THE HOME WINEMAKERS MANUAL

Lum Eisenman

TABLE OF CONTENTS

PREFACE

Most home winemaking books are written like cookbooks. They contain winemaking recipes and step by step directions, but little technical information is included. The goal of these books is to provide enough information so the reader can make a successful batch of wine. Enology textbooks are the other extreme. They are very technical and can be difficult to comprehend without a background in chemistry and microbiology. These books are intended to give professional winemakers the specialized backgrounds needed to solve the wide variety of problems encountered in commercial wine production.

This book is an attempt to provide beginning home winemakers with basic “how to” instructions as well as providing an introduction to some of the more technical aspects of winemaking. However, the technical material has been concentrated in a few chapters, so readers can easily ignore much of the technical content until an interest develops.

If you have a quantity of fresh grapes to convert into wine, read Chapter 1 and the first few pages of Appendix A. This material will give you enough information to start successful grape wine fermentation. Appendix A is written in a quasi outline form, and it provides a brief description of the entire winemaking process.

If you have some fresh fruit and wish to make wine before the fruit spoils, read Chapter 25. This is a “stand alone” chapter, and successful fruit wines can be made from the information provided here. The first few pages provide enough information to prepare the fruit and start fermentation. The rest of the chapter can then be read at your leisure.

Chapters 1, 2, 3, 4, 9, 10, 11, 12, 13, 14, 15, 17, 18 and 19 provide general information on home winemaking. These chapters discuss materials, facilities, equipment and basic processes. Much of this material is basic and should be of interest to most readers.

The material presented in Chapters 5, 6, 7, 8 and 16 is a bit more advanced. These five chapters focus mostly on “what” and “why” rather than on “how.” Beginning winemakers may wish to skip these chapters until they become more experienced.

Chapter 20 describes six common laboratory wine tests. The significance of the tests, materials, apparatus and procedures are discussed in some detail.

Chapter 21 contains practical “how to” information of general interest.

Chapters 22 and 23 are case studies of making a red and white wine. These two chapters provide a detailed chronology of the production of two typical wines.

Chapter 24 describes how to make small quantities of sparkling wine.

Lum Eisenman
Del Mar, 1998

ACKNOWLEDGMENTS

Many people contributed to this book, and I greatly appreciate all their help. In particular, I wish to thank the following people who expended much time and effort on my behalf.

Thanks to Dr. Roger Seapy for critiquing the manuscript for technical content and for providing many corrections and beneficial suggestions.

Thanks to Lynn Alley and Terry Whyte for reading the original manuscript and suggesting many useful changes in content, style and organization.

Thanks to Dr. James Jenkins for providing many helpful discussions and suggestions for improving the manuscript.

Thanks to Jim Graver for reviewing the chapter on fruit winemaking and for providing many helpful suggestions.

Thank you Duane DeBoer for reading the manuscript and making many technical suggestions from the perspective of a professional winemaker.

Special thanks Barbara Scherman for the many hours she spent attempting to untangle my inept prose.

Chapter 1

THE WINEMAKING PROCESS

Winemaking can be divided into four basic phases. The first phase consists of finding a source of high quality fruit and making sure the grapes are harvested in an optimum condition. Buying small quantities of high quality fruit is not easy, and this is the most difficult phase for home winemakers.

The second phase consists of fermenting the grapes into wine. Winemakers manage the fermentation by controlling several different fermentation parameters such as temperature, skin contact time, pressing technique, etc.

During the third phase, the new wine is clarified and stabilized. Winemakers clarify wine by fining, racking and filtration. Removing excessive protein and potassium bitartrate stabilizes wine. These materials must be removed to prevent them from precipitating out of the wine later.

In the fourth phase of winemaking, the winemaker ages the wine. Most high quality wines are aged in bulk and then for an additional time in the bottle. Winemakers have an active role throughout the lengthy bulk aging process. Wines are smelled, tasted and measured every few weeks, and any needed adjustments are made promptly.

Except for the first phase, the other three winemaking phases overlap each other. New wine starts to clarify toward the end of the fermentation period. Some tartrates precipitate out during primary fermentation, and the wine becomes more stable. Of course, wine is aging throughout the winemaking process. Each phase makes a specific contribution to wine characteristics, but the first phase has the greatest influence on wine quality.

RED WINES AND WHITE WINES

High quality, red wine grapes have colorless juice. All of the red color is in the grape skins, and winemakers must leave the juice in contact with the skins for a considerable time to extract the color. Red wine is made by crushing the grapes and then fermenting the juice, the pulp, the skins and the seeds together for several days. Near the end of sugar fermentation, a winepress is used to separate the liquid from the solid materials.

White wine is made by a differently than red wine. First the grapes are crushed and pressed immediately to separate the juice from the solids. After pressing, the skins, stems and seeds are discarded, and the juice is cooled to a low temperature. Then the cold juice is allowed to settle for several hours, and the clear juice is decanted off the residue before it is fermented. White wines are made by fermenting clarified juice. These are the fundamental differences between making quality, red wine and white wine. At first glance, the two winemaking processes may appear similar because several steps are identical. Nevertheless, the steps are done in a different sequence, and the sequence produces a large change in wine characteristics. The red winemaking and the white winemaking processes are shown below in Figure 1.

It has often been said that wine quality is made in the vineyard, and few experienced winemakers disagree with this statement. The soil, climate, the viticulture and all other aspects of the vineyard environment contribute to the quality of the wine. Even if the winemaker does a perfect job, the quality of the starting grapes always determines the potential quality of the wine. Grape quality is extremely important. Many winemakers feel that when a grape growing problem develops, the difficulty must be recognized and promptly resolved to assure fruit quality. Consequently, professional and amateur winemakers prefer to grow their own grapes. Then they have complete control over the vineyards.

FERMENTATION

Two different fermentations occur in most red wines, and these same fermentations are often encouraged in heavier styled white wines like Chardonnay or Sauvignon Blanc. In addition, a variety of yeast and bacteria can grow in wine, and many of these microorganisms can cause other fermentations.

RED WINE PROCESS

Crush > Ferment > Press > Clarify > Stabilize > Age > Bottle

WHITE WINE PROCESS

Crush > Press > Settle > Ferment > Clarify > Stabilize > Age > Bottle

Figure 1. The red and white winemaking processes.

Primary Fermentation

Conversion of the two major grape sugars (glucose and fructose) into ethyl alcohol is called primary fermentation. Yeast in the wine produce enzymes, and the enzymes convert the sugars into alcohol. Converting grape sugars into alcohol is not a simple process. Many steps are involved in this transformation, and the yeast must produce several different enzymes.

Malolactic Fermentation

Malic acid in the grapes is converted into lactic acid during the secondary fermentation. The necessary enzymes are produced by bacteria rather than by yeast. Several different types of bacteria can produce malolactic (ML) fermentation, and these bacteria are called lactic bacteria. Lactic acid is weaker than malic acid, so malolactic fermentation reduces the overall acidity of the wine. In addition, some byproducts produced during the ML fermentation can make a positive contribution to the complexity of the wine.

Other Fermentations

Depending upon the winemaking conditions, several other fermentations can and often do occur in wine. Some bacteria can ferment the glycerol in the wine into lactic and acetic acids. Other types of bacteria can transform the natural grape sugars into lactic and acetic acid. A few species of bacteria can ferment the tartaric acid in the wine into lactic acid, acetic acid and carbon dioxide gas. Vinegar bacteria can convert the alcohol into acetic acid. Then the same bacteria convert the acetic acid into water and carbon dioxide gas. These other transformations can produce materials that detract from wine quality. Sometimes, these undesirable fermentations can be devastating, and when such fermentations occur, wine is often called diseased or sick.

During the fermentation phase, the primary function of the winemaker is to make sure that the primary and secondary fermentations take place in a controlled and judicious manner. In addition, making sure the unwanted fermentations do not occur is also important to wine quality, so winemakers always smell and taste and measure their wines often.

CLARIFICATION & STABILIZATION

At the end of the primary fermentation, the new wine contains many spent yeast cells, several different types of bacteria, tartrate crystals, small fragments of grape tissue, bits of dirt, etc. All these particles interact with light that passes through the new wine. The particles absorb or scatter the light, and they give the wine an opaque, turbid appearance.

Gravity will slowly pull most of these particles down to the bottom of the wine container. Then the winemaker can decant the clear wine off the sediment. The larger sized particles may settle out in a day or two, but smaller particles may take several weeks to fall. Some suspended material may be so small it never completely settles out of the wine. After gravity has removed most of the impurities from the wine, the winemaker may add a "fining" material to help the settling process. Alternatively, most commercial winemakers would choose to filter the wine and mechanically remove the remaining particles.

At this stage of its evolution, the wine may be clear and bright, but the wine probably is not completely stable. In other words, the wine may not remain in a clear condition over an extended time. Most wines contain excessive amounts of protein and potassium hydrogen tartrate. When wine is stored under certain conditions, the protein and the tartrate can precipitate out of the wine and produce a haze or sediment. Any white or blush wine will probably be a total loss if either of these materials precipitates after the wine has been bottled. Wine stability is very important to the winemaker because of the protein and tartrate problems.

Several techniques have been developed to remove excessive amounts of protein and tartrate from wine, and these procedures are part of the normal winemaking process. After the excess protein and tartrate materials have been removed, the wine will be chemically stable. Then the winemaker can continue the winemaking process with reasonable assurance that the wine will remain clear and bright after it has been bottled.

WINE AGING

Odors in the wine that came directly from the grapes are called wine aroma. Bouquet is the term used for the odors in the wine produced by the winemaking process, and winemakers use the term "nose" when referring to both the aroma and the bouquet components.

Aroma

Wine aromas come from the grapes. Aromas do not result from the winemaking process. Cabernet Sauvignon wine smells like Cabernet Sauvignon because of specific aromatic materials in that particular variety of grape. The grassy aroma, so characteristic of Sauvignon Blanc wine, is a consequence of the grape variety, not the winemaking process.

Bouquet

The formation of wine bouquet is a more complicated process. Wine bouquet is a result of the winemaking process. The yeast, bacteria, barrels, winemaking procedures, etc produce wine bouquet. Some bouquet components are prevalent soon after the completion of fermentation, but these components decrease in intensity with time. Other bouquet components may require several years to develop fully. Byproducts produced by the yeast contribute to the fresh, fruity nose so typical of white table wines such as Gewurztraminer, Riesling and Chenin Blanc. However, these odor components are short-lived. They often disappear in less than a year or so. Consequently, these types of wines are best consumed when they are young, and the nose is still fresh and fruity.

Bouquet components decrease, remain constant or increase in intensity as the wine ages. Byproducts produced by lactic bacteria can give wines a lasting buttery attribute. Wines stored in oak barrels slowly accumulate vanillin and other substances from the wood. Wine acids react with alcohols to produce volatile esters, and during bulk storage, oxidation slowly changes many wine ingredients. All these different materials contribute to the bouquet of the wine.

After the wine is bottled, oxygen is no longer available, and a different type of aging begins to take place. Winemakers call these transformations reduction reactions because they take place without oxygen. Reduction aging is responsible for the changes that produce bottle bouquet. This is the bouquet that develops after a wine has been in the bottle for some time. As wine ages, the aroma gradually decreases, and the wine becomes less and less varietal in character. Wine becomes more vinous as the aroma decreases, and the bouquet increases. When wines are blind tasted, wine experts sometimes have trouble distinguishing old Zinfandel wines from old Cabernet Sauvignon wines.

SUMMARY

Winemaking can be divided into four major steps. First, grapes are harvested in optimum condition. Second, the grapes are fermented. In the third step, the new wine is clarified and stabilized. In the last step, the wine is aged to enhance its sensory qualities. Each of the four steps contributes to the quality of the finished wine. However, basic wine quality is determined in the first step.

The potential quality of any wine is established when the grapes are selected and harvested. Once the fruit is harvested, the winemaker attempts to realize the potential quality by carefully guiding the wine through the other three winemaking steps. Making high quality wine from poor quality grapes is impossible, but making poor quality wine from high quality grapes is very easy.

The winemaking process may take a few months, or it can extend for several years. During this time many procedures and operations are performed, so winemakers keep accurate records of the procedures used to make each wine. This record documents the winemaking details starting from several weeks before the grapes were harvested until the wine is bottled.

Chapter 2

HOME WINEMAKING COSTS

Making 50 gallons of wine does not require a great deal of equipment, and much of the equipment needed can be found around the home. Grape crushers and winepresses can be rented by the day for a few dollars each. Used barrels can be purchased for less than fifty dollars, and the deposit on a 15-gallon beer keg is about fifteen dollars. Each year, home winemakers ferment large quantities of red wine in new, 32-gallon plastic trashcans.

FRUIT QUANTITY

Wine is measured by the case, and a case contains approximately 2.4 gallons of wine. Estimating just how much wine can be made from a ton of grapes is difficult. The amount depends upon the grape variety, the equipment used and the winemaking methods employed. Professional winemakers often get 160 to 180 gallons of wine per ton of grapes. Home winemakers working with small basket presses are doing well to get 150 gallons of wine per ton of fruit. One hundred and fifty gallons represent about 62 cases of wine.

GRAPE PRICES

Wine grapes are bought and sold by the ton. The price of a ton of grapes will depend upon the grape variety, the location of the vineyard, the quality of the fruit and upon supply and demand. In 1994, Napa Valley Cabernet Sauvignon grapes sold for about $1200 a ton. Temecula Cabernet sold for around $600, and Cabernet grown in the Bakersfield area sold for less than $500 a ton. Representative prices for grapes grown in the Temecula Valley are shown in Table 1.

	1994	**1995**	**1996**	**1997**
Chardonnay	$600	$600	$900	$1000
Sauvignon Bl.	$450	$450	$700	$800
Riesling	$400	$400	$500	$600
Chenin Blanc	$400	$425	$600	$650
Cabernet	$600	$625	$900	$1000
Merlot	$650	$650	$900	$1100
Zinfandel	$400	$350	$500	$600
Carignane	$225	$250	$250	$300

Table 1. Representative prices for Southern California wine grapes.

When home winemakers purchase fruit in 100 -pound quantities, they often pay a premium price, and grapes purchased by the pound often cost three or four times the per ton price.

PACKAGE COST

Table wine is a very perishable food product. Wine oxidizes quite easily, and wine is susceptible to attack by a variety of microorganisms. If wine is going to be stored for any significant time, it must be sealed in air tight containers and stored in a cool, dark environment.

The standard package for quality wine consists of a 750-milliliter glass bottle, a standard 1 3/4-inch cork, a capsule and an appropriate label to identify the contents. The costs of the fruit and the costs of the package are the major out-of-pocket expenses for the home winemaker.

Glass

Glass bottles are packed in standard cardboard cartons, and the glass is clean and sterile when it leaves the factory. Glass bottles are heavy, so shipping costs are high. Consequently, glass is normally shipped in truckload lots, and the quantities are quite large. Smaller commercial wineries often pool resources and buy a truckload of bottles to reduce their glass costs. This is why the home winemaker seldom has access to new glass. The average home winemaker really has only two alternatives. The winemaker must either wash his own bottles or rely on commercially re-sterilized, used bottles. Commercial bottle washing enterprises usually charge $4.00 to $5.00 for a case of re-sterilized glass. Unfortunately, re-sterilized glass is often hard to find.

Corks

Standard wine corks are sold in large sealed polyethylene bags containing one thousand corks. The bags are gassed with sulfur dioxide, and the humidity in the bag is carefully controlled. The corks are sterile until the bag is opened. Dry corks taken from a new bag are soft and pliable, and they can be driven easily. Unfortunately, corks dehydrate and quickly become hard after the bag is opened, and old, dry corks are difficult to drive. Good quality corks sell for about $300 a bag.

Capsules

Capsules are purely decorative. Home winemakers generally use “push on” or “heat shrink” plastic capsules. Plastic capsules are shipped in cardboard cartons holding about 5000 capsules.

Labels

Wine should have a label permanently attached to each bottle to identify the contents. Custom wine labels are easy to make using a home computer, and attractive labels can be made for a few cents each. However, full color labels, printed on heavy weight papers, often cost more than twenty-five cents each when produced in the small numbers needed by most home winemakers.

REPRESENTATIVE WINE COST

The following example is given to illustrate possible home winemaking costs.
A ton of local wine grapes might cost $600 and produce 62 cases of finished wine. Here, the cost of the fruit needed to produce one case of wine would be $9.68. The cost of re-sterilized glass might be $5.00 per case, and corks might cost $1.50 per case. Label costs can range from less than $0.50 to more than $3.00 per case. However, pleasing labels can be made on a home computer for less than $0.60 per dozen. Plastic capsules cost from $0.40 to $0.60 per case. The cost of miscellaneous winemaking materials like acid, sulfite, etc. will depend upon the characteristics of the wine. An average cost of about $0.65 per case is a good estimate.

Table 2 shows how per case wine cost depends upon the cost of the grapes. Note that the cost of the fruit and the cost of the package are about the same when crushing $500 per ton grapes. When less expensive grapes are used, the cost of the package is the major cost factor. The case cost would be $5.00 less than the values shown if wash your own bottles were used in the above example. Obviously, these estimates do not include the original cost of winemaking equipment, and they do not include the cost of repairs, yearly maintenance, etc.

	FRUIT @ $400/T	**FRUIT @ $600/T**	**FRUIT @ $800/T**	**FRUIT @ $1000/T**
Fruit	$6.45	$9.68	$12.90	$16.13
Glass	$5.00	$5.00	$5.00	$5. 00
Corks	$1.50	$1.50	$1.50	$1.50
Capsule	$0.42	$0.42	$0.42	$0.42
Labels	$0.60	$0.60	$0.60	$0.60
Misc.	$0.65	$0.65	$0.65	$0.65
$/Case	$14.62	$17.85	$21.07	$24.30

Table 2. Typical home wine cost per case.

SUMMARY

Wine is very perishable, and table wine spoils quickly unless it is sealed in airtight containers. The standard package for quality wine consists of a 750-ml glass bottle, a 1 3/4-inch cork, a capsule and an appropriate label. The cost of homemade wine depends on the cost of the grapes and the cost of the package. The cost of the fruit and the package are about equal when $600 per ton grapes are used, but the package cost is dominant when expensive grapes are used. Home winemakers can reduce their winemaking costs by purchasing grapes by the ton and supplies in commercial quantities. Washing used wine bottles is another way to reduce home winemaking costs.

Chapter 3

EQUIPMENT AND FACILITIES

Home made wines are usually produced in five, fifteen, thirty, fifty, sixty or 160 gallon quantities. Some of these quantities may seem a bit strange but containers having these specific capacities are readily available. Wine reacts with oxygen in the air. As the size of the container becomes smaller, producing high quality wine becomes more difficult because of oxidation problems. A one-gallon container is suitable for bulk storing wine for only a few months. Five-gallon "water bottles" are readily available, and they are popular with home winemakers. However, water bottles are marginal bulk wine containers because of their small size.

Small quantities of wine can be made in the kitchen or on a bench in the garage, and little special equipment is needed. However, a larger workspace and access to some winemaking equipment will be necessary when fifty gallons of wine are made each year. When several barrels of wine are produced each season, specialized winemaking equipment, a large workspace and storage space for both bulk wine containers and bottled wine will be needed.

FACILITIES

Winemaking requires two general types of workspace, and each type has different requirements. A crush area is needed to receive and process the grapes, and a cellar area where the wines are fermented, aged and bottled is necessary. In addition, some general storage space is also needed to store winemaking equipment and supplies. A separate area set aside for each specific function is the ideal arrangement. However, most winemakers have limited space available for winemaking, so compromises are often necessary.

Experience shows that careful planning and a few minor modifications can greatly increase the efficiency of any winemaking workspace. For example, a large fraction of the labor in any winery is used to clean and sanitize the equipment and the workspace. Sanitation is an ongoing effort in all winemaking areas, and cleaning operations are repeated often. Arranging the work area in a way that optimizes the various cleaning procedures can save much time and effort.

Crush Area

Crushing and pressing operations at any winery involve handling large quantities of materials. Grapes must be moved into the crush area, and pomace must be removed from the crush area. Consequently, most commercial wineries prefer to have their crush operations outside the main facility to simplify handling the large quantities of bulk materials.

Many home winemakers use their garages as temporary crush areas each season. The crusher is setup near the front of the garage, and the grapes are unloaded from trucks or vans parked in the driveway.

Washing down the crusher and the press should always be done before any fruit can be processed. Then both pieces of equipment must be washed again when the operation has been completed. A heavy-duty hose with an adjustable spray nozzle permanently installed at the crush pad is a great convenience. Provide a hook or other arrangement so the hose can be hung in a convenient place. Cleaning a small crusher or press will generate large amounts of wastewater so water disposal can be a problem. Most commercial crush pads consist of a smooth finished concrete pad that incorporates a large drain. Home winemakers often use their driveways as crush areas.

Pomace should be removed from the crush area promptly. Even sweet pomace will sour quickly on a hot day, and it will attract fruit flies. Ants can become a terrible problem, and the entire crush area should be carefully washed to remove all traces of sugar when the crush operations are finished.

Cellar Space

White wines are fermented, clarified, stabilized, aged and bottled in the cellar. Red wine is often fermented in open containers placed outside the cellar area. Cellar activities can generate a significant amount of lees, and some way of disposing of liquid waste material is needed in the cellar. A good solution to the disposal problem is a conveniently located sewer drain, a water faucet, a dedicated hose and a spray nozzle. A centrally located floor drain equipped with a large grate is a great convenience.

Aging wine is mostly a passive operation, and it requires little more space than is necessary to hold the storage containers. Five-gallon water bottles are about 10 inches in diameter and 20 inches high. Fifteen-gallon stainless steel beer kegs are roughly 15 inches in diameter and 23 inches high. 200-liter oak barrels are about 24 inches in diameter and 36 inches long. A popular 160-gallon polyethylene storage tank manufactured by *Norwesco* is 31 inches in diameter and 55 inches high. Double stacking or even triple stacking barrels is possible. Nevertheless, most winemakers find stacked barrels difficult to handle and clean.

Bottling wine requires a moderate amount of cellar space. A typical bottling setup for an advanced home winemaker or a very small commercial winery might consist of a small transfer pump, a filter, a bottle rinser, a bottle filler, a corker, a labeling rack and a label paster. A large table or bench would be necessary to hold the empty bottles, the bottle rinser, the filler and the full bottles. In addition, a second table or a small bench would be needed to hold the label pasting machine and the rack used to hold the bottles while the labels are applied.

EQUIPMENT

Large wineries use a great deal of equipment in their winemaking operations, but small wineries and home winemakers frequently make due with a minimum of equipment. Basic crush equipment consists of a crusher and a press. The key pieces of cellar equipment are wine storage containers, pumps, and filters, bottling equipment and test equipment. Several pieces of common winemaking equipment are briefly discussed below.

Crusher

A hand crank crusher is probably the most practical method of crushing for the average home winemaker. Both single and double roller crushers work well. However, some crusher designs are easy to crank and some are not. Operation of these little crushers is quite simple. The crusher is placed on top of a suitable container. The hopper is filled with fruit, and the crank is turned. Clusters of grapes pass through the rollers and the crushed fruit and stems drop into the container. Having some way of clamping the crusher on the container is very desirable. If the crusher slides or moves around, it will be more difficult to crank.

Stems can be easily removed by hand using the following technique. Put a clean, plastic milk crate on top of a suitable container. Place a few pounds of crushed fruit in the bottom of the milk crate and make a scrubbing motion with the hand. The crushed fruit will drop through the crate into the container. Discard the stems from the crate and repeat the process. Several hundred pounds of grapes can be de-stemmed using this method.

A power crusher/stemmer will crush and separate the grapes from the stems in one fast, simple operation. The grapes are dumped in the fruit hopper, and the machine does the rest. Power crushers have capacities ranging from about 1 ton to more than 50 tons of grapes per hour. Even the smallest machine will keep one person busy filling the hopper. Unfortunately, power crushers are expensive. The smallest machines cost several hundred dollars. Crusher/stemmers are overkill for most home winemakers, but they can save a tremendous amount of labor if a winemaker produces several barrels of wine each year.

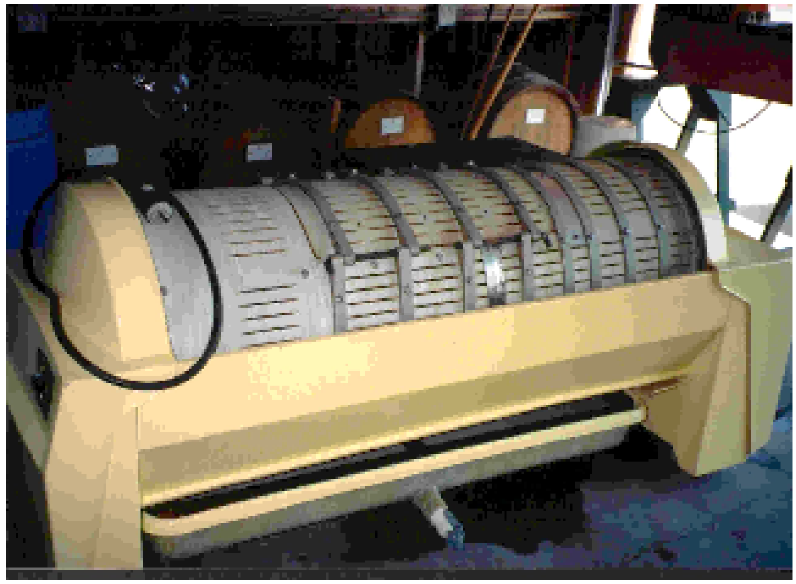
Press

Most home winemakers use a vertical basket press of some kind. These presses are made in a wide range of sizes and in several different styles. Smaller presses can handle 10 to 20 pounds, and large presses hold several tons of grapes in each load. Smaller presses use a screw mechanism to generate the pressure. Large basket presses often use hydraulic cylinders and electric pumps to generate the pressure. Some homemade presses use a hydraulic automobile jack to produce the pressure. Two manufacturers are producing vertical basket presses specifically for home winemakers that use an inflatable rubber bladder to squeeze the grapes.

Although small vertical basket presses are relatively inexpensive, they can produce high quality juice when used properly. The major disadvantage of any vertical press is the large amount of labor required. To crumble the pomace cake, the press must be completely disassembled and the basket removed. After the cake has been broken up, the basket must be reassembled and refilled to start a new press cycle. Several press cycles are usually required to produce dry pomace; so much labor is required.

Some compound basket presses can produce very high pressures. High press pressures can extract the juice with a minimum amount of labor. But, high pressures can also extract excessive amounts of phenolic materials and produce harsh, bitter wines, so these presses must be used with care.

During the 1950's, many California wineries replaced their vertical hydraulic presses with horizontal presses manufactured by *Willmes*, *Vaslin* or other manufacturers. Horizontal presses offer a major advantage because the pomace cake can be crumbled automatically by releasing the pressure and rotating the horizontal basket. Horizontal presses are simple and easy to operate, and they save wineries a tremendous amount of labor. The *Vaslin* presses were made with fiberglass baskets and covers, so they were much less expensive to produce than presses constructed of stainless steel. Although horizontal screw presses are no longer manufactured, many small wineries continue to use one, two and six-ton *Vaslin* presses.



Computers control Modern commercial winepresses, and they can be programmed to execute very complicated press schedules automatically. Modern presses use an inflatable bag, tube or membrane. After the press is loaded, the membrane is inflated and gently squeezes the grapes against the basket to extract the juice. These new presses are nearly self-operating, and they only require attention when the press is being loaded or unloaded.

Bottle Filler

Filling wine bottles with a piece of hose is easy. The hose is inserted into the wine container, and the wine is siphoned into the bottles. However, reducing wine oxidation is always desirable, so wine bottles should always be filled from the bottom with a minimum of splashing and bubbling. Wand type bottle fillers are a great improvement over a piece of hose. Simple wand fillers consist of a 16-inch length of rigid plastic tubing fitted with a small plastic valve at the bottom end, attached to the end of a siphon tube. When the wand is inserted in the empty bottle, the valve presses against the bottom of the bottle, and the wine starts to flow. Wine flow automatically stops when the operator raises the tube. Small diameter fillers often generate excessive amounts of foam; so ½ inch diameter wand type fillers are generally preferred.

Several styles of gravity type bottle fillers are available. These fillers have a small tank to hold the wine and two or more siphon tubes to transfer the wine into the bottles. A float-valve mechanism is used to keep the tank full. Operation of small multi-spout, gravity type fillers is simple. An empty wine bottle is placed on a spout. The machine fills the bottle to a preset level and automatically stops. Two, three, four and six spout machines are common, but gravity bottle fillers as large as 24 spouts are produced. Two, three and four spout fillers are suitable for home winemakers producing 50 or more gallons of wine each year. Large gravity fillers are used by smaller commercial wineries. Many gravity type fillers will fill at a rate of about two bottles per spout per minute. One person is kept quite busy removing and replacing bottles.

Larger wineries use automatic, vacuum type bottle fillers. These large, multiple spout fillers are often integrated into a complete high speed bottling line. Empty bottles are sparged with nitrogen gas, filled with wine, corked under a vacuum and capsules and labels are applied. Completely packaged wine comes off the bottling line, and much of the work is done automatically. Older bottling lines often run at rates of 10 to 40 bottles per minute, and older equipment requires the constant attention of several winery employees. Modern bottling equipment runs at rates of 30 to 200 bottles per minute, and these high-speed lines only require one or two people for efficient operation. Modern high speed bottling equipment has reduced winery labor costs significantly. But, these machines are complicated and very expensive.

Transfer Pump

Pumps are used in wineries to move must, lees, juice and wine. Wine contains significant amounts of acid, so any pump used for wine must be made of corrosion resistant materials. A variety of pump styles are produced to meet the requirements of different winery applications. Transfer pumps are used to transfer juice or wine for filtering and for bottling. Most transfer pumps are either rubber impeller "Jabsco" style pumps or centrifugal pumps. Rubber impeller pumps are generally preferred for moderate flow rate applications when the pressure heads are higher. Centrifugal pumps are generally preferred when large flow rates at moderate pressures are needed.

Home winemakers use a variety of small pumps. Capacities range from three to ten gallons per minute. A typical rubber impeller pump can deliver five gallons per minute, and it has a maximum pressure head of 30 pounds per square inch. Many of these little rubber impeller pumps are self priming, inexpensive and provide good performance. They should not be run dry for extended periods, and their shaft seals have a limited service life. A leaky pump with a worn shaft seal will quickly oxidize the wine, so shaft seals on small pumps must be replaced often

Small, magnetically coupled, centrifugal pumps are quite suitable for general use in any small winery. A magnetically coupled centrifugal pump does not have a shaft seal because the impeller shaft does not penetrate the pump housing. The impeller is coupled to the drive motor by means of two powerful permanent magnets. Magnetically coupled pumps have advantages and disadvantages. They are more expensive than direct-coupled pumps. They are not self-priming, and sometimes getting these pumps started is difficult. On the other hand, magnetically coupled pumps have long, trouble free lives, and they do not have shaft seals to leak air and oxidize the wine.

Corker

Hand corking machines are made in a variety of styles, and prices range from a couple of dollars to several hundred dollars. An effective corking machine must be able to do two functions, and these two functions must be separately. The cork must be compressed first, and then the cork must be driven into the bottle. A good hand corker can drive dry corks without excessive effort. Well-designed floor model corkers sell for about $70 (1995). The better machines are solidly built and have a useful life greater than 100,000 corks. Some small, inexpensive corking machines sold at home winemaking shops are practically worthless.

Sugar Measuring Instruments

Winemakers use a Brix hydrometer or a small optical instrument called a Brix refractometer to measure grape sugar content. Both short-range (16 to 25 Brix) and long-range (-2 to 30 Brix) hydrometers are available. Short-range instruments cover a range of about ten Brix and they cost about twenty five dollars. The scale on short-range hydrometers can be read directly to 0.1 degrees Brix, and good quality hydrometers have a NIST certified calibration. Professional winemakers have a set of three overlapping short-range hydrometers in their winery lab. Long-range hydrometers cover a range of about 30 Brix and they cost seven or eight dollars. The scale on most long range hydrometers can be read directly 0.5 degrees Brix. Most long range Brix hydrometers available at home winemaking shops do not have a NIST certification.

All hydrometers must be used at their calibration temperature, or a correction for temperature must be applied to the readings. A typical hydrometer correction chart is shown in Table 3. Note that significant errors can occur unless temperature is taken into account. Some winemakers avoid temperature corrections by making sure the temperature of the grapes and the hydrometer is at the calibration temperature. Grape samples are brought into the winery lab and allowed to come to temperature equilibrium. When the grapes have cooled to ambient temperature, then both the grapes and the hydrometer will be at or very close to the calibration temperature so temperature corrections will not be needed.

TEMP	CORRECTION
56	-0.38
58	- 0.32
60	-0.26
62	-0.20
64	-0.14
66	-0.08
68	0.00
70	+0.07
72	+0.14
74	+0.22
76	+0.30
78	+0.38
80	+0.46
82	+0.54
84	+0.62
86	+0.71
88	+0.80

Table 3. Hydrometer temperature correction.

About 100 milliliters of juice are required to make a measurement when a short-range Brix hydrometer is used together with a small diameter cylinder. Accuracy, simplicity and low cost are the advantages of using Brix hydrometers to make sugar measurements. But, hydrometers are made of thin glass and they are very fragile instruments. So, hydrometers must be washed and handled very carefully.

Winegrowers like to use refractometers because refractometers can measure the sugar content of a single drop of juice in a few seconds. In most refractometers, each degree is subdivided into five parts, and a value of 0.2 Brix can be read directly on the optical scale. Well made, temperature compensated refractometers cost about $250, and good, uncompensated instruments can be purchased for less than $100. Most winemakers prefer compensated instruments, but data obtained with an uncompensated refractometer can be corrected for temperature easily using the calibration chart supplied with the refractometer.

The major advantage of refractometers is their ability to measure small quantities of juice quickly and easily. But, this ability to measure a single drop of juice can be misleading. The first drop or two of juice squeezed from a berry comes from the softest pulp tissue and the softest pulp tissue contains the most sugar. In general, the first drop of juice squeezed from a grape will measure a couple of Brix higher than the last drop. Measuring drops of juice from individual berries and taking the average produces poorer accuracy than making one measurement of the mixed juice from many berries.

STORAGE CONTAINERS

Cooperage is the general term used for all kinds of bulk wine storage containers. Open containers with straight sides are called vats. Closed wine storage vessels with straight sides are called tanks. Curved-sided containers with a bulge in the center like the familiar barrel are called casks. Casks range in size from 100 to more than 1000 gallons. Depending upon size and proportions, casks are called butts, pipes, puncheons, ovals, etc.

The traditional wood used to make wine containers is white oak. However, in California, redwood was extensively used for constructing wine containers from about 1840 to 1950. Very large wine tanks have been fabricated from reinforced concrete, and concrete storage containers were widely used in wineries from the early 1900's until about 1950. A large bank of concrete tanks could still be seen at the old Galleano Winery in Mira Loma, CA in 1997. Stainless steel has become the material of choice for wine storage tanks, and several manufacturers are now producing wine tanks in many sizes and shapes from high-density polyethylene. The characteristics of several common types of wine containers are discussed below.

Glass

Home winemakers often use gallon jugs, 5-gallon and 6.5-gallon carboys made of glass. Five-gallon water bottles are readily available, and these are the bulk wine containers most often used by beginning home winemakers. Like many other materials, glass storage containers have advantages and disadvantages. Glass can be cleaned easily, and it can be completely sterilized. Glass is transparent, so the progress of fermentation can be easily monitored visually.

On the other hand, glass containers are heavy, and some winemakers find moving full 6.5-gallon carboys difficult. Glass is slick and fragile, and handling heavy glass bottles with wet hands can be dangerous. Five-gallon containers are really a bit too small for long-term wine storage because of the large surface to volume ratio. The price of a new glass water bottle is about $16.00 (~$3.00 per gallon), so the high cost of glass is another negative factor. Even so, a few 1-gallon jugs and some water bottles are handy for storing wine leftovers.

Plastic

Polyethylene is a light weight, strong and inexpensive material. Polyethylene is a recognized “food grade” material, and polyethylene drums are widely used for shipping and storing liquid food and beverage products. New and used poly drums are available in 20, 30, 40 and 55 gallon sizes, and they make excellent wine storage containers for home winemakers.

Several firms now produce polyethylene tanks designed specifically for use as wine storage containers. Heavy walled tanks and drums made from high density polyethylene have negligible oxygen permeability and wine can be safely stored for extended periods in high-density polyethylene containers. Small and medium size poly tanks are relatively inexpensive. They are also easy to handle, so poly tanks are being used in many smaller wineries.

Just like glass, wine storage containers made of polyethylene advantages and disadvantages. They are lightweight, and polyethylene drums can be handled and stored easily. Best of all, they are inexpensive. New poly drums cost about $1.00 per gallon, and good, used, drums can often be purchased for $15.00 or so. That is only $0.27 per gallon for a bulk wine storage container so used poly drums are a bargain. But unfortunately, polyethylene has a porous microstructure, and the small pores make this material difficult to clean completely. Used polyethylene drums can retain odors for long times, and the **residual odors can contaminate wine**. Consequently, secondhand drums must be selected with care. Use and trust your nose when buying used poly drums.

Better-Bottle sells 3, 5 and 6-gallon carboys made from Pet plastic. Pet is much denser than polyethylene. It is less permeable to oxygen and Better-Bottle claims wine can be stored in their containers for extended times. Carboys made from Pet are light, strong and easy to handle.

Plastic sheet materials are now available (bag in a box) that provide low oxygen transfer. The sheet is formed by laminating several different plastics with evaporated metal surfaces together. An Australian firm has been producing large size bags for commercial wineries since 2004. Small laminated plastic bags, suitable for storing small quantities of wine should be available to home winemakers in the next couple of years.

Stainless steel

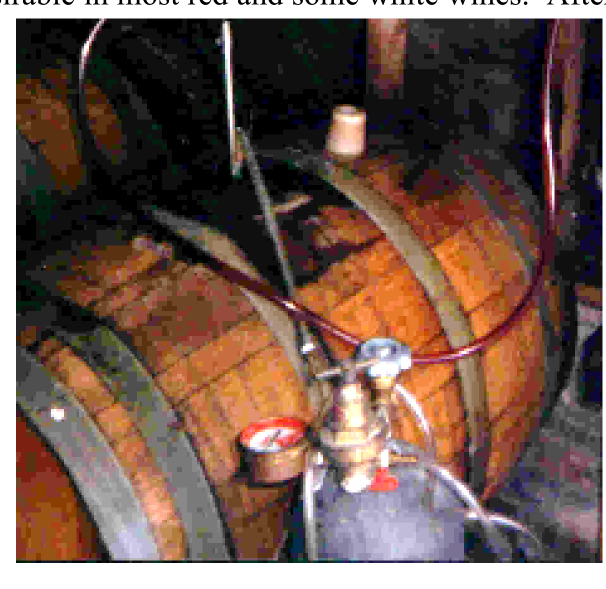
Properly designed stainless tanks are inert, tight and durable, and smooth, polished stainless steel surfaces can be cleaned easily. Unfortunately, stainless steel is expensive and fabrication costs are high. But, stainless containers give many years of trouble free service, so the high initial cost can be easily justified.

Variable capacity (floating lid) tanks made of 304 stainless steel are now being produced specifically for home winemakers and these tanks are available in several sizes. The cost ranges from about $8.00 per gallon for small tanks to $5.00 per gallon for larger tanks (200 gals). These tanks are well made and the variable capacity feature is convenient for small producers. The only drawback is the high per-gallon cost.

Many home winemakers use 15.5-gallon stainless steel beer kegs for wine storage containers. Availability and low cost make beer kegs attractive. Beer kegs come in two shapes. The new style kegs are cylindrical in shape and they have the bung on top. The old style kegs are barrel shaped and they have the bung on the side. The deposit for a 15-gallon beer keg is about $15, and finding a first class wine container for less than a dollar per gallon is difficult. Keep the receipt so you can get your deposit back when you are finished with the keg.

Oak Barrels

Oak barrels have been used for storing wine for hundreds of years. Oak barrels impart a vanillin flavor to the wine, and this oak character is desirable in most red and some white wines. After a barrel is four or five years old, it no longer produces the desirable flavors, so wineries must replace their barrels from time to time. A few wineries replace all of their barrels each crush season, but many commercial wineries only replace about 20 percent of their barrels each year. In 1997, a new French barrel cost about $500 each and a good American barrel cost about $200. The annual barrel replacement is a considerable expense for wineries that use many barrels in their program.



When a new barrel is filled, almost four gallons of wine soak into the wood. When a used barrel is stored empty, the wine in the wood can start turning into vinegar in just a few days. Barrels full of wine require little extra attention. But, empty, used barrels are difficult to maintain and require a great deal of attention. Commercial wineries avoid this problem by not emptying their barrels until new wine is available. They wash their barrels with clean water as they are emptied and then the barrels are immediately refilled with new wine. This is why many commercial red wines are bulk aged in barrels for either one or two years. Of course this practice means that wines are being bottled close to harvest time which complicates crush season.

Oak barrels have several other disadvantages. Barrels are heavy and difficult to handle. Empty barrels weigh almost 100 pounds, and full barrels weigh about 600 pounds. Empty barrels can be moved by hand without much difficulty, but moving full barrels more than a short distance by hand is seldom feasible. Oak barrels are often attacked by wood borers. These tiny insects bore a small hole from the outside all the way through the wood. Then the barrel starts to leak and the winemaker must locate the leak and plug the hole. A round toothpick is the standard plug material. Borer problems can be minimized by coating barrels with a special preservative.

In warm weather, empty barrels dry out quickly. The wood shrinks, and the staves and heads become loose. (Old, dry barrels can literally fall apart). Then the barrels must be filled with water and allowed to soak until all of the leaks have stopped. Several days of soaking may be required for he staves to swell and become tight. Allow the barrels to soak for two or three more days after all of the leaks stop. Then the barrels can be refilled with wine.

Clean, sound, used, barrels can often be purchased from wineries for $25 to $75. But much care is needed if the barrels have been empty for some time. Put your nose down in the bunghole and smell the barrel carefully. Sound barrels smell like wine and sweet wood. **Barrels should not smell like vinegar, finger nail polish remover or a barnyard.**

Oak chips can be added to wine to impart desirable oak flavors, and many wineries use oak chips to flavor their lesser quality wines because of the high cost of new barrels. Some winemakers put the oak chips in a nylon mesh bag and then suspend the bag in the wine. Other winemakers just add the chips directly to the wine. After a few days, the loose chips sink to the bottom of the container, and then the chips are treated just like lees. Estimating the quantity of chips to be added is difficult for the inexperienced winemaker. The amount needed depends on the specific wine and on personal preference. Ten or twelve ounces of chips for 50 gallons of red wine are a reasonable place to start. Considerably fewer chips are appropriate for most white wines. All wines should be tasted periodically after oak chips are added. Then the wine should be racked off the chips when the taste is satisfactory.

Home winemakers should avoid very small oak barrels. Small oak barrels or casks are difficult to build, and they are very expensive per gallon of capacity. They are prone to leakage, and small wood cooperage is more difficult to maintain properly. Wine stored in small oak containers becomes over-oaked very quickly. Oak casks of five or ten-gallon capacity are often recommended by home winemaking shops, but these tiny barrels are little more than expensive toys.

Open Red Fermenters

Many small commercial wineries and most home winemakers use open containers for fermenting red wines. Large amounts of carbon dioxide gas are generated during fermentation, and the wine becomes saturated with carbon dioxide. The constant evolution of gas prevents air from entering the wine, so oxidation is not a problem. But, when fermentation is complete, carbon dioxide gas is no longer produced, and then the wine must then be stored in sealed containers.

Small producers seldom use open fermenters much larger than a few hundred gallons because punching down the cap in a large vat by hand is very difficult. Stainless steel and polyethylene are the usual construction materials for red fermenters. Many small producers often use half-ton, fruit bins as temporary, red fermenters each crush season. A 55-gallon polyethylene drum makes a good open fermenter when the top is removed. Thirty-gallon, food grade polyethylene containers with tight fitting lids are available at most home winemaking shops. Much homemade red wine is fermented in 32-gallon plastic trashcans each year.

SUMMARY

Every winery needs a crush area for processing grapes and a cellar area for fermenting, aging and bottling wine. A third area is needed where equipment and supplies can be stored. At many home wineries, a concrete driveway serves as the "crush area," and the garage is the "cellar." However, summer time temperatures in many garages are too high for wine storage so some of caution is needed here.

Little special equipment is needed to make a few gallons of wine. When larger quantities of wine are made, well-designed winemaking equipment can significantly reduce the amount of physical labor. Basic crush equipment consists of a crusher and a press, and basic cellar equipment includes cooperage, pumps, hoses, and filters, bottling equipment and test equipment. Many home winemakers use new 32-gallon plastic trashcans for open red fermenters and surplus stainless steel beer kegs for wine storage containers. New oak barrels can impart desirable vanillin flavor characteristics to red wines. On the other hand, barrels are difficult to handle in a small winery, and some leakage is always encountered. New oak barrels are expensive, and the oak flavor disappears after the barrels have been used for a few years. Oak chips can be used to impart desirable oak flavors in wine, and chips are inexpensive and easy to use.

Chapter 4

COMMON WINERY MATERIALS

Various materials are added to wine throughout the winemaking process. These materials are used to solve specific wine problems. For example, bentonite is always added to white and blush wines. The bentonite removes excess protein and prevents protein from forming a haze after the wine is bottled. Small amounts of sulfur dioxide are added when the grapes are crushed, and small additions of sulfur dioxide continue until the wine is bottled. Sulfur dioxide helps control the growth of microorganisms, and it reduces the effects of oxidation. Wines fermented from apples and stone fruits often contain excessive amounts of pectin. The pectin makes the wine difficult to clarify, so winemakers add enzymes to break down the pectin into smaller molecules. For home winemakers, the most common wine additives are sulfur dioxide, fining agents, stabilizing materials and wine preservatives.

Winemakers must use care when selecting wine additives. Wine is a food, and any substance added during the winemaking process must be a food grade material. Most materials used in winemaking are also used throughout the food and beverage industries. These materials are widely used and available to the winemaker as normal commercial products. A few wine additives are unique to the winemaking industry, and sources of a few materials may be difficult for home winemakers to find.

Many winemaking materials come from the manufacturer in dry, granular form. These materials are usually shipped in heavy paper or plastic bags containing about 50 pounds of material. With a few exceptions, winemaking materials have a long shelf life. Many winemaking materials can be kept for several years if they are stored in tightly sealed containers and kept at reasonable temperatures.

Home winemakers can reduce their winemaking costs by getting together and purchasing frequently used winemaking materials in commercial quantities. Materials purchased in small quantities often cost three or four times the bulk price, so the savings can be significant. Reagents for wine testing and yeast and sulfites are exceptions, and fresh supplies of these materials should be purchased each season. The characteristics of several common winemaking materials are briefly discussed below.

Anti-foam

Anti-foam is a clear, oily liquid. This is a silicone product, and it has no smell or taste. Anti-foam is used to prevent foam from overflowing containers during active fermentation. About 250 milliliters of anti-foam added to a 1000-gallon wine tank will reduce foaming to a minimum. This material is completely inert and does not react with the wine in any way. Most of the anti-foam added will disappear when the wine is racked. Even if a few drops remain, they will be removed when the wine is filtered.

Ascorbic Acid

Ascorbic acid is vitamin "C." Winemakers add ascorbic acid when wines contain disulfides. In larger amounts, disulfides can smell like a skunk. Smaller quantities give wines a rubber or garlic smell. When very small quantities are present, disulfides can give wine a vague, dirty odor. At even lower levels, disulfides often do not produce a specific odor. Sometimes they are not detectable, but minute quantities of disulfides can kill the normal bouquet of a fine wine.

When ascorbic acid is added to wine, it reacts with the disulfides, and the disulfides are converted into a material called mercaptan. When all of the disulfides are converted into mercaptan, the winemaker adds a very small quantity (0.05 to 0.5 milligrams per liter) of copper sulfate. The copper sulfate removes the mercaptan from the wine. This treatment is only effective when the ascorbic acid is added to the wine several days before the copper sulfate addition.

Many Australian winemakers use ascorbic acid as an anti oxidant when bottling wine. The ascorbic acid is used in combination with sulfur dioxide.

Calcium Carbonate

Sometimes, grapes grown in cold climates contain too much acid. Then winemakers often use calcium carbonates to reduce the acid content of juice before fermentation. This material is occasionally used to reduce the acid content of finished wines by small amounts. However, flavors can be changed, pH values raise other problems can be developed when carbonates are used to reduce the acidity of a finished wine. Grapes grown in warm climates are usually low in acid, so carbonates are seldom used with warm climate fruit.

Carbon

Winemaking carbons are available in two forms. Deodorizing carbon (S51) is used to remove off odors from wine. Decolorizing carbon (KBB) is used to remove unwanted color and oxidation from white and blush wines. But, carbon fining is considered a gross treatment because it is nonselective. It removes almost everything. So, carbon fining is always a tradeoff and careful lab testing must be done to determine the best dose. Most winemakers consider carbon fining to be a last resort treatment. Dose levels range from 1/8 to 4 pounds per 1000 gallons of wine. Sometimes large wineries use 8 or 10 pounds per 1000 gallons on a spoiled wine. At this high level, the carbon removes most of the odors, flavors and color. Then small amounts of the stripped wine are "lost" in large batches of jug wine. Carbon particles are very small so carbon will "fly" allover the place. Therefore, carbon must be handled **very** carefully and problems with packaging and shipping are often encountered.

Citric Acid

Citric acid is one of the work horse materials in the winery, and it is used for several different purposes. Citric acid is mixed with sulfite powder and water to prepare sulfur dioxide solutions. Sulfur dioxide solutions are used to sterilize winery pumps, hoses, filters and other winery equipment. Sulfur dioxide solutions are also used for wet barrel storage. Winemakers use weak (1- percent) citric acid solutions to remove the "paper" taste from new filter pads. Stronger solutions (5 percent) of citric acid are often used to sanitize bottling equipment.

Sometimes, citric acid is added to finished wines specifically to increase acidity and improve acid balance. In small quantities, it provides a fresh, citric characteristic, and the citric quality is often appreciated in white table wines. Nevertheless, bench trials should always be done before making any large additions of citric acid. Significant additions of citric acid are seldom made to red wines. The citric taste does not seem appropriate in most red wines.

Copper Sulfate (1% solution)

Winemakers use a 1-percent solution of copper sulfate pentahydrate to remove hydrogen sulfide (H_2S) stench from wine. The added copper converts the hydrogen sulfide gas into a solid material called copper sulfide. Copper sulfide has no odor and it is not soluble in wine. The copper sulfide settles, and after a few days, the wine is racked off the copper sulfide residue.

Diammonium Phosphate (DAP)

Diammonium phosphate is a major ingredient in many proprietary yeast foods. It is added to juice or must before fermentation to supply extra nitrogen. The additional nitrogen encourages rapid yeast growth and more dependable fermentations. California Chardonnay grapes are often deficient in nitrogen, and many winemakers add DAP to all Chardonnay juices to help the yeast complete fermentation and not leave residual sugar in the wine.

Juices lacking nitrogen can cause another problem. Some types of yeast produce excessive quantities of hydrogen sulfide when a juice lacks sufficient available nitrogen. Here, winemakers add DAP to provide extra nitrogen to reduce hydrogen sulfide formation.

Enzymes

Wineries use enzymes to increase the amount of free run juice when crushing white grapes, to extract more color from red fermentations, to minimize pectin hazes, enhance floral aromas in aromatic grapes, etc., etc. Many types of enzymes are available to winemakers and they can help resolve a variety of winemaking problems. But, excessive quantities of some enzymes can produce off-odors and bad tastes, so the directions supplied by the manufacturer should be followed carefully.

Fumaric Acid

In the past, winemakers often added small quantities of fumaric acid to their red wines. The acid prevented malolactic fermentation from occurring after the wine was bottled. However, since sterile filtration equipment became widely available, fumaric acid is seldom used commercially. Many home winemakers lack filtration equipment, so home winemakers continue to use fumaric acid to control ML fermentation. The customary dose levels range from one to three grams of acid per gallon of wine. Bench testing should always be done before fumaric acid is added to wine. This acid can improve the taste of some red wine, but sometimes fumaric acid produces unusual or off-flavors.

Lysozyme

This naturally occurring protein is used to control bacterial activity. It is effective against the lactic bacteria (*Oenococcus, Pediococcus and Lactobacillus)*. It is not effective against vinegar bacteria or yeast. Sometimes grapes contain excessive populations of *Lactobacillus* and lysozyme is an effective way of reducing the bacterial population during fermentation. Lysozyme is also used to kill bacteria when malolactic fermentation is not wanted in a wine. Lysozyme is extracted from egg whites. It is a protein and like any protein, it reacts with phenols in the wine. So, an average lysozyme treatment has the same general effect as a light egg white fining.

Malic Acid

Vines release malic acid (by respiration) throughout the ripening season. When grapes are grown in hot regions, little malic acid remains by harvest time, and sometimes winemakers add malic acid to white wines to improve the ratio of malic and tartaric acid. Small additions of malic acid raise the total acidity and often give white table wines a pleasing apple-like freshness.

Pantothenic Acid

Yeast often produces excessive quantities of hydrogen sulfide when grapes are deficient in pantothenic acid. Consequently, some winemakers add very small quantities of this material to juice or crushed grapes before starting fermentation. Pantothenic acid is a common vitamin, and it can be purchased in any drug store.

Pectinase (Pectic Enzyme)

Sometimes, commercial wineries use enzymes to increase the amount of free run juice when crushing white grapes. The enzymes break down the cells in the grape pulp, and the juice is released. The additional free run juice reduces the number of press loads, so pressing is quicker after an enzyme treatment. Home winemakers, using small basket presses, use pectic enzymes to make white grapes easier to process. Pectic enzymes are also used to prevent pectin hazes from forming in wines made from fruit or from grape concentrate. Excessive quantities of enzymes can produce off-odors and bad tastes. The directions supplied by the manufacturer should be followed.

Potassium Bitartrate

Sometimes, small quantities of potassium bitartrate (cream of tarter) are added to young wines during the cold stabilization treatment. The potassium bitartrate crystals speed the precipitation of excess tartrate material from the wine. The time required to stabilize the wine is shortened, and winery refrigeration costs are reduced. One to four pounds per 1000 gallons of wine is the normal dose.

Potassium Carbonate

Potassium carbonate is often used to de-acidify juice and wine instead of calcium carbonate. However, when this material is added to wine, the potassium content can be increased significantly. The additional potassium increases wine pH, so potassium carbonate must be used carefully.

Besides increasing pH, a stability problem sometimes occurs because the potassium reacts with tartaric acid in the wine. Potassium bitartrate is formed, and unless this material is removed, it can precipitate out of the wine after bottling. Because of this instability problem, potassium carbonates should not be used after wine has been cold stabilized.

Potassium Caseinate

Potassium caseinate is a common, wine fining material. This material is used to reduce the tannin content in red wine, and it is used for white wine clarification. Potassium caseinate is also used to remove odors and brown colors from oxidized white and blush wines. Sometimes, this material is effective for removing excessive oak character from white wines.

When added to wine, potassium caseinate reacts with wine acids and coagulates quickly. Fining is more successful when a caseinate-water solution is injected into the wine under pressure. Then, a very fine suspension is formed, and better mixing is achieved. Some home winemakers mix the dry powder in water and then they use a large syringe to inject the solution into the wine under pressure.

Potassium caseinate can strip desirable wine flavors, and it can give wine a cheesy taste when excessive quantities are used. Normal dose levels range from 1/10 to 1/4 gram per gallon, and bench trials should always be done.

Potassium Metabisulfite (Sulfite)

Home winemakers use potassium metabisulfite crystals to introduce sulfur dioxide into their wines. Small quantities of sulfur dioxide are used to control wine microbes, and sulfur dioxide also reduces wine oxidation. When sulfite is added to wine, it produces about half its weight in SO_2 (about one gram of sulfur dioxide is produced when two grams of sulfite are added to the wine).

One teaspoon of sulfite powder and two teaspoons of citric acid in two gallons of water makes an effective solution for sterilizing equipment, and some home winemakers use this solution to sterilize bottles just before they are filled with wine. Inert, oak barrels can be stored full of water using a sulfite solution. Add a cup of citric acid and a cup of sulfite crystals and fill the barrel with clean water.

Potassium Sorbate (Sorbate)

Home winemakers use potassium sorbate to stabilize wines containing residual sugar. Potassium sorbate prevents fermentation by acting on the yeast cells, but it does not kill the yeast. Potassium sorbate prevents cells from budding. In other words, sorbic acid prevents yeast cells from reproducing, but it does not stop yeast from fermenting sugar. Sometimes potassium sorbate does not prevent fermentation from restarting because a wine contains too many viable yeast cells. When potassium sorbate and sugar are added to a wine containing many viable yeast cells, the sorbate prevents the yeast from reproducing, but enough yeast cells may already be present to ferment the added sugar. Then, fermentation occurs after the wine is bottled. The wine is spoiled, and the winemaker is unhappy.

