3

Making Red Table Wines

Figure 1 is a schematic of the basic operations involved in making red table wines. Each step is discussed below. Additional information, not depicted in the schematic drawing, is also presented.

Crushing and stemming

This first step may be performed by hand or by machine. For handling a ton or more of grapes, use a mechanical crusher-stemmer. Examples of these devices are shown in figure 2 and are detailed in **Chapter 8** in the section on equipment and supplies. Using a small crusher-stemmer, two persons can crush and stem a ton of grapes in about 1 hour. Smaller lots of grapes can be crushed, using a hand-operated, roller-type crusher. In either case, to collect the crushed grapes (must), the machine is placed and supported above a container, such as a large polyethylene plastic tub or garbage can. If only a crusher is used, place chicken wire over the collecting container to separate out most of the stems; these are intermittently discarded, as necessary. Small, fragmented pieces of stems that get into the must will increase the wine's astringency or bitterness and their inclusion should be avoided as much as possible. The important objective is to minimize bitterness by thoroughly crushing the berries without macerating the seeds, and while recovering all of the skins and juice in the must. After stemming and crushing, the fermentors

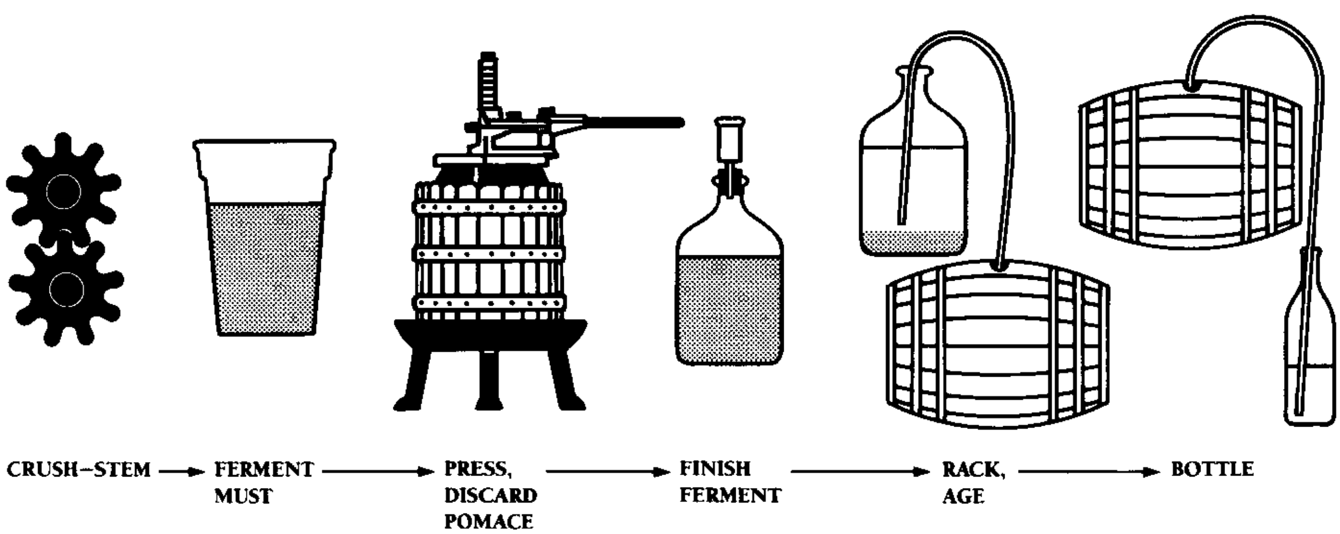


Fig. 1. Essential steps in red wine making.

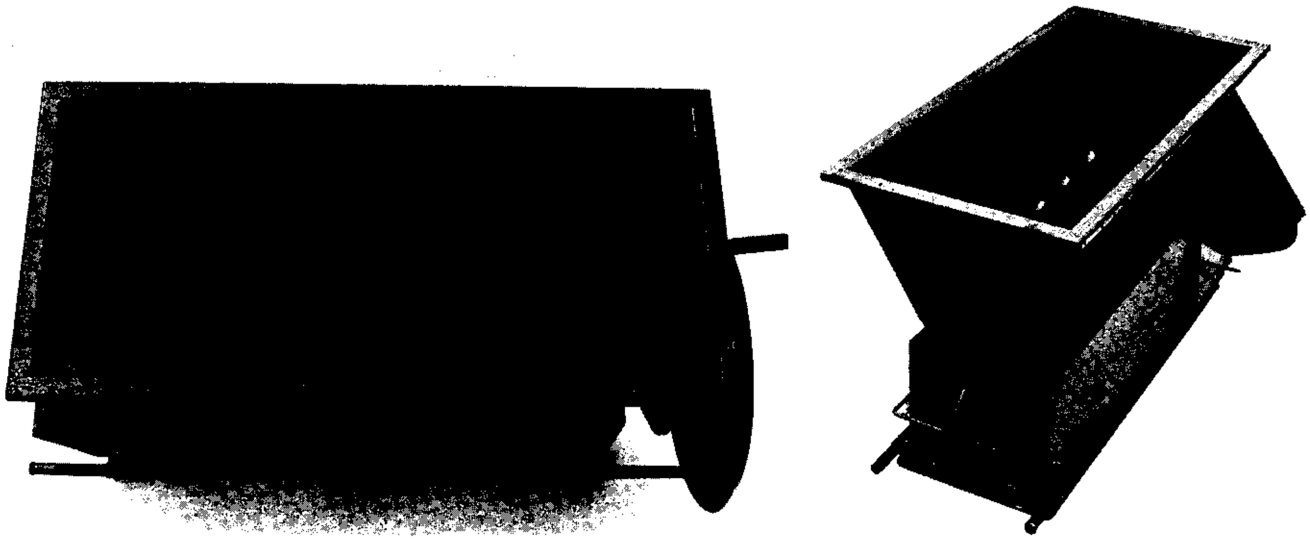


Fig. 2. *Left*, hand-operated roller-crusher; *right*, crusher-stemmer, fitted for motor drive.

are filled with the must to about two-thirds capacity, to avoid foaming-over during fermentation. Probably the most practical and least expensive fermentation vessel is a 32-gallon plastic garbage can (polyethylene plastic is preferable). About eight or nine are needed to handle a ton of crushed grapes.

After all of the must has been poured into the fermentors and sulfur dioxide has been added (see below), the fermentors should be covered with cheesecloth or plastic to keep out insects. Temperature, total soluble solids, titratable acidity, and the free and total SO_2 (note analyses section) of the must in each fermentor should be determined and the results recorded.

