Wines from Cherries and Soft Fruits*

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Cherries

Cherries grow best in a moderately cool climate. They are consumed fresh as well as processed for juice and other products such as wine. Sweet cherries are mostly grown in Oregon, Washington, and California because of the semi-arid climate. Lack of rain at harvest prevents cracking and rotting of the fruit. Tart cherries are more tolerant of rain and are grown in several states east of the Rockies. Michigan, Wisconsin, New York, and Pennsylvania are major tart cherry producing states in the East and Midwest.

Varieties

Sweet cherry varieties include Bing, Tartarian, Schmidt, and Lambert. Generally they are high in sugar and low in acid. They are good for eating but, due to low acid, less suited for winemaking. Tart cherries, on the other hand, are high in acid and relatively low in sugar, and so, preferred for winemaking; but amelioration of the juice is needed to produce a well balanced wine. A blend of sweet and tart cherries can be used to make a balanced must with attractive color and pleasing taste. The important tart cherry varieties are Montmorency, Early Richmond, and English Morello.

To make superior cherry wine, only good quality fruit should be used. Fruit should be well colored with glossy skin, plump and meaty texture, and green stems. Poorly colored, shriveled, seared and rotten fruit (even if it is cheap) should not be used for making wine.

Fruit Composition

Juice composition of four cherry varieties is given in Table 1.

Table 1. Juice composition of cherries.

Variety	% Total solids	% Total acidity	Reducing sugars	Non-Sugar solids
Montmorency	15.23	1.32	9.70	5.53
Early Richmond	13.37	1.51	7.88	5.49
English Morello	18.00	1.86	10.17	7.83
Bing	14.84	0.47	10.56	4.28

Adapted from Swisher and Poe, 1935.

From the data given in Table 1, it is obvious that there is little difference in sugar content among tart and sweet varieties referred to above, but the acid content widely varies between the sweet and tart cherries. The principal sugars in cherry are fructose and glucose, with trace amounts of sucrose. Usually fructose is present in higher amounts than glucose. Malic acid is the chief organic acid but small amounts of citric, succinic, and lactic acids have also been observed. Several amino acids occur but proline is the main one present in ripe fruit. Protein content is generally low, about 1.2 to 1.3 percent. Cherries also contain various phenolic compounds including pigments. Montmorency cherries have been noted to have a phenolic content of 0.2g/100g fresh weight (Caldwell, 1934). Flavans such as catechin and epicatechin have been observed in sweet and tart cherries. The color of the cherries is due to the pigment called anthocyanins. One of the pigments has been identified to be cyanidin-3-monoglucoside. The pigment is largely present in skin and to a smaller extent, also in the flesh. This is true of sweet cherries and English Morello (a tart cherry). In the case of the tart cherry Montmorency, the anthocyanins are located only in the skin. Many odorous compounds are responsible for the cherry flavor. The main constituents of cherry flavors include methanol, ethanol, butanol, pentanol, octanol, geraniol, linalool, ethyl acetate, acetic, isovaleric, and octanoic acids, and benzaldehyde. In addition to the compounds mentioned above, many other important constituents such as pectic substances, vitamins, and minerals are also present.

Soft Fruits

Soft fruits such as berries are commonly used for making jellies, jams, preserves, juice, and berry-flavored drinks. Some interest also exists in making wines. Both table and dessert wines, although generally in a sweeter style, are produced. Many berry fruits are used in winemaking. For the purpose of this discussion, wines from the following fruits will be considered: blackberry, raspberry, blueberry, and strawberry.

Blackberries and raspberries are mainly grown in the Pacific Northwest region. On a limited scale, they are also grown in many other areas of the United States. Fresh fruit is very perishable (soft fruit is susceptible to rot), therefore it should be promptly cooled to 32°F before shipping to distant markets.

If fresh fruit is to be used for winemaking, it must be processed promptly or stored frozen for later processing. Only good quality fruit, free of rot or decay and insect damage should be used for making wine.