A different situation exists when sorbate and sugar are added to a well-clarified wine. Clean wine contains very few yeast cells. Sorbic acid prevents the yeast cells from reproducing. So, the yeast population remains small, and the added sugar is unaffected. Even if fermentation occurred, only a tiny amount of the added sugar would be lost. In time, the few active yeast cells in the wine grow old and gradually die. After a few months, the wine contains practically all of the added sugar and very few viable yeast cells.

Using just the right amount of sorbate can be a problem. Wine flavor can be adversely affected when too much sorbate is used. For most people, the taste threshold of sorbate is 200 or 300 milligrams per liter of wine. However, some people are more sensitive to the taste of sorbate, and a small fraction of the population can detect less than 50 milligrams per liter. Fortunately for the winemaker, many people sensitive to sorbate do not find its taste objectionable in wine.

The amount of sorbate needed to keep yeast cells from reproducing depends upon several wine properties. The normal dose is about one gram of potassium sorbate per gallon. One gram per gallon is equivalent to about 2 level teaspoons per 5 gallons of wine. Wines with a high alcohol content, low pH and 30 to 50 milligrams per liter of free sulfur dioxide require less potassium sorbate. Large quantities of potassium sorbate were used by commercial wineries to stabilize off-dry wines before sterile filtration equipment became available. However, sorbic acid is not widely used today because of the potential flavor problems and the high cost of potassium sorbate.

Bacteria in the wine can react with sorbic acid, and a strange, geranium-like odor can be produced. So, reasonable levels of free sulfur dioxide should be added when potassium sorbate is used to stabilize wines containing residual sugar.

Sodium Bisulfite

Sodium bisulfite provides SO_2 just like potassium metabisulfite, but the sodium compound is less expensive. Sodium bisulfite is mixed with water and used for sterilizing winemaking equipment and for wet barrel storage. Since it adds sodium, this material is usually not used as a source of sulfur dioxide in wine. Both materials are very sensitive to water, and both compounds should always be stored in tightly sealed containers. Even when stored in sealed containers, these materials can degrade, with time and much wine is spoiled by home winemakers using spent sulfite powder. Old sulfite powder should be discarded, and a new supply purchased each season.

Soda Ash

One of the cleaning agents found in all wineries is soda ash (sodium carbonate). It is used to clean and sanitize equipment, tanks, pumps and hoses. Soda ash in water produces a strong caustic solution, and a soda ash solution is particularly useful for removing heavy tartrate deposits from the surfaces of wine storage containers. Soda ash solutions must be carefully rinsed to remove all residue. Home winemakers often use soda ash to soak labels off old wine bottles.

Tartaric Acid

Winemakers add tartaric acid to juice or must to raise acidity and lower pH. Large acid adjustments should be made before fermentation is started. An addition of four grams of tartaric acid per gallon of juice will raise the TA about 0.1 percent. Calculated acid additions are seldom accurate, so calculated acid values should not be relied upon. A small wine sample should be tested before making large acid additions.

Care must be taken when tartaric acid is added to wine late in the winemaking process. The wine may need to be cold stabilized again if very much tartaric acid is added. Otherwise, tartrate crystals may form in the bottled wine.

Thiamine

Thiamine is vitamin B-1, and it is essential for healthy yeast growth. Winemakers often add thiamine and other vitamins to juice before starting fermentation.

Trisodium Phosphate (TSP)

Trisodium phosphate is a popular cleaning material for all types of winery surfaces. This material is inexpensive, effective, and it washes away easily. A chlorinated form of trisodium phosphate is also available, and the chlorinated form is a potent sterilizing material. In many commercial wineries, TSP is the material of choice for decontaminating large, stainless steel, wine storage tanks.

Viniflora Oenos

Viniflora Oenos is a freeze-dried culture of malolactic bacteria. Most ML bacteria are supplied in liquid form, and several days are needed to prepare a "starter." Viniflora Oenos has gained popularity rapidly because it can be added directly to the wine in dry form.

Yeast Extract

Yeast extract is added to juice to stimulate yeast growth and prevent stuck fermentations. Yeast extract provides additional vitamins, amino acids, etc. It is more effective when added before fermentation is started. Yeast extract is a major ingredient in many commercially available proprietary yeast supplements.

SUMMARY

Winemakers add different materials to wine throughout the winemaking process. These additions are made deliberately to improve color, clarity, stability or general wine quality. Each fining material can affect wine characteristics differently. Often one characteristic is improved at the expense of another, so fining wine is usually a compromise of some kind. Considerable winemaking experience is needed before many fining materials can be used effectively.

The types of material and the quantities to be used are usually determined by testing a small batch of wine and observing the results. When the desired results are obtained, appropriate additions are made to the main lot.

Winemaking materials should be kept in tightly sealed containers, and then the containers should be stored in a cool, dry place. With a few exceptions, like yeast and sulfite, most winemaking materials can be kept for several seasons, and purchasing winemaking materials in bulk quantities results in significant savings.

Chapter 5

SUGARS
AND
ACIDS

Sugar molecules are formed from carbon, hydrogen and oxygen, and the natural grape sugars are the materials yeast converts into ethyl alcohol and carbon dioxide. Although sugars are made from only three elements, some sugar molecules are very large and have complicated structures. Several different kinds of sugars exist, and each sugar has its own name. The name used to denote the entire family of sugar molecules is saccharide.

SACCHARIDE

Under certain conditions, sugar molecules have a great attraction for each other, and two small sugar molecules combine and form a larger molecule. Sometimes, many small sugar molecules combine and form large, complex saccharide molecules. Because of this attraction characteristic, saccharide molecules are classified according to the number of small, sugar molecules that are bound together.

The small, simple sugar molecules are called monosaccharides, and two simple sugar molecules bound together are called disaccharides. Three or more sugar molecules bound together into a single molecule are called a polysaccharide. Large polysaccharide molecules consist of hundreds or even thousands of small monosaccharide molecules. Pectin and gums are examples of large polysaccharide molecules.

Monosaccharides

The monosaccharides are called simple sugars, and many different kinds of simple sugars exist. Each simple sugar molecule contains three, four, five or six carbon atoms. The simple sugars are named according to the number of carbon atoms in the simple sugar molecule. For example, pentose sugars contain five carbon atoms, and hexose sugars contain six carbon atoms. Winemakers are primarily interested in the two major grape sugars, glucose and fructose and both are hexose monosaccharides. Enzymes produced by yeast are capable of converting glucose, fructose sucrose into ethyl alcohol.

Glucose is the most common simple sugar, and glucose is a part of many different disaccharides and polysaccharides. This is the sugar that provides energy for the human body. Glucose can be produced by splitting (hydrolysis) certain polysaccharides. For example, cornstarch is a large polysaccharide molecule, and glucose is produced commercially by hydrolyzing (splitting) cornstarch.

Fructose is found in many different kinds of fruit. It is the principal sugar in honey, and fructose is the sweetest tasting common sugar. Fructose is the sweetener of choice in the food and beverage industries because it tastes sweeter than ordinary table sugar (sucrose). Fructose is sometimes called “levulose.”

Disaccharides

Disaccharides are formed when two simple sugar molecules bind together. Sometimes two similar kinds of simple sugars combine. Often, two different kinds of sugar molecules combine to form a disaccharide. Disaccharides are produced commercially by the incomplete hydrolysis of larger polysaccharides. An alternate process combines two monosaccharide sugars by means of a condensation reaction to form disaccharide sugars. Usually, disaccharide sugars must be hydrolyzed and split into their simple sugar components before they can be fermented.

Maltose is a common disaccharide made from two glucose molecules. Maltose can be produced in several different ways. Very large quantities of maltose are produced each year from germinated grain, and then the maltose is fermented to make beer. Maltose is also produced by the incomplete hydrolysis of starch, glycogen or dextrin.

Sucrose (ordinary white table sugar) is found in many fruits and vegetables, and it also occurs in a variety of grasses including sugar cane. Sucrose is a disaccharide made up of one glucose and one fructose sugar molecule. This sugar is produced commercially in great quantities from both sugar cane and sugar beets. Some of the sugar stored in the roots of grapevine is sucrose.

Microorganisms, including wine yeast, produce enzymes that can hydrolyze sucrose, and when sucrose hydrolyzes, each sucrose molecule splits into a glucose and a fructose molecule. This process produces a 50-50 mixture of glucose and fructose monosaccharides called "invert sugar." Sucrose is a non-reducing sugar, and it cannot be accurately measured with *Clinitest* tablets.

Lactose (milk sugar) is found in milk from mammals. It is a disaccharide made up of one glucose sugar and one galactose sugar molecule. Lactose is easily hydrolyzed and is the basis of many dairy products including cheese. Lactose is an interesting because it has practically no sweet taste.

Polysaccharides

Polysaccharides are large, complex carbohydrate molecules containing three or more monosaccharides. Living organisms use polysaccharides to store energy and polysaccharides also form part of cell structural fibers. Starch consists of many glucose monosaccharides hooked together in both linear and branched forms. Pectin, gums and cellulose are also large polysaccharide molecules. Pectin and gums are of particular interest to winemakers because wines containing small quantities of these polysaccharide materials are sometimes very difficult to clarify.

Wines made from grapes infected with *Botrytis* mold, and wines made from cooked fruit often contain excessive quantities of pectin. Wines containing pectin are often difficult to clarify because the pectin tends to hold spent yeast cells, bacteria and small particles in suspension which makes the wine clear very slowly. Grape concentrate is made by heating grape juice, and wines made from concentrate can be difficult to clarify. Pectin rapidly clogs filter pads, so filtration may not be a practical way of clarifying wines containing large quantities of pectin or gums. However, pectic enzymes can be effective in clarifying wines containing excessive amounts of pectin. The enzymes break the pectin down into smaller, more easily managed polysaccharide molecules. Then the wine becomes clear in a reasonable time.

WINE ACIDS

Practically all of the acids in sound wine come directly from the grapes. However, very small quantities of several organic acids are produced during primary fermentation, and under adverse conditions, bacteria in wine can produce enough acetic acid to spoil good wine in a short time. In the United States, titratable acid in wine is expressed in grams of acid per 100 milliliters of wine, and titratable acid is calculated as if all of the different acids in the wine were tartaric acid.

The acid content of most finished table wine ranges from 0.55 to 0.85 percent. The desirable acid content depends on style and how much residual sugar is left in the wine. Ideally, the acid content of grapes should fall in the range from 0.65 to 0.85 grams per 100 milliliters (percent). However, grapes grown in cool climates often contain too much acid, and fruit grown in warm climates generally contains too little acid. One of the more important winemaking tasks consists of adjusting the starting acid content of the grapes before fermentation. The goal is to have just enough acid to produce a balanced wine.

Practically all of the acids found in sound wines are fixed acids. Most of the fixed acids originate in the grape juice, and these acids remain during fermentation and appear in the finished wine. Fixed acids are nonvolatile and nearly odorless. However, bacteria can produce acetic acid in wine, and acetic acid is different from other wine acids. Acetic acid is considered a volatile acid because it evaporates easily. Acetic acid has a distinctive odor, and it gives wine an unpleasant, hot aftertaste.

Acids Produce Hydrogen Ions

In water, some acid molecules ionize, and some acid molecules remain unchanged. Each ionized acid molecule splits into two separate pieces. One piece is a hydrogen atom (minus the electron), and the other piece is the remainder of the acid molecule. Both pieces have an electric charge, and both are called ions. A positive electric charge is carried by the hydrogen ion, and a negative charge is carried by the acid ion. The remainder of the acid molecules (the unionized molecules) remains unchanged in the water solution. Tartaric and malic acids have two hydrogens that can ionize, and these two hydrogens (**H**) are shown in Figure 2.

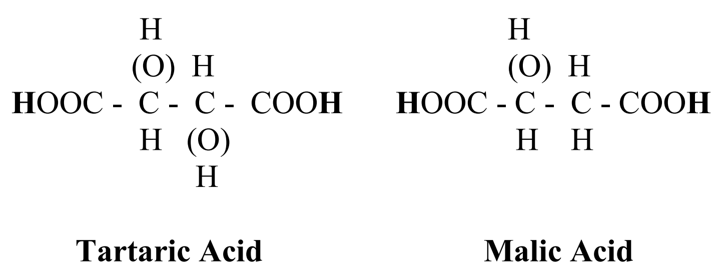


Figure 2. When wine acids ionize, one or both of the hydrogens shown in bold type separate from the main acid structure.

Acid Strength

Acids produce hydrogen ions in water solutions. The number of hydrogen ions produced can be large or small depending on how much acid is present in the solution. The number also depends on the strength of the acid. In water, some acid molecules spontaneously split into positive and negative ions. However, many acid molecules remain unchanged. The fraction of acid molecules that ionize depends upon the strength of the acid. When practically all of the acid molecules ionize, the acid is called a "strong" acid. When only a few acid molecules ionize, the acid is called a "weak" acid. In other words, strong acids ionize completely, and weak acids only partially ionize.

Only a few acids are classified as strong. All of the major organic acids found in wine are weak acids, but tartaric acid is the strongest. Tartaric acid is a weak acid and about one out of every 900 tartaric acid molecules ionizes in water. The other 899 molecules remain unchanged. Malic acid is weaker than tartaric acid. Only one out of every 2500 malic acid molecules ionizes in water. The other 2499 malic acid molecules remain unchanged. Tartaric acid is about 2.7 times stronger than malic acid because tartaric acid produces 2.7 times more hydrogen ions than an equal quantity of malic acid. Smaller quantities of a stronger acid can produce as many hydrogen ions as larger quantities of a weaker acid. Tartaric acid is considered the principal wine acid. It is the strongest of the wine acids, and generally more tartaric acid is present in wine.

Wine can be thought of as a simple, water-alcohol solution, and acids in wine behave much the same as they do in any other water solution. The number of hydrogen ions in a wine depends upon the quantity of acid, the strength of the acids and the quantities of potassium, sodium and calcium present in the wine.

Kinds of Acids

The total quantity and the kinds of acids present produce the tart taste of dry table wine. Tartaric and malic are the major wine acids. These two acids are present when the grapes are picked, and they are carried over through the fermentation process into the finished wine. Wine also contains small quantities of lactic, citric, succinic, acetic and several other organic acids as shown in Table 4. Some of these acids do not exist in the grapes. They are produced in small quantities by microorganisms during the winemaking process.

Malic acid and citric acid can be metabolized easily by microorganisms in the wine. Tartaric acid and succinic acid are more biologically stable, and wine microbes seldom bother these two acids. Even so, under certain conditions, microorganisms can attack tartaric acid, and when this occurs, the wine is usually a catastrophic loss (see Chapter 15).

ACID TYPE	QUANTITY (grams/liter)
Tartaric	2 to7
Malic	0 to 5
Lactic	0.2 to 3
Succinic	0.5 to 1.5
Citric	0.1 to 0.7
Acetic	0.3 to 1

Table 4. Some common wine acids.

Tartaric Acid

Few fruits other than grapes contain significant amounts of tartaric acid. One half to two thirds of the acid content of ripe grapes is tartaric acid, and it is the strongest of the grape acids. Tartaric acid is responsible for much of the tart taste of wine, and it contributes to both the biological stability and the longevity of wine.

The amount of tartaric acid in grapes remains practically constant throughout the ripening period. However, the situation in wine is different. The quantity of tartaric acid slowly decreases in wine by small amounts. Both potassium and calcium combine readily with tartaric acid and form potassium bitartrate and calcium tartrate compounds. Then crystals of these two materials precipitate out of the wine during fermentation. These tartrate materials can continue to precipitate for a long time, and aged wine usually contains about two-thirds as much tartaric acid as the starting grapes because of tartrate precipitation. Unfortunately, these acid salts of potassium and calcium precipitate very slowly at normal cellar temperatures, and wine can contain excessive quantities of these materials even after many months of aging. Wineries use special wine treatments to speed up tartrate precipitation. Cooling the wine is the most commonly used procedure. Just cooling the wine to about 27 degrees causes excess potassium salts to precipitate out in a few days.

Tartaric acid is resistant to decomposition, and wine microbes seldom attack it. This is why winemakers add tartaric acid to grapes deficient in acidity rather than using a less stable acid such as malic or citric. Most winemakers prefer the titratable acid to be about 0.7 percent for white grapes, and about 0.8 percent is preferred for white juice. When the titratable acid content falls below these levels, winemakers often add tartaric acid to juice before starting fermentation.

Malic Acid

Malic acid is prevalent in many types of fruit. This acid is responsible for the tart taste of green apples. Several different types of wine bacteria metabolize malic acid so it is one of the more biologically fragile wine acids. The malic acid content of grapes decreases throughout the ripening process, and grapes are grown in hot climates often contain little malic acid by harvest time.

Grapes grown in cool regions often contain too much acid, and high acidity produces excessively tart wines. During alcoholic fermentation, some malic acid is metabolized, and the malic acid content of the wine decreases about 15 percent. Malolactic fermentation (ML) can further reduce wine acidity. When wine goes through malolactic fermentation, bacteria convert the malic acid into lactic acid. Lactic acid is milder than malic acid, and ML fermentation is a standard procedure used to reduce the acidity of wines made from grapes grown in cool regions.

When grapes are grown in warm areas like southern California, the winemaking situation is much different. In warm regions, the grapes are usually deficient in acid, and removing malic acid by means of ML fermentation may not be a good idea. Now the problem becomes more complicated for the winemaker. Malic acid is not biologically stable, and when malic acid is deliberately retained to improve the acid balance of the wine, special steps may be needed to prevent ML fermentation from occurring after the wine is bottled. The winemaker can use a sterile filter and remove all of the bacteria from the wine before bottling, or he can add small quantities of fumaric acid to the wine. Small additions of fumaric acid can inhibit ML fermentation.

Citric Acid

Only small amounts of citric acid are present in grapes. In sound grapes, only about 5 percent of the total acid is citric. Like malic acid, citric acid is easily converted into other materials by wine microorganisms. For example, citric acid can be fermented into lactic acid by wine microbes, and some types of lactic bacteria can ferment citric acid into acetic acid. Excessive amounts of acetic acid are never desirable in wine, so the conversion of citric acid into acetic acid fermentation can be a serious problem. This potential problem is why citric acid is seldom used to acidify grape must or juice before fermentation. Most winemakers consider the risk of producing excessive quantities of acetic acid too great.

The acetic acid risk is much smaller after wine has been clarified and stabilized, and winemakers often increase the acid content of finished white wines by adding small amounts of citric acid. Citric acid imparts a citric character that enhances the taste of many white and blush wines. However, citric acid is seldom used in red wine. The distinctive citric taste may not be appropriate for some red wines, and the risk of biological instability is greater in red wines.

Home winemaking shops sell a material called "acid blend." Acid blend contains tartaric, malic and citric acids and the three acids are in roughly equal proportions. Acid blend is often used in making fruit wines or wines made from grape concentrates. However, most winemakers will not add acid blend to grapes before fermentation because the citric acid in the acid blend might be converted into acetic acid.

Succinic Acid

Succinic acid is formed by yeast, and small quantities of this acid are always produced during the primary fermentation. The production of succinic acid stops when alcoholic fermentation is complete. The flavor of succinic acid is a complex mixture of sour, salty and bitter tastes, and succinic acid is responsible for the special taste characteristics all fermented beverages have in common. Once formed, succinic acid is very stable, and it is seldom affected by bacterial action.

Lactic Acid

Lactic acid is the principal acid found in milk. Grapes contain very little lactic acid. All wines contain some lactic acid, and some wines can contain significant quantities. Lactic acid in wine is formed in three different ways. (1) A small amount is formed from sugar by yeast during primary fermentation. (2) Large amounts of lactic acid are formed from malic acid by bacteria during ML fermentation. (3) Some lactic bacteria can produce both lactic and acetic acid from sugars glycerol and tartaric acid in the wine. "Lactic souring" is the term used when sugar is converted into lactic acid by bacteria. This type of souring is a form of gross wine spoilage. Lactic souring was a common winemaking problem before the use of sulfur dioxide became widespread, now it is seldom a problem.

Lactic acid can exist in either a right-hand or left-hand form. Lactic acid produced by yeast occurs in the left-hand form, and lactic acid produced by bacteria occurs in the right-hand form. The right-hand form of lactic acid can be distinguished from the left-hand form in the laboratory very easily, so winemakers have a sensitive way of monitoring bacterial activity in wine simply by measuring the two forms of lactic acid.

Acetic Acid

All of the acids discussed above are fixed acids. Fixed acids have low vapor pressures, and they do not evaporate easily. When wine is boiled, the fixed acids do not boil away. All of the fixed acids remain in the wine container. Fixed acids do not have significant odors.

Acetic acid is different from fixed acids. Acetic acid has a high vapor pressure, and it is a volatile acid. Acetic acid evaporates very easily and has a distinctive odor. When wine containing acetic acid is boiled, the acetic acid quickly boils away. The acetic acid disappears into the air much the same as water and alcohol.

Sound grapes contain very little acetic acid. Just like lactic acid, acetic acid in wine can be formed in several different ways. (1) The yeast forms small amounts of acetic acid during alcoholic fermentation. (2) Some acetic acid is always formed during ML fermentation, and bacteria fermenting citric acid in the wine produce much of this acetic acid. (3) In stuck fermentations, lactic bacteria often convert residual sugar into acetic acid. (4) Vinegar bacteria (*acetobacter*) convert ethyl alcohol in the wine into acetic acid, and in the presence of air, *acetobacter* can produce large quantities of acetic acid.

The conversion of ethyl alcohol into acetic acid by vinegar bacteria is different from the other fermentation mechanisms discussed here. Vinegar formation is an oxidation process, and large quantities of acetic acid cannot be produced unless the bacteria have access to large quantities of air. Wine is not converted into vinegar when air is excluded, and this is why novice winemakers are cautioned to keep their wine containers completely filled and tightly sealed.

Acid Salts

Acids in juice or wine occur in two forms. Some acid exists in a free form, and some acid combines with minerals to form acid salts. The acid salts of potassium, sodium and calcium are always prevalent in wine, and these acid salts are not very stable. Potassium and calcium tartrates can precipitate out of the wine after a long time. In particular, potassium bitartrate can precipitate after the wine is bottled unless the winemaker specifically removes some of this material. When the tartrate precipitates out of the wine, crystals are formed in the bottle. The potassium bitartrate crystals are harmless (cream of tarter), but the deposits can cause unsightly hazes in the wine. Sometimes, large crystals are formed in the bottle, and the consumer mistakes the tartrate crystals for "glass" particles. Producing wines with gross visual flaws is not good for business so commercial wineries avoid these public relation problems by "cold stabilizing" all their white and blush wines. The cold stabilization process removes the excess potassium bitartrate material from the wine.

SUMMARY

Grape sugars consist mostly of two monosaccharides, glucose and fructose, and these two simple sugars occur in about equal proportions. Simple sugar molecules can combine and form larger sugar molecules called disaccharides and polysaccharides. Both glucose and fructose can be readily fermented, but most disaccharides and polysaccharides must be split into their smaller, simple sugar components before they can be readily converted into alcohol. Many large sugar molecules can be hydrolyzed and broken into smaller molecules by enzymes, acids or heat.

When sucrose (table sugar) is added to wine, it often produces strange flavors because many weeks may be required before the wine acids can hydrolyze all of the sucrose into glucose and fructose. Even in a warm cellar, the strange flavors can persist for several weeks. However, when all of the sucrose has been hydrolyzed into glucose and fructose, the strange flavor completely disappears, and the wine has a normal taste.

Organic acids produce the tart taste in table wines. Winemakers working with grapes grown in cold climates often encourage malolactic fermentation to reduce the acid content of their wines. Winemakers working with grapes grown in warm climates often add tartaric acid to the juice to increase the acid content of the finished wine. In either case, the winemaker is striving for just the right amount of acid to achieve a balanced wine.

Sometimes winemakers prefer to retain as much malic acid as possible in the wine, so they deliberately discourage ML fermentation. However, wines are not biologically stable when malic acid is retained, and then the winemaker must take special precautions. Professional winemakers put wine containing malic acid through a sterile filter and remove the bacteria when the wine is bottled. Home winemakers prevent ML fermentation in the bottle by adding small amounts of fumaric acid.

Potassium bitartrate can precipitate out of wine very slowly, and unsightly bottle deposits are often formed when tartrates precipitate after the wine is bottled. Consequently, winemakers always use a cold stabilization procedure to remove excess tartrate materials from white and blush wines before these wines are bottled.

Chapter 6

pH
AND
SULFUR DIOXIDE

Winemakers are always concerned with titratable acid (TA) and pH because both parameters influence wine characteristics. As discussed in the previous chapter, titratable acid is primarily responsible for the tart taste of table wines, but pH has little relationship on the tart taste. Several important wine properties including color, oxidation, biological and chemical stability, etc are strongly affected by pH. Although pH depends on the total acid content, other factors like potassium content influence pH, and because of these other factors, pH is not directly related to titratable acid. Nevertheless, wine pH is a fundamental parameter. In addition, pH has a profound influence on the biological and chemical effectiveness of sulfur dioxide in wine.

WINE pH

Chemists use the pH scale to describe the number of hydrogen ions present in a solution. However, it is an upside-down, logarithmic scale, and because of the upside-down scale, a smaller pH value represents more hydrogen ions. For example, a wine with a pH value of 3.0 contains ten times more hydrogen ions than in a wine with a pH of 4.0. Consequently, the pH value of a solution becomes smaller as the acid content of the solution becomes larger. The upside-down scale often confuses novice winemakers. Chemists measure pH several different ways, but a pH meter with three-digit accuracy is the most practical way of measuring wine pH.

Factors Affecting Wine pH

pH is a measure of the number of hydrogen ions present in a solution. Consequently, the pH value reflects the quantity of acids present, the strength of the acids and the effects of minerals and other materials in the wine. Many different factors are involved, but wine pH depends upon three major factors: (1) the total amounts of acid present, (2) the ratio of malic acid to tartaric acid, and (3) the quantity of potassium present. These three factors are discussed below.

Wine acids produce hydrogen ions, and pH is a measure of the number of hydrogen ions present in a solution. Overall, wine pH will be lower when the titratable acid is higher. However, high titratable acid does not always produce low pH values. The presence of potassium and several other factors alter wine pH. Malic acid is weaker than tartaric acid, so wines unusually high in malic acid can have a high TA and a high pH value. High acid, high pH wines require special treatment using an ion exchange technique. However, ion exchange equipment is very expensive, so most small producers have difficulties handling high acid, high pH wines.

Tartaric acid produces almost three times more hydrogen ions than malic acid, so gram for gram, tartaric acid produces a much lower pH than malic acid. Therefore, when the total acid content is fixed, pH depends upon the relative amounts of tartaric and malic acid in the juice or wine.

For example, a wine containing an unusually large amount of malic acid might have a titratable acid of 0.65 percent and a pH of 3.9. A second wine containing more tartaric and less malic acid might have a titratable acid of 0.65 percent, but the pH might be 3.4. Wine pH increases as the relative amount of malic acid increases.

Potassium (K) is essential for vine growth and fruit production. Potassium is a mineral, and vines obtain potassium through their roots. The roots remove potassium from the soil, and the potassium is distributed to all parts of the vine. Early in the season, when the growth rate is high, much of the potassium accumulates in the leaves. Then the potassium ions are moved from the leaves into the berries later in the season when the fruit starts to ripen.

Potassium ions carry a positive electrical charge just like hydrogen ions. Under certain conditions, potassium ions can change places with the hydrogen ions at the extreme ends of the tartaric acid molecules. These are the hydrogens that ionize easily in water solutions, and these are the hydrogen's shown in bold type in Figure 2. Potassium bitartrate is formed when potassium is exchanged for hydrogen, and the hydrogen then becomes a free ion in the solution. Tartaric acid has two hydrogen atoms that can ionize. One of the hydrogen atoms ionizes relatively easily, so tartaric acid is the strongest of the primary wine acids. On the other hand, potassium bitartrate only has one hydrogen atom that can ionize and it does not ionize so easily. Therefore, potassium bitartrate produces fewer hydrogen ions than tartaric acid.

Grape juice contains from one-half to three grams of potassium per liter. Grape skins contain about nine grams of potassium per liter, so grape skins contain four or five times more potassium than the juice. When grape juice and skins remain in contact for extended periods, potassium leaches out of the skins into the juice. The additional potassium from the skins reacts with tartaric acid in the juice and forms potassium bitartrate. When alcohol accumulates during fermentation, the juice cannot hold all the additional potassium bitartrate, and some tartrate precipitates out of the liquid. Red wines usually have a lower titratable acid content and higher pH values than white or blush wines because of the extended skin contact time.

Significant amounts of potassium bitartrate can also precipitate as wine bulk ages. When potassium bitartrate precipitates, the titratable acid of wine decreases, but wine pH may increase, decrease or stay the same. If the starting pH of the wine is 3.6 or less, the pH will become smaller as the bitartrate precipitates out of the wine. If the starting pH is 3.8 or greater, the pH will become larger as the bitartrate precipitates. Little change will occur when the starting pH is between 3.6 and 3.8.

Advantages of Low pH

Over the range of 3.0 to 4.0, pH has little influence on wine taste. Titratable acid is primary factor determining the tart taste of table wines. However, pH strongly influences other important wine characteristics. The pH values range from about 2.9 to 4.2 for most wines, and this may seem like a small range. However, the pH scale is logarithmic, and a pH change of 0.3 represents a change in hydrogen ion content of about 2 times.

The chemical stability and the biological stability are both very sensitive to the pH value of the wine, and most winemakers prefer to have wine pH values between 3.0 and 3.6. Chemical and biological stability are improved so much at these lower pH values, most winemakers believe pH is the more important wine acidity parameter. Wine yeast is quite tolerant of pH. Yeast growth does not change significantly over the normal range of wine pH values, so fermentation characteristics are little affected by pH. But, wine bacteria do not like low pH values, and wine pH strongly influences both bacterial growth rate and bacterial fermentation characteristics. This is why malolactic fermentation is not likely to occur in wines with pH values lower than 3.3. Bacterial activity is reduced in low pH wines, and many of the bacterial problems discussed in Chapter 15 become insignificant.

A variety of chemical reactions can occur in wine and the number of hydrogen ions present has an affect on many of these reactions. For example, wine pH has a direct influence on the hot stability of wine. Under warm storage conditions, protein precipitates out of white and blush wine, and serious haze and sediment problems occur when protein precipitates after the wine is bottled. Consequently, white and blush wines are always treated with bentonite to remove excess protein. Here, pH is an important consideration because bentonite is more effective in removing protein when wine pH is low. As the wine pH increases, bentonite becomes less and less effective, and more bentonite must be used to remove the protein. Excessive amounts of bentonite can strip wines of desirable aromas and flavors, so adding more bentonite is not desirable.

Sauvignon Blanc grapes often contain large amounts of protein, and Sauvignon Blanc wines with high pH values can be difficult to stabilize completely. Sometimes little varietal aromas remain in these wines when enough bentonite is used to remove the excess protein. However, wines with low pH values seldom have this problem.

Wines with low pH values generally have better visual qualities. At low pH values, red wines show more color, and the color is better. Overall color intensity increases, and the red color becomes more purple at low pH values. Both red and white wines have better color stability when the pH is low. Some important polymeric reactions are accelerated at low pH values, and much of the unstable color pigments precipitate out of the wine early in the winemaking process. After the unstable pigments are gone, wine colors are more stable. Table 5 shows how several important wine characteristics are affected by pH.

WINE CHARACTERISTIC	LOW pH (3.0-3.4)	HIGH pH (3.6-4.0)
Oxidation	Less	More
Amount of Color	More	Less
Kind of Color	Ruby	More Brown
Yeast Fermentation	Unaffected	Unaffected
Protein Stability	More stable	Less stable
Bacterial Growth	Less	More
Bacterial Fermentation	Less	More
SO_2 Activity	More	Less

Table 5. Wines with low pH values have many advantages.

SULFUR DIOXIDE

Sulfur dioxide is a colorless gas formed from one sulfur and two oxygen atoms (SO_2). It is foul smelling and noxious. The distinctive smell left by a burnt match comes from sulfur in the match reacting with oxygen in the air and producing sulfur dioxide. Sulfur dioxide gas reacts with water and forms sulfurous acid. Then sulfurous acid can be further oxidized into highly corrosive sulfuric acid. Even so, practically all winemakers add small quantities of sulfur dioxide to their wines.

Benefits

Sulfur dioxide has several desirable attributes when it is added to wine in very small quantities. Natural enzymes in the grapes that cause browning are deactivated by sulfur dioxide. Sulfur dioxide helps protect juice and wine from excessive oxidation. Sulfur dioxide can reduce the oxidized smell of old wine by reacting with acetaldehyde. Sulfur dioxide is very useful in controlling the growth of bacteria and yeast. Man has been adding sulfur dioxide to wine for more than a thousand years. A large body of knowledge exists on the use of sulfur dioxide in wine as well as in many other food products. So, the benefits of using sulfur dioxide in wine are indisputable.

Deactivates Enzymes

Grape juice is in contact with the surrounding air during the crushing and pressing operations and the juice reacts with oxygen in the air and becomes oxidized. Oxidation causes the juice to darken, and the juice gradually turns brown. Browning is greatly accelerated by the presence of naturally occurring enzymes in the grapes. *Polyphenoloxidase* is the name of this enzyme, and it is the same enzyme that causes freshly cut apples to turn an unpleasant brown color. Some grape varieties brown easily, while other grape varieties have less browning tendencies. The differences in susceptibility can be accounted for by the amount of *Polyphenoloxidase* enzyme that occurs in different grape varieties. Enzymes responsible for browning are very sensitive to free sulfur dioxide, and the enzymes are deactivated when sulfur dioxide is added to the juice. The quantity of sulfur dioxide needed is very small, so sulfur dioxide is a powerful tool for reducing enzymatic browning in white and blush wines.

Inhibits Oxidation

The great French scientist, Pasteur, observed " . . . oxygen is the ardent enemy of wine." Air is always present, and oxygen in the air is always ready to react with unprotected juice or wine. Grape juice and wine contain a variety of materials, and many of these substances are adversely affected by oxidation. Unpleasant, bitter, off-odors and off-tastes can be produced when these materials oxidize. Of course, wine components are subjected to small amounts of oxygen throughout the lengthy winemaking process. Many of the desirable changes that take place during bulk aging are oxidation reactions, so oxidation does not necessarily produce adverse changes when small amounts of oxygen are introduced very slowly. However, wine quality is reduced quickly when oxidation becomes excessive.

When small quantities of sulfur dioxide are added to grapes or wine, roughly half the amount added quickly combines with other wine constituents. The uncombined half remains in the wine in a free-state. Only the uncombined or free sulfur dioxide is effective. In the free-state, the sulfur dioxide reacts quickly and combines with any oxygen before any of the other wine constituents become oxidized. Sulfur dioxide is one of the most effective methods available for controlling oxidation, and most winemakers add enough sulfur dioxide when the grapes are crushed to give 30 to 50 milligrams of SO_2 per liter. The recommended amount of sulfite powder is shown in Table 6. Twice as much sulfur dioxide is sometimes used when the grapes are very warm, or when they contain rot. This initial dose of SO_2 deactivates the browning enzymes and helps prevent oxidation during crushing and pressing. Considerable oxidation takes place when wine is bottled and oxidation at this time can be very detrimental. Newly bottled wine will be short lived unless adequate sulfur dioxide is present, so winemakers raise the free sulfur dioxide content of their wines to about 30 milligrams per liter just before bottling.

Pounds of Fruit	**Sulfite (grams)**
100	3
200	6
300	9
400	11
500	14
600	17
700	20
800	23
900	26
1000	29
1500	43
2000	58

Table 6. Recommended initial sulfite additions.

Removes Oxidized Smell

Acetaldehyde is the material responsible for the characteristic nut like odor of sherry wines and although the acetaldehyde smell is desirable in sherry, this distinctive odor is not desirable in table wines. Acetaldehyde is produced when wine oxidizes and acetaldehyde can be thought of as oxidized ethyl alcohol. All wines contain some acetaldehyde but too much acetaldehyde is one of the more common defects in homemade table wines.

Acetaldehyde is an intermediate product when sugar is converted into alcohol, and practically all of the free sulfur dioxide disappears during fermentation by combining with acetaldehyde. Additional sulfur dioxide should be added when fermentation is finished since very little free sulfur dioxide will remain in the wine. The recommended practice is to add enough sulfur dioxide to combine with any residual acetaldehyde and leave 20 to 30 milligrams of SO_2 per liter of wine. Most winemakers routinely add about 50 milligrams per liter of sulfur dioxide when the sugar fermentation and the malolactic fermentation are complete. Then the wines are tested every few weeks and about 30 milligrams per liter of free SO_2 is maintained in the wines throughout the lengthy clarification, stabilization and aging period.

Inhibits Bacteria and Yeast

The initial dose of 30 to 50 milligrams per liter of SO_2 added at the crusher also provides the winemaker an effective way of controlling fermentation. The activity of natural wild yeast is greatly diminished when the yeast cells are exposed to small amounts of SO_2. On the other hand, commercial wine yeast is treated in a special way to give the yeast cells considerable tolerance to sulfur dioxide. So, when small quantities of sulfur dioxide and commercial wine yeast are used to start fermentation, the native yeast cells are deactivated for several hours but the inoculated yeast cells can multiply quickly. Then, the commercial yeast can completely dominate the wild yeast throughout the fermentation period.

Small quantities of sulfur dioxide can eliminate many undesirable bacteria. When used at reasonable concentrations, SO_2 helps control several types of bacteria, and protecting against undesirable bacteria is very important in all wineries. Sulfur dioxide can also inhibit malolactic bacterial activity, so winemakers use SO_2 to help control malolactic fermentation. Sulfur dioxide can exist in wine as free sulfur dioxide or as fixed (chemically combined) sulfur dioxide. The effectiveness of sulfur dioxide in controlling wine microbes depends primarily on the amount of sulfur dioxide that exists in the free form.

Many years ago, Moreau and Vinet studied the antiseptic properties of sulfur dioxide in wine, and they concluded that small quantities of free sulfur dioxide could provide significant wine protection. Fornachon also studied the characteristics of both bound and free SO_2 in Australian wines, and he showed that several types of wine bacteria, including *Lactobacillus*, could be controlled by small quantities of free sulfur dioxide. Over the years, several other sulfur dioxide studies have clearly shown that from 30 to 100 milligrams per liter (30 – 100 ppm) of free sulfur dioxide can provide good microbial stability in both dry and sweet wines.

pH AND SULFUR DIOXIDE

When sulfur dioxide is added to wine, some sulfur dioxide combines with other materials in the wine and becomes fixed, the remainder of the sulfur dioxide remains in a free form. The free sulfur dioxide exists in three different forms, as molecular sulfur dioxide, in the bisulfite form and in the doubly ionized sulfite form. The fraction of free sulfur dioxide that exists in the molecular form is strongly dependent upon the pH of the wine.

The molecular sulfur dioxide is the biologically active form, so winemakers are always interested in how much of the free SO_2 exists as SO_2. The amount of free sulfur dioxide in a wine can be easily and quickly measured. On the other hand, the fraction of free sulfur dioxide that exists in the molecular form is difficult to measure. Fortunately for winemakers, the amount of molecular sulfur dioxide can be easily calculated when both the free sulfur dioxide content and the pH of the wine are known.

Amount of Free SO_2 Needed

The free sulfur dioxide needed to protect wine depends upon wine pH as shown in Table 7. The free sulfur dioxide is given in milligrams per liter (mg/l). For example, Table 7 shows that 32 milligrams of free sulfur dioxide per liter of wine is needed to protect a wine having a pH of 3.4. These data clearly show the amount of free sulfur dioxide needed in a wine is strongly dependent upon wine pH. These data also show that acceptably small quantities of free sulfur dioxide will provide good microbial stability when wine pH is less than about 3.6. But, when the pH exceeds 3.9 or so, significantly large quantities of free sulfur dioxide are required. The table also indicates that at very high values of wine pH, prohibitively large quantities of free sulfur dioxide are needed to provide adequate wine protection.

Wine pH	Free SO_2
3.0	13 mg/l
3.1	16
3.2	21
3.3	26
3.4	32
3.5	40
3.6	50
3.7	63
3.8	79
3.9	99
4.0	125

Table 7. Free SO_2 needed.

SUMMARY

Titratable acid is a measure of the total quantity of all the acids in a wine, and pH is a measure of the number of hydrogen ions present in a wine. Several factors influence wine pH. Wines containing little acid and lots of potassium have high pH values. More tartaric acid, less malic acid, less potassium and greater titratable acid result in a smaller pH.

Low wine pH values inhibit wine bacteria, but wine yeast is not affected. Sugar fermentation progresses more evenly and malolactic fermentation is easier to control when wine has a low pH value. Bentonite is more effective in removing excess protein from wines with low pH values. In addition, red wines with low pH values have more and better color, and white wines do not brown as easily.

The situation is much different when wine pH values are high. Bacteria multiply rapidly in high pH wines, and unwanted bacterial fermentations become more troublesome. High pH wines are less biologically stable, and they have poorer chemical stability. Red and white wines have poorer color when the pH is high. Wines with high pH values always require more attention and greater care than wines with low pH values.

The molecular form of sulfur dioxide is the form most effective against wine microbes. When wine pH is low, very small additions of free sulfur dioxide give winemakers an effective tool for managing wine microbes. In wines with high pH values, excessive quantities of sulfur dioxide are needed to control microbes effectively.

Controlling microorganisms is very important, so winemakers maintain 20 to 30 milligrams per liter of free sulfur dioxide in their wines from the completion of the fermentations until the wine is bottled. However, such small quantities of free sulfur dioxide will not be adequate unless wine pH is low.

Chapter 7

SULFUR DIOXIDE CHEMISTRY

When elemental sulfur is burned, the sulfur combines with oxygen from the air and sulfur dioxide is produced. Chemists use a kind of shorthand notation to describe chemical reactions, and they might write an equation describing the production of sulfur dioxide as:

$$S\,(s) \quad + \quad O_2\,(g) \quad \text{========>} \quad SO_2\,(g) \qquad [1]$$

Here, the “S” represents an atom of sulfur, and the “(s)” indicates sulfur is a solid material. The “O” represents oxygen, the “sub 2” signifies two oxygen atoms and the “(g)” indicates that oxygen is a gas. The “==>” is a shorthand notation for “produces.” The “SO_2” symbol on the right shows one molecule of a material called “sulfur dioxide” is formed, and the “(g)” indicates that sulfur dioxide is a gas. So, the above equation indicates that when sulfur burns, one atom of solid sulfur combines with 2 atoms of oxygen gas and a new gas called sulfur dioxide is formed.

When sulfur dioxide is added to wine, some of the gaseous SO_2 reacts with water in the wine and forms a hydrogen ion and a bisulfite ion. Then some of the bisulfite ionizes and produces a second hydrogen ion and a sulfite ion. These sulfur dioxide reactions can be written in the following way:

$$SO_2 \quad + \quad H_2O \quad \text{<==========>} \quad H^{1+} \quad + \quad HSO_3^{\;1-} \qquad [2]$$

$$HSO_3^{\;1-} \quad \text{<==========>} \quad H^{1+} \quad + \quad SO_3^{\;2-} \qquad [3]$$

The first equation above shows that sulfur dioxide gas (SO_2) plus water (H_2O) produces an ionized hydrogen atom (H^{1+}) and bisulfite ($HSO_3^{\;1-}$). The “1+” following the H indicates that the hydrogen is ionized (it lost its only electron) and carries a positive electrical charge. The “1-” following the “HSO_3” shows the bisulfite is ionized (it gained an electron) and carries a negative electrical charge. The second equation above shows that bisulfite can ionize and produce a second ionized hydrogen atom and a sulfite ion. Here, the “2-” following the “SO_3” shows the sulfite is doubly ionized and carries two negative electrical charges.

One sulfur atom, three oxygen atoms and two hydrogen atoms are shown on each side of the double arrow symbol in the first equation. In the second equation, one sulfur atom, three oxygen atoms and one hydrogen atom are shown on each side of the double arrow symbol. This is typical of chemical reactions. The equations show how the atoms rearrange, but note that **no materials are gained or lost**.

The arrowheads point in both directions in these equations, and chemists use double-headed arrow symbols when reactions can occur in either direction. Reading from left to right, the first equation says…."Sulfur dioxide plus water produces a hydrogen ion plus bisulfite." However, the equation can also be read from right to left. Then the equation says…."Bisulfite plus two ionized hydrogen atoms produce water plus sulfur dioxide."

The two equations above are often written as a single equation.

$$SO_2 + H_2O \Longleftrightarrow H^{1+} + HSO_3^{1-} \Longleftrightarrow 2H^{1+} + SO_3^{2-} \quad [4]$$

This equation indicates that free sulfur dioxide in water exists in three forms. (1) Some of the free sulfur dioxide exists simply as dissolved gas (SO_2) and this form is called **molecular** sulfur dioxide. (2) Some of the free sulfur dioxide exists in the singly ionized **bisulfite** form (HSO_3^{1-}) and (3) some of the free sulfur dioxide exists in the doubly ionized **sulfite** form (SO_3^{2-}).

The two double arrows also show how chemical equilibrium is maintained. If a few SO_3^{2-} ions were to disappear (for whatever reason), the equation shows that a spontaneous change would take place from left to right. A few HSO_3^{1-} ions would spontaneously convert into SO_3^{2-} ions, and a few SO_2 molecules would spontaneously convert into HSO_3^{1-} ions and the **ratio** of the SO_2, HSO_3^{1-} and SO_3^{2-} would then be restored. Since the arrows point in both directions, this equation also shows the reaction can also take place from right to left. In this case, if some SO_2 disappeared, then some of the HSO_3^{1-} ions would spontaneously convert into SO_2 and some SO_3^{2-} ions would spontaneously convert into HSO_3^{1-} ions. Equilibrium would be maintained and the ratio of the SO_2, HSO_3^{1-} and SO_3^{2-} would again be restored. (Please note that when sulfite (SO_3^{2-}) disappears, protons (H^{1+}) are produced by this equilibrium reaction.)

FREE SULFUR DIOXIDE

Please note that the free SO_2 in wine is divided into molecular sulfur dioxide, bisulfite (HSO_3^{1-}) and sulfite (SO_3^{2-}). The way free sulfur dioxide is divided between the three forms depends on wine pH. The distribution does not depend on the amount of free sulfur dioxide in the wine. For normal wine pH values (3.0 to 4.0), roughly 1/2 to 6 percent of the free sulfur dioxide exists in the molecular form, 94 to 99 percent of the free sulfur dioxide exists in the bisulfite form and only 0.01 to 0.12 percent exists in the sulfite form.

Table 8 shows how free sulfur dioxide is distributed with wine pH. Please note from the data in Table 8 that if a wine had a pH of 3.1 and contained 12 mg/l of free sulfur dioxide, then the wine would contain 0.59 mg/l of **molecular** SO_2 (0.049 X 12), 11.4 mg/l of **bisulfite** (0.951 X 12) and 0.0018 mg/l of **sulfite** (0.00015 X 12).

Wine pH	% as Molecular	% as Bisulfite	% as Sulfite
3.0	6.1	93.9	0.012
3.1	4.9	95.1	0.015
3.2	3.9	96.1	0.019
3.3	3.1	96.8	0.024
3.4	2.5	97.5	0.030
3.5	2.0	98.0	0.038
3.6	1.6	98.4	0.048
3.7	1.3	98.7	0.061
3.8	1.0	98.9	0.077
3.9	0.8	99.1	0.097
4.0	0.6	99.2	0.122

Table 8. Wine pH determines how the free sulfur dioxide is distributed.

The free sulfur dioxide content of wine does not remain constant. Molecular SO_2 is a gas and some sulfur dioxide gas escapes into the atmosphere each time a wine storage container is opened. Some bisulfate slowly becomes bound with other wine materials and no longer exists as free sulfur dioxide. Small amounts of sulfite are oxidized into sulfate (see below). So in general, the free sulfur dioxide content of wine slowly decreases. But, it can disappear from wine more rapidly in hot weather or when wine is handled (racked, filtered, bottled, etc.). Consequently, most commercial wineries measure the free sulfur dioxide content of their wines every few weeks and additional sulfur dioxide is added as needed to maintain the molecular SO_2 level at about 0.8 milligrams per liter.

Molecular SO_2

The antiseptic properties of sulfur dioxide in wine depend on the form of the sulfur dioxide and many studies have shown that 0.5 to 1.2 milligrams of molecular sulfur dioxide per liter of wine can provide good microbial stability. Under normal cellar conditions, most winemakers feel that 0.5 to 0.8 milligrams of molecular sulfur dioxide per liter of wine provides adequate protection for dry table wines. Consequently, most commercial wineries maintain at least 0.8 milligrams per liter of molecular sulfur dioxide in their white and blush table wines and 0.5 milligrams per liter of molecular sulfur dioxide in their red table wines.

Most winemakers add an initial dose of 30 to 50 milligrams of sulfur dioxide per liter when grapes are crushed to help control native yeast. Contrary to much home winemaking literature, sulfur dioxide added at crush does not kill native yeast, but it does greatly diminish their activity for several hours. Commercial wine yeast has considerable tolerance to sulfur dioxide and remains active in the presence of normal amounts of sulfur dioxide. When commercial yeast is added to juice containing reasonable amounts of SO_2**,** a large population of the added yeast quickly develops while the native yeast is inactive. The commercial yeast then dominates the fermentation, and this is why all wine yeast manufacturers recommend adding yeast **immediately** after sulfur dioxide additions are made to juice or crushed grapes.

Since molecular sulfur dioxide is the effective antiseptic form, winemakers are always interested in how much molecular sulfur dioxide exists in their wines. Unfortunately, the molecular form of sulfur dioxide is difficult to measure. But, the free sulfur dioxide content and the pH of the wine can be measured easily and molecular sulfur dioxide can be easily calculated from the free sulfur dioxide value and the pH value.

The amount of free sulfur dioxide needed to produce 0.5 and 0.8 milligrams of molecular SO_2 per liter for different values of wine pH is shown in Table 9. The table shows that acceptably small quantities of free sulfur dioxide can produce enough molecular sulfur dioxide to provide good microbial stability when wine pH is less than about 3.8. For example, the table shows that when wine has a pH of 3.4, then 32 mg/l of free sulfur dioxide produces 0.8 mg/l of molecular SO_2. Note that very large values of free SO_2 are required to produce 0.8 mg/l of molecular SO_2 when wine pH exceeds 3.8 or 3.9.

Wine pH	Free SO_2 needed for 0.5 mg/l molecular SO_2	Free SO_2 needed for 0.8 mg/l molecular SO_2
3.0	8 (mg/l)	13 (mg/l)
3.1	10	16
3.2	13	21
3.3	16	26
3.4	20	32
3.5	25	40
3.6	31	50
3.7	39	63
3.8	49	79
3.9	62	99
4.0	78	125

Table 9. Wine pH determines how much free SO_2 is needed to produce 0.5 mg/l and 0.8 mg/l of molecular SO_2.

The unpleasant "burnt match" odor sometimes detected in wine depends primarily on the amount of molecular sulfur dioxide present, rather than on the amount of free sulfur dioxide. Wine with a pH of 3.1 and containing 30 mg/l of free sulfur dioxide might have a noticeable sulfur smell due to the large amount of **molecular** sulfur dioxide. On the other hand, a wine with a pH of 4.0 and containing 120 mg/l of free sulfur dioxide might have little or no perceptible odor. (Even so, not many winemakers would bottle wines containing 120 mg/l of free sulfur dioxide).

Bisulfite

Most of the free sulfur dioxide in wine is in the bisulfite form. Bisulfite contributes little to the antiseptic or the antioxidant properties of sulfur dioxide, but bisulfite is always of interest to winemakers. Alcohol is produced from sugar by a multi-step process and a material called Acetaldehyde is produced in the next to last step of the fermentation process. Acetaldehyde is also produced when alcohol in wine oxidizes (acetaldehyde can be thought of as oxidized alcohol). Acetaldehyde is a volatile liquid and has a peculiar nut-like odor. Sherry wines contain acetaldehyde, and the acetaldehyde gives sherry wines their distinctive nut-like odor. Although desirable in sherry, this acetaldehyde odor is considered a fault in table wines and excessive oxidation, with the accompanying sherry smell, is the most common fault found in homemade table wines. Bisulfite combines readily with acetaldehyde, and unless the wine is badly oxidized, much of the nut-like odor is eliminated. This is why small quantities of sulfur dioxide added to old, oxidized wines often makes the wine smell and taste fresher.

Bisulfite also combines with phenols, pigments, sugars and other wine materials. However, the bonding between bisulfite and these other wine materials is relatively weak. These bonds can be easily broken, and then some of the bound bisulfite can then return to the free bisulfite form. Part of the weakly bound sulfur dioxide makes up a reservoir or pool, and under certain conditions this reservoir can supply some free sulfur dioxide back into the wine.

Normal levels of bisulfite only have a slight narcotic affect on yeast. However, some of the lactic bacteria are sensitive to bisulfite and more than about 50 mg/l of free sulfur dioxide can impede malolactic fermentation. Bisulfite has no smell, but excessive amounts of bisulfite may produce a "soapy" or "metallic" taste in wine.

Sulfite

At normal pH values, only a tiny fraction of the free sulfur dioxide is in the sulfite form. But, sulfite is important because the sulfite form of free sulfur dioxide provides the anti-oxidant properties. Theoretically, sulfite can react directly with free oxygen in wine, but most oxygen in wine is removed by a two step process involving hydrogen peroxide. In either case, sulfate (sulfuric acid) is produced and the oxygen in the wine is reduced. Please note that the quantities of sulfuric acid in wine that are produced by oxygen removal are very small.

$$SO_3^{2-} \quad + \quad 1/2\ O_2 \quad ========> \quad SO_4^{2-} \qquad [5]$$

This equation shows that ....sulfite can react with oxygen (1/2 O_2) and produce sulfate (SO_4^{2-}). The two step reaction is not quite as simple. First, oxygen in the wine reacts with a phenolic compound in the wine, and the oxygen is converted into hydrogen peroxide. Then, when free sulfur dioxide is present, the hydrogen peroxide reacts with the sulfite. Oxygen is removed from the wine and sulfate and water are produced.

$$SO_3^{2-} \quad + \quad H_2O_2 \quad =========> \quad SO_4^{2-} \quad + \quad H_2O \qquad [6]$$

This equation shows how sulfite (SO_3^{2-}) reacts with hydrogen peroxide (H_2O_2) producing sulfate (SO_4^{2-}) and water (H_2O). The conversion of sulfite to sulfate is essentially nonreversible, so free SO_2 is lost from wine when oxygen is removed.

Please note that equation 4 shows how protons are produced as sulfite disappears. When wine oxidizes in the presence of sulfur dioxide, the production of protons (as sulfite disappears) causes the pH to decrease (and the titratable acidity to increase). This effect is small but it can be significant in high pH wines. A reduction of 0.1 or so in pH is often observed when high pH wines are aged in oak barrels for long periods of time.

BOUND SULFUR DIOXIDE

When sulfur dioxide is added to wine, part of the added sulfur dioxide combines with other materials in the wine. The combined sulfur dioxide is chemically **bound** to these wine materials so it no longer exists in the wine as free sulfur dioxide.   So, only part the added sulfur dioxide remains as free sulfur dioxide, and the **free** sulfur dioxide is the part that can ionize in the water and behave as the equations above predict. Wine materials that bind with sulfur dioxide fall into two general classes. Some materials like acetaldehyde develop fairly strong bonds with SO_2 and under normal wine conditions the sulfur dioxide molecules bound to acetaldehyde becomes more or less permanently attached. Other wine materials, such as pigments, sugar, etc., bond more weakly with SO_2. These bonds can be broken more easily and then under certain conditions, some of the weakly bound sulfur dioxide can be converted back into free sulfur dioxide.

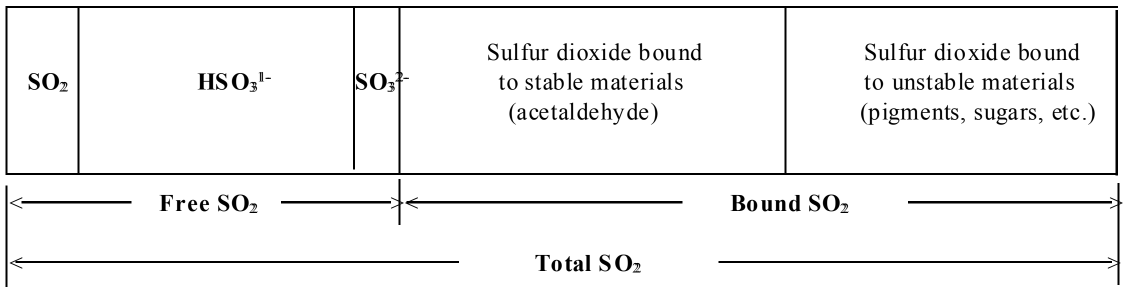
When small additions of sulfur dioxide are added to young wines that contain small amounts of sulfur dioxide about half the added sulfur dioxide quickly becomes bound and is no longer available as free sulfur dioxide. On the other hand, when sulfur dioxide is added to mature wines containing relatively large amounts of sulfur dioxide, very little of the added sulfur dioxide becomes bound. For example, if 40 mg/l of sulfur dioxide is added to a new wine containing little sulfur dioxide, roughly 20 milligrams of the added sulfur dioxide will become bound sulfur dioxide and about 20 milligrams of the added sulfur dioxide will remain as free sulfur dioxide. On the other hand, if 40 mg/l of sulfur dioxide is added to a mature win containing considerable sulfur dioxide, then 30 to 35 mg/l of the added sulfur dioxide will remain in the wine as free sulfur dioxide. The way free SO_2 is converted into bound SO_2 often confuses novice winemakers.