Adding sulfur dioxide

Sulfur dioxide (SO_2) is a chemical compound that has been used in wine making for more than a century. Because it is known that wine yeast produce small amounts of SO_2 during fermentation, SO_2 can be considered a natural constituent of wine. The amounts produced vary widely, and to insure against deficiencies, commercial wineries add small amounts to inhibit development of such spoilage microorganisms as vinegar bacteria and spoilage yeast, and to prevent oxidation and browning. Although SO_2 has proved an effective wine preservative, its use, as with other food additives, has been brought into question. Despite 75 years of enological research, no satisfactory alternative practice has been found for preventing microbial spoilage and oxidation of wine. In reaction to reports that suggested that a very small number of asthmatics ran a potential risk if they consumed wine containing SO_2, new federal regulations were adopted in 1986 for using SO_2. As of January 9, 1988, whenever a wine contains 10 ppm or more total SO_2, the label will be required to disclose that it "contains sulfites."

Judicious and moderate use of SO_2 has long been recommended. Recent research shows that the best quality wines are made when SO_2 has been used both before and after fermentation. Some commercial winery experience indicates that use of SO_2, before alcoholic fermentation, can be minimized or even omitted when freshly harvested grapes are free of mold, mildew, rot, or any other defects (cracked or broken skins), and these grapes are handled, throughout the wine making process, under strict sanitary conditions and in a temperature-controlled environment. These practices are more often successful in making red wines than in making whites. Furthermore, SO_2 should be added after fermentation when usual storage or aging is contemplated and most certainly at bottling to prevent oxidation.

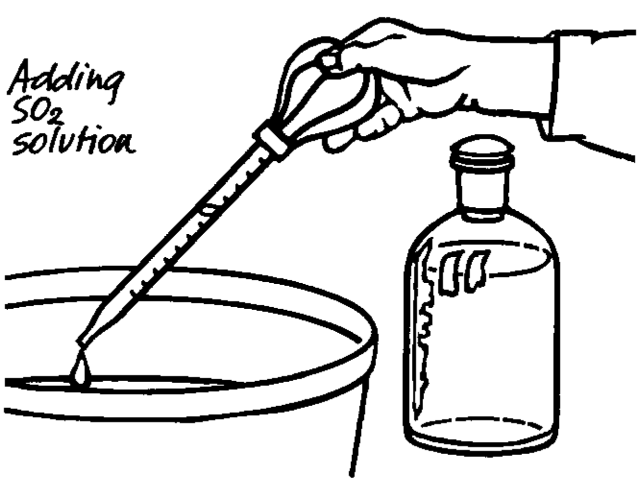
For most home winemakers, adding SO_2 is recommended. It has been observed that the home winemaker is generally unable to achieve strict sanitation, and hence can benefit from the judicious use of SO_2. As stated, adding a small amount inhibits development of molds, wild yeast, and undesirable bacteria, especially vinegar bacteria. For grapes free of mildew, rot, or mold, usually from 50 to 100 parts per million (ppm) is used or about 75 ppm is adequate. This mild antiseptic is commonly used in the form of potassium metabisulfite ($K_2S_2O_5$), and is available from home wine making suppliers. To obtain 75 ppm of SO_2, add ¼ ounce (slightly less than 1 level teaspoon) to each 10 gallons of juice or must. For grapes that have appreciable amounts of moldiness, rot, or broken berries, use twice this amount of SO_2. To add SO_2, dissolve the metabisulfite in a small portion of the juice; then add this back to the bulk of the must to be treated and mix thoroughly. Allow this mixture to stand about 2 hours before adding the wine yeast starter culture (see next step).

For the beginner, some precautions about using and handling SO_2 are in order. Adding too much SO_2, a common mistake, can delay onset of fermentation; excessive amounts can actually prevent it. Using too little or no SO_2 can result in the wine turning to vinegar or spoiling. Therefore, calculate and weigh SO_2 additions carefully. The $K_2S_2O_5$ will lose its strength after being opened and during subsequent storage and openings, especially if it gets damp. Therefore, purchase only enough for one season's use and store tightly closed in a cool, dry place. As with other chemicals, avoid skin and eye contact, wear protective gloves, and wash hands thoroughly after use.

Finally, because wine making at home is a batch operation, it is a relatively slow process. Hence, during crushing and stemming, small portions of juice or must may be obtained over several hours. With this in mind, we recommend adding SO_2 in increments during crushing and stemming rather than after this operation has been completed. Thus, as each 10 gallons of juice or must is obtained, add SO_2 to insure its thorough distribution in the final mixture and to prevent oxidation during crushing.

As mentioned, accurate measurement of SO_2 is critical. Because repeated weighings of $K_2S_2O_5$ are tedious and can cause error, use a concentrated SO_2 stock solution of known strength. A 10 percent solution of $K_2S_2O_5$ (containing about 6 percent available SO_2) is readily prepared and convenient. Remember, however: The solution loses its strength upon repeated opening and should be replaced with a fresh solution after 1 to 2 weeks.

Depending upon amounts of must or wine to be treated, the stock solution volumes involved can be quite small and need to be measured in metric units, that is, milliliters (ml).



To prepare and use the 10 percent stock solution of $K_2S_2O_5$, the following supplies are needed:

Several sizes of graduated cylinders—10, 100, and 1,000 ml (1 liter); 1-ml and 10-ml transfer pipettes (the 1-ml pipette must be graduated in 0.01-ml intervals); and a 1-liter (L) glass reagent bottle that can be tightly stoppered with a tapered rubber or cork stopper. The solution is made by carefully weighing out 100 grams (g) (3.52 ounces [oz]) of potassium metabisulfite, and dissolving in 1 L of water. The purity of the $K_2S_2O_5$ should be noted on the label and if it is less than 100 percent, compensate for this difference by an appropriate adjustment to the amount weighed. For example, if the label on the $K_2S_2O_5$ container indicates its purity to be 96.4 percent, then 103.7 g (3.65 oz) $K_2S_2O_5$ is required for a 10 percent solution (100 g divided by 0.964 = 103.7 g). Dissolve the $K_2S_2O_5$ in 1 L of water and place in the reagent bottle, stopper tightly, label contents, and store in a cool place.

