Red Wine Production*

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The basic procedure of red wine production is outlined in the diagram. An important point in making red wine is that the fermenting must consists of juice skins and seeds. As a result, the composition of red wine is determined by the constituents extracted from skins and seeds in addition to those present in the juice.

Red Wine Styles

Red wines are made into a variety of styles. The stylistic differences are based on differences in wine characteristics such as grape variety, color, flavor, body, mouthfeel, and aging potential. The styles range from simple, fruity, fresh, light colored blushes and rosés to complex, full-bodied, rich and dark red, with long aging potential. Many factors such as a variety, soil, climate, growing conditions, and viticultural practices influence the fruit composition, and therefore, the style of wine that can be produced. In addition to fruit composition, winemaking techniques also play an important role in determining the wine style.

Varieties

Many varieties are available for red wine production. The wines are usually produced as varietals, or as blends containing several varieties. A list of commonly used red wine varieties is given in Table 1.

Table 1. Red wine varieties

Vinifera Group	Labrusca	French hybrids	Others
Cabernet Sauvingnon	Concord	Baco Noir	Northon/Cynthiana
Merlot	Steuben	Chambourcin	St. Vincent
Pinot noir		Chancellor	Vincent
Zinfandel		Foch	
Syrah (Shiraz)		Rougeon	
Grenache		Villard noir	
Cabernet Franc		Colobel	
Barbera			
Gamay			

Varieties from the Vinifera group are most widely used for winemaking. In regions where Vinifera grapes are not grown, French hybrids, Labrusca, and other varieties are often used. Among the Vinifera group, Cabernet Sauvignon alone, or in combination with Merlot and/or Cabernet Franc is used in premium red wine production. Pinot noir, the famous grape of Burgundy, makes excellent red wine. When grown in other parts of the world, the wine does not always attain the same level of quality as found in Burgundy.

Zinfandel, though popular for blush wine, can also make dark, full-bodied, and flavorful red wine. Syrah, the popular grape of Rhône and Australia makes fruity wines with softer tannins.

Concord is the leading red wine variety among American grapes. Wines from these grapes have a strong flavor, which is often referred to as a “foxy” aroma. Another American red wine grape, Cynthiana/ Norton, does not have the foxy aroma and can make full-bodied, dark red wines.

Among the varieties in the French hybrid category, Baco, Chambourcin, Foch, and Rougeon are commonly used for red wines. These varieties, with proper handling, make good red table wines.

Fresh grapes make the best raw material for making red wine. In a situation where fresh grapes are unavailable, frozen grapes or grape concentrate can be used, particularly for making smaller lots of wine.

Maturity and Harvest

The decision to harvest grapes with certain maturity parameters is guided by many factors. These include wine style, variety, and maturity criteria. Typically during the course of maturation sugars accumulate, titratable acidity declines, pH rises, color, and phenolic compounds increase and the formation of distinct varietal aroma components occurs. It would be highly desirable to have all these parameters in an ideal balance. However, in practice this can be difficult to achieve since these parameters are influenced by many factors.

Generally the fruit is harvested based on sugar (ºBrix), titratable acidity, and pH. It should be noted that for making red wine, following only these harvest criteria is not sufficient. Skin constituents such as color, tannins, and flavor strongly influence red wine character and, therefore, their level should also be evaluated when making harvest decisions. Because the skin is fermented with the juice, the skin condition (freedom from rot) and the proportion of skins to juice (depending on berry size) are also important considerations.

Generally, the accumulation of some components such as color and tannin closely follows the accumulation of sugars. But this may not necessarily hold true for the flavor. Aroma development may follow a different pattern. In such a case, sugar measurements to determine harvest may not yield the best result. A good understanding of the fruit composition and the way it is influenced by factors such as region, climate, variety, and viticultural practices is essential in determining optimum fruit maturity, and the time of harvest.

Prefermentation Processing Destem/Crush

The most common practice of handling harvested grapes is to separate the berries from the stems. This is achieved by using the machine called a stemmer/crusher.

The object of destemming and crushing is to remove the stem and gently break the berry skin. Care is taken to avoid excessive skin maceration and breaking of seeds. The crushed fruit consisting of pulp, skin, and seed, called must, is transferred to a container and about 30 mg/L of free SO_2 is added. The purpose of SO_2 addition is to prevent the development of unwanted microbes such as indigenous yeast and harmful bacteria.

