

WINE GRAPE-CULTIVATION WINE MAKING AND IMPROVEMENT OF WINE QUALITY

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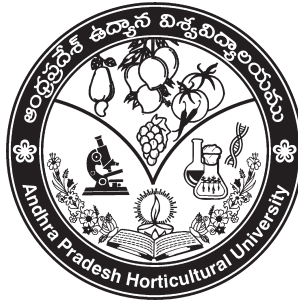
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INTRODUCTION

Historically, grapevine (*Vitis vinifera* L.) is grown mostly for wine making in the world over. In India on the contrary remarkable success has been achieved in table grape production and yield levels of fresh grapes are among the highest in the world. At present in India grape is grown over an area of 60,000 ha with an annual production of 1.6 million tonnes.

Wine has been made in India for as many as 5,000 years. It was the early European travellers to the courts of the Mughal emperors Akbar, Jehangir and Shah Jehan in the sixteenth and seventeenth centuries A.D. who reported tasting wines from the royal vineyards. Both red (Kandhari) and white wines (Bhokri, Fakdi, Sahebi etc.) were produced. Under British influence in the nineteenth century, vineyards were established in Kashmir and at Baramati in Maharashtra and a number of Indian wines were exhibited and favourably received by visitors to the Great Calcutta Exhibition of 1884. However, Indian vineyards were totally destroyed by unknown reasons in the 1890s.

Grapes are unique among fruits. Ripe, they contain sufficient sugar and an appropriate amount of acid so that when they ferment enough alcohol is produced to make a palatable wine that is protected against imminent spoilage. Other fruits do not possess the proper balance of these basic constituents. Hence, sugar, acid, or water, or sometimes a combination of them must be added prior to fermentation. Otherwise, inadequate or excessive alcohol may be formed, fermentations may stuck, and the product could either be so acidic (tart) or so flat that it would taste unpleasant or insipid. Minor adjustments in sugar and acid content of *vinifera* grapes may sometimes be required, but not often. On the other hand, other fruits almost always require additional steps in preparing and handling the raw material that don't apply to making grape wine. Hence, this publication is confined to grape wines.

Grape wine contains more glucose than any fruit. That is why glucose is called grape sugar. Alcohol formed by fermented different sugars will have different quality. Alcohol from glucose have antioxidants *viz.*, polyphenols, anthrocyanidins and resveratrol. The red wine contains anti-oxidant resveratrol in addition to polyphenols, anthrocyanidins. Resveratrol in particular, has been demonstrated to be a potent anti-

oxidant (about 20-50 times as effectively as vitamin C alone) and act synergistically with vitamin C enhancing the effects of each. Resveratrol has been demonstrated to have an anti-clotting effect that prevents the formation of thrombi or blood clots in the blood vessels. The formation of thrombi that block small blood vessels is believed to be a cause of heart attacks and strokes. Resveratrol has been demonstrated to have anti-cancer effects as well.

Resveratrol has also been demonstrated to promote the formation of new dendrites in the brain. Resveratrol and the other bioflavonoids and polyphenols are present in large amounts in the leaves, twigs and bark of the grape vines. Thus, red wine, which is fermented with the skins, seeds, twigs, etc. tends to contain much larger quantities of the beneficial substances than white wine which is fermented only from the pressed juice of the grape.

Grapevines have many natural enemies: insects, molds, bacteria, fungi, viruses and animals such as birds that eat the sweet grapes. Certain soil-borne pests, such as nematodes, phylloxera(wasp), phytophthora (fungus) etc may destroy the roots of grapevines. To counter this problem, vineyards use the rootstocks from resistant American vines (*Vitis champini*, *V. riparia*, *V. berlandieri*, *V. rupestris* and their interspecific hybrids etc.) and the scion cultivars from European species (*V. vinifera*).

Climate & Soil

Overall performance in terms of growth, yield and quality of grapes for wine making is greatly influenced by climate & soils.

Natural factors make wine from a particular region unique, known in the wine industry as *terroir*; these factors include local climate (temperature, rainfall, and sunlight), location of grapevines (altitude and slope) and soil (structure, composition, and water drainage). In general, a grapevine produces the best fruit when the moderate climate provides much sunshine and cool nights without frost or hailstorms and the soil is well drained. Grapevines grow best in sandy, chalky, or rocky soils.

A wine's character is strongly affected by vine growing, or *viticultural* practices such as training, trellising, harvesting, and pruning. Training and trellising enable the viticulturalist to control the sun exposure to ensure the grapes ripen evenly. Grapes harvested when they are not ripe may be low in sugar and may not ferment properly. Overly ripe grapes have very high sugar content and produce wine high in alcohol. Tropical vines do not show high dormancy, the viticulturalist prunes the vines twice a year. First pruning is carried out during summer every year to induce vegetative growth and in this phase fruit bud formations occur in mature canes. The second pruning of

matured canes is done after the rainy season to obtain fruits before the onset of summer. As most of the wine varieties have basal fruitfulness of the canes, pruning level is normally kept low between 4-7 buds from the base depending upon varieties. Pruning enables the grower to control the size and shape of the vines, as well as the number of buds that will develop the next year. Too many buds on a vine may stress nutrient availability, reducing the quality of the future harvest.

Climate

It is the summation of weather conditions throughout the year.

- Factors :**
- i) Temperature
 - ii) Solar radiation, sunshine hours
 - iii) Rainfall, Relative humidity
 - iv) Wind, Evaporation etc.

Vitis vinifera grape varieties grow under wide range of climatic conditions.

Temperature : Diurnal variation with cool nights (15-18° C) and warm days (28-32°C) is essential for successful wine grape production. Degree days that are available during September to March 2200-2750 (Nashik), 2750-3000 (Pune, Narayangaon) 3000-4000 (Sangli, Solapur) normally influences which wine variety to grow and the type of wine to produce. Table wine grapes are grown at 2200-2750 degree days. Dry table wines require mild ripening period with average temperatures of 22-28°C and low diurnal variations. Growing season length should be sufficiently long to mature moderate to heavy crops of grapes. In areas where there is sudden temperature drop and onset of wet weather, there are ripening problems and crop losses. Each variety requires certain heat summation to bring its fruit from full bloom to maturity or a given brix reading. Cool, mild temperatures increase the production of acid (malic and tartaric) in the berries, increase the sugar acid balance and enhances the colour in the red varieties. By contrast hot conditions during ripening period increases the sugar level, hastens maturity, lowers the acid level of grapes and inhibits pigment formation in red varieties. The organic constituents of wine such as alcohol, acids, esters, colour, tannins and aldehydes do have direct bearing on the bouquet, taste and other qualities of individual wines. The level and balance of these constituents in the musts and wines in turn are largely determined by climate (heat summation). High temperatures cause yield loss due to poor fruit set, moisture stress and reduces the rate of photosynthesis. Optimum temperature for photosynthesis 25-30° C and declines rapidly above and falling to zero at 45-50°C and also decreases rapidly below 15°C.

Temperate effect on berry quality

- i) *Sugars (soluble solids)*: Sugar content of grapes is normally higher in hot climate zones. The wine from such grapes may yield higher levels of alcohol, but not necessarily a good quality wine, as high alcohol content masks other quality components of wine. Berries in a warm climate also attain higher levels of sugar and the wine made from such grapes will have better quality. Optimum average temperature is 25°C and the range of day temperature is 18°C - 33°C for higher sugar accumulation in berries. Sugar accumulation is influenced more by the temperature prevailing before berry softening (veraison). Temperatures of 4°C for four days during the initial berry growth stage (15 – 30 days after set) delays ripening and reduce the sugar content of berries at harvest.
- ii) *Effect on acid and pH* : Between the two predominant acids present in grapes, malic acid is more influenced by the temperature than tartaric acid, and the latter contributes more to wine quality. Cool nights associated with warm day temperatures contribute to reduced pH and increase acid levels when compared to warm days and warm nights.
- iii) *Effect on colour*: Colour in red grapes is mainly temperature dependent. Either too cold or too warm conditions are associated with poor colour. The optimum temperature range for anthocyanin synthesis is between 17 and 26°C. Night temperatures are more important than day temperatures. Cool night temperatures of 15 – 20°C promote skin colour better than the night temperatures of 25 – 30°C can do in Cabernet Sauvignon and Pinot Noir. Sometimes days temperatures above 30°C can also reduce the pigmentation.
- iv) *Effect on flavour and aroma compounds* : Night temperatures above 15°C or mean temperatures above 20°C during berry ripening will reduce the flavour / aroma of the wine. Wines produced in warm regions have less varietal aroma / flavour and are harsh mainly due to high concentrations of alcohol and phenols. It is a belief that warm climates produce wines with less and / or different aroma / flavour, but there is no direct and convincing evidence that a cool climate is a prerequisite for superior quality wine. It could be inferred that under warm / hot climates the content of free aroma compounds is low, by the fact that the free monoterpene contents are more in cool climate.

