation within several weeks. Little, if any, remains in the wine after a wine has been carefully racked off the lees. Keep the tip of the racking-wand about ½ to 1-inch above the sediment layer. If you use Bentonite use a product that produces compact lees to avoid picking it up during racking. For example. Pluxcompact (Enartis) helps compact the sediment layer.
- There is no compelling evidence to support the claim that filtering strips a wine of its character. This claim is not supported by research and many commercial winemakers are split on the issue. However, for big reds, filtering may disrupt wine structure temporarily.
- In general, filtering improves appearance and doesn't appreciably affect the taste of aroma wine, and in most cases, it improves quality.

Bottling:

When you're satisfied with the clarity, acidity, mouth-feel, taste, aroma, and balance of a wine, it's time to bottle.

- Agitate (gently stir) white wines aged in carboys or tanks that are still spritzy, in advance of bottling to eliminate as much of the dissolved CO_2 gas as practical, unless there is perceptible sediment at the bottom of the container, in which case, you should rack again. With exception of barrel-aged chardonnays, most whites will retain a small amount of CO_2.

- Adjust SO_2 to the targeted level and remember to account for depletion of SO_2 at bottling due to oxygen pickup, depending on how you bottle.
- Use new bottles or used bottles that have been cleaned and sanitized.
- When filling, try not to leave any more than about ½-inch of headspace (under the cork) in the bottle.
- Purge the bottles with inert gas before filling, or at least the air in the headspace with Argon, Nitrogen, or CO_2 before inserting the cork.
- Closure options include: natural, aggregate, synthetic, screw caps, and a few other designs. Natural cork is traditional, and preferable to many. Quality, though, can be a concern, particularly the least expensive ones, and there is a greater chance of 'cork taint' in the wine—definitely, not good! The rate of taint in cheap (untested) corks can be as high as 1 bottle per case. Cheap corks also tend to crumble when removed after a few years, or they become saturated with wine. Good quality corks start at about 60 cents, and move up to about 75 cents each or higher. The best corks are well over a dollar or more. Aggregate (agglomerated) corks are composed of ground-up cork, formed into a cork using a synthetic glue. As a secure closure, they seem to work just fine and the probability of cork taint is generally low. Diam@, an aggregate cork made from treated cork, are uses by some very good producers. The attraction of synthetic corks is their low cost—about 20 cents each. The early synthetic had some real issues, but the newer ones are much better. Normacork@, the most popular synthetic closure, is in wide use commercially. They make a good seal and are reasonable easy to insert and pull. They also do much the same as real corks for at least for 5 years. Screw caps are great if you can get the bottles and metal cap-closures designed for use without special equipment.
- If you make a lot of wine, cost for closures can be an issue. Do some research and pick one that suits your needs. Check the pros and cons of each type, and shop around for the best price.
- My final racking from a 60-gal barrels is into 15-gal beer kegs for holding prior to bottling. I have a mechanical lift device to elevate the wine-filled kegs well above the bottler to ensure an adequate siphon flow.
- Most home winemakers use a 3 or 5 spout filler. They are reliable, easy to use, and clean. The downside is that they expose the wine in the open reservoir to air. The units are equipped with an adjustable float valve to maintain a consistent level in the reservoir. They have an adjustable bottle tray that can accommodate nearly any bottle size ranging from 375 mL to 1.5 L.
- The 5-spout units are hard-pressed to maintain enough volume to keep the reservoir filled without holding the float valve open.
- Bottling wine using an electric pump is impractical unless you can jury-rig a float device that turns the power to the pump on to fill the reservoir, and off once it's filled. When using gravity flow to fill a bottler's reservoir, elevate the wine in some manner to facilitate a gravity flow rate that will keep the reservoir filled. When using multiple spouts, it may be necessary to manually hold the float valve down to ensure adequate flow, otherwise the vacuum breaks and you have to prime each of the spouts. You can restart the siphon by sucking on the spouts filler hole like it was a flute. Some people use a hoist to lift heavy containers or even a

barrel, high enough to siphon from. Another option, is to rack into carboys and elevate them on a platform near the bottler. A good solution is to use the an **Enomatic** bottling system that incorporates a vacuum pump to move wine from its container on the floor that flows directly to the bottle. The systems get thumbs up from winemakers who use it.

- Bottling on the cheap—one bottle at time. If this works for you: the Ferrari Auto Bottle Filler attaches to a siphon hose and automatically stops when the bottle is full. It's a bargain at under $20. Think of all the money you'll save.