TOTAL SULFUR DIOXIDE

Winemakers use the term **total** sulfur dioxide when referring to the sum of both the free and bound sulfur dioxide in wine.   Both total and free sulfur dioxide content can be easily measured, and the bound sulfur dioxide can be calculated from the measured values. Sulfur dioxide in the free form can react with oxygen and other materials in wine. But, sulfur dioxide in the bound state is no longer available to react with oxygen or other wine materials, so some winemakers feel bound and total sulfur dioxide is not very important.

The relationship between molecular sulfur dioxide, bisulfite, and sulfite, and free, bound and total sulfur dioxide is shown below.   Some of the sulfur dioxide in wine is always bound to acetaldehyde, pigments, sugars, and other materials in the wine. The bound sulfur dioxide is more or less inactive so it is of little interest to the winemaker.

The remaining sulfur dioxide in a wine is free sulfur dioxide, and the free sulfur dioxide content of a wine is always of interest to winemakers because free sulfur dioxide is the active form of sulfur dioxide. So, home winemakers seldom bother to measure total sulfur dioxide unless a problem is encountered in their wine. This is not the case with commercial wineries however. Federal regulations limit the total sulfur dioxide content of commercial wines, so wineries always measure and track the total sulfur dioxide as well as the free SO_2 in their wines. In addition to federal regulations, commercial winemakers track total SO_2 because large amounts of total sulfur dioxide in a wine may indicate excessive microbial activity, excessive wine oxidation, poor storage conditions, etc.



Sulfur dioxide exists in several different forms.

SUMMARY

Sulfur dioxide exists as both free sulfur dioxide and bound sulfur dioxide in wine. Free sulfur dioxide is the active form, and this is the form that protects wine against microbes, oxidation, etc. Bound sulfur dioxide is chemically bonded to other wine materials and this form plays a more or less passive role in winemaking. The sum of the free and bound sulfur dioxide is called total sulfur dioxide.

Free sulfur dioxide exists as molecular SO_2, bisulfite and sulfite, and wine pH determines how free sulfur dioxide is distributed between these three forms. Molecular SO_2 is the form effective against wine microbes, so winemakers try to maintain 0.8 mg/l of molecular SO_2 in their wines to foster bacterial stability. When wine pH is low, small amounts of free sulfur dioxide can be effective in controlling wine microbes. But, even excessive amounts of free sulfur dioxide may not produce enough molecular sulfur SO_2 to effectively control microbes in wines with high pH values. The molecular sulfur dioxide content produces the unpleasant “burnt match" odor in wine. Bisulfite binds with acetaldehyde, pigments, sugars and several other materials in wine. Some of the oxidized odor is reduced when bisulfite binds with acetaldehyde. Some lactic bacteria are also sensitive to bisulfite, so large amounts of free sulfur dioxide can curtail malolactic fermentation. The bisulfite form has no odor. The sulfite form of free sulfur dioxide deactivates the enzymes in grape juice that cause browning. Sulfite also scavenges oxygen from wine. Sulfite has no odor.

Chapter 8

OXYGEN UPTAKE

When wine is exposed to excessive amounts of air, some of the alcohol and other materials in the wine become oxidized. The oxidized wine takes on sherry-like characteristics and the color of the wine darkens. Although prized in sherry, these oxidized smells and flavors are considered major flaws in table wines. Too much oxygen depreciates table wine quality and much wine is spoiled each year by oxidation. Consequently, winemakers must continually guard against excessive oxygen pickup from the time the grapes are crush until the wine is bottled.

DISSOLVED OXYGEN IN WINE

Gases can dissolve in liquids. A chemical reaction is not involver. The gas molecules simply occupy space between the liquid molecules. Liquids become saturated with gas when all of the space is gone, and when a liquid becomes saturated, no more gas can dissolve in the liquid. Air contains about 21 percent oxygen, and when wine is exposed to air, some of the oxygen in the air dissolves in the wine. The quantity of gas dissolved depends on the partial pressure of the gas and the temperature of the liquid. Wine becomes saturated with oxygen quickly when large surface areas of wine are exposed to air. **At room temperature, saturated wine contains about 7 milligrams of oxygen per liter.**

Dissolved oxygen molecules diffuse through wine until other wine molecules are encountered. Some of the wine molecules encountered chemically react with the oxygen, but most wine materials do not. When an oxygen molecule reacts with a wine molecule, a new oxygen containing compound is formed, and a molecule of dissolved oxygen is removed from the wine. But, most wine oxidation reactions occur very slowly and from several days to several weeks may be required before all of the dissolved oxygen in a saturated wine is consumed. So, oxygen uptake in a wine can occur quickly, but under normal winemaking conditions, dissolved oxygen disappears slowly.

Some oxygen always becomes dissolved in wine during normal cellar operations like racking, filtering, bottling, etc. and when handled poorly, wine can become saturated with oxygen. Much more oxygen can dissolve in cold wine than in room temperature wine, so extra care is always needed when handling wines during cold-stabilization operations.

Alcohol Oxidation

Alcohol is produced from sugar by a multi step process. Several enzymes are involved and each of the enzymes is made by yeast. A material called acetaldehyde is produced in the next to last step of the conversion process (just before alcohol). Acetaldehyde is a volatile liquid, something like alcohol, except acetaldehyde has a peculiar nut-like odor. Sherry wines contain much acetaldehyde, and it is the acetaldehyde that gives Sherry wines much of their distinctive character. When wine oxidizes, some of the alcohol in the wine is converted into acetaldehyde. An open bottle of vodka can stand for some time but the alcohol does not oxidize. So, alcohol does not oxidize readily. The vodka may evaporate, but little acetaldehyde is produced. Therefore, the conversion of alcohol in wine into acetaldehyde must involve more than just a simple oxidation process.

Most of the alcohol oxidation that occurs in wine results from an indirect, two-step process. First, oxygen interacts with some of the phenolic compounds in the wine. The phenolic material is converted into quinone, and hydrogen peroxide is produced as a byproduct. Hydrogen peroxide is a strong oxidizing agent, and the hydrogen peroxide interacts with alcohol in the wine and produces acetaldehyde and water. The reaction between alcohol and hydrogen peroxide can be characterized as: alcohol (CH_3CH_2OH) plus hydrogen peroxide (H_2O_2) produces acetaldehyde (CH_3CHO) and two molecules of water ($2H_2O$).

$$CH_3CH_2OH + H_2O_2 \Longrightarrow CH_3CHO + 2H_2O$$

Wine is about 85 percent water, so the tiny amount of extra water produced has little effect on the wine. But, acetaldehyde is aromatic and the distinctive odor of even small amounts of acetaldehyde in any wine is quickly apparent.

The production of hydrogen peroxide in the first oxidation step is of great interest because it provides winemakers with an effective way of reducing wine oxidation. Sulfur dioxide and hydrogen peroxide react with each other and form sulfuric acid. Wine contains about 120 grams of alcohol per liter but only about 0.1 grams of sulfur dioxide per liter. Even so, hydrogen peroxide and sulfur dioxide have an affinity for each other, and when sulfur dioxide is present in wine, much of the hydrogen peroxide produced reacts with sulfur dioxide.

In addition to reacting with hydrogen peroxide and minimizing the amount of acetaldehyde produced, sulfur dioxide can also combine directly with acetaldehyde. After combining with sulfur dioxide, the distinctive nut-like odor of acetaldehyde no longer exists. This is why small quantities of sulfur dioxide added to an old, oxidized wine often makes the wine smell and taste younger and fresher. Therefore, sulfur dioxide is doubly effective in reducing the effects of wine oxidation. First, SO_2 reacts with hydrogen peroxide and reduces the amount of acetaldehyde produced. Secondly, sulfur dioxide binds with some of the acetaldehyde already formed and reduces the deleterious effects of wine oxidation.

Sulfur dioxide-Oxygen Reactions

The equations below are similar to the equations discussed in chapter 7 and they show how sulfur dioxide can react with oxygen in wine.

$$SO_2 + H_2O \Longleftrightarrow H^{1+} + HSO_3^{1-} \Longleftrightarrow 2H^{1+} + SO_3^{2-}$$

$$2SO_3^{2-} + O_2 \Longrightarrow 2SO_4^{2-}$$

Please note that two sulfur dioxide molecules can react with one oxygen molecule and form two sulfate ions. The molecular weight of sulfur (S) is 32 and oxygen (O) is 16, so the molecular weight of SO_2 is 32 + 16 + 16 = 64. Since the weight of SO_2 is 64 and the weight of oxygen is 16, **four milligrams of sulfur dioxide is required to react with one milligram of oxygen.** Knowing that 4 milligrams of sulfur dioxide is required to remove one milligram of oxygen is a handy tool for winemakers.

OXYGEN UPTAKE

Oxygen always dissolves in wine stored in open containers or in closed containers having excessive headspace. The oxygen uptake on an **undisturbed** surface is about 20 milligrams per hour per square foot of exposed wine surface. Consequently, oxygen uptake depends largely on the surface area of wine exposed and the exposure time. Tall slender tanks are preferred to short, wide tanks because taller tanks have less exposed wine surface area. For example, oxygen uptake will be four times less in a 4-foot diameter tank than in an 8-foot diameter tank.

Consider the situation of racking 750 gallons of wine from a 4-feet diameter tank into a similar tank. The racking is done with a small transfer pump and the racking time is two hours. The exposed wine surface area is about 12 square feet, and two wine surfaces are involved (two tanks). Therefore, 480 milligrams of oxygen (20 X 12 X 2 = 480) will be dissolved in the wine each hour, and at the end of two hours, the wine will contain about 960 mg of oxygen. There are 2850 liters in 750 gallons, so 960 mg of oxygen divided by 2850 liters is 0.3 milligrams of oxygen per liter of wine. Since wine holds about 7 milligrams of oxygen per liter when completely saturated, the wine in this example would only be about 5 percent saturated.

The above calculation shows how oxygen uptake can be estimated. But, estimating oxygen uptake this way can be misleading because undisturbed wine surfaces are assumed and smooth wine surfaces may not be the case. Splashing and bubbling often occur during wine transfers. Turbulence is produced on the wine surfaces, and turbulence and foam can increase the exposed surface area by several hundred percent. Instead of the 0.3 mg/l of oxygen uptake calculated above, an uptake of 1 to 3 mg/l is commonplace unless tanks are racked very carefully. Wine can be saturated with dissolved oxygen during racking if excessive splashing takes place or if a small air leak exists in the suction line of the transfer pump.

Monitoring Oxygen Uptake

Commercial wineries monitor the oxygen content of their wines with dissolved oxygen meters. But, home winemakers seldom have this measurement capability, so they rely on simple SO_2 measurements to provide useful information about oxygen uptake in their wines. Recall that the molecular weight of sulfur dioxide is 64 and that of oxygen is 16. Therefore, four milligrams of sulfur dioxide are required to react with each milligram of oxygen in the wine. So, just knowing the ratio of sulfur dioxide to oxygen allows winemakers to estimate oxygen uptake from routine sulfur dioxide measurements.

One example above showed an oxygen uptake of about 2 milligrams per liter resulted from racking a 750-gallon tank of wine. Using the ratio of four to one, 8 mg/l of free SO_2 would be needed to combine with the 2 mg/l of dissolved oxygen. If the wine in the tank contained 20 milligrams of sulfur dioxide per liter before the transfer, about 12 mg/l of SO_2 would remain in the wine after the racking. The drop of 8 mg/l in sulfur dioxide could be detected by measuring the free SO_2 before and after racking.

Here is another example. Bottling always introduces considerable dissolved oxygen. When bottling is done very carefully, the newly bottled wine is often 30% to 40% saturated with dissolved oxygen. Standard wine bottles are 3/4 liters, and saturated wine contains about 7 milligrams of oxygen per liter. Therefore, a bottle of 33% saturated wine contains about 1.7 milligrams of dissolved oxygen. The volume of the headspace in bottles is about 5 milliliters, and room temperature air contains about 280 mg/l of oxygen per liter. So, the bottle headspace contains 1.4 milligrams of oxygen. Most of this oxygen will be driven into the bottle, so each bottle of corked wine would contain about of 3.1 milligrams of oxygen. Since 4 milligrams of SO_2 are required for each milligram of oxygen, 12.4 milligrams of SO_2 is needed to react with the dissolved oxygen in the bottle. So, 16 (12.4 / .75 = 16) milligrams of SO_2 per liter of wine is needed to react with the oxygen introduced during the bottling operation. If the wine contained 25 mg/l of free SO_2, only 9 mg/l of free sulfur dioxide would remain in the wine to provide continued protection.

Estimating oxygen uptake by measuring the decrease in free sulfur dioxide is not a very accurate technique because the reaction between SO_2 and oxygen is very slow. Depending on temperature and other factors, many days may be required for all of the dissolved oxygen to react with the sulfur dioxide. So, the winemaker is never sure just when he should make the measurement. In addition, some dissolved oxygen always reacts with wine materials other than SO_2. Even so, home winemakers can obtain useful information about oxygen uptake by making accurate SO_2 measurements just before wine is handled and then again several days after handling.

WHO CARES

A good understanding of how oxygen is introduced and interacts with wine can help home winemakers avoid many oxygen related wine problems. Understanding how oxygen behaves in wine is important because excessive wine oxidation spoils more homemade wine each year than any other wine defect.

Oxygen and Yeast Development

Yeast need oxygen to produce new yeast cells, so oxygen is required early in the fermentation process so the yeast can multiply. Too few cells develop when yeast lacks oxygen, and then fermentation can be sluggish or even stop. Most yeast strains require 7 to 10 milligrams of oxygen per liter to produce a large, healthy yeast population. (Sometimes, just racking and splashing the must to introduce a new supply of oxygen can restart a stuck fermentation). Grape must is exposed to air during normal crush operations and the juice becomes saturated with oxygen. Saturated juice at room temperature contains 7 milligrams of dissolved oxygen per liter, so the yeast requires little additional oxygen to multiply and produce the large number of cells needed. Therefore, some oxygen uptake is always desirable early in the fermentation process.

Bottle Head Space

Many small producers use multi-spout, gravity fillers when bottling wine. Unfortunately, these little gravity fillers must be used carefully to avoid excessive oxygen uptake. Little bubbling occurs when bottles are filled slowly, but excessive amounts of foam can be generated when bottles are filled quickly. The foam exposes a very large surface area of wine to the air. Much oxygen dissolves into the wine, and the wine becomes saturated with oxygen. Since saturated wine contains about 7 milligrams of oxygen per liter, a 750-ml bottle of saturated wine contains about 5 milligrams of oxygen.

Scavenging oxygen is one of the more important reasons for adding sulfur dioxide to wine. But, deciding just how much sulfur dioxide should be in wine at bottling time is not easy because the bottling operation adds so much oxygen. A further complication is that many home winemakers leave excessive headspace (about 10 milliliters) in their bottled wines. Unless a vacuum corker is used, much of this air is compressed when the cork is driven. This additional air remains in the bottle and can oxidize the wine. At room temperature, 10 milliliters of bottle headspace contains about 2.8 milligrams of oxygen.

Knowing that four milligrams of sulfur dioxide react with each milligram of oxygen can be used to estimate how much sulfur dioxide may be needed at bottling time. Consider this example. A wine containing little dissolved oxygen might become about 1/3 saturated with oxygen if the bottles are filled carefully. Each bottle of wine would then contain about 1.7 milligrams of dissolved oxygen. If the volume of the headspace is 5 milliliters, the headspace will contain about 1.4 milligrams of oxygen. So in this example, the newly bottled wine would contain 3.1 milligrams of oxygen. Four milligrams of sulfur dioxide are needed to react with one milligram of oxygen, so 12.4 milligrams of SO_2 would be needed to react with the oxygen in the bottle. A bottle contains 750 milliliters, so 16.4 milligrams of sulfur dioxide per liter of wine would be required to react with the oxygen. If the wine being bottled contained 30 milligrams of SO_2 per liter, a little more than half (12.4/30 = .55) of the SO_2 would be consumed by reacting with the dissolved oxygen, and about 14 milligrams of SO_2 per liter would remain in the wine to provide long term protection.

Here is a second example. When bottles are filled carelessly, excessive amounts of splashing occur, and the wine may be saturated or nearly saturated with oxygen. A 750-ml bottle of saturated wine contains about 5 milligrams of dissolved oxygen. Under filled bottles may have about 10 milliliters of headspace, and the headspace will contain 2.8 milligrams of oxygen. Then the total oxygen content in each bottle would be about 8 milligrams. Four milligrams of SO_2 are required for each milligram of oxygen. Therefore, 32 milligrams of sulfur dioxide are needed in a 750-milliliter bottle just to react with the oxygen introduced during bottling. So, how bottles are filled is important.

Removing Hydrogen Sulfide

Winemakers often splash wine vigorously to remove hydrogen sulfide gas. The disadvantages of this treatment are the possibility of oxidizing the hydrogen sulfide into disulfide or of oxidizing the wine. However, wine oxidation can be reduced considerably if the splashing operation is done properly. Splashed wine quickly becomes saturated with oxygen. But, once saturated, little more oxygen can enter the wine, and the saturated wine can be splashed for an extended time to remove the hydrogen sulfide. In this case, one large exposure to air produces much less wine oxidation than several small splashing treatments applied over an extended time. Of course, some sulfur dioxide will be consumed, so the free SO_2 level of the wine should be adjusted after the splashing treatment.

Barrel Aging

Air enters wine stored in barrels very slowly. However, little dissolved oxygen exists in wine aging in barrels. The oxygen is consumed by oxidation reactions with other wine materials about as fast as it enters the barrel, so no significant amount of dissolved oxygen accumulates in the wine. Not having an accumulation of dissolved oxygen in the wine is the basis for “micro oxygenation.” This process of exposing wine to tiny amounts of oxygen while minimizing dissolved oxygen in the wine is one of several desirable characteristics obtained from aging wine in oak barrels.

Oops

Novice winemakers often panic when they discover a bung lying on the floor because they are afraid the wine in the open barrel will be oxidized. Wine in an open barrel can become saturated with oxygen quickly, but once saturated, little more oxygen enters the wine. Wine oxidation reactions occur slowly, so the wine in the open barrel remains saturated or nearly saturated for some time. After the bung is returned to barrel, some of the dissolved oxygen reacts with sulfur dioxide in the wine and the sulfur dioxide slowly removes the oxygen. Consequently, a barrel of wine may be open for a day or so, but the saturation effect often prevents extensive wine damage. Of course, catastrophic oxidation may occur if the sulfur dioxide content of the wine is low or if the barrel remains open for several days.

SUMMARY

Oxygen diffuses into wine quickly, and depending on storage conditions, several days or even several weeks may be required before all of the dissolved oxygen is consumed by chemical reactions. Wine saturated with oxygen contains about seven milligrams of oxygen per liter of wine. When bottles are filled carelessly and when excessive amounts of headspace is left, surprisingly large amounts of sulfur dioxide will be consumed (20 to 40 milligrams per liter). Useful estimates of oxygen uptake in wine can be obtained from accurate SO_2 measurements.

Chapter 9

WINERY SANITATION

Winemakers are responsible for many different activities, but one of his or her most important duties is to make certain the winery is maintained in a clean, sanitary condition. Dirty cellar conditions can result in wines with strange off-odors and off-flavors. Wine acts like a sponge, and it absorbs all kinds of odors. Many homemade wines are afflicted with off-odors and off-flavors, and usually these problems can be attributed to a lack of cleanliness or to poor storage conditions. Unless strict sanitary conditions are maintained in the storage area, wine quality is always at risk.

Although winery sanitation is very important, many beginning winemakers do not understand the methods and materials needed to establish and maintain clean, sanitary winemaking conditions.

BASIC SANITATION RULES

The basic principles of sanitation and the ways these principles are applied in the wine industry can be found in a Wine Institute publication by Davison (1963) titled "Sanitation Guide for Wineries." This document identifies the following issues as most important for maintaining basic winery sanitation.

(1) Keep the winery clean and free of refuse both inside and outside.
(2) Inspect the winery premises, the equipment and the cooperage at least once each month and do this inspection on a regularly scheduled basis.
(3) Keep all winery equipment clean and in good working condition. Equipment should be arranged in an orderly way and the work areas kept free of clutter.
(4) Use plenty of clean water, sterilizing materials and cleaning agents, and the entire winery should be cleaned on a regularly scheduled basis.
(5) Get rid of harmful bacteria, yeast, mold, insects and rodents. Then take any measures necessary to prevent a recurrence of these pests.

Although these rules may seem obvious, they should not be taken for granted, and every home winemaker should carefully consider just how these five rules apply to his or her particular winemaking situation.

"Wash equipment just before it is used; then wash everything again when the job is finished" is another simple but very effective winery sanitation rule. Most winery residues can be easily rinsed away when wet, but grape residues are very difficult to remove after they become dry. Cleaning dried grape muck out of a fifty-foot length of transfer hose is a difficult and frustrating task. The "clean before and clean after" rule seems to imply twice as much work. However, this is not so, and the rule will save a tremendous amount of time and labor if it is conscientiously applied. Most commercial wineries practice and rigidly enforce this rule.

Pomace

Pomace should be removed from the winery promptly, and all the pomace should be disposed of in a suitable way. Pomace should never be allowed to accumulate near active fermentations. Even sweet pomace acetifies quickly in hot weather and starts turning into vinegar. Then the pile of pomace is sure to attract fruit flies, and the flies then carry acetic acid bacteria from the pomace pile into the active fermentations.

Putting pomace back into the vineyard is the preferred method of disposal. When pomace is spread in a thin layer, it dries quickly and becomes high quality compost material. Unfortunately, most home winemakers do not have access to vineyards, so they must find other ways to dispose of their pomace. A method that works well in some urban areas is to place 20 to 30 pounds of pomace in large plastic trash bags. Then the bags are placed at the curb on trash collection day. Some wineries rent an extra trash "dumpster" for several weeks each crush season, and this is a very convenient and effective way of disposing of pomace for small producers. Arrangements must be made to have the dumpster emptied promptly, or the pomace will acetify and attract fruit flies.

CLEANING AGENTS

Many proprietary cleaning agents have been developed specifically for use in the wine and food industries, and these materials have properties that make them particularly suitable for the intended job. However, sources of proprietary cleaning materials can be difficult to find. Many cleaning materials are supplied by the manufacturer in 50-pound bags or in large drums, and such large quantities are not suitable for small producers. Fortunately, several common household cleaning materials give reasonable performance in the small winery, and these materials are readily available in small quantities at the corner market.

Sanitation procedures used in the winery cannot be effective unless the proper material is used, and the material must be used in the correct concentration and for a minimum amount of time. In addition, some sanitation materials must be applied at elevated temperatures, so concentration, application time and application temperature are important. Some typical examples are shown in Table 10.

Material	Concentration (mg/liter)	Temperature (F)	Time (minutes)
Hypochlorite	50	75	1
Iodine	15	75	1
Citric Acid	250	75	1
Hot Water	-	170	15
Steam	-	200	5
Hot Air	-	180	20

Table 10. Antiseptic properties depend on exposure time, temperature and concentration.

Detergents

Detergents wet surfaces readily, soften the water, emulsify fats, de-flocculate particulate materials, and good detergents have some sterilizing action. Most important for winery use, a detergent must be easy to rinse away completely. Detergents having all these desirable characteristics are difficult to find so many home winemakers rely on a liquid dishwashing detergent. Most dishwashing detergents do a good job in hot water, but their performance in cold water may be lacking.

Generally, any cleaning products with artificial odors should be avoided, and highly perfumed liquid detergents are particularly bad. Strong perfumes can be difficult to rinse away from winery surfaces, and microscopically porous materials like polyethylene can retain the perfume scent for a very long time. Of course, unscented detergents are available, but sometimes these products are difficult to find at the local market.

Phosphates

Sodium phosphate is an excellent water softener, and it is one of the better winery cleaning materials. Sodium phosphate is the principal ingredient of many automatic dishwasher powders, and in this form, sodium phosphate is inexpensive and readily available. Phosphate-based detergents are often used for soaking off labels and cleaning used wine bottles.

CTSP

Chlorinated tri sodium phosphate (CTSP) is the basic cleaning material used in both commercial and home wineries. The best defense against contamination in small wineries is chlorinated TSP, a stiff brush, hot water and lots of elbow grease. CTSP is readily available, and it lifts dirt well. The chlorine is a powerful sterilizer, and in this form, chlorine is easier to rinse away. When mixed at a useful strength, solutions of CTSP feel soapy or slippery. One to four tablespoons of CTSP in a gallon of hot water produces a useful concentration. TSP can be hard on hands, and rubber gloves should be worn when strong solutions are used. Some automatic dishwasher powders contain significant amounts of chlorinated tri sodium phosphate.

Hypochlorite

Clorox (sodium hypochlorite) is an inexpensive and readily available source of chlorine. Sodium hypochlorite is the active ingredient in Clorox. This material is a powerful oxidizer, and it is one of the most potent disinfectants readily available to home winemakers. Unfortunately, Clorox does not rinse away easily in cold water, and Clorox is particularly difficult to remove from porous materials. Many home winemaking books condemn this material because Clorox is so potent and so difficult to rinse completely. Even so, commercial wineries use large quantities of sodium hypochlorite because it is such an efficient sanitizer. Unscented Clorox can be purchased at any super market. It is all the same material, so buy the least expensive brand.

The following procedure is recommended when Clorox is used to sterilize wine containers. First, the surfaces of the tank are scrubbed with a Clorox solution. Then the surfaces are rinsed two or three times with clean water. Next, the surfaces are rinsed with a solution consisting of one tablespoon of sulfite crystals in a gallon of water. Sulfur dioxide and chlorine combine quickly, and the residue washes away easily. Finally, the tank surfaces are rinsed again with clean water to remove any sulfur dioxide residue. Full strength Clorox must be handled with special care because it can produce poisonous chlorine gas. **Do not breathe Clorox fumes, and do not get Clorox on clothing.**

Rinse Carefully

After the winemaking equipment has been scrubbed down, **all** of the cleaning material must be removed from any surfaces that can come into contact wine. If any doubt exists, all of the surfaces should be rinsed again completely. All of the cleaning agents listed above will do a better job of cleaning when they are used with hot water, and these materials also rinse away more easily when hot water is used.

CLEANING AIDS

A good adjustable nozzle attached to a garden hose is the primary piece of cleaning equipment in most small wineries. The nozzle should provide several spray patterns including a strong, high velocity stream, and the nozzle should not leak. The hose and nozzle will be dropped from time to time, so the nozzle should be of rugged construction. Hang the hose, with the nozzle attached, in a convenient spot in the crush area, and many steps will be saved.

Special, long-handled brushes are made for washing automobile hubcaps, and these brushes are very convenient for scrubbing small tanks, containers and other winemaking equipment. These long-handled brushes can be purchased in the automotive departments of large stores. They are inexpensive, and a couple of these brushes are very handy for all kinds of cleaning jobs in any small winery.

Home winemakers use an assortment of bottlebrushes for cleaning stubborn residues from the inside surfaces of wine bottles, jugs and carboys. These brushes have long twisted wire handles, and they are manufactured in many sizes.

Jet carboy washers are a great aid when washing old wine bottles. These little brass gadgets attach to a water faucet and deliver a powerful jet of water to the inside surfaces of any bottle or jug. The water starts flowing when a bottle is placed in position and automatically turns the water off when the bottle is removed. Often, little scrubbing with a bottlebrush is necessary if dirty bottles are soaked for two or three days and then power rinsed with a jet carboy washer.

CLEANING EQUIPMENT

Proper winery sanitation includes cleaning and sanitizing any surfaces that can contact wine. All winemaking equipment, including the crusher and the press, should be scrubbed with a CTSP solution. After scrubbing, the equipment must be carefully rinsed with lots of clean water. Then the equipment should be washed again with plain water immediately after use before any residue has time to dry. After the second washing, the equipment should be drained carefully. Then when the equipment is completely dry, it can be safely stored away. Novice winemakers should try to develop a habit of washing winery equipment before and immediately after each use.

Hoses and Tubing

Hoses and tubing should be cleaned much the same as other pieces of winemaking equipment. However, scrubbing the inside surfaces is practically impossible, so hoses and tubing require some special care. Strong CTSP solutions remove soil efficiently, but the tubing should be rinsed several times with clean water to make sure no CTSP remains on the inside surfaces.

Mold starts to grow in a short time if water is allowed to stand in a hose. Wineries hang their hoses with both ends down so any water can drain completely. Special hose racks for this purpose are constructed from wood, plastic or metal. Home winemakers often make hose racks from scrap wood or from several nails appropriately placed. Hanging hoses from a single nail will cause permanent kinks. If a length of hose or tubing becomes heavily stained or contaminated with mold, try a treatment of full strength Clorox.

Tanks and Carboys

The “clean before and clean after” rule also applies to carboys and tanks. Two types of tank residues are often encountered, and both types are difficult to remove, even when the tank is cleaned promptly. An ugly brown deposit often forms near the top of small fermenters, and this material can be quite difficult to remove. A good stiff brush and chlorinated tri sodium phosphate are recommended for this job. Residues often occur right at the shoulder of a glass or plastic carboy, and these deposits are difficult to reach. Here, the handle of a large bottlebrush should be bent, and extra effort should be applied.

A second type of cleaning problem arises when a carboy or tank has been in use for several years, and the inside surface has become coated with a heavy tartrate deposit. The tartrate causes no harm if the coating is not excessively thick, and if it does not contain a large quantity of trapped lees.

In fact, a moderate tartrate coating will accelerate the cold stabilization of any new wine that is stored in the container. However, after several years the tartrate coating becomes thick, rough and contaminated with trapped lees. Now, the tartrate coating must be removed. Heavy tartrate deposits are difficult to remove with cold water, but they can be removed quickly with a solution made of a half cup of sodium carbonate in a gallon of hot water and a stiff bristled brush. Thin deposits of tartrate in small tanks or carboys can be removed easily by filling the container with plain water for twenty-four hours.

Used Bottles

Cleaning and sterilizing old wine bottles is not fun. Nevertheless, the high cost of new glass (about $6.00 a case) compels many home winemakers to rely on recycled wine bottles. The inside surfaces of dirty wine bottles are an ideal environment for a variety of molds, yeast and bacteria, and large colonies are often seen growing on the dried residue. Dirty used bottles are always a potential source of contamination, so dirty bottles should not be stored in the winemaking area. A safer procedure is to clean the bottles, as they are collected. Then the clean bottles should be stored points down in clean cardboard cartons.

Used bottles are difficult to clean properly. The usual procedure is to soak the dirty bottles in water for a few days. Soaking loosens the dried wine residue and the inevitable mold colonies. Some winemakers add a half-cup of TSP to the water to speed up the soaking process. After soaking, the bottles can be scrubbed with a bottlebrush using hot water and a strong phosphate-based detergent. A cup of automatic dishwasher powder in two gallons of hot water makes a good bottle cleaning solution. The bottles should be carefully rinsed, drained and dried after they have been washed. A jet carboy washer will save time and hot water when many bottles are being washed. Clean bottles will remain sanitary for some time if they are placed upside down in clean cardboard cases and stored in a dry place.

Barrels

Empty, used barrels are difficult to maintain. The first time a new barrel is filled with wine, more than three gallons of wine soaks into the wood surfaces. Later, when a barrel is stored empty, the wine soaked into the wood quickly acetifies. The wine in the wood turns to vinegar, and the barrel becomes contaminated with vinegar bacteria. Some home winemaking books recommend cleaning barrels contaminated with vinegar bacteria with soda ash. However, sterilizing contaminated barrels is practically impossible. Experienced winemakers use their noses and discard barrels smelling of vinegar.

Empty barrels can be safely stored for several weeks if they are gassed with sulfur dioxide and kept tightly sealed. Home winemakers and small commercial wineries burn sulfur wicks in their barrels. Large wineries purchase sulfur dioxide gas in high-pressure cylinders. Barrels gassed with sulfur dioxide should be washed with clean water before they are filled. Winemakers face another serious problem when empty barrels are stored for long times. After several weeks, the wood in an empty barrel becomes dry, and the staves start to shrink. As the wood shrinks, the hoops become loose, and the barrel loses its shape. In hot, dry climates, barrels often fall to pieces in a few months. At best, empty barrels leak badly when first filled, and several days of soaking are often required before these barrels can be filled with wine.

Barrels can be maintained for extended periods if they are stored wet. First, the barrel is washed several times with clean, cold water. Then the barrel is half filled with clean water, and a cup of sulfite powder and a cup of citric acid are added. Then the barrel is completely filled with water and bunged tight. The sulfite/acid solution will keep the barrel in good condition for some time, but after several months, the sulfite/acid solution must be replaced. Unfortunately, barrels stored in this way lose their oak character just as if they were filled with wine. New 60-gallon French oak barrels sell for about $600 and American barrels sell for about $200. Storing expensive barrels filled with water shortens the effective life of the barrels, so this method is only used for older, inert barrels.

Commercial wineries try to avoid storing empty barrels. They keep their expensive oak cooperage full of wine. When aged wine is removed for bottling, the barrels are washed with clean water and immediately refilled with new wine. Some home winemakers also use this method to maintain their barrels in good condition. However, keeping barrels filled with wine requires bottling last year's wine during the busy crush season, so careful planning is needed.

SUMMARY

Sanitation is an important part of winemaking, and good housekeeping is necessary in any winery. Many proprietary cleaning agents are available, but most small wineries and home winemakers rely on common cleaning agents like sodium phosphate (automatic dishwasher powder), chlorinated TSP and Clorox. The "wash everything just before use and again after use" winemaking rule should always be practiced. Hoses can be maintained easily if they are washed immediately after use. The wet hoses should be hung on a wall with both ends pointing down. Then they can drain and dry out completely.

The bacteria, yeast and molds that grow so profusely on the bottoms of old dirty wine bottles represent a constant source of contamination. Consequently, dirty, used wine bottles should not be stored in winemaking areas. Dirty bottles should be washed and sterilized and stored away in a sanitary condition.

Maintaining empty oak barrels in good condition is difficult. Small producer's burn sulfur wicks in their empty barrels. Large wineries fill their empty barrels with sulfur dioxide gas from high-pressure cylinders. Experienced winemakers avoid empty barrels by immediately refilling their barrels with new wine.

Chapter 10

WINE YEAST

The flavor characteristics of wine depend upon many factors. However, the yeast used for fermentation contributes little to the flavors of **aged** wine, and most flavor contributions from the yeast will be undetectable in red wines aged in oak barrels for normal periods. Many other winemaking factors such as fruit quality, grape variety, the climate, fermentation temperature, lees contact, cap manipulation, etc. influence wine flavors much more than yeast. On the other hand, light bodied, fruity wines are exceptions. These wines are bottled and consumed when they are young, and the effects of the yeast are still noticeable. Under these conditions, subtle flavor and aroma variations can be produced by different strains of yeast.

YEAST CHARACTERISTICS

Large differences in wine yeast do exist but the differences relate to properties other than creating wine flavors. Important yeast characteristics include speed of fermentation, color extraction, how much alcohol is produced, tendencies to stick, the quantity of foam generated, hydrogen sulfide production, etc. A few wineries use a different type of yeast for each wine produced. Many smaller wineries ferment all of their wines with only one or two types of yeast. The research winery at the University of California at Davis uses a single yeast type for all standard fermentations. Some small wineries and many home winemakers use Prise de Mousse or Pasteur Champagne for all their fermentations. Applications of some *Lalvin* yeast are shown in Figure 3

EAST STRAIN	White Wine	Red Wine	Champagne Base	Bottle Ferment	Stuck Ferment
M-1107	X	X			
V-1116	X	X		X	
E.C.-1118	X	X	X	X	X
C-1108	X	X	X	X	X

Figure 3. Recommendations for *Lalvin* active dry yeast.

Yeast names often mislead novice winemakers. For example, Pasteur Champagne yeast is not very good for sparkling wine production. Either California Champagne or Prise de Mousse are better yeast for the secondary fermentation of sparkling wines. Instead of implying use, the name shows the yeast strain originally came from the Champagne region in France. To complicate matters further, different yeast manufacturers have used the same name to identify different yeast strains. Several years ago, two entirely different yeast strains were available commercially, and both were called "Prise de Mousse." Winemakers can avoid confusion when placing orders for yeast by providing the name of the yeast, the name of the manufacturer and the yeast designation number.

YEAST TYPES

Wine yeast can be purchased in both liquid and dry forms. However, dry yeast is easier for small wineries and home winemakers to store and use. Some important yeast characteristics are shown in Figure 4.

Epernay II

This yeast is popular for producing light fruity style white and blush wines, and Epernay is also popular for producing wines made from fruit other than grapes. Sometimes Epernay is used for producing light, fruity style Chardonnay wines. However, Chardonnay juice can be difficult to ferment completely, and stuck fermentation often results when Epernay yeast is used to ferment Chardonnay. Chardonnay wines fermented with Epernay yeast should be closely monitored and they should be tested for residual sugar at the end of fermentation.

Yeast Characteristic	Montrachet	K-1	Prise de Mousse	Pasteur Champagne
Fermentation Rate	Fast	Slow	Fast	Slow
Completeness	Good	V. Good	Good	Good
AlcoholToll.	15%	15%	18%	17%
Sugar Toll.	Good	Good	To 34 B	Good
Opt. Temp.	20	20	15	20
Temp. Range. (C)	15-25	15-30	10-25	15-25
Alcohol Yield	High	High	Medium	N/A
Foaming	High	Low	V. Low	Medium
Flocculation	Normal	Normal	V. Good	Normal

Figure 4. Yeast characteristics of special interest to winemakers.

Epernay is used when fermentation temperatures range from 50 to 70 degrees. Under these conditions, it produces slow, controlled fermentations, and volatile components in the juice are retained well. Excessive foaming is seldom a problem when Epernay is used. Epernay does not ferment well at low temperatures, and it is very sensitive to sudden changes in fermentation temperature (cold shock). Epernay is often the yeast of choice used when winemakers intend to leave some residual sugar in a wine. Often, it is only necessary to lowering the temperature of the fermentation tank to stop an Epernay yeast fermentation.

Epernay yeast is sensitive to high alcohol levels. Consequently, Epernay should not be used in juices with high Brix values unless some residual sugar is wanted. Epernay yeast can produce very pleasant, fruity aroma characteristics in young wines, and home winemakers use Epernay yeast for fermenting fruit wines because of the fruity aromas produced. This yeast is available in five gram packets, 500 gram packages and in bulk form.

California Champagne (UCD 505)

This yeast is used primarily for the secondary fermentation of sparkling wines. It produces a clean, yeasty fermentation, and these characteristics are desirable in most sparklers. After a reasonable aging period, UCD 505 yeast will flocculate into large clumps, and the large pieces of yeast are much easier to riddle. UCD 505 yeast is sensitive to alcohol and sulfur dioxide. To insure prompt, clean secondary fermentations, the free SO_2 level of the cuvée should not exceed about 25 milligrams per liter, and the alcohol content should be less than 11 percent. Small quantities of yeast nutrient are often used with this yeast. California Champagne yeast is available in 500-gram packages and in bulk.

Montrachet (UCD 522)

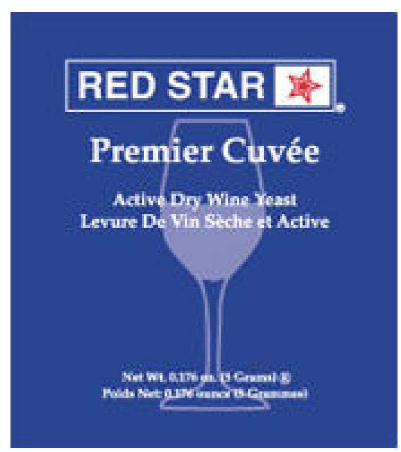
Montrachet yeast was very popular for producing well-colored red wines and big white wines for many years. Montrachet produces strong, vigorous fermentations, and some type of cooling is often necessary in warm weather.

Unfortunately, Montrachet yeast often produces excessive quantities of hydrogen sulfide, and it has fallen into disfavor in recent years. Grapes low in nitrogen should always be augmented with a yeast nutrient or DAP when Montrachet yeast is used, and prudent winemakers make it a point to smell all Montrachet fermentations several times each day. Montrachet yeast should never be used with grapes containing residual sulfur dust. This yeast is available in 5-gram packets, 500-gram packages and in bulk.

Pasteur Champagne (UCD 595)

Contrary to its name, Pasteur Champagne yeast is not well suited for sparkling wine secondary fermentations. It can be used for sparkling wines, but it produces very fine lees and the light, fluffy lees make riddling difficult. Pasteur Champagne yeast is tolerant of high alcohol levels and sulfur dioxide, so it is often used to restart stuck fermentations. Some wineries use this yeast for both white and red fermentations, and it can be counted on to produce clean, neutral fermentations. When used under reasonable fermentation conditions, it seldom leaves residual sugar. Sometimes Pasteur Champagne yeast produces large quantities of foam in warm weather. This yeast is available in 5-gram packets, 500-gram packages and in bulk.

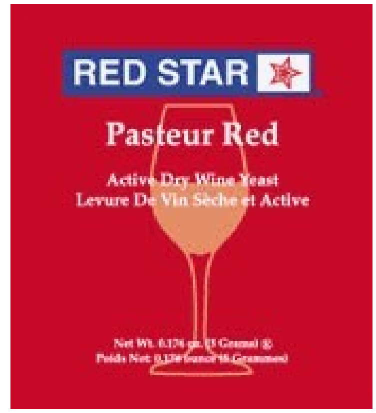
Prise de Mousse (Premier Cuvée)



Since it became available in dry form several years ago, the popularity of Prise de Mousse (PdM) yeast has increased rapidly. PdM is an excellent, general-purpose yeast for both red and white wines. It produces low hydrogen sulfide fermentations, and it ferments vigorously. Since this yeast usually produces a dry wine, it is one of the more popular yeast for California Chardonnay production. This yeast is tolerant to sulfur dioxide, and it is tolerant to high alcohol levels. Consequently, Prise de Mousse is very useful for restarting stuck fermentations. Prise de Mousse is also used for the secondary fermentation of sparkling wine. Under normal conditions Prise de Mousse produces little foam and it seldom causes the winemaker any trouble. Small wineries often use this yeast for all their fermentations. It is available in 5-gram envelopes, 500-gram packages and in bulk.

Steinberg

Steinberg yeast is used for producing classical, "cold fermented" Riesling wines, and it is used extensively for Gewurztraminer production. When used at low fermentation temperatures, Steinberg produces a delicate, complex bouquet of fruit odors in young white wines. This yeast is very cold tolerant, and it often continues fermenting at temperatures below 40 degrees. However, this yeast is very sensitive to sulfur dioxide, and Steinberg fermentations can be retarded significantly if more than 50 milligrams per liter of sulfur dioxide are added at the crusher. Sometimes, winemakers can deliberately stop low temperature Steinberg fermentations just by adding a large dose of sulfur dioxide to the tank. This yeast is only available in 500-gram packages and in bulk.



Pasteur Red

Pasteur Red yeast has been available commercially for some time, but it has only been produced in dry form for the past several years. In dry form, Pasteur Red is rapidly becoming the yeast of choice for producing full-bodied red wines. Pasteur Red produces clean fermentations, and it has good color extraction characteristics. This yeast seems particularly well suited for fermenting deeply colored Bordeaux style red wines. Pasteur Red yeast is vigorous, and some cooling is often needed in warm weather. Pasteur Red yeast can be purchased in 5-gram packets, 500-gram packages and in bulk form.

SUMMARY

The type of yeast used for fermentation has little influence on the aromas and flavors of aged wines. However, yeast can contribute to the aroma of young, fruity wines.

Yeast is available in liquid and dry form, but dry yeast is much easier for small producers to store and use.

Prise de Mousse yeast produces little foam and seldom causes fermentation problems. Some small wineries use Prise de Mousse for all of their red and white fermentations and they also use it to restart stuck fermentations.

Chapter 11

CRUSH SEASON

Crush seasons only lasts about eight weeks, and wineries must pick, transport and crush all the grapes needed for their annual supply of wine in that short time. Crush seasons are busy, hectic times for winery personnel and twelve or fourteen-hour workdays are quite common. Winemakers make many decisions during this busy period, and many of these decisions must be made quickly. Unfortunately, hastily made decisions often result in poor wine quality. Most commercial winemakers prepare a detailed crush plan early each season to reduce the number of these high-risk decisions. Crush seasons are not so hectic for home winemakers. Nevertheless, home winemakers have the same kinds of problems each year, and most home winemakers also benefit from well thought out crush plans.

Deciding what varieties of wine will be made is the first step in developing a crush plan. Then the winemaker decides how many gallons of each variety will be produced. Once the varieties and quantities have been established, the more detailed winemaking issues such as potential sources of grapes, fruit costs, cleaning equipment, cooperage requirements, etc. can be addressed.

Most home winemakers have limited time during crush season, and even routine chores such as repairing and cleaning equipment need to be planned well in advance. Crush plans should be formulated many weeks before harvest time, and then the plan should be followed until all of the new wines are safely stored away in the cellar

GRAPE RIPENING

The vine extracts water and minerals from the soil and carbon dioxide up from the air. When sun shines on leaves, carbohydrates and small amounts of other materials are produced by photosynthesis. Carbohydrate in the form of sucrose is transported from the leaves to the berries and other parts of the vine through the phloem. Then the sucrose is hydrolyzed into glucose and fructose and stored in the berries. Flavor and aroma producing compounds are also synthesized and stored in the berries. Later in the ripening process, at 24 or 25 Brix, the vine diverts the carbohydrates to the woody parts of the vine. Sugar accumulation in the berries stops and the berries start dehydrating. Then the grape skins slacken and the pulp becomes less firm. Brix equals grams of sugar per 100 grams of juice, so the Brix of the berries may continue to increase, but the increase in Brix is caused by a loss of water rather than by sugar gain. Photosynthesis continues, but instead of being transported to the grapes the carbohydrates are being stored in the woody parts of the vine to provide the energy needed to start vine growth the following year.

When are Grapes Ripe

Grape ripeness depends upon the intended use. Table grapes are usually picked at 16 to 18 Brix. Grapes intended for sparkling wines are usually picked at sugar levels of 18 to 20 Brix. Light, fruity table wines are usually made from grapes picked at 21 to 23 Brix. “Big” red wines are expected to have high alcohol, intense flavors and color concentration, so grapes intended for making big red wines are often picked at sugar levels of 25 Brix or higher. So, grape ripeness depends upon the style of wine being made and the crop is considered ripe when the grapes have the correct amount of sugar, acid, color, flavor-intensity and varietal character for the intended use.

In general, under-ripe grapes are lower in sugar, low in flavor, high in acid and under-ripe red grapes usually lack phenolic structure and color. Over-ripe grapes are often high in sugar, low in acid, high in color and intense flavors, but over-ripe fruit often has undesirable cooked or stewed fruit flavors. Over-cropped vineyards produce grapes that are lower in flavor, lower in acid and lower in varietal character. Old or under-cropped vineyards generally produce high quality fruit, but sometimes the wines are overly astringent and require excessively long aging periods. Vineyards with big, shaded canopies produce grapes that lack desirable red fruit flavors and the fruit often has an undesirable "green," herbaceous taste Some grape deficiencies can be successfully mitigated during the winemaking process and a talented winemaker can make **commercial** quality wine out of almost any reasonable quality fruit. Unfortunately, many grape flaws are difficult or even impossible to correct, so picking grapes at the right time is important.

Sugar Content

The accumulation of sugar is the basic definition of fruit ripening and grapes with a sugar content of 24 Brix are considered riper than grapes at 22 Brix. Sugar content can be quickly and accurately measured and sugar level has been used to specifying and document grape ripeness for more than a hundred years. Today, practically all grape contracts specify minimum Brix values, titratable acid and pH values.

Titratable Acid

Tartaric and malic acids make up about 90 percent of the total organic acid content in grapes. The amounts of tartaric acid and malic acid are about equal when grapes start to change color and soften (*veraison*). The quantity of tartaric acid remains roughly constant throughout the ripening period, but the quantity of malic acid decreases as the grapes ripen. The loss of malic acid results in a gradual decrease in the titratable acid (TA) of the juice during the ripening period. In hot ripening years, picking might start a Brix or two lower than usual just to the preserve desirable acid. In cool ripening years, picking might be delayed a Brix or two so the excessively high acid level can drop as much as possible. Depending on variety, the acid content of ripe local white grapes often falls between 0.6 and 0.9 percent and the TA of red grapes falls between 0.5 and 0.7 percent. In most years local grapes have too little titratable acid and the wine often tastes flat or bland unless tartaric acid is added to the grapes before fermentation is started.

pH

Grape acids differ in strength, and tartaric acid is stronger than malic acid. A quantity called pH is used to measure the strength and quantity (the number of ionized protons per mole) of the acids, and pH is defined using an inverse, logarithmic scale. High acid grapes have a low pH, and low acid grapes have a high pH because of the upside down scale. In southern California, pH values range from 3.2 to 4.1 for sound, ripe red grapes and the pH of white grapes is slightly lower.

As grapes ripen, malic acid is slowly lost by respiration. This reduction of malic acid causes the titratable acidity of the grapes to decrease, and it also causes the pH of the juice to increase. Later in the ripening process, as the grapes are beginning to reach maturity, potassium ions begin to accumulate more rapidly in the juice. The increase in potassium ions interact with the acids in the grapes, and this interaction causes the pH of the juice to increase more rapidly as the grapes are reaching maturity.

Amount of Grapes Needed

The quantity of wine produced from a ton of grapes is called wine yield, and wine yield depends on the variety of the grapes, the type of equipment available, the winemaking techniques used, etc. Professional winemakers, using modern horizontal presses, often get 160 or 170 gallons of quality wine from a ton of fruit. Home winemakers generally use small vertical basket presses, and most home winemakers get 130 to 150 gallons per ton. Consequently, most home winemakers require 13 or 14 pounds of grapes for each gallon of wine. When small batches of red wine are made at home without a crusher or press, wine yields will be lower and about twenty pounds of grapes may be needed for a gallon of wine. Making white wines without access to a press is generally not feasible.

Wine containers must be kept completely full throughout the winemaking process. Wine stored in barrels evaporates, and significant quantities of wine are lost each time wine is racked. Wine containers must be "topped up" periodically. Extra wine is always needed to keep the containers full, so winemakers routinely produce extra wine (10 - 15%) to use as "topping material."

Buying Grapes

Wine grapes are bought and sold by the ton, and higher prices are usually paid when home winemakers purchase fruit in much smaller quantities. This is why many home winemakers pool together each season and purchase grapes in ton quantities. Grapes are hauled from the vineyard in field lugs (picking boxes holding about 40 pounds), half-ton bins, and one-ton tanks and in large gondolas. When small quantities of fruit are purchased from a vineyard, the size of the containers used can be important. A serious problem can develop when a ton of fruit is needed, and the grapes are coming out of the vineyard in five-ton gondolas.

When grapes are purchased from an outside source, the grower should be contacted early in the season. Grape growers like to have their grapes sold well before harvest time, so purchase arrangements are best made before the Fourth of July.

The growers harvest criteria should be discussed and carefully considered. Some growers harvest as early as possible each season and red grapes are often picked very close to 22.5 Brix. Trying to make a big red wine from under-ripe grapes is not realistic, and if the grower's harvest criteria are not compatible with the style of wine planned, the winemaker should look for another source of grapes. Who will pick and the price of the grapes should be clearly established when purchases are made from outside sources.

Harvest time depends on many factors, so picking times vary from year to year. Grape varieties, vineyard location, soil, weather conditions and irrigation schedules all influence when the grapes are picked. Rain late in the season often delays picking by a week or two. Many variables are involved, and accurately predicting when grapes will be ripe is nearly impossible. Consequently, winemakers should keep in touch with their grower and follow the development of the grapes as they ripen. Then the winemaker can be ready to process the grapes promptly when harvest time arrives.

Expecting commercial growers to sell their highest quality fruit to home winemakers is not realistic. Commercial growers prefer to use their best quality fruit to entice large wineries into multi year contracts. Fruit contracts of five, seven or even ten year duration can be beneficial to both the grower and the winery. Practically all of the highest quality wine grapes are sold under long term contracts, so home winemakers are always at a disadvantage when attempting to buy quality grapes on the open market. A few home winemakers plant their own vineyards and produce estate wines simply because high quality grapes are so difficult to buy.

Avoid Warm Fruit

Oxidation and other changes start to occur when the grapes are picked, and fruit should be loaded, transported and processed quickly to minimize these changes. However, exceptions to the above rule are sometimes necessary when grapes are picked late in the afternoon on a hot day. Under these conditions, the grapes may be very warm. Hot fermentations are difficult at best, letting the fruit sit overnight and cool down may be the lesser of two evils so in this situation. Larger wineries cool warm fruit with large refrigeration systems. Small wineries and home winemakers try to avoid warm fruit. On harvest day, small producers get to the vineyard early while the grapes are cold. Then they load, transport and process the grapes quickly. Unfortunately, home winemakers seldom have much control over when or how the grapes are picked. Large vineyards must cater to local wineries, and grapes going to a winery are usually the first to be picked and loaded. Handling small quantities of grapes is often difficult for large vineyards, and the grower is usually doing the home winemaker a favor. Therefore, when a home winemaker picks up a ton of grapes, he or she often has little choice and must accept warm fruit picked late in the day.

Growing Grapes

Many professional and amateur winemakers prefer to grow their own grapes because having complete supervision of the vineyard gives the winemaker the greatest control of grape quality. Most home winemakers are never able to purchase really high quality fruit, so when a home winemaker is determined to make quality wines, his only alternative is to plant a small vineyard. When suitable space and water are available, planting a few hundred vines is a practical solution to the high quality fruit dilemma, and more home winemakers are becoming growers.

Materials for a standard two-wine trellis and a drip irrigation system can cost from $1,000 to $4000 per acre.

Sometimes, secondhand vineyard materials can be found, and the savings can be quite large. Vines can be grown on their own roots in areas where the *phylloxera* root louse is not a problem. Cuttings can be planted in these areas, and cuttings are easier, faster and less expensive to plant than rooted stock. Often cuttings can be obtained for nothing each year at pruning time, and when cuttings are planted with reasonable care, a 95 percent "take" can be expected.

Yields

Crop yields from any vineyard depend upon the grape variety, weather, soil conditions, water, etc. Yields of one to two tons of grapes per acre are common in old, dry farmed, coastal vineyards. In the Central Valley, heavily fertilized and irrigated vineyards planted with Carignane, Grenache or Zinfandel grapes often produce twelve or more tons per acre. However at these high crop levels, the color is deficient, the acid level low and overall fruit quality is often poor.

Yields of four or five tons per acre can be expected for well grown high quality grape varieties. If an acre containing 600 vines produces four tons of grapes, each vine would be producing about 13 pounds of grapes. Thirteen pounds of grapes will make about a gallon of wine. But, such yields apply to large, mature vineyards managed by experienced grape growers. Small vineyards are more difficult to manage successfully, and small, isolated vineyards are much more susceptible to deer, coyote, rabbit, bird, and bee and wasp damage. So, one gallon of wine per vine may be too optimistic for small, isolated vineyards.

GETTING READY

Conscientious winemakers take a complete inventory of winemaking materials and supplies, and orders for needed cellar supplies are placed early. Then all of the equipment is assembled, inspected and repaired several weeks before harvest time. Then when each piece of equipment is in good working order, all of the equipment is cleaned carefully. Conscientious winemakers are prepared to make wine long before the first grapes of the season are picked.