Solar Radiation : Optimum light intensity for photosynthesis varies between 700-1100 micro molar units (30,000 - 50,000 lux) depending upon the location, topography, variety and training systems.

Both light intensity and temperature are involved in the formation of fruitful buds during May-August. The number of bunch primordia increase with higher light intensity and the fruitfulness of new buds depends on the daily duration of high light intensity falling on the bud itself rather than on whole plant.

High light intensity with high temperature (>36°C) are not conducive for berry colour development, whereas with moderate temperature (28-32°C) and high light intensity there will be good colour development between veraison and ripening.

Rain fall & relative humidity : Generally for economical wine production a reasonable rainfall amount of 55-65 cm annually is desirable between June- October for recharging the subsoil with moisture.

For maximum yield, vines need at least 75 cm water with good distribution throughout fruiting season. Avoid water stress during flowering and early berry growth period till veraison, whereas slight moisture stress during veraison to ripening enhances the quality of berries.

Evaporation : Evaporation is based on various climatic factors such as temperature, day length, wind, vapour pressure and solar radiation which affects plant growth. The actual and potential evapotranspiration is based on the amount of available water in the root zone and the evaporative power of the air.

Soil requirements of vines

Grapes can adapt to a wide variety of soil types ranging from coarse gravelly sands to heavy clays, shallow to very deep soils and soils of low to high fertility. Best performance is however obtained in deep medium textured soils (loams and sandy loams) which are low in salts and are well drained. Wine Grapes are successfully grown under irrigation on soils that provide 45-60 cm of root zone. However most *V.vinifera* varieties are deep rooted and fully explore the soil to a depth of 6-10 feet or more if the aeration is satisfactory and there is no obstruction to root zone.

Soil physical features such as soil colour affects the absorbance of radiant heat. Soil texture influences water holding capacity, the nutrient status, infiltration rate, permeability and aeration. Soil chemical properties such as pH is a measure of degree of acidity or alkalinity where vines are tolerant to wide range of pH conditions. The pH gives an indication of nutritional status as it is related to cation exchange capacity (CEC). In broad terms acid soils have low CEC broadly dominated by hydrogen, whereas alkaline soils are dominated by calcium, magnesium and potassium. Optimum pH range is 6-6.5 for wine grapes. The quality of wine is related to grape variety, followed by climatic area and by soil type.

IMPORTANT WINE VARIETIES

Cabernet Sauvignon

Most of the great red wines of Bordeaux and some of the finest wines of the New World are based on Cabernet Sauvignon. It is often blended with Cabernet Franc and Merlot and its flavor is reminiscent of blackcurrants or cedarwood. It demands aging in small oak barrels, and the best wines require several years of bottle age to reach their peak.

Merlot

This variety takes second place to Cabernet Sauvignon in most premium red wine blends. Merlot is fragrant and usually softer than Cabernet Sauvignon. It also shows best with oak maturation, but usually requires less bottle maturation before it is ready to drink. Merlot bottled as a varietal is becoming popular in India.

Shiraz

This grape is also known as Syrah. It makes a soft and rich wine often characterized by smoky and chocolate aromas. It matures faster than cabernet and is sometimes blended with it to speed accessibility.

Zinfandel

This variety probably originated in Southern Italy as the Primitivo grape. It is planted by only a few Indian wineries. The quality of wines have been very good, especially when they receive enough oak maturation.

Chenin Blanc

This grape is the Cape's most popular white variety with about thirty percent of her vineyards producing Chenin Blanc. It produces a wide range of wines from sweet to dry, including sparkling and still wines. Its dry wines are fresh and fruity and Chenin Blanc's sweet wines and botrytis dessert wines are becoming more fashionable.

Sauvignon Blanc

India now can produce international quality wines of Sauvignon Blanc as evidenced at few wineries located in Nashik and Pune district. These microclimates in Maharashtra are suited to the growing of this variety. The Sauvignon Blancs tend to be dry and grassy. Its plantings have increased though it is a moderate yielder.

CULTURAL PRACTICES

Soil preparation

All types of soil require deep trench spaced 1.8 M-3.0 M apart and oriented towards north-south direction. Apply 2.5 tons/ha Superphosphate along with 50 tons /ha of FYM. Copious watering of the trench to get weathering & decay of the organic matter at least 15 days in advance before planting.

Planting

Only *Vitis vinifera* varieties shall be used for new plantations. These varieties should be grafted on the recommended rootstocks for wine varieties such as Salt creek, 110 R, 1103 P, 140 Ru, 99R, SO-4, DogRidge, etc which are salt tolerant, drought and nematode tolerant. Plant the rootstocks in the month of Feb-March in enriched soil along the trenches. Graft the desirable scion variety *in situ* on rootstock during September and October. Normally recommended spacing for most wine varieties is 2.0 M between rows and 1.25 M between plants accommodating 4000 plants per hectare.

Training of young grafts/plants

Frame work establishment with single main stem, primary arms and cordons require proper training system. For this recuts, topping, pinching and tipping are followed. Training systems such as Kniffin, double cordon and trellis system are mainly followed. Pandal system which is common for table grape is not recommended for wine varieties. Drip irrigation / fertigation facilities will compliment quick establishment of the vineyard.

Manuring & fertilizer application

For one hectare vineyard 250 kg sulphate of ammonia, 250 kg superphosphate and 250 kg sulphate of potash, 75 kg magnesium sulphate should be given in 3 doses after foundation pruning. The first half doses should be mixed with 40 tons FYM just prior to pruning, second quarter dose should be given 30 days after pruning and next quarter dose after 60 days of pruning. Subsequent nutrient doses should be guided by soil and petiole analysis. Optimum petiole concentrations of yielding wine grape varieties in general, should have for N-0.632 %, P-0.25% and K-0.981%, Ca - 0.6 %, Mg – 0.4 %, S-0.1%, Zn-20 ppm, Cu-8 ppm, Mn – 25 ppm, Fe- 75 ppm and B- 30 ppm.

Fore pruning

Early September is ideal for most of the wine varieties as they take longer period for maturity and harvest. Most of the wine varieties have basal fruitfulness hence the level of pruning is normally kept low; either spur pruning or short cane pruning are adopted.

Training systems for wine grape

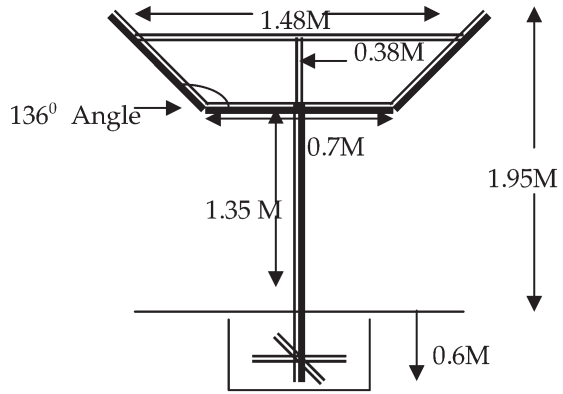
- a) Trellis system
- b) Kniffin system,
- c) Telephone system
- d) Double cordon

It is desirable to have trellis system among the various training systems for most of the wine varieties grown in tropical climate with bright sunlight that may get sun damaged on kniffin. Whereas bower system tends to delay the ripening process and often fruits become highly acidic with poor colour development.