Well, that just about sums up what you need to know to make win, and you thought it was going to be easy…

Appendix:

Some compounds produced by reduction and what they smell like:

compound	structure	sensory description
Hydrogen Sulfide	H_2S	rotten egg, sewage-like
Ethyl Mercaptan	CH_3CH_2SH	burnt match, sulfide, earthy
Methyl Mercaptan	CH_3SH	rotten cabbage, burnt rubber
Diethyl Sulfide	$CH_3CH_2SCH_2CH_3$	rubbery
Dimethyl Sulfide	CH_3SCH_3	canned corn, cooked cabbage, asparagus, vegetal
Diethyl Disulfide	$CH_3CH_2SSCH_2CH_3$	garlic, burnt rubber
Dimethyl Disulfide	CH_3SSCH_3	vegetal, cabbage, onion-like at high levels

Methanethiol, a mercaptan, can also be found in wines that have undergone reduction. It is the recognizable small associated with leaking natural gas.

Other resources:

Fermentation Handbook from Scott Labs www.Scottlab.com
White wine-making guide available from morewinemaking.com

Useful information: I ton of grapes yields 175 to 180 gal (commercially) but about 150 gal using a small basket press, large grapes may yield up to 160 gal.

Helpful: conversions:

Capacity of a Burgundy barrel is about 228 L, about 60 gal.
Bordeaux barrels hold 225L approx., about 59 gal.
1 pound per 1000gal is equal to 0.12 g/L or 4.5 g/gal

Weight/Volume equivalents:

1#/1000 gal =

- 454 g/1000 gal
- 0.45 g/gal
- 0.12 g/L
- 120 ppm
- 12 g/hL

1 g/hL =

- 1 g/26.4 gal
- 0.038 g/gal
- 0.084 #/1000 gal

1 ppm = 1 mg/L

Weight equivalents:

1.00 g = 1000 mg
1.0 kg = 1000 g
1.0 kg = 2.2 lbs
454 g = 1 lb
1 lb = 16 oz
1 oz = 28.35 g

Volume equivalents:

1 L = 1000 mL
1 hL = 100 L = 26.4 gal
1 L = 33.8 oz = 1000mL
1 gal = 128 oz = 3785 mL = 3.785 L
1 qt = 32 oz = 946 mL = 0.946 L
1 pt = 16 oz = 473 mL = 0.473 L
1 cup = 8 oz = 237 mL
4 oz = 118 mL
2 oz = 59 mL
1 oz = 29.57 mL

1 egg white = ~30 g
1 g = largely equivalent to 1 mL
1 mL = 0.001 liter (L) and there are 1000 mL in 1 liter
1 ppm is equal to 1mg of a substance dissolved in 1 liter of water, and there are 1000mL in a liter.
1L
1 mg in 1 liter = 1ppm (ppm can be converted to mg/L by multiplying it with 0.998859).
1 pound = 453 g
1 ounce = 29.4 mL. To convert mL to ounces, multiply by 0.0338) or divide by 29.4
1 gal =3.785 L (liter)
1 T = 0.5 oz or 14 g
1 T = 3 tsp
1 T = 15g
1 tsp = 5 ml
1hl (hectoliter) = 26.4 gal
1 liter = 0.26 gal or 1.057 qts.
1 gallon = 3.785 liters
1 kilogram = 1000 g or 2.2 pounds,
1 gram = 0.0353 ounces 1 milliliter (ml) = 0.2 tsp
1 tsp = 5 ml
Convert liters to gal x 0.26417205 gal
Convert gallons to liters x 3.78541178

1.0 g/L
= 0.10 g/100 mL
= 100 g/hL
= 100 mg/100 mL
= 1000 mg/L
= 1000 ppm
= 1.0 mg/mL
= 1000 µg/mL
= 0.1% (wt/vol)

1 lb/1000gal
= 454 g/1000 gal
= 0.45 g/gal
= 0.12 g/L
= 120 ppm
= 12 g/hL

To convert °C (Celcius) to °F (Fahrenheit)... multiply by 1.8 and add + 32
or 9/5 C + 32

Vineyard yield (premium grapes)	3 to 5 U.S. tons per acre	6 to 9 metric tons per hectare
Grape weight to wine volume (commercial)	1 U.S. ton = 175 gallons red, 160 gallons white	1 metric ton = 730 liters red, 667 liters white
Grapes weight to wine volume (home)	100 pounds = 7 gallons red, 6 gallons white 1 U.S. ton = 140 gallons red, 120 gallons white	100 kilograms (kg) = 58 liters red, 50 liters white 1 metric ton = 583 liters red, 500 liters white
Liquid to bottles (750-milliliter bottles)	1 gallon = 5.1 bottles	1 liter = 1.33 bottles
Cases per ton (commercial)	1 U.S. ton = 75 cases red	1 metric ton = 83 cases red
Grapes per bottle (home)	2.8 pounds of red grapes per 750-ml bottle	1.27 kilograms of red grapes per 750-ml bottle

Critical Conversion for home Winemaking, Manual for dummies