SHW

Sacramento Home Winemakers

Winemaking Manual

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Introduction

Sacramento Home Winemakers, Inc.

Sacramento Home Winemakers (SHW), a non-profit informational and educational organization, was formed in 1976 with the purpose of promoting the art of winemaking by the amateurs through discussions, lectures, field trips, competitions and experiments.

The Club's monthly meetings are focused on technical wine making topics and evaluations. These meetings are complemented with the Club's annual Jubilee (wine competition), winery tours, wine making workshops, harvest activities, and social events.

To encourage excellence in winemaking and volunteerism, SHW honors members and supporters with its annual awards:

- *Hal Ellis Memorial Award* – For Service Above and Beyond the Crush
  This honor has traditionally gone to someone who has contributed many volunteer hours to the events and activities of the Club. The award was created to also honor Hal Ellis, one of the original members of the Club, who tirelessly devoted many hours to SHW. Those who knew Hal also remember him as the maker of some dubious wines, particularly his celery wine.
- *Stu Shafer Memorial Award* – Most Improved Winemaker of the Year
  Stu and his wife, Betty joined SHW a number of years ago. Their early efforts at winemaking were not greatly memorable but after only two to three years in the Cub, Stu shot up earning large numbers of gold awards each year along with the Best of Show at both the SHW Jubilee and the California State Fair. From then on, Stu was known for his award-winning wines.
- *Bob Beck Memorial Award* – Wine Educator of the Year
  A long time SHW member, Bob gave many classes to new winemakers at his home and wine room in Auburn. The basics of those lessons on winemaking are the foundation for this winemaking manual. In addition, Bob and his wife, Jo traveled around the globe, returning with slides and wines, educating the Club with their wine and food travelogues.
- *Winemaker of the Year*
  The best measure of excellence is the opinion of qualified judges in a structured competition environment. This annual award is given to a member who accrues the highest points in amateur/home wine competitions. Candidates must compete in a minimum of three recognized wine competitions during the Award Year. Regardless of the number of competitions entered, the results of only three competitions (selected by the candidate) may be entered in the Winemaker of the Year competition. Among the competitions entered, one must be the SHW Jubilee and one must be the California State Fair.

> Within these pages lies the repository of all useful information related to the making of wine at home. Learn from it, refer to it often, and make the best possible home wine.

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I. GOALS AND OBJECTIVES OF SUCCESSFUL HOME WINEMAKING

In considering making wine at home, the goal should be to make fine wine: wine that is commercially competitive, wine that is proudly served to friends and neighbors. This requires that the wine be made only from quality grapes that are properly fermented, aged, and bottled. The wine should not have any defects and should be bacterially and chemically stable.

It requires special effort to make fine quality wine in the small quantities typically found in home winemaking operations. The large surface to volume ratio makes the wine susceptible to oxidation and other incursions. It requires, in fact, knowledge, skill, experience, tenacity, and the proper equipment.

The German winemaking adage, "Do as little as possible and as much as absolutely necessary" is an important concept to always keep in mind.

II. GRAPES, THE DETERMINANT OF WINE QUALITY

Grapes are a most unique fruit. They are alone in having sufficient sugar and acid to make wine reasonably protected from spoilage with only minor additions occasionally required. Generally, only grapes belonging to the species *vitis vinifera,* grapes of the Old World are capable of making fine wine. Thus, this analysis covers only grape wine production.

The legal basis for home winemaking ironically stems from prohibition. The prohibition law (1919-1933) allowed for tax-free production of wine at home. The regulations were modified in 1979 allowing 200 gallons/family/year without registration. Wine made must be for personal use; it cannot be sold or traded.

The most important elements in making wine are (in order): grape variety, climate (and the weather for the year), soil, and the skill of the winemaker. It is important to acknowledge that the winemaker is last in the order. Given good quality grapes of the proper variety, grown in a year with good weather, and grown on proper soil the home wine makers job is relatively easy.

It is necessary to have an excellent quality of freshly picked grapes to make fine quality wine. They must be free of mold and rot with little or no bird or bee damage so as to minimize oxidation and bacteria problems. They should be freshly harvested with few crushed grapes and not wet (washed) or cooked (subjected to high temperatures). White wine varietals should be cool. They should not contain pesticides, fungicides (especially sulfur), or other chemicals on their surface. Applications of such materials should not have been made after veraison begins (the beginning of ripening when grapes soften and begin to turn color) or earlier. They should not have been irrigated in the month prior to harvest and the grapes should not have been over-cropped (too large a quantity).

Ripe grape fruit is composed of:

1. Water (70-80%)
2. Sugar (17-25%)

a.About 50-50 fructose and sucrose
b. Measure as °Brix (% sugar — actually % of soluble solids)
c. Measure with Hydrometer (specific gravity) or Refractometer (refractive index of sugar)
d. Converted to ethyl alcohol in fermentation (about 56%)

3. Acid (0.3-1.5%)
   a. Composed principally of tartaric and malic acid; tartaric the strongest, malic more sour
   b. Tartaric/malic ratio 1:1 at veraison onset (the beginning of ripening) and 2-4:1 at harvest
   c. Measure quantity of total acidity (actually measured as if all were tartaric) as g/L or mg/100mL (i.e., 7.5 g/L = 0.75 mg/100 mL |which equals percentage of 0.75%)
   d. Also measure strength of acidity as pH, the number of hydrogen ions (range 3.0 - 4.0)
4. Other dry extract (includes phenolic compounds, i.e., tannins, esters, minerals; 0.3-1.5%)
5. Over 400 aroma and flavor compounds

III. PRE-HARVEST OPERATIONS

The first important step in making wine is to obtain a grape source commitment. Developing a home vineyard is an obvious long-term possibility. Finding a source of grapes of your desired variety that meet the objectives previously developed is not an easy task. The Sacramento Home Winemakers is an excellent reference in this regard. It is highly desirable that the grower will allow you to test the grapes as ripening commences if at all possible.

A careful review of the winemaking facility is also important. A separate processing and storage area is required and an adequate source of water must be available (old adage: it takes 10 G of water to make 1 G wine). An adequate waste removal capability to dispose of pomace, gross lees, etc. so as to reduce fruit fly development must be available. The fermentation area must have good ventilation and the storage facility should have some form of temperature control (55° to 65°). It is necessary to insure good sanitation in all areas.

An inventory of the home winery should include an assessment of the adequacy of vessels (carboys, fermentation tanks, etc.), cooling and heating capability, barrels, other machinery, and laboratory chemicals and supplies (See Table 1, Chemical Inventory and Ordering Form, pg. 24). The development of a fully adequate facility is expensive and must be weighed against expected production levels and desire to reliably produce high-quality wine.

IV. THE WINE MAKING PROCESS - AN OVERVIEW (See Table 2, pg. 25)

This table graphically illustrates the wine making process. The most fundamental difference between red and white winemaking is in pressing. White wines are made from pressed grapes (grape juice) while red wines are fermented with the skins and seeds in the must. Table 3 provides an excellent reference during the later description of red and white wine making.

V. THE HARVEST

During the ripening process (veraison and maturation) the berries enlarge and soften and the white varieties turn from green to yellow/green while the red varieties turn from green to purple/red. The sugar, measured by °Brix, accumulates and the total acid, measured as mg/100 mL (or g/L), diminishes (mostly malic acid). During this time tannins, aroma, and flavor compounds are formed.

To determine ripeness, begin sampling each variety during veraison at about 15 °Brix by picking 100 berries from different representative clusters at different areas of the cluster. Crush each sample, strain through cheesecloth, and measure "Brix, Total Acidity, and pH. Record above information in Table 3. Ripeness, p. 26. Harvest at optimum sugar, acid, and pH levels (Table 5, Harvest as a Function of Sugar/Acid Ratio, p. 28).

* Throughout this analysis, G = gallons and g = grams, L = Liters and ml = milliliters

Ripeness measures:

	White Varieties	Red Varieties
°Brix	20-23	21 -24
Total Acidity (TA)	7-9 g/L	6-8 g/L
PH	3.1-3.4	3.3-3.6
(°Brix) x $(pH)^2$ (A better measure)	= 200	= 260

Taste the grapes, the final determinant. Observe the varietal flavor, sweetness, how easily the seeds release from the pulp, and the color of the seeds. The grapes should taste sweet and have the flavor components of the variety. The seeds of ripe fruit release from the pulp easily as the pectin has softened. The seeds should be ripe, i.e., brown, not green.

Harvest only sound grapes which do not have rot or mold (may require cutting away some bad areas). There should not be too many green or raisined grapes or excessive "shot" berries (berries which did not fertilize and remain a tiny green). Keep broken grape skins to a minimum and try to harvest before fall rains. Keep harvested grapes cool, especially white varieties.

VI. THE CRUSH

The less that elapses from vine to the crusher, the better the wine. Allowing white wine grapes to sit around before crushing permits warming of the fruit and the emerging of various insects as well as oxidation. In red grapes maceration and oxidation also occurs which usually is detrimental to the finished product. Don't wash or rinse the grapes to cool or remove bugs, mold, rot, etc. as it dilutes the juice of the grapes. Any rot or mold should be cut out.

The use of a motorized stemmer-crusher for amounts over 500# is desirable. It not only reduces the effort but speeds up the process considerably. Keep crushing area clean by frequent washing down and removal of stems, pommace, etc. so as to reduce fruit flies (Drosophila melanogaster) and reduce the formation of acetobacter bacteria which turns alcohol into acetic acid (vinegar).

In white varietals, fermentation is never carried out on the skins; separation of stems and skins is always necessary. Direct pressing of the clusters is sometimes done, especially for sparkling wine but it may be difficult to obtain sufficient pressure to obtain a complete pressing.

Keep the time for mechanical processing short. Unless skin contact is desired, press as soon after crushing as possible. Skin contact time between crushing and pressing is often desirable with Sauvignon Blanc and (seldom) Chardonnay to increase varietal character (2-8 hours, or more).

In red varietals, the separation of skins and stems from the must occurs during or after fermentation. In some cases, some or all of the stems are added back to the must to enhance tannins or complexity, especially Pinot Noir grapes. It is necessary to have mature stems (dark brown, not green).