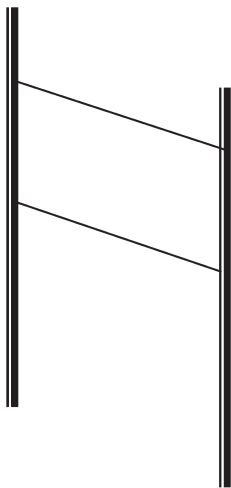
WINE MAKING

The two major kinds of grapes used in the production of grape wines are native American species of grapes, or hybrids thereof, and the European species or *Vitis vinifera*. A well known American grape species is *Vitis labrusca*; many varieties are cultivated in the eastern United States, especially in New York. *Labrusca* varieties include Concord, Delaware, Niagara, Catawba, and Ives Seedling. To varying degrees, these grapes and the wines made from them have a noticeable aroma, commonly referred to as “foxy,” that is partially due to the presence of the compound methyl anthranilate. Primarily, this characteristic distinguishes these wines from those produced elsewhere, particularly in Western Europe and California. Besides their distinct aroma, these native grape varieties generally contain insufficient sugar to produce a balanced table wine. Thus, in eastern wine making adding sugar or chaptalization is permitted. These grapes also have other compositional and physical characteristics that require specialized handling methods. Because of these factors, as well as the more extensive interest in *vinifera* wines, the making of wine from American grape species will not be covered here. However, for those interested in making wine from American grapes, we highly recommend to refer *Grapes into Wine* by P. M. Wagner.

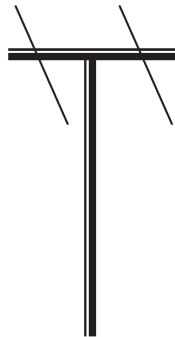
Fig. 1 : Training systems for wine grape



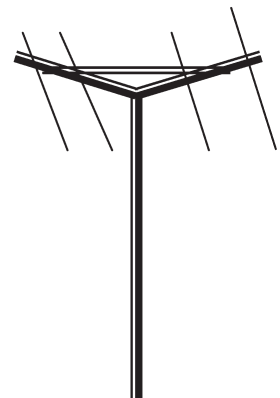
a. Trellis system



b. Kniffin system



c. Telephone system



d. Double cordon

Different training systems for wine grape varieties

Wine types are usually divided into classes according to their alcoholic content, groupings that form a convenient basis for excise taxes upon alcohol. The two major classes are table wines (9 to 14 percent alcohol) and dessert and appetizer wines (15 to 21 percent alcohol). Table wines owe their alcoholic content to the fermentation of sugar naturally present in the grapes and to the sugar that may be added to them. On the other hand, dessert wines obtain their higher alcoholic content from the addition of alcohol (wine spirits).

In response to widespread interest, this guide covers the fundamentals of making table wine that should provide the basis for more successes than failures. Making own wine can be an enjoyable, enriching, and rewarding experience. The ability to consistently make sound, above average, quality wines requires not only the desire to succeed, but, at times, hard work, patience, and attention to detail.

Aside from motivation and adherence to details, two other factors can influence the successful production of table wine at home: the amount to be produced and the kind of raw material used. While a few gallons of sound, palatable wine can be made easily from reconstituted grape concentrate, producing a fine quality wine is more readily realized from larger lots, using fresh, ripe grapes. Successful production of just 5 to 10 gallons of wine from small quantities of grapes requires considerable technical skill, experience, and the proper equipment, owing to the larger surface-to-volume ratio inherent in small volumes. Working with larger quantities of grapes and larger wine volumes minimizes chances of spoilage and oxidation. Thus, we recommend working with a minimum of about ½ ton of grapes to produce about 50 gallons of finished wine. Although these guidelines are presented with these factors in mind, the principles covered apply equally to smaller wine making activities. As a matter of fact, many beginners may wish to start out with one or two 5- to 10-gallon fermentations of reconstituted grape concentrate to become familiar with alcoholic fermentation, the adding of yeast and sulfur dioxide, and other wine making steps.

Types of Wines

a) Based on Colour

- i) **White wine:** White wines are made with much less skin contact, are much lower in Phenolics than red wines. White wines vary enormously in colour from virtually colour less to deep gold.
- ii) **Red wine:** Red wines are actually vary in colour from dark pink to almost

black, with an enormous variation in the amount of blue or yellow to be seen at the rim. Their colour depends on the grape varieties used, the vintage characteristics, the wine's PH.

iii) **Rose wine:** Wines coloured any shade of pink, from hardly perceptible to pale red. They are rarely known as pink wines.

b) Based on residual sugar content

i) **Dry wine:** Dry wines are those in which there is no perceptible sweetness. Dry wines may have as many as 10g/L residual sugar and with high acidity.

ii) **Dessert wine/Sweet wine:** Sweet wines contains more than 30g/L residual sugar.

iii) **Semi dry/Semi sweet:** Wines which contains residual sugar moderately (between 10g to 30g/L residual sugar).

iv) **Sparkling wine:** Wine which bubbles when pumped into a glass, because a certain amount of carbon dioxide has been held under pressure dissolved in the wine until the bottle is unstoppered.

v) **Fortified wine:** Wines, which have been subject to fortification, addition of spirits, usually grape spirit to wine, there by adding alcoholic strength and precluding any further fermentation.

vi) **Vermouth / Spicy wine:** Herb - flavoured fortified wine available in different styles and qualities but usually a much more industrial product than wine.

Composition and Quality of Grapes and Wine

The home winemaker has a choice of three raw materials for wine: freshly picked grapes, grape juice concentrate, or frozen must or juice. Of the three, it is generally recognized that the first offers the greatest quality potential and the second offers the most convenience. Both red and white grape juice concentrate is available from most vendors of home wine making supplies and is readily reconstituted by diluting with water. Follow the suppliers' directions to obtain juice of the desired strength. Varietal concentrate or the concentrated juice of different wine grape varieties is also available for home wine making. The obvious advantage to making wines from reconstituted grape concentrate or frozen must or juice is that they can be made at times other than the usual fall grape harvest.

The best raw material: fresh grapes

Fresh, ripe, varietal wine grapes remain the best raw material for making wine. In planning grape purchases, be aware that many growers who sell small quantities of grapes for home wine making pick into lug boxes that hold about 50 pounds of grapes each. Thus, 1 ton of grapes will require 40 boxes. Some growers may require a deposit for the lug boxes or you may have to provide your own picking containers. Make this arrangement at the time of your order; always return lug boxes clean and dry; large plastic tubs can be substituted for wooden boxes. Depending upon the variety and other factors, the home winemaker can usually expect that 1 ton of grapes for white wine will yield about 100 to 120 gallons of wine; 1 ton of red wine grapes will yield about 120 to 150 gallons of wine (the more press wine used, the higher the yield).

Aside from the form of raw material itself, several important factors influence wine quality. Foremost: Good wines can only be made from good grapes! Grape quality is directly related to the composition of the fruit when it is harvested. In turn, grape composition is influenced by climate. In cooler climates, more grape acids, varietal grape aroma, and flavor compounds develop and, in the case of red types, tannins and color are retained at higher, more desirable levels. These compounds are directly related to wine quality. Table shows the amounts of certain components of white and red wine grapes that are generally considered to be desirable for good quality wines.

Desired sugar, acidity, and pH levels in ripe wine

Wine type	Optimum sugar	Titrateable acidity*	PH+
White wine grapes	20.5-22 ⁰ Brix [#]	8-10 g/L	3.2-3.4
Red wine grapes	22.5-24.5 ⁰ Brix	6-8 g/L	3.3-3.5

* Values expressed as g tartaric acid per L.

+ A measure of free hydrogen (acid) ions in a solution.

A measurement of soluble solids, roughly equal to percent sugar content.

