MODERN HOME WINEMAKING

A Guide to Making Consistently Great Wines

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Preface

MODERN HOME WINEMAKING is for winemakers — amateur winemaking enthusiasts and small commercial winery operators — who aspire to raise the bar and make great wines, consistently, even when faced with a challenging harvest. Mother Nature doesn't always deliver perfectly balanced grapes, but the skilled and methodical winemaker will still be able to craft great balanced wine. Skill requires knowledge and experience, and *MODERN HOME WINEMAKING* is based on modern wine science theory and extensive practical experience that will give you the confidence to expertly craft wines vintage after vintage with all the challenges each brings.

As a seasoned winemaker, you can jump right into any section to further your knowledge and try out new techniques for making wine from grapes, fresh juice, processed 100% juice and concentrate. If you are a beginner highly motivated to make superlative wines, you can take a stepwise approach and tackle sections progressively, perhaps skipping more advanced subsections and coming back to these as you grow your knowledge. You will come to develop your own techniques or adapt others you have read about in other literature but now you will have the knowledge to make informed decisions. You will find additional information in the preamble section in the more advanced chapters.

Much of the content is based on my experience, lots of it based on researching and experimenting different techniques, new equipment, and the many new and specialized products that come to market at a very rapid pace. Much of my experience stems from analyzing wine in great details in my lab, and comparing results to theory — there can be great variations owing to the complex beverage that is wine. You will also find many examples not found in other textbooks to illustrate how specific procedures and calculations are performed. Yes, it will get very technical, but as you grow into your hobby and start appreciating the technical aspect of winemaking, you will be better positioned to make better decisions when, for example, faced with harvest challenges or when something has gone wrong.

First review all the terms defined in the **Winemaking Lexicon** so that you understand all the lingo presented in the introductory chapters. The detailed concepts are then presented in their respective chapters. Chapters are laid out to provide all the theory and practical advice first, then followed by chapters on white, rosé and red winemaking.

Chapter 1 first describes the transformation of grapes into wine, that is, what happens in grape juice as it is transformed by fermentation into wine. Knowledge of some of the more important chemical and microbiological transformations is fundamental in winemaking — decisions are based on science, not guesswork, not myths, not even tradition. This chapter also presents an overview and flowchart of each of the process for making white, rosé and red wine — these styles are the focus of this book.

Chapter 2 gives descriptions of some of the more common vinifera, Native American and hybrid grape varieties used for making great wines. There you will find key characteristics of each variety and the type of wine it can produce, along with helpful tips and advice on dealing with specific peculiarities, such as poor color or high acidity, along with yeast recommendations.

Chapter 3 lists all the essential winemaking and laboratory equipment you will need to make great wine — efficiently. You will be able to choose the right equipment to start small and then what upgrades you need to grow your winemaking.

Chapter 4 describes how to clean and sanitize equipment, and the many kinds of products on the market and their applications with recommendations for cleaning and sanitizing glass, plastic (PET and HDPE), and stainless steel.

Chapter 5 outlines the process for conducting bench trials used, for example, to determine precise sugar or acid additions. Bench trials help you avoid having to treat juice or wine that you have over-adjusted with a blind addition.

Chapter 6 gets into the theory of sugar and alcohol analysis, how to measure the amount of fermentable sugars, how to estimate the amount of alcohol that will be produced, how to make corrections if your juice or grapes do not have enough sugar, or maybe too much sugar, and how and why to measure the amount of leftover or residual sugar in wine.

Chapter 7 discusses one of the most important topic in winemaking and wine chemistry — acidity and pH, with a special focus on the chemistry of potassium bitartrate. Along with alcohol, the amount of residual sugar, and tannins in red wines, acidity plays an important role in wine balance — a marker, however objective, of quality in wine.

Chapter 8 discusses another very important topic — sulfur dioxide (SO_2). SO_2 protects wine from chemical and microbiological faults or outright spoilage, and also enhances aromas. The chapter discusses the intricate but necessary theory of sulfites and SO_2, how to measure SO_2 levels, how to manage SO_2 levels throughout the life of a wine from grapes to bottle, including how to make adjustments like an expert with the objective of maximizing SO_2 efficacy while reducing the total amount used. The chapter also offers alternative additives and strategies for reducing the use of sulfites.

Chapter 9 introduces tannins: what they do, what they are, and where they come from. Understanding how tannins work in creating structure, stabilizing color and improving wine aging potential, is fundamental to red winemaking.

Chapter 10 gives an overview of the main enological enzymes used to, for example, improve pressing (of grapes) and increase juice yields, avoid clarification and filtration problems, or hasten color and tannin extraction when making red wine.

Chapter 11 describes alcoholic fermentation (AF), the yeast growth cycle, nutritional needs and choosing an appropriate yeast for the grape variety at hand and winemaking objectives. It describes how to carry out a trouble-free and efficient fermentation. You will find handy charts listed by manufacturer of the many yeast products available. Since no winemaker has never had to deal with a problem fermentation, this chapter outlines a surefire protocol for restarting a sluggish or stuck fermentation. And if you are into making sweet wines, you will find a protocol to stop an active fermentation to preserve some of the natural sugars.

Chapter 12 describes malolactic fermentation (MLF), nutritional needs, choosing an appropriate bacterium for a desired style of wine, how to conduct a trouble-free MLF, and how to test for completion of MLF. It briefly discusses current theories on the timing of the MLF, i.e., should it be done concurrently with the AF or sequentially following the AF. Here too you will find a protocol to deal with a sluggish or stuck MLF.

Chapter 13 describes the most common processing aids used for fining and clarifying wine — and the difference between fining and clarifying — and how to choose the most appropriate for any application. It also describes related processing, including: juice settling in white and rosé winemaking, racking wine, and degassing for those who make wine from kits or who want to bottle quickly.

Chapter 14 discusses the four main topics of wine stabilization: microbial, pectin, protein and tartrate. Microbial stabilization is specifically concerned with how to manage wine that contains residual sugar from alcoholic fermentation or added by the winemaker, and residual malic acid from an incomplete or partial malolactic fermentation. The chapter describes how to test for instability and how to carry out specific stabilization procedures.

Chapter 15 discusses the benefits of aging wine and how to age wine, either in glass, stainless steel or HDPE tanks, or barrels, with or without the use of oak adjuncts, e.g., oak chips, staves, spirals, etc., and on the lees — the dead yeast cells left over from alcoholic fermentation. For more information on barrel-buying considerations and how to store, maintain and prepare oak barrels, please consult reference [1].

Chapter 16 discusses how to fine-tune wine to: improve balance between, for example, acidity and sweetness by either increasing or decreasing acidity or sweetening; enhance body and structure; reduce bitter and astringent tannins; and augment oak aroma and flavor complexity. It also describes the benefits of blending different wines and how to use the Pearson Square to calculate the required proportions of wines to be blended.

Chapter 17 discusses why and when clarifying and sterile filtration are needed, the various setups and necessary equipment to filter efficiently, and how to expertly filter wine.

Chapter 18 discusses packaging and bottling equipment. Packaging includes bottles, corks, capsules and labels. Bottling equipment includes washing and sanitizing equipment, filler and corker. It also describes the different ways of bottling and the necessary setups for small and large batches.

Then we bring everything together we have learned to this point and, in **Chapters 19**, **20** and **21**, look at step-by-step, crush-to-bottle protocols for making white wine in a fruity style as well as a fuller-bodied, oaked style, rosé wine in a fresh and fruit-forward style, and red wine in a full-bodied style. These are protocols — not recipes — that walk you through the detailed process for making wine expertly.

Chapter 22 discusses twelve of the most common wine flaws and faults: premature oxidation, volatile acidity, surface film, hydrogen sulfide, tartrates, haze/cloudiness, refermentation in bottle, poor color in reds, vegetal character in Cabernet varietals, unpleasant smell of geraniums, cork taint, and *Brettanomyces*. It describes the most probable causes, how to assess problems, how to evaluate and implement remedial actions, and how to prevent flaws and faults in the first place.

Chapter 23 discusses what judges look for in wines submitted into competitions and how to get wines ready for competitions, i.e., how to self-assess one's wines and find and fix faults.

Appendix A lists conversion factors between Metric, U.S. and Imperial systems for relevant measurements.

Appendix B provides handy tables for converting between Specific Gravity, Brix, potential alcohol and sugar concentration, a table to correct hydrometer readings taken at different temperatures than the instrument's calibration temperature, and tables to help you estimate the amount of residual sugars in wine.

Appendix C has a handy winemaking log chart that can be used to record all winemaking and vinification activities. Keeping records of a wine's progress and treatments is key to successful winemaking.

If you want to explore making styles other than dry wines, such as sparkling wine or sweet styles of wines, please consult reference [1]; or if you are just starting out and want to learn the winemaking process using a concentrate in a kit, please consult reference [2]. If you want to learn about making mead, and fruit and country wines, please consult references [3] and [4], respectively.

There are many enological products — additives and processing aids — and test equipment mentioned in this book and which I have used in my own winemaking and wine analysis. These can help you too, but you will come to choose and adapt those that work best for you and according to your objectives.

CONVENTIONS USED IN THIS BOOK

Commonly used words in other languages appear in italics on the first occurrence; for example *bâtonnage*.

Words or phrases are abbreviated on the first occurrence in each chapter, for example, malolactic fermentation (MLF), then the abbreviation is used in the remainder of the chapter.

Grape variety names and (wine) varietal names are capitalized; for example, Sauvignon Blanc, and Muscat Blanc à Petits Grains.

ICONS USED IN THIS BOOK

A short explanation or additional information that you may find useful.

A warning which, if not observed, can result in unexpected or undesirable outcomes or become a health hazard.

Specific advice or instructions for performing a procedure to avoid potential problems.

A useful practical tip that can improve efficiency or simplify a certain procedure.

Montreal, Quebec, Canada
Daniel Pambianchi

July 2021

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Winemaking Lexicon

The winemaking vocabulary is quite expansive, and many terms are used interchangeably, often incorrectly, or are used differently by winemakers. Here you will find short definitions to help you understand the winemaking processes described in Section 1.3 and the vocabulary to describe working with grape varieties in Chapter 2. The terms are defined in greater details in subsequent relevant chapters.

Wine is usually defined broadly as a fermented beverage from any raw material that contains primarily sugar, such as grapes, fruits, vegetables and flowers, but also starch. In this book, "wine" will refer to those made from grapes or grape derivatives (e.g., must, juice, concentrate).

Words in italics within definitions refer to terms defined elsewhere in this lexicon.

A

Acetaldehyde: A volatile substance formed in small amounts by *yeast* metabolism during *alcoholic fermentation (AF)*. It is also formed by chemical *oxidation* of *ethanol* and where it can impart a strong bruised-apple smell, a clear marker of advanced oxidative spoilage. Also known as ethanal.

Acetic acid: The most important acid in *volatile acidity (VA)*. It is produced in tiny amounts by *yeast* during *alcoholic fermentation (AF)* and which adds aroma complexity to wine; however, when detected as a distinct vinegar smell, it is considered a *fault*.

Acidification: The process of adding one or more acids to increase the *acidity* of *must* or wine.

Acidity: The general term used to describe the tart, sour taste of the combined effects of acids in wine. It is quantifiable by measuring *total acidity (TA)*.

Additive: A substance, such as a *fining* agent or *sulfur dioxide* (SO_2), added to and which remains in *must* or wine. Compare *processing aid*.

Adjunct: Any piece of wood, primarily oak, such as, staves, cubes, chips and spirals, used as an alternative to oak barrels for imparting oak *aromas*, flavors and *tannins*. See *oak alternatives*.

Aging: The sojourn of wine in vessels from the end of the *alcoholic fermentation (AF)* to bottling, in the case of bulk aging, or in bottles until consumed, in the case of bottle aging. Also known as maturation.

Aging potential: A qualitative or quantitative description of how long a wine can be expected to age before its quality starts declining.

Airlock: A device used on *carboys* and other winemaking vessels to allow *carbon dioxide* (CO_2) gas to escape during fermentation and aging while keeping air (oxygen), dust and other elements out.

Alcoholic fermentation (AF): The conversion of fermentable sugars — glucose and fructose — into alcohol (*ethanol*) and *carbon dioxide* (CO_2) gas by *yeast*.

Amelioration: A term used to refer to the practice of adding water to *must* for the purpose of lowering the initial sugar level or acidity, i.e., *Specific Gravity (SG)* or *total acidity (TA)*, respectively.

Anthocyanins: The color pigment molecules, belonging to the broad class of *polyphenols*, found in red grape skins and the pulp of certain varieties — called *teinturiers* — that give red wines their color.

Aromas: A term used here to describe all positive odors that can be perceived in wine, i.e., aromas from grapes, from *yeast* metabolism, and from aging in inert vessels as well as barrels, referred to as primary, secondary and tertiary aromas, respectively. Enologists may use the term to refer to the odors of a young wine and differentiate these from the term *bouquet* to refer to the amalgamation of odors only acquired through aging, i.e., tertiary aromas.

1 Making Consistently Great Wine

Making consistently *great* wine goes well beyond following some recipe or set of instructions. Sure, you can make excellent wine relatively easily using a kit or processed fresh juice — that is, juice that your supplier may have adjusted the sugar level, acidity or pH to allow you to make a balanced wine. But as you venture into making wine from grapes or unprocessed fresh juice, you will need to become proficient in all aspects of not only winemaking but also wine science.

To make consistently great wine, you first have to insist on sourcing the best quality raw material you can find and that your budget allows, or on growing fruit adapted to your soil and climate if you have a backyard vineyard. That will be a challenge in itself as you will often have grapes or juice that may not have perfect balance in sugar, acidity, pH and polyphenols to make well-balanced wine. Perhaps you received a load of grapes with a very high sugar level, which you know will be a problem fermenting completely, or perhaps with a high pH, which will require acidification, maybe, maybe not, depending on acidity. Therefore, you will need a solid knowledge of juice and wine chemistry and how to measure the various parameters to be able to understand how to achieve balance — it's not always straightforward — and how and when to intervene when faced with unexpected problems along the way. You will need to be able to assess problems, determine the root cause, and implement corrective actions. Record-keeping will be absolutely essential. You will also need to be familiar with the plethora of commercial winemaking products to help you get more out of your wine. And of course you will need to be familiar with grape varieties so you can make an informed choice for a desired style and decide on processing techniques. We will explore the most common grape varieties in Chapter 2.

If you haven't already done so, first review the terms defined in the *Winemaking Lexicon* section of this book. To help you better manage the winemaking process to make astute decisions, for example, if and how to increase acidity to lower pH, this chapter presents a high-level view of juice and wine chemistry and the transformations that occur from grapes to juice to wine. It provides an overview of the processes for making white, rosé and red wine using grapes, fresh juice, processed 100% juice, and concentrate with detailed protocols presented in later chapters. It also discusses the need and importance of good record-keeping.

1.1 THE TRANSFORMATION OF GRAPES INTO MUST AND WINE

It all starts in the vineyard on vines. After budbreak in the spring, flowers start to grow, pollination and fertilization take place, and then berries form, grow and ripen during the hot, sunny days of summer as fall and harvest approach. The stage at which these ripening changes occur is called veraison. Sugar accumulates, malic acid is slowly metabolized and the high acidity starts declining while tartaric acid remains fairly constant (it doesn't get metabolized), color changes from green to shades of yellow (depending on grape variety) for whites and to hues of deep purple for reds, aromas and precursors develop, and phenolic ripeness increases. Some white varieties, such as Gewürztraminer and Pinot Gris/Grigio, have colored skins that can tinge these white wines with faint pinkish hues.