The final step in crushing is to transfer the must into skin contact vessels or presses for white wines or into primary fermentation vats for red wines.

VII. INITIAL TESTS AND ADJUSTMENTS

It is necessary to estimate the must volume as accurately as possible so as to enable proper additions. Next measure the °Brix, Total Acidity, and pH (expect some variation from sample tests). Then make additions but only if absolutely necessary; i.e., acid or sugar is significantly low (See Ripeness Measures Table 4, pg.27. additions prior to fermentation. It is seldom, if ever, necessary to adjust °Bnx (in California). But should it be required, use ordinary granulated sugar and stir it in well. It requires approximately 1.25 pounds of sugar to raise 10 gallons of must = 1°Brix.

Also adjust pH and Total Acidity only if required. Use Tartaric acid only, as citric acid often leaves a somewhat bitter lemon taste. As a rough guide, 3.8 g/G of Tartaric acid will typically increase the TA = lg/L and lower the pH by = 0.7 Test both pH and TA after additions; as each wine or must will react differently.

A useful method to determine tartaric acid additions using pH targets is as follows:

Target pH: Reds – 3.4 Whites – 3.3

Step 1: (Actual pH) - (Target pH) = pH Delta Example for Red Wine:

3.87-3.4 = .47 (Delta)

Step 2: (pH Delta) x 5.5 grams/liter (this is the "Factor", see below) and yields the Addition Rate (g/l of Tartaric):

.47 x 5.5 = 2.5 g/l Tartaric (Addition Rate)

Step 3: Multiply the Addition Rate by the volume of juice in liters. Example:
Treat a fermenter with 25 gallons of red must –

2.5g/l x 94.6 liters = 236.5 grams (8.3 oz.)

REHYDRATION OF GRAPES: Occasionally fruit is harvested in a high-brix condition. This may be simply due to the winemaker's lack of control over a harvest situation, or it may be part of a winemaking strategy. Some fruit, such as barbera or zinfandel, may be purposely harvested at a high brix level (on the order of 28 to 30 ºBrix) in order to obtain superior mouthfeel dynamics. It is then necessary to adjust (rehydrate) the must to more traditional fermentation levels to avoid a high-alcohol wine or worse, a stuck fermentation. To correct excessively high sugar at harvest:

Add chlorine-free water according to the following formula:

$$\frac{\text{(Gallons of Must) x (Brix of Must)}}{\text{(Desired Brix)}} \quad \text{equals} = \quad \text{Volume of Must AFTER Hydration}$$

Subtract the volume of must you are starting out with from the volume of must AFTER rehydration (the answer to the above equation), to get the amount of water you will add to get the desired Brix level.

Example: 60 G of must at 30-deg brix; desire 26-deg brix

$$\frac{60 \text{ x } 30}{26} = 69.23 \quad 69.23 - 60.00 = 9.23 \text{ G of water to be added}$$

It is nearly always necessary to make at least small $S0_2$ additions. A few commercial wineries are able to bottle wine without adding any $S0_2$ but making small quantities of wine without $S0_2$ is nearly impossible. $S0_2$ reacts with oxygen to reduce oxidation of the must inhibiting or killing bacteria and wild yeast. It encourages rapid and clean fermentation and helps brighten the color of red wines. $S0_2$ encourages the extraction of compounds from the grape skins during maceration.

There are, of course, disadvantages of using $S0_2$ at crush. It has an unpleasant aroma even at low concentrations and may introduce allergic reactions. At improper levels $S0_2$ may interfere with fermentation and preclude purposeful must oxidation in Chardonnay wine making.

There are many other factors to consider regarding the use of $S0_2$ particularly an understanding of active or usable $S0_2$. $S0_2$ combines to form "bound" $S0_2$ with up to 50 wine constituents and only the "free" or unbound SO2 is active in terms of its effect on aroma, yeast, bacteria, or potential oxidation. More specifically, it is that part of the free $S0_2$ which is in molecular form that provides protection. Molecular $S0_2$. the active component, should be maintained at 0.8 ppm for white wines and 0.5 ppm for red wines. These small amounts can only be extrapolated from the amount of free $S0_2$. Furthermore, the amount of $S0_2$ that combines (or its reciprocal, that remains "free") varies from wine to wine and the amount of required $S0_2$ is heavily dependent upon the pH of the must or wine. Also, wine stored in barrels seems to require more $S0_2$ - monitor closely.

Regulations specify the maximum amount of total $S0_2$ allowed (currently 220 ppm). A small amount of $S0_2$ is formed naturally during fermentation hence a wine made without any $S0_2$ additions probably will contain at least 10 ppm $S0_2$, the current commercial minimum level necessitating a warning label. Free $S0_2$ levels are difficult to measure in red wine as pigments interfere with determining the end point with simple titration. The use of a vacuum aspiration assembly provides the only reliable measure.

VIII. ADDING $S0_2$

Although the threshold of perception for most people is about 40 ppm free $S0_2$, it is important to avoid breathing fumes of strong $S0_2$ solutions as they are harmful to nasal passages.

With exceptionally clean fruit (no mold, rot, or mildew) and musts with low pH values, the first addition of $S0_2$ may be delayed until after fermentation. Some Chardonnay wines are allowed to brown (oxidize) with no $S0_2$. These browning agents drop out in fermentation, reducing future oxidation tendency. Also some Red Wines with clean conditions and clean fruit can hold through M/L without $S0_2$.

$S0_2$ additions must be carefully done. It is necessary to accurately measure the must or wine for pH, TA, free $S0_2$ as excessive $S0_2$ spoils the wine and may place a small number of asthmatics at risk. However, under-utilization allows wine to be attacked by bacteria and/or oxidize. The $S0_2$ additions process is defined in Tables 5, 6. and 7, "Sure and Simple $S0_2$ Additions," pp. 28-30. Good records are essential and are a helpful year to year reference.

IX. THE FERMENTATION PROCESS

The fermentation process is a fascinating and critical process whereby grape wine becomes the alcoholic product of fermenting grape juice. It is the conversion of grape sugars (glucose and fructose) to ethyl alcohol (ethanol), carbon dioxide (released as a gas), flavor components, and heat by the action of yeast. The chemical equation is:

$$C_6H_{12}0_6 \xrightarrow{\text{Yeast}} 2\ C_2H_5OH + 2\ C0_2 + \text{Heat}$$

Glucose — Ethanol — Carbon Dioxide

CAUTION! $C0_2$ is a colorless, odorless, heavier-than-air gas capable of causing asphyxiation even at low concentrations. Insure the cellar room is adequately ventilated.

The alcohol yield = (°Brix - 3) X Specific Gravity of must X 0.59

Example: Must with a °Brix of 22.5 has a Specific Gravity of 1.0808 (22.5-3) X 1.0808 X 0.59 = 12.4% alcohol (Obtain Specific Gravity readings with Hydrometer)

An approximation of Potential Alcohol (PA) for the usual ˚Brix levels can be made by using the following formula:

PA = (0.6 X brix) – 1

In reality, fermentation is a very complex process; the steps:

1. Phosphate groups attach to sugars
2. A series of steps occurs where the six-carbon sugars are split into two three-carbon pieces
3. One of the three-carbon pieces is rearranged into the structure of the other
4. After some further rearrangements this molecule loses its terminal carboxylic carbon atom in the form of carbon dioxide gas
5. The residual part is the two-carbon compound acetaldehyde, which goes to alcohol if oxygen is lacking
6. In addition, a number of intermediate compounds are involved
7. The biochemical reactions converting one compound into another are not 100 percent efficient
8. This results in small amounts of intermediate compounds accumulating in the wine
    a. These compounds and their reaction products combine with other substances in the mixture to develop what is known as fermentation or secondary aromas
    b. Included in these aromatic compounds are acetaldehyde, ethyl acetate and numerous other esters and fusel oils

The above set of complex chemical reactions are important to the winemaker only in appreciating the large impact that these tiny amounts of intermediate compounds have on the aroma and flavor in wine. Additionally, many unwanted fermentation by-products can also be developed.

Yeasts are lowly single-cell plants capable or producing fermentation. *Saccharomyces Cerevisiae* and *Saccharomyces Bayanus* are the species most frequently used in wine making but there are several hundred different strains with real or fancied minor differences.

Many yeast genera are usually present in grape musts and participate in the winemaking process. They are typically airborne and spread by fruit flies and are known as wild yeast. They tend to be sensitive to $S0_2$ and intolerant of alcohol much over 5%. They are usually accompanied by

Saccharomyces Cervisiae so "wild yeast" fermentations do complete. Today most New World and increasingly Old World producers use "cultured" yeast to reduce the risk of stuck fermentation.

There is a wide variation of cultured yeast characteristics. These variations include: production and tolerance of alcohol, aroma, flavor, rate of fermentation, temperature tolerance, $S0_2$ tolerance, flocculation characteristics, reducing potential, and micro-nutrient requirements. Assuming complete and proper fermentation, final effect of different yeast strains is somewhat unclear although their early aromas and taste are often pronounced. This effect is often muted with age.

The reaction of six-carbon sugar to ethanol and carbon dioxide yields generous amounts of energy and a large portion of this energy is captured by the yeast and used for its own purpose. However, another major portion is not captured but appears as waste heat and if this heat is allowed to exceed much over 95°F, it may damage or kill the yeast resulting in a stuck fermentation. These high temperatures may also make your wine smell like burnt rubber, or a burnt match stick.

Fermentation is a microbiological process conducted by yeast that was unexplained for centuries until Pasteur's discovery in 1857. Originally, "natural yeast" found on grape skins established fermentation and about 150 of the most favorable yeast strains have now been selected. Yeast cells are tiny—there can be as many as 5 million yeast cells in one drop of fermenting juice. Yeast cells multiply rapidly in their conversion of sugar to alcohol.