Of interest to the winemaker are these major grape components: grape sugars, organic acids, aroma and flavor compounds, polyphenolic compounds or tannins, certain amino acids, and certain metallic ions, such as potassium. Fully mature or ripe grapes contain about an equal concentration of glucose and fructose, which are the simple sugars yeast ferment to form alcohol and carbon dioxide. Ripe grapes contain from 70 to 80 percent water by weight.

Depending upon the variety, the predominant organic acids in grapes are tartaric and malic acids. In addition to their contribution to the flavor and balance of wine, tartaric acid is involved in wine stability, while malic acid is involved in the malolactic fermentation (see Glossary). The complex nature of grapes and wine has been verified by the isolation and identification of more than 400 aroma and flavor compounds present. Such polyphenolic compounds as tannins are also important to wine flavor, stability, and aging, particularly in red wines. Certain amino acids have been shown to influence wine quality, but they are perhaps more important as a source of nitrogen for yeast cell metabolism. Such metallic ions as potassium are constituents important in wine quality and stability. Finally, while the individual and combined interactions and contributions of these grape and wine components to wine quality are complex, they become more understandable with study and experience.

Because climate or other factors are unreliable, it is not always possible to obtain grapes with optimal sugar, acid, and pH. Fortunately, home winemakers are not hampered by both the federal and state regulations that control amelioration in commercial wine making. Sugar levels that exceed 25^o Brix can be lowered by adding water, to avoid difficulty with fermentation. The fermentation may even stop before dryness, resulting in incomplete fermentation. However, adding water to reduce a must's sugar content will also lower its acidity; such a change would be undesirable in a must already deficient in acidity. Thus, there are three options:

1. Ferment without adjustment.
2. Blend before fermentation with juice or must of the same variety that has moderate sugar and high acidity.
3. Before fermentation add water to lower sugar content and raise acidity to taste immediately after fermentation.

A must seriously deficient in acidity may also require acid addition before fermentation. Selection of the most suitable action will vary according to each lot and the winemaker's objectives.

Must or juice sugar and acid that fall well below levels shown in table 1 should be adjusted. A useful rule of thumb: To produce a wine of about 12 percent alcohol, the must or juice should be between 22^o to 24^o Brix. Sugar is increased by adding cane or beet sugar (sucrose). Use the following formula to calculate the amount of sugar to add to increase the ^oBrix:

$$S = W \times \frac{B - A}{(100 - B)}$$

where, S = weight of sugar to be added to increase must or juice to a desired °Brix

W = weight of grape must

B = desired ° Brix

A = original° Brix of grape must

For example, if you want to raise the ° Brix of 10 pounds of juice or must from 15 to 23, calculate the amount of sugar required as:

$$S = 10 \times \frac{22 - 15}{(100 - 23)} = 1.04 \text{ lb}$$

It should be apparent that large amounts of 15° Brix juice require proportionately larger quantities of sugar to raise the ° Brix to the desired level. For example, 10.4 and 104 pounds of sugar would be needed to increase the ° Brix from 15° to 23° with, respectively, 100 and 1,000 pounds of must or juice. Considering the high cost of sugar, riper grapes are obviously preferable.

A less accurate method for raising the sugar content by 1° Brix is to add 1.25 pounds sugar to each 10 gallons of juice or must. Deficiencies in total acidity can be corrected similarly. Table gives the amounts in grams (g) of tartaric acid that must be added to each gallon (gal) of must or juice to increase the titratable acidity (TA) from a given low level to either 6 or 8 g per liter (L). A TA of 6 g/L is considered a minimal acid level and a TA of 8 g/L is optimal acidity, especially for white wine.

Amounts of tartaric acid required to increase

Present acid content (g/L*)	To obtain 6.0 g/L add to each gal: (g)	To obtain 8.0 g/L add to each gal: (g)
3.0	11.3	18.9
3.5	9.4	17.0
4.0	7.5	15.2
4.5	5.6	13.2
5.0	3.8	11.4
5.5	1.9	9.5
6.0		7.5
6.5		5.6
7.0		3.8
7.5		1.9

* Turatable acidity as tartaric acid.

Wine making process

Ten processing operations are common to make white and red table wines. However, they are not all performed in the same order:

1. **Stemming and crushing.** Stems are separated from grape berries, the skins of which are broken to free the juice. The mixture of juice, skins, seeds, and pulp is called must.
2. **Determining sugar and acidity of the juice.** Sugar content is approximately equal to percent soluble solids ($^{\circ}$ Brix).
3. **Adding sulfur dioxide (SO_2).** Needed to inhibit growth of spoilage organisms and prevent oxidation.
4. **Adding pure wine yeast starter cultures.** Facilitates a clean, consistent, and complete fermentation.
5. **Pressing.** Skins and seeds are separated from the juice at the beginning in the case of white wine and after some fermentation on the skins in the case of red.
6. **Fermenting.** Yeast converts sugar to alcohol and carbon dioxide.
7. **Racking wine from lees.** The clear wine is separated from spent yeast cells and other solids after fermentation.
8. **Adjusting SO_2 content.** Prevents spoilage and oxidation.
9. **Aging/topping and/or clarification.**
10. **Bottling.**

These 10 wine making steps may appear relatively easy to the experienced winemaker. The inexperienced winemaker, however, must learn to check details, such as topping in a timely manner, using a pure yeast wine starter culture, or properly using SO_2 , to avoid wine spoilage. For several reasons, good quality red table wines are easier for the beginner to make than are white wines, mostly because white wines are more subject to oxidation and browning. Therefore, start with red table wines to gain experience.

The major difference between red and white wines is that, after stemming and crushing, the juice of the must for red wines is fermented on the skins for several days to extract their red pigments. In white wines, only the clear juice is fermented to minimize extraction of tannins from skins and seeds. Other significant differences:

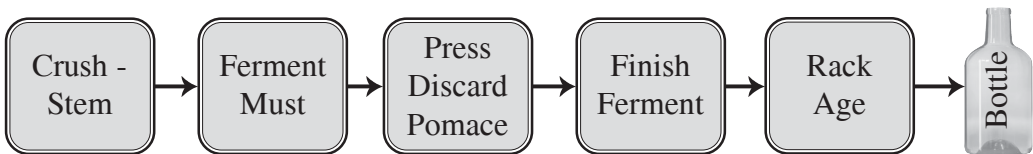
1. White wines should be fermented at cooler temperatures than are reds to achieve the best quality.
2. Red wines gain in quality and complexity by aging in oak barrels.
3. White wines generally are made without wood aging and are consumed when they are relatively young; thus, they retain fresh and fruity aromas and flavors.

For both red and white wines the volume of wine made must be larger than the total storage capacity of the aging or storage containers-glass carboys, gallon jugs, or barrels-because additional wine will be needed to replace the volume lost to lees after fermentation, and for topping during aging to replace wine lost to ullage or evaporation.

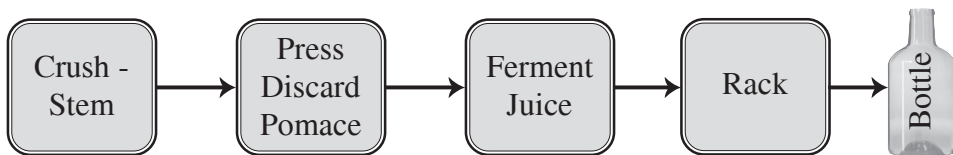
Making Red wine and White wine

Ten processing operations discussed above are common to making red wines and white wines. But the order of process varies.

Essential steps in red wine making



Essential steps in white wine making



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

Potential Spoilage and Stability Problems

Certain problems can arise even when the wine-maker follows recommended methods. Some are best handled by preventative measures; others are generally not considered important in wines made at home for family consumption, but may be important to those interested in wine judgments or simply as a matter of pride or achievement. The major potential problems, their prevention or remedy, are dealt with next.

