Grape Maturation and Ripening

Changes occurring during the ripening process:

Following bloom and fruit set, grape berries undergo a rapid phase of growth by cell division that transitions to growth by cell enlargement. As the berries begin to touch, growth slows that is referred to as the lag phase, and the process of maturation begins at veraison (**Figure 108**). Several changes occur during veraison:

- Skin color of colored cultivars changes from green to red, blue or black (**Figure 109A**).
- Berries begin to soften, with white cultivars becoming more translucent (**Figure 109C**).
- Sugars (*measured as* °Brix or %SS) begin to increase (**Figure 110**).
- Acids [measures as titratable acidity (TA)] begin to decrease (**Figure 110**).
- Juice pH begins to increase (**Figure 110**).

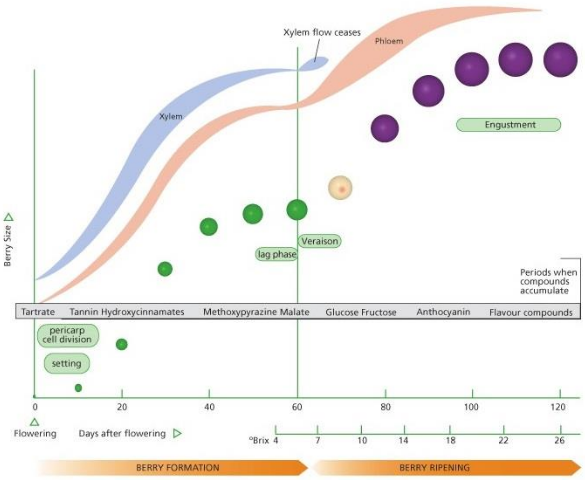

Figure 108. Grape berry development & maturation. (Illustration by J. Koutroumanidis, Winetitles)

Figure 109. Veraison in a red wine cultivar (A). Lag phase (B) and veraison (C) in a white wine cultivar.

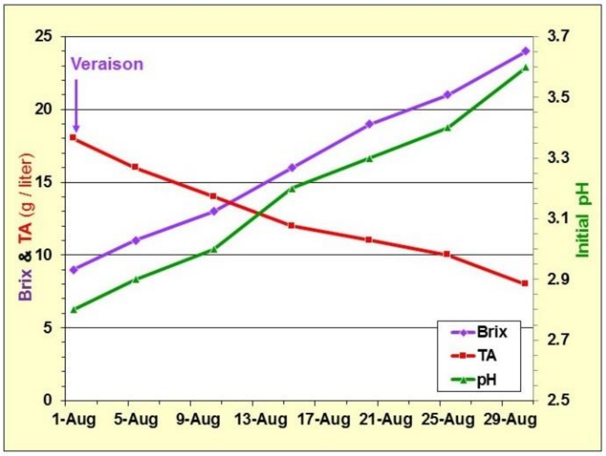

Figure 110. Changes in °Brix, titratable acidity (TA) and initial pH following veraison.

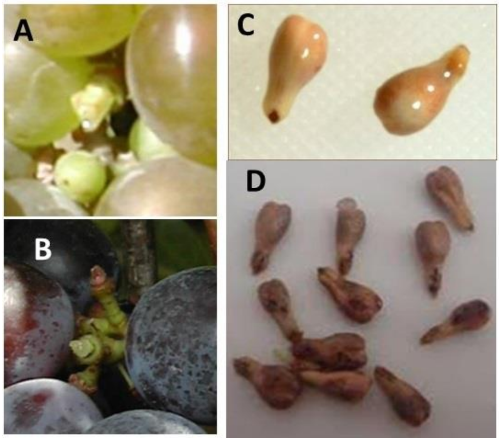

Figure 111. Pedicel/berry abscission zone: immature (A), mature (B). Seed maturity: immature (C), mature (D).