The most common wine making yeasts and their characteristics are:

1. Pasteur red - Fast, strong fermenter for full-bodied red wines made to age in wood or in the bottle; makes complex wines with good extraction; temperature of fermentation may get too high without cooling
2. Premier Cuvee (Prise de Mousse) - Good fermenter at cold temperatures making varietaly true, fruity white wines; compact lees; ferments completely
3. Montrachet - Popular all-purpose yeast for reds and full-bodied whites: tendency to produce hydrogen sulfide
4. Pasteur White - For dry. crisp whites, complexity instead of fruitiness, foamy
5. Pasteur Champagne - All-purpose for whites and reds. Hydrogen sulfide and mercaptans produced if low in nutrients (no! for Sparkling Wine)
6. Epemay 2 - Slow, perfumy fermenter, may not ferment to dryness in nutrient-poor musts (fermentation is quite easily stopped for the making of wines with residual sugar)
7. Assmanshausen - For spicy, complex dark-colored red wines; good for Pinot Noir due to somewhat slow fermentation
8. And many others, including popular Lallemand products such as D254, D80, D45 etc.

Both liquid and dry types of yeast are commonly used in home winemaking. The dry type is easy to use and stores well (2 years if kept cool — not frozen). Use 1 to 2 lb/1000 G (1/2 to 1 g/G). Although this yeast needs to be rehydrated, it is very easy to do. Stir in 10 ml H_20/gram of yeast at 105° C. for 20 minutes. Be sure to use a thermometer; if too cool, it doesn't re-hydrate well, and there is a risk killing the yeast if over 105° F. Liquid yeast cultures require building up the yeast to the volume you need and last about one month and are more difficult to work with.

Adding yeast nutrients is not only helpful to assure complete fermentation but also reduce the possibility of many bad fermentation by-products. Di-ammonium phosphate provides a basic source of nitrogen but a blend of nutrients, such as *Superfood, GoFerm* or *FermaidK* is recommended.

As sugar is converted to alcohol, the density of the solution decreases. It is necessary to measure the progress of fermentation and the easiest method is to measure density with a hydrometer. As hydrometers are calibrated for sugar in water, the presence of alcohol results in a slightly untrue reading. The most illustrative example is the impossible negative sugar reading as fermentation concludes. The use of sugar test strips or urine test tablets are good final checks.

A stuck fermentation is a fermentation that stops before all the sugar has been converted to alcohol. It is notoriously difficult to restart placing the wine at risk of spoilage from oxidation and bacterial disease. Fermenting must reaching 90° F or more causes yeast to release compounds which inhibit future yeast growth making restarting difficult. The causes of stuck fermentations include: a lack of yeast nutrients, especially nitrogen which is exacerbated by keeping must from air and/or having too low a level of solids; temperature of fermentation too high; wide temperature variations; yeast type; and wild yeasts which can produce a "killer toxin." Stuck fermentations are usually corrected by adding a more active yeast, adding yeast nutrients, cooling the fermentation environment, and allowing some aeration of the yeast. See Appendix I, pg. 16.

A number of fermentation by-products also develop during fermentation. These include:

1. Glycerol - a side reaction, greater at high temperatures so more prevalent in red wines, high viscosity contributes to wine body, sweet taste
2. Higher alcohol (fuel oil) - formed by decomposition of amino acids, enhanced by must aeration
3. Volatile acids - mostly acetic acid, a serious problem when caused by aerobic acetobacter (noticeable vinegar smell and taste), usually accompanied by ethyl-acetate, the smell of nail-polish remover
4. Acetaldehyde - oxidized form of ethanol, discolors the wine and smells sherry-like, almost always found in small quantities.
5. Hydrogen sulfide (smell of rotten eggs) - the reduction of sulfite, sulfate or elementary sulfur, especially if there is nitrogen deficiency, also caused by the decomposition of dead yeast cells in the lees if not racked in time, may react with ethanol and produce mercaptans (skunky or cabbage smell) which are <u>very</u> difficult to eliminate.
6. Acetobacter—A group of bacteria capable of spoiling wine by ultimately converting it to vinegar. They can only survive if oxygen is present. They are unusual in that that they can live in the high acid low pH environment of must or wine. They do like warm temperatures (86->100° F), relatively high pH (>3.5), and lots of oxygen.

X. FERMENTATION PROBLEMS AND CORRECTIVE ACTION (See Appendix 1, pg. 18)

XI. MALO-LACTIC (M/L) FERMENTATION

M/L is not a fermentation process at all but a bacterial action formed by the bacterium *Leuconostoc.* It is the conversion of malic acid (the sour acid found in green apples) to lactic acid (the soft acid found in milk). It can provide a softening of wine acids, especially beneficial in red wines.

M/L is also used in some white wines, especially Chardonnay where it adds diacetyl, providing a buttery aroma and taste, but is too often over done. The timing of adding the M/L culture is important. The diacetyl is maximized if M/L occurs after primary fermentation and is minimized if M/L occurs during fermentation. In either case, M/L always reduces fruitiness, at least to some extent.

M/L requires introduction through the use of a M/L culture (unless the M/L bacteria is endemic in the winery—barrels, etc.). M/L culture starter types are basically liquid which must be kept alive, or freeze-dried which is the easiest to use.

A number of conditions are required for M/L culture to multiply. The wine should not be racked or fined prior to the M/L culture introduction and, in general, should contain <50 ppm $S0_2$. The pH should be >3.3 and the temperature should be >66° F. There are specific limitations depending on the culture used, so be sure to read and heed the manufacturer's recommendations.

The use of a M/L nutrient is highly recommended such as *Leucofood* (Micro Essentials Oenos). The completeness of the M/L process is determined with a M/L Chromotography Kit, directions supplied in the kit. Positive chromatography results plus an increase in pH of .15 to .25 are good indicators that M/L is complete.

XII. RESIDUAL SUGAR

Residual sugar (r.s.) is defined as the sugar left in the wine after alcoholic fermentation is complete. In good quality wine, only natural grape sugar is acceptable and ranges from 2-3 g/L (very dry) to >200 g/L (very, very sweet) (.2 - >20%). There is no TTB requirement for labeling, but a common classification of residual sugar (r.s.) is as follows:

1. Off-dry (1-3% r.s.)
   a. Fruity, fresh wines i.e., Chenin Blanc, Riesling, French Colombard, and Muscat
   b. Most "blush" wines
2. Semi-sweet wines, (2 - 7% r.s.) - Spumanti, some Muscat, etc.
3. Sweet, fortified dessert wines, (7 - 18% r.s.) - Port, Madeira, Sherry
4. Late harvest wines (up to 30% r.s.)
   a. Over-ripe or shriveled berries such as German Beerenauslese or Ice Wine
   b. Botrytis affected as French Sauternes

Fermentation is stopped to leave residual sugar by a number of methods. Deep chilling is a common method accomplished by the use of 1/2 the yeast, adding no nutrients, and using Epernay 2 yeast. The temperature is quickly lowered to 32° F., extrapolating so as to determine the right time for the desired residual sugar. The wine is then racked, bentonite fined, and filtered. Alcohol fortification (such as using Ever Clear or high-proof brandy), ascorbic acid yeast inhibitor (which often leaves a geranium-like odor), and sterile filtration are also used to stop fermentation.

XIII. KNOWING YOUR ACIDS

The common measure of acids in wine is titratable acidity (TA), often called total acidity. It is a measure of both the volatile and fixed acids present in grape juice or wine. The principal acid in wine or grape must is tartaric followed by malic acid, citric acid, succinic acid and a small amount of volatile acid. The measurement of TA is obtained by titration, the addition of an alkali of known strength to a measured amount of grape juice or wine until the amount added just equals the amount of acids in the sample. A phenolthalein solution is used which turns pink at the equal or end point. It is, however, very difficult to observe this end point in red wines.

The value of these acids may be measured and expressed by different acids per liter. In the U.S., TA is measured as g/L or mg/100 mL and as if all the acids were tartaric. The typical measures of TA, as an example, are 0.7 mg/100 mL, which is the same as 7g/L. The nominal range of TA for red wines is 6.0 to 8.0 g/L and for white wines is 7.0 to 9.0 g/L. Wine below this range tends to be flabby (not tart, not thirst-quenching) and tends to not hold color. Wine above this range tends to be somewhat acidic and biting on the tongue; it may be long-lived and hold good color, however.

Volatile acids are naturally occurring organic acids separable by distillation. The most common volatile acid in wine, by far, is acetic acid, a small amount of which is a normal by-product of fermentation. At very low concentrations of acetic acid, i.e., below 0.2 g/L, the wine is not deleteriously affected. Higher levels of acetic acid, however, give rise to a vinegary flavor. Acetic acid may also be caused by a group of bacteria called acetobacter. These bacteria require oxygen for growth and survival and cause a reaction between any available oxygen and the wine which then produces vinegar.

XIV. pH, THE STRENGTH OF ACIDS

pH is a unit-less measure of the concentration, or strength, of acid in solution. It is most important as to how grapes ripen and how wine tastes, looks, and ages. Technically, pH is the negative logarithm of the hydrogen ion concentration. It is a "inverse" measure, that is, low pH means high concentration or a strong acid and vice versa. The pH scale is logarithmic, thus an acid with a value of 3.0 is ten times stronger than one with a value of 4.0. The pH scale ranges from 1 to 14 with 7 effectively neutral (drinking water), 7 to 14 basic or alkaline such as caustic soda and 1 to 7 acidic such as sulfuric acid.

There is an impact of soil on pH. Irrigation and soils with high nitrogen encourage vines to produce excessive crops with low organic acids and high pH. pH has little grape-growing impact (although grapes do not like acidic soil, a pH of about 5.5 is the lower limit).

The pH range in most wines is between 3.0 and 4.0. Wines with low pH usually taste very tart while those with high pH taste flat or "flabby". Wines with a pH of 3.2 to 3.5 (upper limit of 3.6 or 3.7 in red wines) tend to taste refreshing and have a clear, bright color.

Of great importance to the winemaker, wines with appropriately low pH are bacteria and oxidation resistant requiring much smaller $S0_2$ additions (see "Sure and Easy $S0_2$ Additions", pp. 29).