Acetification and oxidation

In acetification acetic acid bacteria present in wine under favorable (to the bacteria) conditions will slowly convert alcohol to acetic acid and ethyl acetate, the main components of wine vinegar. This undesirable change is readily prevented by following recommended wine making practices. Specifically, judiciously use sulfur dioxide, avoid air contact with the wine, and keep the wine at 60°F (15.6°C) or below. When these measures are not followed, bacteria can become established and acetification will start. The *reaction, once under way, is irreversible!* Even worse, should this occur in wine stored in an oak barrel or cask, these containers cannot be used again for wine making because there is no known way to sterilize the wood effectively.

Simple oxidation results from excessive or prolonged exposure of wine to air when insufficient or no SO₂ is present. Development of a brownish color and oxidized odors and flavors is readily apparent, especially in white wines not protected from exposure to air.

Hydrogen sulfide (H₂S)

The distinctive “rotten egg” odor of this obnoxious compound can be detected by smell at very low concentrations, that is, 1 ppm or even less. Its formation and presence in wine most often arises from the reduction of elemental sulfur (residue of sulfur dust on grapes from powdery mildew control) by the yeast, and can occur even when the very best wine making practices are followed. As soon as the presence of H₂S is noticed, every effort should be made to remove it. Hydrogen sulfide is often formed during alcoholic fermentation, especially near the end of it, or some time after alcoholic fermentation when the new wine is still in contact with the yeast.

When it is detected, it is sometimes possible to convert the H₂S back to sulfur by adding sulfur dioxide or by vigorous aeration to volatilize it from the wine.

As mentioned in white wine making, if the juice is clarified before fermentation, the possibility for H₂S to form from elemental sulfur is greatly minimized. Deficiency of certain amino acids during fermentation may cause the yeast to form and accumulate H₂S. Adding diammonium phosphate at the time of yeast inoculation (1 to 2 oz/100 gal) should minimize the potential for this to occur.

Cloudiness and deposits

Under certain conditions, several naturally occurring substances in wine can lead to development of a cloudy or hazy appearance or crystalline deposits. These are usually of no concern to the home winemaker, but they are important to the commercial winemaker who must satisfy consumer demands for brilliantly clear wine free of deposits.

A common cause of cloudy appearance is an excess of certain proteins in the wine that may, under prolonged warm storage conditions, 70^o to 85^oF (21.1^o to 29.4^o C) or higher, form complex substances that remain in suspension and appear as a haze. This cloudy appearance is readily apparent in a white or pink wine. If this kind of instability is unacceptable to the home wine-maker, the wine can be protein (heat) stabilized by treating it with an inert clay, bentonite, which removes some protein. (This treatment is called bentonite fining.) The wine can be bentonite fined anytime after the first racking and before bottling, but we recommend before barrel aging. Usually adding about ½ ounce to 1 ounce bentonite for each 10 gallons of wine is sufficient for most white varieties. Others, such as Riesling, Muscat, and Sauvignon blanc, may require twice this amount for complete stability.

Very small, often needlelike crystals of potassium bitartrate (KHT) are the most common precipitate or deposit encountered in wine stored for several days or longer under very cool conditions, 40^oF (4.4^oC) and lower. Tartaric acid is the predominant organic acid in most *vinifera* grape varieties and readily forms the salt potassium bitartrate. The most common method for reducing excess KHT is to chill the wine to 23^o to 25^oF (-5^o to -3.9^oC) and to hold it at that temperature for 2 to 3 weeks. This causes the excess KHT to crystallize and then precipitate. The wine must then be racked carefully or filtered at the same low temperature. The process is facilitated by adding powdered KHT, which acts as a “seed” for crystallization, and is thoroughly mixed with the wine throughout chilling. Cold or potassium bitartrate stability might be accomplished without refrigeration by using a proprietary compound

such as Koldone. The manufacturer of this material suggests that 1 ounce for every 10 gallons of wine will achieve KHT stability, and depending upon the wine being treated, it will also reduce titratable acidity by about 1 gram per liter. If the wine is already low in acidity, this can be an important consideration. Note also, if the wine pH is high, using this agent could lead to calcium bitartrate instability. Therefore, although this material may work in certain wines, it can also create other problems.

Other clarifying and fining agents

Under some circumstances using other clarification or fining agents may be desirable. However, their use requires filtration for removal, a process possible for those not intimidated by filtration equipment and operations. It should be mentioned that all materials, previously discussed and those following, have been legally approved for use in commercial wine production, and home winemakers, therefore, should be confident they are safe.

Some wines may develop tastes considered too astringent or bitter. This is usually related to excessive amounts of certain tannins, as when red wine is left too long on the skins and seeds. Gelatin treatment has been successfully used to reduce astringency and is used in very small amounts, that is, 4 to 8 ounces per 1,000 gallons. Adding egg whites has also been used to “soften” wines that taste “rough.” Because they are proteins, do not use either agent after a wine has been previously protein stabilized. Alternatively, gelatin and/or egg white can be followed by bentonite fining.

Excessive amounts of certain polyphenolic compounds in white wine can lead to browning or cloudiness. One treatment for browning calls for the polymeric resin polyvinylpyrrolidone (PVPP), also known as Poly-Clar AT. This adsorbent resin is expensive, but is added in very small quantities, and is removed by racking or filtration. Poly-Clar AT will probably remove more tannin than gelatin and does not need to be followed with bentonite fining.

Activated carbon or charcoal is useful in removing undesirable odors and flavors and off-color in white wines. However, it can impart other off-tastes and/or remove desirable components, and therefore should be used cautiously. From 1 to 20 lb/1,000 gal (120 to 2,400 mg/L) are usually added directly, followed by about 2 lb/1,000 gal (240 mg/L) of bentonite, and finally by racking or filtration.

Other clarifying agents, such as Klear-Mor and Sparkeloid, may be helpful with wines difficult to clarify just before bottling. Again consult your home wine shop. Further information about fining agents may be found in *The Technology of Wine Making* (see Selected References).

Wine filtration

Most persons making wine at home would not want to go to the expense or effort involved in wine filtration, and by and large it is not necessary. However, advances in filtration technology offer the serious home wine-maker reasonably affordable small-scale equipment and relatively simple techniques. Filtration facilitates wine clarification, can follow fining or aeration, and can also remove yeast and/or bacteria.

Depending upon the objective, there are three major kinds of filtration that relate to the size and amount of particles to be removed from the wine: rough, tight or polish, and microbiological. For home wine making there is now available a series of cartridge-type filters of several sizes, designed to meet the needs of all three objectives. Sheet or pad filters are less expensive. Both are either gravity-flow (quite slow) or pressure-flow (rapid). Rough filters are used to hasten wine clarification, thus reducing the number of rackings, or to filter wine from fining agents, such as bentonite lees. They may involve using a filter aid, such as diatomaceous earth (DE). Tight filtration media, used to polish filter wines before bottling, will remove most yeast cells. It is necessary to polish filter a wine before using a “microbiological” or membrane filter to remove yeast and bacteria—this latter application is useful to the wine-maker who does not want the malolactic fermentation. Further information on filters, filter housings, their use and prices, can be obtained from suppliers listed at the end of this publication.

Analyzing Juice and Wine

Several constituents in grape juice and wine must be measured to help the winemaker make decisions throughout wine making. For example, knowledge of the soluble solids (⁰Brix) content of a given juice will indicate whether adding sugar may be necessary. Know-ing the amount of sulfur dioxide in a wine, as well as its pH, can serve as the basis for determining the amount that may be needed for adjusting SO₂. A paper chroma-tograph without a developed malic acid spot, but show-ing a lactic acid spot, can be evidence that a particular wine had undergone malolactic fermentation (see malic acid analysis below). Although it is possible to make wines without analysis, consistent production of sound, superior quality wines is enhanced considerably with accurate analytical data.