After veraison, sucrose and other sugars are manufactured by photosynthesis as grapevine leaves convert solar energy and carbon dioxide into sugar in conjunction with soil chemistry to deliver water, minerals and other essential nutrients to allow grape berries to ripen. Most of the sucrose is hydrolyzed into glucose and fructose by invertase enzymes so that there is little sucrose left in fully ripened grapes. In *V. vinifera* varieties, i.e., those of European descent, glucose content starts off considerably higher than that of fructose but then drops as berries start switching from sugar to organic acids as substrates, and levels off to about the same concentration during the maturation phase as berries only use organic acids. Therefore, there are approximately equal amounts of glucose and fructose in berries at harvest. If grapes are left to overripen, fructose continues to accumulate and the glucose-to-fructose ratio drops below 1 (one). The relevance of this ratio from a winemaking perspective is that *Saccharomyces cerevisiae* wine yeast is predominantly glucophilic, therefore it converts glucose at

1.3 OVERVIEW OF WINEMAKING

Depending on your level of expertise, equipment, and budget and effort you are willing to invest in making wine, you have several options as to the choice of raw material: grapes from your own backyard vineyard, grapes sourced from a local grape grower or shipped to you through a third party, fresh juice, frozen must, or kits with concentrated or 100% juice. In this book, we will look at how to make dry white, rosé and red wine from any type of raw material. If you want to explore making styles other than dry wines, such as sparkling wine or sweet styles of wines, please consult reference [6].

1.3.1 GRAPES, FRESH JUICE, FROZEN MUST, KITS

GRAPES

If you have your own backyard vineyard, you have total control over the quality of grapes. You decide when to harvest based on an assessment of sugar level and ripeness, flavor development, and acidity and pH. You are looking for as perfect a balance as possible among all the components. The less imbalance, particularly between sugar and acidity, the less intervention will be required in the winemaking. But even in the best of vintages, adjustments are often necessary, for example, to increase the sugar level, reduce acidity, or lower the pH, to get a balanced must. When ready, you harvest and transport grapes to your home winery for immediate processing.

If you live in a grape-growing area, you can purchase grapes directly from a local vineyard, and then haul the load to your home winery for processing. Unless you have an exclusive relationship with a grower, you have no control or say over the quality of the grapes, therefore, you have to be prepared to deal with the possibility of having to make adjustments.

If you live far away from any grape-growing area, you will likely need to order through a grape purveyor who deals directly with growers and arranges refrigerated transportation to a local facility for pickup. Here too you have no control over the quality and balance of the grapes. Work with

1.3.2 WHITE WINEMAKING

Figure 1.2 illustrates a generalized view of the white winemaking process using grapes or fresh juice. Here, the focus is on creating and preserving aromas and flavors.

Grapes are first crushed and destemmed, then pressed, or possibly just pressed without crushing, i.e., whole clusters, to extract the juice. A short maceration of grape skins in juice before pressing can add aromas and flavors. The juice is chilled to inhibit a spontaneous fermentation while heavy solids and particulates settle at the bottom of the vessel. It is then racked to obtain clearer juice, now called must, which is then warmed up slightly to start the alcoholic fermentation (AF), either spontaneously relying on indigenous yeast or by adding cultured yeast. The AF is done in closed containers, such as glass or stainless steel containers, to minimize oxidation effects as aromas and flavors are very delicate in whites. Except for very few grape varieties, most whites are not put through malolactic fermentation (MLF) so as to preserve the fruity style and all the acidity that gives whites their freshness.

For fuller-bodied styles of white wine, the AF is either conducted in oak barrels or the wine is aged in oak barrels post fermentation. Full-bodied whites are usually allowed to go through MLF to reduce acidity for better balance with tannins, but also to add more aroma and flavor complexity. The wine can also be aged on the lees for extra body, aromas and flavors.

Once the AF (or AF and MLF) is complete, the wine is clarified, stabilized with sulfite to protect it from spoilage microorganisms, stabilized against proteins that can cause haze as well as against tartrates. The wine is racked to separate out the sediment, with optional filtering to get a crystal-clear wine, and then bottled.

For making orange wine, the crushed grapes are macerated with the juice and fermented for several days or weeks depending on the grape variety and desired style, much like in red winemaking. When the desired extraction is achieved or when fermentation is complete, the mass of grape solids is pressed but lightly to avoid extracting excessive tannins, and is then clarified and stabilized as any white wine.

Chapter 19 describes detailed protocols for making white wine.

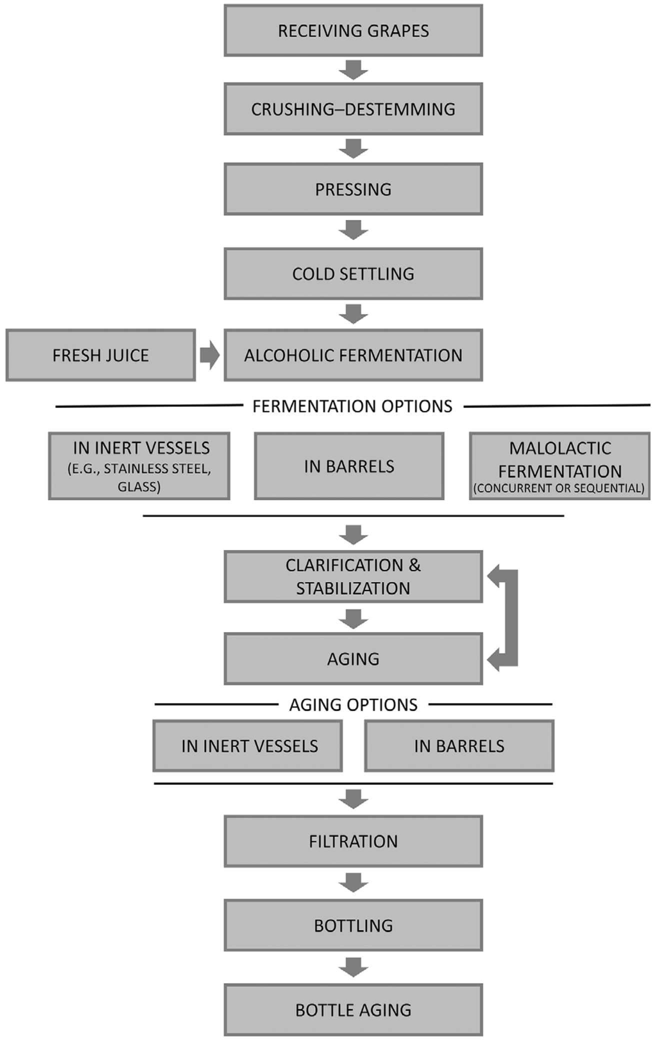


Figure 1.2: Generalized white winemaking process from grapes or fresh juice

1.3.3 ROSÉ WINEMAKING

Figure 1.3 illustrates a generalized view of the rosé winemaking process from grapes. The process is very similar to white winemaking except for a short maceration to extract color. Therefore, in addition to creating and preserving aromas and flavors, the focus here is on extracting just the right amount of color, and protecting that color from the effects of oxidation.

2 A Guide to Popular Grape Varieties

There are many, many grape varieties from which to choose to make white, rosé and red wine, and which can be made in varied styles, from dry to sweet to sparkling. This chapter provides a list of the most common grape varieties and some of the styles of wines they can produce along with some winemaking tips and considerations — you will not necessarily be processing Pinot Noir in the same fashion as Norton.

Grape varieties used for making wine are commonly classified as vinifera, native varieties, and hybrids. They all belong to the genus *Vitis*, Latin for vine. The genus name is usually abbreviated as *V.*, and therefore, *Vitis vinifera* is written as *V. vinifera*. Related varieties that share botanical characteristics are grouped by species, such as *vinifera* and *aestivalis*. Pinot Noir is an example of a variety belonging to *V. vinifera*, and Norton is an example of a variety belonging to *V. aestivalis*.

Grape varieties can be from a specific species, for example, *V. vinifera* or *V. labrusca*, or from crossing two varieties from the same or different species, for example, Cabernet Sauvignon is an intraspecific cross between Cabernet Franc and Sauvignon Blanc, while Baco Noir is an interspecific cross between *V. vinifera* and *V. riparia*. Interspecific crossings are commonly referred to as hybrids.

Species are not that relevant here other to know which varieties are *V. vinifera* since they are by far the most common given their global reach, success and recognition, which are *V. labrusca* given their very characteristic "gamey" and "foxy" aromas, and which have a *V. riparia* lineage that tends to have herbaceous aromas and flavors.

Varieties can also have several clones, such as Pinot Noir, the result of vegetative propagation, and Pinot Gris/Grigio a mutant of Pinot Noir, and which may have different soil or climate adaption, for example. Different clones of the same variety will produce similar wines but perhaps with some differences, for example, in the aroma and flavor profile. There may not always be differences in the wines.

This chapter presents and describes some of the more popular or readily available *V. vinifera*, Native American and hybrid grape varieties for making wine. For additional reading or to learn more about pedigree, origins and viticultural characteristics of grape varieties, please consult references [1], [2] and [3].

ABOUT GRAPE VARIETY DESCRIPTIONS, PROFILES AND YEAST RECOMMENDATIONS

Grape variety descriptions presented here include common types and styles of wines possible. The name of regions are provided in some cases only to inform of origins or where they are best known, which often dictate the style, such as Pinot Noir in Burgundy (France), Nebbiolo in Barolo (Piemonte, Italy), or Marquette in Minnesota (USA). Many varieties are now grown the world over in different climates and soils, and produced into varying styles of wines, and therefore, your results, including aromas and flavors, may vary depending on your source of fruit or juice, choice of yeast, and winemaking techniques. Grape characteristics can vary depending on many factors, for example, vintage and where the grapes are grown. A Cabernet Sauvignon grown in California's Central Valley will have a very different profile than that grown in Washington State (USA) or Chile.

Grapes from colder climates will tend to have lower sugar levels and higher acidity due to higher amounts of malic acid. These may require adding sugar, or chaptalization, to bring the expected amount of alcohol to be produced within standard wine range, or may require deacidification (the lowering of acidity by removing acids). On the flip side, grapes grown in hot climates will tend to have higher sugar levels and lower acidity, which may require the addition of water to produce a wine without excessive alcohol and the addition of acids for better balance.

For additional information on viticultural aspects of growing grapes, you can consult the many references available in print or online. When researching varieties further, be sure that you identify these clearly as they all have many synonyms, many of which are also synonyms for different varieties altogether.

Each grape variety has a pictogram depicting its profile along with a list of recommended yeasts following its description. The profile is to help you quickly identify *typical* characteristics so you can better plan and adapt your winemaking where, for example, you may require to chaptalize a low-sugar harvest or deacidify a high-acid variety.

For white varieties, the profile includes typical SG/Brix and acidity levels, and the most common type of wine in terms of body. Figure 2.1 illustrates the profile for Chardonnay where SG/Brix level would yield a typical alcohol level and with lower acidity, and which would produce a medium-bodied wine.

Figure 2.1: Grape profile example – Chardonnay

For red varieties, the profile includes typical depth of color, SG/Brix, acidity and tannin levels, and the most common type of wine in terms of body. Figure 2.2 illustrates the profile for Cabernet Sauvignon, which is characterized by high color, higher SG/Brix than the average but lower acidity and high tannins, which would produce a full-bodied wine.

Figure 2.2: Grape profile example – Cabernet Sauvignon

As a winemaker, you should measure all relevant parameters within your means and abilities to be able to make corrections towards making great wine, even if from unbalanced fruit. You will have to call upon different techniques, for example, to either increase or lower the amount of alcohol to be produced, or to adjust acidity up or down. Many varieties, especially from cool or cold growing regions and non-vinifera varieties, will have low sugar levels and high acidity.

To avoid repetition in descriptions, it is understood that white wines are almost always put through a chilling process — known as cold stabilization and cold crashing in home winemaking — to avoid having tartrates form in bottles. Tartrate stabilization and the process for stabilizing wines are discussed in Section 14.4. But cold stabilization can also be used specifically for deacidification, i.e., reducing acidity in high-acid wines — both whites and reds.

There is a plethora of yeast strains from the many manufacturers of dry and liquid yeast cultures. Many are only available in large formats, usually 500 g (just over 1 lb), for making wine on a commercial basis. Fewer are available in small formats, e.g., 5 g, 35 mL or 125 mL, geared to amateur winemakers. Yeast strains best suited for each varietal are presented, regardless of format; those available in carboy-sized formats are identified in **bold**. You can search out vendors who repackage yeast cultures into smaller formats, e.g., 8 g, 50 g, 80 g or 100 g, or purchase a larger format and split it with a group of winemakers. Yeast recommendations for each yeast are primarily from manufacturers' product sheets complemented by winemakers' recommendations.

Section 11.7 presents a listing per manufacturer of the most commonly available yeasts and some of their specifications. Be sure to consult manufacturers' product sheets or web pages for complete information on each yeast strain regarding rate of fermentation, flocculation, volatile acidity (VA) production, sulfur dioxide (SO_2) production, malolactic fermentation (MLF) compatibility, and hydrogen sulfide (H_2S) production.

2.1 *VITIS VINIFERA* VARIETIES

The most well-known and most popular wines of the world are made from *V. vinifera* grapes, and are referred to as "vinifera grapes" or simply "viniferas," or as "European varieties" being native to Europe. Viniferas include, for example, Chardonnay, Riesling and Sauvignon Blanc as white varieties, and Cabernet Franc, Pinot Noir and Syrah as red varieties.

The following sections introduce 10 white and 21 red *V. vinifera* varieties to choose from to make exquisite wines.

2.1.1 WHITE VINIFERA VARIETIES

With white viniferas, you will need to make specific winemaking decisions when working with varieties having dominant characteristics. For example, you would approach aromatic whites differently from thiolic varieties, choosing a suitable yeast strain and fermenting at cooler or warmer temperatures that enhance the dominant traits characteristic of each variety.

The most common aromatic whites include Gewürztraminer, Muscat, Riesling and Viognier, but also include Albariño, Chenin Blanc, Pinot Gris and Sauvignon Blanc. Aromatic whites are characterized by high levels of terpenes, compounds that impart very distinctive floral aromas.

Thiolic varieties include Sauvignon Blanc and Grenache as the most common but also Chenin Blanc and Riesling, and are characterized by high levels of thiols, sulfur-based compounds that impart, for example, boxtree, passion fruit and grapefruit aromas.

Albariño (Alvarinho)

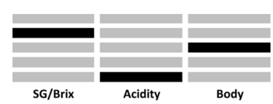
Albariño is a popular Spanish grape variety that produces light but very aromatic whites redolent of citrus fruit, peaches and nectarines. It is also found in Portugal where it is known as Alvarinho and made into the popular spritzy-style Vinho Verde, which translates to "green wine" for its refreshing acidity.

Albariño usually has high acidity that may require deacidification or sweetening for balance. It can age in oak barrels for added complexity and extra body if acidity is lowered.