XV. PRESSING AND FERMENTING WHITE WINE GRAPES

First, destem, crush, and make initial tests and adjustments (see Sections VI and VII. above). The must is pressed typically using a basket press to extract the juice and much of the pulp from the skins and seeds.

To add additional intensity to the aroma and flavor of the wine, skin contact time is sometimes employed, especially with Sauvignon Blanc grapes, prior to pressing. This must be carefully done or the resulting wine will too vegetative. Typically, the pressed grapes are placed in a suitable food grade container for two to eight hours in a cold room (again prior to pressing.)

After adjustments and skin contact time, if deployed, transfer the must to a basket press. For most home winemakers, a 25-35 G press is sufficient and the must can be put in the press with a pail. Generally, the free run juice and the pressed juice are mixed together. It is highly desirable to place the pressed juice into carboys at this time so as to aid in racking the relatively clear juice off the settled juice. If racking into carboys a specially designed funnel is a great aid. Clean up press area and discard pomace.

12-24 hours of settling after pressing is generally desirable as it allows fermentation of cleaner must with fewer unwanted by-products. For small quantities, settling in 5-G carboys allows observation of gross lees level. After settling, rack into clean fermentation vessels, discarding gross lees (in some white wine musts, there may be up to 20% of total volume of gross lees to discard).

Fill the fermentation vats only two/thirds full to allow for foaming during fermentation. Stir in bentonite, if used, at this time. Sauvignon Blanc must typically contain considerable particulate matter which can be reduced by bentonite fining during fermentation. (See Table 9, pg. 33.)

Begin the fermentation process by adding yeast and yeast nutrient, important with settled must (See Table 10, pg. 35). Don't stir, allow the yeast and yeast nutrient to float on surface; they will work themselves into the must. Although fermentation is an anaerobic process, initial yeast growth requires lots of oxygen. The use a paper funnel to facilitate introducing yeast (and nutrients) to the 5-G carboy may be helpful. Add a floating thermometer to a representative carboy or vat and record temperature. Loosely cover the fermenter to keep bugs, etc. out (a wad of cotton works well for carboys).

Fermentation should start in 24 hours or so. It may be difficult to detect at first; look at the bottom of the carboy with a strong light, very tiny bubbles will appear. Maintain (daily, at first) record of fermentation temperatures and °Brix (read with hydrometer, a refractometer won't function on fermented sugars). When fermentation slows significantly, place a fermentation lock in place of cotton wad. When all visible signs of fermentation are over, check for residual sugar with sugar, test tablets. After fermentation is complete, recheck total acid and pH and correct if necessary.

Cold fermentation preserves volatile esters and phenols, adding aroma and flavor to most white wines. It requires small fermentation vats (5 G carboys are good) and good refrigeration control. Although it may delay the start of fermentation, 45 - 50°F is a good starting temperature. Cold fermentation will prolong fermentation, sometimes well over 30 days.

Barrel Fermentation in white wines is principally used for Chardonnay, Pinot Blanc, and some Sauvignon Blanc wines. It can add richness and complexity (vanillin). The wines are often allowed to remain *sur lie* with or without stirring the lees. One difficulty with barrel fermentation is temperature control.

XVI. FERMENTING AND PRESSING RED WINE GRAPES

First, destem, crush, and make initial tests and adjustments (Section VI. and VII. above).

There is increased use of cold-soaking the must for 2-5 days before fermentation, especially Pinot Noir. Properly done, this increases the depth and stability of color and increases flavor components. It is absolutely necessary to have clean fruit and proper $S0_2$ additions.

Place the stemmed and crushed must into a large vat (usually preferable to many vats). Large food-grade plastic barrels used to transport malt for beer work well but stainless steel vats with "floating" lids are the best (and most expensive). These large vats allow fermentation temperatures to reach optimum levels and provide for uniform fermentation and extraction. Cover the vat with a lid, layers of cheesecloth, or plastic to keep fruit flies from breeding.

Add the yeast and yeast nutrient as per Table 8, pg. 31. Don't stir it in; allow to float on the surface. Add a floating thermometer and record temperature. Leave the vat cover slightly ajar (fermentation is anaerobic, but needs air to start). Fermentation should begin in 24 hours or so. Record the °Brix (with a hydrometer) and the temperature, measure after punching down. Punch down cap at least twice a day; 4 to 6 times preferred as it insures better extraction and it precludes excessively high cap temperatures and aeration problems. A dry-wall spackle-mixer tool works well for punching down.

A peak temperature of fermenting must (not cap) of 80 - 90° F is generally desired. There is a danger of wine tasting "cooked" if the temperature is allowed to go much over 90° F. However, light color, aroma, and flavor results if the temperature remains much below 80° F. Cool the fermenter by removing the vat lid, cooling the room, immersing food grade dry ice or plastic milk-containers full of frozen water. Heat by heating the room or wrapping an electric blanket around fermentation vat.

The length of time on skins determines the style of wine: a short time on the skins, without fermentation (2 - 24 hours) makes a Blush to a light Rose" wine. A short time on the skins, with fermentation results in a “Rose" wine. And long fermentation time on the skins, 3-21 days, results in light to deep red, tannic wines.

Some wines, notably Beaujolais and occasionally Pinot Noir (usually partially) are made using Carbonic Maceration or whole berry fermentation, where the grapes are not totally crushed but merely de-stemmed. The destemming % varies widely but some wines may benefit from having some of their stems included in fermentation. The stems must be ripe, i.e., dark brown, not green. The stems are often removed partway through fermentation.

The wine is then separated from the skins and seeds by pressing. A basket press is the usual choice for the home winemaker. Divide the free run wine among storage vessels (usually carboys) and assess the pressed wine quality. If relatively clean, with no off tastes, divide the pressed wine among storage vessels above. If not, store separately, rack often, and reassess later. Don't over press—the small amount of extra wine only produces unstable elements. Keep most of seeds out of the press (they will be at the bottom of the fermenter). After fermentation is visually complete, check total acid, pH, SO_2, and residual sugar (r.s.).

XVII. CELLAR OPERATIONS

Racking - The most fundamental cellar operation is racking (decanting) the wine. It is the transfer of a liquid above its solid sediments. Racking helps to clarify the wine and provides aeration. The basic principle is to rack as little as possible only to separate sediment from the wine and/or when wine needs aeration. The process uses a racking tube, two-holed rubber stopper, and siphoning hose. Starting the siphon with $C0_2$ or nitrogen canister is helpful. It is necessary to use pump if gravity flow not possible. Use a bladder pump, reciprocating pumps are too harsh on the wine. Always test for $S0_2$ and adjust before each racking operation. A typical regimen is to rack shortly after fermentation ceases (1-4 weeks). This prevents extraction of dead yeast constituents into the wine. This racking is, however, sometimes delayed as in Chardonnay *sur lie* which is often stirred and also with exceptionally clean red musts. The wine is also racked after fining and cold stabilizing. Other rackings are made only as required. Smell and taste the wines often.

Cold Stabilization — White wines need the prevention of the crystallization of potassium-bitartrate (cream of tartar) in the bottle which appear as small, clear crystals on bottom of cork and/or at bottom of bottle. They are not at all harmful but slightly unsightly and can be eliminated by chilling the wine to -2°

C, 25° F. for two weeks. Normally, stabilization occurs after the 1" racking. The use of an old refrigerator works well. It may help to "salt" the process with 1/4 t./5 G of cream of tartar added to each carboy. Cold stabilization may be combined with bentonite fining (if required). Check the total acid and pH both before and after stabilizing.

Filtering — Well-made wine will clarify on its own if allowed to stand. In wine made with relatively small containers (< 30G.), the oxidation caused by the filtering process is generally more detrimental than allowing small amounts of fine particles to remain in the wine. But wines can be brilliantly clear without filtering. With proper use of fining materials, white wines will clear and red wines will generally clear without filtering or fining on their own. Should filtering be deemed necessary, there are three types of filters to consider: pad -paper or fiber pads mounted in a frame, generally rough filtering only, membrane - synthetic polymer surface filter, provides for sterile filtration, and mechanical separators - diatomaceous earth and centrifuge.

Fining - Fining is a process which agglomerates particles causing them to gain weight and fall out of suspension. The objectives of fining are to: precipitate out suspended materials, reduce color or undesirable smells, and stabilize the wine against future cloudiness. Use carefully — excessive fining strips the wine of color, aroma, and taste — use lab tests. Fining agents are positive or negative charged materials which agglomerate unwanted particles in the wine accelerating settling. The most common fining agents are:

1. Agglomerated bentonite - aluminum silicate clay, negative charge (-): 2g/G
   a. Effective on protein particles (+) found in white wines (not needed in red wines as the negatively charged tannins provide the necessary agglomeration)
   b. With well-settled must, adding bentonite at time of fermentation effective (see Table 9)
2. Activated carbon: 0.2 g/G for color, up to 1 g/G for off odors (do fining trials)
   a. Reduces color and bad odors through absorption (not by charged particles)
   b. Tends to leave an off-flavor
3. Gelatin (+): 1/8-1/2 g/G
   a. Reduces tannin in red or white wines
   b. Follow by kiesselsol (-) to ensure protein stability caused by excess remaining gelatin
   c. If over-fined, wine tends to become cloudy
4. Egg whites (+): 1 to 3 egg whites/60 G barrel
   a. Best used during barrel aging to reduce tannin levels
   b. Softens astringency, mellows wine
   c. No after-effects
5. PVPP(Poly-Vinyl-Poly-Pyrrolidone)(+): 1/4- 1 g/G
   a. Used in place of gelatin (leaves no aftertaste)
   b. Reduces tannin level, remove browned oxidized polyphenols, and lessen future oxidation
   c. Use with a small amount of bentonite to help settle
   d. Often used with active carbon to reduce undesirable odors
6. Sparkolloid (-): 1 tsp/G
   a. Does not tend to strip wines of flavor or aroma
   b. Fluffy lees cause wine loss

Blending - Blending is effective if sufficient different wines are available. It is used to overcome deficiencies or defects, balance the wine, and enhance complexity. Acidity, pH, alcohol, tannin, varietal aroma, fruitiness, oak flavor, volatile acidity, residual sugar, bitterness, and off-flavor can sometimes be corrected. Remember the axiom: A bad wine blended with a good wine will result in a bad wine.