Wine acidity and pH

Because of their importance, the acidity and pH of grapes and wine are discussed first. Earlier, the acid composition of grapes was said to directly affect

wine quality and pH also played an important role in wine quality and stability. As previously mentioned, grapes and wine owe their acid composition and taste primarily to the presence of tartaric and malic acids, (lactic acid replaces malic in wines that have undergone malolactic fermentation). These fruit acids are defined as weak acids, compared with such strong mineral acids as sulfuric and hydrochloric. In solution, strong acids tend to dissociate or yield their hydrogen ion (H^+) component nearly completely; weak acids dissociate only about 1 percent or less of their hydrogen ions. Aqueous solutions owe their acidity or alkalinity to the ratio of hydrogen ion content to hydroxy 1 ions (OH^-). Thus, such acid solutions as wine have more H^+ ions than OH^- ions. Since the pH of most table wine ranges from 3.1 to 3.6, it should be evident from the foregoing that very small numerical changes within this pH range actually reflect significant changes in wine acidity. Finally, it should be stressed that pH can profoundly affect microorganisms (low pH inhibits acetic acid bacteria and malolactics), the ratio of free to bound SO_2 , both protein and KHT stability, and wine color and flavor.

Soluble solids (°Brix)

Grape juice soluble solids are composed mainly of glucose and fructose and hence are approximately equivalent to the percent sugar by weight, or grams sugar per 100 grams of solution expressed as °Brix. The °Brix of juice, must, or wine can be determined with a hydrometer or a refractometer; the refractometer cannot be used to measure the soluble solids content of wine because the presence of alcohol interferes with the reading. Because hydrometers can be used in juice or wine, a series of hydrometers covering the following or similar °Brix ranges are recommended: 19° to 31°B; 9° to 21° B; 0° to 12°B; and -5° to +5°B. Negative °Brix values (those less than zero) are due to the presence of alcohol, which depresses the specific gravity. Hydrometers are usually calibrated at 68° F (20° C) and require using a correction factor when used in juice or wine of a different temperature. Use a good quality mercury bulb chemical thermometer, one of the newer probe types, or a remote sensor thermometer with a temperature scale range of 20° to 220°F or -10° to 110°C with one-degree scale divisions and a precision of $\pm 1^\circ$, to measure the temperature of the sample. Add or subtract the appropriate correction factor to the hydrometer reading as given in table 6.

Testing for soluble solids in juice. Fill the hydrometer cylinder with a juice sample previously clarified by allowing suspended matter to settle. Grasp the hydrometer stem and gently lower the hydrometer into the juice with a slight spinning motion. Make certain the hydrometer does not rest on the bottom or cling to the sides of the cylinder and make a reading to the nearest 0.1 °Brix after the hydrometer is freely

floating and at rest. Add or subtract the appropriate temperature correction to obtain the final value.

Reducing sugars

Hydrometers are not only used to determine the sugar in juice before fermentation, but they are necessary for monitoring fermentation progress. Near the end of fermentation, when readings are less than -2° Brix (remember, minus readings occur due to the alcohol) and remain so for several days, the wine should be analyzed for reducing sugar (fermentable sugar) content to determine if the wine is, in fact, dry. A very simple and rapid tablet test (Dextrochek) can measure the sugar in the range of 0.1 to 0.2 percent. The test should be replicated at least twice. Because the tablets decompose rapidly when exposed to air or moisture, they should be kept tightly sealed. It is difficult to read the color end-point in cloudy wine; therefore, the sample should be filtered or a sample allowed to clarify by settling for a few days in a refrigerator. Red wines are also impossible to test without first removing the pigment. Decolorize the wine by adding about 1 gram (0.03 ounce, 1 to 2 teaspoons) activated carbon to 50 ml of wine, mix, filter or settle, and proceed with the test.

Titration acidity

As indicated in the Introduction, the titration acidity (TA) content of grapes and the wine is important to quality. Analysis for TA involves titrating a standard dilute sodium hydroxide (alkali) solution against a small juice or wine sample to a color change end-point of an indicator dye solution. Titration kits for determining TA, complete with detailed instructions, are available from home wine making shops. With care and practice, reasonably accurate and useful results can be obtained. The calculated values are expressed as tartaric acid in grams per liter. Note that the accuracy of the titration depends upon the strength of the standardized sodium hydroxide solution which, when exposed to air, loses its strength by reacting with carbon dioxide. Utilize this solution quickly or replace it with a fresh supply, daily if needed, to ensure accurate results. Accuracy can be checked by titrating against a known standardized solution of dilute hydrochloric acid, which should be part of the kit.

Total and free sulfur dioxide

As previously discussed, SO_2 is required to prevent oxidation and growth of undesirable yeast and bacteria. The usual amount added to sound crushed grapes is 50 to 100 ppm. Addition of 75 ppm SO_2 to most musts is sufficient to prevent oxygen uptake by polyphenoloxidase enzymes, which promote browning. During

fermentation some SO_2 is oxidized to sulfate (SO_4^{2-}) and some is bound with such compounds as acetaldehyde.

Malic acid

It can be very important to determine whether the malolactic fermentation has occurred, and the wine is therefore biologically stable. If fermentation has occurred or has been definitely inhibited, the wine can be safely bottled. Paper chromatography, a technique for qualitatively determining organic acids, is universally employed in detecting malolactic fermentation, specifically the presence or absence of malic acid. The method is simple, relatively inexpensive, and reliable. Actually, many wine-makers find this analysis fun to do. Again, home wine shops provide kits that contain equipment, chemicals, and instructions. A few words of caution: For best results, work in a clean, dry place and handle the chromatographic paper with clean dry hands to avoid contaminating the paper. Also, since the solvent is flammable and the fumes noxious and irritating, the air-drying process should be performed outdoors or in a well ventilated area, such as near an exhaust fan. (A stove hood exhaust might help, but don't leave the burners on!)

Evaluating Wine Quality

Perhaps the most important and essential tools available to winemakers are their senses. With sight one can critically examine a wine's appearance; with smell detect pleasing and not-so-pleasing odors; with taste perceive desirable and undesirable flavors. Thus, sensory analysis not only is the ultimate test for evaluating wine quality, it is the best method for controlling quality throughout wine making.

Commercial winemakers have the formidable task of properly and reliably evaluating wine quality, as well as developing and applying an understanding of consumer taste preferences. Fortunately, hobby winemakers need only be concerned with pleasing their own tastes. Even so, certain skills are helpful, such as the ability to recognize volatile acidity, or tartness (acidity levels) and sweetness or lack of sweetness (is the wine dry or slightly sweet?). Practical methods for sharpening these kinds of tasting skills are given in *How to Test and Improve Your Wine Judging Ability*.

The ability to evaluate the overall quality of a wine is largely based upon the taster's previous experience. All judgments of wine are subjective, influenced by the memory of wines previously tasted. Thus, wine quality is easier to recognize than it is to define. A winemaker's ability to recognize wine quality can be enhanced by frequent, regular tasting of many different wines. In addition, it is helpful, especially for the inexperienced, to taste wines, using a standardized and systematic method.

Various kinds of score cards or scoring systems have been developed for this purpose. Moreover, a score card is a permanent record of the sensory analysis that can be used to compare subsequent tastings of either the same wine or other wines. One such scorecard, used for many years to evaluate wine quality, is the so-called “Davis 20-point scale,” developed in the Department of Viticulture and Enology at the University of California, Davis.

IMPROVEMENT IN WINE QUALITY

It is a belief among the consumers, propagated by the classic wine countries, that wines made in hot climate are of poor quality. This is more a commercial propaganda than a reality. Although some quality parameters of grape that contribute to wine quality are affected by growing grapes in hot climate, it is not impossible to minimize the loss of quality components by suitable cultural and vinification processes. It is essential to understand as to what are the quality components of grapes that matter for the wine quality; how are these affected in hot climate leading to poor quality wine and what are the ways to arrest such deterioration in grape quality in hot climate to safeguard and promote wine industry in hot climate zones.

