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Predicting harvest date using berry sugar accumulation

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Sugar loading can be defined as the accumulation of the quantity of sugar per berry, expressed as milligrams (mg) per berry, from *véraison* onward. *Véraison* corresponds with the onset of fruit maturation.

In the grapevine, fruit maturation starts with an abrupt softening of the berry (within 24 hours). This softening goes hand in hand with sugars being actively introduced into the berry (sucrose rapidly hydrolyzed into hexoses: glucose and fructose). In red and black cultivars, *véraison* is characterized, after softening, by skin coloring as a result of the biosynthesis of anthocyanins.

Accumulation of sugar loading in grape berries gives an indication of the ripening process from a new perspective and is a novel approach to identify practical indicators to obtain particular styles of grapes and wine. Sugar loading may also provide information about ripening kinetics and enable the principal phases of ripening to be distinguished.[8] This information provides a greater understanding of how grape quality develops in the vineyard.

Sugar loading calculation

Phloem sugar transport, principally to the flesh cells, has been characterized in studies of plant-to-berry sugar loading and phloem sugar unloading, notably by the peripheral vascular system of the berry.[11] Phloem sugar unloading into cell vacuoles occurs mainly via an apoplastic mechanism, which requires the intervention of hexose transporters.[1,9]

From the above-mentioned studies, it can be concluded that sugar loading into the berry, coupled with the dynamics of sugar concentration changes, may be considered a useful indicator of grape quality. It takes into account the accumulation of sugar per berry (mg per berry) and therefore enables the kinetics of sugar concentration changes to be monitored.

Kinetic monitoring of the quantity of sugar per berry may be considered as a method of measuring the vine's physiological functioning[4,5,7,9] and in particular photosynthesis, which is a reliable indirect indicator of temperatures to which the vine is subjected under given conditions for a specific time period and grapevine water status.

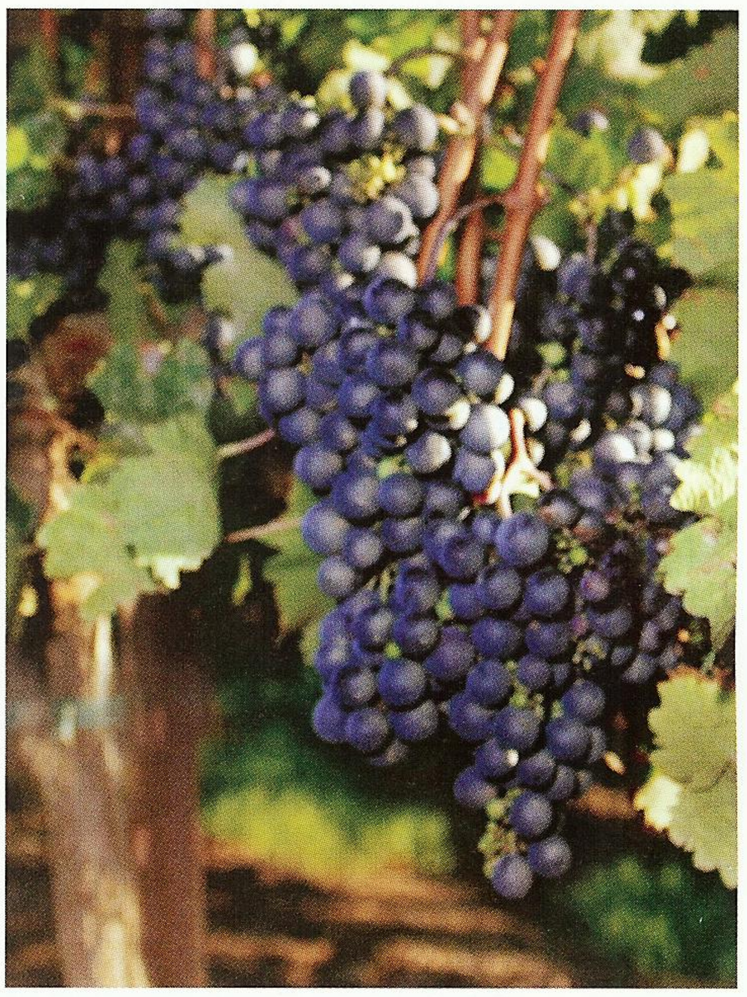
Active sugar loading is calculated on the basis of berry volume (or berry fresh mass) and sugar concentration.[3,9,10]

Example of sugar loading calculation

For a berry with a ripeness level of 25° Brix:

1. Convert 25° Brix to probable alcohol:
25 x 0.59 = 14.75° in probable alcohol, where 0.59 is the coefficient used for yeast activity to convert Brix to probable alcohol (this coefficient to be adapted to the probable alcohol level).

2. Determine mg of sugar per ml probable alcohol:



To obtain 1° probable alcohol, 17 grams per liter (g/L) of sugar is required. 14.75° x 17 g/L = 250.75 g/L, which is equivalent to 250 mg of sugar per ml (in this example).