Blackberry - The cultivated blackberry belongs to the genus Rubus. Many species, subspecies, hybrids and cultivars are included in this genus. They are widely grown throughout the U.S., but the largest amount is produced in the Pacific Coast region of the United States. The blackberry fruit is very perishable. A storage life of 2 to 3 days at 31 ° to 32°F and 90 to 95% humidity has been reported. If the fruit is to be processed at a later date, storage under proper refrigeration and environmental conditions is essential. For winemaking, bright, firm, uniformly colored fruit without mold and decay should be used.

Raspberry - Raspberries require cool summers and moderate winters. Red raspberries are largely grown in Washington, Oregon, and Northern California. The fruit is very perishable. Sound fruit can be stored for 2 to 3 days at 31 ° to 32°F and 95% relative humidity. For processing at a later date the fruit needs to be stored under frozen conditions. For quality winemaking, ripe fruit with firm flesh, bright, well-developed color, and free from decay should be used.

Strawberry - Strawberries are grown in many parts of the U.S. Major strawberry producing states are California, Florida, and Louisiana. Like other soft fruits, strawberries are perishable. For fresh market, they can be stored for 1 to 6 days at 31 ° to 32°F at 90 to 95% relative humidity. If the fruit cannot be processed immediately after harvest, it should be quickly frozen and stored for later processing. Only well-ripened and clean fruit should be used for winemaking.

Blueberry - Many species of blueberries are native to North America, but few of them are commercially important. Two types of blueberries are commonly grown. They are highbush blueberries and lowbush blueberries. The main blueberry producing states include New Jersey, Michigan, North Carolina, and Washington. For fresh market consumption, blueberries can be stored for about two weeks under optimum storage conditions (31 ° to 32°F at 90 to 95% relative humidity). For winemaking, the fresh fruit should be used soon after it is harvested. To make quality wine, well-ripened fruit with good color and no rot or decay should be used.

Composition of Soft Fruits
Water is obviously the main constituent of all soft fruits. Sugars, organic acids, pigments, odorous substances and many other organic compounds are important soluble solids in soft fruits.

Sugars - Quantitatively, sugars make up the largest fraction of soluble solids found in soft fruits. Among the soft fruit being considered here, strawberry, blackberry and raspberry are relatively low in sugar (ranging about 4 to- 8%), while blueberry contains a significantly higher amount (about 12%). Glucose and fructose are the predominant sugars and sucrose is present in small amounts. Table 2 lists the sugar content of soft fruit.

Table 2. Sugar content of mature berry fruit.

	Sugar (%w/w)	Sugar (%w/w)	Total (%w/w)
Fruit	Reducing	Sucrose	Total
Blackberry	-	-	4.30
Rasberry	4.25	1.21	5.34
Blueberry	12.40	1.40	13.80
Strawberry	4.13	0.87	5.00

Source: Hulme 1971

Organic Acids - Organic acids are the second most abundant soluble solids found in soft fruits. With the exception of blueberry, the soft fruits contain significant levels of organic acids. The data on acid composition in given in Table 3.

Table 3. Main organic acids of soft fruits.

			Acidity as	Acidity as	Ind.	Ind.	Ind.

			%w/w Range covered	%w/w Range covered	acids	acids	acids
Fruit	pH	Tyical ripe fruit	Minimum	Maximum	citric	malic	iso-citric, lactone
Blackberry (cultivated)	3.0	1.5	0.68	1.84	tr	0.82	0.81
Blueberry	na	0.3	0.22	0.52	na	na	na
Red Rasberry	3.47	2.8	0.74	3.62	2.06	0.8	na
Strawberry	3.26	1.01	0.57	2.26	0.92	0.09	na

Source: Hulme 1971

As evident from the figures in Table 3, citric acid is the chief organic acid in strawberry, raspberry, and blueberry. However in blackberries, citric acid is present in trace amounts, and malic and isocitric with its lactone are the major organic acids.

Color - Attractive and appealing color is an important feature of the fruit wines. The color is due to the pigment called anthocyanin. Many types of anthocyanins naturally occur in fruits. The differences among various anthocyanin pigments are largely due to their molecular structure. The major kinds of anthocyanins found in soft fruits are shown in Table 4.

Table 4. Anthocyanins of soft fruits.