Supplies

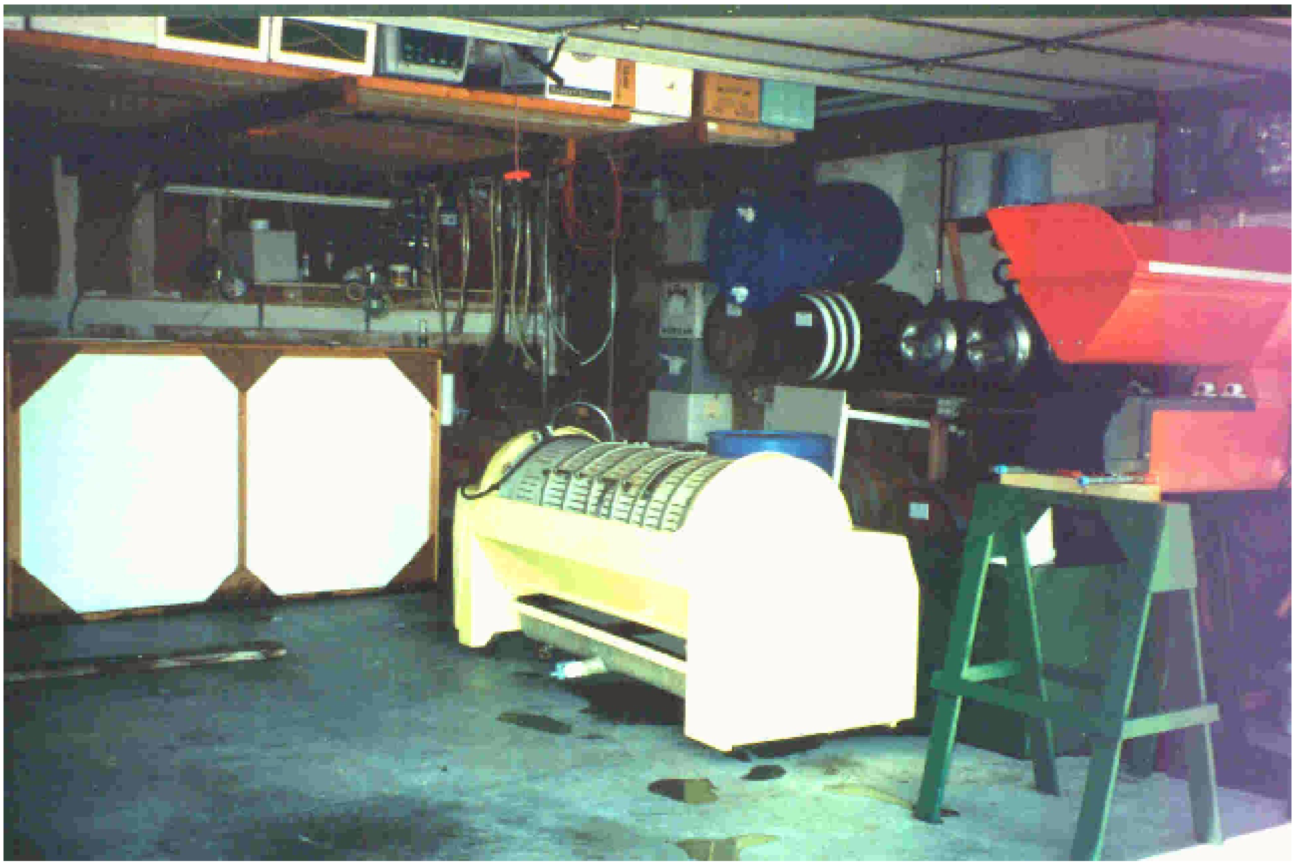
Orders for winemaking supplies should be placed several weeks before harvest time because suppliers are very busy just before and during a crush season. Home winemakers often get together and order winemaking supplies in commercial quantities to reduce their winemaking costs. For example, a 500-gram package of Prise de Mousse active, dry yeast cost $8.50 in 1997. The cost of a 5-gram envelope of the same yeast was $0.75, so buying yeast in five-gram envelopes is expensive.

Home winemakers bottling twenty or so cases (50 gallons) of wine a year will need the following winemaking supplies each crush season.

Tartaric and citric acid.
Active dry wine yeast.
Malolactic bacteria (optional)
Yeast nutrients (Di ammonium phosphate, yeast hulls, *Superfood*, etc.).
Sulfite powder.
Fining materials (bentonite, gelatin and Sparkolloid)
Filter materials (pads or cartridges).
Laboratory test chemicals.
Sanitation materials (chlorinated TSP, Clorox, etc.).

Equipment

Most winemakers assemble, inspect and test their equipment several weeks before harvest time. All machinery should be checked for rust and corrosion, and motor powered equipment should be inspected for cracked belts and frayed electrical cords. Rusty equipment should be scraped, sanded or sandblasted. Then the clean surfaces can be painted. When all repairs are complete, the equipment should be tested for proper function. When everything is in good working condition, the equipment should be scrubbed with a chlorinated TSP solution. Then the equipment should be rinsed with clean water several times and drained completely. All winemaking equipment should be in good working condition, clean and ready for use before the first grapes are expected.



Tanks

All empty tanks, drums and other containers should be checked for leaks. After any needed repairs have been made, the containers should be scrubbed with a chlorinated TSP solution. Then the containers should be rinsed several times with clean water and drained. Drums, carboys and other small containers can be stored away until needed. In a few wineries several weeks of hectic bottling are required each crush season because the tanks are full of last years wine. Most winemakers do not postpone bottling, and they have clean, empty tanks well before the crush season.

Barrels

Empty barrels should be checked for acetification or moldy smells or off-odors, and novice winemakers must learn to trust their noses when cleaning and testing wood cooperage. Sweet smelling barrels should be filled with clean water and carefully checked for leaks. Sometimes leaky barrels must be soaked for several days to swell the stays and stop the leaks. Then the barrels should be sterilized either by burning a sulfur wick or by filling the barrel with SO_2 gas from a high-pressure cylinder. Barrels sterilized with sulfur dioxide can be held in good condition for several weeks if they are kept tightly bunged to retain the sulfur dioxide gas. Barrels stored in this way must be rinsed with clean water immediately before they are filled with wine. Empty barrels stored for more than a few months will require extra attention.

SUMMARY

Lots of things can and do go wrong during crush, and most winemakers develop detailed crush plans early each year to reduce the number of quickly made, high risk decisions

Most winemaking materials keep well, but sulfite powder, yeast and laboratory reagents should be replaced each season. Orders for winemaking supplies should be placed early in the season because suppliers are very busy just before and throughout the crush season.

Generally, large vineyards prefer to sell their grapes early in the season, and outside fruit sources should be contacted and arrangements to buy grapes should be made early.

All winemaking equipment should be inspected, repaired and put in good working condition. Then the equipment should be scrubbed, rinsed and completely drained. The equipment should be ready to use long before the expected harvest time.

Most winemakers try to go into the crush season with a well-thought out crush plan, adequate winemaking supplies, clean functional equipment and empty tanks.

Chapter 12

WHEN TO HARVEST

Chardonnay and Pinot Noir are early ripening grape varieties, and they are among the first grapes picked each year. Cabernet Sauvignon, Nebbiolo and Carignane are late varieties, and these varieties are the last grape varieties picked. In southern California, the crush usually starts in mid August and ends in October. Harvest times vary from year to year. In early years, the grapes are picked two or three weeks earlier than normal. In late years, Carignane grapes are often picked in late October. The start of the grape harvest depends primarily on accumulated heat. The grape harvest in northern coastal regions starts about three weeks later than harvest in Southern California. For a given location, most of the grapes are harvested each year during a seven or eight-week period.

HARVEST DECISIONS

High quality wine can only be made from high quality grapes. The quality of the grapes always determines the potential quality of the wine, so if the grapes are picked too early or too late, wine quality will suffer. Wine made from under-ripe grapes often has a "green" characteristic. These wines contain excess acid, lack color, lack flavor intensity and lack varietal character. When grapes are picked too late, the wine is high in alcohol and low in acidity. Often, wines produced from overripe fruit have stewed fruit, raisin or prune flavors. Quality wine can only be made from high quality, properly ripened fruit, and deciding exactly when to pick the grapes is the most important decision a winegrower makes each crush season.

Acid Content

The amounts of tartaric acid and malic acid are about equal when grapes start to change color and soften (*veraison*), and the quantity of tartaric acid remains roughly constant throughout the ripening period. On the other hand, the quantity of malic acid decreases as the grapes ripen, and the loss of malic acid results in a gradual decrease in the total acid content during the ripening period. In hot growing regions, much of the malic acid is gone by harvest time. Depending upon the variety and the growing conditions, grape juice contains 1.5 to 5 times more tartaric acid than malic acid.

In cold viticulture regions, ripe grapes have an acid content ranging from 0.7 to 1.3 percent. Such high acidity fruit often results in excessively tart wine so winemakers in cold growing regions use special procedures to reduce wine acidity. The situation is quite different when grapes are grown in warm regions like the interior valleys of California. Here, the acid content of ripe grapes often falls between 0.4 and 0.8 percent. Grapes grown in such warm climates often have too little acidity, and wine produced from grapes low in acidity is often bland and flat tasting. Besides producing bland wines, fermenting grapes low in acidity often results in other problems, so adding acid to grapes grown in warm regions is a standard winemaking practice. Large acid additions are best made before fermentation is started.

pH

As grapes ripen, malic acid is lost. The titratable acid of the juice decreases but the pH value slowly increases. Late in the ripening process, just as the grapes are reaching maturity, more potassium ions accumulate in the juice. The potassium ions interact with tartaric acid, and this interaction causes the pH of the juice to increase more rapidly just as the grapes are reaching maturity.

Sugar Content

Historically, sugar content was the primary indicator of grape ripeness, and growers still rely on sugar readings to help them decide when the grapes are ripe. Consequently, obtaining accurate sugar measurements is important. In the United States, grape sugar content is measured in units of degrees Brix, and the measurement is made with a hydrometer or a refractometer. Most growers prefer to use a hand-held, temperature compensated refractometer in the vineyard. Refractometers are handy sugar measurement instruments because they can measure the sugar content of small amounts of juice quickly. Well built, temperature compensated refractometers cost about $300, and good uncompensated instruments can be purchased for less than $150.

TAKING SUGAR SAMPLES

Making accurate sugar measurements in large vineyards is not easy. The grapes from a single cluster contain different amounts of sugar. Grapes from high on the cluster normally contain more sugar than grapes from the bottom of the cluster. Grapes taken from clusters exposed to the sun contain more sugar than grapes taken from clusters growing in heavy shade. Grapes taken from vines growing in different parts of a vineyard can have large differences in sugar content. Variations of two degrees Brix often occurs over a ten-acre vineyard block.

Because of the large variations in sugar content, large size samples must be collected to produce accurate results. Samples of about 100 individual berries are considered the minimum size for small vineyards, and many winemakers prefer 200 to 1000 berries.

Besides a large sample size, measurement accuracy also depends on how sample grapes are collected. The grapes must be collected in a consistent way from the area to be picked, or the results will be misleading. For example, picking one grape from each vine in a 100-vine vineyard could collect a uniform and reasonable size sample. In a tiny vineyard of 30 vines, picking one grape from three or four clusters on each vine would be appropriate. A much larger sample would be picked in vineyards containing several thousand vines. Here, picking one grape from every fourth or fifth vine would collect a uniform sample of several hundred grapes.

Collecting a representative sample of grapes from the area of the vineyard that will be picked is very important. If the intent is to pick the first six rows in a block of vines, then only first six rows should be sampled. If the whole vineyard will be picked, then sample the entire vineyard.

Collection Procedure

The following grape collection procedure has been used for some time. This method produces good results, and the procedure is particularly useful when several different vineyard blocks are sampled on the same day.

(1) A quart size, heavy weight, zip-seal “baggy” is used to collect the grapes. The date and the vineyard block being sampled can be written on the baggy with a “magic marker.”
(2) Grapes can be collected from each vine, every other vine, every fifth vine, etc. But at least 100 grapes should be collected from the vineyard block of interest.

(3) Most of the sample grapes should be picked from the bottom of the clusters (watch out for bees and wasps), and most of the sample grapes should be picked from clusters growing in the heavy shade.
(4) The baggy should be sealed and the grapes kept cool until the measurements have been made.

Sugar Measurement Procedure

The measurement procedure described below assumes the sugar content is being measured with a short-range hydrometer. However, once the juice has been collected, either a hydrometer or a refractometer can be used to measure the Brix.

(1) Remove any air from the baggy. Seal the baggy tightly, and lay it on a smooth flat surface. Use a heavy, flat-bottomed glass tumbler to crush the grapes in the baggy gently. Crush all the grapes, but be careful not to press too hard because the seeds can puncture the baggy and cause messy leaks.
(2) Use both hands and knead the mass of grapes in the baggy for several seconds to extract the juice.
(3) Unseal the baggy and hold the lip of the baggy over a hydrometer cylinder with the left hand, and carefully squeeze the juice out of the baggy with the right hand. (With a little practice, the seeds, skins and pulp can be retained in the baggy).
(4) When the cylinder is about half full of juice, lower the hydrometer into the cylinder and give it a gentle twist.
(5) Add more juice until the hydrometer is floating at a convenient height.
(6) Wait a minute to let the hydrometer settle. Then tap the cylinder a few times to make sure the hydrometer is not stuck to the side of the cylinder.
(7) Read the hydrometer scale at the bottom of the meniscus and record the Brix value.
(8) Remove the hydrometer from the sample, and measure the temperature of the juice with a thermometer.
(9) Using a hydrometer temperature correction chart (see Table 3), apply the appropriate correction to the measured value.

Other Ripeness Criteria

While sugar and acid levels are very important to winemakers, these parameters do not tell the whole story regarding grape ripeness. Red grapes from one vineyard may be perfectly ripe and make excellent wine when harvested at 23 Brix. But, the same variety of grapes in a nearby vineyard may produce poor quality wines when picked at 23 Brix. The grapes grown in the second vineyard may not be fully ripe until they reach 25 or 26 Brix. So, sugar and acid content alone are an inferior way of gauging grape ripeness. Winegrowers do pre-harvest sugar sampling and measure Brix, TA and pH, but they also consider other parameters when making harvest decisions. Here are some of the additional parameters that winegrowers use to judge grape ripeness just prior to harvest.

Here are some of the additional parameters winegrowers and winemakers use to help them judge grape ripeness.

(1) Berry Texture: The texture of the pulp changes as grapes ripen. When transport in the phloem slows, the berries start to slowly desiccate. Then the pulp begins to soften and the skins become slightly slack.

(2) Pedicel Attachment: The pedicels can be pulled off the berries with little or no attached pulp when the grapes are ripe.

(3) Red Fruit Flavors: Under-ripe grapes often have a green, herbaceous smell and taste. Ripe grapes have less herbaceous character and more plum and cherry flavors.

(4) Brown-Crunchy Seeds: As grapes ripen, the color of the seeds changes from green to brown and the texture of the seeds becomes harder and crunchy.

(5) Ripe Tannins: Early in the season, the tannin in the skins is harsh, bitter and astringent. As the grapes ripen, the harsh, bitter astringency of the tannin slowly diminishes.

Of course, none of the above parameters are complete indicators of grape ripeness. Brown seeds and clean pedicels do not guarantee ripe fruit. However, these parameters do provide useful information, so when harvest time approaches the winegrower goes to the vineyard every few days to check the status of the fruit. First, he looks at the overall condition of the vineyard to see if the vines are strong enough to continue ripening the crop. Then the winegrower walks up and down the rows picking sample grapes. The winegrower looks at each berry to see if the skins are slack and he gently squeezes the berries between his thumb and forefinger to see if the pulp has started to soften. He removes the pedicel from the berry and looks to see how much pulp is attached. The winegrower then tastes the juice and smells the pulp to see if the herbaceous character has diminished and if the desired red fruit flavors have developed. The winegrower crunches some seeds between his teeth and he spits some seeds into his hand to see if the seeds have changed color. Then the winegrower chews the grape skin to see if the tannins have softened.

After the winegrower has sampled a few dozen grapes, he walks up and down the vineyard again and collects his "sugar sample" of several hundred berries. Later, the winegrower will measure the Brix, TA and pH of the sample grapes. The Brix, TA and pH measurements from the grape sample, together with his vineyard observations, will be used to help the winegrower decide when the vineyard should be picked.

SUMMARY

High quality wine can only be made from high quality grapes, and grapes are in prime condition for just a few days. Picking wine grapes near optimum ripeness is very important, so winemakers start sampling the grapes well before harvest time. Large size samples are collected and a variety of measurements are used to decide when to pick the grapes each crush season.

Sugar content is the traditional way of judging grape ripeness, but winemakers also measure acidity and pH. In addition, winemakers also carefully smell and taste the flavor characteristics of the sample juice. Each winemaker has his or her way of noting and recording grape flavor attributes, and experienced winemakers make his or her picking decisions based on many different factors.

Chapter 13

GRAPE PROCESSING

Beginning winemakers often view crushing and pressing as the most important parts of winemaking. However, these operations are only simple, mechanical operations. Machines do the crushing and the pressing, and if the machines are designed and operated properly, the mechanical operations have little influence on the quality of the wine. Fruit quality depends on many factors such as where the grapes were grown; when the grapes were picked, the acidity and the pH of the juice, fermentation temperature, skin contact time and other parameters. Wine quality is far more elusive than just being careful how the grapes are mashed and squeezed.

Oxidation and biological changes start when the grapes are picked, and just a few hours can make a significant difference in hot weather. Consequently, winemakers should get to the vineyard early on picking day, and they should be prepared to load, transport and process the fruit as quickly as possible. Other problems can occur when grapes are picked late in the afternoon on a hot day. Fermentation temperatures can become excessive when warm grapes are fermented. But, high temperature fermentations are not conducive to wine quality. In addition, hot fermentations can kill the yeast and result in stuck fermentations. Commercial wineries use a heat exchanger and a large refrigeration system to cool juice quickly. Home winemakers often let warm fruit sit overnight and cool before it is crushed. Either way, experienced winemakers try to avoid crushing hot grapes.

CRUSHING

Crushing breaks the skins of the berries and allows the juice to flow. Crushing should be done with a minimum of grinding and tearing of the grape tissues, and the seeds should never be cracked or broken. Destemming is done to remove the fruit from the stems. Stems contain high levels of phenolic materials, and these materials contribute bitterness and astringency to wine. Excessive quantities of stems can also introduce a green, herbaceous characteristic to the wine, so practically all red grapes should be de-stemmed before fermentation is started. On the other hand, removing the stems from white grapes is not necessary when the fruit is pressed immediately. Sometimes, not removing stems from white grapes can be an advantage. The pulp of some white grape varieties is very slippery and difficult to press. These slick grapes are much easier to press when the stems remain in the must.

Crushing Red Grapes by Hand

Crushing a small quantity of red grapes by hand is easy, but wine yields will be low unless a good winepress is used to separate the new wine from the solids at the end of fermentation. Several hand-crushing techniques have been developed, and most of these procedures are satisfactory for handling small quantities. The following procedure is simple, and it can be used for quantities of 200 or 300 pounds.

(1) Place a clean plastic milk crate on a new 32-gallon plastic trashcan or any other suitable ridged container.
(2) Place several pounds of grapes in the crate. Smash the clusters with a board or both hands.
(3) Use a wash board, scrubbing motion with one hand. The grapes and juice will fall through the bottom of the crate into the container, and the stems will remain in the crate.
(4) Remove the bare stems from the crate.
(5) Repeat this procedure.

Not all of the grapes will be crushed, but unbroken berries will not cause problems. When the fermentation is pressed, the winepress will break the skins of the whole berries, and most of the juice will be recovered. In fact, some winemakers deliberately leave some whole berries in their fermentations. These winemakers feel the presence of whole grapes during fermentation increases the fruitiness of the finished wine.

The stems of some grape varieties are abrasive, and sometimes the above procedure can be hard on the hands. After an hour or two of scrubbing grapes, fingers can become raw, and hands can become badly stained. So, a pair of heavy rubber gloves may be desirable when large quantities of fruit are crushed by hand.

Crushing by Foot

Crushing grapes with bare feet is a popular notion, but bare feet are not very practical. Grapes stain bare feet black, not red. Grape tannin can cause bare feet to become dry, and the skin around the toes sometimes cracks. Some varieties of grapes have stiff, sharp stems, and these stems can be uncomfortable to tender, bare feet.

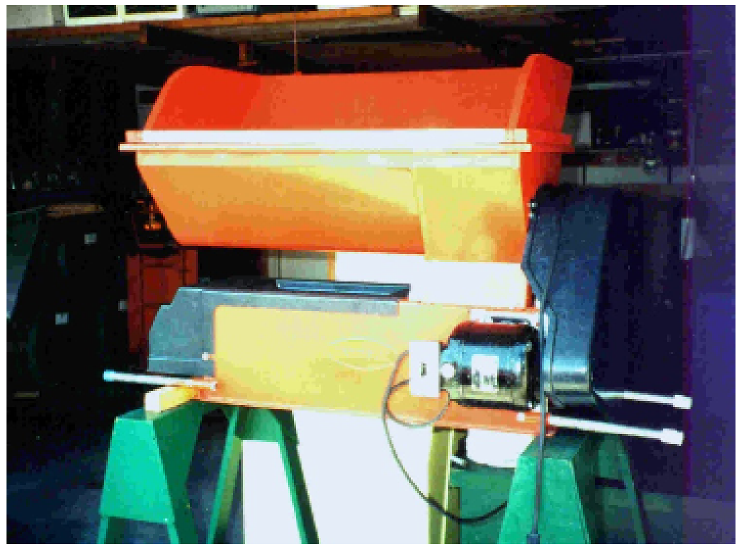
Crushing several hundred pounds of red grapes by foot is quite feasible, but instead of bare feet, an old pair of well-scrubbed rubber boots should be used. A shallow, rigid container of some kind is needed to hold the fruit. Large, plastic mortar boxes are available at large hardware stores, and these shallow boxes make suitable containers. A rhythmic motion should be used when crushing. The feet should be kept moving around in the container to make sure the grapes in the corners of the container are crushed. Grapes can be slippery, and some kind of hand support will be needed to help maintain balance as the grapes are stomped.

Hand Crank Crushers

Most home winemakers use a hand crank crusher. Crushers with both single and double rollers work well, although, some machines are easier to crank than others. These little machines are simple to operate. Place the crusher on top of a suitable container, and fill the hopper with fruit. Turning the crank at a moderate rate pulls the clusters of grapes between the rollers. The grape skins are broken, and the crushed grapes, juice and stems drop into the container. Hand crank crushers should be adjusted to a convenient working height, and cranking the crusher will be much easier if a clamp is used to hold the machine steady. Most winemakers crush all of the grapes, and then they destem the must. A few winemakers do not destem some red varieties at all.

Crusher/Stemmer

Practically all commercial wineries and some advanced home winemakers use motor driven crusher/stemmers to process the grapes. A crusher/stemmer crushes the berries and removes the stems in one easy operation. The better machines have power driven augers to move the fruit along the hopper into the crushing mechanism. Operation is simple and fast. Grape clusters are dumped into the hopper, and the machine does the rest.



Power crushers have capacities ranging from about 1 ton to more than 50 tons per hour. Even the smallest machines crush and destem large quantities of fruit in a short time. One person is busy keeping the hopper full of grapes. Power crushers save a great deal of labor, but they are expensive. Small power crushers made of painted steel sell for six or seven hundred dollars. The same machine fabricated from stainless steel, sells for about $1000. Justifying the expense of a power crusher is difficult for home winemakers unless several barrels of wine are made each year.

PRESSING

The process used to separate the liquid from the grape solids is called pressing. Squeezing a small amount of juice from white grapes by hand is possible. However, juice yields will be low, and a surprising amount of labor is required to squeeze sweet pomace by hand. A press of some sort is a practical necessity for making more than a gallon or two of white wine.

Pressing red fermentations is a different situation. As red grapes ferment, alcohol breaks down the cell tissues. The partially disintegrated pulp then gives up the juice more readily, and red pomace is much easier to press than white grapes. Pressing small, red fermentations by hand is relatively easy, and reasonable quantities of wine can be recovered.

Hand Pressing Red Pomace

The following method is suitable for pressing by hand if the red grapes were crushed completely before the fermentation was started.

(1) Obtain a plastic milk crate and cut a piece of 3/4-inch plywood to fit inside the crate.
(2) When fermentation is complete, carefully siphon off as much "free run" wine as possible.
(3) Place the plastic milk crate on a 32-gallon plastic trashcan or other suitable container and put a double layer of plastic window screening in the bottom of the crate.

(4) Nearly fill the crate with the wet pomace and place the plywood on top. Press the pomace by hand and then place a heavy weight on the plywood.
(5) Let the pomace drain for 15 or 20 minutes. Then stir the pomace and repeat step four.

Depending upon the grape variety and the length of the fermentation, 60 to 80 percent of the potential wine can be recovered by hand pressing using this method.

Basket Press

Most home winemakers use a vertical basket press of some kind, and some of these presses are designed to produce high pressures. High press pressures dry the pomace quickly, but high pressures can also produce astringent and bitter wines. Very high press pressures are not desirable, and compound, ratchet type presses must be used with care. The following procedure produces good results when modest press pressures are used.

(1) Fill the basket with crushed fruit. Add the top plates, the blocks and the press head. Apply a small amount of pressure until a steady flow of juice is produced.
(2) When the flow almost stops, increase the pressure by a small amount and wait again. Large amounts of foam between the basket slats will oxidize the juice, and the foam is an indication that pressure is being applied too rapidly.
(3) Continue increasing the pressure in steps until no more liquid can be obtained.
(4) Disassemble the press by removing the press head, blocks, top plates and the basket.
(5) Remove the pomace cake from the press. Place the pomace in a shallow container or on a clean concrete floor and crumble the cake with a shovel.
(6) Replace the basket on the press. Fill the basket and start the next pressing cycle.

Depending on the variety of the grapes, about 150 gallons of high quality juice can be produced from a ton of grapes using these procedures. But, the pomace cake must be crumbled several times to produce 150 gallons of juice. Pressing white grapes with a vertical basket press is a lengthy procedure, and much labor is required to break down the press and crumble the press cake.

Labor is expensive. So most commercial wineries no longer use vertical basket presses. Instead, most wineries use bladder or membrane horizontal presses because the machines can crumble the pomace cake automatically. Consequently, many press cycles can be used economically, and six or more press cycles are often used to dry the pomace completely. Instead of using high pressures and two or three press cycles, modern horizontal winepresses use low pressures and many cycles to produce 160 to 180 gallons of high quality juice from a ton of fruit.

MUST ADJUSTMENTS

Winemakers carefully measure the juice when the grapes are crushed; so they can make any needed adjustments before starting fermentation. If sulfur dioxide were not added when the grapes were crushed, it would be added at this time. Small additions of yeast nutrient would be made to grapes grown in vineyards deficient in nitrogen, and tartaric acid would usually be added to fruit grown in warm viticulture regions.

Sulfur Dioxide (SO_2)

Sulfur dioxide helps control wild yeast growth, and it is effective in suppressing several types of bacteria. It also helps reduce oxidation of the must, juice or wine. Big wineries use large quantities of SO_2, so they purchase sulfur dioxide gas in steel pressure cylinders. Small wineries and home winemakers generally add a solution or water and potassium metabisulfite (sulfite) crystals to produce sulfur dioxide gas in their wines. In general, 25 to 50 milligrams of SO_2 per liter of juice are added prior to starting fermentation.

Sulfur dioxide is more effective when it is added early in the process. Larger wineries have an SO_2 container and a metering pump mounted right on the crusher. The sulfur dioxide is automatically dispensed whenever grapes are going through the crusher. Home winemakers usually add a half-teaspoon of sulfite crystals for every 100 pounds of grapes. The sulfite powder is dissolved in a small amount of water, and the solution is added as the grapes are being crushed.

A few winemakers do not add sulfur dioxide early. They feel white wines retain better color and malolactic fermentation is easier to complete when no sulfur dioxide is added when the grapes are crushed. These winemakers prefer to make the first sulfur dioxide addition later in the winemaking cycle. However, most experts (UC Davis, Vinquiry, The Wine Lab, etc.) recommend the addition of small quantities of sulfur dioxide early, when the fruit is being crushed. Adding sulfur dioxide early is a much safer procedure for beginning winemakers.

Yeast Nutrients

Many yeast cells are needed to complete fermentation, and yeast must have access to nitrogen, vitamins, minerals and other materials to produce new cells. Some grape varieties like Chardonnay often lack sufficient nitrogen to meet the needs of the yeast, and Chardonnay juice is often difficult to ferment to dryness unless extra nutrients are added. Small wineries and home winemakers seldom have the equipment needed to measure juice nutrients, so these winemakers add small quantities of nutrients to all grapes. Nevertheless, yeast nutrients must be used with care because excessive quantities can produce off-odors and other problems in the wine. The directions supplied should be followed carefully.

Acid

Tartaric, malic and citric acids are present in grapes, and several other organic acids are present in wine. The tart taste of wine is directly related to the quantity of acids present. When a wine contains too much or too little acid, the wine will be out of balance. Most grape varieties grown in the interior valleys of California are deficient in acid when fully ripe. When grapes lack acidity, winemakers often add tartaric acid. Large acid additions should be made before starting fermentation.

Titratable acid (TA) is a measure of the sum of all the organic acids in juice or wine. Most winemakers prefer to ferment white juice when the titratable acid is in the 0.7 to 0.9 percent (gram/100 milliliters) range. Red musts are often adjusted to a titratable acid of about 0.7 percent before fermentation. The titratable acid of the fruit is always measured at crush time, and any needed acid adjustments are made before fermentation is started. Table 11 shows the approximate quantities of tartaric acid to add when juice is deficient in acidity. The acid values are given in grams of acid per gallon of juice. However, acid additions cannot be estimated accurately, so the values given should be considered rough guides.

Grapes grown in cool viticulture regions often contain too much acid, and the finished wine may be too tart. When grapes contain excess acid, winemakers often use calcium carbonate ($CaCO_3$) or potassium carbonate (K_2CO_3) to reduce the acid content of juice or must before fermentation is started. These materials precipitate acid salts from the juice, and when most of the acid in the grapes is tartaric acid, substantial acid reductions are possible. Approximately 3.5 grams of calcium carbonate per gallon of juice will reduce the titratable acid by 0.1%. These carbonates must be used with caution because large quantities of potassium carbonate can raise the pH of the juice to high values. Most winemakers use just enough carbonates to raise the pH of the juice to about 3.3. At a pH value of 3.3 or higher, ML fermentation is not too difficult to start and it can usually be relied on to reduce the acid content to a reasonable level.

TA of Juice (%)	To Obtain 0.7% (g/gal)	To Obtain 0.8% (g/gal)	To Obtain 0.9% (g/gal)
0.40	11.4	15.2	19.0
0.45	9.5	13.3	17.1
0.50	7.6	11.4	15.2
0.55	5.7	9.5	13.3
0.60	3.8	7.6	11.4
0.65	1.9	5.7	9.5
0.70	-	3.8	7.6
0.75	-	1.9	5.7
0.80	-	-	3.8

Table 11. Tartaric acid additions for deficient juices.

pH

The pH of the juice is another important parameter because it gives the winemaker information about just how much sulfur dioxide will be needed to control wine microorganisms. Juices with low pH values (2.9 - 3.3) require little sulfur dioxide, and medium pH juices (3.4 - 3.6) require an average dose. High pH juices (3.7 - 4.1) often require a prohibitively large addition of sulfur dioxide to control the wine microbes effectively.

When working with grapes grown in a warm area, some winemakers add tartaric acid until the titratable acid is raised to approximately 0.8 percent. Other winemakers simply ignore the titratable acid content, and they add tartaric acid until the pH of the juice drops to about 3.4. Experienced winemakers taste the juice and measure the titratable acid and pH. These winemakers use all of the information available when making pre fermentation acid adjustments.

Sugar Additions

When grapes are mature, low sugar content is not a problem. Grapes low in sugar, were picked too soon, and making high quality wine from immature grapes is difficult. Immature fruit will be high in acid, low in flavor and low in varietal flavors and aromas. Home winemakers are often advised to add sugar to immature fruit. The additional sugar will increase the alcohol content of the wine, but the extra sugar will not reduce the acidity, increase the flavor or improve the weak varietal characteristics. Unless the winemaker is interested in producing wines high in alcohol, adding sugar to under ripe grapes is seldom advisable. In colder growing regions, frost danger sometimes occurs before the grapes are completely ripe, and growers must pick or lose their crops. Here, adding sugar to the juice until the hydrometer reads 20 Brix or so might result in better quality wine. Attempting to make a big red wine from such immature fruit is hopeless. Generally, under ripe red grapes are best used by making blush wine. Ordinary white table sugar (sucrose) should be added to the juice or must.

COLD SETTLING WHITE JUICE

Much research has been done on white wine fermentation, and this work clearly shows that fresher, fruitier wines are produced when bits of skin and pulp fragments are removed before fermentation is started. Removing solid materials from the juice results in slower, better-controlled fermentations and the wines have less off-flavors and off-odors. Treating white juices to reduce the amount of suspended material to 1 or 2 percent before fermentation has become a standard winemaking procedure. Solids can be removed from juices with a centrifuge, by filtration or by cold settling. Centrifuges and lees-filters are expensive pieces of equipment, so smaller wineries and home winemakers generally use a cold settling procedure to clarify white juices.

The procedure is simple. Immediately after pressing, the juice is cooled about 50 degrees so it will not start to ferment. The cold juice is allowed to settle overnight in a closed container. In the morning, the clarified juice is racked off the sediment, and the solid material is discarded. Only clear juice is fermented when making white or blush wines. Sometimes additional clear juice can be obtained by resettling the lees. But, the container of lees must be kept cold or a spontaneous fermentation may start.

SUMMARY

Crushing is the mechanical operation that breaks the skins of the berries and starts the juice flowing. Crushing should be done with a minimum of grinding and tearing of the grape tissues. Grape seeds should never be broken. Pressing is the mechanical operation used to separate the liquid from the solids. Pressing should be done at low pressures to reduce the extraction of bitter and astringent materials. Twenty-five to fifty milligrams of sulfur dioxide per liter of juice should be added to the grapes as they are crushed. Juice should be tested, and any needed adjustments should be made before fermentation is started.

Chapter 14

PRIMARY FERMENTATION

Practically all red grapes have clear, colorless juice. The red pigment is in the grape skins. Red wines are made by fermenting the juice, pulp, and skins together, so the red color can be extracted from the skins during fermentation. After several days of fermentation, the new red wine is pressed, and the liquid is separated from the solids. Besides color, other materials are extracted from the skins during fermentation, and these materials produce the astringency and some of the flavors that are typical of red wines.

White and blush wines are produced differently. These wines are made by crushing and then pressing the crushed grapes. White and blush wines are made by fermenting clear juice produced by settling cold juice overnight. Then the juice is racked off the solids before fermentation is started. Almost no skin contact occurs, and only small amounts of color, bitterness or astringency are extracted from the skins.

White wine can be made from red grapes if the contact between the juice and the skins is carefully limited. French Champagne is made from Pinot Noir grapes, and Pinot Noir is a red grape. White Zinfandel and all blush wines are considered white wines because the juice is separated from the solids before fermentation. Rosé wines, on the other hand, are considered red wines because they are fermented with the juice and the skins in contact for a short time. Winemakers use the terms white and red in two different ways. Besides describing color, these terms also indicate the way wine is fermented.

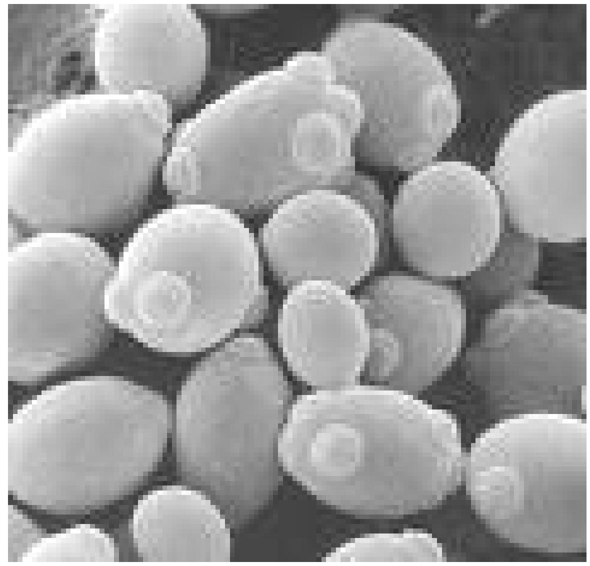
YEAST GROWTH

Wine yeasts are microscopically small, single-cell organisms. Like every living organism, yeast needs energy to survive, and the necessary energy is obtained by metabolizing grape sugars. Ethyl alcohol is produced as an end product, but the yeast does not use the alcohol. They are only concerned with the energy produced when the sugars are converted into alcohol. Besides sugar, yeast must have access to many other materials in order to reproduce new cells.

The conversion of glucose into alcohol is a complicated, multi step, biochemical process. Several different enzymes are needed to convert the sugars, and yeast must have access to vitamins, minerals, oxygen, nitrogen, etc. to produce the required enzymes. Grape juice normally contains all the necessary materials, but sometimes fermentations will lack one or more of these critical growth factors and the yeast cannot convert all of the grape sugars into alcohol. Most stuck fermentations are caused by deficiencies in the starting juice or by excessively high or low temperatures.

Yeast need Oxygen

Yeast reproduces rapidly when sufficient oxygen is available, and yeast populations can double in an hour or two when conditions are just right. The rapid period of yeast growth is called the exponential growth phase, and an enormous yeast population (more than 10 million cells per milliliter of juice) can develop in less than 24 hours. Rapid cell growth occurs during the exponential growth phase, but little alcohol is produced. The situation is different when oxygen is restricted. With little oxygen, yeast cell reproduction is slower, but the yeast cells produce larger amounts of alcohol.



Having oxygen available early in the fermentation process is always desirable from a winemaking point of view. Yeast cells then multiply rapidly, and a large yeast population is produced quickly. Later in the fermentation, oxygen is deliberately restricted to promote alcohol production. This simple technique allows winemakers to encourage early yeast growth, and the resulting large yeast population will convert the grape sugars in a dependable way.

A lack of oxygen is seldom a problem when wines are fermented under typical home winemaking conditions. The necessary quantity of oxygen is rather small, and more than enough oxygen is introduced when the grapes are subjected to the normal winemaking processes of crushing, pressing, etc.

Yeast need Nitrogen

Yeast must have protein to make new cells, and yeast must have nitrogen to produce the protein. Normally, grapes contain enough nitrogen to meet the yeast needs. However, vineyards needing fertilization often produce fruit excessively low in nitrogen content, and then the yeast has problems producing the large numbers of cells needed to complete fermentation. Winemakers often add small quantities of diammonium phosphate (or other sources of nitrogen) to juices low in nitrogen. The diammonium phosphate gives yeast the nitrogen needed to produce new cells and complete the task of fermentation. The yeast and the winemaker are then happy.

Sometimes, a problem develops when nitrogen is added near the end of fermentation. A significant amount of alcohol has accumulated by this time. The alcohol seems to prevent the intake of nitrogen by the yeast cells, and sometimes the fermentation sticks. To avoid this problem, winemakers monitor their fermentations carefully and correct any nitrogen deficiencies early in the fermentation cycle before large amounts of alcohol accumulate.

Yeast need Nutrients

Yeast needs an assortment of vitamins, minerals and other growth factors. Yeast requires very small quantities of these substances, so winemakers often call these materials “micro nutrients.” Normally, grapes contain adequate quantities of these nutrients, but some vineyards consistently produce grapes deficient in some particular growth factor. In these cases, winemakers try to avoid fermentation problems by adding a complete “yeast food” to the juice. Commercial products such as *Superfood* are produced specifically to supply yeast with these necessary nutrients.

Yeast often produces excessive amounts of hydrogen sulfide when they lack *pantothenic acid*. Hydrogen sulfide produces the familiar rotten egg smell, and even small quantities of hydrogen sulfide can damage wine quality, and commercial and home winemakers routinely add minute quantities of *pantothenic acid* to fermentations. *Pantothenic acid* is a common vitamin, and it can be purchased in any drug store.

Handling Dry Yeast

Dry yeast consists of live cells, so it must be handled with care. Yeast weakened by mishandling often requires an unusually long time to start fermenting, and damaged yeast sometimes has trouble fermenting the juice to dryness. Figure 5 shows several ways yeast can be damaged. Dry yeast will remain viable for at least two years when unopened packages are stored in a cool, dry place. However, once a package has been opened, the yeast should be used within a few months. Using open packages of dry yeast the next crush season is risky even when the open packages are stored under optimum conditions. Old, dry yeast should be saved. It is useful for fining wines containing ethyl acetate.

> (1) By prolonged storage at temperatures above 95 degrees.
> (2) By prolonged exposure to air after the package is opened.
> (3) By rehydrating yeast in too hot or too cold water.
> (4) By excessive amounts of sulfur dioxide in the juice.
> (5) By juice temperatures either below 60 degrees or above 90 degrees.
>
> **Figure 5. Dry yeast can be damaged in several ways.**

Rehydrating Dry Yeast

Nine times out of ten satisfactory small fermentations can be started just by sprinkling dry yeast on the must. To avoid problems the tenth time, all yeast manufacturers recommend rehydrating dry yeast before it is added to the must. Yeast rehydration is a simple procedure. Just add the dry yeast to a small amount of warm water. However, the temperature of the water is important, and a thermometer should be used to adjust the water temperature to 100 degrees. About one cup of water is needed for a tablespoon of dry yeast. Stir the yeast mixture until it is smooth. Let it rehydrate for 20 to 30 minutes and then pour the yeast mixture into the must or juice. Most winemakers use about one gram of dry yeast for each gallon of must.

Sulfur Dioxide

Practically all winemakers add small amounts of sulfur dioxide (SO_2) to their fermentations. Added sulfur dioxide deactivates browning enzymes, reduces juice oxidation and suppresses unwanted bacteria and yeast. Reasonable amounts of SO_2 will **not** kill native yeast, but the added SO_2 can suppress wild yeast activity for several hours. Sulfur dioxide can also subdue most wine bacteria. Malolactic bacteria are sensitive to sulfur dioxide, so pre fermentation sulfur dioxide additions should be limited to 50 ppm or less if malolactic fermentation is desired later. Most winemakers add 30 to 50 ppm of SO_2 when red grapes are crushed. Large commercial wineries use compressed carbon dioxide gas because it is relatively inexpensive. Home winemakers usually add sulfur dioxide to their fermentation in the form of potassium metabisulfite powder dissolved in a small amount of water.

RED FERMENTATIONS

Wine contains phenolic compounds in quantities ranging from 0.03 percent for white wines to about 0.5 percent for red wines. Although these quantities are small, phenolic compounds are among the most important wine ingredients because phenolic materials are responsible for wine color, some bouquet and flavor components, bitterness, astringency, browning characteristics, etc.

Extraction

Tannins (large condensed polymers) and anthocyanins (color pigments) are the phenolic compounds of greatest interest to winemakers. Most of the phenolic materials in wine come from the grape skins, seeds and stems. Some phenolic compounds are more soluble than other phenolic compounds. The more soluble compounds are extracted from the grape solids quickly, but longer soak times are necessary to extract the less soluble phenolic materials. Other phenolic materials (tannins) are more soluble in alcohol than in water, and these phenolic materials are extracted late in the fermentation cycle when the alcohol level is high. Pigment compounds and some flavor compounds are quite soluble in water, and these materials are extracted earlier in the fermentation.

Table 12 shows how pigment and tannin compounds accumulate as a function of skin contact time. These data were obtained from a typical Cabernet Sauvignon fermentation, and the data show four important features. (1) More than 90 percent of the total available color was extracted in the first four days of the fermentation. (2) The color intensity of the liquid started to decrease after about eight days of skin contact time. (3) After 20 days of skin contact, the color dropped to about three fourths of the maximum value. (4) Tannins continued to accumulate over the entire 30-day interval.

Skin Contact Days	Color Intensity	Tannin Grams/ Liter
1	0.5	0.8
2	0.9	1.8
3	1.3	2.0
4	1.5	2.5
6	1.5	2.6
8	1.6	3.2
10	1.4	3.4
15	1.3	3.6
20	1.2	3.7
30	1.2	3.8

Table 12. Color and tannins are accumulated differently during fermentation.

Tannins and pigments are extracted from grape solids differently. The data in Table 12 show that most of the color was extracted from the skins by the fourth day, but the tannin content increased throughout the 30-day period. The color pigments (and some flavor materials) are more soluble in water, so these materials are extracted early. Tannins are more soluble in alcohol, so the harsh, biter materials are extracted later in the fermentation when more alcohol has accumulated.

Cold Soaking

Winemakers have developed several techniques to help control the phenolic content of wine. Sometimes a method called “cold soaking” is used to produce red wines with a softer, fruitier character. Wines produced this way require less aging, and some wines can be consumed a few months after bottling.

Small producers often use the following procedure to produce light, fruity red wines. (1) Sound grapes are crushed, and a small amount (30 mg/l) of sulfur dioxide is added. (2) The crushed grapes are placed in a closed container, and the headspace is blanketed with carbon dioxide gas. (3) The must is cooled to 50 degrees or lower. (4) The crushed grapes are held at the cold temperature for a time ranging from one to several days. (5) The refrigeration is then removed, and the crushed grapes are allowed to warm. (6) When the crushed grapes reach room temperature, they are inoculated with yeast and fermented in the usual way.

Significant quantities of color and flavors are extracted from the grape solids during the prolonged, cold skin contact time. However, relatively little tannin is extracted during the cold soak because the juice contains no alcohol. This technique can be used with any grape variety, but cold soaking is particularly effective for Pinot Noir fermentations.

Fermentation Temperature

Red wines are normally fermented at temperatures ranging from 70 to 90 degrees. Within this temperature range, fermentations lasting from four to ten days are typical. Small wineries and home winemakers often use open fermenters, and most small red fermentation tanks are not fitted with elaborate temperature control equipment. Red fermentations can become fast and generate large quantities of heat in warm weather, and sometimes winemakers get into trouble. Yeast is sensitive and cannot survive for long when fermentation temperatures exceed 90 degrees. Consequently, small producers watch their fermentations carefully, and when necessary, they use cold water, ice or any means available to cool their fermentation tanks. Red fermentation tanks in larger wineries are temperature controlled, and fermentation temperatures are established simply by adjusting a thermostat.

Cap Management

Bubbles of carbon dioxide gas are formed during active fermentation, and the bubbles stick to the grape skins. The bubbles make the skins more buoyant, and the skins float to the surface of the fermenting liquid. After a few hours, a thick layer of skins and pulp is formed. As the layer of skins rises, liquid slowly drains away. The "cap" of skins becomes dry and dry caps create problems for winemakers. Some skins are no longer in the liquid, so color and flavor extraction decreases. Then vinegar bacteria can grow in the cap. The vinegar bacteria convert alcohol into acetic acid, and the acetic acid spoils the wine. So, winemakers periodically breaking up and submerging the cap.

Few home winemakers are equipped to handle batches much larger than a half-ton and a half-ton of grapes can be fermented in a 150-gallon container. Caps on fermentations done in these small containers are only a few inches thick so caps can be managed easily by manually punching down with a suitable tool. Many winemakers punch the fermentation cap down twice a day. But, several studies have shown that more color and more flavors are extracted when the cap is gently punched down several times each day.

Large wineries ferment their red wines in closed stainless steel tanks, and they use a technique called "pumping over" to keep fermentation caps wet. A powerful pump is used to move liquid from the bottom of the tank to the top of the tank where it is sprayed over the cap.

Early Pressing

The phenolic content of red wine depends on the length of time the liquid is in contact with the grape solids, and skin contact time is a common method used to control the astringency of red wines. The term early pressing is used when red fermentations are pressed before they reach dryness, and early pressing is a common and effective technique for producing soft, fruity red wines. Skin contact times are short, so the tannin content is low. Usually, four to seven days of skin contact will produce ample extraction when red wines are fermented at normal temperatures.

Winemakers often produce light, fruity red wines by pressing the fermentation when the sugar content drops to four or five degrees Brix. However, wines pressed too early are often too light in structure, and these wines can also lack complexity. Full-bodied red wines are normally pressed when the hydrometer reads zero, and some big red wines are kept on the skins for three or four weeks.

Sometimes novice winemakers attempt to make a big red wine by using an extra long skin contact time. But, more than long skin contact times are required to make exceptional wines so such attempts usually fail. High quality wines can only be made from very high quality grapes, and home winemakers seldom have access to outstanding fruit. Skin contact time is always something of a compromise and there are no fixed rules. Knowing when to press a red fermentation is part of the winemaking art.

Press Pressure

More tannin is extracted from the solids when press pressures are high. Because of this pressure effect, "press wine" (the wine obtained late in the pressing operation) contains more phenolic material than "free run" wine (the wine obtained before much pressure is applied). Consequently, winemakers also use pressing technique to help control red wine astringency.

Most home winemakers mix the free run wine and the press wine together, but many professional winemakers ferment and age the more astringent press wine separately. Then if the winemaker feels more body and astringency are needed, the press wine is blended into the main batch later in the winemaking process. Holding press wine separate from the main batch gives these winemakers a simple, convenient way to adjust red wine astringency.

WHITE FERMENTATIONS

White wines are different from red wines. White wines contain less phenolic material than red wines, and consumers can tell the difference even when the wines are tasted in complete darkness. White wines have less bitterness and astringency than red wines because the phenolic content is lower.

Quality red wine can be made with rudimentary equipment, but high quality white table wine is much more difficult to make with simple equipment. White wine oxidizes easily, and the effects of oxidation are more apparent. Any off-odors or off-tastes are very apparent in white or blush wines. More and better winemaking equipment is needed to make high quality white table wine, and home winemakers must be prepared to expend more time and effort.

Pressing White Grapes

White grapes are more difficult to press than red grapes. The pulp of some white varieties is very slippery and slimy, and extracting juice from slimy pulp is difficult. Modern, winepresses can be programmed to apply low pressures and execute many press cycles automatically. The low pressures used together with many press cycles can remove juice efficiently from white pomace without extracting large amounts of astringent materials. However, most home winemakers use vertical basket presses, and separating juice from slippery pulp with a small hand press can be a difficult and time-consuming job.

Cold Settling White Juice

Cleaner tasting, fruitier wines are produced when juice contains less than 2 percent solids, so removing solids before fermentation is an important step in producing high quality white and blush wines. Large wineries remove juice solids with a large filter system or with a centrifuge. Either method requires expensive equipment. Smaller wineries and some home winemakers use a simple, cold settling procedure to remove the solid materials from their white juices. First, the juice is cooled to less than 50 degrees, and the solids are allowed to settle. After 12 to 48 hours, the clear juice is racked off the residue. The juice is then allowed to come to room temperature and fermentation is started. This is a simple, effective procedure, but unless the juice is well chilled, it will start to ferment. When spontaneous fermentation starts, the carbon dioxide gas creates turbulence, and the turbulence stirs up the juice and prevents the solid material from settling.

Fermentation Temperature

Fermentation temperature is an important quality factor in white wine production. Producing high quality, white table wine is very difficult unless fermentation temperatures can be kept below 60 degrees. Often, novice winemakers do not appreciate the need for cool fermentation temperatures, and large amounts of poor quality white wines are made each season because of excessive fermentation temperatures. Low fermentation temperatures are necessary to retain the desirable fruity characteristics of the grapes.

Light, fruity, white or blush wines like Riesling, Chenin Blanc or white Zinfandel are produced by fermenting well-clarified juice at temperatures ranging from 40 to 55 degrees. Fermentation is very slow at these low temperatures. The carbon dioxide gas is produced slowly and little turbulence is produced. So, the volatile materials are retained in instead of being blown away by violent bubbling.

Steinberg yeast will ferment well at low temperatures, and it is often used to cold ferment Riesling wines. Prise de Mousse yeast also ferments well at low temperatures, but some types of yeast do not. For example, Epernay yeast seldom ferments to dryness at temperatures lower than 50 degrees.

Sometimes full-bodied white table wines like Chardonnay or Sauvignon Blanc are fermented in barrels, and malolactic fermentation is often encouraged. These wines are often aged both in bulk and in the bottle to produce depth and complexity. Full-bodied white wines are usually fermented at temperatures ranging from 55 to 65 degrees.

COMPLETING FERMENTATION

Winemakers monitor fermentations carefully to tell if the sugar is being converted at a reasonable rate and to detect any problems early. Small producers measure the temperature and the Brix of ongoing fermentations once a day. In larger wineries, fermentations are often tested twice a day. Each time the sugar is tested, winemakers also check for potential problems by carefully smelling and tasting the sample. This close attention allows any fermentation problems to be detected early and early detection allows winemakers to take prompt corrective action and avoid catastrophic wine failures.

Testing for Residual Sugar

Sometimes novice winemakers have trouble deciding when fermentation is complete. Fermentation may be complete when the following three conditions are met: (1) all bubbling has stopped, (2) the hydrometer reads **less than minus one Brix** and (3) the hydrometer readings have remained constant for several days. Even when all three conditions have been met, some sugar can remain in the wine. Consequently, most winemakers measure the residual sugar content in all wines shortly after the end of primary fermentation. Low levels of residual sugar can be quickly and easily measured using *Clinitest* tablets. These inexpensive tablets can be purchased at most winemaking supply stores for a few dollars. Clinitest tablets are easy and simple to use but be sure and follow the directions supplied.

STUCK FERMENTATIONS

Occasionally fermentation will stop before all of the sugar is gone, and these "stuck fermentations" are always a concern. Residual sugar in wine represents a major biological instability because fermentation can restart anytime. Winemakers are always frustrated when fermentation restarts late in the winemaking cycle because much of the work done to clarify and stabilize the wine will need to be repeated. More handling is required, and the additional manipulation will not have a positive effect wine quality. Even worse, fermentation can restart after the wine is bottled. Then the yeast produces unsightly sediment in the bottle. The wine becomes effervescent, and sometimes the corks are pushed or the bottles explode.

Causes

Fermentation can stop for a variety of reasons including accidental contamination. However, most stuck fermentations are caused by the following conditions: (1) excessively low or high fermentation temperatures, (2) a lack of available nitrogen, (3) a lack of an essential yeast micro nutrient, (4) the use of damaged dry yeast, (5) excessive quantities of acetic acid. Each of these problems is discussed below.

Fermentation Temperature

Undoubtedly, the most common fermentation problem occurs when red fermentations overheat. The conversion of sugar into alcohol and carbon dioxide produces heat (exothermic). Yeast ferment faster at higher temperatures. Then the yeast ferments more sugar and produce more heat. This can become a run away situation and fermentations can become fast and hot in warm weather. Then problems occur because wine yeasts die when fermentation temperatures exceed 94 degrees for just a few hours. This is why most winemakers check their fermentation temperatures once or twice a day.

Another kind of temperature problem sometimes occurs when Epernay yeast is used for very low temperature, white wine fermentations. Epernay does not tolerate low temperatures well, and it is very sensitive to thermal shock. In fact, Epernay yeast usually stops fermenting if the juice is quickly cooled below 45 degrees or so.

Nitrogen Deficiency

Yeasts require nitrogen to produce the large number of cells needed for healthy fermentations. Most large wineries measure the nitrogen content of each batch of grapes and added nitrogen when needed. Most small producers simply add diammonium phosphate (DAP) to juice and must to provide extra nitrogen and encourage rapid yeast growth. DAP is usually added to juice or must before fermentation is started. DAP is often added with other ingredients (see below), and it is a major ingredient in most proprietary yeast foods.

Practically all wine yeasts produce excessive amounts of hydrogen sulfide when juice lacks sufficient available nitrogen. Here, winemakers add DAP to provide extra nitrogen to the fermentation and help reduce the quantity of hydrogen sulfide produced.

Lack of Micro Nutrients

Besides nitrogen, yeasts require vitamins, minerals and amino acids to reproduce new cells, and grapes deficient in these materials can be difficult to ferment to dryness unless extra micro nutrients are added to help the yeast. “Super Food,” “Startup,” “Yeast Extract,” “Yeast Hulls” etc are some of the commercial preparations used by winemakers to supply micro nutrients and extra nitrogen to their fermentations.

Excessive Acetic Acid

Acetic acid is toxic to all strains of *Saccharomyces* (wine) yeast. Yeast activity is curtailed when the acetic acid content of fermenting juice exceeds about 0.1 percent, and fermentation begins to slow. When the acetic acid content exceeds 0.2 percent or so, few viable yeast cells can be found and fermentation stops.

A subtle fermentation problem can develop in the following way. Controlling bacteria with sulfur dioxide becomes difficult when the pH of the juice is high (above 3.8). Under these conditions, a large population of *Lactobacillus* bacteria can develop early in the primary sugar fermentation. The *bacteria* convert the grape sugars into acetic acid, and the acetic acid content begins to rise. Little or no ethyl acetate is produced by the *Lactobacillus bacteria.* Acetic acid does not have a strong odor, and without ethyl acetate, the winemaker may not be aware of the problem. Undetected, the lactic bacteria can quickly raise the acetic acid content of the juice into the range of 0.1 to 0.4 percent. The yeast cannot tolerate such high concentrations of acetic acid. The yeast cells begin to die, and the fermentation soon stops. The unhappy winemaker is then left with a fermentation that is high in volatile acid and high in residual sugar. The high acid content and the high sugar level, produces a sweet-sour taste in the wine that is a basic characteristic of stuck fermentations that contain too much acetic acid.