- Juice color begins to change. White's – greenish to whitish. Red's – begin to take on some skin pigment.
- Skin tannins begin to polymerize to become more desirable.
- Seed tannins (undesirable) begin to become less extractable.
- Varietal flavor components begin to increase.
- The rachis begins to mature.
- An abscission zone between the pedicel (berry stem) and berry begins to develop (**Figure 111A, B**).

- Seeds begin to mature (**Figure 111C, D**).

As these changes occur, the transport system to the berries changes from xylem transport of mostly water associated with berry enlargement to phloem transport of mostly sugars as the berries enter the engustment (ripening) phase.

Testing grape maturity:

Following veraison, you should begin testing the maturity of the grapes to determine when to harvest, and there are several tests that can be used to monitor the changes that occur during the maturation process.

Sugars: The concentration of sugars, expressed as either ºBrix or % SS, increases during maturation and can be measured with a refractometer or a hydrometer. The Brix refractometer measures the degree sugar molecules bend light as it passes through a prism with the degree of bending being associated with the concentration of sugars. The hydrometer measures the specific gravity of the sugars (soluble solids) in the grape juice. The refractometer is easy to use and can be taken into the field to sample berries, while the hydrometer requires enough juice to be floated. Sugars are important for wine making because to 1% sugar converts to 0.55% alcohol (% SS x .55 = % alcohol).

Sugars are easy to measure and are a common measurement in the wine industry, but it is not a good measure of maturity when used alone. This is particularly true for some of the Northern hybrids such as Frontenac, La Crescent and Marquette that are high in acids and can have high concentrations of sugar shortly after veraison. In addition, there is a poor relationship between sugar levels and accumulated berry flavors (Wolf, *editor*, 2008).

Initial Juice pH: During maturation, juice pH increases and is measurable with a pH meter. Juice pH is important because wine balance or the perception of sourness or tartness, aroma, microbial stability, and physiochemical stability of the wine. When grapes harvested at a below optimal juice pH, the wines tend to be sour, herbaceous and lack character. At a pH above 3.5 to 3.6, wines may be "flat" in character, more prone to microbial infection, more oxidized and have less color, and have less desirable flavors (Wolf, *editor*, 2008).

Titratable acidity (TA): During maturation the organic acids in the juice decline, and this can be measured as titratable acidity. It requires a pH meter to measure the amount of a strong base [0.1 N sodium hydroxide (NaOH)] to neutralize the juice to an end-point of 8.2 pH for tartaric acid. Titratable acidity is expressed as either the percentage acidity (% TA) or grams of acid per liter where 1 % TA is equivalent to 10 g/liter TA. Titratable acidity serves as a measure for developing a sugar/acid balance of the juice and determines how sweet a wine needs to be finished to maintain a good balance (Wolf, *editor*, 2008).

The ºBrix, initial juice pH and TA are measurable indicators of maturity and when used together, provide good guidance in determining when to harvest, and optimum maturity indices have been developed for different styles of wine (**Table 39**).

Table 39. Optimal juice ºBrix, initial pH and titratable acidity (TA) for different styles of wine.

Wine Style	ºBrix (% SS)	Initial pH	TA (g / liter)
White table wine [z]	21 - 22	3.2 – 3.4	7 – 9
Red table wine [z]	22 - 24	3.3 – 3.5	6 – 8
Sparkling wine [y]	17 - 20	2.8 – 3.2	7.0 – 9.0
White table wine [y]	19 - 23	3.0 – 3.3	7.0 – 8.0
Red table wine [y]	20 – 24	3.2 – 3.4	6.0 – 7.5
Sweet table wine [y]	22 – 25	3.2 – 3.4	6.5 -8.0
Dessert wine [y]	23 – 26	3.3 – 3.7	5.0 – 7.5

[z] Dharmadhikari and Wilker. 2001. **Micro Vinification**, a practical guide to small-scale wine production.

[y] Wolf, *editor,* 2008. **Wine Production Guide for Eastern North America**.

These are optimal indices, but for Northern hybrids that are characteristically high in acids, grapes are typically harvested before the TA drops into the optimal range. Often the initial pH is allowed to approach the upper end of its optimal range to allow the TA to come down to a reasonable level.