As it is a thick-skinned variety, it does pose a challenge at the press. It is recommended to first crush and then use rice hulls in the press. A light pressing is best to minimize extraction of bitter tannins from seeds.

Recommended Yeasts

LALLEMAND	LAFFORT	ENARTIS	RED STAR	WHITE LABS	WYEAST	RENAISSANCE
71B-1122, Cross Evolution, DV10, **QA23**, R2, VIN 13	DELTA, VL1, X16	Q Citrus, Q9	**Côte des Blancs**, **Premier Blanc**	**WLP730**	**4028**, **4783**	Allegro



Auxerrois

What we know today in North America as Auxerrois is specifically named Auxerrois Blanc de Laquenexy, a thin-skinned variety known to make delicious wines in northeast France as well as in other cool-climate grape-growing areas in the US and Canada. It should not be confused with other varieties that are also commonly referred to simply as Auxerrois, including Malbec (a red variety) as it is called in Southern France, or Auxerrois Gris, which is really Pinot Gris. And according to Jancis Robinson, even Chardonnay was once known as Auxerrois Blanc. Auxerrois is in fact a sibling of Chardonnay [1].

Auxerrois tends to have low acidity, especially in warmer vintages, and therefore the must (juice) may need a small acidification for a wine style other than dry. It produces very good, albeit alcoholic wines with honey aromas. It is otherwise often blended with one or more of its Pinot relatives, such as Pinot Gris, or Pinot Noir (when made as a white wine), or Chardonnay or Seyval Blanc for better acidity balance.

Recommended Yeasts

LALLEMAND	LAFFORT	ENARTIS	RED STAR	WHITE LABS	WYEAST	RENAISSANCE
71B-1122, Alchemy I	CX9, VL1, X16	ES181, Vintage White, VQ10	**Côte des Blancs**, **Premier Blanc**	**WLP715**, **WLP730**	**4021**, **4783**	Bella

3 Essential Winemaking Equipment

If you are just starting out in winemaking, you only need basic equipment to make a standard 23-L (6-gal) batch. Home winemaking supply shops sell a basic starter kit (Figure 3.1) that includes:

- a pail or bucket (referred to as a primary fermentor in kit winemaking) for fermenting juice
- a 23-L (6-gal) glass or PET carboy (referred to as a secondary fermentor in kit winemaking) for completing fermentation and for storing wine; PET (polyethylene terephthalate) is a type of durable plastic
- a hydrometer and test cylinder
- a fermentation lock (airlock) and stopper (bung)
- a racking cane and siphon hose for transferring wine from one fermentor to another
- a long-handle spoon for stirring

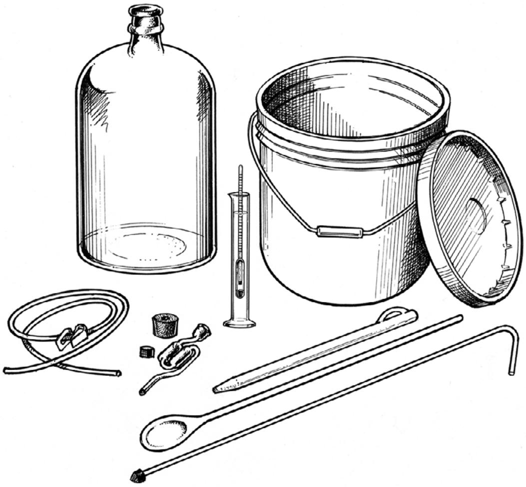


Figure 3.1: Basic winemaking starter kit

A starter kit may also include some extra equipment such as:

- a wine thief for drawing wine samples from fermentors
- a thermometer for monitoring fermentation temperature
- a bottle brush for washing used bottles
- a simple bottle filler
- a hand corker for inserting corks into bottles

You can invest in other equipment for greater efficiency and flexibility as you grow your hobby to larger batches or if you'll be making different types of wines at once, or if you decide to go full out and make wine from grapes.

Filtration and bottling equipment are discussed in Chapters 17 and 18, respectively.

3.1 CRUSHERS AND PRESSES

The first important decision and investment you will make as you take the plunge into winemaking using grapes is the purchase of a crusher and press. If you make red wine from frozen must, you only need a press. The decision on the type of crusher and press is based on your expected annual production, desired efficiency and budget. Be sure to forecast your future needs as your hobby will likely grow very quickly.

There are various models of manual and motorized crushers and crusher–destemmers (Figure 3.2) to suit any budget.

The purpose of the crusher is to split berries open to allow them to be exposed to yeast and release juice in red winemaking, or simply to facilitate pressing and release juice when processing white grapes. Stems are usually removed, or destemmed, as these can impart harsh tannins and unpleasant green aromas, except when you want to press whole clusters, for example, in white winemaking where grapes may go straight to the press without crushing or destemming. If you intend to make more than just a few 16.3-kg (36-lb) cases, consider investing in a motorized crusher–destemmer as destemming by hand is messy and laborious. A crusher–destemmer crushes grapes into a large vat while removing and expelling stems out.

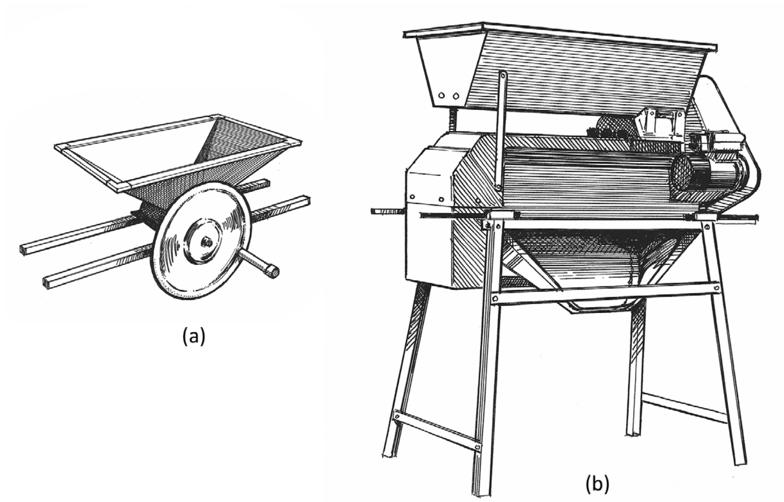
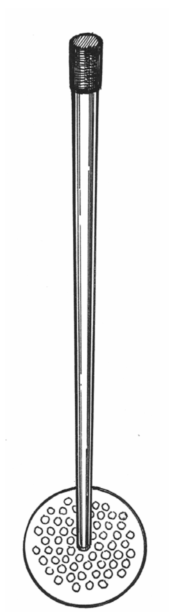


Figure 3.2: a) Manual crusher; b) Motorized crusher–destemmer with stand/chute

You typically crush right into a large vat, but if you are making smaller volumes or your crusher–destemmer is larger than your vat, use a crusher stand/chute (Figure 3.2) to crush into pails, then transfer the crushed grapes to fermenting vessels.



In red winemaking, you need a punchdown tool (Figure 3.3) to submerge several times a day crushed grapes back into the wine as it ferments and carbon dioxide (CO_2) gas pushes grape solids to the surface and form what is called a cap. This helps extract color and tannins, promotes a healthy fermentation, uniforms temperature distribution, and keeps surface spoilage microorganisms in check. You can also do pumpovers where wine is pumped from the bottom valve of a vat, tank or other fermentor and onto the cap to douse and resubmerge it. It is more efficient than punchdowns although it is a fairly aggressive procedure that some will argue it causes excessive oxygen uptake; it also requires a fairly expensive pump that can move grape solids.

Figure 3.3: Punchdown tool

Then you need a press if making wine from grapes, including frozen must. In white winemaking, the press is used to release juice from crushed grapes or from whole bunches. In red winemaking, the press is used to release wine from grape solids that have macerated and fermented in the wine.

If your winemaking is limited to making single-pail, 23-L (6-gal) batches from grapes or frozen must, a small stainless steel press (Figure 3.4) is all you need. You will need a basket or bladder press (Figure 3.4) for larger batches.

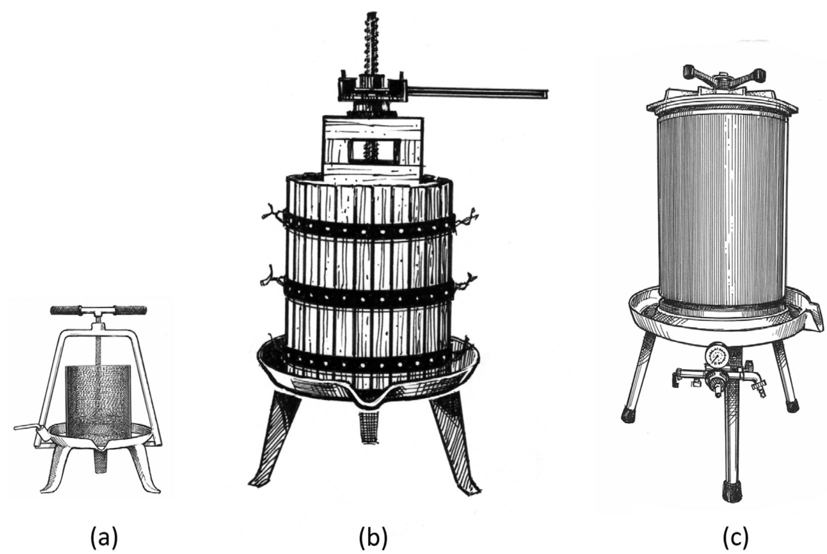


Figure 3.4: a) Small stainless steel press; b) basket press; c) bladder press

Presses can be a significant investment, therefore be sure to pick a size that will keep pace with your growing production, keeping in mind that it will be very difficult to press a small load in a large press and a lot more work to press a large load in a small press. You have to work as fast as possible during pressing cycles to limit the exposure of juice or wine to the elements.

Basket presses range in size from small to very large to handle up to 500 kg (1100 lbs) or more of crushed grapes. Basket size or capacity is typically denoted by a number, such as 45, which simply indicates the diameter of

4 Cleaning and Sanitizing Equipment

Making consistently flawless wines starts with rigorous sanitization of all winemaking equipment. Inadequately cleaned or sanitized equipment — or a dirty winemaking area — can lead to contamination and possibly wine faults or outright spoilage.

Everything — carboys, racking cane, stirring spoon, hoses, pump, etc. — that will come into contact with juice or wine must be thoroughly cleaned and properly sanitized to avoid microbial contamination and possible spoilage. Ambient rogue microorganisms are always present and ready to strike at the most opportune moment. Once wine is infected, it can be very difficult to eradicate the culprit and perhaps impossible to fix if severely flawed. The proverb that "an ounce of prevention is worth a pound of cure" is most appropriate when it comes to implementing a sound cleaning and sanitization protocol in your winemaking.

This chapter describes the difference between cleaning and sanitizing, how to implement an effective cleaning and sanitizing protocol, and how to choose from the many kinds of products available from your winemaking supply shop.

4.1 CLEANING VERSUS SANITIZING

Cleaning and sanitizing are not the same and are not interchangeable; cleaning always precedes sanitizing. And each step is only as good as the previous, that is, if not cleaned properly, then the sanitizing is not effective.

Cleaning is the process of removing organic and inorganic contaminants or residues, such grape fragments, dried juice, soil and dust from the

4.7 CLEANING AGENTS MATERIAL COMPATIBILITY AND USE

Table 4.1: Cleaning agent material compatibility and use

		MATERIALS					
Product or Brand Name	Dilution rates, contact times, and special instructions	Soft glass carboys	Stainless steel (304)	Food-grade plastics	PET carboys	Silicone equipment	Wood barrels
Sodium carbonate (soda ash)	10 g/L Allow 10–20 minutes contact Follow with sulfite–citric rinse	◆	●	●	◆	●	■
Sodium percarbonate	1–3 g/L Allow 10–20 minutes contact Follow with sulfite–citric rinse	◆	●	●	◆	●	●
Sodium hydroxide (caustic soda) Potassium hydroxide (caustic potash)	10–30 g/L Allow 10–20 minutes contact Follow with sulfite–citric rinse	■	●	●	■	■	✖
PBW (Powdered Brewery Wash) (Five Star Chemicals)	5–10 g/L If soaking, heat to 60 °C (140 °F) and soak for 4 hours or allow to soak cold overnight	◆	●	●	◆	●	✖
One Step No-Rinse Cleanser (Aseptox) (Logic)	5–10 g/L For heavy soils, use 30 g/L, heat to 50–70 °C (120–160 °F) and allow 30 minutes contact	◆	●	●	◆	●	✖
Barrel OxyFresh (Logic)	1.5 g/L Allow 4 hours contact time (follow with a citric acid treatment as per manufacturer's instructions)	◆	●	●	◆	●	●
B-Brite Cleanser (Crosby & Baker)	4 mL/L Use warm water and soak up to 24 hours as required	◆	●	●	◆	●	■
OxiClean (Church & Dwight)	20–30 g/L Allow 5–30 minutes contact	◆	●	●	◆	●	✖

Legend:
- ● Safe to use on material
- ◆ Use caution; may affect material
- ■ Generally NOT recommended; may affect material integrity; use caution
- ✖ Do NOT use; will likely have adverse effects on material

5 Conducting Bench Trials

You will often have to use additives or processing aids to make adjustments to must or wine or to perform specific treatments for a number reasons, such as:

- To increase or decrease acidity for taste or to adjust pH (Section 7.5)
- To determine how much fining agent (e.g., bentonite) to add to treat proteins (Section 14.3)
- To sweeten to balance gripping acidity (Section 16.1)
- To add or soften tannins to improve mouthfeel (Sections 16.2 and 16.3)
- To determine how much copper sulfate ($CuSO_4$) to add to eliminate a stinky hydrogen sulfide (H_2S) smell left over from fermentation (Section 22.4)

NOTE *These adjustments are discussed in section numbers shown in parenthesis. We will look at conducting bench trials for the purpose of blending two of more wines to create a certain style or to correct deficiencies in Section 16.5.*

All these scenarios require finding the optimal amount of a substance — e.g., tartaric acid, bentonite, sugar — needed to achieve some desired results. This requires performing tests on a small scale with juice or wine samples with varying amounts of the substance and doing some comparative assessments, and then scaling up the trial results to treat an entire batch — this process is referred to as conducting bench trials.

6 Wine Analysis and Control: Sugar and Alcohol

You can certainly make wine — good wine — without any knowledge of wine chemistry or analysis. When making wine from a kit or some "recipe" you found on the internet, you can simply follow the instructions and have a very good chance of making good wine. Concentrate in kits or processed juice have sugar, acidity and pH levels adjusted to make a well-balanced wine.

However, if you want to make great wine with impeccable balance from grapes or unprocessed juice, and consistently, you will need some basic knowledge of wine chemistry and analysis; more often than not, you will be faced with unbalanced must chemistry or perhaps subpar grapes that will necessitate making adjustments. This knowledge and analytical skills will also help you replicate a style from year to year, or help you identify and resolve winemaking problems — you can only make as great wine as your ability to fix problems.

Sugar, acidity and pH are the three most basic essential control parameters in winemaking. This chapter discusses analysis and control of sugar and alcohol, and how to make adjustments to increase or decrease sugar or alcohol. Chapter 7 discusses the same for acidity and pH. Sulfur dioxide (SO_2) chemistry too is an essential control parameter; it is a more advanced topic and is discussed in detail in Chapter 8.