XVIII. AGING AND OAK BARRELS

What's nice is that oak and aging is a discretionary operation, and is a good way for a winemaker to express his own preferences in the wine he makes. Toasted oak has been a part of winemaking for centuries, and for good reason. Oak and wine support each other in a way that truly bring out the best that each can offer. Oak can provide a unique combination of structuring tannins, along with sweet vanilla, butterscotch, floral, smoke and spice elements which perfectly support the berry freshness of wine. Fortunately for us, we no longer need to rely on an oak barrel to realize the benefits of oak – chips, beans/cubes, and staves can do the job just fine. These are sometimes called "oak alternatives."

Oak aging of wine provides slow oxidation, adds oak phenols expanding the complexity and bouquet, and improves the balance of red wines between varietal aroma, aging bouquet, and oak. Some negative aspects regarding the use of oak include the difficulty in maintaining barrels due to leakage, sanitation, temperature control, and empty maintenance problems. Some wine is also lost; up to 6% will evaporate through the barrel in one year.

Oak barrels vary widely in size from 5 to 60 G or more and are typically made from French, American, or Hungarian wood. It is important to insure that American barrels have been made from air dried wood. The barrels are toasted or lightly charred while being made. A light toast allows more of the oak characteristics and vanillin in the wine. A heavy toast leaves a heavier smoky flavor. Many winemakers find medium toast to their liking.

Soak new barrels with water prior to use until they stop leaking and sterilize by a burning sulfur wick in barrel.

The use of barrels is wine type dependent. Some considerations:

1. Fruity white wines - barrel aging undesirable (will lose their freshness)
   a. Usually bottled within 3 to 6 months
   b. Chenin Blanc, Riesling, Gewurztraminer, Muscats and Sauvignon Blanc where maximum varietal character is desired
2. White wines with complex character
   a. Chardonnay, Sauvignon Blanc, Semillon
   b. Often totally or partially barrel fermented
   c. Variable length of time in barrels; up to several months
3. Red wines capable of balance between varietal aroma, aging bouquet, and oak character
   a. Air-dried American Oak increasingly used, especially for Zinfandel, Petit Syrah
   b. Medium toast. Northern French barrels most common, American increasingly used.

Barrels and oak alternatives are available in several levels of toasting; Light, Medium, Medium-plus and Heavy. Here are some generalizations:

- The lower the toast, the more tannins and wood-like structure
- The higher the toast, the more spice and smoke tones

- The higher the toast, the deeper the caramel tones, eventually going to butterscotch and then charcoal
- Vanilla will increase up through medium-plus toast and decrease thereafter
- American oak will be more aromatic, but French oak will give more structure (tannins)

Here are the basic attributes of the three main types of oak:

- French oak has a cinnamon/allspice character along with custard, milk chocolate and roasted coffee notes. As toast levels increase, fruitiness can change from fresh to jammy to cooked or raisin in character.
- American oak has an aromatic sweetness with some roasted coffee attribute at all toast levels; medium-plus and heavy have the most intensity. Fruit appears more as "cooked." Exhibits good fullness and mouthfeel.
- Hungarian oak at medium toast displays good vanillin content with roasted coffee, chocolate and black pepper characters. Medium-plus and heavy toast produce good mouthfeel and pronounced vanillin. Unique leather and black pepper perceived at all toast levels.

What about dosage? For oak cubes, StaVin suggests 3.4g/L for a six-week exposure. It's a good idea to start sampling after one month, then pull the cubes out when the taste suits. Be careful about over exposure – once oak is in your wine, it is prone to stay! Oak should be a subtle nuance, not a dominating character.

In the barrel aging process, wine is racked in barrel generally after crude clarification. Frequent racking is not necessary unless bad odors or taste require aeration or treatment. The total time in barrel is dependent on barrel size, newness of barrel, temperature of barrel room, richness of the wine, and desired oak flavor. Hints regarding barrel handling:

1. Try to keep barrels full of wine; if not possible; rinse barrel, burn sulfur wick, and store bung down - periodically re-soak and repeat above
2. Never use used red barrels for white wine
3. A little over-oaking will be mitigated by bottle aging
4. Keep barrel room around 55° F, if possible
5. Top off with clean wine as required (ullage - dead air space above the wine - is a source of oxidation and spoilage)
6. Barrel maintenance critically important; if a used barrel doesn't smell like wine but like vinegar or nail-polish remover, <u>discard</u> it!

XIX. BOTTLING, CORKING AND AGING

Try to use the correct bottle type when bottling wine: Bordeaux wines (Cabernet Sauvignon, Merlot, Sauvignon Blanc etc) have square shoulders, green for red wines; white to greenish-amber for white wines. Burgundy (Pinot Noir, Chardonnay, Zinfandel (?)) have sloping shoulders, colors as above. Hock (Riesling, Gewurztraminer, Chenin Blanc) have tall, sloping shoulders, green or brown. The use of used bottles is acceptable if rinsed fully after emptying and properly sterilized.

Use good quality corks from a reliable supplier (avoids corkiness problems as much as possible).

Unless long term aging is expected (10+ years), top quality not necessary. Top off bottles with a capsule to improve appearance, heat-shrink plastic effective.

Before beginning the bottling process, be sure wine is in proper condition to bottle. It should be brilliantly clear with no defective aromas or tastes. The $S0_2$ level should be at least 15 ppm. The sterilization process is as follows:

1. Rinse bottles with water using bottle washer.
2. Rinse bottle with bottle sterilizer using 500ppm sulfur dioxide solution.
3. Rinse again with water.
4. Drain on bottle drainer

Fill the bottle with a bottle filler, siphon hose, and racking tube (multiple bottle fillers desirable for large quantities, e.g., 25 cases or more). The bottle filler leaves the correct ullage in the bottle. Cork immediately with sterile corks (dampen in dilute SO_2 solution) with corker.

Labeling is aesthetically important and provides some semi-permanent identification. Store in cases, bottles right side-up at first for a couple of weeks (allow compressed air to evacuate).

Bottle storage and aging is quite variable, white wines that are fresh and fruity wine types are ready to drink almost immediately. Full, rich white wine types - can benefit from 1 - 2 years of bottle aging and there are rare white wine types that age up to 10 years or more. Red wines generally are bottled 1 1/2-3 years after harvest. A bottle age of 1 - 3 years or more adds additional bottle aroma and richness. There are some light red wines where bottle aging is not required and excessive aging is not desirable.

XX. AFTER ALL THE TECHNICAL MEASURES AND ANALYSES HAVE BEEN MADE, LOOK, SMELL, AND TASTE -THE FINAL DETERMINANT IS THE WINE ITSELF. ENJOY!

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APPENDIX I - SOME FERMENTATION PROBLEMS AND THEIR CORRECTION

Aldehydes, especially acetaldehyde, are a class of chemical compounds between the alcohols and the organic acids in their state of oxidation. They are formed during any phase of processing in which an alcoholic beverage is exposed to air. Many aldehydes have quite potent odors, even if they are usually present in only trace concentrations in wines. They contribute to overall wine character, both positively and negatively.

A number of the aldehydes play an important part in the perfumes of fruits and flowers. Vanillin, for example, is a complex aromatic aldehyde present in the vanilla bean and in many other plants, including some grapes. It also occurs as a component of the lignin structure of oak wood. Some of this vanillin is extracted from the wood into the wine where it can add complexity to the aroma and flavor

Acetaldehyde is the next to last substance involved in fermentation and is a minor constituent of all fermented products. It has a penetrating and unpleasant aroma in heavy concentrations but, in the low concentrations found in most wine, it is not unpleasant. Above these levels, however, it can make the wine smell "flat" and vapid. And at higher levels, the wine has the distinctive smell of fine sherry. In white wines it creates a vapid oxidized smell and browning of color. In red wines it binds with anthocyanin pigments, assists in tannin formation, and is seldom a problem.

It is the first compound formed when oxygen reacts with the ethanol in wine, however. So special care must be taken with white wines, especially during bottling, to keep oxygen from damaging the wine's delicate aroma.

Acetobacter is a group of bacteria capable of spoiling wine by converting it ultimately into vinegar. It can only survive in the presence of oxygen and is one of the very few groups of bacteria which can live in the high acid and low pH environment of wine (lactic bacteria is another.)

The main flavor constituent of vinegar is acetic acid, produced during primary fermentation. Acetic acid is the primary contributor of volatile acids (see below) in wine and is the result of normal yeast activity. Held to small levels (0.08 g/L, for example), it is not a problem.

Ideal conditions for the growth of acetobacter are temperatures between 86° and 104°, pH values >3.5, low alcohol concentrations, little or no sulfur dioxide, and a generous supple of oxygen. Safe wine making favors low storage temperatures, good levels of alcohol and acidity, use of sulfur dioxide as a disinfectant, and containers kept full at all times to minimize oxygen contact.

Ethyl acetate, is the most common ester in wine, and a natural organic compound present in most fruits, berries, other foods, and alcoholic drinks. It is formed by the reaction of the acetic acid in young wine and ethanol, the alcohol produced by fermentation.

Ethyl acetate dominates the aroma of young wines and is modified and varied by the different combinations of other chemical compounds that are present. Grape variety, weather, soil, and winemaking practices govern the types and concentrations of these other components and thus the aroma and bouquet of the resultant wine. Present in moderate concentrations, ethyl acetate is perceived as contributing to the generally fruity character of wine, although people vary in their sensitivity to the compound.

At higher concentrations, however, ethyl acetate can become unacceptably dominant and increasingly impart the character described as volatile and, eventually, vinegary. The signal for this problem is the ever so slight smell of fingernail polish remover. In wine, the concentration of ethyl acetate is governed by the level of acetic acid.