Other tests for measuring changes that occur during the grape maturation process are available and can aid in determining when to harvest. However, they are subjective measurements, and often require several years of experience to master. These measures include:

Skin tannins: As grapes mature the skin tannins polymerize from short chain to long chain molecules. With practice, this change can be detected on the tongue, particularly with red cultivars. Un-polymerized "unripe" tannins cause friction in the mouth when they bind with salivary proteins, while polymerized "mature" tannins cause less binding with the salivary proteins. To test for skin tannins, separate the skins form the berry pulp and chew it to release the tannins. Then press and move your tongue against the roof of your mouth (palate). If the tongue sticks or binds against the palate, the tannins are "green" or gripping and less mature. If the moves freely and "slides", the tannins are judged smooth or "silky" and more mature (Wolf, *editor*, 2008)

Berry detachment: As grapes mature an abscission zone begins to form between the pedicle and berry, and ease of berry detachment can serve as an indicator of maturity. When detaching a berry from a cluster, observe where the pulp and skin detach cleanly from the pedicel. If some pulp and/or skin remain attached to the pedicel (**Figure 112A**), the berry is considered un-ripe. If the no pulp remains attached to the pedicel (**Figure 112B**), the berry is judged to be ripe (Wolf, *editor*, 2008). Once the abscission zone is formed, the berries will not mature any further, but can become sweeter from of dehydration. For cultivars such as La Crescent that are prone to shelling, checking for the beginning of berry detachment is an important procedure for determining when to harvest.

Seed maturity: As grape seeds mature, their color changes from green to brown to dark brown. This color change is associated with oxidative reactions and corresponds with the decrease in extractable seed tannins. Seed color has been used as an indicator or maturity, but uniform and complete brown seed color is seldom achieved in Eastern and Midwestern vineyards (Wolf, *editor*, 2008).

Aroma and Flavor: Both aroma and flavor can be used as indicators of grape maturity. With training human sensory skills can be developed to recognize flavor, aroma, sweetness and acidity development that characterize the maturation of a particular grape cultivar. However, it takes years of experience to develop these skills. It is one of the few ways to assess "balance" (Wolf, *editor*, 2008).

Table 40 summarizes these maturity tests that can be conducted for determining when to harvest and provides guidance regarding there use.

Table 40. Harvest parameters that can be performed to determine when to harvest wine grapes.

Harvest parameter	Run the test?	Comments
°Brix	Yes	Test along with initial pH and TA.
Initial juice pH	Yes	Test along with °Brix and TA.
Titratable acidity	Yes	Test along with °Brix and initial pH.
Skin tannins	Check	Use along with °Brix, initial pH and TA.
Berry detachment	Check	Use along with °Brix, initial pH and TA as an indicator.
Aroma	Maybe	Along with °Brix, initial pH and TA, learn to develop the skill to detect changes for each cultivar.
Flavor	Maybe	Along with °Brix, initial pH and TA, learn to develop the skill to detect changes for each cultivar.
Seed color	Maybe	Use along with °Brix, initial pH and TA as an indicator.

Collecting a sampling to test for maturity:

Sampling to test for maturity should begin following veraison. Initially it can be done in the vineyard with a refractometer to determine when to begin collecting a larger sample to run a more through test for °Brix, juice pH and TA. When collecting a sample, it is very important to collect a sample that is representative of the crop. Grape maturity is not uniform between vines, within vines and within grape clusters. Differences in maturity between clusters on a shoot and berries within a cluster exists because they bloom at different times (**Figure 112A**). Berries near the top of the cluster will be more mature than those near the end (tail) of the cluster (**Figure 112B**). In addition, differences will exist between sun-exposed berries and those in the shade.