Prompt Action Required

The winemaker should try to restart stuck fermentations quickly to prevent bacterial problems. First the winemaker should use a thermometer and make sure the temperature of the stuck fermentation is reasonable. If a nitrogen deficiency is expected, diammonium phosphate should be added to the stuck wine. When fermentation stops early and a large quantity of sugar remains, the additional nitrogen may restart fermentation. Next, the stuck fermentation should be racked with some splashing and bubbling. Sometimes just racking the wine and introducing a little oxygen will be enough to rejuvenate the yeast. When fermentation stops late and little sugar remains, the stuck fermentation should be re-inoculated with a fresh batch of alcohol tolerant yeast such as Prise de Mousse.

When All Else Fails

Some stuck fermentations are very difficult to restart and considerable effort may be required. The following method is often successful **if the original problem has been corrected**. (1) First make a gallon of starter using either Pasteur Champagne or Prise de Mousse active dry yeast. (2) When the gallon of starter is active, add a gallon of the stuck wine to the starter. (3) Wait until the starter becomes active again, and then add two gallons of stuck wine. (4) Wait until the starter is active again, and then add four gallons of stuck wine. (5) Continue this process of waiting until the starter is active and then doubling the volume until all of the stuck wine has been added.

Once active fermentation is underway, the wine should be monitored carefully by measuring the Brix twice a day. When the hydrometer reads less than zero, test the wine with a *Clinitest* tablet to be sure all the sugar is gone

HYDROGEN SULFIDE PROBLEMS

Hydrogen sulfide (H_2S) is a colorless, flammable gas, and it produces the distinctive odor of rotten eggs. The nose is very sensitive to H_2S, so this gas can easily be detected. Most people can detect less than one part per million of H_2S, so very small quantities of hydrogen sulfide can completely spoil a fine wine. In smaller amounts, hydrogen sulfide can give wines a "skunky" or rotten cabbage odor. In even smaller quantities, H_2S may not produce a recognizable odor, but it often destroys the fruity noise of the wine.

Any hydrogen sulfide problems should be corrected as soon as they are detected. Unless hydrogen sulfide is removed from wine promptly, it can react with other wine materials forming mercaptan. Then, mercaptan can be oxidized into disulfide. Disulfide also produces very disagreeable odors and disulfide is very difficult to remove from wine successfully.

Avoiding H_2S

Hydrogen sulfide gas is often produced from elemental sulfur during primary fermentation. Grapes are often treated with sulfur sprays to control powdery mildew, and the residual sulfur on the grapes is transferred into the juice. The sulfur is then converted into hydrogen sulfide by the reducing atmosphere of fermentation. To avoid this problem, most grape growers stop spraying with sulfur several weeks before harvest time.

Sometimes, hydrogen sulfide is encountered during fermentation even when the grapes contain no residual sulfur. Here the problem occurs because the yeast runs short of some needed material. Hydrogen sulfide can be produced when yeast lacks micro-nutrients or vitamins including *pantothenic* acid. A common cause of stinking fermentations is a lack of nitrogen, and mild cases of H_2S can often be cured by adding a small quantity of DAP to the fermentation. Many winemakers add extra nitrogen, micro-nutrients and *pantothenic* acid to their fermentations specifically to avoid the production of hydrogen sulfide gas. Diammonium phosphate is often used as a source of nitrogen, and proprietary yeast foods such as Super Food (from the Wine Lab) can be added to provide micro-nutrients. *Pantothenic* acid is one of the B-vitamins, and it can be obtained at any drug store.

Some strains of yeast produce more hydrogen sulfide than other strains. Montrachet yeast is a particularly bad offender, and it has fallen into disfavor in recent years because of this tendency. Montrachet yeast should never be used with grapes containing residual sulfur dust

Hydrogen sulfide can also be produced when wine is left on the gross lees for long times. Winemakers avoid this problem by promptly racking new wines off the gross lees, or by periodically stirring the wine when long lees contact times are desired.

Removing H_2S by Racking

Hydrogen sulfide should be removed promptly because it becomes more difficult to remove the longer it stays in the wine. Home winemakers often use the following procedure to remove mild cases of hydrogen sulfide from wine. (1) About 50 milligrams per liter of sulfur dioxide is added to the wine (1/4 tsp. of sulfite powder in 5 gals) when fermentation is complete. (2) The wine is then aerated by racking with a great deal of splashing and bubbling to blow off the H_2S gas. (3) The sulfur dioxide in the wine converts a small amount of hydrogen sulfide back into elemental sulfur, and the sulfur settles to the bottom of the storage container. (4) After a week or two, the wine should be racked or filtered to remove the elemental sulfur, or the smell may reappear. Sometimes a stinky wine needs to be racked two or three times to remove the stench completely.

Aeration is often effective in treating mild cases of hydrogen sulfide. But, **aeration should always be used with caution**. Aeration may oxidize mercaptan in the wine into disulfide, and disulfide is as stinky as H_2S and much more difficult to remove.

Removing H_2S with Copper Sulfate

Copper converts hydrogen sulfide gas in wine into a solid material called copper sulfide and the copper sulfide has no odor. Copper sulfide is not soluble in wine, and it settles to the bottom of the tank. After a few days, the winemaker racks or filters the wine off the copper sulfide residue. Some home winemakers rack their stinky wine through a clean piece of copper screen, or they place a few copper pennies in the wine container. But, placing copper metal in wine is not a good idea. Wine has a low pH, and acid in the wine can easily dissolve too much copper. Excessive amounts of copper may be deposited in the wine, so copper metal in wine should be used with care.

Professional winemakers prefer to use a 1-% solution of copper sulfate pentahydrate to remove H_2S because the amount to copper added can be accurately measured. A simple method of removing H_2S is to add enough 1-percent copper sulfate solution to produce about 0.1 ppm of copper in the wine.

Then the wine should be stirred thoroughly. Then, after a few hours, the wine should be carefully smelled. Table 13 shows how much of the 1-percent copper sulfate solution is needed to produce a 0.1 ppm treatment.

One treatment is often enough, but a second or even a third treatment may be necessary for difficult cases. The wine should be left undisturbed for several days after this treatment so the copper sulfide (a very fine black powder) can settle to the bottom of the container. Then the wine should be carefully racked off the copper sulfide residue.

The following rules may be helpful when using copper to remove hydrogen sulfide odors from wine. (1) Never add copper to active fermentations. Copper sulfate added during fermentation often causes more hydrogen sulfide to be formed. (2) Only small quantities of copper sulfate solution are required, so use a pipette and measure carefully. (3) Add the 1% copper sulfate solution in small (0.1 ppm) doses rather than a single large dose. Very little copper will remain in the wine when copper sulfate is used in this way. More copper can be added if needed, but excessive amounts of copper are difficult to remove from wine. (4) The TTB limit for copper in wine is 0.5 ppm so avoid adding much more than 0.5 ppm total.

Gallons of Wine	Milliliters of 1% Solution
5	1
10	2
15	3
20	4
25	5
30	6
35	7
40	8
45	9
50	10
100	20
500	100

Table 13. Milliliters of 1% copper sulfate solution needed to produce 0.1 ppm of copper.

SUMMARY

Red wine is made by fermenting the juice, pulp and skins together. During fermentation, the red color is extracted from the skins. Fruity red wines can be produced by using several well known winemaking techniques such as cold soaking, short skin contact times, careful cap management and low press pressures.

White and blush wines are produced by crushing and then pressing the grapes before fermentation is started.

Slow fermentations at low temperatures are essential for producing a fruity style, white table wine.

A few simple precautions will avoid most fermentation problems. Active, dry yeast should be stored in a cool, dry place (not in a refrigerator), and yeast in packages from packages that have been open for more than a few months should be avoided. Yeast suitable for the fermentation conditions, temperatures and wine style should be chosen, and the directions supplied by the manufacturer should always be followed when storing and rehydrating dry yeast.

Fermentation progress should be monitored by measuring the Brix each day with a hydrometer and by smelling and tasting the juice. If fermentation appears sluggish, nitrogen should be added before much alcohol has accumulated.

Home winemakers remove hydrogen sulfide from wine when fermentation is complete by adding about 50 milligrams per liter of sulfur dioxide. The wine is then racked with a great deal of splashing and bubbling. Commercial wineries use copper sulfate to remove hydrogen sulfide from their wines.

Chapter 15

MALOLACTIC AND OTHER FERMENTATIONS

Beginning winemakers often think the transformation of sugar into ethyl alcohol is the only fermentation process occurring in wine, but many other types of fermentation are possible in wine. Although the alcohol content and the high acidity makes wine a hostile environment for many microorganisms, several yeast and bacteria can exist and reproduce in wine. Besides the sugar transforming yeast, other microorganisms can convert one or more wine components into new materials. The microorganism might use the new material as a growth building block, or the transformation might be a source of energy for the microorganism. The organic acids, alcohols and glycerol are the wine ingredients most often metabolized by these other microorganisms. Winemakers call the transformation of grape sugars into ethanol by yeast primary fermentation, and they usually call the other transformations secondary fermentations.

MALOLACTIC FERMENTATION

Most high quality red wines are produced by two distinctly different fermentations. First, yeast converts the grape sugars into ethanol, and then bacteria in the wine convert malic acid into lactic acid. The conversion of malic acid into lactic acid by bacteria is called malolactic (ML) fermentation, and ML fermentation produces significant changes in wine. Lactic acid is weaker than malic acid, so ML fermentation reduces wine acidity. This reduction in acidity is often used to improve the balance of wines with excessively high acid content. ML fermentation removes unstable malic acid from the wine, and when all of the malic acid is gone, the wine is more biologically stable. Small quantities of different byproducts are produced during malolactic fermentation, and some of these byproducts make positive contributions to the quality and complexity of the wine.

Several different types of wine bacteria can convert malic acid into lactic acid. These lactic bacteria consist of both cocci (round) and bacilli (rod shaped) microorganisms. The principal bacteria responsible for ML fermentation in wine belong to the *Leuconostoc, Pediococcus* and *Lactobacillus* genera. Each genus contains several different species, so the term "malolactic bacteria" refers to a group of microorganisms. When wine undergoes spontaneous ML fermentation, several different kinds of bacteria may be involved. These different microbes react in the wine in different ways and depending upon conditions, the microbes can produce a variety of byproducts.

Diacetyl

Diacetyl is one of several materials produced by ML bacteria. Diacetyl has an odor much like butter, and diacetyl in wine can modify aroma characteristics significantly. Generally, changes in wine aromas are subtle, but some wines like Chardonnay are often enhanced by very small quantities of diacetyl. Winemakers produce specific wine styles by skillfully managing ML fermentation.

Diacetyl is produced **and** metabolized by both ML bacteria and yeast. When ML fermentation occurs during primary fermentation or while wine is aging on active yeast lees, the yeast metabolizes much of the diacetyl and little of the diacetyl produced remains in the wine. A similar situation occurs when ML bacteria are allowed to remain in the wine after malolactic fermentation has been completed. Here, the bacteria consume the diacetyl, and after a few weeks little diacetyl remains in the wine.

Sometimes winemakers leave larger amounts of diacetyl in the wine to produce the buttery characteristics so typical of a full-bodied Chardonnay. When a winemaker wishes to leave larger quantities of diacetyl in the wine, he uses the following strategy. (1) When primary fermentation is complete and much of the yeast has settled, the wine is racked off the gross lees. (2) The wine is inoculated with ML bacteria. (3) The ML fermentation is carefully monitored at least once each week. (4) When ML fermentation is complete, the winemaker adds about 50 milligrams per liter of sulfur dioxide to the wine, and the sulfur dioxide kills the ML bacteria before they can metabolize the diacetyl. Considerable diacetyl can be left a wine using this technique.

At other times, the winemaker may choose to leave little diacetyl in his wine. Here, he uses a different strategy. (1) The wine is inoculated with malolactic bacteria either during or just after the alcohol fermentation when many viable yeast cells are present in the wine. (2) When ML fermentation is complete, both the yeast lees and the bacteria are allowed to remain in the wine for several weeks before any sulfur dioxide is added. During this time, the yeast and the bacteria consume much of the diacetyl. (3) When most of the diacetyl is gone, the winemaker adds about 50 milligrams per liter of sulfur dioxide to kill the bacteria. The winemaker uses standard winemaking procedures to clean up the wine.

Encouraging ML Fermentation

Often, winemakers wish to encourage ML fermentation even when diacetyl is not wanted. Red wines high in acid benefit from ML fermentation because the total acidity is reduced, and the wine has a better balance after ML fermentation. Red wines are more stable when the malic acid is gone, and many winemakers do not want to risk ML fermentation after the wine is bottled.

Spontaneous malolactic fermentation can be encouraged in several ways. (1) Only small amounts (20 to 30 milligrams per liter) of sulfur dioxide are added to the grapes when they are crushed. (2) Keeping wine pH values greater than 3.2 encourage the bacteria. (3) Keeping the wine temperature above 60 degrees encourages ML fermentation. (4) Keeping wine on yeast lees for several weeks can encourage ML fermentation.

Winemakers often inoculate their wines with malolactic bacteria to promote ML fermentation, and pure strains of bacteria are commercially available in both liquid and dry forms. *Leuconostoc oenos* are the bacteria most often used. Bacteria and yeast compete for nutrients in the juice, so ML fermentation is more likely to occur when the bacteria are added early in the sugar fermentation before the yeast has consumed all the nutrients.

Discouraging ML Fermentation

Wines produced from grapes grown in warm areas are often excessively low in acid, and these low acid wines may or may not benefit from ML fermentation. Many winemakers feel malolactic fermentation is not suitable for light, fruity wines because the bacterial fermentation decreases fruitiness.

The following steps are often taken to discourage ML fermentation. (1) Normally, 50 mg/l of sulfur dioxide are added to the grapes when they are crushed. (2) When primary fermentation is complete, the free SO_2 level is raised to about 30 milligrams per liter. (3) The wine is racked off the yeast lees promptly and clarified quickly. (4) Keeping wine cold will also discourage ML bacteria.

Wine Stability

The presence of malic acid in any wine represents a potential stability problem. When wine contains malic acid, ML fermentation can occur anytime, and when ML fermentation occurs after wine has been bottled, the results are often disastrous. ML fermentation in the bottle results in bottle deposits, off-odors, bad tastes and effervescent wine. Any red wine containing malic acid cannot be considered biologically stable, so before these wines are bottled, commercial winemakers take specific steps to improve long term, wine stability.

Commercial red wines containing malic acid are passed through a membrane filter at bottling time. These wines are often perfectly clear, and the filtration is not done to improve their appearance. The filtration is done to remove the ML bacteria from the wine, and sterile filtration is an effective means of preventing ML fermentation in the bottle. Fumaric acid can also be used to prevent ML fermentation in bottled wine. Before effective sterile filters were available, some winemakers added about 500 milligrams of fumaric acid per liter to their red wines just before bottling. Most home winemakers do not have sterile filtration equipment, and many home winemakers continue to use fumaric acid to inhibit ML fermentation in bottled red wine.

OTHER FERMENTATIONS

Malolactic fermentation can produce desirable changes in wine characteristics, but many of the other secondary fermentations produce gross wine spoilage. The changes depend upon when the fermentations occur in the winemaking cycle, on conditions and on the types of byproducts produced. Several common wine microorganisms and some problems produced by these microbes are discussed below.

Lactic Souring

Spontaneous malolactic fermentation is a common red winemaking phenomenon. However, several different kinds of ML bacteria exist, and different types of bacteria produce different byproducts in wine. Unfortunately, many byproducts produced by malolactic bacteria (other than ML fermentation) are detrimental to wine quality.

The French enologist, Emile Peynaud, gives several rules for making red wine in his excellent book "*Knowing and Making Wine*." One of his cardinal rules is " . . . make sure the sugars are fermented by yeast, and the malic acid is fermented by bacteria." This is sage advice because most types of lactic bacteria can and will ferment sugar. When lactic bacteria attack grape sugars, the glucose is converted into lactic acid and acetic acid, and the fructose can be converted into a material called mannitol. When lactic bacteria ferment sugar, the volatile acidity of the infected wine can increase rapidly, and the wine often takes on a characteristic sweet-sour taste. This type of bacterial spoilage occurs most often when wines have an excessively high pH.

Lactic souring and vinegar formation are quite different. Lactic bacteria produce acetic acid by fermenting the sugar. Unlike *acetobacter*, lactic bacteria produce little ethyl acetate and large amounts of air are not required. Sometimes this type of spoilage is difficult to diagnose because the wine often has a good bouquet and the flavor may be good. However, a hot, burning characteristic is always present in the aftertaste. A sweet-sour taste sometimes occurs when considerable sugar remains in the wine. Lactic bacteria are probably the culprits rather than *acetobacter* when wine contains excessive acetic acid and little ethyl acetate.

Controlling bacteria early in the fermentation is important because some types of lactic bacteria prefer sugar to malic acid. Most experts recommend treating grapes with 30 milligrams per liter of SO_2 at the crusher, even if ML fermentation will be encouraged later in the winemaking process. Even at this low level, the sulfur dioxide is effective in limiting early bacterial growth. After a few days of fermentation, the sulfur dioxide level in the wine will be very low, and it will no longer inhibit the desired ML fermentation.

Residual Sugar & Lactic Bacteria

Stuck fermentations often occur in the following way. First, a neglected, red fermentation overheats, and the high temperature kills the yeast. Fermentation abruptly stops, and considerable sugar remains in the wine. The wine is warm, and the wine contains sugar. In this condition, wine is extremely vulnerable. Some lactic bacteria are always in wine, and when the wine is in this condition, these bacteria often attack the remaining sugar. The wine is warm, and large amounts of acetic acid can be produced quickly. A wine can spoil in a short time in this condition.

Lactic souring is the great danger always associated with stuck fermentations, and any significant amount of residual sugar places the wine in jeopardy. Consequently, stuck fermentations should be restarted promptly before lactic bacteria can multiply to excessive levels. This is why some winemakers prefer to inoculate with ML bacteria late in the alcohol fermentation when very little sugar remains in the wine.

Restarting a stuck fermentation of this kind can be very difficult. Large amounts of acetic acid are in the wine, and acetic acid is toxic to wine yeast. Large wineries remove the acetic acid by using a special reverse osmosis process. When the excess acetic acid is gone, new yeast is added to restart fermentation, but reverse osmosis is a complicated process and applying it to small quantities of wine is seldom feasible. Small wineries and home winemakers deal with lactic souring problems primarily by prevention. This is one reason 30 to 50 milligrams per liter of sulfur dioxide should be added when the grapes are crushed. Then tartaric acid is added to the crushed grapes, and the pH is lower to less than 3.5 before fermentation is started.

Acetaldehyde Production

Candida mycoderma can oxidize ethyl alcohol in the wine into a very volatile liquid called acetaldehyde. In small quantities, acetaldehyde gives wine a distinctive nut like aroma. Acetaldehyde is the material that gives sherry its distinctive characteristics. Although the nutty quality is highly desirable in sherry, excessive quantities of acetaldehyde give table wine a tired, oxidized quality that most people do not appreciate. Like vinegar bacteria, *Candida mycoderma* needs large amounts of air. This yeast is often seen as a thin, patchy film floating on the surface of wine, so winemakers call *Candida mycoderma* “film yeast.” Fortunately, film yeast is sensitive to sulfur dioxide.

The following is an effective treatment for wine infected with film yeast. Mix an appropriate quantity of sulfite crystals in a small amount of water then pour the sulfite solution onto the top surface of the wine. Pour carefully so mixing of the sulfur dioxide solution and the wine is reduced, and a large amount of sulfur dioxide is concentrated at the surface. Since the bacteria are growing on or near the surface, this is a potent treatment. Such dramatic treatments are seldom needed if the sulfur dioxide is maintained at reasonable levels and the wine containers are kept completely full and tightly sealed.

Glycerol Fermentation

Under certain conditions, some types of lactic bacteria ferment glycerol in the wine into lactic and acetic acids. Small amounts of acrolein are also produced during glycerol fermentation. The infected wine increases in volatile acidity, and the wine takes on an unpleasant, bitter taste. This type of glycerol fermentation occurs most often in wines low in acid and with high values of pH. Glycerol fermentation is also more common in wine made from heavy press fractions or wines made from moldy grapes. Glycerol fermentation is not very common today because adjusting wine pH to 3.5 or less and maintaining 30 milligrams of sulfur dioxide per liter of wine usually provides adequate protection against this type of wine infection.

Tourne

Tartaric is one of the more stable organic acids. However, a few species of lactic bacteria can ferment tartaric acid into lactic acid, acetic acid and carbon dioxide gas. When tartaric acid is fermented, the fixed acidity of wine decreases and the volatile acidity of wine increase. The wine takes on a strange, dull appearance, and the color turns brown. A strong and disagreeable "mousy" odor often develops.

The French name for this unfortunate wine condition is "Tourne," and when the disease is advanced, the wine becomes undrinkable. Tourne is a gross transformation, and this sickness is more prevalent in wines having high pH values. Fortunately, these bacteria are very sensitive to sulfur dioxide, and maintaining reasonable levels of molecular sulfur dioxide in wine will prevent the development of Tourne.

Vinegar Formation

Vinegar bacteria (*Acetobacter)* are found in the vineyard, on the grapes, in the cellar, on the equipment, in the wood of used wine barrels and in the wine. *Acetobacter* is the bug that converts ethyl alcohol into acetic acid (vinegar). Sometimes, very small amounts of acetic acid in a red wine make a positive contribution to the aroma, but when acetic acid exceeds about 0.04 percent, it produces a burning aftertaste that quickly decreases wine quality. In a warm cellar and with sufficient air present, acetification can progress rapidly, and fine wine can be spoiled in a short time. Along with the acetic acid, vinegar bacteria also produce ethyl acetate, and ethyl acetate has a strong, aromatic smell like finger nail polish remover. This odor is easy to identify, and the smallest hint of ethyl acetate suggests *Acetobacter* activity in a wine.

Vinegar bacteria must have access to large quantities of air to oxidize the alcohol into acetic acid. Colonies of bacteria often develop as thick, wrinkled mats on the surface of the wine where they have direct access to the air. However, vinegar bacteria can and do exist in the bulk of the wine. Barrels infected with vinegar bacteria should be taken out of service because disinfecting materials like wood is nearly impossible. *Acetobacter* activity is controlled by keeping the sulfur dioxide content of the wine at a reasonable level and by keeping wine containers completely full and tightly sealed.

SUMMARY

Besides the primary alcoholic fermentation, several other microbial transformations often occur in wine. Malolactic fermentation reduces wine acidity and improves the long term stability of red wine. ML fermentation produces the butter-like quality prevalent in heavier style Chardonnay wines, and it adds pleasing complexity to red wines. ML fermentation is generally encouraged in red wines because red wine containing malic acid is biologically unstable.

Besides yeast, many other microorganisms exist in wine. These organisms can ferment normal wine components into significantly different materials, and the products of some of these other fermentations can reduce wine quality.

When winemakers are aware of the microorganisms present, they can take effective measures to prevent spoilage. Most types of bacteria are sensitive to small quantities of sulfur dioxide, and many bacterial problems can be avoided by maintaining 20 to 30 milligrams per liter of free SO_2 in the wine. Wine bacteria can also be controlled by other simple techniques. Adding tartaric acid to decrease wine pH and maintaining the wine at low temperatures are both effective control techniques. Keeping wine containers full and excluding air is usually all that is necessary to control vinegar bacteria. Winemakers often use sterile filtration to remove bugs from wine mechanically, and under adverse condition, pasteurization is sometimes necessary.

Chapter 16

FINING AND FINING MATERIALS

Fining materials are used for the specific purpose of removing something from wine. A wine might be fined to remove unwanted color, haze, bitterness, excessive astringency, off-flavors, unpleasant odors, etc. Usually, the fining agent itself is eliminated before the wine is bottled. Wine has been made for thousands of years, and over that lengthy period many different materials have been used as wine fining agents. Each fining material has different characteristics.

Sometimes two or more fining materials are needed to solve a single wine defect. At other times, the winemaker might be lucky and discover that a single fining agent can eliminate multiple wine problems. For example, a dark, murky, blush wine might be fined with bentonite. This single bentonite application might (1) remove excessive protein and make the wine hot stable, and it might also (2) improve the clarity of the young wine and (3) remove a small amount of the excess color.

USING FINING MATERIALS

Sometimes novice winemakers attempt to clear dull, cloudy wines by filtration, but these attempts can be frustrating and expensive. Polysaccharide (gums), yeast cells and some types of bacteria clog filter media very quickly, and the unfortunate winemaker spends much time and expense changing filter pads. Using a fining material to clean up the wine before filtration is often a better approach.

Bench Testing

Bench tests are done on individual wines to decide which fining agent is the best material for the job. Bench tests are also used to learn how much fining material is needed. Tests are made by adding a carefully measured quantity of the proposed fining material to a small quantity of wine. Winemakers make several test samples, and each sample contains a different quantity of the fining material. After an appropriate time, the winemaker examines the samples to see which quantity of fining material produced the desired results. Bench testing is a quick and convenient way for winemakers to try several different fining materials or different dose levels. Many winemakers use clear, 750 milliliter wine bottles for bench testing. However, small wine samples require very small quantities of fining materials, so precise measurements are necessary. An accurate scale and good procedures are needed for meaningful results.

Importance of Dispersion

All fining materials must be evenly dispersed throughout the volume of the wine. Many fining agents are dry powders, and these materials must be mixed with a small amount of water (or wine) before being added to the wine. Most fining materials should be added slowly and thoroughly stirred into the wine. A long handled spoon is satisfactory for mixing a fining agent into a few gallons of wine. A motor-driven, propeller type mixer is more appropriate for larger containers such as barrels or small tanks. Many small wineries do not have mixing tanks, so they often add fining materials when the wine is being racked from one tank into another. The circulation produced by the pump provides adequate mixing.

Multiple Fining

Sometimes a new wine will have several recognizable defects, and it will be obvious to the winemaker that multiple fining treatments are needed. When no other considerations exist, fining operations should be done in the following sequence. (1) Treat hydrogen sulfide problems with copper sulfate. (2) Cold stabilize the wine. Chilling also helps clean up the wine, and chilling also reduces the microbe population. (3) Use protein materials (gelatin, casein, Isinglass, egg whites, etc.) to fine the wine for astringency, clarity or color problems. (4) Fine with bentonite to remove protein and hot stabilize white and blush wines. The bentonite fining will help remove any left over protein material, and it will also improve wine clarity. Sometimes, Klearmore, Sparkolloid or Kieselsol are used to compact the bentonite lees.

Wineries often depart from the sequence given above to reduce handling operations. They fine their white and blush wines with bentonite and then immediately cold stabilize the wine. During cold stabilization, the soft bentonite lees are compacted by the tartrate crystals making racking much easier.

White and blush wines will usually require some kind of treatment to improve clarity, and Sparkolloid is the fining material of choice for this purpose. However, white wines and blush wines are difficult to get completely clear and bright without using some kind of filtration is difficult. On the other hand, most red wines do not require extensive fining treatments. These wines are often given a light protein fining, racked a couple of times during bulk aging and then bottled.

Partial Fining

Removing unwanted material without removing other desirable wine components may not be possible, and compromise is often required. For example, a delicate white table wine might have a slight bitterness in the aftertaste. Fining with a protein material might eliminate the bitterness, but the protein might also remove much of the delicate fruit character. This is a poor trade, and the winemaker is faced with a dilemma. Sometimes, an old German winemaking technique is effective in such circumstances. Here, half the wine is deliberately over-fined, and half the wine is not fined at all. When the wine is combined, at least half the fruit characteristics are preserved, and the bitterness may be reduced by 50 percent. Often, the taste of the resulting product is superior to the original wine.

Multiple Fining

Sometimes, multiple fining applications can effectively reduce wine astringency without devastating wine flavors and aromas. For example, some winemakers prefer to give tannic red wines several light applications of gelatin during bulk aging instead of one large dose. Little extra handling is needed if the wine is fined before a regularly scheduled racking.

FINING MATERIALS

Many materials can be used to fine wine. Some fining materials are expensive, and other materials are difficult to find. Some fining materials are difficult to prepare. Metal removing agents contain cyanide compounds, and these fining materials can be dangerous to use. A few fining materials like gelatins, skim milk and egg whites can be purchased at the corner market. Although many materials can be used to treat wine, most winemakers only use a few fining materials each year.

The preparation and use of several fining materials are outlined below, and the use of several of the more common fining materials is shown in Table 14. These materials are not very expensive and they are easy for home winemakers to use.

Albumin (Egg white)

Egg whites are often used for reducing astringency in red wines. The protein removes some of the harsh phenolic material in the wine. Egg whites have been used to fine French Burgundy and Bordeaux wines for hundreds of years, and it is still used today for fining high quality red wines. Egg-whites are also used to polish clarify red wines to give added brilliance. Egg whites should not be used to clarify cloudy wines. They are not beneficial when used in cloudy wines.

The whites from one to four eggs are the usual quantities used for a barrel (60 gallons) of wine. This is roughly equivalent to ½ to 2 milliliters of egg albumin per gallon of wine. A small pinch of table salt should be added to a cup or so of warm water. The egg white should be separated from the yoke carefully. One part egg white should be mixed with two parts salt water. The mixture should be stirred thoroughly before being added to the wine, but the mixture should not be beaten to a stiff froth. Add the egg white mixture to the wine slowly and stir continuously. The wine should be racked after a week or so.

MATERIAL	PURPOSE	DOSE RANGE	TYPICAL DOSE
AAA Carbon	remove odors (H_2S)	1/4 to 4 g/gal	1 g/gal
	strip wine for blending	2 to 8 g/gal	4 g/gal
KB Carbon	remove unwanted color	1/8 to 1 g/gal	1/2 g/gal
Bentonite	remove protein	1/2 to 4 g/gal	2 g/gal
	general clarification	1/2 to 2 g/gal	1 g/gal
Casein	remove browning	1/8 to 1/4 g/gal	1/4 g/gal
	remove bitter taste	1/4 to 1 g/gal	1/2 g/gal
	remove excess oak	1/8 to 1 g/gal	1/2 g/gal
Gelatin	white wine clarification	1/16 to 1/4 g/gal	1/8 g/gal
	remove bitter taste	1/8 to 1/2 g/gal	1/4 g/gal
	tannin reduction	1/4 to 2 g/gal	1/2 g/gal
Egg whites	red wine clarification	1 to 4 eggs per barrel	- -
	tannin reduction	1 to 6 eggs per barrel	- -
PVPP	remove browning	1/4 to 1 g/gal	1/2 g/gal
	remove excess color	1/4 to 2 g/gal	3/4 g/gal
	remove oxidized taste	1/4 to 1 g/gal	1/2 g/gal
	remove bitter taste	1/4 to 1 g/gal	1/2 g/gal
Sparkolloid	white wine clarification	1/4 to 1 g/gal	1/2 g/gal
	topping over bentonite	1/8 to 1 g/gal	1/2 g/gal

Table 14. Dose levels of some common fining materials.

Bentonite

Bentonite is an extremely fine, clay-like material and it carries a negative electrical charge so Bentonite is used to remove positively charged particles from wine. Bentonite is almost universally used to remove excessive amounts of protein from both white and blush wines. It is also used for clarification fining of white and blush wines, and sometimes bentonite is effective in clearing hazy fruit wines.

A normal dose is 1 to 2 grams of dry bentonite per gallon of wine. However, it is often used at dose levels that range from ½ to 4 grams per gallon. Bentonite can strip desirable aromas from wine when used in excessive amounts (more than 2 grams per gallon), so bench testing should always be done. Bentonite should be mixed with water and allowed to stand for twenty-four hours before being adding to the wine.

Bentonite can be mixed easily in a blender. Put the required amount of hot water in the blender, turn the blender on, and slowly add the dry powder. When the mixture is cool, place it in a refrigerator and allow the bentonite mixture to hydrate for at least 24 hours. Add the hydrated mixture to the wine slowly and stir continuously. Bentonite is a popular fining material, but it has a major disadvantage. It produces large quantities of lees, and the lees are light and fluffy. Wine is difficult to rack off bentonite lees because the lees are so light.

Carbon (Charcoal)

Carbon is fine, black, lightweight powder used to remove unwanted color and odors from wine. Although a common commercial fining material, finely ground carbon is difficult to handle because it flies easily. This material can be extremely dirty, and sometimes, home winemakers have difficulty obtaining carbons in small quantities because of the handling problem.

KBB carbons are acid-activated, and these carbons are used to remove unwanted color from wine. KBB is often used to remove excessive browning from white table wines. This material can improve the appearance of oxidized white and blush wines, and it can give these wines a fresher, cleaner taste. KBB carbon is also used to treat juice from moldy grapes, and large quantities of KBB carbon are used to remove excess red color from blanc de noir champagne materials.

AAA carbon is steam-activated, and it is most useful for removing undesirable odors from wine. Sometimes AAA carbon is used to remove the “nail polish” smell produced by ethyl acetate and it is used routinely when wines containing hydrogen sulfide (rotten egg smell) are treated with copper sulfate. After the copper treatment, a light AAA carbon fining is done to help keep the bad hydrogen sulfide odors from returning.

Carbons are used at dose levels ranging from 1/16 to 5 or more grams per gallon of wine, but more than a ½ gram per gallon can strip desirable color, bouquet and flavors. Carbons must be used carefully, and bench testing should be done before any carbon additions are made to the main batch. Sometimes commercial wineries use large quantities of carbon to strip a “hopeless” white wine completely. Practically all of the bouquet, aromas and flavors are removed by the carbon treatment. Then the stripped wine is blended into a large batch of mediocre wine, and a few gallons of Muscat are added to the blend to improve the nose. Inexpensive, off dry, jug wines often contain a portion of stripped wine in the blend. Obviously, the technique does little for wine quality.

Casein

“A half pint of skimmed milk in 5 gallons of wine” is a traditional fining treatment for white wine. Milk contains casein, and casein is still a popular fining material for white and blush wines. Casein is a protein, and it is used to remove phenolic materials including tannin, excessive oak character and some bitter flavors from wine. Sometimes casein is used to remove small amounts of unwanted color from blush wines, and it is often used to remove the brownish tinge from oxidized white wines. Casein is very difficult to mix with wine, so winemakers prefer to use this material in the form of potassium caseinate.

Potassium caseinate solutions are not very effective when stirred directly into wine. The casein reacts very quickly with acids in the wine, and large lumps are formed. The lumps of casein do little more than settle to the bottom of the container. A better method is to inject the casein solution into the wine under pressure. Large wineries use small, high-pressure pumps to inject a cloud of tiny casein into the wine. Home winemakers often use a large syringe or a rubber bulb.

Typical doses range between 0.1 and 1 gram of potassium caseinate per gallon of wine. Wines fined with excessive quantities of casein can develop a cheesy smell. Bench testing should always be done before the main batch is treated. Wine should be racked off casein lees after a week or ten days.

Gelatin

Gelatin is a popular protein fining material, and gelatins are often used to reduce the bitterness and astringency of red wines. Gelatin removes a quantity of tannin roughly equal to its own weight. Some white and blush wines have a slightly bitter finish, and sometimes fining with a small quantity of gelatin can reduce the bitterness. Gelatins are also used to clarify white and blush wines, and Kieselsol is used to precipitate any excess gelatin residue.

Most commercial winemakers prefer to use a high-grade (higher than 100 bloom) gelatin, but some home winemakers buy gelatin for fining red wines at the local grocery store. The grocery store product is sold as Knox's gelatin, and it comes in a box that contains four, handy seven-gram envelopes. Read the package carefully and be sure to buy an un-flavored gelatin.

Gelatin must be dissolved in water before being added to wine. Gelatin solutions can be prepared by using 1 or 2 grams of gelatin powder for 100 milliliters of warm water. The gelatin powder should be added to the warm water slowly, and much stirring is needed. The mixture should stand for a few minutes, and then the solution should be stirred again until all of the lumps are dissolved. Gelatin solutions should not be boiled because the heat will denature the protein and render the gelatin less effective. The gelatin solution should be used while warm. Add the warm gelatin solution to the wine very slowly, and stir the wine continuously to assure good mixing.

From 1/4 to 2 grams of dry gelatin per gallon of wine are used to reduce tannins and astringency in red wines. Doses ranging from 1/8 to ½ grams of dry gelatin powder per gallon of wine are used to remove bitterness from white and blush wines and from 1/16 to 1/4 grams of gelatin per gallon of wine are used to clarify white and blush wines. Gelatin must be used with care. Small doses can strip wines of desirable character, so bench testing should be done.

Isinglass

Isinglass is a protein material made from the air bladders of Sturgeon fish. The granular form of Isinglass is called Biofine, and this form is much easier to use than the dried, sheet material. Isinglass is used to clarify quality white wines. Some winemakers feel this material improves wine flavors and aromas. Small quantities of Isinglass are often added to sparkling wines to help riddling.

Typical doses of Isinglass range from 0.05 to 0.3 grams of dry Isinglass per gallon of wine. A nominal dose for white table wines is about 0.1 grams per gallon of wine. Make a solution by dissolving Isinglass in a small quantity of low pH wine. Use about 100 milliliters of wine for each gram of granular Isinglass and stir this solution into the wine thoroughly.

Kieselsol

Kieselsol is a silica colloid, and Nalco 1072 is the material most often used in the U.S. wine industry. This material reacts with protein in the wine and precipitates out quickly. Kieselsol is often used in combination with gelatins to clarify white and blush wine, and a gelatin-Kieselsol fining often produces excellent clarification. The gelatin solution should be added to the wine first. Then the Kieselsol should be added a day or two later. Kieselsol is sometimes used to remove excess protein material from white and blush wines. Only very small quantities of Kieselsol are added to the wine, so careful and accurate measurements must be made when using this material. About 1 milliliter of Kieselsol is required for each gram of the gelatin. The wine should be racked off the lees after a week or ten days.

PVPP (Polyclar AT)

PVPP is sold under the brand name Polyclar AT. It is manufactured in the form of very small, round plastic beads. PVPP is a light weight plastic similar to nylon, and this material is completely insoluble in water or wine. PVPP is used to remove browning or pinking pigments from white or blush wines. It is used to remove oxidized odors and for removing small amounts of bitter phenolic compounds. PVPP is often used to fine juice pressed from moldy grapes. Sometimes a light fining with Polyclar can be very effective and produce almost miraculous results. At other times, this material may not be very productive.

PVPP is an easy material to use. The powder is mixed with a small amount of water and then added to the wine. Dose levels range from 1/4 to 2 grams per gallon. About 1 gram per gallon is considered a typical dose. This material reacts with the wine very quickly, so it can be removed from the wine after just a few hours. However, Polyclar does not settle out of wine very quickly, and many winemakers prefer to filter the wine after a PVPP treatment. Sometimes small amounts of bentonite are used as a topping material to help settle the PVPP particles quickly.

Sparkolloid

Sparkolloid is a proprietary material manufactured by Scott Laboratories. It contains a polysaccharide substance dispersed in diatomaceous earth. It comes in hot-mix and cold- mix forms, but the hot form is preferred for clarification fining. Sparkolloid is the material of choice for clarifying white and blush wines. Sparkolloid is one of the more benign fining materials, and when used in reasonable quantities, it seldom strips wine flavors or aromas. It is also used as a topping material, and Sparkolloid can be useful following bentonite or carbon treatment.

Sparkolloid does have a significant disadvantage. It produces very fine lees, and the lees settle out of the wine slowly. Consequently, this material should not be used less than 30 days before bottling time, or small amounts may precipitate later in the bottles. Many winemakers allow for an eight-week settling time just to be on the safe side.

Dose levels range from 1/4 to 1 gram of dry Sparkolloid powder per gallon of wine. About 1 gram per gallon is considered a nominal dose. A solution can be made by stirring Sparkolloid powder into boiling water. The mixture should be boiled for an additional 20 minutes after the powder is added. The Sparkolloid solution is not allowed to cool. The hot solution should be added to the wine and stirred in carefully.

SUMMARY

Many different materials are used to fine wine, and each material has different properties. Therefore, the winemaker must carefully select each material carefully to produce the desired results.

Bench testing is done by treating a small quantity of wine with the proposed fining material. After an appropriate time, the test wine is examined to verify that the desired results have been achieved. When the winemaker feels the fining goal has been met in the test sample, he adds the correct quantity of the fining material to the main batch.

Unsightly protein hazes can form in the bottles unless white and blush wines are hot stabilized. Bentonite is used to remove excess protein from these wines.

Chapter 17

CLARIFICATION AND STABILIZATION

The consumers' first impression of any wine is a visual one. Wine is seen before it is tasted, and wine is expected to be brilliantly clear and have an appropriate color. The consumer is always disappointed when a wine does not meet these visual expectations. Even zealous wine advocates shy away from turbid, dirty-looking wines. Judges at home wine competitions occasionally face this problem, and sometimes, considerable courage is needed to taste a particularly ugly wine.

TYPES OF HAZES

Grape particles and fragments, microbes, protein, tartrate, phenolic polymers, polysaccharide and metals cause most wine haze problems. Wine clarity problems are not mysterious, and unless a wine has been grossly contaminated by the addition of some foreign material, wine haze is normally the result of one or more of these factors. Sometimes a winemaker will encounter a haze that is particularly difficult to remove, but these cases are rare. Identifying the offending material and then acting accordingly solves most haze problems.

Particles and Fragments

Grape particles seldom cause long-term haze problems. Even the smallest bits and pieces of grape pulp and skins are large enough to settle out of wine in a few weeks. However, ML fermentation can produce enough carbon dioxide gas to cause a significant turbulence in a small tank, and the turbulence prevents the smaller particles from settling out. ML fermentation can continue long after the sugar is gone, so winemakers check for the presence of carbon dioxide gas to make sure all fermentations have been completed. When the gas is gone, the particles will settle out, and after the wine has been racked a time or two, it will be clear and bright.

Microbial Hazes

Yeast cells are several microns in diameter, and if the wine is not disturbed, the yeast cells readily settle to the bottom of the container in a few weeks. Usually a little patience will take care of yeast haze problems, but the situation is not so simple with bacterial hazes. Bacteria are 10 to 100 times smaller than yeast cells. Bacteria are so small they may never completely settle out of wine. Large wineries have sophisticated analytical equipment in their testing labs, but even then, some types of bacteria are difficult to identify and treat. Fortunately, many wine bacteria are sensitive to sulfur dioxide.

Once established, a bad bacterial haze can be difficult to overcome. The infected wine can be pasteurized, or the wine can be passed through a sterile membrane filter. Both techniques are effective, and both are common wine procedures in commercial wineries.

Unfortunately, few home winemakers have the sophisticated and expensive equipment needed to apply either of these treatments. Since gross bacterial infections are difficult to handle, home winemakers should maintain strict hygienic winemaking conditions and they should always maintain reasonable amounts (20 to 30 mg/l) of free sulfur dioxide in their wines. Taking these two simple steps will reduce the occurrence of bacterial infections to a very low level. Sometimes home winemakers can rent sterile filtration equipment, and sterile filtration might be a feasible way of saving a particularly pleasing wine. Nevertheless, the equipment and sterilization procedures are complicated. For the average home winemaker, prevention is the most effective way of dealing with bacterial problems.

Protein

Grapes contain small quantities of protein, and some varieties (Sauvignon Blanc) sometimes contain large amounts. Protein is carried over from the grapes into the wine during fermentation. Originally, the protein molecules are much too small to be visible in the wine. However, under certain conditions protein molecules link together (polymerize) and grow larger. After many protein molecules have linked together, the protein particles are large enough to be visible, and the particles are too large to remain suspended in the wine. This growth process is very slow at normal cellar temperatures, but when wine becomes warm, the protein molecules grow more rapidly. At temperatures of about 120 degrees, protein molecules can link together and form large particles in a short time.

A bad protein haze is very unsightly in a bottle of white or blush wine. The protein particles are light and fluffy, and they produce a swirling cloud when the bottle is disturbed. When white or blush wines are subjected to warm storage conditions, protein hazes can form quickly, and all commercial white and blush wines are specifically treated to remove the excess protein before bottling. Winemakers call protein haze hot instability because warm storage conditions trigger the phenomena. Leaving a bottle of Sauvignon Blanc in a car trunk on a hot summer day can easily produce a graphic demonstration of hot instability.

Excess protein seldom causes stability problems in red wine. Red wines contain phenolic compounds that react with the protein during primary fermentation, and the excess protein precipitates out of the wine. White and blush wines contain very little phenolic materials, so the winemaker must use a special treatment to remove the excess protein from these wines.

Potassium Bitartrate

Grapes contain several organic acids including tartaric acid, and they contain potassium. Vines manufacture tartaric acid through the photosynthesis process, and the vines obtain potassium from the soil. Potassium reacts with tartaric acid and forms a material called potassium bitartrate. Potassium bitartrate is a clear, crystalline material, and grapes always contain some of this material. Cooks usually refer to potassium bitartrate as cream of tarter, but most winemakers call this material "tartrate."

Potassium bitartrate has several interesting physical properties. (1) Only small quantities of this material can be dissolved in grape juice. (2) After grape juice ferments and alcohol accumulates, even less potassium bitartrate is soluble in the water-alcohol mixture. (3) The quantity of potassium bitartrate dissolved in wine is strongly dependent upon temperature, and cold wine cannot hold as much potassium bitartrate as warm wine.

In combination, these three properties produce an interesting winemaking problem. Generally, grape juice contains all the potassium bitartrate it can hold when the grapes are picked. Alcohol begins to accumulate when the grapes are fermented. As the alcohol concentration increases, the new wine becomes saturated, and potassium bitartrate precipitates out of the wine. As fermentation continues, more alcohol is produced, and more tartrate is forced to precipitate out of wine. New wine is over saturated with potassium bitartrate when fermentation is complete, and the tartrate continues to drop out of the solution. However, tartrate precipitation is very slow at normal cellar temperatures. The tartrate crystals often continue to precipitate for a year or more, so potassium bitartrate causes serious long-term stability problems for the wine industry.

The following example illustrates a common tartrate stability problem. A new white wine is clarified and aged for several months. The wine is then filtered with a 0.45-micron membrane and bottled. The newly bottled wine is clear and bright, but the wine is still nearly saturated with potassium bitartrate. Ultimately, a consumer puts a bottle of this wine into a refrigerator for a few hours before it is served. The wine cools rapidly in the refrigerator, and potassium bitartrate precipitates out of the cold wine. (See property number three above).

As tartrate drops out of solution, suspicious looking crystals are formed in the bottle, or haze forms. Tartrate hazes are very unsightly, and sometimes the consumer mistakes the tartrate crystals in the bottle for glass particles. In any case, the consumer is unhappy, and the winemaker is embarrassed. All commercial white and blush wines are cold stabilized sometime during the winemaking process to remove the excess tartrate material before the wine is bottled.

Phenolic Polymers

Phenolic compounds are present in wine in small amounts. The quantity may be small, but phenolic materials are very important wine ingredients. Phenolic compounds are responsible for color, bitterness, astringency and some odors and flavors. Many phenolic compounds polymerize just like protein molecules, and these phenolic molecules combine and slowly grow larger. Phenolic molecules carry an electric charge, and the molecules repel each other in the wine. Large phenolic molecules can remain suspended in the wine for a long time because of the electric charges.

Since phenolic molecules remain suspended for a long time, haze and bottle deposit problems often occur a few months after red wines are bottled unless the excess phenolic material is removed. To avoid phenolic problems, experienced winemakers remove excessive quantities of phenolic materials from red wines by fining or filtration. Any protein fining material such as gelatin, casein, egg white or isinglass can remove phenolic materials from wine, and many red wines are lightly fined with egg whites or gelatin several weeks before bottling time. The quantity of fining material used is small, so the fining treatment does not alter other wine characteristics significantly. Practically all red wines produced commercially receive a light protein fining or a tight pad filtration to reduce bottle deposits.

Making red wines completely phenolic-stable is not practical, and most red wines will show some bottle deposit when several years old. Phenolic haze problems rarely occur in white or blush wines. These wines receive practically no skin contact, so they contain very little phenolic material.

Polysaccharides

Polysaccharides are very large molecules consisting of many simple sugar molecules (monosaccharides) linked together. Pectin and gums are common examples of polysaccharides. Pectin is the material that makes jam and jelly solidify, and pectin often produces hazes in fruit wines. However, pectin hazes are seldom a serious problem in wines made from grapes because grapes contain a naturally occurring enzyme that breaks down the large pectin molecules into smaller molecules that cause little trouble.

When they do occur, pectin or gum hazes can be difficult to remove from wine. These large polysaccharide molecules often carry electric charges, and the charges help hold the molecules in suspension. Most fining materials used for wine clarification are not very effective in removing this type of haze because of the chemical nature of these materials. Filtration is not always an effective way of removing pectin hazes. Filter pads are plugged quickly by pectin and gums, and trying to filter wine with a sever pectin haze often becomes a frustrating and costly undertaking.

Winemakers often use pectic enzymes instead of trying to remove pectin hazes by fining or filtration. Pectic enzymes are available commercially, and they are added to the juice or the wine to break down the large troublesome pectin molecules. Alcohol interferes with enzyme action to some extent, so sometimes pectic enzymes are more efficient when added to juice before fermentation is started. Occasionally, just chilling the wine to a low temperature (28 degrees) will cause a bad pectin haze to speed out as if by magic.

Metals

Fifty years ago most winemaking equipment was made of iron or brass. Wine acids are strong enough to dissolve tiny amounts of these metals, and in the past, iron and copper hazes were common problems throughout the wine industry. Several proprietary fining materials were developed specifically to remove these excess metals from wine. But unfortunately, the effective products then available were based on poisonous, cyanide compounds, and great care and much testing was required when these products were used. In recent years, the prevalent use of stainless steel and plastic materials has virtually eliminated metal haze problems.

THE CLARIFICATION PROCESS

Large quantities of carbon dioxide gas are produced during primary fermentation, and considerable turbulence in the wine is produced as the bubbles rise to the surface. When fermentation is finished, bubbles are no longer produced, and the wine becomes still. When the wine is still, gravity slowly pulls the suspended material to the bottom of the container. Settling time depends on the size of the suspended material, and smaller particles require more time to settle than larger particles. Pulp and skin fragments settle out of small containers in just a few days. Yeast cells are much smaller, and a week or more is usually required for spent yeast cells to fall 24 inches. Bacteria are so small they never completely settle out of the wine.

New wines contain many different types of suspended particles, and these particles often have an electrical charge. The charges can act like magnets, and the "like" electrical charges repel each other. Then, even larger particles may never settle out of the wine until the electrical charges are neutralized.

Racking

The muck that slowly accumulates on the bottom of wine containers is called lees. Clean wine is separated from the lees by a decanting process called racking. After wine is racked two or three times, it becomes clean, clear and bottle bright. Besides clarifying wine, racking helps remove other unwanted materials, so racking also contributes to long-term wine stability. Siphoning the wine off the lees with a piece of clear plastic tubing is the usual way of racking small containers like 5-gallon carboys. Barrels and drums are often racked with a small pump and plastic tubing. Wineries use powerful electric transfer pumps and large diameter hoses made from food grade materials to rack their large stainless steel wine tanks.

White wines are normally racked off the gross yeast lees shortly after the finish of alcoholic fermentation. These wines are racked a second time after they have been hot and cold stabilized. Red wines are often left on their gross lees until ML fermentation is finished. They are then racked for the first time. Red wines are usually racked two more times the first year and then at six month intervals. Most winemakers rack wines promptly (a week or so) after a fining treatment.

Fining

Most white and blush wines will be almost clear after being hot stabilized with bentonite, but additional clarification steps are usually necessary to produce a bright, clear wine. These additional clarification steps might consist of fining with Sparkolloid or gelatin/Kieselsol or filtering the wine through a course pad or cartridge. Commercial wineries use large filters to clarify their wines because filtration is safer and quicker when the proper equipment is available. Most home winemakers do not have filtration equipment, so they rely to a great extent on fining materials and aging to clarify and stabilize their wines.

Something is amiss when a white or blush wine does not come clear after being hot stabilized with bentonite and then fined with Sparkolloid. Excessive fining or filtering can devastate wine quality, so care must be taken when attempting to clarify a stubborn wine. The first step is to identify the specific problem. Second, appropriate steps should be taken to eliminate the problem, and then the wine clarification and stabilization process can be continued.

Sound red wines come clear without any fining or filtration treatments because the tannin in red wine acts as a fining agent. Red wines are usually clear and bright after being racked a couple of times and aged a few months. Although clarity is seldom a problem in red wine, long-term bottle stability is always an issue. Red wines generally produce significant amounts of bottle deposit unless they are filtered or lightly fined with a protein material. Light fining or filtration with a medium pad will not significantly alter flavors or bouquets, but either procedure can effectively reduce bottle deposits. Excessive bottle deposits can be very unsightly; either fining and/or filtration are used to stabilize most commercial red wines before they are bottled.

Filtration

Today, consumers demand brilliantly clear white and blush wines. Unfortunately, maximum wine clarity is difficult to produce by fining alone. In addition, fining wine is time consuming, produces lees and always involves some risk. Consequently, filtration plays an important role in the clarification of commercially produced wines.

Pad and frame type filters and cartridge type filters are extensively used throughout the wine industry. Both styles of filters have advantages and disadvantages. Pad and frame type filters are best suited for filtering large quantities of wine. Filter pads are inexpensive, but the frame assembly is very expensive. Pad and frame filters are best suited for commercial applications because of the large initial capital investment. Home winemakers often use cartridge type filters because inexpensive, plastic filter housings are available in most hardware stores. Filter cartridges are more expensive than filter pads per gallon of wine filtered. However, since home winemakers produce smaller quantities of wine, the cost of filter cartridges is not prohibitive. Both types of filters are discussed in the next chapter.

WINE STABILIZATION

Wine is often exposed to considerable heat when shipped long distances in the summer time. Most white and blush wines are chilled to about 50 degrees for several hours before they are served. Temperature stability is an issue, and commercial wines are specifically treated to make them stable. After stabilization, wine appearance or quality will not be altered by reasonable temperature extremes. Most commercial winemakers consider wine stable if the wine does not show significant changes when exposed to storage temperatures ranging from 40 to 100 degrees.

Stabilizing a light, fruity white table wine is not trivial exercise because light, fruity wines can be damaged easily by over processing, excessive handling or by excessive oxidation. So, producing good long-term bottle stability without reducing the quality of a delicate wine requires considerable winemaking skill.

Occasionally, a winemaker bottles a wine without doing stability tests. The wine has been brilliantly clear for several months, so the winemaker assumes the wine is stable. A few weeks after bottling, the wine develops a bad haze or drops ugly sediment in the bottles. Now the winemaker has little recourse because un-bottling, treating and re-bottling would destroy wine quality. Bottling an unstable wine can be a discouraging event for any winemaker.

Cold Stabilization

Most new wines contain excessive quantities of potassium bitartrate, and the tartrate precipitates out of cold wine as crystals or hazes. All white and blush wines require cold stabilization before bottling, and most commercial producers cold stabilize their red wines as well. Wine can be effectively cold stabilized in several ways. A few large wineries use ion exchange columns to remove potassium from the wine. Ion exchange columns are filled with resin and work on the same principle as domestic water softeners. This type of wine cold stabilization requires large, expensive equipment, and a trained chemist is needed to establish the proper operation of the exchange column. However, once the equipment is operating, the ion exchange method is a fast and economical cold stabilization process. But, wine quality can be reduced when the ion exchange method is used inappropriately.

Smaller wineries use a much simpler method to stabilize their wines. The wine is cooled to about 27 degrees and held at this low temperature for a week or two until the excess potassium bitartrate precipitates. This method of cold stabilizing wine also has advantages and disadvantages. Low temperatures are beneficial to new wine in several ways. Besides causing the potassium bitartrate to precipitate, the cold temperature helps other unwanted materials settle out of the wine. Sometimes suspended pectin and gums can be removed by chilling the wine. In addition, several days of low temperature storage can be helpful in developing long-term wine stability. Unless the wine is carefully handled, considerable oxygen can be absorbed while the wine is cold. The oxidation problem can be managed by purging wine containers with an inert gas, keeping the containers completely full and by maintaining adequate levels of sulfur dioxide in the wine. The high cost of energy needed to operate the large capacity refrigeration system raises production costs, and many wineries use specially insulated tanks to stabilize their wines.

Tartrate crystals also form in red wines, but the dark color obscures small deposits of tartrate crystals. Red wines are not chilled before serving, so a haze seldom forms. Often the tartrate crystals in red wines are found adhering to the cork, and the crystals are removed when the cork is pulled. Tartrate crystals are not so noticeable in red wine, so a few smaller wineries and many home winemakers do not bother to cold stabilize their red wines. However, most commercially produced red wines are cold stabilized before being bottled.

Hot Stabilization

Commercial wine is shipped long distances in warm weather, and under these conditions, protein instability causes hazes to form in white or blush wine. Protein hazes are unsightly, so the wine industry considers excess protein removal essential for all white and blush wines. Excess protein is not difficult to remove from most wines, but sometimes Sauvignon Blanc wines can be difficult to stabilize completely without damaging aromas and flavors. The standard treatment for white and blush wines is to fine with bentonite. The bentonite fining can be done anytime during the winemaking process, but the procedure is more efficient when the bentonite fining is done after the new wine has been rough filtered. Bentonite additions rang from one to ten pounds per thousand gallons of wine. High dose rates can strip desirable flavors, so bench testing should always be done to measure the minimum quantity of bentonite needed. The treated wine should settle for a week or so before racking. Tannin in red wine reacts with protein and the protein precipitates out during fermentation. Little protein remains at bottling time, so protein hazes are seldom a problem in red wines.