Some winemakers retain a small (15 to 20%) amount of whole berries and also add a fraction of stems to the must. The stem addition is intended to extract extra tannins. In some cases, this can be beneficial; however, the stems can also contribute to harshness and loss of pigments.

Cold Soak

In the practice of cold soak or cold maceration, the must is cooled to about 15 to 20 ºC (41 to 68 ºF) to slow down the onset of fermentation by indigenous yeast, and contact between skins and juice is promoted. The purpose of cold soaking is to encourage extraction of pigments and other phenolic compounds from skins in the absence of ethanol. The skins are soaked for one to two days and the must is pumped over or mixed to facilitate the phenolic extraction.

The cold maceration is thought to improve color, body, and mouthfeel of the resulting wine. The effectiveness of this approach will depend on variety, fruit composition and the condition of the fruit.

Must Adjustment

Grapes are generally harvested at 22 to 24 ºBrix for red wine production. Some varieties may not have sufficient amount of sugar at harvest. For these varieties (e.g., Concord), sugar addition to the must would be necessary. Sugar addition can be done to the must at the beginning of fermentation. However, one needs to make an allowance for the volume of seeds and skins when calculating the amount of sugar needed. To circumvent this problem, some winemakers prefer to add sugar to the fermenting must after pressing and removing seeds and skins.

In low sugar, high acid American grapes such as Concord, a sugar syrup in place of dry sugar can be used. This process is also called amelioration. The advantage of this process is that while sugar content increases, the acid level decreases due to dilution. To ensure the quality of the resulting wine, the extent of amelioration within legal limits should be carefully evaluated.

Prefermentation Processing

Adjusting Acidity

Compared to white wines, red wines are produced with lower acidity levels. Generally a titratable acidity in the range of 6.5 to 7.5 g/L and a pH value of 3.4 to 3.6 is preferred. If the grapes are low in acid content (e.g., less than 5 g/L) then the acidity should be raised by tartaric acid addition. It is important to bear in mind that a portion of the tartaric acid added to the must will be lost (by precipitation of potassium bitartrate) following fermentation and cold stabilization. Allowance for this acid loss should be made when determining the amount of tartaric acid addition.

Sometimes red grapes at harvest contain high acid levels (>9 g/L). To produce well balanced wines from these grapes, a reduction in acid level may be desired. To reduce acidity, a winemaker should consider chemical as well as biological (yeast and malolactic fermentation) deacidifications.

Must Treatment

The issue of SO2 addition needs some consideration. Some winemakers do not add free SO2 to red must prior to fermentation. The rationale is to minimize SO2 levels in wine, facilitate malolactic fermentation, and maybe to achieve flavor complexity by allowing indigenous yeast to participate in alcoholic fermentation. The problem with this approach is that no SO2 addition can leave must unprotected from the activity of undesirable microorganisms such as wild yeast and spoilage-causing bacteria. We recommend the addition of a small amount (20 to 30 mg/L free SO2) of SO2 to the clean must; must with rot will need higher (75 to 100 ppm) doses. This level (20 to 30 ppm) is sufficiently high to discourage spoilage organisms but not too high to suppress malolactic fermentation, if it is so desired.

Pectolytic enzymes have been in use for white wine production. In recent years some commercial enzyme preparations have been made available for red winemaking. These enzymes are designed to promote the release of pigments, tannins, and polysaccharides in the must. For certain styles of wines, use of these enzymes may be beneficial. However, the merits of using these enzymes should be experimentally evaluated.

Adequate nutrient level is necessary to ensure sound and complete fermentation. Therefore, addition of diammonium phosphate (DAP), (a nitrogen source) and yeast nutrient containing essential vitamins is recommended. The amount of DAP required will depend on must nitrogen status, yeast strain, and the conditions of fermentation. Generally a DAP addition in the range of 250 to 500 mg/L should be sufficient to prevent fermentation problems such as H2S formation and ensure a clean fermentation.

Fermentation

After making all the necessary adjustments (sugar, acid, etc.) and additions, the red must, consisting of juice, skin, and seeds is ready for fermentation. The must can be fermented in open top containers. This allows for ease in must handling, cap management, and temperature control. However, some provision should be made to keep the fruit flies away from the fermenting must. Some winemakers prefer to use fermenters with closed tops or some cover to keep fruit flies away. Smaller lots can be fermented in tubs, tanks, bins, or other containers made of plastic or stainless steel.