A sample can consist of whole clusters or berries. Collecting clusters overcomes the variability within clusters and is often necessary if a hydrometer is used to determine °Brix. At least 10 clusters representative of the vineyard should be collected. When berries are collected a sample should consist of 100-200 or more berries collected over the vineyard with no more than two berries collected from a vine. Because berries on a cluster vary in their maturity, the sample should consist of berries collected from the top, middle and bottom of the clusters as well as being collected from the sun-exposed and shaded sides of the clusters. An alternative procedure is to collect berries from the mid-portion of the clusters. If green berries are present, they should be included in the sample in proportion to their presence in vineyard, unless they will be separated out before or during the crush.

Figure 112. Difference in bloom between clusters on a shoot and within clusters (A), and maturity of berries on a cluster (B).

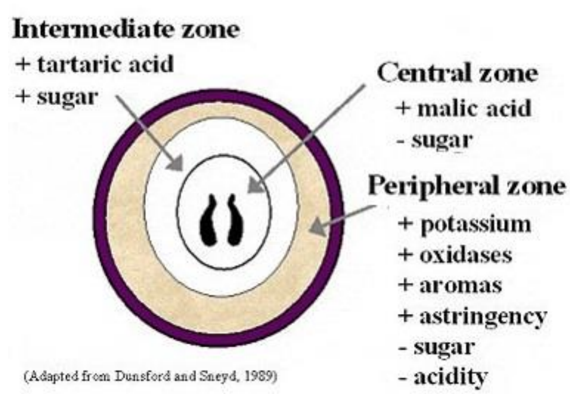

Figure 113. Location of juice components within a grape berry (Zoecklein, 2001).

When preparing the sample for testing, it is important to thoroughly crush the berries because the components in the juice are located in different regions of the berry (**Figure 113**). Samples can be either crushed or blended. Crushing is quick and easy, and gives a good estimate of maturity. It is better suited for white wine cultivars because it can miss skin tannins in red wine cultivars, but this not a critical issue when determining when to harvest. When using a blender, the berries are blended for six seconds. The procedure is more time consuming but gives a better estimate of maturity. It is best suited for red wine cultivars and is probably overkill for white wine cultivars.

Calculating TA:
A pH meter is needed to determine the initial juice pH and TA. Other items needed include: pH 4 & 7 buffer solutions, 0.1 N sodium hydroxide (NaOH), buret & buret stand, beakers, 10 ml & 100 ml graduated cylinders, magnetic stirrer & stir bars. To determine the TA, 5 ml of grape juice (diluted with distilled or de-ionized water is titrated with 0.1 N NaOH to a pH of 8.2. Using the buret, the milliliters (ml) of 0.1 N NaOH needed can be accurately measured and the TA can be calculated (**Table 41**). Because tartaric and malic acids in the juice are organic acids and exhibit a buffering capacity, the change in pH is not directly proportional to the amount of NaOH added (**Figure 114**).

Table 41. The basic formula for calculating the Titratable Acidity (TA).

Basic formula	$\%TA = \dfrac{\_\_\_\_\text{ml NaOH x }\_\_\text{normality of NaOH x .075*}}{\_\_\_\_\text{ ml of grape juice}} \text{ x 100}$
Using 0.1 N NaOH & 5 ml grape juice	$\%TA = \dfrac{\_\_\_\_\text{ml NaOH x } \underline{0.1} \text{ N NaOH x .075*}}{\underline{5} \text{ ml of grape juice}} \text{ x 100}$
Example: used 8 ml 0.1 N Na OH to titrate to pH of 8.2	$\%TA = \dfrac{\underline{8} \text{ ml NaOH x } \underline{0.1} \text{ N NaOH x .075*}}{\underline{5} \text{ ml of grape juice}} \text{ x 100} = \textbf{1.2\% TA}$
Convert %TA to g/liter TA	**1.2** %TA x 10 = **12** g / liter TA
Short cut when using 0.1 N NaOH & 5 ml grape juice	g / liter TA = ___ml 0.1 N NaOH x 1.5 g / liter TA = **8** ml 0.1 N NaOH x 1.5 = **12** g / liter TA