Combined Hot & Cold Stabilization

All white and blush wines require both hot and cold stabilization treatments, and some winemakers combine both stabilization procedures into a single operation to reduce handling. First, the wine is fined with bentonite, and then the wine is immediately chilled to about 27 degrees. The wine is held at the cold temperature for a week or so while the tartrate precipitates. When the excess tartrate is gone, the cold wine is racked or filtered off the bentonite and tartrate lees. This combined procedure has some advantages. The tartrate crystals settle on top of the fluffy bentonite lees forming a crusty layer, so the wine is much easier to rack off the compacted lees. The procedures are accomplished in a single operation, so labor is reduced and the potential for oxidation is reduced.

Finishing White Wines

Many of the desirable qualities of light bodied, white table wines come from the characteristics of the grapes. These wines are only a few months old when bottled because lengthy aging destroys the desirable fruit qualities. For example, light fruity Riesling wine is often finished in the following way. After fermentation, the free sulfur dioxide content is adjusted to about 30 milligrams per liter, and then the wine is hot and cold stabilized. After cold stabilization, the acid level is adjusted (if necessary), and the wine is allowed to rest for a few weeks. Then the wine is critically evaluated, and any other necessary adjustments are made. If large adjustments were made, the winemaker would test the wine again for both hot and cold stability.

At bottling time, the free sulfur dioxide content of the wine is raised to about 30 milligrams per liter. Riesling wine normally contains residual sugar. Any residual sugar may cause fermentation to restart, so a sterile filter would be used to remove all of the yeast cells from the wine when it is bottled. Most home winemakers do not have sterile filtration equipment, so they use a different method to leave residual sugar in wine. Home winemakers add potassium sorbate to the wine. The sorbate stabilizes the wine by preventing the yeast cells from multiplying. Wines containing residual sugar are carefully watched for several weeks after bottling to make sure the wine is completely stable. Typical white wine finishing steps are shown in Figure 6.

1. A bentonite fining is done to remove excess protein and hot stabilize the wine.
2. The wine is chilled to about 27 degrees and held at the low temperature for several days to remove excess tartrate crystals and cold stabilize the wine.
3. The wine is racked or filtered off the bentonite and tartrate lees while still cold.
4. After a few weeks, the wine might be fined with Sparkolloid to improve clarity.
5. After a few more weeks, the SO_2 is raised to about 30 milligrams per liter, and the wine is racked, polish filtered and bottled.

Figure 6. Typical finishing processes for dry white table wines.

Finishing Red Wines

The finishing process for full-bodied red wine is different from that described above. Following cold stabilization, most high quality red wines are barrel-aged for 12 to 24 months. During this lengthy aging period, the wine is tasted and tested periodically, and the free sulfur dioxide is maintained at a reasonable level of 20 to 30 mg/l. The barrels are topped up each time the wine is tested. After the gross lees are removed, red wines are racked two or three times a year. If the wine seems too astringent, the winemaker might use a gelatin or egg whites to reduce the tannin content. At the end of the aging period, the winemaker tastes and critically reviews the wine for any needed corrections, and the free sulfur dioxide level is raised to about 30 milligrams per liter. The wine is then filtered and bottled. High quality red wines are often aged in the bottle from six months to several years. During this time, the wine develops bottle bouquet.

Experience Required

Many factors are involved in producing high quality wine, and considerable judgment must be exercised throughout the finishing process. From the time the grapes are crushed until the wine is bottled, many winemaking decisions must be made. The time wine spends in the barrels, the frequency and method of racking, how much tannin should be left in the wine, etc., etc. all contribute to the ultimate quality of the product. Making high quality wine requires experience and good judgment, and this kind of preparation is difficult to get just by reading books.

SUMMARY

Wine enjoyment is strongly influenced by first impressions, and our first impression with any wine is visual. Consequently, clarity and stability are extremely important to both homemade and commercial wines.

Practically all wines can be clarified, stabilized and prepared for bottling using standard winemaking practices. These procedures include cooling the wine to cold temperatures, fining the wine with suitable materials and using appropriate filtration methods.

All white and blush wines require both hot and cold stabilization, and most commercial red wines are cold stabilized. Although they are perfectly clear, red wines can throw a noticeable deposit after bottling unless they have been stabilized by fining, filtering or bulk aged for an unusually long time.

Many factors are involved in producing high quality wine and much time, effort and good judgment are required.

Chapter 18

WINE FILTRATION

Most red wines self-clarify in a few months, and they usually do not require special clarification treatments. Even when red wines are not brilliantly clear; the dark color obscures any slight cloudiness. White and blush wines are different. Here, any lack of clarity will be painfully evident and most white or blush wines require one or more specific clarification steps.

Cloudy wine is difficult to sell, and sometimes getting a white or blush wine clear and bottle bright without using some kind of filtration is difficult. Consequently, practically all commercially produced white and blush wines are filtered before they are bottled. Of course, home winemakers always prefer to produce brilliantly clear wine, but such clarity is seldom essential unless the home winemaker actively participates in homemade wine competitions.

FILTER TECHNOLOGY

Filtration can be accomplished by two different ways. Unwanted particles are attracted and entangled in a porous filter material in the first mechanism. This type of filtration is an adsorption process and electrostatic and adhesion forces are responsible for trapping and retaining the particles. The cavities in the filter material are larger than the trapped particles. This kind of filtration is called "depth" filtration because the particles are trapped within the thickness of the filter material.

Membrane filters employ a different filter mechanism. Here, the liquid is forced through a membrane containing many small holes or pores. Pore size is large enough to allow desirable (smaller) particles to pass through the membrane, but the pores are small enough to block the larger, unwanted particles. Filter membranes are made of special plastic materials. The plastic is very thin, and the pore diameters can be made very small. Membrane filters are usually called sterile filters when the pores are small enough to remove wine microbes.

In the past thirty years, great strides have been made in filter technology. Now, a variety of filters are available for removing microorganisms, and these filters can produce sterile wine when used properly. Molecular sieve filters can remove color and other large phenolic molecules from wine. Over the past few years, reverse osmosis filtration techniques have been developed specifically for the wine industry. These sophisticated ultra-filtration techniques can selectively remove acetic acid and other small molecules from wine.

Desirability

Sterile filtration equipment gives wineries a very useful production tool. Practically all of the yeast cells can be removed from wine by simple, inexpensive filtration. Off-dry and sweet wines can be bottled with little worry the residual sugar will start fermenting, and wine quality does not suffer significantly when the filtration is done properly.

In the past, wines containing excessive quantities of acetic acid were difficult to handle. Often, these wines were added to sound fermentations in small quantities, or acetic wines were sent to the "still house" to be converted into alcohol. Now, ultra-filtration apparatus can effectively remove acetic acid, and defective wines can be salvaged using modern filtration techniques. In addition, the new filter technologies have significantly reduced wine production costs, and the quality of inexpensive jug wines has improved significantly. Even so, extreme levels of filtration are not necessary or desirable for normal wines, and many winemakers believe the less treatment a healthy wine receives, the better the quality of the finished product. These winemakers pursue a minimum filtration philosophy for the production of fine wines, but minimum filtration does not mean zero filtration. Producing brilliantly clear white or blush, table wines without using some reasonable level of filtration is difficult and sometimes impossible.

FILTER TYPES

Most commercial wineries use pad type filter assemblies. Normally, pads are made of depth type materials. But, some manufacturers produce special adapters that allow membrane filter media to be used in their pad type filter assemblies. Commercial wineries and home winemakers use cartridge type filter assemblies, and both depth cartridges and membrane cartridges are made to fit standard cartridge housings. Each filter material and each filter type is most efficient when used for the intended purpose, so recommendations by the manufacturer should be followed.

Pad Filters

Pad type filter assemblies consist of a stack of ridged plastic or stainless steel frames held together by a powerful clamping mechanism. A filter pad separates each frame. The wine flows into half the frames, through the filter pads and then out of the other frames. Pad type filter assemblies are made of stainless steel and molded plastic. The clamping mechanisms are large, and the materials are expensive. In addition, the frames contain many ridges, so filter presses are difficult and expensive to manufacture. Consequently, pad type filter assemblies are expensive. On the other hand, filter pads become much more economical when large quantities of wine are filtered, so all commercial wineries use pad type filters.

Cartridge Filters

Cartridge type filters consist of filter materials made in the shape of a hollow cylinder. The cylindrical filter cartridge is housed in a plastic or stainless steel container. Wine flows into the housing and through the filter cartridge from the outside to the inside. After passing through the filter material, the wine flows out of the housing. Both depth type filter cartridges and membrane type filter cartridges are available. Cartridge type filter housings made of plastic are used extensively for domestic water filtration. These plastic housings are made in large quantities, so they are relatively inexpensive. Practical filter systems can be built from these inexpensive plastic housings, so home winemakers often use cartridge type filter assemblies.

Pad Filters

Depth filters are used to remove grape fragments, tartrate crystals, yeast cells and general debris from wine. Depth filters are made by compressing and bonding fibrous substances into a mat or pad. In the past, asbestos fibers were used extensively, but modern depth filters are made from specially prepared cellulose. The cellulose fibers are specifically processed to give them a net residual electrical charge. The long path lengths, created by the overlaid fibers, trap the particles within the body of the pad. Smaller size particles are retained when the pads are made tighter and denser. However, liquid flow through the pad becomes slower as the density of the pad increases. Rates of flow for typical commercial filter pads are shown in Table 15. The rates of flow shown in the Table are for gallons of water per minute for one square meter of pad area at a pressure of 10 psi.

Depth filter pads are manufactured in several sizes and in bulk roles and sheets. Eight by eight, sixteen by sixteen and thirty-six by thirty-six-inch square pads are common sizes. Sixteen-inch pads are the most popular size for small winery use. Pad thickness depends on porosity, but most pads are about 3/16 inches. Depth type filter cartridges are made from a variety of materials including cellulose and spun plastic fibers. Cartridges are made in several sizes and with different end patterns. Double open-ended, 10-inch cartridges are the most popular size. Single, open-ended cartridges equipped with Buna "N" gaskets are preferred for wine filtration.

Filter Number	**Flow Rate**
2	30
3	26
4	20
5	16
6	14
7	11
EK	5
EKS	3

Table 15. Typical flow rates through filter pads.

Washing depth filters before filtering wine is a standard practice. Washing removes any contamination, bad odors or off tastes that may be present. The standard washing procedure is to assemble the filter system and circulate a 1-percent citric acid in water solution through the system. Then the system is drained, and clean water is circulated. After a short rinse, the water coming out of the filter is tasted. If the water has a paper taste, washing is continued.

Porosity

Depth filters can be purchased with porosities ranging from 50 microns to about 0.2 microns. Two different scales are used to rate the porosity of depth filters, and a large difference in particle retention ability exists between the two scales. "Nominal" filters are rated using a 50 percent criterion. For example, a 1-micron nominal filter will pass about half the 1-micron particles present. "Absolute" filters use a more stringent standard. Absolute filters use a 10 out of a million criterion. A 1-micron absolute filter only passes ten 1-micron particles out of a million. The filter retains the other 999,990 1-micron particles. A 1-micron nominal filter is more porous than a 1-micron absolute filter. Filter pads are usually rated using the absolute scale, but many inexpensive cartridge filters are often use rated using the nominal scale.

Membrane Filters

Membrane filters work in a different way. The filter material is a thin, flexible plastic membrane. A special manufacturing technique is used to produce the plastic, and the plastic sheet contains an enormous number of very small holes. Membrane filters acts just like a sieve. Particles larger than the holes are mechanically blocked at the surface of the membrane. Smaller particles can pass right through the holes.

Filter membranes are made from several plastic materials including polypropylene, cellophane and polyester. Since the membrane is very thin, additional mechanical support must be provided, and filter membranes are placed on top of a backing structure to provide greater strength. Membrane filter cartridges are more expensive than depth filter cartridges because of more complicated construction methods and more costly materials.

The porosity of membrane filters is rated using the absolute scale, and porosities are designated by the equivalent size of the holes. For wine industry use, the three most popular membrane filter porosities are 0.65, 0.45 and 0.2-microns. Because of the simple sieve action, membrane filters are easily plugged or blocked. To reduce plugging, all wine going into a tight membrane filter must be filtered with a 1-micron absolute depth filter first. Membrane filters can be washed, reverse flushed to remove some of the blocking particles and reused several times.

Membrane filters are used to sterilize wine just before bottling. A membrane filter with a 0.45-micron absolute rating will remove all wine yeast and bacteria from the wine. Membrane filters are commonly used in all commercial wineries, and 0.45-micron membrane filters are often mounted on the bottling line just ahead of the bottle filler.

FILTERS FOR HOME WINEMAKERS

A filter assembly suitable for the home winemaker can be easily made from standard, 10-inch housings. These filter housings are used to improve drinking water quality. They are made of plastic, and they can be purchased for about $25. Two plastic tubing fittings ($2) are needed to connect plastic tubing to the inlet and outlet ports in the housing. This type of filter assembly can be used with any small transfer pump that can deliver a pressure of at least 10 pounds per square inch. Alternatively, a gas transfer system can be used to move the wine through the filter.

One-micron (nominal) depth type cartridges cost four or five dollars and they are suitable for rough filtration of all types of wine. Either 0.5-micron (nominal) depth cartridges or 0.2-micron (nominal) depth cartridges costing can be used for polish filtration. These cartridges cost about seven dollars and twenty dollars respectively. A 0.2-micron nominal cartridge is preferred for final filtration of white and blush wines. Cartridge life can be extended by carefully cleaning up the wine by fining and racking before it is filtered.

This type of cartridge filter assembly can produce excellent wine clarity, and it gives the small producer a very practical filtration system. Best of all, the filter can be easily assembled from standard parts for a few dollars.

SUMMARY

Getting white and blush wines sparkling bright is difficult without using some kind of filtration but filtration must be done carefully to avoid wine oxidation and other problems. Home winemakers often use cartridge type filters, and these filters can produce excellent wine clarity.

Commercial wineries use sterile filtration techniques when they bottle wines containing residual sugar. The filter removes all of the yeast cells and prevents fermentation from occurring after the wine is bottled.

Chapter 19

BOTTLING

Light bodied, white table wines and most blush wines are bottled a few months after primary fermentation. These wines are valued for their young fruity characteristics, and they do not benefit from aging, and light. Heavier-bodied white table wines, such as Chardonnay and Sauvignon Blanc, are usually given several months of bulk aging. These heavier white wines and light, fruity red wines are usually consumed when one or more years old. Heavier style red wines are usually given one to three years of bulk aging before they are bottled, and then the highest quality red wines are often several years old before they are consumed.

PRE BOTTLING ADJUSTMENTS

Bottling is the culmination of the entire winemaking process. Wine is always oxidized to some extent when the bottles are filled, and experienced winemakers take special care throughout the bottling operation. Oxidation reduces table wine quality, so excessive foaming and splashing should be avoided whenever possible. Although bottling may seem like a simple procedure, several important issues need to be considered before the bottles can be filled.

Clarity

All wines should be brilliantly clear before bottling. Most sound red wines become clear and bright when they are several months old, so clarity is seldom a problem for these wines. On the other hand, practically all white and blush wines require special clarification treatments such as fining and tight filtration before they attain adequate clarity.

Stability

Besides being clear, wines must also be stable before bottling. Blending should be done well before bottling time, and the winemaker should observe the new blend for several weeks to be sure the new blend is stable. Commercial wineries test to be sure their red wines are tartrate stable, but most home winemakers do not bother. All white and blush wines should be cold stabilized, and these wines may require an additional cold stabilization treatment if much tartaric acid is added late in the winemaking process. Sometimes a white or blush wine needs a small acid addition just before bottling to improve acid balance. Citric acid is often used for this purpose, and additional cold stabilization is often not needed when moderate amounts of citric acid are used.

All white and blush wines should be tested for stability before bottling. Wine can be checked for cold stability by placing a small sample in the refrigerator. After 48 hours, the wine sample is removed from the refrigerator and set aside for several hours. When the sample reaches room temperature, the wine sample should be carefully examined for any cloudiness or for any tartrate deposits.

White and blush wines can be checked for hot stability by holding a small wine sample at 120 degrees. After 48 hours at the high temperature, the wine is removed and allowed to stand over night at room temperature. The wine is then carefully inspected for any protein haze or sediment.

Free Sulfur Dioxide

The free sulfur dioxide content of all wines should be measured and raised to about 30 milligrams per liter a few days before bottling. Bottling wine with less than 30 milligrams per liter of free sulfur dioxide will result in a short-lived product.

Residual Sugar

Wines containing more than 0.2 percent residual sugar are not biologically stable, and these wines can start fermenting anytime. Most wines are a complete loss when fermentation restarts after the wine is bottled. To avoid such catastrophic losses, additional precautions are always required when off dry or sweet wines are bottled. Generally, four methods can be used to deal with the residual sugar problem. (1) The wine can be pasteurized to kill the yeast. (2) Ethanol can be added to raise the alcohol content of the wine above 18%. (3) Sterile filtration can be used to remove all of the yeast cells when the wine is bottled. (4) A special material can be added to prevent yeast in the wine from fermenting the residual sugar.

Pasteurization reduces wine quality, so this process is seldom used for quality table wines. Adding ethanol is suitable for dessert wines, but additional alcohol is seldom desirable in table wines. Commercial wineries use a sterile filtration process when wines containing residual sugar are bottled. Most home winemakers do not have access to sterile filtration equipment so they often add small amounts of potassium sorbate to their off-dry or sweet wines to prevent the residual sugar from starting to ferment again.

Potassium Sorbate

Potassium sorbate does not interact with the residual sugar in any way. Sorbate prevents fermentation by acting on the yeast cells, but it does not kill the yeast. Sorbic acid passes through the cell membrane easily, and the yeast cell is prevented from generating a new bud when enough sorbic acid molecules have accumulated. In other words, sorbic acid prevents yeast cells from reproducing, but it does not stop yeast from fermenting sugar.

Sometimes potassium sorbate does not prevent fermentation from restarting because the wine contains too many viable yeast cells. When potassium sorbate and sugar are added to a wine containing many viable yeast cells, the sorbate prevents the yeast from reproducing, but enough yeast cells may be present all ready to ferment the additional sugar. Then, fermentation often occurs after the wine is bottled. The wine is spoiled, and the winemaker is unhappy.

A different situation exists when sorbate and sugar are added to a well-clarified wine. The clean wine contains very few yeast cells. The sorbic acid prevents the small number of viable yeast cells from reproducing, and the added sugar is unaffected. Even if fermentation occurred, only a tiny amount of the added sugar would be lost because only a few yeast cells are present in the wine. In time, the few active yeast cells in the wine grow old and gradually die. After a few months, the wine contains practically all of the added sugar and very few viable yeast cells.

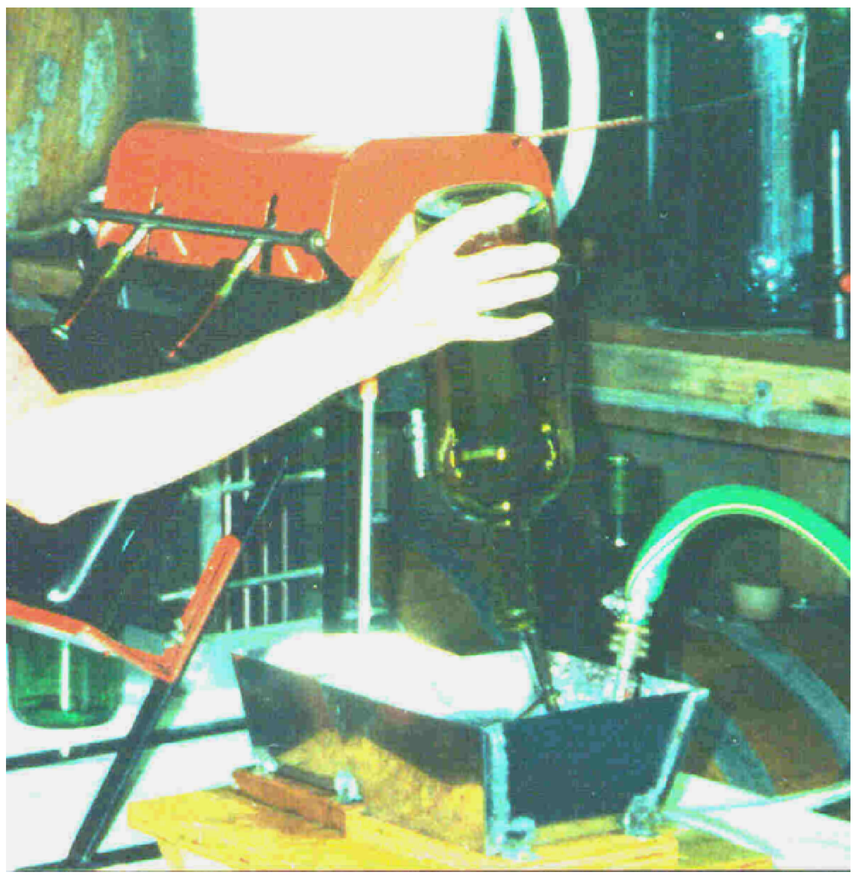
Using just the right amount of sorbate can be a problem. Wine flavor can be adversely affected when too much sorbate is used, but the wine may restart fermentation if too little sorbate is added. The sorbate needed to keep yeast cells from reproducing depends upon several wine properties. The normal dose is about one gram of sorbate per gallon. One gram per gallon is equivalent to about 2 level teaspoons per 5 gallons of wine. Wines with a high alcohol content, low pH and 30 to 50 milligrams per liter of free sulfur dioxide present require less potassium sorbate.

An additional problem sometimes develops when potassium sorbate is added to wines low in sulfur dioxide. Large bacterial populations can exist in wines low in sulfur dioxide. Sometimes the bacteria in the wine can react with the sorbic acid, and a strange geranium-like odor is produced.

Large quantities of potassium sorbate were used by commercial wineries to stabilize off-dry wines before practical sterile filtration equipment became available. However, sorbic acid is not widely used today because of the potential flavor problems and the high cost of potassium sorbate. Now, sterile filtration is the preferred treatment, and few commercial wineries use potassium sorbate. Potassium sorbate is not a very stable material. Unopened containers have a reasonable shelf life, but potassium sorbate can deteriorate rapidly after the package is opened.

FILLING BOTTLES

New glass bottles leave the factory in a sterile condition. However, new bottles often contain carton dust, and even new glass should be rinsed. Bottles stored for extended times should always be rinsed before filling. Some home winemakers turn up the hot water heater a few hours before starting to bottle wine. Then clean (previously washed), used bottles are rinsed with very hot water just before filling.



Other winemakers rinse each bottle with a sulfur dioxide solution. The sulfur dioxide solution is made by mixing 1/4 tsp. of sulfite powder and ½ tsp. of citric acid in 750 ml of clean, cold water. This sulfite solution is strong enough to sterilize the bottles, but care must be taken to drain the bottles completely.

Plastic milk crates are a convenient way of handling glass while bottling. Milk crates hold about 20 bottles, and they are easy to keep clean. If one end of the crate rests on a block of wood, the empty bottles will be held on a slant, and the angle makes filling easier.

Some type of bottle filler should be used at bottling time to minimize wine oxidation. However, wine is always exposed to a significant amount of air when the bottle is filled. Most home winemakers use a piece of clear plastic hose fitted with plastic, wand type bottle filler to siphon the wine into the bottles. Simple bottle fillers have a small valve on the end of a rigid plastic tube. The plastic tube is placed in the empty bottle and the valve opens when it contacts the bottom of the bottle. Wine begins to flow when the valve opens, and the bottle is filled from the bottom. Little splashing occurs when filling is done slowly, and wine oxidation is held to a minimum.

Small, two or three-spout gravity type bottle fillers specifically designed for home winemakers can be purchased for about one hundred dollars, and these fillers are very convenient moderate quantities of wine are made. Gravity fillers are much faster than wand type fillers, and smaller commercial wineries often use larger, multiple spout gravity fillers. Gravity fillers consist of a small tank to hold the wine, a float valve assembly that keeps the wine in the tank at a constant level and the filler spouts. Two and three-spout machines can be filled by siphoning with large diameter tubing. Tanks on machines with several spouts are best filled with a small transfer pump. Operation of gravity type bottle fillers is quite simple. The operator places an empty bottle on an empty spout, and the machine starts filling the new bottle. Filling continues unattended while the operator removes other full bottles and places empty bottles on the spouts. When the new bottles become full, the machine automatically stops filling. Once the filler is adjusted properly, all of the bottles will be filled to the same uniform level. Little spillage occurs, and if the operator is careful, the outside surfaces of the bottles remain clean and dry. Although these little machines are simple in design, they are surprisingly fast. Most gravity bottle fillers can fill two bottles per minute for each spout. For example, a machine with four spouts can fill more eight bottles a minute, and one person is kept busy changing the bottles.

Bottles should be filled so there is 1/4-inch of space between the wine and the bottom of the cork. Most wand type bottle fillers leave too much air space in the bottle. Some winemakers prefer to fill and cork one bottle at a time. Other winemakers prefer to fill several bottles and then cork the lot. In any event, leaving full bottles of wine open for long periods is not a good practice.

CORKING

Standard wine corks are sold in large, sealed polyethylene bags containing one thousand corks. The corks are sterilized with sulfur dioxide gas when packaged, and the corks remain in a sterile condition until the bag is opened. The water content of the corks is carefully adjusted just before packaging, and the humidity in the bags is carefully controlled. Corks taken from a sealed bag are soft, pliable and resilient. They can be driven easily, and the soft, pliable corks quickly conform to the neck of the bottle and form a tight seal.

Dry corks should be driven into the bottle whenever possible, but many small corking machines cannot adequately compress hard, dry corks. Then the winemaker has little recourse, and softening the corks is necessary. The normal procedure is to soak hard corks in cold water until they become soft enough to drive with the corker available. A pinch of sulfite can be added to the water to help sterilize the corks as they are soaking. Very wet corks are undesirable because excessive "cork water" will be left when the corks are driven into the bottle. Cork water can be avoided by soaking the corks for a few hours. Then cover the corks with a clean cloth and let them drain overnight.

Corks can be quickly softened (and probably sterilized) in a microwave oven. First the corks are rinsed in clean water and then sealed a plastic, zip-lock storage bag. The sealed bag is then placed in a microwave oven. However, corks burn easily so some experimentation with the time and power settings of the microwave oven may be necessary.

Corking machines should be adjusted so the top of the cork is set just below the lip of the bottle. Spilled wine should be removed from the outside surface of the bottles when the corking operation is completed because wine left on the glass makes labels difficult to apply. Mold often grows on the spilled wine, and after a few weeks an unsightly residue can form on the bottles.

LABELING

All wine should have a label permanently attached to each bottle. Producing custom wine labels with a home computer is easy and fun. If a scanner and a color printer are available, a variety of artwork can be incorporated into the label design, and very professional looking labels can be produced easily. Some glues wrinkle light weight papers, so labels are best printed on medium weight paper. Some bond papers seem to work well. Wetting one side of a sheet with water, and then carefully observing the paper for a few minutes is a good test for label papers. Papers that stretch and wrinkle excessively probably will not be suitable for labels. Layout 4, 6 or 8 labels on a sheet of standard size 8.5 X 11-inch paper. If the layout is carefully done, the labels will be easy to cut with a paper cutter, and little paper will be wasted. A few extra labels should be made when the labels are printed. The extra labels can be pasted on the cartons to identify the contents, and the labels give case goods a professional look.

Capsules and labels can be applied when the bottles are clean and dry. Home winemakers often use an inexpensive, short bristled, 1-inch brush to apply glue to labels. White "Elmers" glue works well with heavy weight papers. Unfortunately, this glue is water-based, and it may shrink or wrinkle some types of papers.

The following procedure works well for labeling small quantities by hand. Cut a piece of cardboard a little smaller than the label. Place the label face down on the cardboard and apply the glue with the brush. Apply the glued label to the bottle and quickly smooth out any wrinkles. Try to place the label in the proper position the first time to avoid smearing the bottle with wet glue. Clean the brush and glue container with warm soapy water when finished. A "glue stick" is very convenient when just a few bottles are being labeled.

For short runs, commercial wineries use a "label paster" to apply just the right amount of glue to the back surface of plain paper labels. These wonderful little machines apply glue quickly and easily, and they save a great deal of time. Unfortunately, small pasting machines are expensive. New machines cost $600 or $700. Used label pasting machines are in great demand, so they are very difficult to find.

CAPSULES

Most home winemakers and some commercial wineries use plastic capsules. Plastic capsules can be obtained in a variety of colors, and they can be custom printed with designs. Plastic capsules are inexpensive, and they provide an attractive, finished look to any bottle of wine. "Push-on" capsules are made of relatively heavy weight, plastic material, and many home winemakers prefer this type of capsule because they are so easy to apply. The capsule is simply pushed onto the neck of the bottle by hand.

Unlike push-on capsules, "heat-shrink" type capsules are made from thin plastic material. They are available in a greater range of colors and finishes, and they are slightly less expensive. Heat-shrink capsules are placed over the neck of the bottle, and then heat is applied to shrink the plastic material tightly to the bottle. Large wineries pass the bottles through a heat tunnel to shrink the capsules in place. Home winemakers use electric heat guns, or they shrink the capsule by dipping the neck of the bottle in boiling water.

BOTTLE AGING

Time is required to age wine properly. Although considerable research has been done, no practical way has yet been found to speed up the wine aging process. Wine ages in two different ways and each type of aging changes the wine in a different manor. Bulk aging takes place in large storage containers, and small amounts of air are always present. Bottle aging takes place after the wine is bottled. Here, no air is present, and oxygen is not involved.

Most high quality, dark red table wines are bulk aged from one to three years. After bottling, these wines are aged in the bottle for a year or more to develop a bottle bouquet. Very tannic red wines often require several years of bottle aging to reach maturity. Heavier white wines are usually bulk aged for several months and then aged in the bottle for an additional time. Aging in the bottle is best accomplished by placing the bottles on their sides in a cool, dark, quiet place.

Novice winemakers sometimes become very enthusiastic about their first few winemaking efforts, and they often consume their wines too early. Two cases of wine can be consumed in a short time, and many new winemakers exhaust their supply before the wine even starts to approach maturity. This is one argument against making wine in five-gallon water bottles. A 15-gallon beer keg holds six cases, and this is about the smallest size container suitable for home wine production. Of course, five-gallon glass bottles are handy for storing leftover wine.

SUMMARY

Dirty wine bottles are a potential source of contamination. Dirty bottles should be washed and placed in clean cartons, and the cartons should be stored in a clean, dry place.

All wine must be brilliantly clear and stable before it is bottled. Any blending should be done several weeks before bottling time. Early blending allows the winemaker to check the wine for several weeks to make sure the new blend is stable before bottling time.

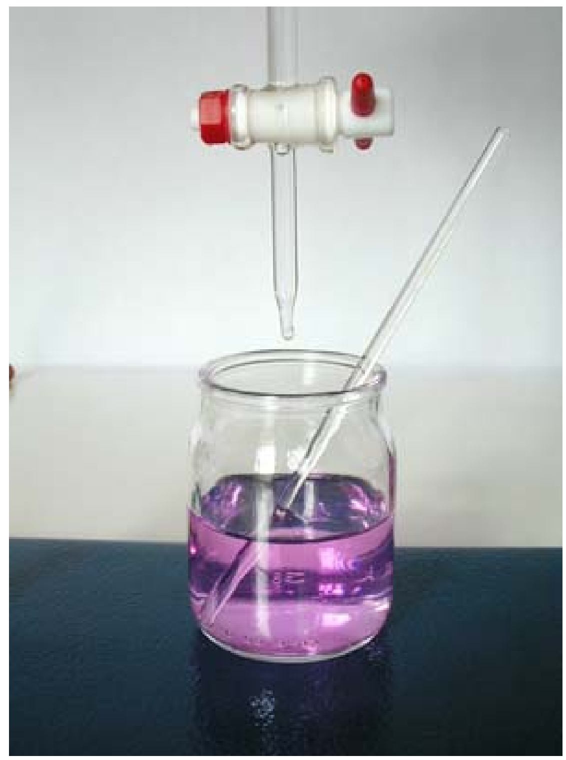
Wines containing more than 1/4 percent residual sugar can restart fermenting anytime and these wines must be treated in some way to insure bottle stability. Home winemakers often use potassium sorbate to prevent fermentation in off-dry or sweet wines. The right amount of sorbate must be added, and wines treated with sorbate should also contain at least 30 milligrams per liter of free sulfur dioxide.

Oxidation is the most common fault found in homemade wines, and some wine oxidation always occurs during bottling. Some type of bottle filler kind should be used, and the bottles should be filled slowly from the bottom with a minimum of splashing and bubbling. Corks should be set flush or slightly below the lip of the bottle. All bottled wine should have an appropriate label to identify the contents. Custom wine labels are easy to make using a home computer.

Chapter 20

LABORATORY WINE TESTING

About 30 tons of grapes are required to make 5000 gallons of wine. High quality fruit might cost $1500 per ton, so the grapes needed to fill a 5000-gallon tank can cost $45,000. Losing a tank of wine can be very expensive, so commercial winemakers depend on laboratory wine measurements to minimize the number of gross wine failures. Laboratory measurements also help winemakers produce wines more consistent in style and quality from year to year. Consequently, laboratory measurements are indispensable in commercial wineries, and they play an important role in most home winemaking programs.



Large wineries maintain extensive in-house laboratory facilities and expensive equipment. Many small wineries cannot afford extensive measurement facilities because the equipment is too expensive. So small wineries rely on basic wine tests that can be done with a minimum amount of apparatus, and they depend on the winemaker's trained nose to provide much of the needed additional information.

Noses are wonderful test instruments. Noses can detect and identify extremely small quantities of many different materials, so they are wonderful measurement devises for quickly determining the condition of wine. Noses are always available, unless the winemaker has a cold, and an educated nose is the most valuable measurement tool any winemaker possesses.

The equipment and methods for doing six of the basic wine measurements are discussed below.

BRIX

Sugar in juice or wine is measured using the Brix scale. This scale was developed specifically for winemaking, and one degree Brix is equal to one gram of sugar per 100 grams of juice. Winemakers usually measure Brix with an optical refractometer or a hydrometer.

Sugar content is one of several criteria used to judge fruit maturity, and most grapes are picked when the sugar content is between 20 and 25 Brix. Winemakers start measuring grape sugars several weeks before harvest time, and they continue sugar testing until the fruit is picked.

Taking hydrometer readings during fermentation is important. Most winemakers measure Brix at least once each day to monitor the speed and consistence of their fermentations. Moderate drops in sugar each day is an indication of normal fermentation. If an unusual change in sugar level is observed, the winemaker can make corrections promptly.

Novice winemakers often believe fermentation is complete when their hydrometers measure zero. However, alcohol has a density less than water, so hydrometers read **less** than zero Brix when a completely dry wine is measured. Dry white table wines usually measure -1.8 to -2.4 Brix, and dry red table wines measure -1.4 to -2.2 Brix because of the accumulated alcohol.

Brix Measurement Materials

Sugar can be accurately measured using an inexpensive ($20), short range Brix hydrometer. Many winemakers use a set of three instruments. One instrument reads from 16 to 24 degrees Brix. The second instrument reads from 8 to 16 degrees, and the third hydrometer reads + 5 to - 5 Brix. All three hydrometers are calibrated in 0.1 Brix steps. Some home winemakers rely on a single hydrometer with a zero to 30-degree Brix scale. These long-range instruments are inexpensive and readily available. Unfortunately, these long-range hydrometers are difficult to read accurately.

The following materials are needed to measure the sugar content of juice.

Brix hydrometers
A hydrometer cylinder

Brix Measurement Procedure

Hydrometers are made from very thin glass. They are fragile, and these instruments must be handled carefully. The following procedure can be used to measure Brix in juice.

1. Strain un-clarified juice to remove the solids.
2. Fill the hydrometer cylinder within a few inches of the top with juice.
3. Gently lower the hydrometer in the liquid and give it a slight twist motion. The twist will release any bubbles sticking to the glass.
4. When the hydrometer is floating freely, wait a few seconds and then read the hydrometer scale. Read the scale in line with the bottom of the meniscus curve.
5. Record the reading.
6. Discard the sample and rinse the cylinder and hydrometer with clean water.

TITRATABLE ACID

Titratable acid (TA) is a measure of the sum of all the organic acids in juice or wine. In healthy wine, the major acids are tartaric and malic, but all wines contain small quantities of citric, succinic, acetic, butyric, and lactic and other organic acids. In the United States, wine acidity is expressed as if all of the acids in the wine were tartaric acid. The titratable acid of juice ranges from 0.4 to 1.2 grams per 100 milliliters of liquid. One hundred milliliters of juice weighs approximately 100 grams so "grams per 100 ml" is roughly equal to percent.

The tart of wine is strongly related to titratable acid. When wine contains too much acid, it will have a very tart taste. When too little acid is present, wine often lacks freshness and tastes flat. Grapes grown in warm areas are usually low in acid, and additions of tartaric acid are often needed to produce a balanced wine. TA is always measured when the grapes are crushed so any needed acid adjustments can be made before fermentation is started. TA is also used to judge fruit maturity at harvest time.

The titratable acid of normal wine slowly decreases as the wine ages, and any rise in wine TA during the aging period is a danger signal to the winemaker. When the TA rises, acetic acid may be forming, and the wine may be turning into vinegar. Therefore, most commercial winemakers measure titratable acid periodically from the time fermentation is complete until the wine is bottled. Small producers often measure titratable acid once each month.

Titratable acid of wine or juice can be measured by several different analytical techniques. However, the measurement procedure below is simple, and the laboratory apparatus is inexpensive.

TA Measurement Materials

Titratable acid can be measured by a simple titration procedure using a calibrated (0.1 N) sodium hydroxide solution. Phenolphthalein solution is used to show the titration end point.

The following materials are needed to measure the titratable acid of white wine and juice.

5-ml serological (transfer) pipette
10-ml serological (transfer) pipette
250-ml Erlenmeyer flask
0.1 normal sodium hydroxide
1% phenolphthalein solution
Distilled water

TA Measurement Procedure

This procedure is satisfactory for measuring the titratable acid of juices and white wines.

1. Draw 5 milliliters (ml) of juice or wine into the 5-ml pipette and transfer into the flask.
3. Add about 50 ml of distilled water and three or four drops of phenolphthalein solution.
4. Fill the 10-ml pipette with 0.1 N sodium hydroxide solution.
5. Titrate with the sodium hydroxide while mixing the wine sample by rocking the flask
6. Stop titration when the sample turns a **faint** pink.
7. Record the quantity of sodium hydroxide solution used.
8. Rinse the flask and pipettes with clean water.

TA Calculations

Titratable acid can be calculated using the following formula.

A TA (%) = 0.15 X milliliters of sodium hydroxide used.

In the above formula, the titratable acid is given in grams of acid per 100 ml of wine (percent), and TA is expressed as if all of the acids in the wine were tartaric acid. Two examples of how titratable acid is calculated from the measured data follow.

Example # 1.

A white wine sample was titrated drop by drop. Rocking the flask from side to side mixed the sample during titration. A faint but persistent pink color was reached, and the pipette scale was read. In this example, the scale showed 5.3 ml of sodium hydroxide had been added to the sample. The titratable acid of the sample was calculated by multiplying 0.15 times 5.3. This gave a TA of 0.79 grams of acid per 100 milliliters of wine or 0.79 percent.

Example # 2.

A pipette was used to add 0.1 N sodium hydroxide solution to a red wine sample. The titration was done slowly, so the stir bar could keep the sample mixed, and the pH meter was carefully watched.

Titration was stopped when the meter read 8.2. The pipette scale was read, and it showed 3.9 ml of sodium hydroxide had been added to the sample. The acidity of the red wine sample was calculated by multiplying 0.15 times 3.9 which give 0.58 grams per 100 milliliters (0.58 percent)

Alternative Procedure for Red Wines

The above procedure does not work well for dark red wines because the end point is very difficult to recognize in dark red wines. Diluting red wine samples with up to 200 milliliters of water makes the measurement easier, but most winemakers prefer to use the following procedure when testing dark red wines. However, a pH meter, ring-stand and a magnetic stirrer are required for this procedure (see pH measurement below).

1. Place the probe in a ring-stand clamp so the probe is centered above the stirrer plate.
2. Draw 5 milliliters (ml) of wine into the pipette and transfer it into the beaker.
3. Add about 50 ml of distilled water and place the stir bar in the beaker.
4. Place the beaker on the stirrer plate. Adjust the ring-stand so the probe is immersed in the sample but do not allow the stir bar to strike the end of the probe.
5. Turn the stirrer on.
6. Fill the pipette with 0.1 N sodium hydroxide solution.
7. Titrate the wine sample while watching the pH meter.
8. Stop the titration when the pH meter reads 8.2.
9. Record the quantity of sodium hydroxide used.
10. Discard the sample and rinse the probe, beaker, stir bar and the pipettes in clean water.

FREE SULFUR DIOXIDE

Winemakers try to maintain 20 to 40 milligrams per liter of free SO_2 in their wine from the completion of fermentation until the wine is bottled, but the amount of free SO_2 does not remain constant. Sulfur dioxide is consumed as it does its job, and the free sulfur dioxide slowly decreases with time. Consequently, winemakers measure the free sulfur dioxide in their wines every few weeks, and they make appropriate additions to maintain the sulfur dioxide near the desired level.

SO_2 Measurement Materials

5-ml serological pipette
10-ml serological pipette
250-ml clear glass container
Dilute sulfuric acid (1 part acid in 3 parts water)
1% starch solution
0.01 N iodine solution
Distilled water

The starch indicator solution is made by mixing one half teaspoon of cornstarch in about 200 ml of water and boiling the mixture for a few minutes. Add an aspirin tablet and the starch solution can be used when it is cool.

A 0.01 normal iodine solution is a weak solution, and weak iodine solutions are not stable. Weak iodine solutions should be stored in dark brown glass bottles, and the bottle should be tightly sealed and stored in a dark place. Even then, the calibration (normality) of the iodine solution will change slowly.

Free SO_2 Measurement Procedure

The following procedure can be used to measure free sulfur dioxide in juice or wine.

1. Draw exactly 10 milliliters (ml) of wine into the pipette and transfer the wine into a small, clear glass container.
2. Add about 5 ml of diluted sulfuric acid (H_2SO_4) to the wine sample.
3. Add 2 or 3 ml of the starch solution to the sample.
4. Immediately fill the 5-ml pipette with the iodine solution and titrate the wine sample until a faint purple color is reached. This is the end point. The purple color will fade in a few seconds, but do not add more iodine.
5. Record the quantity of iodine solution used to reach the end point.
6. Rinse the pipettes and the glass container in clean water and place them in a drying rack.

Most commercial wineries routinely use the iodine method to measure sulfur dioxide in white and blush wines. However, this method is not very accurate when used with red wines because phenolic materials in red wines also react with the iodine. These side reactions can give erroneously high results, and the measured values are often more than 20 percent too high.

Besides the side reactions, the end point is difficult to recognize in dark red wines. Generally, a distinct purple color does not occur when red wines are titrated. Instead, a slight darkening of the wine color indicates the end point. Diluting red wine with distilled water often makes the end point easier to recognize, and as much as 150 ml of water is sometimes used. Viewing the diluted red wine with a strong yellow sidelight is often helpful. Some winemakers have a 75-watt, yellow "bug light" in a desk lamp specifically for measuring sulfur dioxide in red wines. Measuring sulfur dioxide in dark red wines with the iodine method requires some practice.

Sulfur Dioxide Calculations

The amount of free sulfur dioxide in the wine sample is calculated from the measured volume of the iodine solution used in the titration and from the normality of the iodine. The formula for free SO_2 can be written as:

$$SO_2 = 3200 \text{ X volume of iodine X normality of iodine.}$$

In the above formula, the free sulfur dioxide content of the wine sample is given in milligrams of sulfur dioxide per liter of wine (mg/l).

Two examples of how free sulfur dioxide is calculated from the measured data are given below.

Example # 1.

A faint purple color was produced when 2.2 milliliters of 0.01 N iodine solution was added to 10 milliliters of white wine. The free SO_2 level of this wine was obtained by multiplying 3200 times 2.2 (the quantity of iodine solution) times 0.01 (the normality of the iodine solution). The multiplication (3200 X 2.2 X .01) gives 70.4 milligrams per liter of free sulfur dioxide.

Example # 2.

A dark red wine sample was diluted with about 100 milliliters of distilled water. When 1.2 ml of 0.01 N iodine solution was added to the wine sample, the color darkened slightly. The free SO_2 level of this red wine was calculated by multiplying 3200 times 1.2 times 0.01. This measurement gave 38.4 milligrams per liter (mg/l) of free sulfur dioxide.

pH

pH is one of several parameters used to judge fruit maturity, and most winemakers start monitoring the pH of the grapes several weeks before harvest time. pH also gives the winemaker important information about how much sulfur dioxide is needed to control microbes. Wine stability characteristics are dependent on pH.

Red wine color is influenced by pH. Red wines with low pH values have more and better red color. Wines with high pH values have a dull, less attractive color. Winemakers monitor wine pH every few weeks until the wine is bottled.

pH Measurement Materials

A pH meter with a three-digit resolution is the only practical way of measuring pH, and an instrument with a separate probe on a 36-inch cable is a great convenience for wine measurements. All pH meters should be calibrated just before use, and most instruments have long warm-up times.

pH meter
pH probe
7.00 standard pH solution
4.00 standard pH solution
100-ml beaker
Ring stand
Magnetic stirrer
Stir bar

pH Measurement Procedure

The following procedure can be used to measure the pH of any wine, must or juice.

1. Place the probe in the ring-stand clamp and arrange the stand so the probe is centered above the stirrer plate.
2. Place 30 or 40 milliliters of the 7.00 standard solution and the stir bar in the 100-ml beaker.
3. Place the beaker on the stirrer plate. Adjust the stand so the pH probe is immersed in the sample but do not allow the stir bar to strike the end of the probe. Turn the stirrer on.
4. Adjust the "calibration" knob until the meter reads 7.00.
5. Discard the standard solution and rinse the beaker.
6. Place 30 or 40 milliliters of the 4.00 standard solution and the stir bar in the beaker.
7. Place the beaker on the stirrer plate and adjust the stand so probe is immersed but above the stir bar.
8. Turn the stirrer on and adjust the "slope" knob until the meter reads 4.00.
9. Discard the standard solution and rinse the beaker.
10. Place 30 or 40 milliliters of wine or juice in the beaker.
11. Place the beaker on the stirrer plate. Adjust the stand so the probe is immersed in the sample but do not allow the stir bar to strike the end of the probe.
12. Turn on the stirrer and wait a few seconds for the juice to mix. Then read the pH meter and record the value.
13. Rinse the probe, beaker and stir bar in clean water.

RESIDUAL SUGAR

Fermentation can restart in wine containing sugar anytime, so winemakers always measure the residual sugar contents of their wines shortly after fermentation to be sure no sugar remains. Large wineries use a wet chemistry method, but small wineries and home winemakers use *Clinitest* tablets to measure residual sugars in wine. This measurement method is simple, and it provides reasonable accuracy when the residual sugar content is less than about 2 percent. *Clinitest* tablets are sold by some of the larger drugstores and tablets and a special color chart can also be ordered from any of the winemaking supply companies.

Residual Sugar Measurement Materials

The following equipment can be used to measure the residual sugar content of any table wine.

Eyedropper
Small clear container
Clinitest tablets
Clinitest color chart

Residual Sugar Measurement Procedure

This procedure can be used to measure the residual sugar content in any wine containing less than 2 percent sugar. Wines with higher values of sugar can be measured by diluting the wine appropriately. Measurements are made by comparing the color of a treated wine sample to the color on a calibrated chart. However, the color pigments in red wines do not seem to cause significant errors.

Directions and a color chart are provided with the *Clinitest* tablets.

1. Draw a small amount of wine into the eyedropper.
2. Place 5 drops of wine in the clear container.
3. Rinse the eyedropper carefully (several times) with clean water.
4. Draw a small amount of distilled water into the eyedropper.
5. Place 10 drops of distilled water in the clear container.
6. Place one *Clinitest* tablet in the container.
7. After the boiling stops, wait 15 seconds then read the sugar content by comparing the color of the liquid to the colors on the chart.
8. Rinse the eyedropper and the small container several times with clean water.

Clinitest tablets are sensitive to moisture, so the bottle should be kept tightly sealed.

CHROMATOGRAPHY

Most winemakers measure the malic acid content of their red wines. They want to know ML fermentation is complete and if all the malic acid is gone. An additional treatment may be needed to stabilize the wine when malic acid remains, and paper chromatography is a simple and reliable means of determining what kinds of acids are present in wine. Yeast produces small quantities of lactic acid during primary fermentation, so all wine contains some lactic acid. So, the progress of ML fermentation should be judged by the disappearance of malic acid, **not** by the appearance of lactic acid. ML fermentation is considered finished when the malic spot on the chromatogram has disappeared.

ML Chromatography Materials

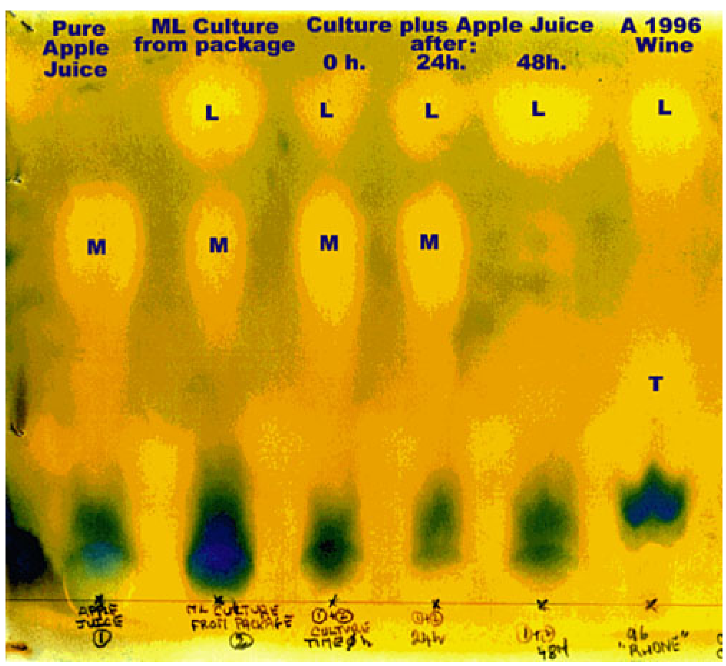
The following materials are needed to measure the status of ML fermentation in wine.

A 1-gallon wide mouthed jar
ML solvent
ML paper
Micro pipettes (capillary tubes)
Standard malic acid solution

ML Measurement Procedure

The following procedure can be used to identify and estimate the quantities of tartaric, citric, malic and lactic acids in wine or juice.

1. Place a sheet of chromatography paper on a clean surface. Use clean hands and try to hold the paper by its edges.
2. Make a light pencil line along a long side about 3/4 inches up from the bottom, and then make marks about 1 1/4 inches apart along the pencil line. Label each mark either as the malic acid standard or for each of the wine samples being measured. The first mark on the left is commonly used for the malic acid standard.
3. Use capillary tubes to draw up a small quantity of the acid standard and wine samples. Do not allow any contact between the tubes.
4. Touch the end of each tube to the mark on the line very quickly. The wet spots should not be larger than about 1/4 inch in diameter.
5. Allow the spots to dry and then repeat the above step twice (3 applications). Let the dots dry between each application.
6. Pour enough ML solution into the wide mouthed jar to cover the bottom. The solvent should cover about 1/8 inch of the bottom edge of the paper. The solvent should **not** come up to the pencil line.
7. When all of the dots are completely dry, staple the short sides of the paper together forming a cylinder.
8. Stand the paper cylinder upright in the jar with the pencil line near the bottom and place the cover on the jar.
9. Let the jar stand until the solvent front has climbed nearly to the top of the paper (six or more hours).
10. Remove the paper from the jar. Pour the ML solvent back into the original container, wash and dry the jar and discard the capillary tubes.
11. Remove the staples from the sheet of paper and hang the paper in a well-ventilated place.



Chapter 21

HINTS,
KINKS
AND GADGETS

Winemaking consists of many small operations, and some winemaking procedures are only done once each season. Consequently, several years of experience may be needed to develop basic winemaking skills. Novice home winemakers can get many useful ideas and gain experience by visiting experienced home winemakers or small commercial wineries. Much practical information can be learned simply by observing how specific winemaking operations are done, and "tricks of the trade" can be learned quickly. Information on methods, techniques and gadgets suitable for producing small quantities of wine is presented here.

GETTING READY

Some home winemakers are disappointed each crush season when they are unable to purchase wine grapes. These winemakers discover they have waited too long, and grapes are no longer available. Beginning winemakers often experience this problem, and they become frustrated. Other winemakers simply procrastinate, and they are never ready to make wine when the grapes become ripe. These winemakers suddenly "discover" the grapes are ripe, and they scramble to get their winemaking equipment checked, cleaned and ready to process the grapes.

Buying Grapes

All growers and vineyard managers like to sell their crops early in the year. So, commercial wineries usually complete their arrangements for purchasing grapes by June or early July. Home winemakers should contact commercial growers early and complete arrangements no later than the 4th of July.

Be Ready

Most home winemakers should consider the first week in August as "get ready" time, and all of the winemaking equipment should be taken out of storage, checked, repaired and cleaned thoroughly. The equipment will then be ready to handle the crush expeditiously when the grapes are ripe. An inventory of winemaking supplies should be taken, and orders should be placed for needed materials. Yeast and sulfite should be replaced each year.

Wine Yield

Most wineries use automatic or semiautomatic horizontal presses, and a minimum amount of labor is required to produce dry pomace with these machines. Depending on the variety of grapes, horizontal presses produce 150 to 180 gallons of wine per ton of grapes. On the other hand, most home winemakers use small, vertical basket presses. These little presses can produce high quality juice. However, considerable work is required, and most home winemakers are not prepared to expend the labor needed to dry the pomace completely. Consequently, home winemakers often get 140 to 150 gallons of wine from a ton of grapes. A case of wine contains 2.4 gallons, so most home winemakers get from 58 to 62 cases of wine from a ton of fruit.

Pounds of Grapes	Gallons of Red Wine	Gallons of White Wine
100	7	6
200	15	13
300	22	19
400	30	25
500	37	31
600	45	38
700	52	44
800	60	50
900	67	56
1000	75	63
2000	150	125

Table 16. Typical wine yields when a small basket press is used.

Grape Quantities Needed

Sometimes beginning winemakers have trouble estimating how many grapes are needed. The data shown in Table 16 provides a reasonable basis for making fruit estimates. Home winemakers often get about 150 gallons per ton for red wines. However, white grapes are more difficult to press than red pomace, and white grapes are particularly difficult to handle with a vertical basket press. Consequently, most home winemakers only get 120 to 130 gallons of white juice per ton of grapes. The values shown in Table 16 are based on a yield of 150 gallons for red wine and 125 gallons for white juice.

CONTAINERS

A variety of containers are needed for winemaking. Boxes or other shallow containers are used to transport grapes from the vineyard to the winemaking area. Open containers are used for mixing and for red fermentations. Closed containers are used for fermenting white juice and for aging wine.

Stainless steel is the material of choice for wine storage containers because it is inert, cleans easy and lasts for many years. Unfortunately, small stainless steel tanks suitable for wine storage are very expensive, so storage containers made of glass, polyethylene and wood are often used. Surplus 15-gallon beer kegs are an exception, and even though they are heavy when full, many home winemakers use stainless steel beer kegs for wine storage.

Bulk Grape Containers

Standard 2-ton gondolas measure 96 inches long by 48 inches wide by 48 inches high. A 1-ton tank measures about 48 x 48 x 48 inches. A fruit bin measuring 48 inches by 48 inches by 22 inches will hold about 1000 pounds of grapes.

A 48-inch x 32-inch x 24-inch box will hold about 650 pounds of grapes, and standard 32-gallon plastic trashcans hold about 135 pounds. When lined with trash bags, plastic milk crates hold 35 or 40 pounds of grapes. Round 5-gallon plastic buckets hold 22 to 24 pounds.

Bulk containers are usually not needed when home winemakers purchase grapes by the ton. Large quantities of grapes can be hauled easily by lining the bed of a pickup truck with a sheet of 4-mil polyethylene. The fruit is dumped directly into the bed of the truck.

Open Fermenters

Many home winemakers use 32-gallon plastic trashcans for fermenting red wine. Plastic trashcans are inexpensive and lightweight. Open red fermenters should only be filled to 80 percent of capacity to prevent over flowing, so 32-gallon trashcans can ferment about 230 pounds of crushed grapes. Almost 400 pounds of crushed grapes can be fermented in a 55-gallon polyethylene drum with the head removed, and a plastic, half-ton bin will ferment about 1400 pounds of grapes.