For larger must volumes, specially designed stainless steel fermenters should be used. The fermentation should be conducted in a well-ventilated area, and provisions should be made to remove excess CO2 generated during fermentation.

Yeast

A wide selection of yeast strains is available for conducting red wine fermentation. The winemaker should choose the strain that will ferment the must efficiently and completely with very little (below sensory threshold) amounts of undesirable compounds such as acetic acid, ethyl acetate, and hydrogen sulfide. To obtain a clean and rapid fermentation, commercially produced strains of active wine yeast in dry form should be used. Dry yeast must be properly rehydrated before inoculating the must. We suggest that winemakers experiment with various strains to make proper selection.

Some winemakers use indigenous yeast strains. This practice can sometimes give good results; however, it is risky and requires a lot more skill and attention. We prefer commercially produced pure culture stains and suggest their use in red wine fermentation.

Controlling Fermentation Temperature

The fermentation releases a significant amount of heat, which further increases the must temperature. Increased temperature enhances the rate of fermentation and also the extraction of color and phenolic compounds. Beyond a certain level (e.g., above 89 to 95ºF) the excessively high temperature can cause stuck fermentation, promote the growth of undesirable microorganisms and contribute to the formation of off-odor compounds.
Therefore, controlling temperature during fermentation is critical.

Red must is generally fermented in the temperature range of 77 to 86ºF.
As the fermentation begins, the skins and seeds rise to the top and form a cap. A portion of the heat released leads to a higher temperature in the cap as compared to the fermenting liquid below. In order to

release the trapped heat and promote extraction of skin constituents, the cap is periodically broken and the must is stirred.

In smaller lots, stirring the must can be sufficient to lower the fermentation temperature. For larger must volumes, pumping over, along with the use of cooling jackets, or must chiller may be needed to control the temperature.

Cap Management
With the onset of active fermentation the skins rise to the top of the fermenting liquid and form a cap. Thus the skins and juice in a fermenter are somewhat separated. In order to maximize the extraction of color and flavor from skin it is important to keep skins in close contact with the juice during fermentation. To achieve this, the cap is punched and skins and juice are mixed. For smaller lots, punching the cap twice daily is sufficient to facilitate extraction and release heat.

For larger lots, punching the cap is difficult. In such a case, the juice can be drawn and pumped over the cap. Some winemakers use a sprinkling device that sprinkles the juice on top of the skin using a pump. The object is to thoroughly moisten the cap to release the heat; thus, cooling the must and encouraging extraction of skin constituents. When using pump-over, about one volume of juice is pumped over the cap; and this is done about twice a day. Some winemakers vary the volume and frequency of pump-over and choose the best approach that suits them. Using smaller and shallower fermenters, punching the cap, and mixing the must gives good color and flavor extraction.

Extraction of Skin Constituents during Maceration
Skin constituents have a significant influence on the quality and style of red wine. A good understanding of these components, their extraction pattern, and their evolution during maturation and aging is important in making stylistic decisions in red wine production.

The color and tannins are the two major components that are extracted from skins during fermentation. The purplish-red color of red grapes is due to the pigments known as anthocyanins. The pigments are located mostly in the outer layers of the skins. In grapes, many kinds of anthocyanins are present. They occur in both color and colorless forms. The amount of pigment in colored or colorless form is strongly influenced by the pH of the wine and also by the presence of free sulfur dioxide. Lowering the pH shifts the equilibrium towards the colored form and SO2 has a bleaching effect on the (monomeric) anthocyanins.

Tannins are complex polymeric phenols. They react with proteins, and it is this property that is used in tanning hides to make leather. They are bitter and astringent compounds with a wide range of molecular sizes. Condensation and polymerization of smaller tannin molecules leads to the formation of bigger tannin molecules such as condensed and highly condensed tannins. These large tannin polymers are less astringent and assume yellow-red to yellow-brown color. When the tannins become too large, they precipitate.

Tannins also play an important role by forming complexes with pigments, which contributes to color stability. These polymeric pigments (pigment and tannin complexes) are less sensitive to changes in pH and SO2 levels in wine. During alcoholic fermentation, both the pigments and tannins are extracted from the skin, but their pattern of extraction is slightly different.

The extraction of color is rapid at the beginning of fermentation. It reaches a peak in the first two to three days; and, then slightly declines during the remainder of fermentation. This means a short maceration time of about two to three days is sufficient to obtain good color.