* Conversion factor for tartaric acid

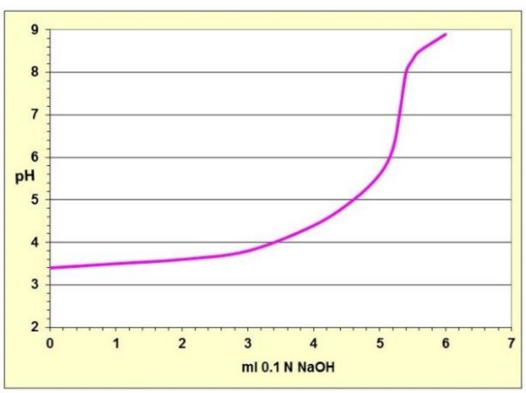

Figure 114. Typical titration cure for grape juice.

Grape Maturity

Cultivar:				Year:			
Date	Total berry wt. (g)	No. of berries	Avg. berry wt. (g)	°Brix (% SS)	Initial pH	TA (g/liter)	Comment

Figure 115. An example of a recording sheet that can be used to monitor changes in grape maturity during the season and from year to year.

Maturity testing results should be recorded for the growing season and maintained from year to year (**Figure 115**). By maintaining such a record, changes in maturity can be plotted (**Figure 110**) and aid in predicting when to harvest. Wolf (2008) presents an example of a maturity evaluation sheet that includes the subjective maturity indicators.

Vineyard Best Management Practices – Grape Maturation and Ripening

Rate your pre-harvest vineyard practices:

Management Area: **Evaluating when to harvest**	**Best Practices**	**Minor Adjustments Needed**	**Concern Exists: Examine Practice**	**Needs Improvements: Prioritize Changes Here**
Maturity testing	Evaluate juice ºBrix, initial pH and TA, on a weekly basis following veraison; and develop skills to use one or more of the subjective measures of maturity.	Evaluate juice ºBrix, initial pH and TA on a weekly basis following veraison.	Begin evaluating juice ºBrix, initial pH and TA about a week before you think it is time to harvest.	Evaluate juice ºBrix to determine when to harvest.
Record keeping	Maintain annual records of maturity test results.			Do not maintain annual records of maturity test results.

Making Wine from Minnesota Grown Grapes*

As early fall harvest season approaches, many grape growers become interested in and enthusiastic about making wine from part or all of their harvest. At this point, it's important to remember that different grapes are suited for different uses; fruit that can be delightful for jelly production or eating out-of-hand is often unsuitable for wine making. Table and juice grapes often have lower sugar, lower acid, lower skin-to-pulp ratio, and fewer seeds than wine grapes; making palatable table wines from these grapes may be tricky at best and impossible at worst.

In the realm of wine grapes, a differentiation should be made between French-American hybrid grapes, Swenson cultivars, and cold-hardy hybrids with *V. riparia* ancestry. French-American hybrids, like Maréchal Foch and Leon Millot, contain lower acid and sugars, have low to moderate tannins in red cultivars, and may have herbaceous notes. Swenson's varieties, which are largely based on *V. labrusca*, may have sugar low enough to require chapitalization (the addition of sugar) and acids similar to French-American hybrids. St. Croix and St. Pepin are examples of Swenson cultivars often used for quality wine production. Some, like Edelweiss, show their *labrusca* heritage in characteristic 'foxy' flavors, which will be present in the final wine; this can be an asset or a major flavor flaw, depending on personal taste. The newer UMN cold-hardy hybrids, like Frontenac and La Crescent, have enough wild *V. riparia* in their make-up that they produce much higher acids and sugars when ripe. With these cultivars, it's important to allow grapes to fully ripen before picking, and to be prepared to perform acid reduction if necessary.