Fruit	**Major Anthocyanins**
Blackberries	Cyanidin 3-glucoside Cyanidin 3-rutinoside Pelargonidin 3-glucoside
Blueberries	Delphinidin 3-glactoside Delphinidin 3-arabinoside Malvidin 3-galactoside Malvidin 3-arabinoside Petunidin 3-glactoside Petunidin 3-arabinoside
Red Raspberries	Cynanidin 3-glucoside Cyanidin 3-sophoroside
Strawberries	Pelargonidin 3-glucoside Cyanidin 3-glucoside Pelargonidin glycoside

Source: Mazza and Miniati 1993

In an aqueous acidic media such as juice or wine, a given anthocyanin can exist in four structural forms. These forms exist in an equilibrium which is strongly influenced by pH. Thus, the relative distribution of these four forms is pH dependent. Generally at a low pH (or acidic medium), the pigments are mostly in red form, as the pH increases, the color shifts to blue, violet or purple. A further increase in pH renders the medium colorless. It should be noted that in addition to pH, several other factors influence the color. Some of the important factors include molecular structure, concentration of pigment, temperature, light, oxygen, $S0_2$ and other constituents.

As indicated in Table 4, the major pigments in blackberries include cyanidin 3-glucoside and cyanadin 3-rutinoside. In addition to the pigments mentioned above, other types of anthocyanins are also present in trace amounts. During ripening, the concentration of pigment increases along with the soluble solids. During processing, some loss of color occurs depending upon the kind of treatment given.

Two main kinds of blueberries are grown commercially. The main anthocyan in both types of blueberries are listed in Table 4. As evident from the table, a large variety of anthocyanin pigments occur in blueberries. Like blackberries, the concentration of pigment increases during ripening. Enzyme treatment of the pulp yields more intensely colored juice. In the case of lowbush blueberries, thermovinification orfermentation on the skin produces deeply colored juice or wine. Cold pressing extracts less color in the juice. Loss of color has been noted during aging of blueberry wine.

Red raspberries are more commonly grown in North America than blackberries. The main anthocyanin pigments are given in Table 4. It is interesting to note that cyanidin pigments predominant in the fruit and the amount of different kinds of cyanidin pigments present varies among the many cultivars of red raspberry grown. During processing loss of color can occur, particularly under certain unfavorable conditions. It has been noted that the pigment (color) is relatively more stable under low pH, low oxygen, and low processing and storage temperatures. Loss of color also occurs during fermentation. Cyanidin 3-glucoside is very unstable and is lost during fermentation. However, another major pigment, cyanidin 3-sophoroside, was found to be more stable. Red raspberries also contain other phenolic compounds which interact with anthocyanins, and thus influence the color. To obtain better color in wine, it may be helpful to use those cultivars which contain a greater percentage of stable anthocyanin pigment.

The strawberry is another soft fruit used in making wine. Like many other fruits, the anthocyanin concentration in the fruit rises during ripening. The main pigment in cultivated strawberries is reported to be pelargonidin 3-glucoside. Another anthocyanin, cyanidin 3-glucoside has also been found but in small amounts (see Table 4).

The pigment in strawberries appears to be relatively unstable. A loss of color has been noted during the processing of the fruit. Storage temperature is important for good color retention. Higher temperature enhances color loss. The negative impact of high temperature is enhanced due to the presence of oxygen, ascorbic acid, and metal ions. The enzyme polyphenoloxidase (PPO) also seems to play an indirect role in the destruction of anthocyanin pigment in strawberries. Blanching the fruit can overcome the adverse influence on enzyme action. Treatment of pulp with pectolytic enzymes increases the concentration of pigments in the juice. Several pectolytic enzymes are available in the market. It is prudent to conduct a small scale trial to choose the best enzyme in order to maximize color extraction. Use of pectolytic enzymes, low processing and storage temperatures, minimum oxygen exposure, low pH, and use of clean fruit (free of mold and rot) are the important factors in producing a strawberry wine with a pleasing and attractive color.