Tannins and other phenolic substances are also extracted quickly at the beginning but their rate of extraction slows down as the fermentation proceeds. However, the concentration of total phenols (this includes tannins) continues to increase towards the end of fermentation.

The extraction of color and tannins is influenced by temperature, length of skin contact, and the cap management technique followed during fermentation. Increasing fermentation temperature from 20 to 30 ºC causes an increase in color (pigment) and tannin content of the resulting wine.
Various cap management options have already been mentioned. For better extraction, a thorough mixing of must is essential. Large wineries use autofermenters and rotary fermenters to facilitate good mixing. However, smaller lots can be mixed by punching the cap and mixing the must.

The length of skin contact also influences extraction. A longer contact time generally means greater extraction of skin and seed constituents into the wine.

Skin Contact Time and Pressing Options
The winemaker has several options in determining the length of time of skin contact during red wine fermentation. The decision is based on the wine style and the level of extraction of skin component that the winemaker wishes to have in the wine. Although a winemaker has many choices, presented are three of the widely used approaches.

Short or No Skin Contact
Red grapes are crushed and pressed, and the skins are separated immediately. The must is treated like a white wine. This approach will have very little color in the wine. To obtain slightly more color, a short skin contact of about 24 hours may be allowed before the must is pressed. Wines produced in this style have a light color and a fruity aroma with some residual sugar. They are processed for early consumption. Blush and light rosé wines are the examples of this style.

A More Common Approach
Many winemakers typically ferment the must until the sugar level drops between 5 to 0 ºBrix. Depending on the conditions of fermentation, it may take three to five days to reach this level. Note that in this range (0 to 5 ºBrix), the must will contain some residual sugar and the fermentation will be expected to continue after the must is pressed and skins are removed. This approach should yield wines with good color and fruit flavor with a soft and round mouthfeel. These wines are consumed when relatively young or after a short maturation period. They would not require prolonged aging to achieve a higher quality.

Press At Dryness or After Extended Skin Contact
The must is fermented until it reaches dryness, i.e., all the fermentable sugar is used up, and then pressed. If a winemaker wishes to extract more tannins, the skin contact time is extended for one to three weeks. Generally, after the completion of fermentation, the tank is closed and the must is left undisturbed. Over time the cap sinks to the bottom and the must is then pressed. This approach is recommended for the production of full-bodied, dark, and tannic red wines. They require a long maturation and aging time before they are ready for consumption.

Carbonic Maceration
Carbonic maceration, also called whole berry fermentation, consists of fermenting whole berries, without crushing, in a CO_2 saturated atmosphere. In this method, the tank, or any other container containing CO_2 is filled with whole clusters. Some winemakers place a small amount (about 5 to 10%) of fermenting must in the bottom of the tank, which generates CO_2. The idea is to surround all the fruit with CO_2 and create an anaerobic atmosphere. The tank is sealed after it is loaded with the fruit. Under anaerobic conditions, partial fermentation begins within the cells. This fermentation is caused by the cell's own enzymes, (without yeast). The fermentation produces a small amount of alcohol (about 1.5 to 2.5%), and brings about many changes in the must composition.

The fermentation is carried out for about eight to ten days. The temperature is held near 95 ºF. Following this whole berry fermentation, the clusters are removed and pressed. The partially fermented juice is inoculated with wine yeast and the fermentation is complete. Wines so produced are softer due to lower phenolics and reduced acidity and have a characteristic fermentation aroma. These wines are clarified, stabilized, finished, and offered for consumption within a few months of the vintage.

Pressing
A decision to press the must is made according to the desired wine style, when an optimum amount of color, flavor, tannins, and other constituents are extracted. Generally the juice is drained or pumped, the cap is transferred to the press and the must is then pressed. Following pressing, the young wine is placed in containers and is allowed to finish alcoholic (if unfermented sugar remains) and malolactic fermentation.

Malolactic Fermentation

Red wines are often subjected to malolactic fermentation (MLF). The object is to reduce the acidity and achieve flavor complexity. The wine also achieves some degree of biological stability, but it is important to realize that MLF wines are not necessarily stable and that bacterial activity can occur if the conditions become favorable.

In the traditional approach, the malolactic fermentation is allowed to occur naturally. This practice, however, is risky because the MLF remains uncontrolled and the storage conditions favoring MLF are also conducive to microbial spoilage. It is, therefore, prudent to use a selected pure culture of ML bacteria for conducting

MLF. The lactic acid bacteria culture is commercially available in two freeze-dried forms. In one case, the culture requires reactivation and propagation before addition to the must. In recent years, another form of freeze-dried culture for direct addition (without the need for reactivation) has been developed and is commercially available. We suggest the use of this freeze dried, direct addition culture form for conducting MLF. To use the culture, follow the supplier's directions.