The first step in successful winemaking is harvesting grapes at the appropriate ripeness, which varies from cultivar to cultivar. In this area we generally need from 6 to 8 weeks of hot, sunny weather after the grapes have changed color (veraison) before they are at the proper sugar/acid level to be picked. As the sugar in the grape increases, the acid content decreases. To a winemaker it is important that the grapes be picked only when the best balance possible is achieved; this balance can often be measured only by careful and experienced tasting. Generally, sugar concentrations in locally grown grapes will reach 18° to 24°Brix depending on cultivar and growing conditions; for low sugar varieties, it's a good idea to sweeten to 22°Brix to produce a finished wine with 11-12% alcohol. Acid concentrations in Minnesota grapes will range from 0.8% to 1.3%.

Sometimes frost arrives before the grapes are fully ripe. If this occurs, grapes must be harvested immediately, as they will no longer ripen and the vine may sustain damage that will impair its ability to survive winter. Harvest in the Minneapolis/St. Paul area usually occurs between the last week in August and the first week in October, depending on grape cultivar. You should not schedule any spraying within 10 days of harvest as the residue may get into the wine and either inhibit fermentation or lead to the formation of off odors in the wine.

Once you have harvested the grapes it is essential to cull diseased and damaged grapes prior to crushing. Do not use anything except sound, ripe fruit. Washing fruit is usually unnecessary, and water will be absorbed by the grapes, causing dilution of sugars and flavor.

At this point, specific processing methods depend on the type of grape to be fermented, whether the grape is red or white, and the desired wine style. A general method is listed at the end of this section, but a good home winemaking book or webpage will provide detailed information about processing specific varieties and styles. Developing a good relationship with your local amateur winemaking store is highly recommended.

The initial processing step is crushing and destemming. Crushing involves simply breaking open the grape skins, so that the grape juice can begin to leak out. Grapes may be removed from the stems by hand prior to crushing, or whole clusters may be run though a crusher and the stems removed afterwards. Stems will leach bitter tannins into the wine, so removing as many as possible is key to fine wine production. Once the stems are separated from the must (the crushed grapes in their juice) grapes may be pressed to remove the juice for white wine production, or fermented on the skins (maceration) to produce red wine. For white wine production, the must is pressed, and the juice settled for 24 hours with the aid of pectic enzyme to allow the gross lees (suspended pieces of pulp and other field trash) to settle to the bottom. The clear juice can then be racked off, and fermentation started. For red wine production, yeast is added to the must and the juice is fermented on the skins for 3-5 days to extract color and flavor, then pressed and allowed to finish fermentation off the skins.

After fermentation is complete, wines must be racked into a full container, as air contact results in oxidation and conversion to vinegar. At this point, adjustments to acid can be made, and additional racking and fining, if necessary, can be performed to obtain a clean, bright finished product. Clearing and aging may take from 3 months to 3 years, depending on the wine. It is important to emphasize that cleaning and sanitizing all equipment is a must. Spoilage organisms occur naturally on both the fruit and in the atmosphere, and must be dutifully battled to prevent wine loss.

A note on additives: most Minnesota grapes contain high acids, so addition of tartaric or acid blends are generally unnecessary. Adding appropriate enological tannins may be desired for some wine styles, but their use is tricky and not recommended for the beginner.

For most home winemakers, the easiest way to make a sweet wine is to first ferment the original wine to dryness, then back sweeten with table sugar. This method allows small-scale sweetening trials, so exactly the right acid/sugar balance can be achieved. When sweetening a wine, it is necessary to add the stabilizer potassium sorbate at the same time as the sugar to prevent further fermentation. Potassium sorbate must be added in the correct dose and all at once, so careful reading of product directions is essential. Adding additional sugar at the start of fermentation will not produce a sweet wine- rather, the sugar will be converted to alcohol, making a dry wine with higher alcohol content.

Basic ingredients for one gallon of grape wine:

15# ripe wine grapes, culled to remove diseased fruit

Sugar (if needed, recommended if harvest Brix is less than 22°)

1 tablespoon wine yeast, rehydrated prior to use

1 tablespoon yeast nutrient

1 oz pectic enzyme (added to white juice prior to fermentation; not used in reds)

1 campden tablet (SO_2)

* Rewritten by Anna Katharine Mansfield. 2006. University of Minnesota