Table 4 shows the various volumes in ml of the stock solution required for final concentrations of SO_2 at given volumes of juice or wine. Sulfur dioxide solutions volatilize readily and the vapors can seriously irritate eyes, nose, throat, and lungs. Therefore, when dispensing aliquots of the $K_2S_2O_5$ stock solution avoid breathing the fumes, use in a well-ventilated area, and wear a fume-type face mask if you are especially sensitive. It may be helpful to position a fan so that the fumes are blown away from your face or work with the SO_2 solution outdoors. All measurements of small volumes that require use of pipettes should be done with a rubber bulb to supply suction. **Never use your mouth!**

Table 4. Making SO_2 stock solution additions

	Desired final SO_2 concentration (ppm)*							
Must/wine	10	20	25	30	40	50	75	100
(gal)	Add ml of 10% stock solution							
1/10	.07	.13	.16	.20	.26	.33	.49	.65
1/5	.13	.26	.33	.39	.53	.66	.99	1.3
1/2	.33	.66	.82	.99	1.3	1.6	2.5	3.3
1	.66	1.3	1.6	2.0	2.6	3.3	4.9	6.6
2	1.3	2.6	3.3	3.9	5.3	6.6	9.9	13.1
3	2.0	3.9	4.9	5.9	7.9	9.9	14.8	19.7
4	2.6	5.3	6.6	7.9	10.5	13.1	19.7	26.3
5	3.3	6.6	8.2	9.9	13.1	16.4	24.6	32.9
10	6.6	13.1	16.4	19.7	26.3	32.9	49.3	65.7
25	16.4	32.9	41.1	49.3	65.7	82.1	123.2	164.3
50	32.9	65.7	82.1	98.6	131.4	164.3	264.4	328.6

*The volumes indicated assume 100 percent purity of the potassium metabisulfite ($K_2S_2O_5$) and full strength of the stock solution.

Adding pure wine yeast starter cultures

The use of pure wine yeast starter cultures to promote alcoholic fermentation is practiced widely in commercial wine making and is recommended for the home winemaker. The active dry form of wine yeast is available from home wine shops. Of two strains commonly used, Montrachet and Champagne, avoid Montrachet if the grapes were sulfured a few weeks before harvest, as this strain readily produces hydrogen sulfide when residual sulfur is present. Usually, two 5-gram packets of dry yeast pellets, sprinkled on the must surface with mixing, provide an adequate inoculum for each 10 gallons of must. If the must is highly sulfited, or it is difficult to start fermentation, use twice this amount of yeast. For best results, the yeast should be rehydrated before use. If rehydration is not followed precisely, yeast activity will be reduced. Therefore, we do not recommend it for very small lots.

To rehydrate, add 1 kilogram of dry yeast pellets to about 2 gallons of water or must previously warmed to 100° to 105°F (38° to 41°C). After 10 to 20 minutes, mix well and use 25.6 oz of this mixture to inoculate each 100 gal of must. This is approximately equivalent to an inoculation rate of 1 g yeast per gal of must. Note that higher temperatures, lower temperatures, and prolonged soaking in water, even at the correct temperature, can all reduce yeast activity.

Some winemakers prefer to acclimatize the yeast by first growing it in juice or sweetened diluted wine until about one-half of the sugar has fermented. This actively fermenting mixture of yeast cells is then used as the inoculum.

Alcoholic fermentation

Grape wine is the alcoholic product of the fermentation of grape juice, and the essential feature of this fermentation is the conversion of the grape sugars, glucose and fructose, to ethyl alcohol (ethanol), carbon dioxide (released as a gas), and flavor components. This complex process is accomplished by living yeast cells and is illustrated in the following chemical equation:

$$\underset{\substack{\text{1 molecule glucose} \\ \text{180 g}}}{C_6H_{12}O_6} \xrightarrow{\text{yeast}} \underset{\substack{\text{2 molecules ethanol} \\ \text{92 g}}}{CH_3CH_2OH} + \underset{\substack{\text{2 molecules carbon dioxide gas} \\ \text{88 g}}}{CO_2}$$

The alcohol produced through fermentation is a wine's major flavor component. It also affects the solubility of many wine constituents. Some is used in forming other flavor compounds. It also enhances wine's resistance to spoilage. Moreover, wines traditionally are classified according to their alcoholic content. Indeed, the amount of alcohol formed from a given amount of grape sugar is of considerable practical importance to the winemaker. According to the equation above, the maximum theoretical yield of ethanol is 51.1 percent of the molecular weight of the sugar ($92/180 \times 100 = 51.1$). However, in actual practice, the alcohol yield is somewhat lower, since some sugar is utilized by the yeast for growth and for production of small amounts of other compounds. Also fermentation efficiency (ability to produce alcohol) of the yeast is not perfect or constant, and in addition some alcohol escapes with the evolution of the carbon dioxide gas. Hence, on the average, actual alcohol yields are about 47 percent by weight, instead of the 51.1 percent just shown in the previous calculation.

Given a known amount of sugar in grapes, it should be possible to estimate the amount of alcohol that can result from fermentation. Thus, a must containing 22 percent sugar by weight should yield a wine containing 10.34 percent alcohol by weight ($22 \times 0.47 = 10.34$). Note, however, that the alcoholic content of wine is expressed as percent by volume, owing to the method of its measurement. From specific gravity tables, the 10.34 percent value converts to 12.82 percent alcohol by volume.

Unfortunately, this relatively simple method cannot be used to calculate how much alcohol can be obtained from a must of a certain sugar content, as determined by the °Brix measurement. This latter term, described more fully later on, denotes the percent sugar of pure solutions. Since must or grape juice contains nonsugar-dissolved solids, the °Brix value must be corrected to give a more true percentage of the sugar content, when alcohol production is estimated. The amount of nonsugar solids has been estimated to average 3.0 percent. Thus, °Brix minus 3.0 gives the must's approximate sugar content. This value, multiplied by its specific gravity (table 5) and then multiplied by the fermentation conversion factor of 0.59 (this term represents the alcohol by volume that forms from 1 gram of sugar), will provide an estimate of the approximate percent alcohol by volume resulting from a given °Brix must.

The following example illustrates this convenient calculation: Assume that a given must or juice is 22.5° Brix. Subtracting the nonsugar correction factor of 3.0 percent, the "true" sugar content is actually 19.5 percent by weight. To convert this to percent by volume, multiply 19.5 by the specific gravity of 1.0803 (obtained from table 5). Then multiply by 0.59. The result is an approximate alcoholic content of 12.4 percent by volume.

Usually, in natural grape table wine fermentations (where no sugar is added) the alcohol produced ranges between 11 and 14 percent by volume, depending upon initial sugar levels. In dessert and appetizer wines, such as port and sherry, alcoholic content is higher, ranging from 17 to more than 20 percent. As explained previously, this higher alcoholic content is achieved commercially by adding wine spirits.

Fermentation in wine making is not only fascinating but it is critical to success. Typically, there are three distinct stages.

1. A quiescent period of 12 to 24 hours, during which yeast cells grow and increase in sufficient numbers to commence the fermentation.
2. Vigorous activity of 2 to 3 days, during which the yeast rapidly ferments one-half to two-thirds of the sugar to alcohol and carbon dioxide gas—the latter development is accompanied by frothing—and the skins rise to the surface, become compact, and form the "cap."
3. A more or less quiet stage of relatively slow fermentation for 3 to 4 days after pressing the partially fermented juice off the skins.