6.1 SUGAR AND ALCOHOL

Wine is the transformation of sugars into alcohol, more specifically the transformation by yeast fermentation of glucose and fructose into ethanol, and therefore, the amount of sugar in grapes or juice dictates the *maximum*

Set aside a 200-mL sample in the refrigerator; you may need to come back to it later on to perform some extra analysis, for example, when doing a root-cause analysis.

If the wine has fermented to complete dryness, your final % ABV should be close (up to ±0.5% ABV is quite acceptable) to your calculated PA based on measured SG/Brix. However, if the wine has stopped fermenting or you deliberately stopped fermentation for a sweeter style of wine, then you have to subtract the PA at the final SG/Brix from the initial PA. Section 11.6 describes how to halt a fermentation for retaining some residual sugar and sweetness.

If you want to measure the actual amount of alcohol in your wine to see how close it is to the measured PA at the juice stage, there are analytical techniques, equipment and kits available, but these tend to involve work, handling dangerous reagents, or expensive equipment. If you want to explore this further as you progress in your winemaking, you can research ethanol analysis by ebulliometry, chemical oxidation (e.g., Vinmetrica's Alcohol By Volume Kit), or distillation.

Let's look at an example to understand how all this works in practical terms.

EXAMPLE 6.1

Estimating PA from SG, Brix

You just received your pail of white juice and it is very cold. You measured a SG of 1.093 (22.5 Brix) at 10 °C (41 °F) using your hydrometer calibrated at 20 °C (68 °F). Using Table B.2 in Appendix B, the SG is corrected by –0.003, so that the adjusted SG is 1.090 (21.9 Brix).

To calculate PA, convert 21.9 Brix to 219 g/L of fermentable sugars, which, using a factor of 17.5 g/L, gives an estimated PA of 219 ÷ 17.5 or 12.5%. If fermented to dryness, i.e., SG below 0.995 (Brix below –1.5), the wine can be expected to have a final % ABV close to 12.5%.

7 Wine Analysis and Control: Acidity and pH

PREAMBLE

Acidity and pH chemistry is one of the most complex topics in winemaking, second to sulfur dioxide (SO_2) chemistry, which we explore in Chapter 8. The fact that expected results when acidifying or deacidifying rarely match actual results is testament to the complexity of managing acidity and pH.

The acidity and pH adjustment approaches presented in this chapter go well beyond the theory; they reflect practical experience that will give you confidence in managing acidity and pH beyond guesswork. This requires that we delve into some acidity theory and concepts, though this is a review of high school or college chemistry.

HOW TO USE THIS CHAPTER

If you are a beginner and are not ready for acidity/pH chemistry, you can skip Sections 7.1 and 7.4. Without a solid knowledge of acidity/pH theory and concepts, making adjustments to must (juice) or wine can be hit-and-miss that can very likely lead to undesirable results, perhaps irreversible. Make small adjustments to small batches, experiment, to the extent possible, and learn — it will help avoid huge disappointments. As you gain experience and confidence, come back to these sections; you'll become more comfortable tackling acidity and pH concepts.

Acidity and pH are very important chemistry topics in winemaking as they impact taste and balance, microbial stability, tartrate stability, oxidative potential, as well as color intensity and stability in reds.

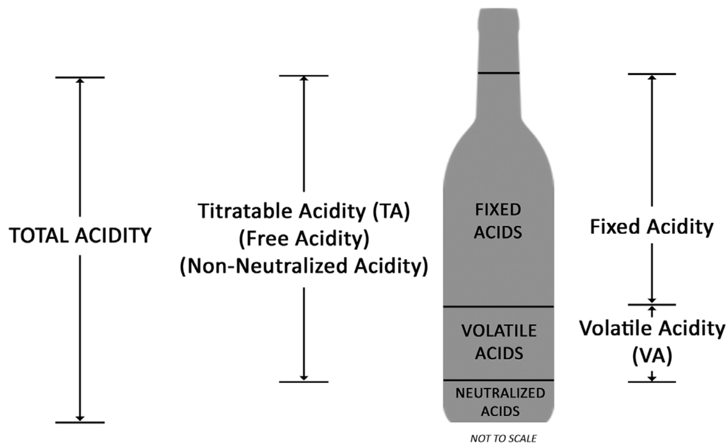


Figure 7.1: Acidity terminology used in winemaking

TA is expressed in g/L or as a weight-to-volume percentage, which means g/100 mL. TA numbers in the literature often specify that TA is expressed as "tartaric acid equivalents" since other countries use different acids as the reference, for example, France uses sulfuric acid. A wine with a TA of 6.5 g/L or 0.65% expressed as tartaric acid equivalents means that if you were to convert all the acids to tartaric acid, the wine would measure 6.5 g of tartaric acid per liter of wine, or 0.65%, i.e., 0.65 g/100mL.

VA is expressed in g/L, but most often in mg/L since values tend to be well below 1 g/L.

The definition of pH does not change since it is a measurement of the amount of dissociated protons — it does not distinguish protons among the many acids. However, juice and wine are complex solutions that also contain significant amounts of potassium translocated from the soil into berries and into wine, and therefore protons (H^+) are "exchanged" for potassium ions (K^+) and raise the pH accordingly. And, for example, the greater the amount of rainfall in a poor vintage, the greater the amount of potassium in grapes and consequently the higher the pH.

Table 7.1 lists recommended ranges for TA and pH in must (juice) and for different styles of wines from vinifera grapes. These ranges will be significantly different when making wine from hybrid or Native American grapes, or from grapes from cool- or cold-climate growing areas or from a very poor vintage where TA of grapes can often exceed 12 g/L, making

ing with must with low TA, for example, 4 g/L, TA will drop but only minimally given the smaller amounts of tartaric and malic acids, and therefore, adding tartaric acid will raise TA (but keep in mind that there will be a slight decrease during cold stabilization). And if you have must with very high TA, say above 10 g/L, you likely have a situation of high malic acid and low tartaric acid, in which case you can expect a large drop in malic acid during MLF (if done) and possibly no change in tartaric acid, in which case you may need to add tartaric acid to compensate for the large drop in malic acid.

Tartrate stabilization using protective colloids does not impact TA or pH.

Let's tackle the topics of how to manage acids and pH and how to make necessary adjustments with some examples.

7.5 ADJUSTING ACIDITY AND PH

In a perfect vintage, grapes are harvested at the ideal level of ripeness where taste, SG/Brix/PA, TA and pH are in perfect balance. But all too often Mother Nature gives us a late start to the growing season, perhaps a cool season or excessive rainfall, and one or more parameters that are out of balance.

Acidity can be very low in a very hot vintage as much of the malic acid in grapes has been metabolized, whereas acidity can be very high in a poor vintage because excessive malic acid has not been metabolized to the extent that it should have. And therefore, low-acid juice may require the addition of an acid to boost TA, a practice known as acidification (also as acidulation), and high-acid juice may require the reduction or removal of one or more acids, or deacidification, to lower TA. Acidification and deacidification are also used to decrease or increase pH, respectively.

But as home winemakers we are only equipped to measure TA (and pH), not the concentration of individual acids. This makes choosing and implementing acidification and deacidification techniques tricky as we have to guess on the relative concentrations of tartaric and malic acids (Figure 7.3) and predict how those acids and TA and pH will change throughout winemaking and end up with a final TA within a desired range. Different

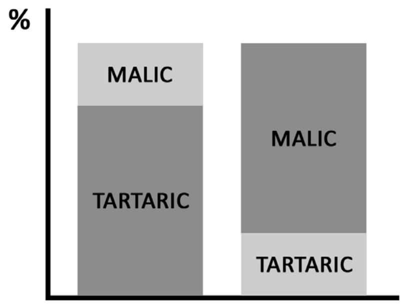


Figure 7.3: Musts or wines with different relative tartaric and malic concentrations will require different approaches to adjusting TA or pH

acidification and deacidification approaches are required depending on the relative concentrations of tartaric and malic acids.

NOTE *If you are inclined to try enzymatic assaying, you can use Vinmetrica's SC-50 MLF Analyzer Kit to quantify malic acid (see Section 12.5).*

And given the complexity of weak-acid chemistry in buffered solutions, these techniques seldom yield textbook results — the addition of 1 g/L of tartaric does not always cause a 0.1 drop in pH, or any drop for that matter. And, as we have seen, a drop in TA due to cold stabilization does not necessarily translate into an increase in pH. It can seem like an overwhelming challenge managing TA and pH — it is!

The same goes for online calculators that help you figure out your acid adjustments — these may not take these factors into consideration, and will therefore often yield results much different from expected theoretical results.

There will be a lot of guesswork involved in making adjustments, hence why bench trials are absolutely necessary. Here are tips to improve your chances of balancing TA, pH and taste when making adjustments.

Your total here is 250 g (8.8 oz) instead of the planned 200 g (7.0 oz) owing to the larger volume than estimated. You can now estimate the juice yield more accurately using these results:

$$Estimated\ volume\ (L) = 100\ L\ \times \frac{250}{200}$$
$$= 125\ L\ (33\ gal)$$

Your expected yield is therefore 125 L (33 gal) and all subsequent additions should be based on this volume.

EXAMPLE 7.4

Acidification with tartaric acid for the purpose of decreasing pH

You just crushed a load of red grapes, taken a sample to the lab, and measured a TA of 6.0 g/L and a pH of 3.80. TA is good but the pH is a bit high — you wish to reduce it to around 3.60.

Since tartaric acid is the acid that has the biggest impact on pH, the best approach here is to run bench trials with stepwise additions of tartaric acid as a 10% solution and monitoring pH changes to determine how much tartaric acid is needed to drop pH from 3.80 to around 3.60.

Example 5.2 in Section 5.3 describes the procedure for running these bench trials. Since you know about buffering now, don't make any assumptions as we did in Example 5.2; you may need more tartaric acid than expected (i.e., more than 1.0 g/L for each 0.1 pH drop).

If, as in Example 5.2, your TA is 6.0 g/L and you determined that you need 2.5 g/L of tartaric acid, this raises TA to 8.5 g/L — somewhat high for a red wine, particularly a tannic red. But you will likely put the wine through MLF, and that will reduce TA although it will raise pH. The extent of TA and pH changes depend on the amount of malic acid. If TA is still too high after MLF, you have the option of cold stabilizing the wine.

If this were a white wine, a TA of 8.5 g/L might be just okay knowing that it will drop once the wine is chilled at the cold stabilization stage. Predicting pH from cold stabilization is tricky and is best estimated by doing bench trials.

8 Wine Analysis and Control: Sulfur Dioxide

PREAMBLE

Sulfur dioxide (SO_2) chemistry is one of the most complex topics in winemaking, and certainly an intimidating one to new hobbyists. It's a tough one to master without understanding the underlying chemistry. And then, there are as many approaches to managing SO_2 as there are winemakers. But with knowledge and experience, you will come to expertly manage SO_2 and adopt your own protocol that works best for you.

In this chapter, I share my years of experience in measuring SO_2 extensively and rigorously — that is, not only free SO_2, but also total SO_2 and dissolved oxygen (DO) — and correlating the parameters. I have amassed and analyzed a wealth of data, which have helped me optimize SO_2 management practices in my winemaking. I am a strong advocate of SO_2 use in winemaking, but I also strive to use the "right" amount — no more, no less — and this work has translated in lower amounts of total SO_2 in my wines.

HOW TO USE THIS CHAPTER

If you are a beginner and are not ready for SO_2 chemistry or if you are not inclined to measure SO_2 levels, still read Section 8.1 to get an appreciation of why SO_2 is needed and how it protects wine, and then jump to Section 8.5 for instructions on how to blindly add sulfite — you should still be adding sulfite to your wines. Then come back to this chapter as you gain more knowledge and experience and become more comfortable tackling SO_2 concepts.

Sulfur dioxide (SO_2) has long been used in winemaking as a sanitizing agent (see Section 4.5.1) but more importantly as a preservative against oxidative and microbial spoilages, and aroma loss. But the chemistry and mode of action of sulfur dioxide is not always well understood and is often a source of frustration amongst winemakers — novice and experienced alike.

Although SO_2 analysis and control is considered an advanced topic in home winemaking, these concepts and techniques will help you better manage SO_2 towards making consistently, technically better wines. All too often wines become prematurely tired — past their peak and lost precious aromas and flavors — due to oxidation from underuse of SO_2; or they lack aroma freshness from blind overuse of SO_2.

Here you will learn about the importance of the use of SO_2 in winemaking, how to add the "right" amount of SO_2, and how to manage SO_2 from crush to bottle.

This chapter presents principles in SO_2 chemistry and the differences among the terms sulfur dioxide, bisulfite and sulfite — the terms are used interchangeably but they have very different meanings and have different mechanisms of action in protecting wine. Specifically, we will learn about:

- The different sources of SO_2
- How SO_2 protects against oxidation and microbial spoilage
- How SO_2 interacts with wine components
- Practical aspects of SO_2 management in the cellar
- Methods and strategies to optimize and minimize the use of SO_2

8.1 WHY THE NEED FOR SO_2?

Sure! Wine can be made "naturally" without adding any SO_2. But the judicious use of SO_2 will not only improve microbial stability, it will also protect against chemical oxidation and vastly improve the wine's ageing potential, maintain freshness, and protect against aroma loss or degradation.

Use Table 8.3 to determine how many mL of 10% KMS solution is needed per liter or gallon of wine to increase FSO2 by a desired amount.

EXAMPLE 8.6

Determining how much 10% KMS solution to add

You would like to add 56 mg/L FSO2 to a 23-L (6-gal) batch.

From Table 8.3, an increase of 56 mg/L is achieved as (5×**10** + 1×**5** + 1×**1**), and therefore, calculate the required amount of 10% KMS solution as follows:

8

$$Amount\ of\ 10\%\ solution\ (mL)$$
$$= (5 \times 0.17 + 1 \times 0.09 + 1 \times 0.02) \times 23\ L$$
$$= 22\ mL$$

EXAMPLE 8.7

First KMS addition after fermentation

Your medium-bodied Cabernet Sauvignon just completed both AF and MLF. And it's time to stabilize the wine with SO_2. You transferred the wine to a single 23-L (6-gal) carboy for aging in your cellar at a temperature of 13 °C (55 °F). You don't know the actual % ABV but you had measured a PA of 14.5% and fermented the wine completely dry. Wine pH is 3.55 and you assume that, since you don't measure SO_2 levels, both FSO2 and TSO2 are 0 mg/L for all practical purposes.

Summary of wine parameters and measurements

Time (months)	Batch size	% ABV	pH	Temp.	Measured FSO2 (mg/L)	Measured TSO2 (mg/L)
0	23 L 6 gal	14.5	3.55	13 °C 55 °F	0	0

Since this is a medium-bodied red, you decide to use 0.5 mg/L MSO2. Using the equation in Section 8.2, calculate the required FSO2 as follows:

$$FSO2\ (mg/L) = 0.5 \times \left[1 + 10^{(3.55-1.81)}\right]$$
$$= 28\ mg/L$$

9 Understanding Tannins

The topic of tannins is fundamental in understanding red wine structure and body, and managing the red winemaking process. Tannin chemistry is an advanced topic; however, you will often come across the different types of tannins occurring in wine or which are added during winemaking, and you will need to understand how these work — at a functional level — so that you can make informed decisions on if, when and how to use tannins to, for example, stabilize color, or how to correct for deficiencies in structure and body. As you browse through a vendor's product catalog to choose an appropriate tannin product, you will often see tannins split into three categories: fermentation, aging and finishing tannins.