3. Calculate quantity of sugar per berry:
In addition to measuring °Brix, the volume of a berry (or berry fresh mass thereof) should also be measured so that the quantity of sugar per berry can be calculated. Approximately 50 berries should be used to determine berry fresh mass so that the single berry fresh mass is an average of a berry population.

To determine quantity of sugar per berry, multiply 250 mg x the volume of a berry (or the berry fresh mass thereof, because for many varieties there is a linear correlation between berry volume and fresh mass).

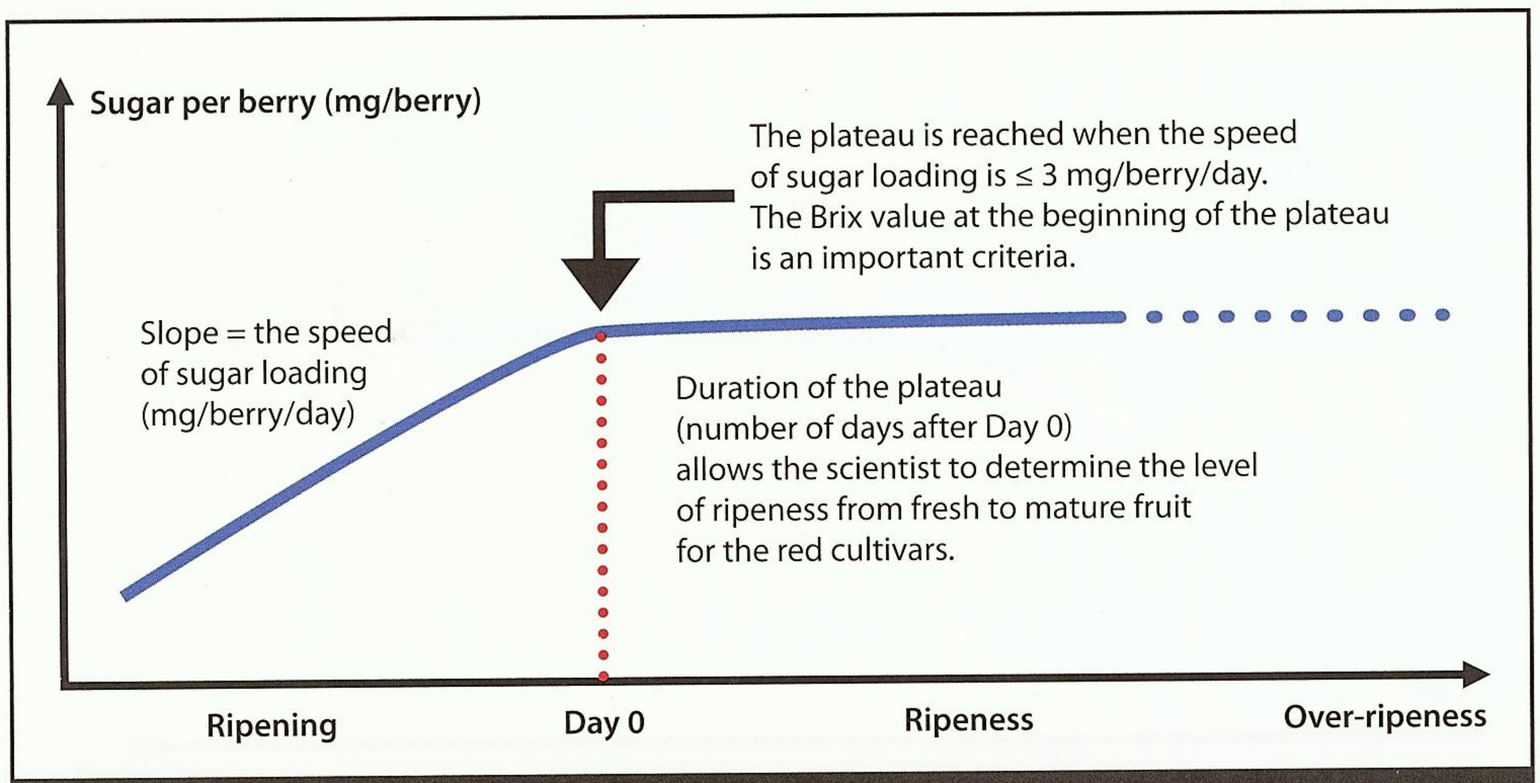


Figure I — Berry sugar loading concept: This theoretical curve is based on data obtained over five years with at least 20 different grape varieties in different countries, principally France, Spain, Argentina and Chile. This curve has been recently calibrated for some South African viticulture areas and cultivars (in collaboration with Distell).

Please take into consideration that this calculation is only an approximation of sugar loading into berries. This is due to many reasons, among others: seed volume and number, sugar distribution between skin and pulp. Despite the calculation being an approximation with shortcomings, it nevertheless is a useful indicator, and its use is becoming more common.