Note: The rate or speed at which each event occurs depends upon fermentation temperature and amount of yeast inoculum, as well as availability of yeast nutrients. Typically, red wine fermentations take 1 to 2 weeks.

In addition to the conversion of grape sugar into alcohol and carbon dioxide, energy in the form of heat is produced, usually about 56 kilocalories per gram molecular weight of glucose fermented. Lowering or raising this heat during fermentation is essential to controlling the fermentation's progress. Within limits, the higher the temperature, the faster the fermentation rate. In red wine making, it is recommended that fermentation start at 60° to 70° F (15.6° to 21.1° C); be allowed to proceed at 75° to 80° F (23.9° to 26.7° C); and just before pressing off the skins be allowed to rise for a day or so to 85° F (29.4° C). The remainder of the fermentation should be conducted at between 68° to 70° F (20° to 21.1° C). Temperatures that reach 90° to 95° F (32.2° to 35° C) or higher can lead to a "stuck" fermentation, because at these high temperatures yeast cells die and it can be very difficult to restart fermentation. Prolonged fermentation at temperatures above 85° F (29.4° C) can create "cooked" odors and flavors. The temperatures outlined here allow for an even fermentation rate and the relatively warm conditions before pressing facilitate color extraction. Once the cap forms, the highest temperatures in the fermentor are trapped in the juice just under it.

How does the home winemaker achieve effective temperature control during fermentation? A few sample measurements will quickly indicate for each home wine making circumstance how much control is required. Unfortunately, few methods are inexpensive. Probably

Table 5. Percentage by weight (° Brix) and specific gravity (20° C/20° C) of sugar solutions*

° Brix	Specific gravity	° Brix	Specific gravity	° Brix	Specific gravity
14.0	1.0568	18.0	1.0741	22.0	1.0919
.1	.0573	.1	.0746	.1	.0924
.2	.0577	.2	.0750	.2	.0928
.3	.0581	.3	.0755	.3	.0933
.4	.0585	.4	.0759	.4	.0938
.5	.0590	.5	.0763	.5	.0942
.6	.0594	.6	.0768	.6	.0947
.7	.0598	.7	.0772	.7	.0951
.8	1.0603	.8	.0777	.8	.0956
.9	.0607	.9	.0781	.9	.0960
15.0	1.0611	19.0	1.0785	23.0	1.0965
.1	.0615	.1	.0790	.1	.0969
.2	.0620	.2	.0794	.2	.0974
.3	.0624	.3	.0799	.3	.0978
.4	.0628	.4	1.0803	.4	.0983
.5	.0633	.5	.0808	.5	.0988
.6	.0637	.6	.0812	.6	.0992
.7	.0641	.7	.0816	.7	.0997
.8	.0646	.8	.0821	.8	1.1001
.9	.0650	.9	.0825	.9	.1006
16.0	1.0654	20.0	1.0830	24.0	1.1010
.1	.0659	.1	.0834	.1	.1015
.2	.0663	.2	.0839	.2	.1020
.3	.0667	.3	.0843	.3	.1024
.4	.0672	.4	.0848	.4	.1029
.5	.0676	.5	.0852	.5	.1033
.6	.0680	.6	.0857	.6	.1038
.7	.0685	.7	.0861	.7	.1043
.8	.0689	.8	.0865	.8	.1047
.9	.0693	.9	.0870	.9	.1052
17.0	1.0698	21.0	1.0874	25.0	1.1056
.1	1.0702	.1	.0879	.1	.1061
.2	.0706	.2	.0883	.2	.1066
.3	.0711	.3	.0888	.3	.1070
.4	.0715	.4	.0892	.4	.1075
.5	.0719	.5	.0897	.5	.1080
.6	.0724	.6	1.0901	.6	.1084
.7	.0728	.7	.0906	.7	.1089
.8	.0733	.8	.0910	.8	.1093
.9	.0737	.9	.0915	.9	.1098

*Adapted from tables in: Bates, F. J., and associates. 1942. *Polarimetry, Saccharimetry and the Sugars*. Circular of the National Bureau of Standards C440, U.S. Department of Commerce, Government Printing Office, Washington, D.C.

for most, the use of a well air-conditioned room, especially in a warm or hot climate, is generally chosen for starters. (**Caution:** A small confined or closed space, with either numerous small or a few large-scale fermentations, should be ventilated with a good exhaust air system to remove CO_2 gas, as even at relatively low concentrations it is very toxic and can quickly lead to asphyxiation. Remember, CO_2 gas is colorless and odorless.) An alternative cooling method would be to add dry ice to the fermentation. One hundred pounds of dry ice will cool 100 gallons of fermenting must by about 20° F (13° C). Thus, if the temperature of the must begins to exceed 85° F (29° C), add about 20 pounds of crushed food-grade dry ice to each 20 or so gallons of must and thoroughly mix. (Wear heavy duty, padded, work gloves when handling dry ice.) Should food-grade dry ice not be available, substitute plastic gallon milk or water containers, filled with water and then frozen.

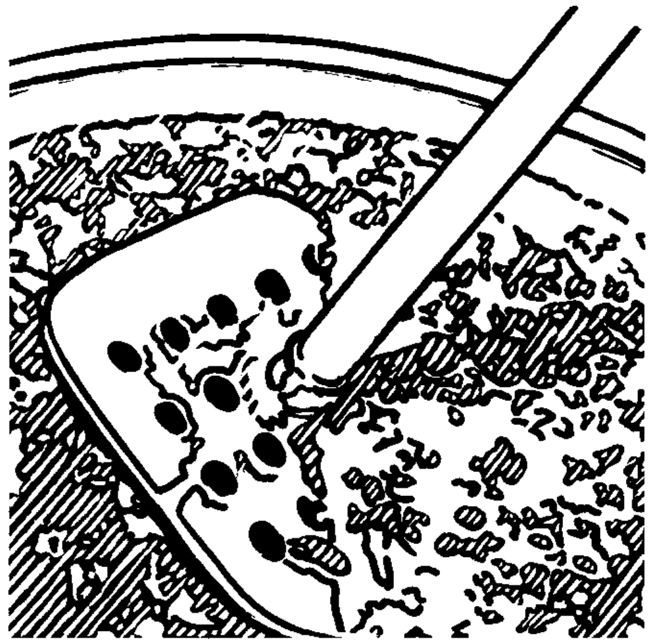
A more expensive alternative: Use a small stainless steel heat exchanger (copper or other metals are not recommended), either of plate design or coiled tubing, through which ice water or a refrigerant is pumped. The heat exchange unit is immersed into the must and coolant circulated through the unit while simultaneously the must is stirred around the cooling surfaces of the unit, either with a clean wooden stick or paddle or by using a motorized stirring unit or a slow, recirculating pump.