In this chapter, you will learn what tannins do, the different kinds of tannins, where they come from, and how tannin products are used in winemaking. There is a lot of terminology — some of it can be very confusing — so we'll clear it all up.

9.1 TANNINS: WHAT ARE THEY, WHAT DO THEY DO, WHERE DO THEY COME FROM?

Tannins are a broad class of heterogeneous compounds, known as polymerized flavonoid phenols or simply polyphenols, found in grape skins, seeds and stems, certain types of woods and nuts, plants, green tea and dark chocolate, and which are mainly known for their bitter taste and astringency. Astringency is a tactile sensation of dryness and roughness on the palate, or what is often described as a "puckery mouthfeel," and is due to tannins binding with saliva proteins when we taste and drink red wine. High acidity will reinforce bitterness and astringency of tannins, hence why tannic reds typically have lower acid levels.

10 Understanding Enzymes

Enzymes are proteins that enable or catalyze specific reactions without themselves undergoing any change. These reactions could otherwise not happen or could take much longer to occur. You may already be familiar with, for example, sucrase, the enzyme that hydrolyzes sucrose into glucose and fructose.

Microbiological processes in juice and wine are all enabled by a plethora of enzymes, from the transformation of sugars into alcohol by yeast during fermentation, to the conversion of malic acid into lactic acid by lactic acid bacteria during malolactic fermentation (MLF), and to microbial spoilage reactions, such as the oxidation of ethanol into acetic acid by acetic acid bacteria. All these enzyme-enabled reactions are said to be of microbiological nature as they involve microorganisms.

Many other enzymatic reactions in juice and wine are of a chemical nature, that is, they do not involve microorganisms. We have already encountered many such reactions, such as phenolic browning caused by naturally occurring polyphenol oxidases (PPOs) in grapes that cause juice to oxidize and turn brown if not protected from oxygen, and pectin breakdown by naturally occurring pectinases in grapes.

Winemakers add specific enological enzymes to enable or hasten reactions that act on specific substrates, such as breaking down grape cell walls and proteins, and releasing aromas from their non-volatile part (see Section 1.1).

Enzymes are easily identifiable by their prefix, usually the name of the substance they act on or how they perform that action, plus the suffix –*ases*; for example, pectinases break down pectin, and glycosidases cleave a specific bond that releases a sugar molecule from an aroma molecule.

11 Alcoholic Fermentation

Alcoholic fermentation (AF) is the transformation of fermentable sugars — glucose and fructose — by yeast into ethanol and vast amounts of carbon dioxide (CO_2) gas as the main products, plus a plethora of by-products that give wine a multitude of aromas and flavors. These by-products include aroma-carrying esters and terpenes, glycerol, acids and higher alcohols. Yeast will benefit from a good supply of nutrients in the form of nitrogen, minerals and vitamins to carry out the AF successfully and avoid sensory deviations.

The common practice is to add commercially produced cultured yeast in dry or liquid format. Cultured dry yeast comes in 5-g packets for home winemaking use or in larger sizes, for example, 500-g and 1-kg "bricks" for bigger operations; cultured liquid is available, for example, in 35 mL and 125 mL formats to make a standard, carboy-sized batch of wine. Cultured yeast comprises strains from the *Saccharomyces cerevisiae* (abbreviated to *S. cerevisiae*) species as they are best suited for making wine. *S. cerevisiae* yeast can withstand the harsh conditions of increasing alcohol and ferment to 16% ABV with some strains capable of reaching 18% ABV.

Many winemakers, especially those that espouse natural winemaking, rely on indigenous yeast that comprise *S. cerevisiae* as well as non-*S. cerevisiae* strains, the latter being much weaker and usually cannot complete fermentation on its own, but which can add aroma and flavor complexities. Most non-*S. cerevisiae* yeast can initiate fermentation but then die off at around 3–5% ABV at which point *S. cerevisiae* yeast takes over and completes fermentation.

Unless you manage your own backyard vineyard and are familiar with its microflora and the kinds of wines it can produce, relying on opportunistic indigenous yeast can cause off-aromas and flavors or possibly a stuck fermentation — a condition when yeast is no longer able to metabolize

To rehydrate and prepare dry cultured yeast (Figure 11.2), add rehydration nutrients as per manufacturer's instructions to fresh, clean, chlorine-free water at around 43 °C (110 °F) in a suitably sized, sanitized beaker. As an example, if using Go-Ferm as rehydration nutrients, add 0.3 g/L or 0.4 g/L to must with SG below or over 1.110 (26 Brix), respectively. The amount of water needed is typically about 20 times the weight of rehydration nutrients to be added; for example, if instructed to add 0.3 g/L for a 23-L (6-gal) batch, you will need to add about 7 g to 140 mL of water — let's say 150 mL; it's an easier number to work with beakers or flasks. Stir well while adding the nutrients and continue stirring until completely dissolved; there should be no clumps.

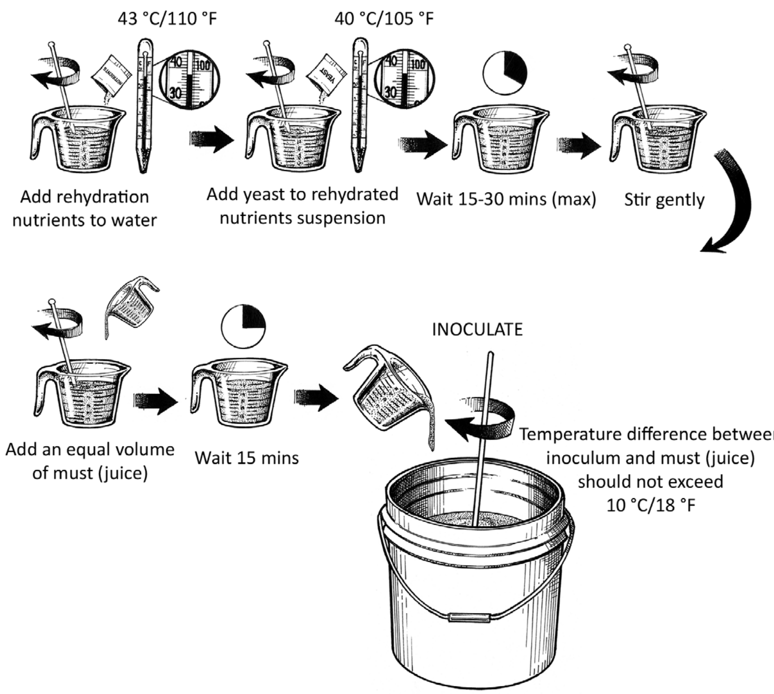


Figure 11.2: Rehydrating yeast

Although rehydration nutrients contain plenty of minerals to provide yeast with a balanced environment, as a precaution, do *not* use distilled water as it may inhibit or kill yeast if there is a mineral deficiency.

Let the suspension drop to around 40 °C (105 °F), then add the yeast while *very gently* stirring with a sanitized spoon for no more than a minute.

11.7.1 LALLEMAND

Yeast[1]	Temp. range (°C)	Temp. range (°F)	Alcohol tolerance	Nutrient needs	Restart stuck ferm.[2]	Malic degradation	Types of wines: White	Rosé	Red	Recommended varieties[3,4]
71B-1122	15–29	59–84	14%	Low		★	★	★	★	AL, AU, **BN**, **CN**, **CO**, **GY**, LC, **LM**, **MF**, **MQ**, NI, **NR**, **NT**, PG, RI, **FR**, **GR**, **SC**, SV, VB, Rosé
Alchemy I	13–16	55–61	15.5%	Med			★			CH, CB, LC, PG, RI, SB, SV, TR, VB
BDX	18–30	64–86	16%	Med					★	**CF**, **CM**, **CS**, **ME**, **PV**, **SY**, **TN**, **ZF**
BM45	18–28	64–82	15%	High			★		★	CH, **CN**, **CS**, **GR**, **MF**, **SG**, **ZF**
BM4X4	18–28	64–82	16%	High			★		★	**AG**, CH, **CN**, **CW**, **CS**, **FR**, **GR**, **MQ**, **PS**, **PT**, **SG**, **ZF**
BRG	18–31	64–88	15%	High			★		★	CH, **GY**, **PN**
BRL97	16–29	61–84	16%	Med					★	**BB**, **MA**, **ME**, **MF**, **NB**, **NR**, **NT**, **PN**, **PV**, **ZF**
CLOS	14–90	57–90	17%	Med					★	**AB**, **AG**, **BB**, **CN**, **GR**, **MA**, **MQ**, **NR**, **NT**, **PS**, **PV**, **SC**, **SY**, **TN**, **TP**, **ZF**
Cross Evolution	14–20	57–68	15%	Low			★	★		AL, CH, GW, MU, VI, Rosé
CSM	15–32	59–90	14%	Med					★	**CF**, **CM**, **CN**, **CS**, **FR**, **ME**, **MQ**, **PV**, **SC**
CY3079	15–25	59–77	15%	High			★			CB, CH, PG
DV10	10–35	50–95	17%	Low	★		★	★		AL, CH, GW, PG, Rosé
EC-1118	10–30	50–86	18%	Low	★		★	★	★	All varieties
ICV-D21	16–30	61–86	16%	Med			★		★	CH, **CS**, **ME**, **SY**, **TN**, **ZF**
ICV-D254	12–28	54–82	16%	Med			★		★	CH, VI, **CF**, **CN**, **CS**, **MA**, **MQ**, **NT**, **PV**, **SG**, **SY**, **TN**, **ZF**
ICV-D47	15–28	59–82	15%	Low			★	★		CH, VI, Rosé
ICV-D80	15–28	59–82	16%	High					★	**AB**, **AG**, **CM**, **CN**, **CS**, **ME**, **PS**, **PT**, **SY**, **TN**, **ZF**
ICV-GRE	15–28	59–82	15%	Med			★	★	★	CB, RI, VI, **CF**, **CS**, **GR**, **ME**, **SY**, **TN**, Rosé
K1V-1116	10–35	50–95	18%	Med	★		★	★	★	CB, **CW**, VB, Rosé
Lalvin C	15–30	59–86	16%	Low	★	★	★	★	★	LC, **FR**, **NT**, SN, Rosé
QA23	15–32	59–90	16%	Low			★			AL, CB, CH, CW, GW, LC, MU, PG, RI, SB, SV, TR, VB, VI
R2	10–30	50–86	16%	High			★			AL, CB, GW, LC, MU, PG, RI, SB, TR, VB, VI
RC 212	15–30	59–86	16%	Med					★	**BN**, **CN**, **CS**, **FR**, **GR**, **GY**, **MF**, **MQ**, **PN**
RP15	20–30	68–86	17%	Med					★	**CF**, **CS**, **FR**, **GR**, **LM**, **MA**, **ME**, **MF**, **MQ**, **NT**, **PS**, **PV**, **SY**, **TN**, **TP**, **ZF**,
SVG	16–28	61–82	15%	Med			★	★		LC, PG, RI, SB, SV, VI, Rosé
SYRAH	15–32	59–90	16%	Med					★	**AB**, **AG**, **ME**, **MV**, **PS**, **PV**, **SY**, **TN**
Uvaferm 43 RESTART	13–35	55–95	17%	Low	★		★	★	★	All varieties
VIN 13	12–16	54–61	17%	Low			★	★		AL, CH, CB, LC, MU, SB, SN, TR, VI, Rosé

[1]Yeast identified in **bold** are available in 5-g packet for fermenting standard carboy-sized batches.
[2]Can be used for all varieties.
[3]"Rosé" means any variety that can be used for making a rosé wine.
[4]Red varieties are identified in bold.

12 Malolactic Fermentation

Most red wines and only a handful of whites go through what many call a "second" and even "secondary" fermentation where lactic acid bacteria (LAB) convert naturally occurring, sharper-tasting malic acid (think green apples) into the softer, weaker lactic acid (think dairy products) and reduce overall acidity (and increase pH) in what is known as malolactic fermentation, or MLF. The sight of tiny, slow-rising carbon dioxide (CO_2) bubbles post alcoholic fermentation (AF) is usually a telltale sign of an active MLF. And just as with indigenous yeast, some winemakers familiar with the microflora in their vineyards and wineries may rely on indigenous LAB, but it's otherwise very risky as there are many more rogue bacteria that can outcompete "good LAB" and produce off-aromas and flavors, biogenic amines, and possibly outright spoilage. Biogenic amines are contaminant substances, some of which have physiological effects, such as headaches, and include histamine, putrescine and cadaverine. Modern winemakers appreciate the predictability and reliability of commercial cultured LAB, which are screened to remove the enzymes responsible for biogenic amine production.

NOTE *If you make wine from kits, you can skip this chapter. Juice and concentrate in kits have been prepared to produce balanced wines. Putting such wines through MLF can compromise quality and yield unexpected results that can be very different than the style the kit vendor intended.*

MLF produces many by-products that contribute positive aromas and flavors. Diacetyl — the same substance that's added to your popcorn at the movies — is produced by some LAB strains used in MLF and is partially responsible for the buttery aroma in, for example, barrel-aged and barrel-fermented Chardonnays.

As the paper dries, it will turn a blue–green color with yellowish spots corresponding to each acid. When dry, remove the staples and uncurl the paper — it is now called a chromatogram. Figure 12.4 shows an example of an actual (digitally-enhanced) chromatogram illustrating separation of acids.

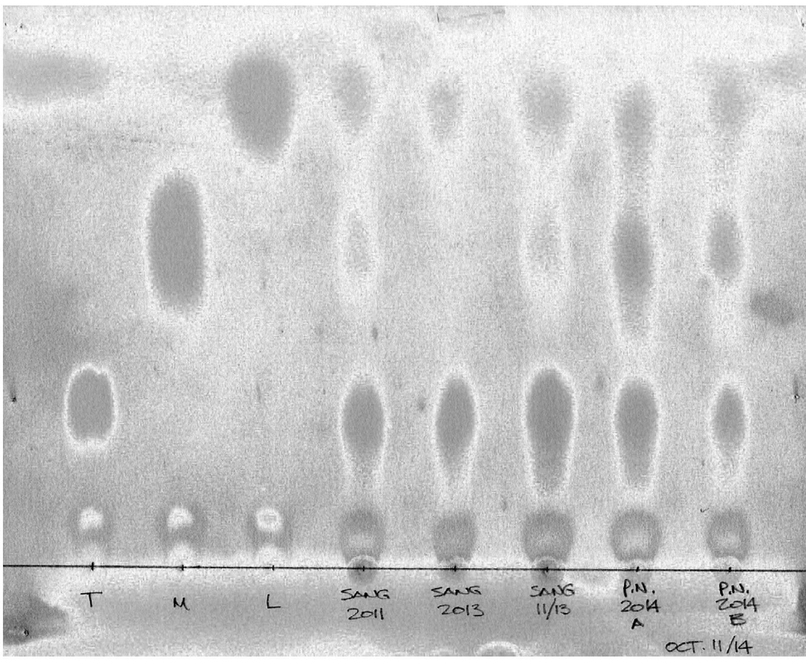


Figure 12.4: Example of a chromatogram showing separation of acids. MLF is in progress in wine samples SANG 2011, SANG 11/13, P.N. 2014A and P.N. 2014B, with the SANG (Sangiovese) much further ahead than the P.N. (Pinot Noir) samples. The absence of a malic spot for the SANG 2013 sample indicates that this batch has completed MLF.