Wines exposed to oxygen begin to lose their fresh fruitiness and become vapid in smell and taste due to the acetaldehyde resulting from the oxidation of ethanol. The oxidation goes further to yield acetic acid from the acetaldehyde intermediate and then, when some of the acetic acid reacts with ethanol, ethyl acetate is produced. The key, of course, is to limit oxygen exposure without reducing the wine. (See oxidation and reduction below.).

Hydrogen Sulfide (H_2S) is the foul smelling gas, reminiscent of rotten eggs, which can form during fermentation, either in the active phase or at the end. The formation of H_2S during the active phase is associated with a deficiency of nitrogen in the grape must or juice. This problem can usually be suppressed by the addition of nitrogen, typically in the form of diammonium phosphate. Some varieties, depending upon soil type and vintage conditions, tend to have low nitrogen content. Chardonnay, Riesling, and Syrah are examples.

The amount of H_2S produced can also be affected by the addition of a high level of Sulfur Dioxide (SOJ to the must shortly before inoculation with yeast and/or the strain of yeast involved. Certain yeasts, notably Montrachet, more readily reduce sulfate, especially sulfur dioxide, to H_2S when deprived of nitrogen. This is a futile attempt to make the amino acids required for cell growth. The addition of diammonium sulfate stops H_2S from forming in the wine, not by stopping its formation but by enabling the yeast to make amino acid precursor compounds which react with the H_2S to form sulfur-amino acids.

Hot climate red wines, which are prone to rapid fermentations at higher temperatures, use more nitrogen and tend to develop sulfurous smells more readily.

Small amounts of sulfur used as vineyard fungicide can easily be reduced to H_2S by the highly reductive conditions generated by yeast. Reducing or eliminating sulfur applications several weeks before harvest can help.

Just small amounts of H_2S can spoil a wine's aroma. Fortunately, however, H_2S is very volatile and is usually removed by the stripping action of carbon dioxide during fermentation. However, H_2S formed towards the end of fermentation or, worst still, after fermentation is completed is of greater concern to the wine. If allowed to remain in the wine, it reacts with other wine components to form mercaptans, thiols, and disulfides which have pungent garlic/on ion/rubber aromas, which are difficult, if not impossible, to remove. The smell of rotten eggs is always a fault in a finished wine but acceptance of trace amounts of mercaptans and disulfides is more controversial.

H_2S can usually be removed in a new wine by a small addition of copper sulfate (See Appendix II, *A Penny for Your Faults,* pp. 20).) In robust wines, especially reds, H_2S removal is usually accomplished by aeration through simple racking.

Oxidation is a wine fault caused by too much exposure to oxygen (as opposed to aeration, which is deliberate, controlled exposure to oxygen.) Wines spoiled by oxidation are said to be oxidized. In a broader context, oxygenation is the chemical reaction of oxygen with another chemical entity, whether it be the browning of an apple or the blue-green acquired by copper exposed to the elements.

Oxidation is a threat as soon as the grape is crushed, which is why high-quality grapes are transported to the winery as fast as possible in shallow containers, and why field pressing stations sited as close as possible to the vineyard are increasingly common. When grapes are crushed, unless special precautions are taken to exclude oxygen, they immediately start to react with the liberated juice compounds. The most obvious change is the browning of the juice resulting from the oxygenation of the phenolics, which is why oxidation is a much greater danger to white wines than to reds.

The presence of molds associated with rot on the grapes introduces enzymes which accelerate reactions with oxygen, especially those involved with browning. Small amounts of sulfur dioxide are usually added at the time of crushing to inactivate enzymes and counter the oxidation of phenolics.

Some wine makers deliberately encourage a certain amount of pre-fermentation oxidation of grape varieties such as Chardonnay, in order to develop a range of flavors other than those associated with primary fruit aromas. It is thought that this early browning makes the resulting wine less susceptible to future oxidation.

Reduction is a chemical reaction that is, in effect, the compliment of oxidation. It is a reaction where an element or compound gains electrons. The essential feature of an oxidation is that electrons are transferred from the component being oxidized to one being reduced. The reaction cannot be isolated; in order to have a reduction something else must be oxidized.

Common reduction reactions are those of iron ore to iron (the metal) or the reduction of acetaldehyde to ethanol as happens in the final stage of alcoholic fermentation. Wine in a stoppered bottle or any other airtight container is in a reductive state because any action that takes place reduces the possibility for further change by using up some of the available oxygen.

Reducing conditions are desirable towards the end of fermentation (unlike at the beginning when oxidizing conditions encourage yeast growth) in order that alcohol is produced along with carbon dioxide from the acetaldehyde. Reducing conditions continue to be generally preferable throughout the elevage of wine in the cellar, particularly for white wines.

Red wines held in the absence of oxygen may suffer from excess reduction, resulting in the slow polymerization of tannins and pigmented tannins. A wine that is reduced tastes dirty and frequently smells of reduced sulfur compounds such as hydrogen sulfide and mercaptans. This can usually easily be cured by aeration, a simple racking of the wine. This usually produces some oxygen strong enough to prevent the reduction of most sulfur compounds.

Stuck Fermentation is a wine maker’s nightmare involving an alcoholic fermentation which ceases before completion. Such fermentations are difficult to restart and the wine is at risk of spoilage from oxidation and bacterial disease. Fermentations that are allowed to reach excessively high temperatures of over 95° C. cause yeast cells to be killed and release compounds which inhibit future yeast growth. Restarting of the fermentation becomes difficult if not impossible even after cooling.

Stuck fermentations have many documented causes, with the most common being a deficiency of nitrogen. Grapes, particularly the varieties Chardonnay and Riesling, which come from vineyards deficient in nitrogen yield fruit with a low ratio of nitrogen to sugar. This limits the development of yeast cells, and fermentation activity is not sustained after the yeasts become starved of nitrogen.

The problem is exacerbated in the fermentation of white grape varieties where, in an attempt to produce wine with a clean, pronounced varietal character, the must is kept highly protected from air and with a very low level of grape solids. In the absence of air, these grape solids, which contain lipids, are essential for strong yeast growth and for sustaining high yeast cell viability during the critical final stage of fermentation. This problem can be controlled either be increasing the level of grape solids or exposing the fermentation to a small amount of air once the yeast is active.

Failure of added wine yeasts to dominate the wild yeasts that are invariably present in grape must can result in a stuck fermentation if these yeasts have a lower tolerance to alcohol. Wild yeasts, which produce the "killer toxin" (zymocidal yeasts) can be especially aggressive by actively eliminating the sensitive wine yeast. This problem is diminished considerably by using highly active preparations of dried yeasts, innoculating with wine yeast that is resistant to killer toxin, reducing the number of active wild yeasts present by cool harvesting and processing, and by the addition of nitrogen nutrients (diammonium sulfate (DAP) to the must.

Volatile acidity of a wine is its total concentration of volatile acids, those naturally occurring organic acids of wines that are separable by distillation. Wine's most common volatile acid by far is acetic acid. A few other acids such as formic, succinic, and lactic are also volatile.

Acetic acid, in small amounts, is a by-product of the normal action of yeast in grape juice. However the major source is the action of a group of acetobacter bacteria which require oxygen for their growth and survival, and cause a reaction between the alcohol of the wine and oxygen to produce acetic acid. Very low concentrations of acetic acid (< 0.2 g/L) do not affect the taste adversely. Increasing concentrations change the taste of the wine from added complexity and fruitiness to a vinegary flavor at levels much above 1.5 g/L.

Trichloroanisole (TCA). TCA and related compounds are products that result when certain mold spores metabolize phenols together with a chlorine-containing molecule. The resulting “corked” wine may smell moldy, musty, mushroom, compost, earthy or like wet cardboard.

APPENDIX II

A PENNY FOR YOUR FAULTS
BY DAN BERGER, LA TIMES WINE WRITER

When you buy a bottle of wine and it smells a little like rotten eggs or onion, you may be able to fix it for a penny—and not Jose your penny.

Modern winemaking techniques generally keep wine free of most flaws, but imperfections are not unknown. The most common —aromas of onions, garlic, or diesel fuel—are a result of the chemical ethyl mercaptan, with is a by-product of fermentation that went awry. It is seen more often in Chardonnays that were aged on the lees (dead yeast cells) to give the wine complexity. The smell of rotten eggs can be generated by tiny amounts of hydrogen sulfide (H_2S) produced in the wine during fermentation. In such minute amounts, H_2S is harmless, but the aroma can be off putting.

Both of these chemicals react with copper, and winemakers can usually remove them by passing the wine through a brass screen (brass is a copper-zinc alloy). Copper converts the free sulfide into an insoluble substance that falls to the bottom of the tank and is left behind when the wine is bottled; it can also be removed by filtration.

Other winemakers prefer to aerate foul-smelling wine to remove the off aromas, but these can return after the wine is bottled, especially if the bottles are not stored properly. If you find such a wine, try dripping a penny into the glass, swirling it for a few seconds, and then removing it. The copper in the penny should do the same thing that a brass screen does in the winery.

This was demonstrated graphically last week at the annual wine competition staged in conjunction with the Farmers Fair of Riverside County. During the judging of Pinot Noirs, one wine had a noticeable rotten egg smell fromH_2S. A panel of four judges was given a group of 13 wines to evaluate, one of which was the Pinot Noir with the funny smell. Another glass had the same wine to which a penny had been added for a few seconds. The judges were not told that two of the wines were otherwise identical.

All four of the judges rejected the untreated wine, but said the treated wine was acceptable. (The wine was not permitted to win an award because of the flaw.)

Other aromas that creep into wines not carefully cared for are canned corn (which may come from dimethyl sulfide) and wet wool (ethyl- methyl sulfide), according to Clark Smith, who teaches university-level Wine chemistry courses. Smith points out that such aromas may not be the fault of the winemaker but may be due to poor storage. Bottles of wine left in direct sunlight or under florescent lamps (such as those used in the cold case of supermarkets) may develop some of these aromas.

This occurred a lot more frequently before 1990, the year most glassmakers began using a UV protector in their glass to block the effects of the light. But in some bottles (notably clear glass), the aroma can develop after as little as 10 minutes of exposure. Darker bottles protect the wine better than lighter ones.