The time of inoculation is an important consideration in conducting MLF. Some winemakers inoculate the must during alcoholic fermentation. This approach may have some benefits, but we think that the risk outweighs the benefits. Therefore, we recommend conducting MLF after the completion of alcoholic or primary fermentation. This approach is also suitable for using a freeze-dried culture, especially designed for direct addition to the must.

Proper inoculation is an important step in conducting MLF. We strongly recommend following the supplier's instruction to obtain good results.

Wine Clarification
Young red wine is cloudy. The turbidity is caused by particles that remain in suspension. The particulate matter includes grape fragments, crystalline compounds (potassium bitartrate), colloidal compounds and microorganisms such as yeast and bacteria. During storage, many of the particles slowly settle to the bottom leaving the wine relatively clear. To achieve greater clarity, i.e., to make wine brilliantly clear, wine is subjected to treatments such as racking, fining, and filtration.

Racking
After the alcoholic and malolactic fermentation, the wine is racked off the lees. Generally, the amount of sediment is greater in the first racking and its volume decreases in subsequent rackings. The procedure for racking red wine is similar to the one described in the white wine section with one exception. In white wine racking, the wine should be protected from undue aeration; whereas, in red wine racking, limited air exposure, particularly in the first racking, is desirable. Controlled air exposure during wine transfer is beneficial to the aging of red wine. It also allows for the removal of off-odors (such as hydrogen sulfide) that may have developed during fermentation. Racking wine three to four times a year should yield fairly clear wine. It is important to add appropriate amounts of free SO2 after each racking.

Fining
Red wine can be fined to achieve greater clarity. However, the fining agents also tend to influence the flavor of the wine. Red wines are rich in pigments and phenolic compounds such as tannins that contribute to a harsh and astringent taste. Proteinaceous fining agents such as gelatin and egg white are often used to lower the tannin level, soften the wine, and enhance clarity. The choice of a fining agent and the amount of fining material needed should be determined by conducting a fining trial and blind tasting the wines.

For egg white fining, separate the egg white from the yolk and mix it with some water. The solution will be cloudy, but adding a pinch of salt should make it clear. The egg white solution should be slowly added, without foaming, to the wine while gently stirring. Generally five to eight egg whites per barrel (50 gallons) are used for fining.

Gelatin for fining is commercially available in liquid and/or dry powder (leaf) form. For convenience and better results, we recommend using low bloom liquid gelatin. The amount of gelatin used in fining should be based on the supplier's recommendation.

Filtration
Filtration is another option that can be used alone or in combination with fining agents. A wide variety of filters are available to small-scale wine producers. A small plate and frame or cartridge filter can be used to filter and clarify the wine. The filters come in various pore sizes. A polish or sterile grade filter pad often gives satisfactory results.

Stabilization
The practice of stabilization refers to the treatment of wine to prevent cloudiness and formation of sediment in the bottle. Red wines are rich in tannin contents, which carry a negative charge. The tannins interact with positively charged proteins which lead to agglomeration and settling of the tannin-protein complex. Due to the removal of proteins in this manner, the problem of proteinaceous haze in red wines is not a serious one.

Some winemakers use a small dose of bentonite to clarify the wine, which also helps in protein stability. However, winemakers generally do not treat wine for protein instability unless a test warrants it.

The precipitation of bitartrate in the bottle can be a serious fault. Therefore, red wine is stabilized to prevent this problem.

One approach is to hold the wine at 28 to 35ºF for two to three weeks and remove the precipitated potassium bitartrate by filtering the cold wine. Some winemakers feel this treatment to be too harsh and prefer to stabilize wine by chilling or seeding with bitartrate crystals at much higher temperatures, such as in the range of 41 to 50 ºF. The rationale behind this approach is that the red wines are stored and consumed at warmer temperatures than white wines, and therefore subjecting these wines to severe low temperatures is not necessary.

Deep red and high tannic wines generally throw sediment during long bottle aging. The sediment primarily consists of pigment polymers and some bitartrates. Such sediment is not perceived as faulty and wine is simply decanted before consumption.