Grape composition and wine quality

The composition of grapes determines the quality of wine. Many quality components are carried over from grape juice into wine and a few undergo reactions to form compounds that are distinctive to wines. Grape juice contains sugars, organic acids, phenolics, aroma compounds, vitamins, minerals and nitrogen compounds. Alcohol content in wine is directly dependant on the sugar content of berries. Higher sugars give body to the wine. While vitamins, minerals and nitrogenous compounds are essential for yeast growth and fermentation, the basic flavour of a wine is formed from the relative contents of sugars, acids, phenolics, and ethanol.

Phenolics contribute to the astringency/bitterness of wine, and are also responsible for the most of the colour. Six types of phenolics are found in grapes, namely, catechins, procyanadins, anthocyanins, flavonols, hydroxycinnamates and hydroxybenzoates. The difference between red and white grapes (wines) is due to the presence of different types of phenolics. The simple phenolics, namely the hydroxycinnamates and hydroxybenzoates occur in the pulp of the berry and so occur in it is generally accepted in alphasones (cool climates) that, as the fruit exposure to sunlight increases, the fruit composition and wine quality improve.

In warm regions (San Joaquin valley) it was true with the clusters located on the north or after noon shaded side of the canopy. But in case of clusters located on

the south or afternoon exposed side of canopy, berry colour was most negatively affected by excursive sunlight exposure with increasing temperatures.

It was concluded that canopy management practices that provide high amounts of diffused light in the fruiting zone, rather than direct sunlight exposure, are best suited that warm regions. Training and trellising systems, row orientation and canopy management practices should be considered carefully in order to avoid prolonged fruit exposure to direct sunlight in such regions.

Both red and white wines. The other more complex phenolics collectively known as “flavanoids” occur in the skin and seeds; hence more in red wines.

Flavouring compounds in combination with the specific volatile aroma compounds present in different grapes will give the wines made from them the district aroma (Bouquet-as quite often called). More than 100 volatile compounds have been identified in wines all over the world. The most important volatiles in grape are the monoterpenes present in minute quantities (less than 4 ppm). These give a range of odours in different classes, viz; floral, spicy or fruity. The monoterpenes exist in both free volatile form and as bound glycosides. The glycosides are not volatile and so do not contribute to aroma. They are slowly hydrolysed in the acid conditions of the wine and contribute to aroma as the wine ages. In addition to terpenes, other volatiles also contribute to aroma, such as methoxy pyrazines contributing to district ‘Sauvignon’ aroma in Cabernet Sauvignon and Sauvignon Blanc; and methyl anthranilate contributing to ‘foxy’ aroma in *labrusca* grapes.

Means to obtain good quality wine in hot climate

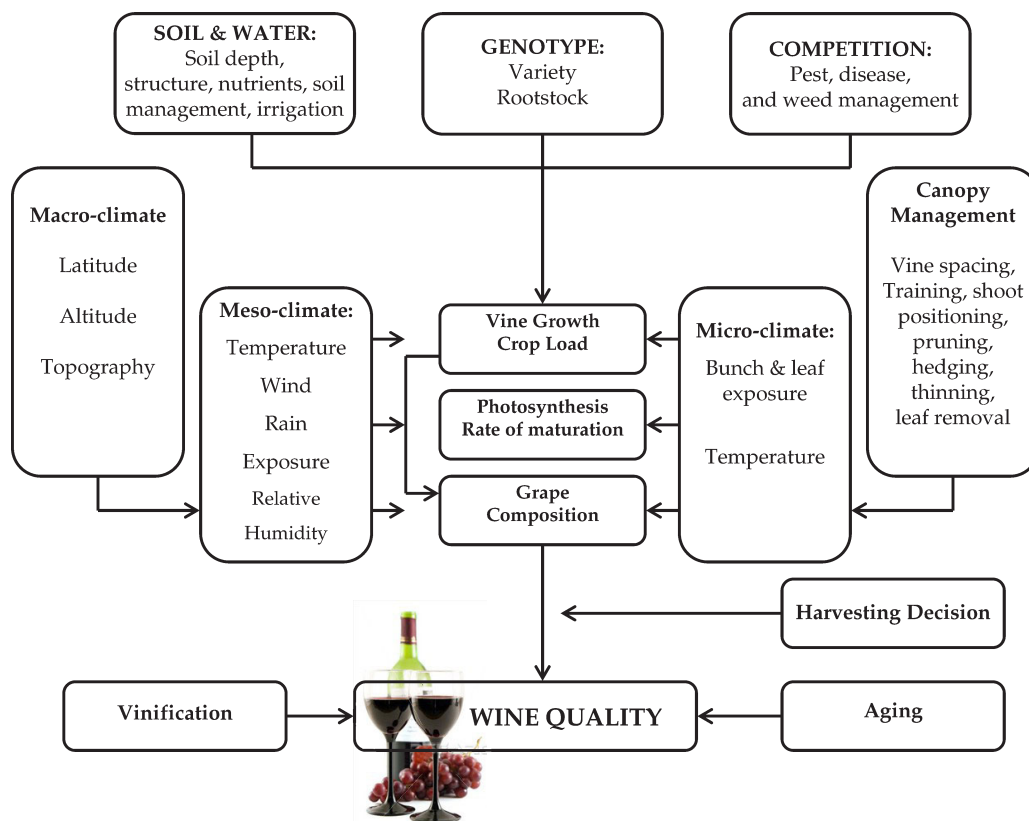
It is true that regions with long ripening period are required to produce superior wines? It is not true that many wines of quality are produced from warm to hot climates? During the tasting and judging of the Indian wines at the International Symposium on grapes held at Baramati, the wine tasters from France, Germany and Israel opined that the wines from Sauvignon Blanc and Pinot Noir were comparable to that wine made in classical wine countries in cool climates. Then where is the catch? To get an answer, the quantitative changes in the composition of grapes grown in warm / hot climate needs to be critically analyzed and compared with the quality components of grapes grown in cool climate with reference to their contribution to wine quality. The sugar content will be high, acids content will be low and pH will be high (more than 3.6), phenols and anthocyanin contents will be low and the free aroma compounds will be low without any change in the bound aroma compounds in hot climate. When wines made from grapes ripening during warm season in a cool region are better why cannot be grapes ripened in cold season in hot region make good wines?

- i) *Viticultural Practices:* Wine quality predominantly depends on grape composition. It is said that “the best quality wines are made in the vineyard but not in the winery”. This means grape composition contributes more towards wine quality than vinification. In addition to macroclimate (climate of the zone contributed by latitude and altitude) and mesoclimate (climate of the location contributed by topography, slope aspect of slope, temperature, wind, rain, sunshine and relative humidity), grape composition depends on the microclimate (variation in humidity, temperature and light in the vine canopy) caused by viticultural practices, such as row direction, vine spacing, training system, shoot positioning, time of pruning, shoot thinning, leaf removal and other canopy and management practices. Grape composition is also determined by the soil structure, depth, nutrient and water management. Vine vigour and crop load, primarily the variety and rootstock will also contribute to the composition of grape. In addition to grape composition, the stage of harvest, vinification techniques and aging of wine contribute to wine quality. Factors contributing to wine quality are schematically presented in fig-4. Is it not possible to overcome the ill effects of hot climate on wine quality, by favourably adjusting all other contributory factors towards wine quality? If yes, let us discuss on the scope of improving wine quality by various means in hot climate.

High sugar content in berries in hot climate is not a disadvantage, so long as the high temperatures do not reduce the total acids content below 0.7 per cent, increase the pH above 3.6 and adversely affect the pigmentation. A brix content of $22 \pm 1^{\circ}\text{B}$ is adequate for making good wine. In the event of high sugar and high pH coupled with low acids and pigments, developing dense canopies by allowing about 20 shoots / m length of row, retention of lateral shoots, avoiding training to vertical trellises, shoot positioning, reducing the number of leaves / bunch and increasing the number of clusters / vine are recommended. These is one more myth that higher yields reduce the wine quality. So long as leaf / fruit ratio is maintained and the berry size is controlled, one need not worry about quality deterioration due to higher yields. East – west row direction, closed spacing of vines, and shoot positioning to cover the clusters facing South will help maintain the levels of total acids and berry pigments in desirable range.