Using the yellow spots formed by each of the reference acids, you can now see the component acids for each wine sample. Since all (grape) wines have tartaric acid, there will be a tartaric acid spot in each sample at the same height as the tartaric reference spot. For each sample, moving up the paper from its tartaric acid spot, look for the presence of a malic acid spot. If there is no visible sign of a yellow spot, it means that the MLF has completed and converted all malic acid into lactic acid for that sample, and therefore, if you move up the paper for that sample, there should be a

12.7.1 LALLEMAND

Bacteria[1]	Format	Addition method	Temp. range (°C)	Temp. range (°F)	Alcohol tolerance	Nutrient needs	Minimum pH	Maximum Total SO_2 (mg/L)	Diacetyl production	Restart stuck MLF	Types of wines: White	Rosé	Red
Enoferm Beta	Freeze-dried	Direct[2]	14–27	57–81	15%	High	3.2	60	Seq.: High Co-inoc: Low		★	★	★
Lalvin MBR 31	Freeze-dried	Direct[2]	13–28	55–82	14%	Med	3.1	45	High		★	★	★
Lalvin MBR VP41	Freeze-dried	Direct[2]	16–28	61–82	16%	Low	3.1	60	Low	★	★	★	★
PN4	Freeze-dried	Direct[2]	16–28	61–82	16%	Med	3.1	60	High				★
ML Prime	Freeze-dried	Direct[2]	20–26	68–79	10%	Very Low	3.4	50	Very Low				★

[1]All strains are from the species *Oenococcus oeni* , except ML Prime, which is from *Lactobacillus plantarum* .
[2]Direct inoculation possible with or without rehydration.

12.7.2 LAFFORT

Bacteria[1]	Format	Addition method	Temp. range (°C)	Temp. range (°F)	Alcohol tolerance	Nutrient needs	Minimum pH	Maximum Total SO_2 (mg/L)	Diacetyl production	Restart stuck MLF	Types of wines: White	Rosé	Red
Lactoenos B16 Standard	Freeze-dried	Rehydrate in must/wine	16–25	61–77	16%	Low	2.9	60	Low	★	★	★	★
Lactoenos B7 Direct	Freeze-dried	Direct[1]	16–25	61–77	16%	Low	3.2	60	Low		★	★	★

[1]Direct inoculation possible with or without rehydration.

13 Clarifying and Fining for Taste and Visual Appeal

The terms "clarification" and "fining" are used interchangeably although they have different meanings to experienced winemakers.

Clarification is the process of treating or processing must or wine for the purpose of achieving clarity, or limpidity in winemaking-speak. It is achieved by natural sedimentation by gravity, by the use of processing aids (referred to as fining agents in this context) to aid in flocculation, by filtration, or a combination of these. Sedimentation and the use of fining agents cause a more or less voluminous mass of sediment to form at the bottom of vessels. The liquid portion is separated from the sediment and transferred to another vessel by what is referred to as racking.

Fining is the process of treating the must or wine with fining agents for the purpose of achieving clarity, modifying or correcting color, mouthfeel, flavors and aromas, removing unwanted compounds, and stabilizing against potential instabilities. You will also often hear the terms counter-fining or two-stage fining; these refer to the practice of adding a second fining agent or other processing aid to either improve the efficacy of the first fining agent or, for example, to help it sediment. If you have made wine from kits, you will be very familiar with the duo-pack of kieselsol and chitosan at the clarification stage where chitosan is used to counterfine kieselsol — we'll learn why and how.

This chapter discusses how to carry out clarification and fining operations, and given their controversy, it also address their impacts on color, mouthfeel, aromas and flavors. Filtration is discussed separately in Chapter 17.

If you will be clarifying using a fining agent, be sure to degas *before* you add in the fining agent — the wine will not clarify if there is excessive CO_2 still. This is an all-too-common cause of fining problems in "rushed" wines.

Degassing is accomplished by mechanical means (Figure 13.3), either by agitation or using a vacuum pump. You can use the handle of a long-handled spoon and lots of elbow grease, or better yet, a lees stirrer mounted on an electric drill, or a vacuum pump or compressor with one of several attachments or devices available on the market, such as the Headspace Eliminator (it's also a degassing device) and Gas Getter (Figure 13.3).

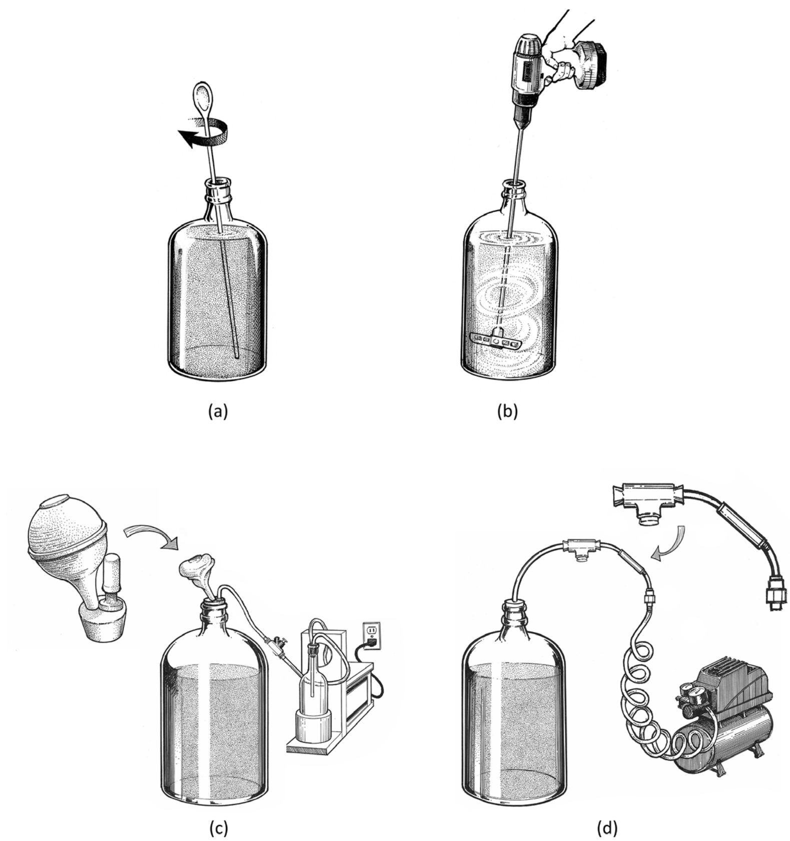


Figure 13.3: Degassing with a) handle of a long spoon, b) a lees stirrer, c) a Headspace Eliminator, and d) Gas Getter

First transfer the wine to a larger vessel as there can be a lot of foaming. You can degas immediately or transfer the vessel to a warmer area and wait

SUMMARY CHART OF FINING AGENTS

Table 13.1: Fining agents

Fining Agent (charge, if any)	Application	Recommended Dosage	Comments
Bentonite (–)	• Clarifying of whites and rosés • Removing of proteins in whites and rosés	0.25–1.0 g/L	• Creates heavy, voluminous lees; counterfine with kieselsol or gelatin • Strips color in reds
Silicon dioxide (–)	• Clarifying of whites, rosés and reds • Removal of proteins and tannins in whites and rosés	0.25–0.50 mL/L (1–2 mL/gal) as a 30% suspension	• Very efficient, compact lees • Counterfine with gelatin, isinglass or chitosan
Casein (+)	• Reducing bitter tannins in over-oaked or overly tannic white wines • Reducing browning due to oxidation of polyphenols	0.50–1.0 g/L as a caseinate suspension	• Can strip aromas and color • Requires a counterfining with bentonite or PVPP depending on application
Egg white (+)	• Taming aggressive tannins in barrel-aged reds	2–3 fresh egg whites per 100 L (25 gal) 3–8 fresh egg whites per standard 225-L (59-gal) barrel	• Too aggressive for young or low-tannin wines
Gelatin (+)	• Taming aggressive tannins in whites, rosés and reds • Counterfining bentonite to compact lees	0.01–0.05 g/L	• May strip flavors if not used properly
Isinglass (+)	• Clarifying whites and rosés	0.01–0.03 g/L	• Use at cool cellar temperature • Throws fluffier deposit; counterfine with bentonite
Chitosan (+)	• Clarifying whites • Reducing Brett character	Varies by product	• Allergy risk with products derived from shellfish

(continued)

14 Mitigating Microbial, Chemical and Physical Instabilities

Once wine has completed fermentation, both alcoholic and malolactic, the latter if performed, it must remain stable throughout its sojourn in carboys, tanks and barrels, and in bottles; that is, it should not undergo any unwanted or unexpected changes, and certainly not spoilage. Sulfur dioxide (SO_2) is added as an antimicrobial and antioxidant agent, as described in Chapter 8. But it does not end there. What about residual sugar that could trigger a renewed alcoholic fermentation? Or proteins in whites that can cause a perfectly clear wine to go cloudy? Or tartrates that can form in bottles?

As a winemaker you have to anticipate any such potential instabilities and proactively implement proper stabilization protocols to avoid problems.

This chapter describes four of the most important topics in wine stabilization — microbial, pectin, protein and tartrate. It describes how to predict or test for instabilities, and how to stabilize wine.

Blending two or more stable wines does not guarantee that the final blend will be stable; the blended wine must be tested and treated, if necessary, for stability.

14.1 MICROBIAL STABILITY

There exists a very varied and broad population of microorganisms — yeasts and bacteria — in juice and wine. These can become active and start effecting spoilage under favorable environmental conditions if they can find something to feed on. Many microorganisms can feed on minuscule amounts of sugar, even under fairly hostile conditions, for example, of high

15 Aging Wine for Greatness

Wine is a "living" beverage; it progresses and transforms during aging, or what is also referred to as maturation, what the French call *élevage*, akin to raising a kid. These transformations are the results of many seemingly surreptitious reactions occurring throughout the life of wine. For example, aroma compounds come slowly freed from their other binding components, as we had seen in Section 1.1. Once freed, those aroma compounds are volatile and can then be smelled. New esters are also created as alcohol and acids interact to give rise to other wonderful aromas. Oxygen also enters bottles, and once it becomes dissolved in wine, it enables other reactions, some good, some not so good. One of the favorable reactions involving oxygen we have seen in Section 9.1 is tannin polymerization; it's what causes tannins to soften.

Well-made wines produced from sound raw material and having good structure and balance will improve with "some" aging. They can improve over just a few months or over several years depending on many factors, such as wine pH, tannin content and cellaring conditions. Far too often wines are consumed before they have reached their peak, and that's okay for those who are partial to the fruitier aromas instead of the more complex, more subtle tertiary aromas that develop during aging.

In this chapter, we will first look at the phases of wine progression and aging potential to set the context, and then we will look at specific techniques for aging wine.

16 Fine-Tuning and Blending Wine

You're at the maturation/aging or pre-bottling stage and your great wine is missing a little something — it's just not quite perfect. Perhaps it's a dry white wine with just a tad too much acidity in spite of your best efforts to deacidify down to the "right" level. Maybe it's a full-bodied red that needs a little more bite, or, on the flip side, that needs to be tuned to reduce some slight bitterness or astringency, or you just didn't get enough oak from your barrel aging.

Almost invariably when making wine from grapes or frozen must you will need to make minor tweaks to satisfy your palate. This is not about fixing flaws or faults — those are discussed in Chapter 22.

This chapter will help you fine-tune your wine post fermentation or pre bottling to improve balance between acidity and sweetness, to improve body and structure or increase mouthfeel, to tame tannins to reduce bitterness and astringency, to increase oak aromas and flavors, and to create a greater wine by blending two or more wines.

16.1 SWEETENING: BALANCING ACIDITY AND SWEETNESS

You did a judicious pre-ferment deacidification of your juice or must and you cold stabilized the wine specifically to reduce the high acidity further in wanting to make a dry white wine, but acidity (i.e., TA) is still just a tad high, or perhaps you want to create more of an off- or medium-dry style and make the fruit aromas and flavors stand out a smidgen more. This is easily accomplished by sweetening, or what is commonly referred to as "backsweetening" in home winemaking, that is, by adding sugar in the

EXAMPLE 16.1

Pearson Square; blending two wines to increase TA

You have a 23-L (6-gal) batch of low-acid Chambourcin wine with a TA of 5.2 g/L (this is the B value) that you would like to increase to 6.0 g/L (this is the C value) using Frontenac wine with a TA of 10.0 g/L (this is the A value). Determine as follows how much Frontenac you need to add to the Chambourcin to achieve the desired TA:

The Pearson Square says that you need 0.8 parts of Frontenac wine for 4.0 parts of Chambourcin wine, or:

$$Volume\ of\ Frontenac\ needed\ (L) = 23\ L \times \frac{0.8}{4.0}$$
$$= 4.6\ L$$

This example illustrates that, even for what may seem like a small adjustment in TA from 5.2 to 6.0 g/L, blending to make such corrections may require not insignificant amounts of the second wine (20% here), which could substantially alter the character of the original wine.

EXAMPLE 16.2

Pearson Square; adding concentrate to must to increase SG/Brix/PA

In Example 6.4 in Section 6.4.1, we looked at chaptalizing must by adding concentrate from a kit. Specifically, we needed to determine the amount of concentrate having a SG of 1.155 (35 Brix) to add to 26 L (7 gal) of must to increase SG from 1.091 to 1.102, or Brix from 22.0 to 24.5, to achieve a desired PA of 14.0% ABV.

17 Filtering Like the Pros

Filtration is the mechanical process of removing particulates and colloids, including yeast and bacterial cells, using a filter medium for the purpose of achieving greater clarity or removing unwanted yeast and bacteria left over from alcoholic and malolactic fermentations. Filtration intended for clarifying wine is referred to as clarifying filtration and that for removing yeast and bacterial cells to achieve microbial stability is referred to as sterile filtration.

This chapter describes the equipment necessary for clarifying and sterile filtrations, and how to filter efficiently. But first, let's understand the need for filtering.

17.1 WHY FILTER?

Filtration is a very controversial topic because, interventionism notwithstanding, many believe that it strips wine of aromas, flavors and color, or that it causes excessive oxygen uptake.

Aroma and flavor molecules are so much smaller than the porosity of filter media used in winemaking that filtration cannot strip aromas and flavors. Yes, the filter medium can affect aromas and flavors, particularly pads, *if not properly prepared*. If you filter wine though pads without adequately rinsing with plenty of water, the wine can indeed pick up a cardboard smell and taste. Some winemakers will also point out that wine tastes different after filtration, once bottled. This is not a filtration problem but, rather, a condition where the wine is temporarily "knocked out" from processing, a condition known as "bottle sickness," often referred to as "bottle shock" although the two have slightly different meanings in winespeak.