Beer Kegs

Surplus, stainless steel beer kegs make excellent wine storage containers. Modern beer "kegs" hold 15.5 gallons, and they are readily available. Used beer kegs cost about a dollar a gallon. Stainless steel kegs are easy to clean, and they last forever. A #11 stopper or a silicone bung can be used to seal beer kegs.

Oak Barrels

Wine barrels are made in two standard sizes, 200 liters and 225 liters. Two hundred-liter barrels hold approximately 52 gallons, and 225-liter barrels hold about 59 gallons. Most American-made barrels hold 52 gallons, and most French barrels hold 59 gallons. A half-barrel holds 25 to 30 gallons.

Bungs

Some winemakers place small pieces of cloth or burlap under wooden bungs. Although popular, such an arrangement allows considerable air to enter the barrel, and this technique should not be used for quality table wine production. Although more expensive, silicone rubber bungs are much better than old fashion wood bungs. Rubber bungs seal the barrels tightly, and they are easy to remove. Best of all, they do not deform the bungholes in expensive barrels.

Storage Container Capacity

Five-gallon glass carboys contain two cases of wine. Full 15.5-gallon beer kegs hold six cases. A 27-gallon polyethylene drum holds about 12 cases. A full 59-gallon barrel holds 26 cases. A 165-gallon polyethylene tank holds about 75 cases, and a 1000-gallon tank contains about 445 cases.

SANITATION

Maintaining sanitary conditions in any winery is an important function, and keeping the home winery clean entails more than just hosing down the garage floor. Sanitation activities include washing old bottles, cleaning the equipment, disposing of pomace, controlling ants and fruit flies, keeping winemaking and storage areas clean, etc., etc.

Wash Equipment Before and After

Washing the winemaking equipment just before use is necessary for good sanitation. Washing the equipment immediately after use saves the winemaker a great deal of time. Grape residues are easy to wash away when wet, but dried residues are very difficult to remove.

Spray Nozzle

A hose equipped with a good spray nozzle is a necessity in the crush area. The nozzle should produce a fine spray and a solid stream. The hose and nozzle will be dropped from time to time, so the nozzle should be designed for rough usage and constructed of strong materials. Hang the hose and nozzle from a hook that is placed conveniently in the crush area because the hose and nozzle will be used often.

Hoses

Transfer hoses can remain wet for long periods, and then mildew can grow on the inside surfaces. Hoses should be washed immediately after use and hung on a wall with both ends down, and the hoses will drain completely. Full strength Clorox will remove mold and other stains from the inside surfaces of hoses (or other difficult to reach places). However, surfaces treated with Clorox must be rinsed carefully. **Clorox must be used care and do not breathe the fumes.**

Dirty Bottles

Dirty wine bottles usually contain mold, yeast and a variety of bacteria. Dirty bottles are always a potential source of contamination, so home winemakers should not store dirty bottles in the winemaking area. The best arrangement is to wash dirty bottles as they are collected. Liquid dishwashing detergents are difficult to rinse away when used for washing old wine bottles, and they can leave unsightly water spots. A cup of automatic dishwasher powder in three-gallons of very hot water cleans bottles well, and the residue rinses cleanly. A teaspoon of liquid detergent should be added to the dishwasher powder if the water is hard. The clean bottles should be stored upside down in cardboard cases and stored in a clean, dry place.

Power Bottle Brush

Most bottlebrushes have a loop on the end of the wine handle. Some home winemakers remove the loop and chuck the wine handle in an electric drill. This "power" bottlebrush removes stubborn residues quickly**. But use this method great care and only with low drill speeds.**

Jet Bottle Washer

A jet carboy washer attached to a water facet or hose is a great convenience for washing old wine bottles. These washers are made of brass, and they last for many years. The washers are inexpensive, and they save much time and large amounts of hot water.

Auto Wheel Brush

Brushes with long handles can be purchased in large automotive supply stores. These stiff-bristled brushes are used for washing auto hubcaps and wheels, but home winemakers find them handy for scrubbing all kinds of winemaking equipment. The long handles make these brushes particularly useful for scrubbing the inside surfaces of small fermenters and tanks.

FERMENTATION TECHNIQUES

This section contains practical information and several suggestions on how to cope with some common problems encountered during primary fermentation.

Under-ripe Grapes

Trying to make a dry, red table wine from under-ripe grapes is seldom successful. When under-ripe fruit is used, wine flavor and bouquet will be lacking, and wine color will be poor. Most red grape varieties are not ripe until the sugar level reaches 22½ to 23½ Brix. Unfortunately, home winemakers often have little control over when their grapes are picked, and under-ripe fruit is often encountered. Most under-ripe, red grapes are best used to make blush wines. The low alcohol content, skimpy flavors and the high acid levels of under-ripe grapes are more appropriate for making light, fruity blush wines.

White grapes are not ripe until the sugar level reaches about 22 Brix and Chardonnay grapes are often picked well above 23 Brix. Riesling grapes, on the other hand, are usually picked at low Brix values before they lose their greenish color. Overripe, white grapes are often best used for producing dessert wines. At the other extreme, under-ripe white grapes can be used to produce excellent sparkling wines.

Adding sugar to under-ripe grapes seldom produces high quality wine. The sugar increases the alcohol content, but the added sugar does nothing to improve the poor color, the puny flavors or the lack of varietal intensity. Sugared wines are often too alcoholic, pale in color and under flavored. In addition, under-ripe, red grapes often produce wine with an unpleasant vegetal characteristic.

Sulfur Dioxide

Making and aging quality table wine without using small quantities of sulfur dioxide is difficult, and most winemakers add small quantities of sulfur dioxide when the grapes are crushed. About 1/2 level teaspoon of sulfite powder for every 100 pounds of grapes is the right amount.

Practically all of the free sulfur dioxide disappears during fermentation, so winemakers add 1/4 level teaspoons of sulfite powder for every five gallons of wine when fermentation is complete. This quantity of sulfite powder will add about 40 milligrams per liter of sulfur dioxide to the new wine. However, about half the sulfur dioxide will combine with other materials in the wine quickly, so only 20 - 30 milligrams per liter of free sulfur dioxide remains in the new wine. The sulfite powder should be dissolved in an ounce or two of water before it is added to the wine.

Wine should always be tested just before bottling time, and the free sulfur dioxide content should be adjusted to about 25 milligrams per liter. Wines bottled with less than 20 to 30 milligrams per liter of free sulfur dioxide oxidize quickly, and they are short lived. Table 17 shows how much sulfite powder is needed to produce 25, 50 and 75 milligrams per liter of sulfur dioxide in various quantities of wine. The values given are in grams. For example, Table 17 shows that 5.8 grams of sulfite powder produces 50 ppm of SO_2 in 15 gallons of wine.

Gals of Wine	25 mg/l SO_2	50 mg/l SO_2	75 mg/l SO_2
1	0.2	0.4	0.6
2	0.4	0.8	1.2
3	0.6	1.2	1.8
4	0.8	1.6	2.4
5	0.9	1.8	2.7
10	1.8	3.6	5.4
15	2.9	5.8	8.7
20	3.8	7.6	11.4
30	5.7	11.4	17.1
40	7.6	15.2	22.8
50	9.5	19.0	28.5
60	11.4	22.8	34.2

Table 17. Grams of sulfite powder needed to produce 25, 50 and 75 mg/l of SO_2.

Hydrogen Sulfide

All wine yeast produce small quantities of hydrogen sulfide gas (rotten egg smell) during fermentation, but under normal conditions, the quantities produced are very small and of little consequence. The primary cause of excessive amounts of hydrogen sulfide is elemental sulfur on the grapes. Sulfur is used to control mildew in vineyards, and excessive amounts of sulfur sometimes remains on the grapes. Here, the winemaker should complete fermentation, and then copper sulfate can be used to remove the hydrogen sulfide. Some types of wine yeast produce more hydrogen sulfide than other types. Montrachet yeast is a particularly bad offender, and it should not be used with grapes containing sulfur residues.

Besides the sulfur problem, yeast often produces objectionable quantities of hydrogen sulfide gas when the grapes lack nitrogen, nutrients or vitamins. Commercial wineries and some home winemakers added small quantities of yeast nutrients and a substance called pantothenic acid to fermentations to reduce the production of hydrogen sulfide. Pantothenic acid is a vitamin and can be purchased at any drugstore.

Crushing by Hand

A mechanical crusher is not necessary for making small quantities of red wine. A few hundred pounds of fruit can be easily crushed by hand. Set a clean plastic milk crate on top of a clean container. Pick up grapes with both hands and squeeze them. Then scrub the grapes through the bottom of the milk crate.

Punching Down

A handy gadget for punching down small fermentations can be easily made with a few hand tools. Find a 6 x 6 x 2-inch piece of wood and an old broomstick. The exact size is not important. Bore a hole in the middle of the wood block, apply glue and insert the broomstick. The new "puncher downer" will be prettier and easier to keep clean if it is finished with three or four coats of varnish.

Skin Contact Time

Most of the red pigment and fruit flavors are extracted during the first few days of skin contact. Four or five days of skin contact are enough to produce a quality product when the grapes are ripe. Tannins continue to be extracted for many days.

Cooling Hot Fermentations

Fermentations can become violent when warm red grapes are fermented in hot weather and the yeast cells can die when fermentation temperatures exceed 90 degrees for several hours. Such conditions require prompt action, and fermentation temperature must be reduced quickly. Stainless steel containers can be cooled easily by flowing cold water over the outside surfaces. Sometimes blocks of dry ice are used to cool hot fermentations. Home winemakers often fill plastic milk containers with water and keep the containers in their freezer. Later, the containers of ice are placed in hot fermentations to reduce the temperature. All winemakers try to avoid fermenting hot fruit.

Completing Fermentation

Fermentation may be complete when three conditions are met. Check if the bubbling has stopped and make sure the wine is still and quiet. Make sure the hydrometer reads less than zero Brix. Measure the Brix for several days to make sure the hydrometer reading remains constant.

Beginning winemakers often have trouble deciding when fermentation has finished. The above procedure is useful, but the only way to be sure fermentation has finished is to measure the residual sugar in the wine. *Clinitest* tablets can be purchased at most large drugstores, and these tablets are a very convenient way of measuring small quantities of sugar in wine. Use the "5-drop" method. When the sugar content measures less than 1/4 percent, the wine is considered dry.

Short Range Hydrometers

"Plus and minus five" short-range hydrometers are useful for monitoring sugar content near the end of fermentation. These hydrometers have a special scale. Zero Brix is in the center of the scale, and plus five degrees and minus five degrees run in each direction from the zero point. The scale is large, and 0.1 degree Brix can be read easily.

CELLAR TECHNIQUES

Cellar operations start when fermentation is complete and continues until the wine is released. Cellar operations include clarification, stabilization, bulk aging, etc.

Hot and Cold Stabilization

All white and blush wines should be both hot and cold stabilized before bottling. Many winemakers use the following technique to accomplish both stabilization steps in a single operation.

Three teaspoons of dry bentonite in a cup of hot water are used for 5 gallons of wine. The water is placed in the blender, and the blender is run at high speed while the bentonite is added slowly. The bentonite mixture is chilled in a refrigerator for 24 hours, and then the mixture is stirred into the wine. After the bentonite addition, the wine is placed in a refrigerator, and the temperature control is set to the coldest position. After a couple of weeks in the refrigerator, the cold wine is racked into a clean container. Bubbling and splashing should be minimized because cold wine oxidizes easily.

Gelatin

Gelatins are useful for fining astringent red wines, and a suitable gelatin can be found in the canning section of most grocery stores. “Knox” gelatin comes in a box containing four handy, pre measured envelopes. Be sure to buy an un-flavored gelatin.

Power Stirring Tool

Small wine containers can be mixed easily with a clean wooden dowel. However, stirring a barrel or small tank of wine is not so easy, and a special stirring tool can be very helpful. A variety of stirring tools can be purchased, or a propeller type stirrer can be made easily. First, form a small propeller by cutting and bending a piece of stainless steel sheet. Drill a hole in the center of the propeller blade and bolt the blade to a 36-inch length of 1/4-inch stainless-steel rod. Secure the propeller with two stainless steel nuts and washers. A barrel of wine or a small tank can be quickly mixed with the homemade stirrer and a small electric drill.

Oak Chips

Many home winemakers add oak chips to red wines stored in glass, plastic or stainless containers. About 2 oz of oak chips for every 10 gallons of wine is a good starting quantity. The chips can be placed in a nylon bag and suspended in the wine, or the chips can be added directly to the container. After the chips are added, the wine should be tasted twice a month to make sure the wine does not get too “oakey.” When the wine has the desired oak character, remove the bag of chips, or rack the wine off the loose chips into a clean container

Wine Filter

Inexpensive but effective wine filters can be made from standard, 10-inch cartridge type water filters. These filters are available at hardware stores, and a variety of cartridges are manufactured to fit these standard housings. Five-micron water filter cartridges are available at hardware stores. These cartridges are inexpensive, and they are useful for rough filtering large quantities of wine. However, a 5-micron cartridge is quite porous and will not completely clarify dirty wine. One-micron cartridges are used for general clarification, and many home winemakers use cartridges with 0.5 or 0.2 micron ratings for filtering wine at bottling time.

Wine Filter Use

All filter media should be washed before any wine is filtered. First, completely assemble the filter system, and then flush the system with several gallons of clean water. The water coming out of the filter should be tasted to make sure no “paper” taste remains. If the rinse water tastes clean, the filter is drained and used. Washing is continued if the water has a paper taste. Some winemakers prefer to wash the complete filter system with a 1- percent citric acid solution. The citric acid seems to remove the paper taste quickly, and the acid helps sterilize the filter. After the acid solution is removed, the filter system is washed with clean water. A short length of plastic tubing permanently attached to a hose connector is handy for flushing small filters.

Storing Used Filter Cartridges

Used filter cartridges are difficult to maintain, but the following method works reasonably well. Immediately after use, the filter should be back flushed with several gallons of clean water. Then the water is drained, and the housing is filled with a 50% ethyl alcohol solution (inexpensive 100- proof Vodka). The inlet and outlet of the housing should be tightly sealed with small rubber stoppers, and the filter should be stored in a cool, dry place. When the filter is needed, drain the alcohol, and flush the housing with clean water. Set the alcohol aside, so it can be reused later.

BOTTLING

Bottling is the last major step in the winemaking process. Lots of things can go wrong, so bottling is often a difficult operation for home winemakers. Ways of avoiding several common bottling problems are discussed below.

Bottling Supplies

In 1997, sealed bags of one thousand, number one quality, wine corks sold for about $150. The cost of new glass ranged from $4.50 to $6.50 per case, and re-sterilized glass sold for $3.50 to $4.50 a case. A carton of 4800 fancy, heat-shrink capsules sold for about $130.

Handling Bottles

Plastic milk crates are a convenient way of handling and moving wine bottles. Crates are handy containers for washing used bottles and for filling bottles. These crates are strong enough to easily hold full bottles. Milk crates are easy to keep clean, and they are always handy to have in any home winery. Standard size, plastic milk crates hold about 20 wine bottles.

Softening Corks

Soaking in cold water for a few hours will softened hard corks. After soaking, poured off the water, and cover the container of corks with a clean rag. Let the corks drain overnight to remove excess cork water. Excessive cork water is undesirable because it stains the top of the corks and makes a mess.

Old corks can be softened quickly in a microwave oven. Rinse the corks in cold water, and then seal the wet corks in a plastic freezer bag. Heat the bag of corks in a microwave oven for a short time. A bag containing 50 corks might require a one minute exposure at a 50 percent power setting. However, the time depends on the microwave oven, and some experimentation may be needed. Corks burn easily, so always use the minimum power and time necessary. The intense microwave energy may also be effective in sterilizing the corks. Please note this technique should **not** be used with corks treated with paraffin.

Bottle Filling

Avoid wine oxidation when filling bottles by not splashing and causing bubbles in the wine. Small pressure heads reduce bubbling, so when siphoning, the wine container should be just two or three feet higher than the bottles. Bottles should be filled from the bottom slowly until no more than 1/4-inch gap remains between the wine and the bottom of the cork. The small pressure head increases time needed to fill the bottles. However, filling time can be reduced significantly by using a large, (1/2 inch diameter) wand type bottle filler. But, many of the larger diameter wand type bottler fillers leave excessive head space in the bottles.

Making Labels

Inexpensive labels can be made easily with a home computer. A variety of artwork can be included, and professional quality labels can be produced easily if a scanner and color printer are available. Most lightweight papers wrinkle badly when the glue is applied, but many medium weight bond papers are suitable for labels. Four, six or eight labels should be made from standard 8.5 X 11 inch sheets of paper, and very little paper will be wasted if the layout is done carefully.

Label Paster

Small wineries use a label-pasting machine when small lots are labeled by hand. These handy machines quickly apply just the right amount of glue to the back surface of any label. Unfortunately, these little machines sell for several hundred dollars, and most home winemakers do not produce enough wine to justify the cost.

Gluing Labels by Hand

White "Elmer's" glue is often a satisfactory adhesive for applying labels printed on heavy weight paper. Use a wide, short bristled brush to apply glue to the back of the labels. A piece of stiff cardboard smaller than the label makes pasting easier. The label is placed face down on the cardboard, and then the glue is applied with the brush. A "glue stick" is a very convenient adhesive when only a few bottles are being labeled.

SUMMARY

Some winemaking procedures are done only once each year, so several crush seasons are needed for novice winemakers to develop certain skills. Beginning winemakers can learn basic winemaking techniques and get many useful ideas by visiting other home winemakers or small commercial wineries, and visiting other winemakers is always an enjoyable way to gain practical information quickly.

Chapter 22

RED WINE: A CASE HISTORY

Carignane grapes are widely grown in France, Spain, California, Italy and Chile. Carignane is not a well-known variety because it is seldom bottled as a varietal wine. However, Carignane grapes produce more red wine than any other grape variety. Carignane wine is often blended with wines made from other grape varieties because it is astringent. In France, Carignane wine is the primary component of *vin de pays.* In California, it is the major component in "Hearty Burgundy" and in most other red jug wines. Sometimes, Carignane grapes are called "poor mans grapes" because Carignane produces such large quantities of unremarkable, red table wine.

Wine made from Carignane grown in southern California is often lacking in color. However, these Carignane wines can be quite astringent, so the winemaker must handle the primary fermentation carefully. When properly fermented and aged in wood for a few months, Carignane can produce a robust, almost friendly, red wine.

Obtaining Grapes

A local grape grower was contacted the third week in June 1993. Arrangements were made to purchase a half-ton of Carignane grapes for $125. In early October, the grower left a message saying the Carignane fruit was ripe. He said his crew would start picking at daybreak the following Saturday, and the grapes could be picked up any time after 6:30 a.m.

Finding the block of Carignane vines in the dark was difficult, but the darkness did not bother the picking crew. The bed of a pickup truck was lined with a large sheet of 4-mil polyethylene, and a half-ton of Carignane grapes was dumped directly into the bed of the truck. The grapes were loaded by 6:45 a.m. They had been off the vines for just a few minutes and felt cold.

GRAPE PROCESSING

Crushing started shortly after 8:00 a.m. A small, power crusher-stemmer was placed on top of a half-ton plastic fruit bin, and the crusher and bin were carefully washed and drained. The truck was backed up to the crusher-stemmer, and the grapes were unloaded into the crusher-stemmer with a long handled fork.

Thirty-five milligrams per liter of sulfur dioxide were added as the grapes were being crushed. The fruit bin was about 2/3 full when all of the grapes had been crushed. Crushing, including washing the equipment before and after, took about an hour.

Testing Fruit

After the equipment had been washed, a small sample of juice was tested. The juice was measured with a short-range hydrometer, and the sugar was 23.8 Brix. The titratable acid was 0.56 percent, and the pH was 3.73. The measured data showed the sugar content was fine. However, the acid content of the grapes was low, and the pH of the juice was too high. In previous years, Carignane grapes from the same vineyard always had TA values ranging from 0.55 to 0.60 and a pH of about 3.8, so the low acidity was not a great surprise.

Adjustments

About seven ounces of tartaric acid was dissolved in a little water and added to the grapes. After the acid addition, the titratable acid measured 0.67 percent, and the pH value of the juice had dropped to 3.64. Grapes from this vineyard had been slow to ferment in previous years, and the juice was considered low in nitrogen. Four ounces of diammonium phosphate were dissolved in a small amount of water. The DAP was stirred into the crushed fruit to give the yeast a little extra nitrogen.

Add Yeast

After lunch, a 500-gram package of dry Pasteur Red yeast was opened, and 120 grams of dry yeast were weighed out. The temperature of 800 milliliters of water was adjusted to 98 degrees, and the dry yeast granules were slowly stirred into the warm water. The yeast was stirred several times until the mixture became smooth and creamy. After standing for about 25 minutes, the rehydrated yeast was added to the crushed Carignane grapes.

FERMENTATION

The grapes showed definite signs of fermentation the following morning. By evening a cap had formed, and the cap was gently punched down for the first time. For the next several days, the cap was punched down three or four times each day. Fermentation was monitored carefully. Each afternoon the temperature was measured, and the sugar content was checked with a hydrometer. Juice was tasted for astringency and carefully smelled to make sure hydrogen sulfide was not developing. On the sixth day after crushing, the hydrometer read 4 Brix. The depth of the color of the new wine was lighter than usual. But, a noticeable amount of astringency had developed. It was time to press.

Pressing

A homemade hydraulic basket press was used to press the Carignane pomace. The fermentation mass was transferred from the plastic fruit bin directly into the press basket with a three-gallon plastic bucket. Much of the liquid ran through the press as the basket was being filled, and an eighteen-gallon container caught the liquid coming out of the basket. A small magnetically coupled transfer pump and half-inch plastic tubing were used to transfer the wine from the press sump into a pair of 42-gallon polyethylene drums.

Pressure was applied slowly to reduce the quantity of foam appearing between the slats at the bottom of the basket. The pomace cake was broken up twice, and three press cycles were completed before the pomace was acceptably dry.

This press has a 1/3 ton capacity, so two partial press loads were needed. All of the press wine was added to the main batch, and the half-ton of Carignane grapes produced about eighty gallons of wine. Including the time needed to wash the press before and after and to clean up the mess, the pressing operation lasted almost four hours.

Completing Fermentation

Since the wine was nearly dry, foam problems were not anticipated, and the plastic drums were sealed with fermentation locks. A wine sample was taken every day, and the Brix was measured with a “plus and minus five degree” short range hydrometer. After the wine had been in the plastic drums for eight days, the hydrometer read -1.7 Brix. After ten days, the reading was -1.6 Brix, and after 13 days, it read -1.7 Brix. Hydrometer readings had remained steady at less than -1 Brix and for several days. The hydrometer suggested fermentation had finished, so the residual sugar in the wine was measured with a *Clinitest* tablet. The *Clinitest* measurement showed fermentation was complete.

CELLAR WORK

Twenty days after the yeast addition, the wine was dry, and it had started to clear. The Carignane wine was racked for the first time into a 12-year-old, 60-gallon oak barrel, two glass carboys and a one-gallon jug. Most of the gross lees had settled out, and care was taken not to disturb the muck. Seventy-one gallons of new wine remained after the first racking.

ML Fermentation

Malolactic fermentation started spontaneously in the barrel just as it had in previous years, but the wine in the glass containers showed no evidence of ML activity. After two weeks, 10 gallons of wine was withdrawn from the barrel. Wine in the glass carboys was pumped into the barrel, and the carboys were refilled with the transferred wine. After three more weeks, a paper chromatogram showed no malic acid remained in the wine in any of the containers.

Post Fermentation SO_2 Addition

Sulfur dioxide had been added when the grapes were crushed, but very little of the initial SO_2 remained after primary fermentation. The absence of malic acid meant malolactic fermentation was complete, so a standard post ML fermentation addition of 50 milligrams of sulfur dioxide per liter of wine was made to all of the containers. After another week, the fermentation lock on the barrel was replaced with a silicone rubber bung. The barrel was kept full by checking the level and topping up every second week.

2nd Racking

About four weeks after the first racking, all of the wine was racked into a large, temporary container. The barrel and both carboys were washed and then refilled with wine. A sample was tested, and the measurements showed the wine contained 24 milligrams per liter of free SO_2. The titratable acid was 0.61 and the pH was 3.70.

Oak Chips

Ten ounces of loose oak chips were added to the 60-gallon barrel on January 22, and a small sample of wine was removed. The sample was measured, and it showed: color = ok, clarity = ok, aroma = ok, taste = ok, SO_2 = 21 milligrams per liter, TA = 0.60 and pH = 3.70.

A sample of wine was taken from the barrel on February 25. The sample was measured, and the results were color = ok, clarity = ok, aroma = ok, taste = ok, SO2= 16 milligrams per liter, TA= 0.58 and pH = 3.73. The free SO_2 content of the wine was getting too low, so 20 milligrams per liter of sulfur dioxide was added.

3rd Racking

The Carignane wine was racked for a third time in early March. All of the wine was racked into a large temporary container. The barrel and the carboys were washed and then refilled with wine. As expected, more than a gallon of Cabernet Sauvignon wine was needed to top up the second glass carboy.

WINE AGING

Aging was done in the 60-gallon oak barrel and two 5-gallon glass water bottles. The wine was tasted and measured on March 29. The results obtained were color = ok, clarity = ok, aroma = ok, taste = ok, SO_2 = 24 milligrams per liter, TA = 0.58 and the pH = 3.71. A wine sample was tested on April 24, and this time the results showed: color = ok, clarity = ok, aroma = ok, taste =? (The wine tasted harsh). SO_2 = 19 milligrams per liter, TA = 0.58 and pH = 3.75.

On May 30, the wine was tested with the following results: color = ok, clarity = ok, aroma = ok, taste =?, SO_2 = 17 milligrams per liter, TA = 0.56 and pH = 3.70. The oak was starting to show. The wine seemed astringent.

The wine was tested again on June 27. The test results were color = ok, clarity = ok, aroma = ok, taste =?, SO_2 = 15 milligrams per liter, TA = 0.58 and pH = 3.74. The wine seemed too astringent at this time. The SO_2 was low, so an addition of 20 milligrams per liter of sulfur dioxide was made.

Gelatin Fining

On July 29, the wine was measured again, and several people tasted it. The measurements showed: color = ok, clarity = ok, aroma = ok, taste =?, SO_2 = 26 milligrams per liter, TA = 0.57 and pH = 3.76. Everyone agreed that the oak flavors were good, but four out of five people felt the wine was too astringent.

The wine was tasted several additional times on different days. Finally, a decision was made. The wine was too astringent to bottle, and it needed to be fined to remove some of the excess tannin. About fifty grams of dry gelatin powder were mixed with warm water, and the solution was stirred until smooth. The gelatin solution was added slowly while the wine was stirred continuously. The wine was allowed to stand for ten days, and then it racked off the gelatin lees.

Getting Ready to Bottle

Two samples of wine were removed a couple of days before bottling time. One wine sample was tasted and used for lab measurements. Everything seemed fine, but the pH was almost 3.8. This is not an unusually high pH value for a red wine made from grapes raised in southern California. However, such a high pH value reduces the effectiveness of sulfur dioxide. So, enough sulfur dioxide was added to increase the free SO_2 content of the wine to 40 milligrams per liter.

The second wine sample was used to fill a clear 375-milliliter wine bottle. The bottle was tightly sealed with a cork, and the sample was placed in a refrigerator. After two days the bottle was removed and allowed to come to room temperature. After the bottle had been at room temperature for about 24 hours, the sample was carefully examined. The wine showed no haze or tartrate crystals. The wine looked good, tasted good and it passed the stability test. So, the wine was declared ready for bottling.

Bottling

The 1993 Carignane wine was bottled on 16 September 1994. All of the wine was racked into a large temporary container. The wine was pumped from the temporary container, through a one-micron absolute pad filter, into a two-spout, gravity bottle filler. The wine was bottled in clean (previously washed), used bottles. Before being filled, each empty bottle was rinsed with clean hot water and then given a rinse with a strong sulfur dioxide solution. After the bottles were corked, any spills or drips on the glass were removed with a clean dry towel.

About two hours were required to rinse, fill and cork the bottles. The next day, plastic heat shrink capsules and labels made on a home computer were applied to the bottles. The bottles were placed in cardboard cases, and extra labels were applied to one side and one end of each case. The cases were sealed with clear tape, so they could be stacked six cases high.

FOLLOW UP

At bottling time the Carignane wine was clear and stable. The wine had a medium ruby color and a clean, nondescript nose. It had the typical "dusty" and "woody" taste of young, over-oaked Carignane wine. The titratable acid was 0.58. The pH was 3.78, and the free sulfur dioxide was 40 milligrams per liter. Twenty-eight cases were bottled at a cost of $7.39 per case ($0.62 per bottle). After several months, the excessive oak taste had diminished, and the wine had developed a pleasant, vanillin bottle bouquet.

Chapter 23

WHITE WINE: A CASE HISTORY

Many people feel Chardonnay is the premier white wine grape. It produces the great white Burgundy wines including Chablis, Poully-Fuissé and Montrachet. Chardonnay vines are widely grown around the world. In 1995, there were about 72,000 acres of Chardonnay planted in California vineyards so Chardonnay was the most widely planted California wine grape variety.

Chardonnay is an early ripening grape variety, and it is often the first variety picked each year. It has small clusters of round, thin skinned, light yellow colored berries. The thin skin and its early ripening characteristics, make Chardonnay fruit vulnerable to bird, bee and wasp damage. Chardonnay prefers a cool growing climate, and wines made from fruit grown in warm regions often lack acidity and varietal intensity.

Chardonnay table wine is often produced in two different styles. A light fruity style wine emphasizes the clean, spicy, apple characteristics of Chardonnay grapes. A heavier style wine integrates the rich, complex, buttery qualities obtained from malolactic fermentation together with aging in oak barrels. Much of the Chardonnay wine produced California falls somewhere between these two extreme wine styles.

Obtaining Grapes

Arrangements were made to obtain Chardonnay fruit from a small home vineyard about thirty miles away. The arrangements were simple. The vineyard owner would supply the grapes. The winemaker would supply the corks and bottles, and the winemaker would be responsible for harvest decisions and the winemaking. The finished wine would be divided evenly.

This vineyard was known to ripen early, and the grapes were usually picked in the second or third weeks of August. The first sugar sample was taken on July 26. The grapes were tested, and the TA, pH and Brix values were recorded. Sugar samples were gathered and measured each Friday morning until the grapes were picked.

Picking & Transport

The grapes were picked very early the morning of 20 August 1995. When it was light enough to see the grapes, three people started picking. Cluster stems were cut with small hand shears, and the picked fruit was carried in 5-gallon, plastic buckets. When the buckets were full, they were dumped directly into a half-ton fruit bin in a pickup truck. About 600 pounds of Chardonnay grapes were picked in less than two hours. The cold grapes were covered and transported to the crush area quickly before they became warm.

GRAPE PROCESSING

A small power crusher-stemmer was placed on top of a ½ ton plastic fruit bin. The equipment was washed and carefully drained. Crushing started around 9:30. The grapes were moved from the truck into the crusher-stemmer with a long handled fork. Sulfite solution was added as the grapes were being crushed. The sulfite solution provided 35 milligrams of sulfur dioxide per liter.

A small vertical basket press was used to press the Chardonnay fruit. The crushed grapes were transferred from the fruit bin into the press basket with a three-gallon plastic bucket. As the basket was being filled, about half the juice ran through the press into a 5-gallon bucket. When the bucket was full, it was emptied into a 55-gallon polyethylene drum.

Press pressure never exceeded 25 psi, and the pressure was applied slowly to reduce foaming. The press cake was broken up and repressed three times before the pomace was dry. The small press had a 200-pound capacity, and three complete press loads were required.

Including the time needed to wash the crusher and the press before and after; the entire crushing and pressing operation lasted more than four hours. The 600 pounds of Chardonnay grapes (and much work) produced forty-five gallons of juice.

Testing Fruit

Testing was done when juice became available. Sugar content was measured with a short-ranged hydrometer. A value of 23.3 Brix was obtained after a temperature correction was applied (the juice was cold). The acid was tested, and it was 0.58 percent. The pH was 3.52.

Cold Settling Juice

The Chardonnay juice was settled in a homemade "cold-box." The cold-box is made from 1-inch thick, ridged foam insulation panels, and it measures four feet wide, four feet high and eight feet long. The top of the box is hinged and can be raised for easy access. A small 7000-Btu window air conditioner mounted in one end of the insulated box keeps the temperature of the box below 56 degrees. The 55-gallon drum of Chardonnay juice was moved into the cold box when pressing was completed. The temperature of the juice was 64 degrees when placed in the box.

In the morning, the juice temperature was down to 57 degrees. Then, 39 gallons of clear juice was racked off the sediment into a clean 42-gallon polyethylene drum. The remaining juice and sediment were resettled in a refrigerator, and an additional two gallons of clear juice was reclaimed.

Adjust Fruit

The acid content of the Chardonnay juice was low just as it had been in previous years, and enough tartaric acid was added to raise the TA of the juice to 0.69 percent. Juice pH was re-measured, and the tartaric acid addition reduced the pH to a value of 3.41. California Chardonnay grapes are often low in available nitrogen, so three ounces of diammonium phosphate were also added. The DAP crystals were dissolved in a little water and stirred into the juice.

FERMENTATION

Forty grams of active, dry Prise de Mousse yeast were stirred into 350 milliliters of warm water. Water temperature was adjusted to 99 degrees, and the yeast mixture was stirred several times.

The mixture was allowed to rehydrate for about 20 minutes before it was stirred into the juice, and the drum was sealed with a fermentation lock. No signs of fermentation were found the following morning, and fermentation could not be detected on the second morning. However, by the evening of the second day, the bell in the fermentation lock was up, and the Chardonnay juice was gassy. Fermentation was underway.

The temperature of the Chardonnay juice was maintained at 56 to 58 degrees during the fermentation. Each evening the temperature was measured, and a hydrometer was used to check the sugar content. The Chardonnay wine was removed from the cold box on September 5 and the wine was allowed to warm to room temperature. After three days at room temperature, the wine measured -2.3 Brix. After two more days, the hydrometer reading had not changed. A complete fermentation record for the Chardonnay wine is shown in Table 18.

DATE	TEMP	BRIX
8/21	58	23.3
8/22	56	23.3
8/23	57	23.3
8/24	57	22.5
8/25	56	21.1
8/26	57	17.0
8/27	56	14.9
8/28	57	12.5
8/29	58	10.8
8/30	57	9.9
8/31	57	8.7
9/1	56	7.7
9/2	56	6.4
9/3	56	5.0
9/4	56	3.8
9/5	moved	-
9/6	73	0.8
9/7	75	-1.7
9/8	75	-2.4
9/10	74	-2.4

Table 18. The Complete Fermentation record for the 1995 Chardonnay wine.

ML Fermentation

A packet of dry *Viniflora Oenos* was added directly to the wine to start malolactic fermentation. Several days later, the bell on the fermentation lock was up, and ML fermentation appeared to be underway. A chromatogram was made on October 6 and the chromatogram showed that no malic acid remained.

SO_2 Addition

An addition of 50 ppm sulfur dioxide (mg/l) was made to the new Chardonnay wine. The container was then topped up and sealed with a fermentation lock.

CELLAR WORK

The wine remained on the gross lees for another two weeks. Then the wine was racked into a clean container, and the container was topped up and sealed with a fermentation lock. A sample of wine was tested, and the measurements showed free SO_2 = 22 ppm, TA = 0.64 and the pH was 3.41.

Oak Chips

On 2 December, five ounces of loose oak chips were added to the Chardonnay container. A sample of wine was taken, and measurements showed: color = ok, clarity = ok, aroma = ok, taste = ok, SO_2 = 19 milligrams per liter, TA = 0.65 and pH = 3.40.

On January 6, a sample of Chardonnay was taken from the container. The wine was measured, tasted and carefully examined. The following results were obtained: color = ok, clarity = ok, aroma = ok, taste = ok, SO_2 = 16 milligrams per liter, TA = 0.64 and pH = 3.43. The free SO_2 was getting low, so 25 milligrams per liter of sulfur dioxide was added to the wine at this time.

Hot & Cold Stabilization

One liter of hot water was placed in a blender, and 60 grams of agglomerated bentonite were slowly added to the water while the blender was running at high speed. The bentonite mixture was allowed to cool for several hours. The mixture was then sealed in a plastic bottle and placed in a refrigerator for a few days. In mid January, the 60 grams of hydrated bentonite were stirred into the Chardonnay wine. The next day, the container of wine was moved into a small, upright freezer. The freezer is not equipped with an adjustable thermostat, but the temperature can be controlled within a few degrees with an electric timer. The freezer operated continuously until the temperature of the wine reached 29 degrees. The timer was then used to keep the wine temperature between 27 and 30 degrees. The wine was held at that temperature for six days. Then the cold wine was racked into a clean container and allowed to warm to ambient temperature.

Aging

On February 9, the Chardonnay was carefully tasted and measured. The February testing gave the following information: color = ok, clarity = ok, aroma = ok, taste = ?, SO_2 = 24 milligrams per liter, TA = 0.61 and pH = 3.46. The winemaker felt that the wine would benefit from more oak character, so two additional ounces of oak chips were added to the container.

On March 6, the wine was tested with the following results: color = ok, clarity = ok, aroma = ok, taste =? SO_2 = 20 milligrams per liter, TA = 0.60 and pH = 3.44. Little oak was showing.

The wine was tested again on April 10. The results of these tests showed: color = ok, clarity = ok, aroma = ok, taste = ok, SO_2 = 16 milligrams per liter, TA = 0.58 and pH = 3.45. Some oak was starting to show. An addition of 15 milligrams per liter of sulfur dioxide was made at this time.

Getting Ready to Bottle

Two samples of the wine were taken a couple of days before bottling. Lab measurements were made on one of the samples, and the data showed: color = ok, clarity = ok, aroma = ok, taste = ok, SO_2 = 19 milligrams per liter, TA = 0.61 and pH = 3.44. The sulfur dioxide was too low, so it was increased to 28 milligrams per liter.

The second wine sample was placed in a clear 375-milliliter wine bottle and the bottle was placed in a refrigerator. After two days, the bottle was removed from the refrigerator. After the sample had been at room temperature for 24 hours, the wine was carefully examined. The Chardonnay wine showed no haze or tartrate crystals, so the wine was declared to be cold stable. The next day, the Chardonnay wine was filtered with a 2-micron absolute pad to prepare the wine for bottling.

Bottling

The Chardonnay was bottled on 1 May 1996. The wine was pumped directly from the polyethylene drum, through a 0.5-micron filter and into a two-spout, gravity bottle filler. Each empty bottle was rinsed with clean, hot water just before it was placed on the filler spout. About an hour was required to fill and cork the bottles. Capsules and labels were applied to the bottles the following day, and the bottles were placed in cardboard cases. Labels were placed on each case to identify the contents, and the cases were sealed with 2-inch, clear plastic tape.

FOLLOW UP

At bottling time the wine had a pale straw color and it was brilliantly clear. The TA was 0.61, and the pH was 3.44. The free sulfur dioxide content was 28 milligrams per liter. Sixteen cases of Chardonnay wine were bottled. The taste improved significantly after the wine had been in the bottle for a few months.

Chapter 24

MAKING SPARKLING WINE

Sparkling wines are produced in France, Spain, Italy, etc., but only those sparkling wines made in a small region of France using the classical method are called Champagne. Sparklers produced anywhere else are properly called “sparkling wines.” Sparkling wines are blended from several carefully selected lots of still wine, and the French word for the batch of starting wine used to make Champagne is Cuvée. Classical sparkling wines are made by applying a multi step process to blended, still wines. A second sugar fermentation takes place in the bottle, and this fermentation produces a carefully controlled volume of carbon dioxide gas and a small amount of ethyl alcohol. The carbon dioxide gas produces the desired effervescence

Four steps are used to produce traditional sparkling wine. (1) First, sugar and yeast are added to a finished still wine, and the wine is bottled. (2) Fermentation converts the added sugar into alcohol and carbon dioxide gas. (3) The new sparkling wine is aged on the yeast lees for a year or more. (4) After aging, the sparkling wine is finished. During finishing, upside-down bottles are turned repeatedly to work the yeast lees down onto the bottle caps. After several weeks of turning, when the yeast is on the caps, the yeast lees are disgorged from the bottles. Wine lost in disgorging is replaced with a small quantity of still wine containing sugar, and the bottles are corked.

Novice winemakers may find this process complex, but the whole procedure becomes relatively simple when each step is understood. Nevertheless, the production of traditional sparkling wine is by necessity a lengthy and labor intensive process. The quality of sparkling wine is determined primarily by the starting cuvée, and by the length of time the wine is aged on the yeast lees. Long aging times and much handling are required to produce a quality product. Considerable time and effort are required to produce quality sparkling which accounts for its high cost.

MAKING THE CUVÉE

Finished sparkling wine quality depends largely on the characteristics of the starting cuvée, and the starting wine should have several specific characteristics. The starting wine must be dry, or if it contains sugar, the quantity of the sugar must be accurately known. Cuvée should have a clean, neutral bouquet, and any varietal flavors should be subtle. Cuvée has a high acid content ranging between 0.7 and 0.9 percent. In addition, the starting wine should be low in free sulfur dioxide (less than 25 milligrams per liter), and the alcohol content should be between 10 and 11.5 percent.

Grapes harvested specifically for making sparkling wines are picked before they are completely ripe. Sugar content is often only 17 to 20 Brix. Early picking helps insure subtle varietal flavors and a high acid level. Early harvested grapes also produce a starting cuvée with low alcohol content, and the low alcohol makes the second fermentation easier to start.

In the Champagne region of France, cuvée is made from about 2/3 Pinot Noir grapes and about 1/3 Chardonnay grapes. Chardonnay is a white grape, but Pinot Noir is a red grape. Most red grapes have colorless juice. The color is in the grape skins. Since the red color is in the skins, red grapes must be handled gently and pressed quickly to avoid introducing a blush color into the cuvée. In California, high quality "Blanc de Blanc" cuvée is often blended from wines made from Chardonnay and Pinot Blanc grapes. In Italy, the famous "Asti Spumante" sparkling wine is made entirely from White Muscat grapes.

Blending Cuvée

Sparkling wine cuvée must be clean, stable and brilliantly clear. Home winemakers often produce a satisfactory cuvée by blending and modifying available dry white wines. The alcohol content may be too high when white table wines are used, and flavor levels are often too intense. However, the blend can be diluted with a small amount of water. A 10 percent water addition may reduce the alcohol too less than 11.5 percent without diluting flavor intensities excessively.

The titratable acid and the free sulfur dioxide content of the cuvée will also need adjusting. Most available table wines will require modest additions of acid to raise the TA to about 0.80 percent. Large additions of tartaric acid should be avoided, or the wine may need to be cold stabilized again. Citric acid is often used for small acid adjustments because it does not produce instability problems.

The second fermentation in the bottle will be very difficult to start if the sulfur dioxide content of the starting wine is too high. When the free sulfur dioxide content exceeds 25 milligrams per liter, hydrogen peroxide can be used. An addition of 3.5 milliliters of 3% hydrogen peroxide in 5 gallons of wine will remove 10 milligrams per liter of free sulfur dioxide. Wine flavors or aromas are not affected significantly when hydrogen peroxide is used properly. However, hydrogen peroxide is a potent, oxidizing agent. Bench testing should be done when using hydrogen peroxide and accurate sulfur dioxide measurements are necessary.

Measuring the Sugar

The total sugar content of the cuvée must be very carefully controlled. If the sugar content is too low, the finished wine will not have enough effervescence. However, if the sugar content is too high, excessive pressures will be generated in the bottle, and **high pressures can cause the bottles to explode.** When commercial sparkling wines are made, enough sugar is added to produce bottle pressures of about 90 pounds per square inch (psi). However, home winemakers are strongly advised to work with less pressure. Exploding bottles are the subject of jokes, but they are serious hazards.

One and one-half (1.5) ounces of sugar are recommended for each gallon of **completely** dry wine. This quantity of sugar will produce a lively sparkle in the finished wine, and bottle pressures will be held to about 40 psi. Ordinary white, granulated household sugar should be used. The starting wine must be completely dry, and the residual sugar should be measured with a *Clinitest* tablet. The quantity of sugar must be accurately weighed, and the volume of the cuvée accurately measured. Do not guess at any of these quantities. The carefully measured sugar and a small amount of yeast nutrient should be added to the wine. About 1/4 tsp. of diammonium phosphate in 5 gallons of wine is the right amount. Stir the cuvée until all of the sugar and DAP are dissolved.

SECONDARY FERMENTATION

Starting the second fermentation is very much like starting a stuck wine. The process is quite simple, but considerable attention by the winemaker is required. First, a pint of starter is made from dry yeast and a spoonful of sugar. Prise de Mousse or California Champagne yeast should be used.

These yeasts are tolerant to both alcohol and sulfur dioxide. Despite its name, Pasteur Champagne yeast is not very good for sparkling wine production. It will ferment satisfactorily, but Pasteur Champagne yeast lees are difficult to riddle.

When the starter is active, an equal volume of cuvée is added to the starter, and the quart of starter is set aside. Wait until the starter becomes active again, and then add a quart of cuvée. When the starter is again active, two quarts of cuvée is added. This doubling process is continued until the entire batch of cuvée shows signs of active fermentation. The doubling process can be accomplished in twenty-four hours or so if the starter is kept warm. Low temperatures will require more time. Bottle the cuvée when a ring of fine bubbles appears around the edge of the container.

The starting wine must be bottled in Champagne type bottles. **Do not use other kinds of bottles because the pressures are too high.** Each bottle should be cleaned and inspected carefully, and any bottles with scratches, chips or cracks should be discarded. Clean, sound bottles should be filled until the headspace is about two inches. All domestic champagne bottles are made with a special lip that allows the bottles to be closed with "crown" (beer) caps. Crown caps should be used to seal the bottles rather than corks. Caps are less expensive, and they are much easier to remove later. Caps can be quickly and easily applied with a small hand, capping machine.

Aging

Much of the desired character of sparkling wine is derived from the wine being in contact with the yeast lees for an extended time. Yeast contact time is very important, and a high quality product cannot be produced quickly. All high quality sparklers spend at least one year on the yeast lees. In France, all Champagne must spend at least one year on the yeast lees or the word "Champagne" cannot be placed on the label. Some home winemakers produce a three or four year supply in a single batch. Making a large batch seems to be a good technique. Some wine is available to drink after a year, but much of the sparkling wine can be aged for an extended time.

Sparkling wine should be aged in a cool, dark environment free from excessive vibration. The bottles can be laid on their sides and stacked up like firewood. When the bottles are stacked this way, the yeast lees are spread over a large surface area, and the large surface area is an advantage. However, if adequate space is not available, the wine can be stored in cardboard cartons with the bottles standing vertically with the points up. In either case, the bottles should be shaken **gently** every six months to agitate the yeast sediment back into suspension. **Considerable care, leather gloves and safety glasses are appropriate for the shaking procedure.**

THE FINISHING PROCESS

Sparkling wine is ready to finish after it has aged on the yeast lees for an appropriate time. Finishing a sparkling wine consists of three basic steps. (1) First, the yeast lees are induced to slide down the side of the bottle until all of the lees rest on the crown cap by riddling. (2) The yeast lees are removed from the bottle by disgorging. (3) Finally, the new sparkling wine is sweetened to the desired level, and the bottle is corked.

Riddling

When aging is complete, the next step is to remove the yeast lees from the bottle. Riddling is the name of the process used to move the yeast sediment down onto the crown caps. Traditionally, large wooden racks were used to hold the bottles in a slanted position with their points down, and each bottle was rotated about an eighth of a turn each day. Traditional wood riddling racks are large and heavy, and considerable space is needed when using these racks.

Fortunately, other techniques have been developed to coax the yeast down the side of the bottle onto the crown cap. A simple method of riddling consists of placing the bottles in ordinary cardboard cartons with their points down. Then each day the bottles are jostled, bumped or twisted. Early in the process, the cartons are propped over at an angle. Later, after the yeast has started to move down the side of the bottle, the cartons are moved to a more vertical position. The riddling process is strongly influenced by the type of yeast used and the cleanliness of the bottles. Usually several weeks are needed to complete the riddling operation. But, under adverse conditions, three or four months may be required and if the bottles were not scrupulously clean, sparkling wines can be almost impossible to riddle.

Disgorging

Since small producers often work with a minimum of equipment, removing the yeast sediment from the bottle is often the most difficult step in the sparkling winemaking process. The objective of the disgorging operation is to remove all of the yeast from the bottle without reducing the carbon dioxide pressure significantly.

The classical method of removing the yeast is a multi step process. (1) The bottles are chilled with their points down until the temperature of the wine is less than 45 degrees. (2) The necks of the bottles are placed in a cold brine solution until a plug of ice inch or so long freeze in the necks of the bottles. (3) The bottles are removed from the brine solution, and the necks of the bottles are dipped in clean, room-temperature water. (4) After the brine has been washed away, the necks of the bottles are raised to a 45-degree angle, and the crown caps are removed quickly. (5) The plug of ice flies from the bottles, and the ice carries most of the yeast sediment away. (6) The left thumb is judiciously applied to each bottle to control gushing. If the wine is cold and if the bottles were clean, gushing quickly subsides. (7) The winemaker then uses the little finger on his right hand to wipe away any remaining yeast from inside the mouths of the bottles. A written description of this process sounds complicated, but after a few bottles have been disgorged, the whole procedure becomes quite simple.

Sweetening and Corking

Most people prefer off-dry sparklers, and wines containing 1 to 4 percent of residual sugar are common. The desired level of sugar is introduced by adding a small dose of syrup to each bottle after the yeast has been removed. This syrup also contains a small amount of sulfur dioxide to help preserve the sparkling wine. The syrup is made up ahead of time, and the syrup must be well chilled before it is added to the disgorged bottles.

Typical syrup contains 375 grams of sugar, one gram of sulfite powder and 700 ml liters of dry white wine. When 30 ml of this syrup is added to a standard 750-ml bottle, the finished sparkling wine will contain about 2 percent sugar and about 30 milligrams per liter sulfur dioxide. Of course, the sugar and SO_2 can be adjusted to any desired level.

Syrup should be added to the bottles after any remaining yeast has been wiped away. Each bottle is tipped to a 60-degree angle, so the syrup runs down the inside surface of the bottle. The syrup must be cold, and it must be added slowly and continuously to avoid gushing. After the syrup has been added, the liquid level in the bottle should be adjusted by adding wine from a reserved bottle of cold sparkling wine.

When the headspace is correct, the bottle can be sealed with a polyethylene stopper, and a wire hood should be attached to hold the stopper in place. After all the bottles are sealed, the outside surfaces should be rinsed clean with cold water. Then the bottles can be set aside to dry, and labels can be applied after the bottles reach room temperature. New sparkling wines should be allowed to rest for a few weeks in a cool, quiet place to recover from bottle shock. After a short rest, they will be ready to use. Sparkling wines usually keep well, but after the yeast has been removed, the wine will show little improvement with further aging.

SUMMARY

Sparkling wine is made by adding sugar and yeast to a still wine, and the wine is tightly sealed in bottles specially designed to withstand high pressures. A second fermentation takes place in the bottle, and the carbon dioxide gas produced gives the wine the desired effervescence.

Quality sparkling wine is aged on the yeast lees for a year or more. Then the wine is ready to finish. The yeast is worked down the side of the bottle until all the sediment rests on the cap, and then the yeast is expelled from the bottle. The wine is then sweetened with syrup, and the bottle is sealed with a polyethylene stopper.

The starting wine must be dry, and the added sugar must be measured carefully. Only sound Champagne type bottles can be used for making sparkling wine.

Chapter 25

MAKING FRUIT WINES

The grape harvest period in southern California extends from about mid August until early October, so wine can be made from grapes for only a few weeks each year. On the other hand, excellent wines can be made in California from fresh fruit six or seven months of the year. When frozen fruit is used, wine can be made the year around. Making fruit wine is different from making wine from grapes. Grapes have just about the right amount of sugar and acid to make a balanced wine, but most other kinds of fruit often require large additions of sugar and significant acid adjustments. The sugar and acid content of different types of fruit varies considerably, so fruit winemaking is a bit more complicated than making wine from grapes. Consequently, when fruit wine is made, the winemaker must carefully measure and adjust both the sugar content and the acid content of the fruit and then appropriate must adjustments should be made before the yeast is added and fermentation is started.

Although dry wines can be produced easily, most people prefer off dry or slightly semi-sweet fruit wines. A small amount of residual sugar seems to preserve and enhance the characteristics of the fruit used to make the wine. Consequently, most fruit wines are finished with a sugar content ranging from one to four ounces of sugar per gallon of wine (0.75 to 3 percent sugar). Some types of fruit seem particularly suitable for making dessert style wines. These wines often contain four to twelve ounces of sugar per gallon of wine. In addition, desert wines are sometimes fortified with additional alcohol. Dry, red table wines can be made from blackberries, loganberries, boysenberries, elderberries, etc, and when they are properly made and aged, berry wines are often difficult to distinguish from high quality grape wines.

FRUIT WINEMAKING STEPS

Making fruit wine consists of several different steps. Although several steps are required, not a great deal of time or effort is required. Drinkable wine can be made in two or three months, but most high quality white or blush table wines made from fruit are bottled when they are six months or more years old. Heavy, dark colored fruit wines are often twelve or more months old when bottled.

Fruit winemaking can be divided into five basic steps. Each of the following steps contributes to the overall quality of the wine. However, the quality of the finished wine depends primarily on using high quality, properly ripened fruit.

(1) Fruit is inspected and prepared for fermentation.
(2) Appropriate amounts of water, sugar, acid and sulfur dioxide are added to the fruit, and sometimes other materials are added to produce a fermentable "must."
(3) Adding a suitable type of wine yeast to the prepared must starts fermentation.

(4) When fermentation is complete, the new wine is clarified and stabilized by racking, fining and filtering.
(5) When the wine is clear and stable, it is bottled.

FRUIT

Wine can be made from practically any type of fruit, but not all types of fruit are suitable for making all styles of wine. Selecting a wine style to match the type of fruit available is an important part of fruit winemaking, and winemaking experience is needed when wine is made from exotic fruits like pineapples, guavas or mangos.

Amount of Fruit

The quantity of fruit needed to make a given wine style depends on the flavor intensity of the particular fruit and on the flavor level wanted in the finished wine. Usually from 3 to 6 pounds of fruit are needed for each gallon of wine. Raspberries and a few other types of fruit have very strong flavors, and wines made from six pounds of raspberries per gallon have intense raspberry flavors. Other fruits such as bananas have very bland tastes, and producing wines with strong banana tastes would be difficult.

Three to six pounds of fruit per gallon of wine generally produce an acceptable product. However, experience with a particular type of fruit is always helpful when a winemaker is trying to decide how much fruit to use. Unless exceptionally strong fruit characteristics are wanted, three or four pounds of fruit are a good starting point.

Fruit Preparation

Only sound, ripe fruit should be used for winemaking. Most types of fruit should be washed to remove insecticides, fungicides or bugs. Superficial blemishes on the fruit will do no harm, but rotten fruit should be discarded. Moldy fruit will give the finished wine a moldy taste, and rotten or badly bruised fruit can carry harmful bacteria into the wine. Off-flavors can be avoided by sorting over the fruit carefully and using a sharp knife to remove gross blemishes, rot or mold.

Stems and leaves should be removed from the fruit. Seeds should be removed if they have a distinctly bitter taste, and most fruit winemakers prefer to remove the stones from plums, prunes, peaches, apricots and cherries. However, some winemakers deliberately retain a few seeds from these fruits to provide extra tannin. Most stone fruit wines are made in an off-dry or sweet style.

On the other hand, skins contain desirable flavor materials, so skins are usually retained. Usually, plums, prunes, apricots, peaches and most berries are fermented with the juice, pulp and skins together for a few days to extract flavors. Here, the fruit should be chopped and then crushed. Putting fruit through a very course grinder is a practical way of preparing large quantities of fruit.

Although most fruit wines are made with some residual sugar, some very pleasant, dry red table wines have been made by fermenting a mixture of several different kinds of dark colored berries. This style of red fruit wine is often fermented, aged and finished just like a red grape table wine. Juice, skins, pulp and seeds of blackberries, boysenberries, cranberries, elderberries, blueberries, gooseberries, Loganberries, mulberries, raspberries and strawberries are usually included in the fermentation. Berries used for winemaking should be very ripe and sorted carefully. Berries can be prepared for fermentation easily by mashing. Seeds contain a variety of tannin materials. Too much tannin can give wine a bitter taste and make the wine excessively astringent, so seeds should not be ground, mashed or cracked.

Wine made from oranges oxidizes very easily, so good orange table wines are difficult to make. However, pleasant sherry style wines can be easily made from oranges. Citrus fruit skins contain considerable oily material, and most winemakers prefer to eliminate skins from citrus fruit fermentations. The membrane under grapefruit skins contains much bitter material, and this white pulpy material should be removed carefully.