In summary, to achieve temperature control during fermentation on the skins:

1. Monitor fermentation progress by measuring and recording the ° Brix of the juice at least twice daily.
2. Measure and record the temperature of the must several times daily.
3. Thoroughly break up the cap and mix with the juice by "punching down" two or more times daily.
4. Cool the fermentation as juice temperatures indicate.

When making temperature readings use a long-stemmed, probe-type thermometer so that it can be inserted readily through the must. Always measure the temperature of the must after punching down. Deviations from this procedure, such as removal of small samples of juice to measure temperature, can result in erroneous readings by as much as 10° F or more. Punching down the cap facilitates color extraction, aids in temperature control by allowing accumulated heat to dissipate, and is fun to do. It is easily accomplished, using a clean, wooden stick or post that has a small, clean paddle perpendicularly attached.

Those who wish to ferment on a larger scale, that is, 100 to 150 gallons or more, should use stainless steel tanks. Temperature control can be achieved by wrapping the outside of the tank with a special plastic cooling jacket called a heat exchange jacket. The jacket consists of very narrow, long, continuous coils of tubing through which can be pumped ice water or ice water containing brine or a refrigerant, such as propylene glycol. (Use of the latter requires a refrigeration system.) Such a plastic jacket can provide very good cooling, especially if insulated externally with about 1 inch of urethane foam. The heat exchange jacket is less expensive than a jacketed stainless steel tank, and if needed, can be easily removed and mounted on another tank. Plastic jackets are available from The Compleat Winemaker (see **Sources of Equipment and Supplies for Home Wine Making**).



Punching down the cap

If they can be found, 100- to 300-gallon, used, jacketed, stainless steel tanks from dairies serve well as temperature-control fermentors. In larger-scale fermentations, "pumping over" is used to break up the cap and mix the juice with the skins. This requires a valve opening located about 1 foot up from the tank bottom, to which a small pump can be attached. A hose is attached to the pump's discharge end and the juice is forcefully sprayed over the cap. Pumping over should be done at least twice daily and perhaps more often, depending upon fermentation temperature, must volume, and grape variety. Each time pumping over occurs, all of the juice should be pumped over the cap solids. Appropriate types and sizes of pumps, hoses, fittings, and valves are available from many home wine supply shops.

When not punching down or conducting measurements, keep the open-top red wine fermentors covered with a double layer of cheesecloth or plastic sheet. This not only keeps out insects but traps evolving CO_2 vapors, which inhibit growth of spoilage bacteria. As fermentation proceeds, the °Brix will steadily decrease. For most varieties, once the Brix has dropped to about 6° to 8°, about 90 percent of the color will have been extracted during the first 3 to 5 days of fermentation. Longer fermentation on the skins will extract more tannins; the result is that the wine may require more aging before it becomes palatable. Conversely, early pressing off the skins will result in a fresh and fruity wine that can be consumed while relatively young, but with less color and limited aging potential. This presents a choice for the winemaker. We suggest that if sufficient grapes and other supplies are available, the beginner may want to try one lot pressed at 10° to 12° Brix, a second lot at about 5° Brix, and a third lot at dryness (−2° Brix or less). After tasting each lot, let your taste determine when you prefer to separate the juice from the skins in subsequent wine making. Keep in mind, however, that subsequent lots of grapes may not have the same composition and color content.

As mentioned, should a fermentation "stick" or cease before completion it is difficult to restart. This problem usually occurs due to too high fermentation temperatures or to insufficient yeast nutrients. Whatever the cause, the following actions are recommended:

1. Cool or warm the must, as appropriate, to about 68°F (20°C).
2. Add a fresh, actively growing yeast starter.
3. Add a yeast nutrient, such as Yeastex.

At the time of yeast re-inoculation, aerate the must by stirring or pumping over two to three times daily for 1 to 2 days. Fermentation should resume. If after several days, fermentation has not started, try a second re-inoculation. While waiting for fermentation to restart, keep the must or wine at the proper temperature. Whenever possible, use must or wine from an active fermentation for the yeast inoculum. Failure to restart after several attempts only emphasizes prevention; do not add excessive sulfur dioxide and maintain proper fermentation temperatures.

Pressing

This operation can be accomplished with a basket press or by squeezing batches of must through several layers of washed cheesecloth. (Wear rubber gloves to avoid staining the hands.) The squeezing is lengthy, requires considerable physical exertion, and results in poor yields. Using a basket press is recommended for the serious winemaker, working with one-half ton or more of grapes (fig. 3). Basket presses are available in various sizes, either hand-operated, motor driven, or hydraulic driven. The basket press, probably the most expensive piece of equipment needed in home wine making, is also one of the most worthwhile investments. A properly cared for press should provide a lifetime of trouble-free service.

Fill the basket with partially fermented must and allow the liquid portion to flow freely into a stainless steel bucket or a polyethylene plastic pail covered with plastic window screen to catch solids. Discard solids (pomace) from the screen surface as needed. This portion of the partially fermented juice or wine is referred to as the "free-run," and after all of it has been collected, apply pressure slowly and not for too long a time. Too rapid application of pressure causes the wet solids to squirt through the basket openings, which defeats the pressing operation, results in losses, and creates a mess throughout the work area. Some or all of the press wine may be added to the free-run or all of it may be kept separate; press wine can yield an additional 20 to 40 gallons. The more press wine added to free-run, the higher the tannin content; hence, a more astringent wine that will require more aging. Some winemakers prefer to keep the press wine separate and use some of it later for topping during aging.

As pressing proceeds, the free-run and/or the press wine should be placed into narrow-necked glass containers or clean oak barrels to about 90 percent of capacity, for fermentation to complete. (If you have chosen to ferment to dryness on the skins, proceed to the