Dick Arrowood, owner-winemaker of the Arrowood Winery in Sonoma County and an organic chemist by training, says that brass fixtures were commonly used in old wineries. Therefore, aromas from ethyl mercaptan and hydrogen sulfide almost never occurred in their wines. "That's why it's good to have a few brass fittings (hose) fittings and a copper valve here and there, because just that amount of contact with copper eliminates any problems you might have."

When you detect one of the offending smells and want to treat it with a penny, choose one minted between 1962 and 1981. These contain 95% copper. Michael White of the U.S. Mint in Washington, said pennies minted after 1982 contain only 2.5% copper, the remainder zinc.

"Treating wine with a penny is a neat magic trick," says Smith. "It doesn't always work, but when it does, it can save a bottle of wine that you otherwise wouldn't drink."

REB COMMENT:

If you know or suspect that your grapes were sulfured within 2 months of harvest, it's a good idea to treat for H_2S with the above copper treatment method by pouring the wine through a copper or bronze screen after pressing the grapes in primary fermentation. Don't use too fine a screen. It doesn't take much. If, at any stage, an H_2S smell is detected, rack through a screen as above or suspend a penny in a 5 gallon container for 2 hours or so and rack immediately. With luck, the rotten egg smell will be gone.

Mercaptans and brettanomyces can also be controlled by the above, especially if minimum amounts of $S0_2$ are maintained. But they are best eliminated by insuring your grapes have sufficient nitrogen during fermentation.

TABLE 1

WINE MAKING CHEMICAL SUPPLIES

DATE: _______________

ITEM	LIFE	STOCK	ORDER	TOTAL
CL1NITEST TABLETS (36)	(1)			
HYDROCHLORIC ACID, HCL 0.010 N	1 YR			
HYDROCHLORIC ACID, HCL, 0.10 N	I YR			
HYDROGEN PEROXIDE, $H_20_{2:}$. 30%	6 MO (2)			
IODINE, 0.0156 N	1 YR			
M/L CHROMATOGRAPHY SOLVENT	1 YR(3)			
PHOSPHORIC ACID, H_3P0_4,25%	(4)			
PHENOLPHTHALEIN, 0.5%	(4)			
pH BUFFER, pH 4	1 YR			
pH BUFFER. pH 7	1 YR			
SODIUM HYDROXIDE, NaOH, 0.010 N	1 YR			
SODIUM HYDROXIDE, NaOH, 0.067 N	1 YR			
SODIUM HYDROXIDE, NaOH, 0.10 N	1 YR			
SODIUM HYDROXIDE, NaOH, 10%	1 YR			
SODIUM THIOSULFATE,NaSA. 0-025N	1 YR			
STARCH	1 YR			
SULFURIC ACID, H_2S0_4 25%	(4)			
VACUUM ASPIRATOR SO, INDICATOR	1 YR			

NOTES:

(1) DISCARD IF BRIGHT BLUE "MEASLES"
(2) IF REFRIGERATED
(3) REPLACE INTO BOTTLE IMMEDIATELY AFTER USE
(4) INDEFINITE

TABLE 2

OVERVIEW OF THE WINEMAKING PROCESS

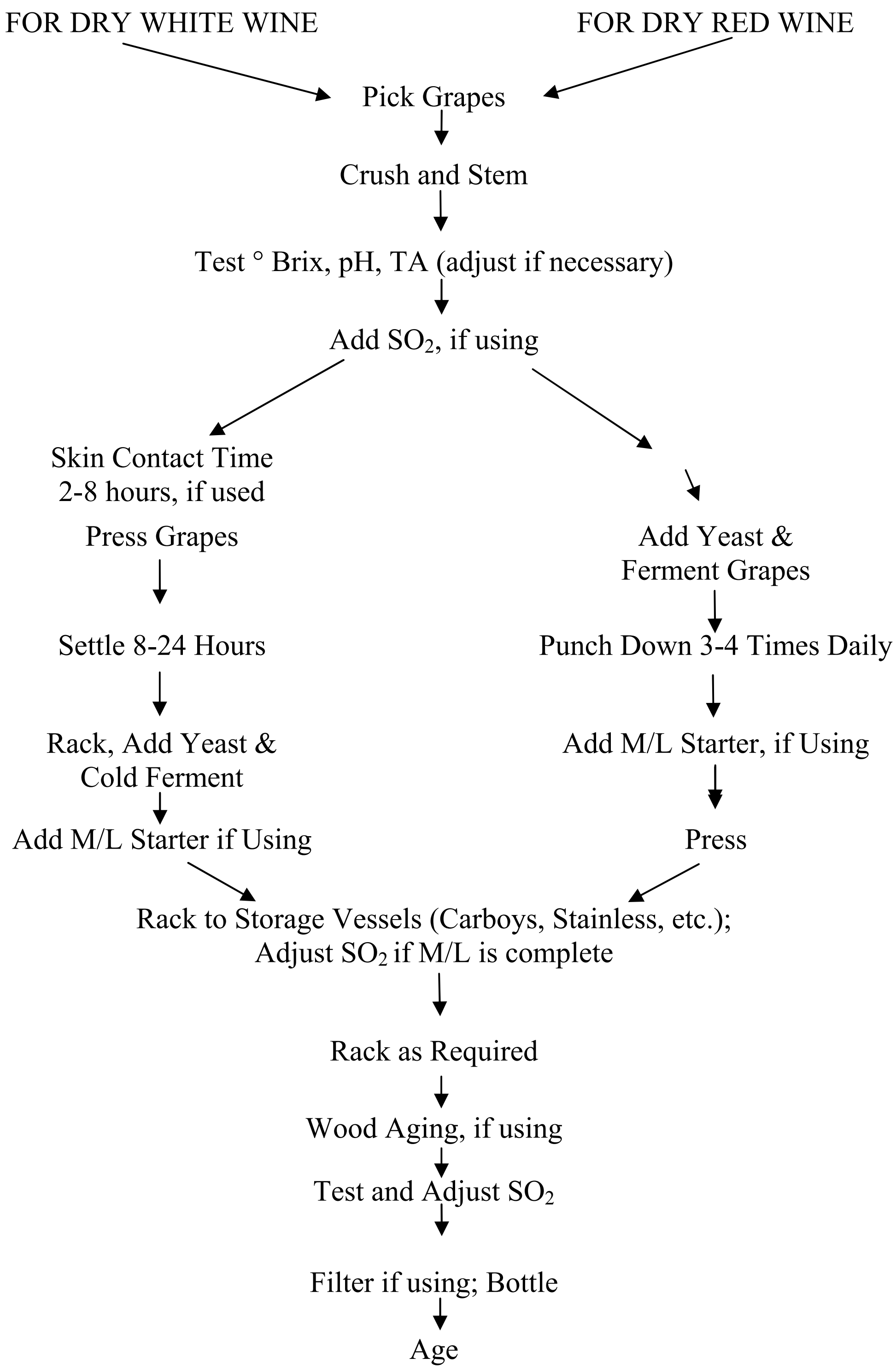

TABLE 3

RIPENING

Year _______________

Varietal______________________________________

Sample #					
Date					
# Berries					
Total Weight					
Avg. Wt. per Berry					
° Brix					
Total Acidity (TA)					
pH					
° Brix ÷ TA					
° Brix x pH^2					

° Brix ÷ TA: 30:1 to 35:1 pH^2 x ° Brix: 260 (Reds)

TABLE 4

RIPENING

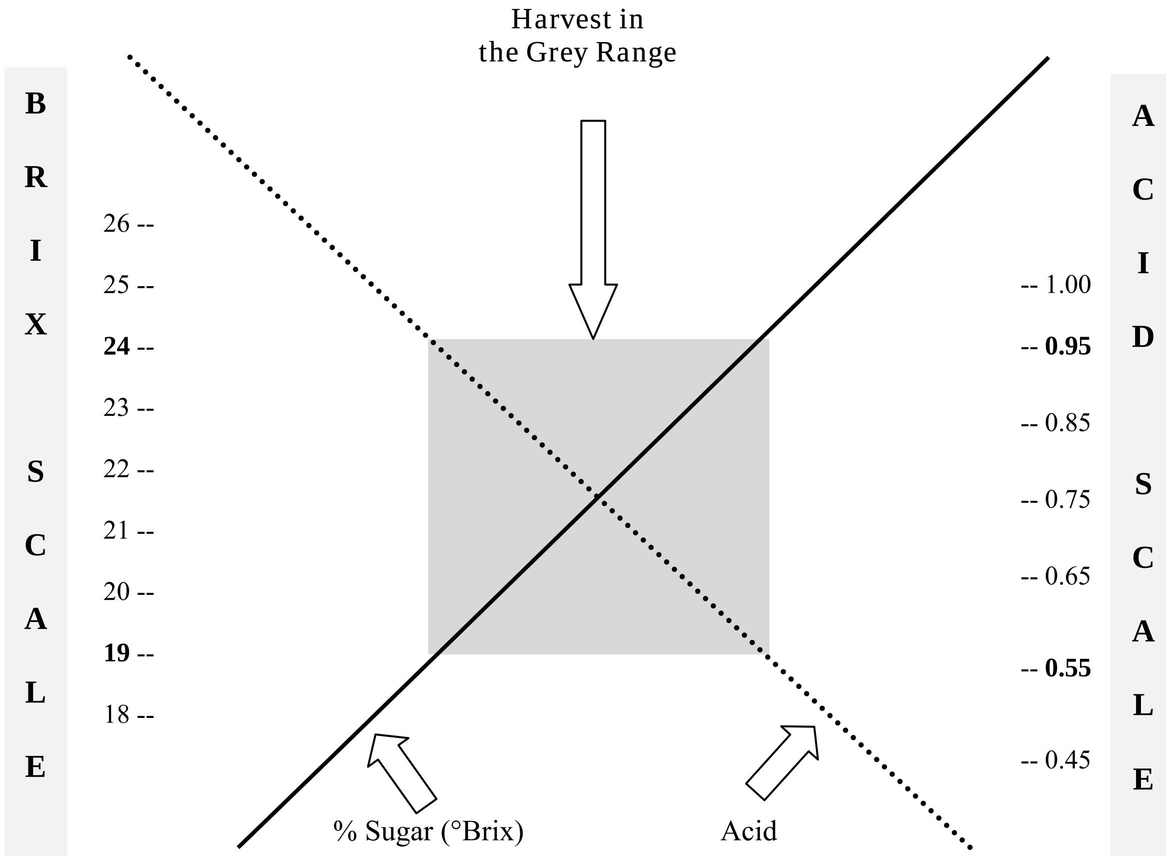

TABLE 5

SURE AND EASY SO_2 ADDITIONS

1. Measure the existing $S0_2$ in the wine by the vacuum aspiration method

2. Prepare 4 Oz./Gal of Potassium Metabisulfite (KMBS) solution. Since it's not likely that you will need a full gallon, just mix one ounce of KMBS into 32-oz of cold water. Shake and stir well (don't sniff-it's bad on the nasal passages). Keep fresh, don't store for over 2 months and use fresh KMBS, not over 6 months old.