Many fruit winemakers simplify the handling of skins and pulp by placing these materials in a nylon mesh jelly bag. When fermentation is started, the jelly bag full of pulp is suspended in the liquid. The wine gets all the benefits from the solid materials, but separating the liquid from the pulp at the end of fermentation is much easier.

PREPARING THE MUST

Grapes contain all the necessary ingredients to make a balanced wine. However, this is not the case with other kinds of fruit and additions of different kinds of materials are often needed before the fermentation can be started. Besides the fruit, good quality water will be needed, and the sugar and acid content of the must will probably need to be adjusted.

The sugar content of the must can be measured easily with a Brix hydrometer. A reading of about 22 Brix will be right for most fruit wine fermentations. Add a small quantity of sugar to the must, stir until all the sugar is dissolved, and then take a reading with the hydrometer. Continue this procedure until the hydrometer reads 22 Brix. Ordinary, white, granulated table sugar (sucrose) should be used to increase the sugar content of the prepared fruit.

Measure the acid content of the must with an "acid test kit." A value of 0.60 to 0.70 percent (grams per 100 ml) is about right for the starting acid content for off-dry fruit wines. A value of 0.60 to 0.65 percent may be more appropriate when the wine will be finished dry. Most winemakers use "Acid blend" to increase the acidity of fruit musts. Acid blend is a mixture of citric, malic and tartaric acids. The acid crystals must be completely dissolved.

Very small amounts of sulfur dioxide should be added to musts made from fruit. One Campden tablet for each gallon of must is about the right amount. The sulfur dioxide reduces juice oxidation and kills some of the unwanted bacteria. Sulfur dioxide also helps control any wild yeast that is always present on the fruit. Making a satisfactory fruit wine without using small quantities of sulfur dioxide is difficult.

Depending on the specific circumstances, tannin may or may not be added to fruit wine musts. Tannin is a material in the skins and seeds of fruit, and it adds desirable astringency to wine. Tannin also acts as a wine purifier and a natural preservative.

Yeast requires nitrogen to multiply properly during the early stages of fermentation, and many fruits are low in available nitrogen. Consequently, small quantities of a material called yeast energizer are often added to fruit musts to supply extra nitrogen and help the yeast multiply quickly.

Many types of fruit, particularly apples and plums, have high pectin content. Pectin causes fruit juice to solidify into jam or jelly, and pectin can cause problems in wine. The pectin carries over through fermentation and makes the wine difficult to clarify. Most fruit winemakers add small amounts of pectic enzymes (see below) to their musts before fermentation is started. The enzymes break down the pectin in the fruit, and then the wine can be clarified more easily. Enzymes also help extract color from the fruit.

Many fruit winemakers add mashed, fresh bananas to their fruit wine musts. The bananas do not change wine flavors significantly, but after fermentation, the bananas help the new wine clarify. Bananas also increase the body of the wine, and from ½ to 2 pounds per gallon often improve the mouth-feel of the finished wine.

FERMENTATION

Wine yeast is available either as a liquid culture or in dry granular form. Either type works well, but dry yeast is easier to prepare and use. Many different strains of wine yeast are available. Some types of yeast can produce high alcohol levels. Other types of yeast cannot ferment at low temperatures. Some types of yeast produce excessive amounts of foam, and the foam causes the containers to overflow. Epernay II is a slow fermenting yeast, and it is often used for light, off-dry, fruity style wines. Pasteur Champagne yeast is more vigorous, and it is often used for dry wines when neutral flavors are wanted. Prise de Mousse, dry yeast is general-purpose yeast. This yeast is vigorous, but it produces little foam.

A good general rule is to use one gram of dry yeast for each gallon of must. Some winemakers prefer using half as much; other winemakers prefer to use twice this amount. Many fruit winemakers just sprinkle the dry yeast on the must, but all yeast manufacturers recommend rehydrating dry yeast in a small amount of warm water. About a cup of water for each tablespoon of dry yeast should be used. The temperature of the water should be 95 degrees, so a thermometer should be used. The yeast mixture should be stirred several times, and then the yeast mixture should stand for about twenty minutes before it is poured into the must.

Active fermentation should start 12 to 48 hours after the yeast is added. The time will depend upon the temperature of the must, how much sulfur dioxide is used and several other factors. When fruit pulp is fermented in an open fermenter, the container should be covered with a sheet of plastic. Stir the must at least once each day. After two or three days of active fermentation, the liquid is separated from the pulp with a nylon jelly bag, by racking or by straining. The solid materials are discarded, and the liquid should be placed in a closed container to finish fermentation. Carbon dioxide gas from the fermentation must be vented from the closed contained. Fill a fermentation lock half full of plain water and attach the lock to the container.

Generally, hot, fast fermentations are undesirable. Rapid fermentations produce large quantities of carbon dioxide, and much of the desirable fruit odors and flavors are carried away by the gas. In addition, fast fermentations do not provide enough time to extract adequate fruit odors and flavors from the solid materials. Long, slow fermentations produce more flavorful wines, and fermentation temperatures can affect wine flavors considerably. Temperatures between 70 and 75 degrees are desirable at the start of fermentation. However, once fermentation is underway, the temperature should be reduced and kept between 60 and 70 degrees. The lower temperature provides the slow fermentation needed for good wine quality.

Dry White Wines

Making good quality, dry, white table wine from fruit is a difficult undertaking, but fruit winemakers become very skilled in producing this style of wine. The most suitable types of fruit for making dry table wines are pears, apples or gooseberries. These types of fruit are also suited for making sparkling wines.

Some dry, white table wines are best when made by fermenting only clarified juice. First the fruit is washed and then converted to purée by crushing. Some winemakers prefer to use a food processor for preparing fruit for dry white wine, but the seeds should not be ground up. Water, sugar, acid, sulfur dioxide and all of the other ingredients, except the yeast, are added to the finely chopped fruit. The must is then covered with a sheet of plastic and cooled to a low temperature. The must is kept cold for 24 to 72 hours to extract as much flavor from the pulp and skins as possible. After a suitable time, the liquid is separated from the solid material. Much of the solid material settles to the bottom of the container while the must is standing. The clear liquid can then be removed by siphoning, straining or pressing. The solids are discarded, and only clear juice is fermented when making dry table wines.

All fruit contains natural yeast cell on the skin, and this technique of cold soaking is only effective if the must can be kept cold. Otherwise, the native yeast may start a spontaneous fermentation. Even at low temperatures, some danger of spontaneous fermentation exists, so the winemaker should watch the cold must carefully. If signs of spontaneous fermentation appear (a ring of bubbles around the edge of the container), the juice should be racked off the solids, and a suitable wine yeast added.

An open fermenter is not needed when clarified juice is fermented, so a closed fermenter should be used to reduce oxidation. Fill the closed fermenter about three-fourths full, and seal the container with a fermentation trap filled with plain water. When fermentation is complete, rack the wine off the yeast lees and add one Campden tablet for each gallon of wine.

CLARIFICATION AND STABILIZATION

New wines contain yeast cells, bacteria, small bits of skin, pulp, etc. These particles are pulled down by gravity, and they slowly settle to the bottom of the container. The smaller the particle, the slower it sinks to the bottom of the container. Some particles are so small they never sink to the bottom, and these particles remain suspended in the liquid.

"Racking" is a process used to separate the clean wine from the lees (the muck on the bottom of the container). The muck will be gone and the wine will become clear and bright after the wine has been racked two or three times, When small containers are used, the wine can be siphoned off the lees with a piece of transparent plastic hose. Exposing wine to air can cause excessive oxidation, so wine should not be splashed, frothed or bubbled when racking. New wines should be racked into a clean container two or three weeks after the completion of fermentation. Most of the yeast lees will be left behind if the racking is done carefully. One Campden tablet for each gallon of wine should be added, and the container sealed with a fermentation lock.

When fruit wines are six to eight weeks old, they should be racked from the secondary lees, and a few weeks after the second racking some fruit wines will be clear and bright. If a new fruit wine is not clear at this time, it should be "fined" to remove the suspended particles. The fining material causes the very small particles to lump together. The particles grow in size, and the larger particles settle out of the wine more quickly. Sparkolloid and bentonite are two effective fining materials for clarifying fruit wines. However, the directions on the packages should be carefully followed when using these materials.

Sparkolloid is the least harmful fining material. Too much bentonite can strip desirable aromas and flavors from fruit wine, so most winemakers prefer to clarify with Sparkolloid. Three weeks after a Sparkolloid addition, the wine should be racked again to separate it from the Sparkolloid lees. Splashing and bubbles in the wine should be avoided when racking. If Sparkolloid does not provide adequate wine clarity, a bentonite treatment may be necessary.

Most off-dry fruit wines will be ready to prepare for bottling a month or two after clarification fining. Some home winemakers hold back a small quantity of the original juice by freezing. Then, a few weeks before bottling time, the juice is thawed, clarified by racking and added to the wine. The added juice provides more fruity flavors, and it adds a small amount of residual sugar to the wine. However, the wine contains sugar after the juice addition, and special precautions are required to prevent renewed fermentation (see below). The amount of sugar to add can best be determined by tasting the wine.

BOTTLING

Fruit wines must be brilliantly clear and completely stable before bottling. Wine bottled without sufficient SO_2 will be short lived, so the free sulfur dioxide content should be raised to 30 or 40 milligrams per liter a few days before bottling time. One crushed Campden tablet for each gallon of wine is the correct amount. If sugar is added to sweeten the wine, potassium sorbate should also be added. The added sugar will start to ferment without the sorbate, and fermentation after bottling will generally produce cloudy hazes or sediment and spoil the wine. Directions supplied with the sorbate should always be followed, and sorbate additions should always be measured carefully.

Clean, used, wine bottles should be rinsed with very hot water before the bottles are filled with wine. Although bottles can be filled with a plastic hose, a "bottle filler" of some kind should always be used to reduce wine oxidation. Bottles should be filled from the bottom, and filling should be done slowly to reduce the quantity of foam produced. Bottles should be filled until no more than a quarter inch of space exists between the wine and the bottom of the cork. Most plastic wand type bottle fillers do not fill the bottles high enough, and a bit more wine must be added after the filler is removed.

Dry corks should be driven into the bottles if possible. However, many small corking machines will not adequately compress dry corks, so soaking corks in cold water for a few minutes may be necessary. A pinch of sulfite added to the water may help sterilize the corks. After all the corks have been driven, the top of each cork should be wiped to remove the excess "cork water." The full bottles should stand upright for several days to let the pressure equalize in the bottles. When the pressure has equalized, the bottles can be laid on their sides and stored in a cool place.

After wine has been bottled for a year or two, the winemaker may have trouble remembering what type of wine is in the bottles, so all bottled wine should have an appropriate label.

FRUIT WINEMAKING MATERIALS

Depending on the circumstances, winemakers use many different materials for the production of fruit wines. Most fruit wine fermentations are made using readily available materials, but an exotic material may be needed occasionally to solve a specific problem. Some common fruit winemaking materials are briefly discussed here.

Acid

The three most important organic acids found in fruit are tartaric, malic and citric. Acid balance is very important for producing high quality wine, and the acid content of the fruit must be adjusted carefully. If the wine contains too little acid, it will taste flat and bland. When too much acid is present, the wine will taste too tart. Wines containing considerable sugar need more acid to be balanced. Tartaric acid, malic acid, citric acid or acid blend (a mixture of all three acids) is used to increase the acid level in fruit wines. Large quantities of citric acid should be used with some caution because a strong citric taste may not be appropriate in some types of fruit wine.

Fining Materials

Fining agents are often used in the production of fruit wines. Gelatins are sometimes used to remove excess astringency from fruit wines. The clay-like material bentonite is used to remove excess protein and improve the stability of these wines. Sparkolloid and bentonite are the two materials of choice for clarifying most types of fruit wine. Wines are usually fined with Sparkolloid first, then if the wine does not come clear, bentonite is used. Other fining materials like isinglass or casein are also used to clarify both red and white fruit wines. Most fining materials require from a few days to two weeks for the sediment to settle to the bottom of the container. Then the clear wine is racked off the sediment and very little of the fining material remains in the finished wine. Instructions supplied with fining materials should be followed carefully.

Pectic Enzymes

Pectin makes jam and jelly set. All fresh fruits contain some pectin, and some types of fruit like apples, apricots and plums contain large amounts. Pectin often causes problems for the fruit winemaker. Pectin can hold small particles in suspension, and wines containing excessive pectin often remain cloudy. "Pectinase" breaks the large pectin molecules into smaller, less-troublesome molecules, so it is a great help in clarifying cloudy wines containing excessive amounts of pectin.

Potassium Sorbate

Wines containing residual sugar and less than 16 percent alcohol can start fermenting anytime. Consequently, all off-dry and sweet wines must be stabilized by a special treatment. Potassium sorbate added to clean clear wine can prevent fermentation from restarting. However, sorbate will not stop active fermentations, and it cannot stop wines containing large numbers of viable cells from fermenting. Sorbate only works if the wine has been carefully racked or filtered to remove most of the yeast. Potassium sorbate is not a very stable material, and poorly stored sorbate can deteriorate in a few months.

Sulfur Dioxide

Sulfur dioxide is used in wine to inhibit the growth of microorganisms and to help reduce the effects of oxidation. However, sulfur dioxide is a pungent gas. This material must be carefully measured, and it must be used in very small quantities. Potassium metabisulfite (sulfite) crystals are added to juice or wine to provide the sulfur dioxide gas. Campden tablets are made by compressing sulfite crystals into a pill form, so Campden tablets can also be used to provide sulfur dioxide. Campden tables contain "filler" materials, and some winemakers feel filler can cause haze problems in some kinds of wine. Campden tables are easier to use when just a few gallons of wine are being produced. However, when larger quantities of wine are made, most winemakers prefer to use sulfite crystals. The crystals should be mixed with an ounce or two of water.

Sugar

The alcohol content of the finished wine depends upon the quantity of sugar in the juice. Sometimes home winemaking shops recommend special kinds of sugar, but ordinary white household sugar (sucrose) is quite satisfactory for making fruit wine. The yeast produces the enzymes needed to convert the sucrose into glucose and fructose.

Tannin

Tannin materials give wine its characteristic astringency. Tannin helps a young wine spontaneously clear, and it contributes to the longevity of the wine. Tannin originates in the seeds, stems and skins of fruit. Some types of fruit, like bananas, contain very little natural tannin, and producing a balanced wine from fruit low in tannin can be difficult. Consequently, winemakers often add extra tannin to fruit musts that lack sufficient natural astringency.

Yeast Energizer

Yeast cells need available nitrogen to reproduce and create the large population of cells needed for successful fermentation. Yeast energizers contain food grade diammonium phosphate (DAP), and the DAP provides extra nitrogen to keep the yeast happy, healthy and reproducing new yeast cells. High alcohol levels seem to prevent yeast from assimilating nitrogen, so nitrogen should be added early in the fermentation cycle before a large amount of alcohol has accumulated.

Wine Yeast

A variety of wine yeast can be obtained in dry form. Epernay is very popular for fermenting all types of fruit wines. Pasteur Champagne yeast is vigorous and tolerant of sulfur dioxide. Prise de Mouse is excellent, general-purpose wine yeast. Winemakers use many different types of yeast, but the different yeasts are used for reasons other than creating wine flavors.

FRUIT WINEMAKING EQUIPMENT

With one or two exceptions, little special equipment is needed to make fruit wine, and many home winemakers ferment small quantities of wine each year using implements from the kitchen. However, specialized winemaking equipment can reduce time and labor and purchasing specialized pieces of winemaking equipment may be desirable when large quantities of wine are made. Beginning winemakers should beware of the gadgets sold in some home winemaking shops. Many of these accessories are poorly designed and cheaply made. Like most other things, cheap winemaking equipment is generally a poor value. Several basic pieces of fruit winemaking equipment are briefly discussed below.

Acid Test Kit

The acid content of different kinds of fruit varies widely, and acid content varies from year to year. The only practical way of controlling acid balance in the finished wine is to measure and adjust the acid content of the must before fermentation is started. Wine quality improves greatly when the winemaker obtains the necessary equipment and takes the time to learn how to measure acidity. Acid test kits can be purchased at most home winemaking shops.

Bottle Filler

To reduce wine oxidation, bottles must be filled from the bottom with a minimum of splashing and bubbling. Filling bottles without splashing is difficult with a siphon hose, so some type of type bottle filler should be used. Wand type fillers consist of a length of rigid tubing with a small valve at the bottom end. When the filler is inserted in an empty bottle, the valve presses against the bottom, and the wine starts to flow. The flow stops automatically when the operator raises the tube. Fillers allow bottles to be filled with a minimum of splashing, and wine oxidation is minimized.

Corker

Driving a cork into a wine bottle by hand is very difficult, so a corking machine of some kind is needed when using cork finished bottles. Inexpensive corking machines are slow and most are difficult to use. Most of the inexpensive machines are not suitable for corking more than a few gallons of wine. A good corking machine is indispensable when several cases of wine are produced. Unfortunately, good floor corkers cost about $100. Corkers are not used very often, so beginners can often borrow a corker from a fellow winemaker.

Fermentation Locks

Fermentation locks are used on closed fermenters to let the carbon dioxide gas escape while keeping air from coming in. Rubber stoppers are used to attach the locks to the containers.

Fruit Wine Containers

Wine must always be protected from air, or the wine will oxidize and become undrinkable. Winemakers use two kinds of containers. During active fermentation, large amounts of carbon dioxide gas are produced, and the gas effectively excludes the air from the wine. Consequently, open fermenters can be used for the first few days of fermentation when lots of carbon dioxide gas is produced. When fermentation starts to subside, much less carbon dioxide gas is produced. Then the wine must be transferred into a closed container, and a fermentation lock must be attached. The lock lets the carbon dioxide gas escape, but it keeps air out of the container.

Open fermenters are used for mixing ingredients, or they are used for fermentations that contain solid materials like skins or pulp. A large, food grade, polyethylene container, equipped with a removable lid, makes an ideal open fermenter. However, many fruit winemakers have used new, plastic trashcans as open fermenters.

Closed fermenters have small openings, and they can be sealed easily with a cork, cap, bung or fermentation lock. Closed containers are always used when the fermentation does not contain solid materials, and closed containers are always needed at the end of all fermentations when the CO_2 gas starts to subside. Five-gallon water bottles (carboys) make good closed fermenters, and they are very popular for making fruit wine. Water bottles are easy to obtain, and glass is easy to clean and sterilize. However, glass water bottles have several disadvantages. Glass water bottles are heavy, and they are expensive. Glass is fragile, so glass carboys must be handled very carefully.

Some winemakers prefer to use polyethylene drums for making fruit wines, and these containers are available in sizes ranging from 10 to 60 gallons. Polyethylene containers have several advantages. Polyethylene drums are light, practically unbreakable and easy to store. Many commercial wineries are now using polyethylene storage tanks. These new tanks are made of high-density polyethylene, and they are much less expensive than stainless steel tanks.

Stainless steel is still the material of choice for large commercial fermentation and storage tanks. Stainless tanks are easy to clean, and stainless steel conducts heat well. Small size stainless steel containers are very expensive and often cost several dollars per gallon of capacity. However, used, stainless steel beer kegs are readily available, and they make excellent storage containers for all kinds of wine.

Oak barrels are often used for aging high quality, commercial red wines. The oak wood imparts desirable flavors to the wine. However, oak flavors are not suitable for many types of fruit wines. In addition, new barrels are expensive, and oak barrels are difficult to maintain properly.

Hydrometer

Hydrometers are used to measure the sugar content of must before and during fermentation, and a hydrometer is one of the few indispensable pieces of winemaking equipment. Most fruit does not contain enough sugar to make stable wine, so additional sugar is usually needed. Different kinds of fruit contain widely varying amounts of sugar, and a hydrometer is always needed to measure fruit wine musts. Some fruit winemakers prefer hydrometers calibrated in specific gravity because many fruit wine recipes list sugar content in these units. Commercial winemakers use hydrometers calibrated with the Brix scale. A cylinder is needed to use a hydrometer effectively.

Racking Hose

Racking is done to move wine from one container to another, and when racking is done properly, practically all of the sediment is left behind. Siphoning is the easiest way of transferring wine from one container to another, and a 6-foot length of ½ inch plastic tubing should be kept specifically for that purpose. The tubing should always be washed just before it is used and then washed again when racking is finished. Finally, hang the tubing up on a rack or several nails driven into a wall, so the water can drain completely.

Miscellaneous Equipment

A thermometer is often needed to monitor fermentation temperatures and to measure water temperature when rehydrating dry yeast. An 8-inch plastic funnel is useful from time to time. A large wooden spoon is handy for stirring small fermentations. Bottlebrushes are necessary when old wine bottles are recycled. A set of plastic measuring spoons is helpful for measuring small quantities of winemaking materials. A large plastic beaker calibrated in both milliliters and liquid ounces is handy for measuring liquids.

SUMMARY

Little specialized equipment is required to make fruit wines, and most of the items can be found in the kitchen. Excellent wines can be made from fruit, and fresh fruit is available for several months each year. Most fruit wines are finished in an off-dry or sweet style, but very pleasant dry, red table wines can be made from a mixture of dark colored berries.

Fermenting the pulp, skins and juice together is a popular way of making fruit wines. Some dry table wines are best when the must is chilled and allowed to stand. Then, after about 48 hours, the clear liquid is separated from the pulp, and only the clarified juice is fermented.

PEACH, APRICOT OR PLUM WINE

(Makes five gallons)

STEP 1 INGREDIENTS

15 lbs peaches **or** apricots **or** plums
5 gallons of water
8 lbs white granulated sugar
1 level teaspoon yeast energizer
6 level teaspoons acid blend
2 level teaspoons grape tannin
1 level teaspoon pectic enzyme
5 Campden tablets

STEP 2 INGREDIENTS

3 lbs white granulated sugar
2 teaspoons of acid blend

STEP 3 INGREDIENTS

1 pkt of Epernay wine yeast

STEP 5 INGREDIENTS

5 Campden tablets

STEP 7 INGREDIENTS

1-4 cups granulated sugar
2 tsp. potassium sorbate
3 Campden tablets

METHOD

1. Use only ripe fruit. Remove the stones and discard any rotten fruit. Crush the fruit, finely chop the fruit or run it through a food processor (do not process into a fine pulp). Put all step 1 ingredients in an open fermenter and stir well.

2. Use a hydrometer and adjust the sugar to 22 Brix by adding sugar in small quantities and stirring well. Use an acid test kit and adjust the acid to 0.65 percent by adding small quantities of acid crystals and stirring well. If a hydrometer or an acid test kit is not available, use the amounts shown in steps 1 and 2, but the quality of the wine will suffer.

3. Open the packet of dry yeast and sprinkle it on top of the must. Cover the fermenter, in 20 to 40 hours fermentation should start (bubbles form around the edge of the container).

4. Stir the must and measure the Brix each day.

5. When the hydrometer reads 12 to 14-Brix, strain out and discard the solids and siphon the liquid into a closed fermenter. Attach a fermentation lock filled half full of plain water. Make sure the containers are full of wine and always keep the fermentation lock half full of clean water.

6. After three weeks, rack the wine into a clean, closed container and add 5 crushed Campden tablets.

7. After three months the wine should be clear. If it is not clear, fine with Sparkolloid and rack three weeks after adding the Sparkolloid.

8. In a month or so, when the wine is clear and stable, add 3 Campden tablets. Add the sweetening sugar (to taste) and 2 level teaspoons (5 grams) of fresh potassium sorbate. Finally, bottle the wine.

DRY PEAR TABLE WINE

(Makes five gallons)

STEP 1 INGREDIENTS

20 lbs very ripe pears
4 3/4 gallons of water
8 lbs white granulated sugar
1 level teaspoon yeast energizer
8 level teaspoons acid blend
2 level teaspoons grape tannin
1 level teaspoon pectic enzyme
5 Campden tablets

STEP 2 INGREDIENTS

3 lbs white granulated sugar
3 teaspoons of acid blend

STEP 3 INGREDIENTS

1 pkt of Epernay wine yeast

STEP 5 INGREDIENTS

5 Campden tablets

STEP 7 INGREDIENTS

3 Campden tablets

METHOD

1. Try to get very ripe fruit. Remove the stems, quarter, remove all of the seeds and discard any rotten parts. Run the pears through a food processor until they become course pulp. Put all step 1 ingredients in an open fermenter. Stir the must until the sugar is dissolved completely.

2. Use a hydrometer and adjust the sugar to about 22 Brix by adding additional sugar in small quantities and stirring well. Use the acid test kit and adjust the acid to 0.65 percent by adding small quantities of acid crystals and stirring well. If a hydrometer or an acid test kit is not available, use the amounts shown in steps 1 and 2, but wine quality will suffer.

3. Cover the fermenter and place it in a refrigerator. Let the must stand for 48 hours. Siphon the clear liquid off the solids into a clean, closed fermenter, and attach a fermentation lock filled half full of plain water.

4. When the juice reaches room temperature, sprinkle the dry yeast on top of the juice. Fermentation should start (bubbles form around the edge of the container) in 20 to 40 hours. Retain the solids in a smaller container and place in the refrigerator. The next day, siphon off the clear juice and add it to the fermenter. Discard solids or resettle a third time.

5. Keep the fermentation cool, 50 to 60 degrees is fine. After 3 weeks the wine, measure the liquid with a hydrometer. If the hydrometer reads minus 1 Brix or less, added 5 crushed Campden tablets and rack into a clean fermenter. If the hydrometer reads higher than minus 1 Brix, wait another week and then repeat this step.

6. After three months the wine should be clear. If it is not clear, fine with Sparkolloid and rack 3 weeks after adding the Sparkolloid.

7. In another month when the wine is clear and stable, add 3 crushed Campden tablets and bottle the wine. Be careful not to disturb any sediment on the bottom of the container.

BERRY PORT

(Makes five gallons)

STEP 1 INGREDIENTS

6 lbs Blackberries
6 lbs Loganberries
6 lbs Blueberries
6 lbs very ripe bananas
2 lbs dried dates
2 lbs dried figs
4 1/4 gallons of water
10 lbs white granulated sugar
1 level teaspoon yeast energizer
6 level teaspoons acid blend
2 ½ level teaspoons grape tannin
1 level teaspoon pectic enzyme
5 Campden tablets

STEP 2 INGREDIENTS

3 lbs white granulated sugar
3 teaspoons of acid blend

STEP 3 INGREDIENTS

Pasteur Champagne yeast

STEP 5 INGREDIENTS

4-6 lbs white granulated sugar

STEP 6 INGREDIENTS

5 Campden tablets
1 oz oak chips

STEP 7 INGREDIENTS

5 Campden tablets
6 cups white sugar

METHOD

1. Cut dates and figs into thin slices and bring to a boil in 3 cups of water. Simmer for 15 minutes and set aside to cool. Crush the berries and bananas. Mix all step 1 ingredients in an open fermenter, and pour in the dates and figs including the liquid.

2. Use a Brix hydrometer and adjust the sugar to 24 Brix by adding sugar in small quantities and stirring well. Use the acid test kit and adjust the acid to 0.65 percent by adding small quantities of acid crystals and stirring well. If test equipment is not available, use the sugar and acid shown in steps 1 and 2.

3. Open the packet of dry yeast and sprinkle it on top of the must. Cover the fermenter.

4. Measure the Brix each day. When the hydrometer reads about 5 Brix, siphon the liquid off into a closed fermenter. Discard the solids. Attach a fermentation lock filled half-full of plain water.

5. Measure the Brix every few days. When the hydrometer reads 0 Brix, withdraw a half-gallon of must. Dissolve 2 cups of sugar in the must and return to the fermenter. The hydrometer will now read 2 or 3 Brix. Repeat this step until the hydrometer stays steady **and** reads slightly above 0 Brix (several sugar additions).

6. When the hydrometer stays steady and reads above 0 Brix for 4 weeks, the wine will contain about 16 percent alcohol. Rack into a clean container; add 5 crushed Campden tablets and 1-oz oak chips. Top up and attach the fermentation lock. In about three months, rack the wine into a clean container. If the Port is not clear, fine it with Sparkolloid. Rack the wine into a clean container three weeks after adding the Sparkolloid.

7. After another month, when clear and stable, the wine can be bottled. Add 5 crushed Campden tablets, 6 cups of additional sugar and stir well. Let the wine stand for six weeks to make sure it is stable, and then bottle.

STRAWBERRY DESSERT WINE

(Makes five gallons)

STEP 1 INGREDIENTS

15 lbs very ripe strawberries
4 3/4 gallons of water
8 lbs white granulated sugar
1 level teaspoon yeast energizer
8 level teaspoons acid blend
2 level teaspoons grape tannin
1 level teaspoon pectic enzyme
5 Campden tablets

STEP 2 INGREDIENTS

3 lbs white granulated sugar
3 teaspoons of acid blend

STEP 3 INGREDIENTS

1 pkt of Epernay wine yeast

STEP 5 INGREDIENTS

5 Campden tablets

STEP 7 INGREDIENTS

2-6 cups granulated sugar
2 tsp. potassium sorbate
3 Campden tablets

METHOD

1. Try to get one day old, overripe fruit. Remove the stems and the caps, discard any rotten fruit. Mash the fruit or quickly run it through a food processor but do not process into a smooth pulp. Put all step 1 ingredients in an open fermenter, stir well.

2. Use a hydrometer and adjust the sugar to about 22 Brix by adding sugar or water in small quantities and stirring well. Use the acid test kit and adjust the acid to 0.60 percent by adding small quantities of acid crystals and stirring well. If a hydrometer or an acid test kit is not available, use the amounts of sugar and acid shown in steps 1 and 2.

3. Open the packet of dry yeast and sprinkle it on top of the must. Cover the fermenter, in 20 to 40 hours fermentation should start (ring of bubbles forms around the edge of the container).

4. Stir the must and measure the Brix each day. When the hydrometer reads 12 to 14-Brix, siphon the liquid into a clean carboy, strain and discard the solids. Attach a fermentation lock filled half full of plain water. The fermenter should be kept full of wine and keep the fermentation lock half full of water.

5. After 3 weeks, rack into a clean closed fermenter and add 5 crushed Campden tablets.

6. After three months, the wine should be clear. If it is not clear, fine with Sparkolloid. The wine should be racked 3 weeks after adding the Sparkolloid.

7. In about a month, when the wine is clear and stable, add 3 crushed Campden tablets. Add sugar (to taste) and 2 level teaspoons (5 grams) of fresh potassium sorbate. Bottle the wine.

APPENDIX A

STEP BY STEP WINEMAKING

In southern California, the annual grape-crush usually starts in late August and ends in early October. Many factors influence grape ripening time including grape variety, temperature, soils, and irrigation practice, sun light, etc.

Fruit
"Wine quality is made in the vineyard," and high quality wine can only be made from quality fruit.
When grapes are picked too early, the wine may be high in acid, low in alcohol and lack fruit flavors and aromas.
When grapes are picked too late, the wine is often low in acid, high in alcohol and has stewed fruit, raisin or prune flavors.
"Second crop" fruit often makes poor quality wine.
Professional winemakers get 150 to 180 gallons per ton, but home winemakers seldom get more than 140 to 150 gallons.
Bulk wine containers must be topped up regularly and kept completely full, so winemakers always produce extra wine.

Nominal Sugar Levels
17 to 19 Brix for sparkling wine.
19 to 22 Brix for blush and light white wines.
22 to 24 Brix for Chardonnay and Sauvignon Blanc.
23 to 25 Brix for most red wines.

GRAPE PROCESSING

Grapes can deteriorate quickly on a hot day.
Boxes of picked grapes should not be left in the hot sun.
Grapes should be moved to the winemaking area quickly.
Winemakers prefer fruit picked early in the morning when the grapes are cold.

Crusher
For most home winemakers, a hand crank crusher is the most practical method of crushing fruit.
Both single and double roller crushers work well.
Good machines crank easily, but poorly designed and poorly constructed machines do not.
Power crusher/stemmers crush the grapes and remove the stems in one simple, fast operation.
Removing the stems from white grapes is not necessary if the grapes will be pressed immediately.
Stems can be removed from red fermentations by hand using the following technique.

(1) Place a clean, plastic milk crate on top of a clean, plastic trashcan.
(2) Place a few pounds of crushed fruit in the bottom of the milk crate and use a scrubbing motion.
(3) The crushed fruit will drop through the crate.
(4) Discard the stems from the crate and repeat the process.

Sulfur Dioxide (SO_2)
Making quality table wine without using small quantities of sulfur dioxide is difficult.
Sulfur dioxide helps control native yeast and bacteria.
Sulfur dioxide also reduces oxidation of the must and wine.
Usually, about 35 milligrams per liter of sulfur dioxide is added when the grapes are crushed.
One-half level teaspoon of sulfite powder in 100 pounds of grapes is the correct amount.
The sulfite should be dissolved in a small amount of water and then stirred into the crushed grapes.

Press
Small quantities of red wine can be made without a press, but a winepress is necessary to make white wine.
The following procedure works well with small, vertical basket presses.
(1) Fill the basket, add the top plates, blocks and press head.
(2) Apply a small amount of pressure until the liquid flows.
(3) When the flow decreases, increase the pressure.
(4) Excessive foam between the basket slats show pressing is being done too quickly.
(5) When the flow stops, disassemble the press, crumble the press cake and repress.
Most home winemakers crumble the press cake two or three times when pressing expensive grapes.
Ratchet type basket presses can produce high pressures, but high pressures often produce harsh, bitter wines.
Moderate pressures are desirable, and the fruit should be pressed slowly.

JUICE AND MUST CORRECTIONS

Acid content (titratable acid) strongly influences the taste of the wine.
Wine can taste flat and insipid when the acid content is too low.
Wine tastes too tart when the acid is too high.
Titratable acid should be between 0.65 and 0.85 percent before fermentation.
Small quantities of tartaric acid should be added to the must if the acid level is much lower than 0.65 percent.
Acid crystals should be dissolved in a small amount of water before the acid is added to the must.
Stir the must well, and then re-measure the acid content.
Only small amounts of acid should be added at a time.

Sugar Corrections
Ordinary white table sugar can be used for sugar additions.
Low sugar is not a problem in California.
If the sugar content is too low, the grapes are not mature.
High quality table wines cannot be made from immature grapes.
Grapes lacking sugar should be harvested later in the season when the fruit is fully ripe.

Yeast Nutrients
Yeast requires nitrogen, vitamins and several other materials to reproduce new yeast cells and ferment the grape sugars.
Grapes deficient in these materials can be difficult to ferment unless extra nutrients are added.
Chardonnay juice deficient in nitrogen occurs regularly, so winemakers often add extra nitrogen to all Chardonnay juice.
Directions for yeast nutrients should be followed carefully to avoid off-flavors in the wine.

Settling White Juice
Fresher white table wines are produced when bits of skin, pulp and other debris are removed from juice before fermentation.
When the solids have been removed, fermentations are cleaner and better controlled.
Juice is often settled over night and then the clear juice is racked off the sediment the next day.
The juice must be kept cold, and the proper amount of sulfur dioxide should be used.
Sometimes, additional clear juice can be obtained by resettling the residue.

FERMENTATION

Grape skins have a waxy coating, and the coating is covered with native yeast.
Native yeast can spontaneously ferment grapes (without the winemaker adding additional yeast).
Sulfur dioxide is used to arrest yeast activity, but reasonable quantities will not kill the yeast.
Most winemakers prefer to add pure cultured yeast to start fermentation.

Dry Yeast
Most home winemakers prefer dry yeast because it is easier to store and use.
Some yeast like Epernay does not tolerate high levels of alcohol.
Steinberg yeast does not tolerate high levels of sulfur dioxide.
Montrachet yeast produces more hydrogen sulfide (rotten egg smell) than many other types of yeast, so Montrachet should never be used with grapes containing residual sulfur dust.
Pasteur Champagne yeast can produce large amounts of foam in warm fermentation.
Small wineries often use dry Prise de Mousse yeast to ferment all of their wines.
The type of yeast used has little impact on the flavor of aged wine.

Dry Yeast Rehydration
Yeast manufacturers recommend rehydrating dry yeast.
Add dry yeast to a small amount of warm water to rehydrate active, dry yeast.
About a cup of water should be used for each teaspoon of yeast.
The water temperature should be between 95 and 100 degrees.
After stirring, the yeast mixture should stand for 30 minutes.
Most winemakers use about one gram of dry yeast for each gallon of must or juice.

White Fermentations
Fermentation temperature is one of the most important factors for producing quality white table wines.
Light, fruity white wines like Riesling are always fermented at temperatures ranging from 40 to 55 degrees.
At these low temperatures, white fermentations often continue for two or three weeks.
Heavier style white wines are often fermented at temperatures between 55 and 65 degrees.

White juice should always be settled over night.
Only the clarified juice is fermented.
White wines are always fermented in closed containers sealed with a fermentation trap.
Measure the Brix each day to monitor fermentations.
When fermentation is complete, the new wine should be racked into a clean container, and 50 milligrams per liter of sulfur dioxide should be added.

Red Fermentations
Red grapes have colorless juice.
The color is in the grape skins.
Red wine is made by fermenting the juice, pulp, seeds and skins together for several days.
Lengthy skin contact does not increase color, but it does increase wine astringency.
Short skin contact time produces softer, fruitier red wines.
Skin contact time is always a compromise, and winemaking experience is needed.
Usually, five to eight days is adequate for red fermentations.
A cap of skins will begin to float after fermentation starts.
If the cap becomes dry, vinegar bacteria can grow and convert the alcohol into vinegar.
To prevent this acetification problem, the cap should be broken up periodically and kept wet.
Caps on small fermentations will not be very thick and can be managed by stirring twice a day.
On larger fermentations, a special tool is needed to punch the cap down into the juice.
Caps should be punched down at least twice a day.
More punching down will do no harm, and it may improve the color of the wine.

Pressing Red Must
Small red fermentations can by pressed by hand if the grapes were thoroughly crushed.
The following procedure works well.

(1) Cut a piece of 3/4-inch thick plywood to fit inside a plastic milk crate.
(2) Let the cap rise, and then the liquid can be carefully siphoned off.
(3) The plastic milk crate is placed on a suitable container, and a piece of plastic window screen is placed in the bottom of the crate.
(4) Fill the crate half full of pomace, and place the plywood on top.
(5) Press by hand, and then place a heavy weight on the plywood.
(6) Let the crate drain for 15 or 20 minutes, and then stir the pomace and repeat.

After pressing, red wine should be placed in a closed container, and the container should be sealed with a fermentation lock.
When fermentation is complete, the new wine should be racked off the gross lees and 50 milligrams per liter of sulfur dioxide added.

CELLAR OPERATIONS

Cellar operations include wine clarification, stabilization, bulk aging, bottling and bottle aging.

Clarification
Racking, fining and filtration are used to accomplish clarification.
Most white and blush wines will need to be clarified by fining with Sparkolloid.
Most red wines become clear automatically.
Red wines are often fined with protein materials such as a gelatin, or egg whites to reduce astringency.

Un-flavored "Knox" gelatin, purchased at a grocery store, can be used to remove red wine astringency.
One level teaspoon of dry gelatin powder for each 5-gallons of wine is an average dose.
The powder should be mixed in a cup of warm water.
The warm gelatin liquid should be added slowly while constantly stirring the wine.
After a week or so, the wine should be racked off the fining lees.
A light gelatin fining can be effective in reducing the amount of bottle deposit.

Stabilization
Stable wines remain clear after they are bottled.
Unstable wines often change color, produce hazes or throw ugly sediments after they are bottled.
Wine is made stable by fining, racking, chilling, adding sulfur dioxide and aging.
White and blush wines should be hot stabilized with bentonite.
Two grams of dry bentonite per gallon of wine are often used, but testing should be done.
The wine should be racked a week or so after adding the bentonite.
All white and blush wines should be chilled to about 28 degrees to make them cold stabile.
Excess tartrate crystals precipitate when wine is chilled.
After a week or two, the cold wine is filtered or racked off the bentonite lees.
White wines are normally racked two or three times before bottling.
Red wines should be racked about every month for the first three months, then twice a year.
The free sulfur dioxide content of the wine should be maintained at 25 to 30 milligrams per liter.

Bulk Aging Wine
Aging is a natural process, and no way has been found to speed up the process.
Small amounts of oxygen are always present when wine is aged in the cask.
Aging in the bottle, takes place in an absence of oxygen.
Light white wines and blush wines are usually bottled a few months after harvest.
Chardonnay and Sauvignon Blanc are often bottled after six to 12 months.
Most quality red wines are bottled after one to three years of barrel aging.
Containers must be kept full, and the sulfur dioxide must be maintained at 20 to 30 milligrams per liter.

Oak
Oak wood can impart desirable flavors to wine.
Storing wine in oak barrels for extended periods is the best way to produce oak flavors.
But, barrels are expensive, and they no longer produce the desirable flavors after four or five years.
Oak chips can also produce oak flavors in wine.
The quantity of oak chips needed depends upon the style of the wine and personal preferences.
One to two ounces of chips for 5-gallons of wine is a good starting quantity.
The wine should be tasted every few weeks after the chips are added, and the wine should be racked off the chips when the taste is satisfactory.
More chips can always be added, but removing excess oak flavor from wine is difficult.
Most aromatic wines (Riesling, Muscat, etc.) do not benefit from oak aging.

BOTTLING

Wine must be brilliantly clear and stable before bottling.
Bottling is a simple operation, but several points should be considered before the bottles are filled.

Pre Bottling Adjustments
Any blending should be done many weeks before bottling time so the winemaker can be sure the new blend is stable.
Large additions of tartaric acid can make wine unstable and require additional cold stabilization.
Usually, small amounts of citric acid can be added to white wines without upsetting cold stability.
Cold stability should be checked before bottling white or blush wines by placing a wine sample in the refrigerator for 48 hours.
Holding a sample of the wine at 120 degrees for 48 hours is a good check for hot stability.
The free sulfur dioxide content of the wine should be tested and adjusted to about 30 milligrams per liter a day or two before bottling.
Wines bottled with less than 30 milligrams per liter of sulfur dioxide will be short lived.

Filling Bottles
Clean bottles should be rinsed with very hot water just before filling.
Then rinse each bottle with a sulfite solution and drain the bottles.
Make the sulfur dioxide solution by mixing 1/4 teaspoon of sulfite crystals and a teaspoon of citric acid in 750 ml of water.
This sulfite solution is strong enough to kill most bacteria, but the bottles must be drained carefully before they are filled.
Use some kind of bottle filler to reduce wine oxidation.
Bottles should be filled from the bottom and with a minimum amount of foam and splashing.
Bottles should be filled until there is about 1/4 inch of space between the wine and the bottom of the cork.

Corking
Driving dry corks is preferred.
Some small hand corkers cannot compress dry corks adequately and presoaked corks must be used.
Presoak corks in cold water for an hour or so to soften them.
A pinch of sulfite added to the water may help sterilize the corks.
Drive corks flush with or slightly below the lip of the bottle.
Remove spilled wine from the bottles, or the wine residue will become moldy.

Labeling
All bottles should have some kind of label to identify the contents.
Attractive wine labels can be made with a home computer.
Common white glue is often used for attaching wine labels.
A few labels can be applied quickly with a “glue stick.”
Capsules and labels can be applied when the bottles are clean and dry.

Bottle Aging
Bottles should stand upright for a week or two after corking.
Then after the pressure has equalized, the bottles can be stored on their sides or upside down in a cool place.
Red wines are usually aged in the bottle for one or more years to develop bottle bouquet.
Heavier style white wines also benefit from bottle aging.

SUMMARY

High quality wine can only be made when high quality fruit is picked in optimum condition.

Small quantities of sulfur dioxide should be added to grapes when they are crushed.

The titratable acid of the juice should be adjusted to 0.60 to 0.75 percent before fermentation.

White juice should be settled over night, and fermentation temperatures should be kept below 60 F.

Red wine is made by fermenting the juice, pulp, seeds and skins together.

Caps on red fermentations should be punched down at least twice a day.

Four to seven days of fermentation time will be adequate for most red grape varieties.

About 50 milligrams per liter of SO_2 should be added when fermentation is complete.

Wine is made stable by fining, racking and chilling.

White and blush wines require both hot and cold stabilization treatments.

All wine must be brilliantly clear and stable before bottling.

The free SO_2 level should be raised to about 30 milligrams per liter a day or two before bottling.

APPENDIX B

EQUIVALENTS AND MEASURES

Except for metric units, the quantities given here are standard US measure.

ABBREVIATIONS

mg = milligram = 1/1000 gram
g = gram
kg = kilogram = 1000 grams
ml = milliliter = 1/1000 liter
l = liter
mg/l = milligrams per liter
oz = ounce
lb = pound
gal = gallon
tsp. = teaspoon (level)
ppm = parts per million

CONVERSION FACTORS

1 ml of wine = 1 gram
1 oz = 28.4 grams
1 fluid oz = 29.6 ml
1 g = 0.035 ounce
1 lb = 454 grams
1 lb = 16 oz
1 kg = 2.2 pounds
1 gal = 3.8 liters
100 l = 26.4 gallons

SULFUR DIOXIDE DOSES

1 gram sulfite per gallon = 150 mg/l
1 gram sulfite per 5 gallons = 31 mg/l
1 tsp sulfite per 5 gallons = 170 mg/l
2 tsp sulfite per 5 gallons = 87 mg/l
1/4 tsp sulfite per 5 gallons = 43 mg/l
1/8 tsp sulfite per 5 gallons = 22 mg/l

EQUIVALENTS

1 mg per liter = 1 ppm
1 g per liter = 1000 mg/l
1 g per gallon = 263 mg/l
1 g per 5 gallons = 52 mg/l

FINING DOSE RATES

1 lb per 1000 gallons = 0.5 gram/gal
2 lbs per 1000 gallons = 1 gram/gal
4 lbs per 1000 gallons = 2 gram/gal
6 lbs per 1000 gallons = 3 gram/gal
8 lbs per 1000 gallons = 4 gram/gal

EQUIVALENT DRY VOLUME -WEIGHTS

AAA charcoal	1 tsp equals 1.5 grams
Acid blend	1 tsp equals 5.1 grams
Ascorbic acid	1 tsp equals 4.2 grams
Bentonite (agglomerated)	1 tsp equals 3.4 grams
Calcium carbonate	1 tsp equals 2.6 grams
Citric acid	1 tsp equals 4.9 grams
Diammonium phosphate	1 tsp equals 4.9 grams
Fumaric acid	1 tsp equals 5.3 grams
Gelatin	1 tsp equals 3.3 grams
Malic acid	1 tsp equals 4.6 grams
Pectic enzyme	1 tsp equals 4.0 grams
Polyclar AT (PVPP)	1 tsp equals 1.2 grams
Potassium bicarbonate	1 tsp equals 3.3 grams
Potassium bitartrate	1 tsp equals 3.8 grams
Potassium metabisulfite	1 tsp equals 6.1 grams
Potassium sorbate (prilled)	1 tsp equals 3.0 grams
Sparkolloid	1 tsp equals 1.1 grams
Sodium bisulfite	1 tsp equals 5.7 grams
Tannin	1 tsp equals 2.8 grams
Tartaric acid	1 tsp equals 5.0 grams
Yeast ghosts	1 tsp equals 2.8 grams

APPENDIX C

REFERENCES

WINEMAKING

Yair Margalit, *Winery Technology & Operations,* San Francisco: Wine Appreciation Guild Ltd., 1990.
(For the small to medium size winery or for the advanced home winemaker, $25).

David Jackson, Danny Schuster, *The Production of Grapes and Wine in Cool Climates,* Wellington, New Zealand: Buterworths, 1987.
(A well written book covering grape varieties, grape growing and winemaking, $39).

Philip Jackisch, *Modern Winemaking*, Ithaca: Cornell University Press, 1985.
(Excellent book for beginning winemakers, $25)

Jeff Cox, *From Grapes to Wine*, New York: Harper and Row, 1985.
(Good book for beginning home winemakers, covers grape growing and winemaking, $29).

Emile Peynaud, *Knowing and Making Wine*, 2nd ed., New York: John Wiley & Sons, 1984.
(Excellent reference book for advanced home winemakers a famous French enologist, $43).

Richard P. Vine, *Commercial Winemaking*, Westport: AVI Publishing Co., 1981.
(This reference book is suitable for commercial wineries and a few advanced home winemakers, $38).

Amerine, M. A., et al, *Technology of Winemaking*, 4th ed., Westport, Conn.: AVI Publishing Co., 1980.
(A detailed work on wine technology for professionals, graduate students and advanced amateurs, $40).

Desmond Lund, *Leisure Winemaking*, Calgary: Detselig Enterprises, 1978.
(An interesting book on the chemistry of winemaking, recommended for the serious home winemaker).

Philip Wagner, *Grapes into Wine*, New York: A. A. Knopf, 1976.
(An excellent book for beginning home winemakers, the easy to read and clearly written text covers all of the basics, $15).

A. Dinsmoor Webb, editor, *Chemistry of Winemaking*, Washington, D.C.: American Chemical Society, Advances in Chemistry Series 137, 1974.
(A technical reference book on wine chemistry).

Amerine, M. A. and M. A. Joslyn, *Table wines: The Technology of Their Production*, 2nd ed., Berkeley: University of California Press, 1970.
(This standard enology textbook is suitable for professionals and advanced amateur winemakers, $40).

Ough, C. S., *Winemaking Basics*, New York: Haworth Press, Inc., 1992.
(This is an excellent reference for the advanced home winemaker, $40).

R. Boulton, et al, *Principles and Practices of Winemaking,* New York, Chapman & Hall, 1997.
(This is the current text at UCD).

GRAPE GROWING

D. P. Pongracz, *Practical Viticulture*, Cape Town, South Africa: David Philip, 1978.
(This interesting book reflects the European point of view).

Philip M. Wagner, *A Grape Grower's Guide*, 2nd ed., New York: Knopf, 1978.
(This book covers grape growing basics from the eastern perspective, $15).

A. J. Winkler, et al., *General Viticulture*, Berkeley: University of California Press, 1974.
(This definitive work on commercial grape production is a standard university text, $40).

PERIODICALS

American Journal of Enology and Viticulture, American Society of Enology and Viticulture, P.O. Box 411, Davis, CA 95617.

American Wine Society Journal, American Wine Society, 3006 Latta Road, Rochester, NY 14612.

Grape Grower, Western Agricultural Publishing Company, 4974 E. Clinton Way, Suite 123, Fresno, CA 93727-1558. ($18 per year, published monthly).

Practical Winery & Vineyard, 15 Grande Paseo, San Rafael, CA 94903. ($30 per year, published bimonthly).

Wines & Vines, 1800 Lincoln Avenue, San Rafael, CA 94901.
($27.50 per year, published monthly).

APPENDIX D

SOURCES OF SUPPLIES AND EQUIPMENT

All-World Scientific, 5515 186TH Place SW, Lynnwood, WA 98037, 1-800-289-6753.

Cole-Parmer Instrument Company, 7425 North Oak Park Ave., Niles, IL 60714, (708) 647-7600.

Fleming-Potter Co., Inc., 1028 S.W. Adams Street, Peoria, IL 61602, (309) 676-2121.

Napa Fermentation Supplies, 575 Third Street, Napa, CA 94559, (707) 255-6372.

Presque Isle Wine Cellars, 9440 Buffalo Road, North East PA 16428, (814) 725-1314.

Scott Laboratories, Inc., 2220 Pine View Way, P.O. Box 75049 Petaluma, CA 94975-0249, (707) 765-6666.

Vinquiry, 16003 Healdsburg Ave, Healdsburg, CA 95448, (707) 433-8869.

The Wine Lab, 477 Walnut Street, Napa, CA 94559, (707) 224-7903.

APPENDIX E

SELECTED WINE TERMS

ACETALDEHYDE - a volatile wine component; only small quantities are present in table wines; oxidized wine contains excessive quantities; gives sherry its nut-like characteristics.
ACETIFICATION - the formation of acetic acid in wine; vinegar formation.
ACID - produces the sharp, tart taste in wines.
AMINO ACIDS - naturally occurring in grapes; protein building blocks; necessary for yeast growth.
AROMA - the part of the wine fragrance produced by the grapes used to make the wine.
ASTRINGENCY - the puckering, drawing sensation in the mouth; produced by phenolic compounds (tannins) in the wine.
BALANCED - when all the elements of a wine are in harmony.
BENCH TEST - testing done on small quantities of wine to make sure a wine treatment will produce the desired result.
BENTONITE - a clay-like fining agent; used to remove excess protein and make white wine less sensitive to high storage temperatures.
BINNING - laying bottled wine down for aging; bottles stacked on their sides like a cord of wood.
BOUQUET - fragrance produced by fermentation and aging.
BRIX - a scale used for expressing sugar content as grams per 100 milliliters (percent).
BROWNING - the undesirable color changes that occur when wine is exposed to excessive amounts of air.
CAP - a dense layer of skins that floats on the surface of the liquid during red fermentations.
CASK - round wine container with curved sides (i.e., barrel).
CHARACTER - wine complexity showing distinctive features.
CHROMATOGRAPHY - a measurement used to identify malic, lactic and other acids in wine.
CITRIC ACID - one of the organic acids in grapes and wine.
CLEAN - the absence of foreign or unpleasant odors.
COLD STABILIZATION - a process used to remove excessive amounts of potassium bitartrate from wine and prevent haze and crystals from forming after the wine is bottled.
COPPER SULFATE - a chemical used to remove hydrogen sulfide from wine.
COOPERAGE - bulk wine storage containers.
CRUSHER - a machine or apparatus used to break the grape skins and cause the juice to flow.
CRUSHER-STEMMER - a machine used to break grape skins and remove stems in a single operation.
CUVIE - the blend of still wines used as the starting material for making sparkling wine.
DECANT - to pour off a clear liquid leaving any residue behind.
DELICATE - light bodied, low alcohol, young, fresh wine.
DRY - a still wine that contains almost no sugar.
EARTHY - a bouquet component that is reminiscent of rich, damp soil.
ENOLOGY - the art and science of winemaking.
EXTRA DRY - this term only applies to sparkling wines; “extra dry” is sweeter than “dry.”
FERMENTATION - the process of converting grape sugar into ethanol and carbon dioxide.

FLINTY - a clean, hard, dry, austere white wine.
FLAT - any wine not containing enough acid; an uninteresting or dull wine.
FLOWERY - wine with a sweetish, pleasant, appealing nose.
FOXY - the distinctive flavor and nose produced by native American grapes like "Concord."
FREE-RUN - the juice or wine that runs through the press before any significant pressure is applied.
FRUCTOSE - one of the primary, fermentable sugars in grape juice.
FRUITY - an abundance of fruit-like aromas and flavors.
GLUCOSE - one of the primary, fermentable sugars in grape juice.
GREEN - thin, harsh, high acid wines that lack softness.
HOT STABILIZATION - process used to remove protein and prevent hazes in bottled wine.
HERBAL - wine odor characteristic of herbs, alfalfa, hay, fresh cut grass, etc.
HYDROGEN SULFIDE - a noxious smelling gas; it produces the familiar "rotten egg" smell, and a minute quantity of hydrogen sulfide will taint wine badly.
HYDROMETER - an instrument for measuring the sugar content of grape juice.
LACTIC ACID - one of the organic acids in wine; produced from malic acid by bacterial action.
LEES - the sediment deposited on the bottoms of wine containers.
MALIC ACID - one of the major organic acids in grapes and wine.
MALOLACTIC FERMENTATION - bacterial conversion of malic acid into lactic acid.
MELLOW - a soft, round, ripe, mature, easy drinking wine.
MUST - crushed grapes; the juice, pulp, skins and seeds.
NOSE - a wine tasting term for bouquet and aroma.
OFF-DRY - wine containing a small amount of residual sugar; any wine that is not completely dry.
OXIDIZED - the sherry-like smell that results when wine is exposed to excessive quantities of air.
pH - a measure of the number of hydrogen ions present in a solution.
PHENOLIC - grape materials associated with color, flavor and astringency.
POMACE - the pulp, skins and seeds that remain after the liquid has been removed.
PRESS - apparatus used to separate juice or wine from the solids.
PUMP OVER - pump juice from the bottom of a tank onto the cap to keep it wet.
PUNCH DOWN - to break up the cap and mix the skins and pulp into the juice.
RACK- decanting wine off the sediment into a clean tank.
RIPE - wine aged to perfection: fruit that is ready to pick.
SOFT - wines low in astringency.
SOUR - term used for wines containing vinegar; (not used to describe wines with high acidity).
STUCK FERMENTATION - a fermentation that stops prematurely before all the sugar has been converted into alcohol.
TANK - Bulk wine containers having straight sides.
TANNIN - the phenolic compounds responsible for astringency and bitter flavors.
TART- any wine high in acid (see sour).
TARTARIC ACID - one of the major organic acids in grapes and wine.
TITRATABLE ACID - the sum of all acids present; usually measured by titration.
TOPPING UP - adding small quantities of wine periodically to keep containers completely full.
VINOUS - relating to wine; made of wine; wine-like.
VINTAGE - the grapes or the wines from a single harvest.
ULLAGE - the empty space that develop in bottles or bulk wine containers