Aroma compounds - With the advent of gas chromatography, many aroma compounds have been identified. These compounds generally belong to chemical groups such as alcohols, aldehydes, ketones, acids, lactones, esters, phenols, and terpenes. The important aroma compounds found in raspberries are the 'raspberry ketone' 1-(p-hydroxy phenyl)-3-butanone, cis-3-hexen-1-o1, and μ and β ionnone. In strawberries, many aroma compounds have been identified, but the characteristic strawberry aroma cannot be attributed to anyone particular compound. The main volatile compounds contributing to ripe, blueberry aroma where reported to be trans-2-hexanol, trans-2 hexanal, and Iinolool. Aroma compounds constitute a very small portion of the many substances present in the fruit, but they have a major impact on the sensory qualities of fruit and fruit products. During the course of processing, they undergo changes and the final aroma of the processed product, such as wine, represents a combined effect of the compounds initially present as well as those transformed during the course of processing.

Pectic substances - Pectic substances are an important constituent of soft fruits. The average pectin content, expressed as (%w/w) calcium pectate was found to be 0.40 for raspberry, 0.54 for strawberry, 0.93 for blackberries, and 0.66 for blueberries.

The amount of pectic substances decreases during the ripening of soft fruits. It is important to note these compounds contribute to the problem of dejuicing and clarification during processing.

Nitrogenous compounds - Soft fruits are characteristically low in nitrogen content. The nitrogenous compounds include proteins, polypeptides, and amino acids. They are utilized by the yeast during fermentation. To facilitate vigorous fermentation of fruit musts, the addition of nitrogenous compounds such as diammonium phosphate is recommended.

Phenolic substances - Soft fruits contain a wide variety of phenolic compounds. The kind and amount of phenolic compounds is influenced by many factors such as species, variety, season, location, cultural practices, and incidence of diseases. The major classes of compounds such as nonflavonide cinnamic acid derivatives, flavonoids such as catechin, epicatechin, and anthocyanins are important phenolic constituents. The anthocyanins (pigments) have been discussed. Catechins are involved in browning reactions; they contribute to astringency and bitterness. They also play an important role as copigments, thus favorably influencing the color.

Processing Cherries and Berries for Wine -
Dejuicing Cherries
Fresh cherries can be dejuiced to make wine. In situations where fresh fruit is not available, cherry juice, syrup, or concentrate can also be used for winemaking. Using high quality fresh fruit gives greater control of the quality of the wine and should be a preferred method.

There are several ways in which cherries can be processed to obtain juice. A brief description of these methods is given below.

Hot Pressing - Cherries should be washed, pitted (e.g. using Elliot pitter), and heated in a stainless steel kettle to 140° to 150°F. The hot fruit should be pressed and the juice cooled to 50ºF and stored for settling. Clear juice should then be siphoned off the sediment and filtered. The hot, pressed juice is darker and richer in color, but can have a canned cherry aroma instead of a fresh fruity aroma.

Cold Press - Cherries are washed, pitted, and pressed in a rack and cloth hydraulic press. The juice yield varies between 61 to 68%. The flavor is good, however, the color is not as dark as hot, pressed juice.

Cold Pressing Thawed Fruit - Cherries are washed, pitted, frozen, and stored at 0ºF or lower. When needed, the fruit is thawed. When the frozen fruit warms up to 45° to 50°F, it is pressed with a hydraulic press. The freezing and thawing action breaks the cells and helps in better extraction of color. The juice can be clarified by treating it with pectolytic enzyme and filtration. This process yields 60 to 75% juice of fresher flavor and richer color. This process yields better quality juice and, due to frozen storage, fruit can be processed at a later date at the winemaker's convenience.

Berries can also be processed into juice in a similar manner; but many winemakers directly crush and use pulp (rather than the juice) for winemaking. Some vintners freeze the fresh fruit and process at a later date. The action of freezing and thawing helps in breaking the cells in fruit and thus facilitates maceration. In dejuicing pulpy fruits such as strawberries, raspberries, and blackberries, the addition of a press aid can help with dejuicing.

Must adjustment- Generally, in the case of fruit wines, the must is not naturally well-balanced for production of table wines. The sugar content is usually low and the acid content can be either too much or not enough to produce a balanced table wine. Among the fruits being considered here, raspberries, blackberries, and strawberries are low in sugar (4 to 6%); blueberries and cherries are relatively high (about 10 to 12%). To produce fruit wine of 11 to 12% alcohol by volume, a sweetening material such as sugar, syrup, or concentrate should be added to raise the sugar content to 20 to 22°Brix.