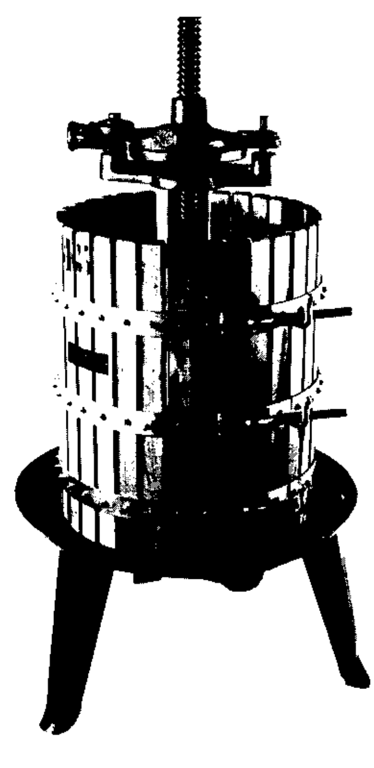


Fig. 3. Basket press

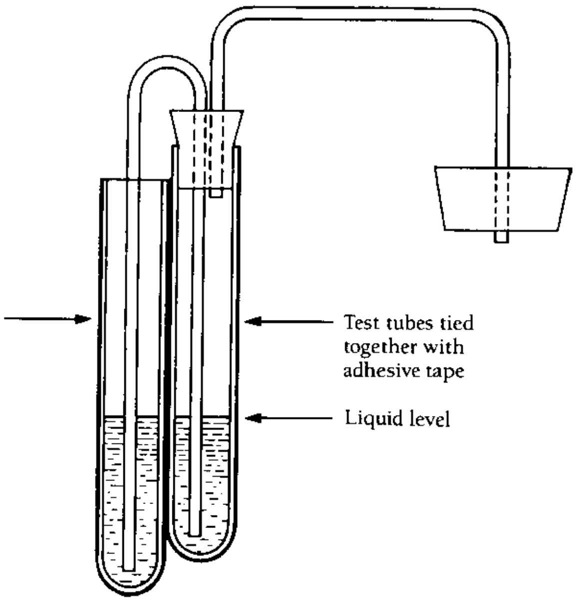


Fig. 4. Diagram of fermentation trap

discussion of malolactic fermentation.) These fermentors should be equipped with a fermentation trap (fig. 4) to protect the wine from air contact and oxidation. The trap allows carbon dioxide to escape, prevents air from entering, and should be kept in place until the wine is ready for its first racking. Before continuing with this and subsequent steps in wine making, read the discussion below on malolactic fermentation. It is discussed now because of its importance in making red wine.

Malolactic fermentation

A phenomenon distinct from alcoholic fermentation, this fermentation is accomplished by the activity of lactic acid bacteria, most commonly by species of the genus *Leuconostoc*. The term malolactic refers to the ability of these bacteria to convert malic acid to lactic acid and carbon dioxide, usually during or soon after alcoholic fermentation. Malic acid, one of the organic acids naturally present in grapes, is a stronger acid than lactic acid. Thus, the most marked change brought about by these bacteria is reduced acidity. In warmer grape growing regions, this deacidification is not desirable and is discouraged; in the cooler regions it is encouraged.

Malolactic fermentation is widespread among wine districts worldwide and is common in certain California red wines. Often the winemaker will encourage it by inoculating the fermenting must with a pure culture of the bacteria. Once malolactic fermentation is completed, the wine can be considered stable and can then be bottled and aged. Wines that have not undergone this fermentation before bottling are unstable; if fermentation occurs after bottling, the carbon dioxide gas produced can cause corks to push out with resulting wine loss, oxidation, and spoilage. Generally, better quality California red table wines have undergone malolactic fermentation, perhaps in part because the metabolism of the bacteria during the fermentation improves flavor complexity. When using California grapes, except those from the warmest growing areas, we recommend the malolactic fermentation in red table wines but do not recommend it for white table wines. Malolactic fermentation may be desirable in white table wine, if the grapes were grown in a very cool area, where acidity is naturally high (10 g/L or higher). In cases where the malolactic fermentation causes too much loss of acidity, this can be remedied by adding tartaric acid.

Several factors can either encourage or inhibit a malolactic fermentation. Malolactic bacteria have complex nutritional requirements for growth. These nutrients are either naturally present in wine or released into the wine by yeast cells during alcoholic fermentation. Thus, bacterial growth is enhanced the longer the wine is left in contact with the lees or inhibited if the wine is separated from the lees soon after alcoholic fermentation. Other factors that will tend to inhibit bacterial growth include: Low pH (3.3 or lower); relatively high levels of SO_2 (adjusted to at least 100 ppm after yeast fermentation); cool storage temperatures, 60°F (15.6°C) or lower; and nonuse of wooden cooperage. Conversely, wines more apt to undergo the malolactic fermentation have a higher pH (3.4 and above); have low levels of SO_2 (not above about 50 ppm total after alcoholic fermentation); are stored at warm temperatures, 65° to 86°F (18.3° to 30°C); and are held in wooden cooperage with a history of this fermentation. Unfortunately, relatively low SO_2 and warm storage conditions also favor development of spoilage yeasts and vinegar bacteria and wines held for too long under these conditions are indeed at risk. Therefore, practice careful sanitation.

As mentioned, the inoculation of partially fermented must with a pure malolactic culture, under favorable conditions, will usually induce a malolactic fermentation. A few firms sell starter cultures, which should be purchased 2 months before intended use. The major reason for discussing this subject at this point is that experience indicates that probably the best time to inoculate is at the beginning or sometimes at about the middle of the alcoholic fermentation, e.g., at pressing. Even with apparently favorable conditions, including inoculation of the must or wine, malolactic fermentation sometimes will not occur. If it does not occur several weeks after alcoholic fermentation has ended, even when it has been encouraged and the winemaker is anxious to bottle the wine, the total SO_2 should be increased to at least 100 ppm (30 ppm free SO_2), the temperature lowered, and the wine clarified by racking or filtration, and then bottled.

An easy and reliable method for determining whether a wine has undergone malolactic fermentation is by the paper chromatographic separation and identification of malic and lactic acids in the wine. This simple test requires no special skills or training and provides decisive results (see **Chapter 7**).

Completing alcoholic fermentation

The following discussion does not apply if fermentation on the skins has been allowed to proceed to dryness. Monitor the progress of this final phase of the alcoholic fermentation with daily hydrometer readings and temperature checks. Up to 2 weeks may be required to ferment the remaining sugar, depending upon temperature and other factors. Fermentation temperature should be maintained at between 65° to 75°F (18.3° to 23.9°C); during this phase, the fermentation rate is slower and less heat is generated. The fermentation can be considered complete (when the wine is dry); that is, the wine contains less than 0.2 percent reducing sugar, as determined by the reducing sugar tablet test (see **Chapter 7**). After fermentation has finished, keep the wine in its secondary fermentor with fermentation trap in place. During the next 2 to 3 weeks, spent yeast cells and other particulate matter will settle to the bottom of the fermentor, forming a sediment referred to as fermentation lees. If the malolactic fermentation has also been completed, proceed with racking (see next section). If it has not been completed, and completion is desired, leave the wine on the lees a while longer (perhaps 1 to 3 weeks) and follow the suggestions and precautions indicated previously. If it is not desired, the wine should be racked, the SO_2 adjusted, and the wine aged or bottled.