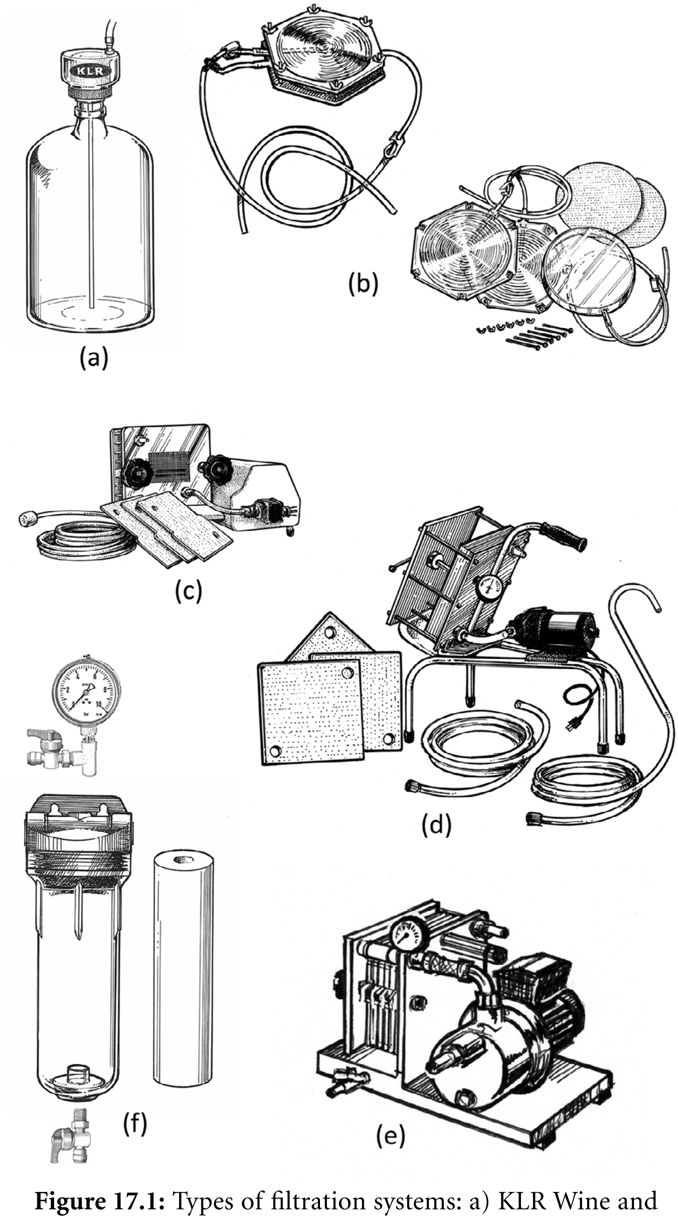


Figure 17.1: Types of filtration systems: a) KLR Wine and Beer Filter; b) round plate-and-frame filter and pads; c) Buon Vino Mini Jet and filter pads; d) Buon Vino Super Jet and filter pads; e) Pillan F6 plate-and-frame filter; f) 10-inch filter housing and cartridge with optional gauge and purge and drain valves, such as a Sioux Chief ¼” PDQ × ⅛” MIP.

18 Packaging and Bottling

"'*Winemaking' continues after bottling.*" [1]

You have invested considerable money in sourcing the best fruit or must from one of the finest grape-growing regions of the world, and many months, if not years, in crafting a superlative wine. You are now ready to bottle and start enjoying the wine or, perhaps, cellar it for a few more months or years to give it additional time to evolve into an even greater wine. It's time now to choose a type of bottle, closure and capsule, design and print labels, and plan your bottling.

Bottling involves washing and sanitizing bottles, if these had been previously used, filling bottles, corking, and dressing bottles with capsules and labels.

This chapter looks at packaging choices and considerations, the necessary equipment for washing and sanitizing bottles, and bottling small or large batches, then outlines the bottling process.

18.1 PACKAGING

You will be making many, many decisions related to packaging: types of bottles, closures, capsules and labels. There's a lot of advance planning to do here.

18.1.1 BOTTLES

Glass bottles with a "cork finish" remain by far the predominant type of packaging in home winemaking — and the focus of this section — as they

ALL-IN-ONE WINE PUMP AND VACUUM BOTTLE FILLER

The All-in-One Wine Pump bottle filler (Figure 18.12) uses an electric vacuum pump to displace wine and fill bottles, one at a time, to a (adjustable) preset fill level using a stopper attachment that includes an adjustable vacuum valve to control the flow of wine and down the side of the glass to minimize foaming. Overflow wine is sucked back to the carboy or vessel, and so, it must sit below the level of bottles during the filling operation.

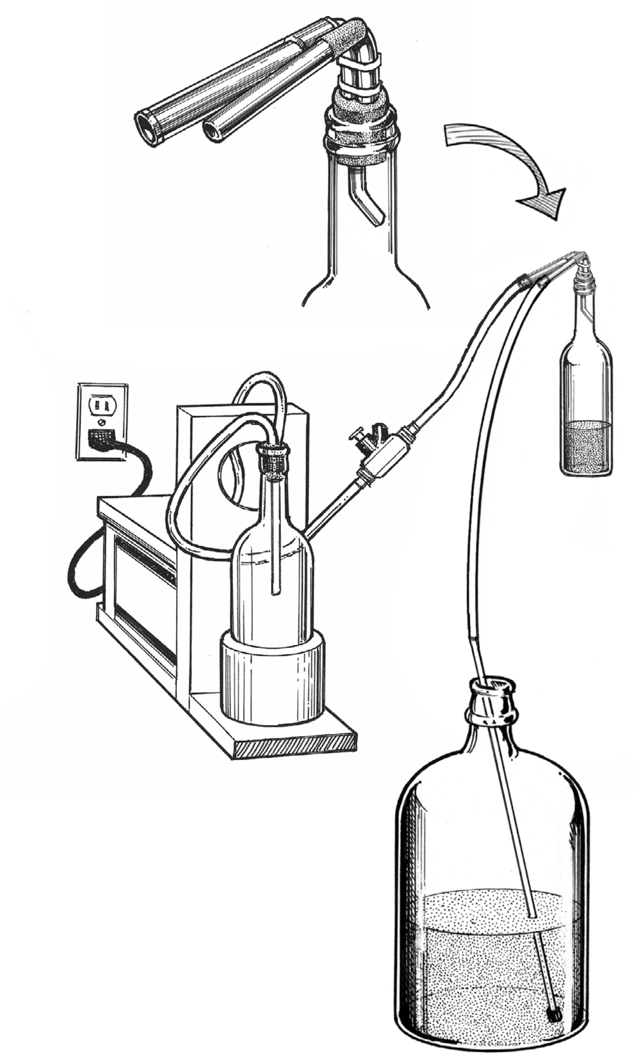


Figure 18.12: All-in-One Wine Pump bottler filler; note that the carboy is below the level of bottles

19 Making Fruity and Full-Bodied White Wines

This chapter describes the protocols for making two styles of white wines from grapes — purchased or from your backyard vineyard — or from fresh, unprocessed juice.

You may want to first refresh your memory on the white winemaking process; refer back to the process flowchart presented in Figure 1.2 in Section 1.3.2.

The general process for making white wine involves crushing and pressing grapes, cold settling the juice, carrying out alcoholic fermentation (AF), clarifying and stabilizing the wine followed by a short aging period, then filtering and bottling. There is usually no maceration, or perhaps just a very short maceration, of grape skins in juice.

There is, however, orange wine, which is made by macerating and fermenting on the skins, much like is done in red winemaking. Orange wine is a deep, orange-hued, bold, somewhat sour and tannic style of white wine with intense aromas of honey, bruised apples and nuts, all resulting from limited oxidation.

As there are many different variations of making white wine, some involving fermenting or aging in oak barrels, two of the more common protocols are presented here — one for making a dry, light, fruity style and one for making a dry, full-bodied, oaked style. As you gain experience with varieties you work with and depending on your preferred style, you will come to develop your own variations.

Review and understand the protocols *before you start* making wine to be sure you are equipped and prepared to execute all the necessary steps. And, although not essential, if you are able to implement techniques and use equipment that minimize wine exposure to air during processing, particularly during racking operations, you will make even greater wine. For ideas on techniques and equipment, consult the protocol for making rosé wine in Chapter 20 — oxygen exclusion is more critical in rosé winemaking.

And a reminder to keep a meticulous log of all processing activities, additives and processing aids used, measurements taken, as well as progress tasting notes (see Section 1.4). You can use the log sheet in Appendix C, which can be downloaded at ModernHomeWinemaking.com.

19.1 MAKING A DRY, LIGHT, FRUITY-STYLE WHITE WINE

Light, fruity whites are fermented relatively cool and slow to preserve delicate fruity esters while light whites meant to feature more of the varietal characteristics are fermented warmer and faster. Both styles of wines are seldom put through malolactic fermentation (MLF) so as to preserve the fruity character as well as freshness from their higher acidity that characterizes these styles. These wines are bottled within 6–9 months and are meant to be consumed relatively quickly, within another 6–9 months.

Figure 19.1 illustrates a typical timeline for making a dry, fruity-style white wine from grapes, with no MLF, and bottled 6–9 months from the start of the process.

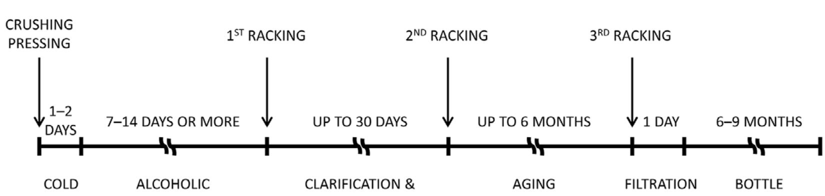


Figure 19.1: Typical timeline for making a dry, fruity-style white wine from grapes, with no MLF, and bottled in 6–9 months

Generally, you will want a wine with 11–12.5% ABV, which means you need a starting SG in the range 1.080–1.090 (19–22 Brix), and TA in the range 5–8 g/L for a dry style with residual sugar (RS) less than 5 g/L.

LOG CHART — CONTROL CHECKPOINTS: FRUITY WHITE WINE

Date	CHECKPOINT	Volume (L or gal)	Temp. (°C/°F)	SG / BRIX	Temp-adjusted SG / BRIX	PA or Actual % ABV	TA (g/L)	pH	FSO2 (mg/L)	TSO2 (mg/L)	DO (mg/L)	YAN (mg N/L)	RS (g/L)
	MUST ANALYSIS												
	ALCOHOLIC FERMENTATION												
	FIRST (POST-AF) RACKING												
	MICROBIAL STABILIZATION												
	CLARIFICATION AND STABILIZATION												
	AGING												
	FILTERING												
	BOTTLING												

19.2 MAKING A DRY, FULL-BODIED, OAKED WHITE WINE

Full-bodied whites, particularly those barrel-fermented or barrel-aged, will have greater complexity defined by more subtle aromas and flavors of toasted oak, and lighter acidity as they are usually put through MLF. Their exposure to oak gives them more of a bite due to tannins, and longer aging potential. These wines are bottled within 12–18 months and can be drunk young but are best appreciated after 12–18 months more bottle aging.

Figure 19.2 illustrates a typical timeline for making a dry, full-bodied, oaked white wine from grapes, with sequential MLF, no sweetening, and bottled 12–18 months from the start of the process.

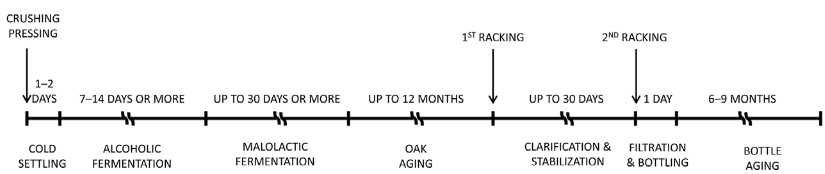


Figure 19.2: Typical timeline for making a dry, full-bodied, oaked white wine from grapes, with sequential MLF, and bottled in 12–18 months

Generally, you will want a wine with 12.5–13.5% ABV, which means you need a starting SG in the range 1.090–1.100 (22–24 Brix), and TA around 5.0 g/L for a dry style with residual sugar (RS) less than 2 g/L.

NOTE *"Dry style" does not equate to microbially stable. Only dry wines with RS less than 2 g/L are considered microbially stable; those with 2–5 g/L RS (or more) would still require to be properly stabilized, as outlined in Section 14.1.1.*

Chardonnay, Seyval Blanc, Vidal Blanc and Viognier are all excellent choices for this style of wine. Consult Chapter 2 for processing considerations and tips for your variety.

The log chart in the CONTROL CHECKPOINTS section at the end of this chapter provides a view of which measurements you should be taking

20 Making Attractive Rosé Wine

This chapter describes the protocol for making rosé wine from grapes — purchased or from your backyard vineyard.

You may want to first refresh your memory on the rosé winemaking process; refer back to the flowchart presented in Figure 1.3 in Section 1.3.3.

The general process for making rosé wine is very similar to making white wine except that there is a short maceration phase following crushing to extract the desired amount of color. Highly pigmented varieties might go straight to the press as whole bunches or perhaps destemmed because they would otherwise liberate too much color with even the shortest of maceration if first crushed.

As there are many different variations of making rosé wine and particularly with achieving a desired color profile, a common protocol for making a light, fruity-style rosé is presented here. The *saignée* method, a French term that translates to "bleeding," is a variation involving running off some juice from crushed red grapes to make a rosé wine though the primary objective is usually to concentrate flavors and color in the rest of the juice in making the red wine. As you gain experience with the varieties you work with and depending on your preferred style and color, you will come to develop your own variations.

There are two challenges in making rosé wine, great rosé, that is: limiting oxygen exposure and minimizing tannin extraction.

One of the appeals of rosé wine is color. Red dominates, or it should, but orange hues may make the wine appear more orange than red — the result of phenolic browning due to polyphenol oxidation. In rosé winemaking, you should make every effort possible to limit oxygen exposure and "rough" processing to minimize oxidation of juice and wine. This will be particularly important when working with thiolic varieties to prevent

21 Making Blockbuster Red Wine

This chapter describes the protocol for making red wine from grapes — purchased or from your backyard vineyard — or frozen must.

You may want to first refresh your memory on the red winemaking process; refer back to the flowchart presented in Figure 1.4 in Section 1.3.4.

The general process for making red wine involves crushing grapes with an optional cold soak to start extracting color from skins, macerating grape solids and juice while carrying out alcoholic fermentation (AF) with frequent punchdowns or pumpovers to hasten color and tannin extraction, pressing grapes, carrying out malolactic fermentation (MLF), clarifying and stabilizing the wine whilst aging in barrels or inert vessels with oak alternatives, optionally filtering, and bottling.

Although the common practice is to crush and ferment each grape variety into a varietal and then possibly blending different varietals during aging or at bottling, it is also possible to crush and coferment different varieties, possibly viniferas with non-viniferas, as a single wine in what is known as "field blending" or cofermentation. Field blending can simply be used for practical reasons where you have only one wine to manage, or to address a deficiency, for example, to add tannins or improve color, to balance sugar by blending high and low-sugar grapes, or to extract complementary aromas and flavors.

Cofermentation is also used in a very interesting application where a small amount of white variety grapes, up to 5%, for example, are added to a batch of red variety grapes, for example, Viognier added to Syrah, right at crush to increase red color intensity and stability via a phenomenon known as copigmentation whereby anthocyanins link in a stacking fashion to only other anthocyanins, but also colorless compounds. These colorless compounds include naturally occurring polyphenols called flavonols, and

22 Troubleshooting and Fixing Common Faults and Flaws

Making wine is relatively easy but making *great* wine is a perpetual challenge because the raw material is often not balanced and winemakers must therefore make important decisions on how best to make adjustments and ensure success.