Acid adjustment is an important consideration in preparing must for fermentation. In the case of a high acid must, such as cherry, blackberry, raspberry, and strawberry, the acid content can be lowered by ameliorating the must with syrup. In the case of blueberries, the must is usually deficient in acid level and, therefore, acid addition is recommended to raise the acid content. For acidification, only the acid that is naturally present in a given fruit should be used. For example, in blueberries, citric and malic acids occur naturally and these can be added to increase acidity in blueberry must.

Must treatment - Fruit musts are prone to oxidation and microbial spoilage. To prevent these conditions, addition of sulfur dioxide to must in the range of 50 to 75 ppm is suggested. The must is also rich in pectic substances. These compounds contribute to cloudiness in wine. To facilitate wine clarification, treatment of the must with pectic enzymes is beneficial.
It should be noted that the nature of the pectic substances vary among different fruits. A given enzyme may work well in one kind of fruit and not so well in another. Therefore, several pectic enzymes preparations should be tried in order to choose the most effective one for depectinization. Nitrogen is an important nutrient for yeast growth. Generally the nitrogen content in many fruits is relatively low. To ensure vigorous and complete fermentation, the addition of yeast nutrients and diammonium phosphate is recommended.

Fermentation - Fermentation is the key process that transforms a must into wine. The basic reaction involves utilization of sugars to yield ethanol (and numerous byproducts), CO_2, and heat. To ensure clean and smooth
fermentation, a pure culture of a selected yeast strain should be used. Many strains are commercially available, and the choice of a strain depends on the winemaker's preference. However, a good all purpose strain, such as Prise de Mousse, can be used for fermenting various kinds of fruits. The yeast strains are

sold in an active dry form. They need to be properly rehydrated before inoculating the must.

A good rehydration procedure was recommended by Monk (1986), which is given below.

1. Use water, 5 to 10 times the weight of the yeast. For example, for 500 grams of dry yeast, use 3 to 5 liters of water for rehydration.
2. Rehydrate in warm water, 104° to 113°F (40 to 45°C).
3. Slowly add yeast to water to obtain even hydration. Do not add water to yeast, this will cause clumping.
4. Allow yeast to remain in warm water for 5 to 10 minutes before stirring.
5. Do not leave yeast in water for more than 30 minutes. The longer duration will reduce yeast activity.
6. Do not add rehydrated yeast to cold must. The temperature difference between yeast starter and must should not be more than 18°F.
7. To reduce the possibility of cold shock, gradually cool the starter, then add it to the must.

The procedure given above should be used as a general guideline, but it is equally important to follow the manufacturer's recommendation for rehydration and storage of yeast.

The usual rate of inoculation is about 2 Ibs/1000 gallons. However, as mentioned earlier, the recommendations of the yeast producer should be followed.

Controlling temperature during fermentation is very important. Research with grape must has shown that a fermentation temperature of about 59°F encourages the formation of volatile esters. To produce wines with good, fruity aroma, many winemakers ferment fruit must at a relatively low (58° to 60°F) temperatures. In the case of apples and cherries, where the fermenting must is juice, the temperature can be regulated by employing jacketed stainless steel tanks equipped with refrigeration. Soft fruits are usually fermented as pulp and temperature regulation during fermentation is, in this case, somewhat difficult. However, effort should be made to keep the fermentation temperature preferably under 75° to 80°F.

Depending on temperature, the fermentation can last from several days to a few weeks. Fruit wines are usually fermented dry. Following fermentation, the young cherry wines should be promptly racked and sulfited. The must of berry fruits needs to be pressed at the end of fermentation. To facilitate the pressing, a press aid, such as rice hulls, is often used. The pressed wine should be sulfited and stored in full containers.

Wine clarification - The young fruit wine is usually cloudy due to the particulate matter than remains in suspension. To clarify the wines, the suspended solids need to be removed. This is achieved by holding the wine in full containers and allowing the solids to naturally settle. The clear wine is racked leaving the lees behind. The process of clarification can be expedited by using various filters and a centrifuge.

In general, fruit wines should be clarified as soon as possible. During wine transfers, care should be taken to protect the wine from excess air (oxygen) exposure.

Fining can also be used to clarify the wine. Many winemakers use bentonite to clarify and stabilize wine.