Racking

Racking or siphoning, a simple and convenient technique for clarifying wine, should be done carefully, so that the wine will obtain a degree of clarity satisfactory to most winemakers as well as to wine consumers. By siphoning or racking, clear wine can be separated from sediment in one container and transferred to another clean container. For small-scale operations, utilize clean, food-grade rubber or plastic hose of about ½ inch inside diameter and 4 to 6 feet long (see **Chapter 8** regarding materials used in wine processing). For larger volumes—100 gallons or more—larger diameter and longer hoses and pumps may be used. Insert one end of the hose into the wine several inches below the surface, apply suction to the outlet end, and immediately insert it into the receiving container toward the bottom to avoid aeration. The outlet end of the hose must be below the inlet end, but the difference should not be too great to avoid disturbing the sediment (fig. 5). Very carefully lower the inlet end of the hose gradually into the wine being transferred as the sediment is approached. Don't try to transfer every last bit of clear wine from the sediment, as once the sediment is disturbed, it quickly transfers to the receiving container. When racking wine from one barrel into another, notice that liquid levels and sediment layers cannot be seen. Therefore, attach a clean stick to the inlet end of the hose so that the stick extends about 4 to 6 inches beyond the hose opening (fig. 6). The stick with attached hose should be lowered very slowly through the sediment to the barrel bottom. This technique will prevent the inlet end of the hose from entering into the layer of sediment, unseen from the

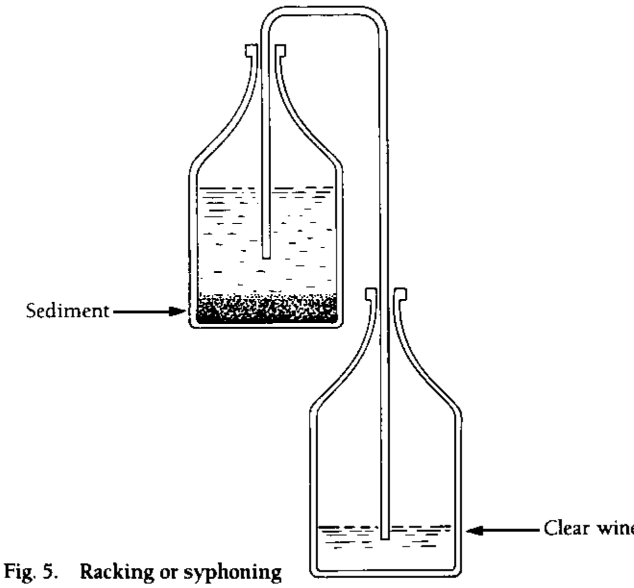


Fig. 5. Racking or syphoning

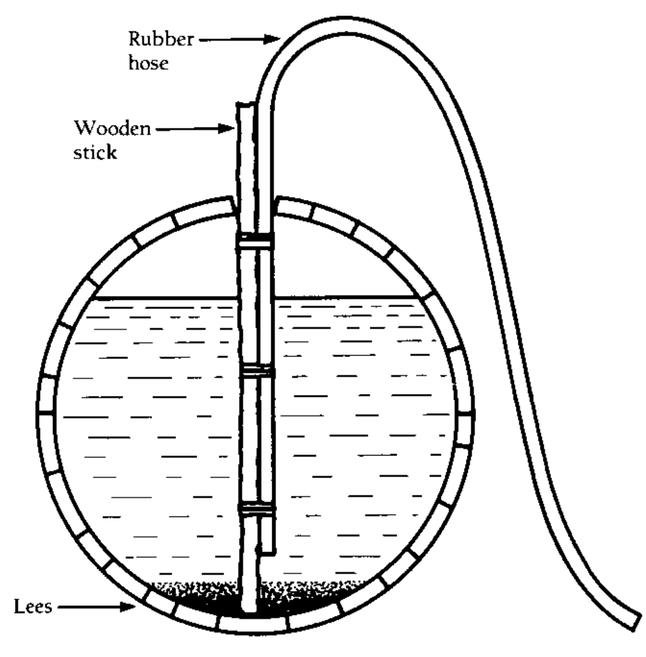


Fig. 6. Racking hose affixed to stick for barrel racking

barrel's exterior. Some home wine shops sell racking hoses especially designed for barrel racking. The first racking off the fermentation lees results in the greatest loss of volume. In subsequent rackings, the hose may be lowered closer to the bottom of the barrel, since there is a smaller amount of lees.

New wine racked off the gross fermentation lees is usually transferred into a clean oak barrel for aging. It may also be transferred into a clean glass carboy, jug, or other suitable container. Because the SO_2 initially added is exhausted during fermentation, it should be added again at this time (about 50 to 75 ppm, but not over 50 ppm total SO_2, if the malolactic fermentation has not yet occurred and is desired). The barrel should be completely filled and the bung loosely inserted into the bung hole for the next 2 weeks or until malolactic fermentation ends. After that, the barrel should be filled to the point of almost overflowing and the bung inserted tightly. Usually, additional rackings every 4 to 6 weeks up to a total of four or five rackings will facilitate clarification.

Aging and topping

Most red wines benefit from aging in oak barrels. In addition to the many slow reactions that occur during aging, wood extractives contribute to the wine's overall flavor complexity. Naturally, care should be taken to avoid excessive woodiness by controlling the wood aging time. New barrels will impart more wood flavor much faster than will older, used barrels. Thus, special care should be exercised when aging wine in new barrels and especially in barrels smaller than 50 gallons capacity. Whereas, red wines are generally aged in used 50- to 60-gallon barrels from 1 to 2 years or more, they would be aged only 1 to 3 months or less in new barrels of the same size. Wine in new oak barrels should be tasted every 1 to 2 weeks and, once it has attained the desired degree of oak character, as determined by taste, it should be transferred to a "neutral" or older, used barrel for further aging or storage if desired. If no further aging seems necessary, it should be transferred to glass storage containers or bottled.

During aging in old used barrels for the first year, the wine should be racked about every 2 to 3 months for a total of three to five rackings. These rackings are in addition to the initial racking from the fermentation lees. Wine can also be stored and aged in glass containers, but, of course, it will not obtain wood flavors. The containers must be filled completely, tightly sealed with tapered corks, and stored on their sides to keep the inner surface of the corks moist with wine. With 1-gallon jugs or larger glass carboys, the cork must be tied to the neck of the container to keep it in place, because pressure builds up from temperature changes or from gas formation or dissolution.