In spite of all the care and caution, things can — and will — go wrong, even for the most seasoned winemaker. Experience is key here, but a winemaker is only as good as his/her ability to resolve a problem. Faults and flaws happen, and you must be able to identify them, assess them, and take corrective actions. This entails first carrying out a root-case analysis to evaluate possible causes; never jump to unfounded conclusions. The challenge is in recognizing faults and flaws, and this depends on your experience and detection threshold. We all have different thresholds on detecting, for example, volatile acidity (VA), and therefore, training will be important as well as asking other winemakers or wine enthusiasts for their opinions. And always look beyond what you see when trying to identify root causes — leaky corks may not necessarily point to a cork problem, but perhaps to a bottle refermentation issue.

Jamie Goode, in *Flawless: Understanding Faults in Wine*, uses two terms to describe defects: faults and taints [1]. Faults refer to defects resulting from the fermentation process, though this should be understood to mean the winemaking process. Oxidation, volatile acidity (VA) and *Brettanomyces* are examples of faults. Taints refer to defects resulting from an extraneous flavor chemical or some external factor, such as cork taint. Here we make no distinction, as Goode goes on to discuss faults and taints as one, as both are defects. However, a flaw is considered less serious than a fault, and may become a fault if left uncontrolled and cause a wine to be rejected. For example, tartrates are considered a flaw as they do not adversely affect the taste of wine, whereas VA was said to be fault because it would cause the wine to be rejected outright.

This chapter describes twelve of the most common defects, and how to resolve them confidently and expertly, where possible, towards salvaging a problem batch of wine.

For dealing with a stuck or sluggish alcoholic fermentation (AF), or stuck or sluggish malolactic fermentation (MLF), refer to Sections 11.5 and 12.6, respectively.

22.1 PREMATURE OXIDATION

DESCRIPTION

Oxidation occurs in every wine, ever so slowly during the winemaking process and aging, including bottle aging, but it should not occur prematurely or unexpectedly in young wines, either in bulk or bottled.

Premature oxidation is a condition of uncharacteristic early browning of wine and smell of acetaldehyde (bruised apple) and nutty aromas and flavors, which mute other desirable aromas.

CAUSES

Reference Sections: *8.1–8.4*

Premature oxidation is the result of chemical oxidation of polyphenols and ethanol due to prolonged exposure to oxygen with very low or no sulfur dioxide (SO_2) protection. This is usually a result of poor oxygen and SO_2 management, most often due to leaving too much headspace in carboys or other vessels, or excessive processing in the absence of SO_2 protection. In bottled wine, it can also result from the use of poor closures with high oxygen transfer rates (OTR).

Aging and storage temperatures are also important factors as warmer temperatures accelerate oxidation reactions.

This fault is often accompanied by volatile acidity (VA), described below in Section 22.2, and possibly by a whitish surface film, described in Section 22.3.

ASSESSMENT

A wine affected by premature oxidation will have a very distinctive smell of bruised apple from acetaldehyde, a sure sign that free SO_2 (FSO2) has been depleted. If you are able to measure FSO2, confirm to what extent free SO_2 has been used up — in all likelihood, it is below the critical 10 mg/L threshold, or possibly completely depleted.

Acetaldehyde is easily detected given its very low detection threshold, in the 500 µg/L (that's parts per billion, or ppb) range. Once detectable, wine quality is seriously compromised and remedial actions can make the wine drinkable, maybe, or it may have to be discarded depending on the severity. Unfortunately, there is no simple analytical tool for home winemakers to monitor acetaldehyde concentration; you will need to rely on your nose.

Whites affected by premature oxidation will exhibit a dark or brownish color.

In reds, you will need to assess the wine in a glass; tilt the glass and look for an orange, brownish hue at the rim. It can be very difficult, if not impossible, to fix an oxidation problem in a red wine; it is best left alone.

If a whitish film has formed on the surface of the wine, you have advanced oxidation and a surface yeast problem; refer to Section 22.3.

REMEDIAL ACTIONS

If you detect acetaldehyde, add potassium metabisulfite (KMS) immediately to bind the acetaldehyde to make it non-volatile. Add KMS to the recommended FSO2 level based on pH. Then taste the wine again, and if you still smell the acetaldehyde, try adding 50% of the amount of FSO2 just added, then repeat another time if the smell persists. For example, if you first added 50 mg/L FSO2, try adding another 25 mg/L and another 25 mg/L. At this point, you would have added twice the recommended FSO2 level; if you can still smell the acetaldehyde, your wine is likely beyond fixing and is best discarded.

For whites affected by limited oxidation and showing a darkish yellow color with light-brown hues, first treat with casein at a rate based on bench trials, then treat with bentonite to assist in settling the casein. If your bench trials conclude that casein strips out too much aromas, try using PVPP instead. You can also try specially formulated casein–bentonite preparations, such as Bentolact S (IOC – Institut Œnologique de Champagne). Refer to Section 13.4 for fining agent dosages.

Following a successful treatment to an acceptable color without excessive loss of aromas and flavors, add specific inactivated yeast with high antioxidant properties containing polysaccharides and/or glutathione (GSH), such as OptiMUM White or Glutastar (Lallemand), to protect against further oxidation.

If a white wine is affected by advanced oxidation and has a dark-brown color, it is likely not salvageable. As an absolute last resort only and when other treatments have not been effective, you can try removing some of the brown color using activated carbon. Perform bench trials first to make sure the treatment produces acceptable results. Add the activated carbon powder directly to the wine and stir thoroughly; never add more than the maximum because it will strip color excessively and leave an off carbon-like flavor. Add bentonite at the maximum rate of 1 g/L immediately after the activated carbon treatment, rack after a few days, and filter the wine before bottling.

If you have managed to cure the wine, be sure to top up whichever carboy or vessel it was in.

PREVENTIVE ACTIONS

To prevent premature oxidation, avoid prolonged oxygen exposure during processing and particularly during storage and aging. Top up carboys and barrels with the same or similar wine making sure to top up barrels regularly — at least once a month — due to evaporative losses. Although you can use inert gas or create a vacuum to protect wine in partial carboys or tanks — but not in barrels — this is only a short-term strategy; it's always best to top up.

Maintain adequate FSO2 levels based on pH and molecular SO_2 (MSO2) for the type of wine. *Never* allow FSO2 to fall below 10 mg/L.

23 Entering Wines into Competitions

Entering wines into competitions is an excellent way to get feedback from respected judges. Sure, medals can be rewarding, but without feedback, you won't know why your wines did not score higher; you will have no idea of what the judges didn't like or if they identified flaws or faults. There are many local, state or provincial, national and international competitions run by reputable organizations. Choose those that will provide feedback, not just medals. Remember! You want to elevate your hobby to making *great* wines.

And if going after medals, be sure you understand how these are awarded. Some competitions will award medals based on total score for each wine, for example, 12–14 (out of 20) points is awarded bronze, 15–17 points is awarded silver, and 18–20 points is awarded gold. All wines scoring in medal range are awarded medals. Other competitions award bronze, silver and gold medals only to the highest-scoring wine, that is, only three wines will be awarded first, second and third place. As there are several judges tasting and scoring each wine, the final score may be an average of all the judges' scores, or in some cases, to remove biases or scoring abnormalities, the highest and lowest scores are removed and an average is calculated from the remaining scores.

23.1 WHAT JUDGES LOOK FOR IN WINE

Different competitions have different scoring systems. The most common ones (Figure 23.1) score wines on a 0-to-20 scale awarding, for example, 0–3 points for appearance, 0–6 points for aroma and bouquet, 0–6 points for taste, 0–3 points for aftertaste or finish, and 0–2 points for overall impressions.

Appendixes

Appendix A: Conversion Factors Between Metric, U.S. and Imperial Systems

Table A-1: List of abbreviations for systems and units of measure used in this book.

Unit of measure	Abbreviation
atmosphere	atm
bar	bar
Baumé	B° *or* Bé°
degrees Brix (Brix)	°B *or* °Bx
centimeter	cm
cup	cup
degrees Celsius	°C
degrees Fahrenheit	°F
fluid ounce	fl oz
foot (feet)	ft
gallon	gal
gram	g
gallon per liter	gal/L
gram per liter	g/L
hectoliter	hL
hectoPascal	hPa
inch	in
inch of mercury	inHg
International System of Units	SI
kilogram	kg
kilogram per square centimeter	kg/cm^2
kiloPascal	kPa
liter	L
meter	m
metric ton (tonne)	MT

Unit of measure	Abbreviation
micrometer	micron *or* mm
milligram	mg
milligram per liter	mg/L
milliliter	cc *or* mL
millimeter	mm
millimeter of mercury	mmHg
Oechsle	°Oe
ounce	oz
parts per billion	ppb
parts per million	ppm
parts per quadrillion	ppq
parts per trillion	ppt
Pascal	Pa
percent alcohol by volume	% ABV *or* % alc/vol
pound(s)	lb(s)
pound per square inch	psi
Specific Gravity	sp gr or SG
tablespoon	tbsp
teaspoon	tsp
temperature	T
ton	T
United States	U.S.
volume	vol *or* v
weight	wt *or* w

Appendix B: Sugar Concentrations, Potential Alcohol, and Conversions

Use Table B.1 to convert between °Brix, Specific Gravity (SG), sugar concentrations expressed in Metric and U.S. units, and Potential Alcohol (PA) expressed in % alc/vol (% ABV), for measurements at 20 °C (68 °F).

°Brix and SG data in Table B.1 is partly derived and adapted from data from Table II – Evaluation of sugar by refractometry of Method OIV-MA-AS2-02 in the OIV Compendium of International Methods of Analysis of Wines and Musts [1]. Sugar concentrations in g/L are approximated to 10 times the °Brix value, and a factor of 17.5 is used to derive PA. For further information, please refer to Section 6.2.

Use Table B.2 to correct readings to compensate for temperature differences when taking hydrometer readings at temperatures other than 20 °C (68 °F).

Use Table B.3 to estimate the amount of residual sugars in wine based on initial SG and total acidity (TA) in g/L, as per the method outlined in Section 6.5 [2].

Use Table B.4 to estimate the amount of residual sugars in white and rosé wines at a given final SG (Brix) and % ABV in the range 10.0–12.5, and Table B.5 in red wines at a given final SG (Brix) and % ABV in the range 12.5–15.0.

Table B.1: Conversions between °Brix, SG, sugar concentrations and PA (adapted from [1])

°Brix	SG	Approx. sugars (g/L)	Approx. sugars (g/gal)	PA	°Brix	SG	Approx. sugars (g/L)	Approx. sugars (g/gal)	PA	°Brix	SG	Approx. sugars (g/L)	Approx. sugars (g/gal)	PA
-2.3	0.991				0.0	1.000	0	0	0.0	2.3	1.009	23	87	1.3
-2.2	0.992				0.1	1.000	1	4	0.1	2.4	1.009	24	91	1.4
-2.1	0.992				0.2	1.001	2	8	0.1	2.5	1.010	25	95	1.4
-2.0	0.993				0.3	1.001	3	11	0.2	2.6	1.010	26	99	1.5
-1.9	0.993				0.4	1.002	4	15	0.2	2.7	1.010	27	102	1.5
-1.8	0.993				0.5	1.002	5	19	0.3	2.8	1.011	28	106	1.6
-1.7	0.994				0.6	1.002	6	23	0.3	2.9	1.011	29	110	1.7
-1.6	0.994				0.7	1.003	7	27	0.4	3.0	1.011	30	114	1.7
-1.5	0.994				0.8	1.003	8	30	0.5	3.1	1.012	31	117	1.8
-1.4	0.995				0.9	1.003	9	34	0.5	3.2	1.012	32	121	1.8
-1.3	0.995				1.0	1.004	10	38	0.6	3.3	1.013	33	125	1.9
-1.2	0.995				1.1	1.004	11	42	0.6	3.4	1.013	34	129	1.9
-1.1	0.996				1.2	1.005	12	45	0.7	3.5	1.013	35	133	2.0
-1.0	0.996				1.3	1.005	13	49	0.7	3.6	1.014	36	136	2.1
-0.9	0.997				1.4	1.005	14	53	0.8	3.7	1.014	37	140	2.1
-0.8	0.997				1.5	1.006	15	57	0.9	3.8	1.015	38	144	2.2
-0.7	0.997				1.6	1.006	16	61	0.9	3.9	1.015	39	148	2.2
-0.6	0.998				1.7	1.006	17	64	1.0	4.0	1.015	40	152	2.3
-0.5	0.998				1.8	1.007	18	68	1.0	4.1	1.016	41	155	2.3
-0.4	0.998				1.9	1.007	19	72	1.1	4.2	1.016	42	159	2.4
-0.3	0.999				2.0	1.008	20	76	1.1	4.3	1.016	43	163	2.5
-0.2	0.999				2.1	1.008	21	80	1.2	4.4	1.017	44	167	2.5
-0.1	1.000				2.2	1.008	22	83	1.3	4.5	1.017	45	171	2.6

(continued)

Appendix C: Winemaking Log Chart

Use the following example *Winemaking Log Chart* to track all your winemaking activities and lab measurements. You can download a printable version of the chart from ModernHomeWinemaking.com. You can also download a version, created in Microsoft Excel, which makes use of drop-down lists to enter data, such as grape variety and type of operation, and which has a DASHBOARD that populates summary fields at the top of the chart as you enter data to provide a single, simple view of the status of your batch.

As each batch of the same wine can potentially be different, create a separate log chart for each batch. Then, for example, if you blend batches, create a new log chart for the now-blended wine.

Maintain meticulous records of all activities, making sure to enter the date and, where needed, the time of day where you might be performing several activities in a few hours or day. This level of tracking and commitment to maintaining accurate and complete records will allow you to perform a root-cause analysis if a problem occurs; it will be guesswork trying to figure out what went wrong without that data.

Under "Operation or Checkpoint," enter the specific activity, such as crushing/destemming, must analysis, pressing, alcoholic fermentation, free SO_2 adjustment, etc., and record any pertinent analytical data. Use the suggested control checkpoints in the log charts presented in the respective winemaking sections in Chapters 19, 20 and 21.

Variety: ____________________ Vintage: __________ Style: __________ Batch ID: __________

Source: ____________________ Quantity: __________ Price: __________

DASHBOARD:

Date	Operation or Checkpoint	Additive or Processing aid	Quantity added	Volume (L or gal)	Temp. (°C/°F)	SG / BRIX	Temp-adjusted SG / BRIX	PA or Actual % ABV	TA (g/L)	pH	FSO2 (mg/L)	TSO2 (mg/L)	DO (mg/L)	YAN (mg N/L)	RS (g/L)	MLF Check	Comments

Index

Page numbers in **bold** type indicate important and most relevant references, particularly where there are multiple page entries.

"*See*" refers to another, more appropriate index entry; "*See also*" refers to another index entry for additional, related information.

A semi-colon separates references to key index entries; for example, "astringency" and "balance" are two key index entries in "bitterness, 35, … , **406**. *See also* astringency; balance."

A comma separates a key index entry and a sub-entry; for example, "bound SO_2. *See* sulfur dioxide, bound" refers to the key entry "sulfur dioxide" and sub-entry "bound."

1–9, %

A

Notes