3. Accurately measure (or have measured) your wine's pH.

4. From Table 7, determine the ppm (Parts per million) Free $S0_2$ required for the pH of the wine as measured in Step 3. Try to keep white wines at 0.8 ppm and red wines at 0.5 ppm. Subtract the amount of existing $S0_2$ in Step 1 from this figure

5. From Table 8, determine the actual amount of the solution made in Step 2 that is required and add it to the wine. Stir Well!

6. Measure the new $S0_2$ level in the wine in 3 or 4 days and adjust again, if necessary. Measure and adjust, if necessary, after every cellar operation and before bottling.

7. Add the smallest of amount of $S0_2$ necessary to prevent deterioration of wine quality. Try to keep pH at a level that allows fewer than 120 ppm $S0_2$ total additions throughout the wine making process. Consider reducing pH to 3.50 or below to minimize SO_2 additions.

8. Remember--you must have accurate measures of pH and Free $S0_2$ to be certain in making $S0_2$ additions.

TABLE 6

FREE $S0_2$ REQUIRED AT VARIOUS pH LEVELS TO MAINTAIN 0.8 AND 0.5 ppm MOLECULAR SO_2

Try to **keep white wines at 0.8 ppm** molecular and **red wines at 0.5 ppm** molecular

pH	0.8 ppm Free SO_2	0.5 ppm Free SO_2
2.90	11	7
2.95	12	7
3.00	13	8
3.05	15	9
3.10	16	10
3.15	19	12
3.20	21	13
3.25	23	15
3.30	26	16
3.35	29	18
3.40	32	20
3.45	37	23
3.50	40	25
3.55	46	29
3.60	50	31
3.65	57	36
3.70	63	39
3.75	72	45
3.80	79	49
3.85	91	57
3.90	99	62
3.95	114	71
4.00	125	78

At pH levels of 3.50 or higher, consider lowering pH with Tartaric Acid additions.

TABLE 7

Sterilizing

Tablespoons or Cups of 4 oz./Gallon of $K_2S_2O_2$ Solution
Required for Various Levels of Sterilizing Power

Desired Free SO_2 (ppm)	*Total Solution To Add (ppm)	Tablespoons (T) or Cups (C) of 4 oz/Gallon $K_2S_2O_2$ to Add per		
		5 Gallons	10 Gallons	15 Gallons
5	7.5	5/8 T	1 ¼ T	2.0 T
10	15	1 ¼ T	2 ½ T	3 ¾ T
15	23	1/ 7/8 T	3 ¾ T	5 3/8 T
20	30	2 ½ T	5.0 T	½ C
25	38	3/ 1/8 T	6 ¼ T	5/8 C
30	45	3 ¾ T	7 ½ T	¾ C
40	60	5.0 T	5/8 C	1.0 C
50	75	6 ¼ T	¾ C	1 ¼ C
60	90	7 ½ T	1.0 C	1 ½ C
70	105	8 ¾ T	1 1/8 C	1 ¾ C
80	120	5/8 C	1 ¼ C	2.0 C
90	135	¾ C	1 ½ C	2 ¼ C
100	150	7/8 C	1 ¾ C	2 ½ C

* Assumes 2/3 of the added SO_2 remains in free form and 1/3 combines. Some extrapolation may be necessary for fully accurate additions and for larger quantities. However some rounding is acceptable. After the first addition much is learned as to how each particular wine reacts to SO_2 additions and provides guidance for future additions.

TABLE 8

<u>YEAST ADDITIONS</u>

Procedure: Heat water (20x yeast weight) to 104° F. When temperature is stabilized, it's safe to add yeast. Stir until lumps are gone; let stand for 15 to 20-minutes. Slowly (over a 5-minute period) add to equal amount of must (bring must temperature to within 17° F of fermentation culture before adding). When complete, add mixture to fermenter as follows: If the temperature of the target must is proper (room temperature), add the culture and stir well. If the must is cold, create a small pocket in the center of the must and pour the hydrated mixture in – do not stir.

If you use GoFerm in the hydration process: 30g per h/L (26.4-gal) stirred into 20 x weight in water at 109-deg. Let cool to 104° F before adding yeast (see above).

For 60-gal of must: Use 70-g of GoFerm in 50-oz of water. Have 50-oz of must warmed to room temperature and standing by.

GoFerm contains no nitrogen, so augment the must with DAP or one of the DAP blends. DO NOT use any of these in the rehydration process with GoFerm.

USAGE LEVELS:

Sacramento Home Winemakers recommends using 5 grams yeast per 5 Gallons of wine for direct inoculation (as above) and doubling this amount for highly sulfated must or for must of greater than 30 ºBrix. Read manufacturer's directions carefully.

YEAST NUTRIENTS:

DAP (Diammonium Phosphate):

Contains fermentable non-organic nitrogen at 25g/HL, and phosphorus. 1g/liter provides 258 mg/l fermentable nitrogen. Since California fruit is frequently deficient in nitrogen, it is a good idea to use DAP or one of the commercial blends thereof during fermentation. This can head off the formation of H_2S, for instance. If GoFerm is used as a fermentation nutrient, it is essential to also use DAP or one of the commercial blends, unless YAN (Yeast Available Nitrogen) is known to be above 250. It is also permissible, but usually not necessary, to use DAP <u>and</u> FermaidK, Superfood, etc.

Application rate: For 30-gal must, use 117g (4-oz).
Stir in half at the end of lag phase (6 to 12-hrs)
Stir in half after 1/3 sugar depletion

SUPERFOOD:
Primary nutrient added to must during inoculation. Main nutrient is DAP.
Contains yeast hulls.

Application rate: 1.5 to 2.5-oz per 25-gallons of must.
Stir in half at the end of lag phase (6 to 12-hrs)

Stir in half after 1/3 sugar depletion

FERMAID K:

Primary nutrient added to must during inoculation. Main nutrient is organic nitrogen at 25g/HL. Contains yeast hulls.

Application rate: 1g per gallon of must.

Stir in half at the end of lag phase (6 to 12-hrs)

Stir in half after 1/3 sugar depletion

TABLE 9

BENTONITE ADDITIONS TO WHITE WINES

Bentonite has a negative electrical charge and is used to remove protein to achieve "heat stability." Heat Stability simply means that the resulting wine is less likely to form a haze when subjected to higher than optimum temperatures.

Bentonite is prepared by making a slurry (5% weight/volume solution) by mixing 50g of bentonite powder into one liter of hot water. It is important that the resultant mixture be very smooth and free of lumps, so it is recommended that the slurry be prepared in a blender. Allow to hydrate for at least 24 hours.

Dosage: Use 4.5ml of the slurry per liter of wine.

Note: Some wines, such as Sauvignon Blanc, Riesling, and Muscat Canelli may require double this amount.

The interaction of bentonite with proteins occurs within minutes. Bentonite is more effective the lower the pH, and sodium bentonite is the most effective form. Bentonite creates high quantities of light lees. Careful – excessive use of bentonite can strip body and flavors and impart an earthy taste to the wine.

For greater flavor and aroma intensity, use bentonite on whites after the second racking. Fining with bentonite prior to fermentation has been shown to cause stuck fermentations and can cause hydrogen sulfide production.

Bentonite is often used to counter-fine protein fining agents such as gelatin or silica gel.

TABLE 10

WHAT DOES IT COST TO MAKE A BOTTLE OF WINE?

The *cost of consumables* associated with home winemaking are all over the map, depending primarily on the cost of fruit, but also dependent upon the type of wine (dry, dessert or bubbly), the amount of wine made and the sophistication of chemicals and additives utilized by the home winemaker. The following analysis is based on converting 1500-lb of red vinifera into wine. The cost of the fruit is $1500 per ton ($.75-lb) and will yield 90-gal of finished wine (about 37 cases – 444 bottles).

	Cost ($)	Per Bottle
Fruit		
1500-lb Shenandoah Barbera	1125.00	2.52
Yeast & Nutrients		
Lallemand D254 (250g)	25.00	
GoFerm	12.00	
Fermaid K	8.00	
Enoferm A (ML bacteria)	42.00	
Opti-Malo Plus (ML nutrient)	12.00	
	99.00	.22
Chemicals & Additives		
KMBS	12.00	
Tartaric acid	6.00	
Opti-Red	11.00	
Pectic enzyme	8.00	
Potassium carbonate	8.00	
Fresh buffers (4 & 7)	11.00	
Sodium hydroxide	12.50	
Hydrogen peroxide	11.00	
Oak cubes (American)	45.00	
	129.50	.29
Bottle		
Glass @ $7.50/case	278.00	
Cork @ $0.20 ea.	89.00	
	367.00	.82
		$3.85
Finish (Optional)		
Label	67.00	
Capsule	23.00	
	90.00	.20
		$4.05

These are the approximate costs of *consumables only*. Not included are the costs of buckets, carboys, pH meter, press, oak barrel, corker etc. Still, $1500 invested in equipment and paraphernalia amortized over five years would add only about 67 cents to each bottle of wine in this analysis.

-- Courtesy D.D. Smith