In hot climates, the contents of phenols and anthocyanin pigments will be low; particularly when the night temperature goes above 15°C and the mean temperature above 20°C . So is the case with flavour/aroma compounds, particularly the free aroma compounds. Berry composition will be ideal for good wine making, if the ripening occurs within these temperature limits, say night temperatures between $10^{\circ} - 12^{\circ}\text{C}$ and day temperature between $28^{\circ} - 30^{\circ}\text{C}$. As every variety require a specific

Fig. 2 : Environmental and viticultural inputs into grape composition and wine quality



(Source : D.I. Jackson and P.B. Lombard. 1993)

number of heat units for its ripening to attain $22 \pm 1^{\circ}\text{B}$, slow ripening at low temperatures is essential. While exposure to light is not undesirable, exposure to high temperature is undesirable. Hence location of vineyards on high altitude sites is desirable, because the full light is available at reduced temperatures. Location of vineyards in the eastern side slope of the hill is advantageous for quality wine making.

It is possible to synchronize the ripening period with low night temperatures around 10°C and day temperatures around 30°C (February) in tropical Indian conditions and high altitude locations of the Deccan Plateau by pruning for fruiting in August/September depending upon the head unit requirement of the variety.

Success in producing the quality wines lies basically in matching variety to terrior and it also very important to produce quality wines in hot climate. Average temperature being $< 20^{\circ}\text{C}$, the duration of availability of period with ideal temperature

viz., the ideal temperature of minimum high temperature < 15°C is the point of consideration. For quality wine, different varieties recommended for different duration periods are as follows:

- 25 – 30 days : White wine varieties i.e. Sauvignon Blanc, Chenin Blanc
- 30 – 35 days : Zinfandel, Shiraz
- 35 – 40 days : Cabernet Sauvignon,
- > 40 days : Merlot

Foremost thing is the matching of variety with the temperature increase pattern after berry set. Because the skin contains a high concentration of most aroma/flavour and phenols, the berry surface area to volume ration is important in determining the concentration of these quality components. This ratio will be 'one' when berry diameter is 6 mm, increasing berry diameter above 6 mm reduce the ratio. There is specific ratio for each variety. Ingenuity of viticultural practices lies in maintaining the desirable small size of the berry and achieving the higher yield/unit area.

Foremost consideration to maintain the wine quality in hot climates is to retain/maintain the levels of free aroma compounds. Free aroma compounds are volatile and their contents reduce if the day temperatures exceed 35°C without affecting the levels of bound aroma compounds. The ratio of bound to free aroma compounds vary between 1 to 4 in different grape varieties. Bound aroma compounds were found to increase with phosphorus nutrition to Cabernet Sauvignon vines. Ruggeri rootstock which accumulates less chloride than Salt Creek rootstock was found to increase the concentration of aroma compounds in Cabernet Sauvignon wine under saline water irrigated conditions.

Variation in ripening of bunches on a vine or in a vineyard is also a problem under tropical conditions. Selected harvest of fully ripe bunches with 21 - 23°B is essential. It is also essential to chill to grapes overnight at 10°C before crushing to obtain better flavour.

- ii) *Vinification techniques:* It is an essential option to release the bound aroma compounds in the grape into wine during the process of fermentation. As said earlier, the bound aroma compounds are bound by glycosides. They can undergo acid or enzyme hydrolysis, releasing free volatiles and potentially increasing aroma, sometimes typical to the grape variety. Normally the wine yeast is added to the grape must/juice for fermentation. The standard wine yeast is *Saccharomyces cerevisiae* var. *ellipsoidens*. Different strains of this yeast are used by different wineries, namely Red Star, Burgandy strain, Tokay strain, Champagne strain, Levuline ALS strain, etc. Different species of *Saccharomyces* yeast are also being used for alcoholic fermentation of wine. These yeasts produce the majority of

important wine aroma compounds during alcoholic fermentation. However, their capacity to produce these compounds vary. Identification of a suitable species and strain of yeast for the variety and terroir can go a long way in increasing the free aroma compounds in wines in hot climate. α -glycosidase enzyme can hydrolyze the glycosidic bonds and release the bound aroma compounds. Two different approaches have been followed by the utilization of these enzymes (i) Direct addition of enzymes to the must / juice and (ii) inoculation of must with the enzyme producing yeasts / organisms. The activity of glycosidase enzymes is generally inhibited even by small concentrations of glucose and therefore must be added after the completion or at the end of fermentation. Their activity is not inhibited by the alcohol content, but can be removed from wine by precipitation with tannin phenols. They must not be used in the presence of bentonite, which will also remove them from the wine. Sometimes they release bound phenol glycosides which may increase the bitterness of some white wines. So care must be exercised while adding the glycosidase enzymes to must/ juice to release the bound compounds. Addition of glycosidase enzyme to must at the end of fermentation increased the concentration of free aroma compounds, namely terpenes, volatile phenols, C-13, norisoprinoids and aromatic alcohols at the expense of glycosidically bound aroma compounds. The lactic acid bacteria *oenococcus oeni* can also hydrolyze the aroma precursors in wine during malolactic fermentation and improve the wine aroma.

- iii) *Post-fermentation treatments*: The bound aroma compounds also slowly hydrolyse in acid conditions of the wine and contribute aroma during the aging of wine. Heat can accelerate the aging process of wine. Post-fermentation thermal storage reduced the bound aroma compounds and increased the volatile free aroma compounds. The storage temperature and duration have to be standardized for different varieties grown in different terroirs.

SUMMARY

Table grapes are grown successfully in India. Certain pockets are also suitable for successful cultivation of wine grapes. Quality wines are produced in vineyards not in winery. Important cultural practices suggested for producing good quality wine from grapes grown in tropical regions of the country are:

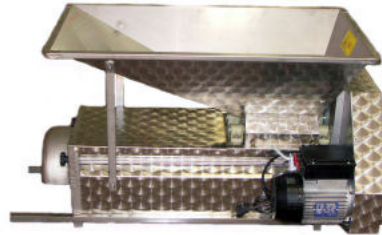
1. Select the locations where the days are available with minimum temperature $< 15^{\circ}\text{C}$ and the average $< 21^{\circ}\text{C}$ in winters.

2. Match the variety to the location depending upon the number of such days available in the winter; viz.,
25 – 30 days : White wine varieties i.e. Sauvignon Blanc, Chenin Blanc
30 – 35 days : Zinfandel, Shiraz
35 – 40 days : Cabernet Sauvignon,
> 40 days : Merlot
3. Grow the vines in elevated areas at least 600–1000 m above msl.
4. Plant on the eastern aspect of slope with East-West row direction.
5. Train the vines to short arm V trellis with foliage wires facilitating drooping of shoots to cover the bunches to protect from sun burn.
6. Time the pruning to synchronise ripening with maximum available length of suitable whether.
7. Thin out shoots retaining three shoots per cane.
8. Thin out the flower clusters retaining only five clusters on each cane with more than 8 mm diameter and three clusters in thinner canes.
9. Restrict irrigation to only 8000 ltrs/acre/day from berry set to harvest.
10. Position the shoots on the Southern side of the vine canopy, at colour break stage.
11. Monitor the sugar and acids content every alternate day from 20 days after colour break.
12. Harvest during cool hours.
13. Harvest when T.S.S. content shows $22 \pm 1^{\circ}\text{B}$ and harvest selectively the clusters having $22 \pm 1^{\circ}\text{B}$.
14. Chill grapes overnight at 10°C before crushing.
15. Add the most efficient and suitable species of *saccharomyces* yeast.
16. Add β -glycosydase enzyme after fermentation, but before clarification to release the bound aroma compounds.
17. Subject the wines to thermal storage adding oak chips for 20 days at 45°C before cellar storage to improve aroma.

Equipments for grape wine Making



Crusher 1



Stemmer & Crusher 2



Presses



Fermenters

Important Wine Varieties



Cabernet Sauvignon



Merlot



Shiraz



Chenin Blanc



Sauvignon Blanc