Maturation, Aging

The process of maturation and aging involves a series of changes that lead to the improvement in the appearance, color, taste, and flavor of a wine. Red wine color is due to the presence of anthocyanin pigments, which occur in monomeric and polymeric forms. Young wines have higher levels of monomeric anthocyanin pigments in various colored and colorless forms. The proportion of colored and colorless types is pH dependent. In the range of wine pH, the lower the pH, the greater the concentration of pigments in red form. Therefore, to produce young red wines of attractive color, the winemaker should strive for a lower wine pH. The monomeric pigments are also susceptible to sulfur dioxide, which causes bleaching. This reaction, however, is reversible and loss of SO2 can restore original color. This point is important to remember when sulfating young red wines. As the wine matures, the monomeric pigments are polymerized and the color becomes more stable. It is then less responsive to changes in pH and SO2 levels.

Another important phenolic compound in red wines is tannins. Their structure is complex and they result from oxidative and non-oxidative polymerization reactions involving many other compounds. They contribute bitterness and astringency to wine.

During maturation, some of the tannins are lost due to precipitation, while others undergo reactions that diminish astringency and increase suppleness in red wine.

The flavor of the wine becomes complex as fruit, fermentation, and oak-derived aromas become integrated.

The processing technique and the duration of maturation depend on the style of red wine. Rosé, light red, and nouveau style wines, destined for early consumption, are matured and aged for relatively short periods. The appeal of these wines is their youth and fruit-derived aromas. They are simple wines and delicious to taste when young. Medium to full-bodied, deep-colored and high tannin wines require prolonged maturation periods before they become drinkable. During maturation and aging, their tannins become soft and the complex flavors become integrated, resulting in balanced and harmonious wines.

Generally, the containers used for red wine storage include stainless steel tanks and wooden barrels. For home winemakers and others dealing with smaller lots, glass carboys may be more suitable. In glass and steel containers, there is no loss of wine due to evaporation. However in wood barrels, usually 2 to 5% of the wine is lost due to evaporation. Because of this loss, it is necessary to top the barrels with wine to keep them completely full.
The operation of topping and filling the barrel exposes wine to air which results in limited oxidation. A certain amount of air exposure (oxidation) is considered necessary for the maturation of red wine.

It is commonly believed that wine can breathe through wood, and, therefore, to facilitate the oxidation, wood barrels should be used as a container of choice for maturation. It has been demonstrated that a sealed and airtight barrel (wet staves) does not allow air to enter the barrel, and oxidation of wine occurs when the barrels are opened during topping and filling operations.

Fruity and young wines are generally matured in steel tanks (or used wood barrels) and are usually made without oak character. Medium and full-bodied premium reds are commonly matured in wood barrels. The barrels used include a mix of new and used barrels. In this approach, the winemaker is aiming for flavor complexity, including oak character. The length of wood maturation depends on grape variety, wine style, kind of barrel, winemaker’s preference, and consumer choice.

Winemakers have a wide range of choices in selecting barrels based on species of oak, geographic origin, toast levels, and method of barrel production. For a small-scale producer, the use of a 50-gallon wood barrel may or may not be practical. Barrels are generally expensive, require space for storage (full and empty), and are difficult to clean and sanitize. Many winemakers use oak chips as an alternative to oak barrels.

In smaller lots where the use of a wine barrel is not practical or possible, oak chips can be used to obtain oak character in the wine. Both American and French oak chips are available in various sizes and grades. The usual rate ranges between 10 to 15 lbs/1000 gal (4.5 to 6.8 g/gal), and the contact time between oak chips and wine varies between one to three weeks. Some winemakers prefer to use a higher dose in a portion of the wine and then blend it back with the untreated portion to obtain a desired level of oakiness in wine. It is desirable to conduct a trial to determine the optimum quantity and length of contact time.

Maintaining Proper SO2

Managing proper SO2 levels in red wines is critical. The amount of SO2 used should be low enough to permit some oxidation, but high enough to control spoilage-causing microorganisms. This can be a difficult exercise, particularly if the wine pH is high (3.6 and more). This is because at a higher pH, the higher dose of SO2 necessary to control microorganisms can adversely affect the taste and flavor of the wine. To avoid the need of using excess levels of SO2, the winemaker should attempt to keep the wine pH lower, reduce microbial load by filtration before prolonged storage, and conduct all cellar operations under stringent hygienic conditions. The SO2 levels should be periodically checked and adjusted to the proper level.

Bottling

The procedure for bottling red wine is quite similar to bottling white wine.

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