Topping is the winemaker's most important task during barrel aging. As wine ages, some is lost by evaporation or ullage, typically a 2 to 5 percent volume (1 to 2 gallons per 50-gallon barrel) loss per year. The ullage rate is directly related to temperature, relative humidity, and the size of the barrel, or the ratio of surface to volume. The ullage rate is more rapid in small barrels (larger surface-to-volume ratio) stored under warm conditions. Wine lost to ullage must be replaced to avoid oxidation and to prevent growth of vinegar bacteria, which will develop in the presence of air under favorable temperatures. Thus, wine should be aged under cool conditions, not above 60° F (15.6° C) and preferably 52° to 55° F (11.1° to 12.8° C). The barrels should be topped with wine as needed, at least every 2 weeks, and the SO_2 checked and adjusted after each racking to maintain a level of about 20 to 25 ppm free SO_2. Topping wine should be kept in completely filled glass containers and its SO_2 kept at the same level as the wine being topped. If all the wine in a gallon jug is not used for a single topping, the remainder should be placed in smaller glass bottles that are also filled completely and tightly corked for use in the next topping. Screw-capped bottles are convenient small containers for topping wines and must be clean; the inner seal should be plastic or coated paper, also clean, and in sound condition. Do not use rusty or corroded caps. Topping wine can be wine you have produced or purchased, but it should be the appropriate color and a similar type. Be sure to taste the topping wine for off-odors or off-flavors before use, as it can cause contamination.

Aging will vary according to the grape variety used, the size and age of the barrel, and the desired level of wood flavor. Due to the greater surface-to-volume ratio, wine aged in 5- or 10-gallon used barrels will mature relatively quickly, within a month or so. Wines in used 50- or 60-gallon barrels usually will require 1 to 2 or more years before they are ready to finish and bottle. Note previous comments about new barrels.

Before use, barrels should be washed and thoroughly rinsed and should be clean smelling. Barrels that leak or that have been allowed to sour through lack of proper care should not be used. (Cleaning, sanitizing, and care of cooperage are discussed in **Chapter 8**.)

To attain wood character, a rapid, convenient, and generally satisfactory alternative to barrel aging is the use of oak chips or granular oak. These materials can provide wood odor and flavor in wine stored in glass or stainless steel containers and can enhance the oakiness of wine aged in very old barrels. The amount of chips or granules required to produce a recognizable taste effect is relatively small and is determined by individual preference. Simply add a small amount; usually from 100 to 300 grams per 50 gallons of wine (3.5 to 10.5 ounces per 50 gallons) are sufficient. Allow to stand for up to 1 week with occasional gentle mixing. Compare the taste with untreated wine. Once the desired wood flavor has been obtained, the oak chips or granules are separated from the wine by rough filtration. Or to avoid filtration, the oak materials can be contained in a cheesecloth bag that is then suspended in the wine. Another method: The wine is allowed to trickle slowly through a cylindrical column packed with the chips or granules. Some winemakers prefer using alcoholic oak extract that may be purchased ready to use or prepared at home.

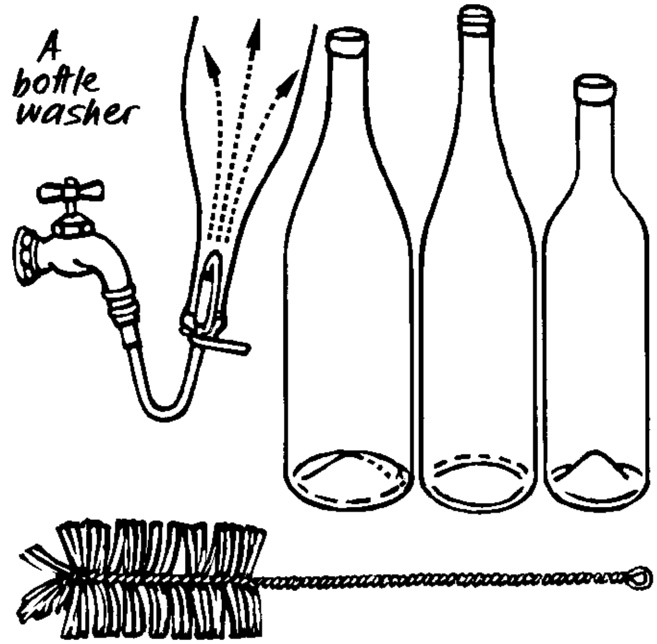
A suggested recipe for oak extract follows: Add 4 oz of oak chips (previously rinsed in cold water and drained) to a half-and-half mixture of vodka and white wine. Warm to about 100°F. Allow mixture to stand for 2 to 3 months. Small amounts of this extract will impart considerable oak flavor.

Because oak chips or granules are made from either American or European oak, different sensory effects can be produced according to preference. Home winemakers are encouraged to try these various oak treatments for introducing flavor complexity easily and quickly and improving wine quality. Contact your home wine shop for availability.

Bottling

The wine is "ready" for bottling after the desired degree of wood aging has been attained, as determined by taste, and malolactic fermentation has been completed. It should also be assessed as free of apparent or preventable defects or instability(s) within quality standards acceptable to each winemaker, by examination for desired clarity, smell, and taste. If any off-odors or off-tastes or other defects are detected, refer to **Chapter 5** (on spoilage and stability problems) before proceeding with bottling. Finally check the free and total SO_2. It is customary to adjust the free SO_2 as needed to about 25 to 30 ppm (100 to 150 ppm total) at bottling. This helps to prevent oxidation of the wine after bottling due to dissolved oxygen already present in the wine or oxygen that may be picked up during bottling. Bottling equipment, bottles, corking devices, and corks are available from home wine making shops.

When selecting bottling devices, it is highly desirable to minimize aeration, which in turn will minimize oxidation of the wine after bottling. This is best achieved using devices that provide for gravity flow of the wine and fill the bottles from the bottom. Such bottling devices are often referred to as "gravity bottom filling." New wine bottles should be rinsed in hot water to remove dust particles and air dried before use.



Used wine bottles should be washed with hot water and detergent solution using a bottle brush, thoroughly rinsed, and air dried before filling. Fill each bottle to allow only about a ¼-inch space between the wine level and the inserted cork in the neck of the bottle. This will minimize air contact with the bottled wine and avoid development of oxidized flavors. Corked bottles of wine should be labeled with appropriate identification information and dates and stored on their sides to keep the inner surface of the cork moist for a tight seal. Most red wines will improve with some bottle aging, while many achieve optimum complexity and palatability after 1 to 3 years or more.

Making rosé or pink table wines

As in red table wine making, these wines are usually made from red grapes that are crushed and stemmed. The juice is allowed to stand in contact with the skins for only 8 to 12 hours, and pressing is done when the desired pink color has been obtained. After pressing, fermentation and all other steps are as described for making white table wine, including juice settling, fermentation, and storage at the recommended cool temperatures. As with white wine, wood aging is not usually preferred and the wines are bottled as soon as possible for early consumption.

Alternatively, rosé or pink wines can be made by blending white and red wines. Stabilization and finishing are performed on the blend.