Wine stabilization - Major acids in the fruits being considered here are malic and citric and they do not form an insoluble precipitate like tartartic acid in grapes, when the wine is chilled. Because of this difference in acid composition, cold stabilization is not a matter of concern in fruit wines.
Fruit wines can contain some heat sensitive proteins, and thus cause haze. To attain protein stability, the wine is treated with bentonite. The amount of bentonite needed varies with the kind of fruit used for making wines. A small scale laboratory trial to determine protein instability is recommended.
Besides the physical instability mentioned above, microbial instability is a great concern in fruit wines. Major acids of the fruits (malic and citric) are biologically not stable. They can be metabolized by lactic acid bacteria. Malolactic fermentation in fruit wines is not desired since it can cause significant loss of acidity, may produce undesirable changes in flavor and result in high wine pH. To discourage malolactic fermentation in fruit wines, the following steps are suggested.

1. Maintain adequate free $S0_2$ levels. (>0.8 molecular).
2. Store wines at cooler cellar temperatures.
3. Aim for lower pH (preferably <3.3) in the finished wine.
4. Use germ proof bottling (0.45 micron filter).
5. Stringent cleaning and sanitary measures during processing.

Aging and finishing operation - Fruit wines are generally bottled within 2 to 4 months following fermentation. In strawberry wine, color stability is a problem; therefore, it should be produced and marketed for early consumption. Dry apple and blueberry wines are sometimes produced with some oak aging. However, fruitier style wines are not aged in oak.

Many fruit wines are made into semi-sweet or sweet styles. To achieve this, sugar or concentrate is often used as a sweetening material. To prevent refermentation of sugar, sorbic acid is usually added. The finished wine is polish filtered or membrane (0.45 micron) filtered and bottled.

Some Critical Issues in Fruit Wine Production

Making fruit wines closely resembles the process of producing white and red table wines from grapes. However, there are certain critical issues that differentiate fruit wines from grape wines. For this presentation, the fruit wines we will consider include apple, cherry, and berry.

A brief discussion of these topics would be helpful in understanding the techniques involved in fruit wines. The first and most obvious difference is in the composition of fruit.

Fruit contains various amounts of sugar, but not in sufficient amounts to produce sound table wines. Therefore, the addition of a sweetening material is needed. There are many kinds of sweetening agents used, such as sugar, syrup, juice, and concentrate. There are legal limits on the amounts of materials permitted for sweetening. The important points to consider here are that the kind of materials used and the extent of dilution of the must, both would have an impact on sensory attributes of the must.

Organic acid composition is another key difference in the composition of fruit as compared to grapes. The main acids in the fruits being considered here are malic and citric. Generally these acids tend to give higher pH values; and they are not biologically stable. This means we need to adopt (winemaking) techniques suited to making high pH wines and also follow the measures that will discourage microbial spoilage during processing, as well as storage. It is important to note that generally higher pH (3.6 to 4.0) encourages the activity of spoilage microbes, and oxidation of wine. It results in poor color, has an impact on wine stability and the action of preservatives, such as SO_2 and sorbic acid. Another important attribute of these organic acids is that they do not form significant precipitate when the wine is chilled. Consequently, cold stability is not a matter of great concern in making fruit wines.

Fruit also contains significant amount of pectic substances. These compounds contribute to the difficulty in dejuicing the fruit and juice and wine clarification. Because of them, the use of pectolytic enzyme is crucial to fruit winemaking.

Fruit wines are also relatively more susceptible to oxidation, loss of color, and microbial spoilage. To protect wines from oxidation, judicious use of SO_2 and use of inert gases during wine transfer and storage is recommended. SO_2 also plays a key role in discouraging malolactic fermentation and microbial spoilage. As mentioned earlier, its effectiveness is influenced by pH. Periodic adjustment and the maintenance of an adequate amount of free SO_2 in wine is very crucial to making fruit wines. Following rigorous cleaning and sanitizing practices is a must for fruit wine production. Use of preservatives should not be relied upon as a substitute for sound cleaning and sanitizing measures. Fruit wines are generally produced as sweet wines. They rarely benefit from prolonged aging. They should therefore be produced for early consumption.

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