Profiles of sugar loading

It is possible to distinguish three principal sugar loading profiles:

1. Continual and rapid loading — This type of sugar loading occurs from *véraison* and is related to the active functioning of carbon production sources (leaves) that supply plant sinks (berries, secondary shoots etc.) during their growth phases. It is therefore often associated with significant vegetative growth and greater berry volume. Phenolic maturity is not affected. This type of loading is often considered beneficial for production of rosé, fresh fruity red wines or pleasant aromatic white wines.

2. Slow sugar loading/inhibition of ripening — Low sugar content per berry, associated with a slow loading rate, can be considered to "block" ripening, and this could be indicative of vine imbalance. If major physiological problems such as mineral deficiencies, viral diseases, etc., are excluded, blocked ripening can often be related to excessive water deficit, heat waves or an excessive crop load in relation to the exposed leaf surface.[5]

In all grape varieties, this type of situation is far from ideal in terms of standard vinification practices in white and dry red wine production. Furthermore, in relation to red and black grapes, this situation may be associated with blocked technological and phenolic maturities. Ultimately, it may be necessary to adapt the fermentation procedure to this type of grape, with thermovinification and short maceration with limited extraction being preferred options.

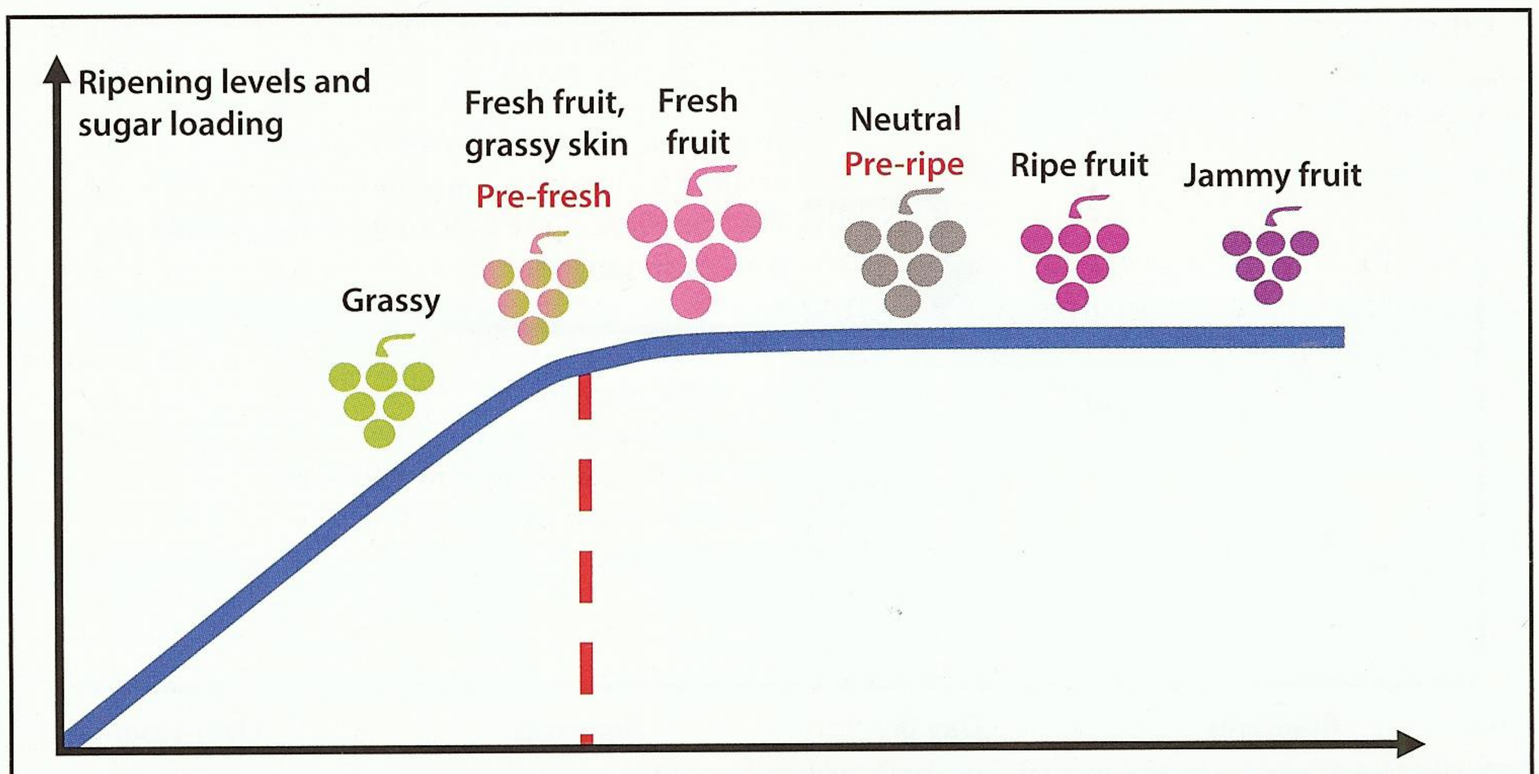


Figure 2: The berry aromatic sequence of most red cultivars is indirectly related to potential wine style (Vivelys and Deloire, 2008).

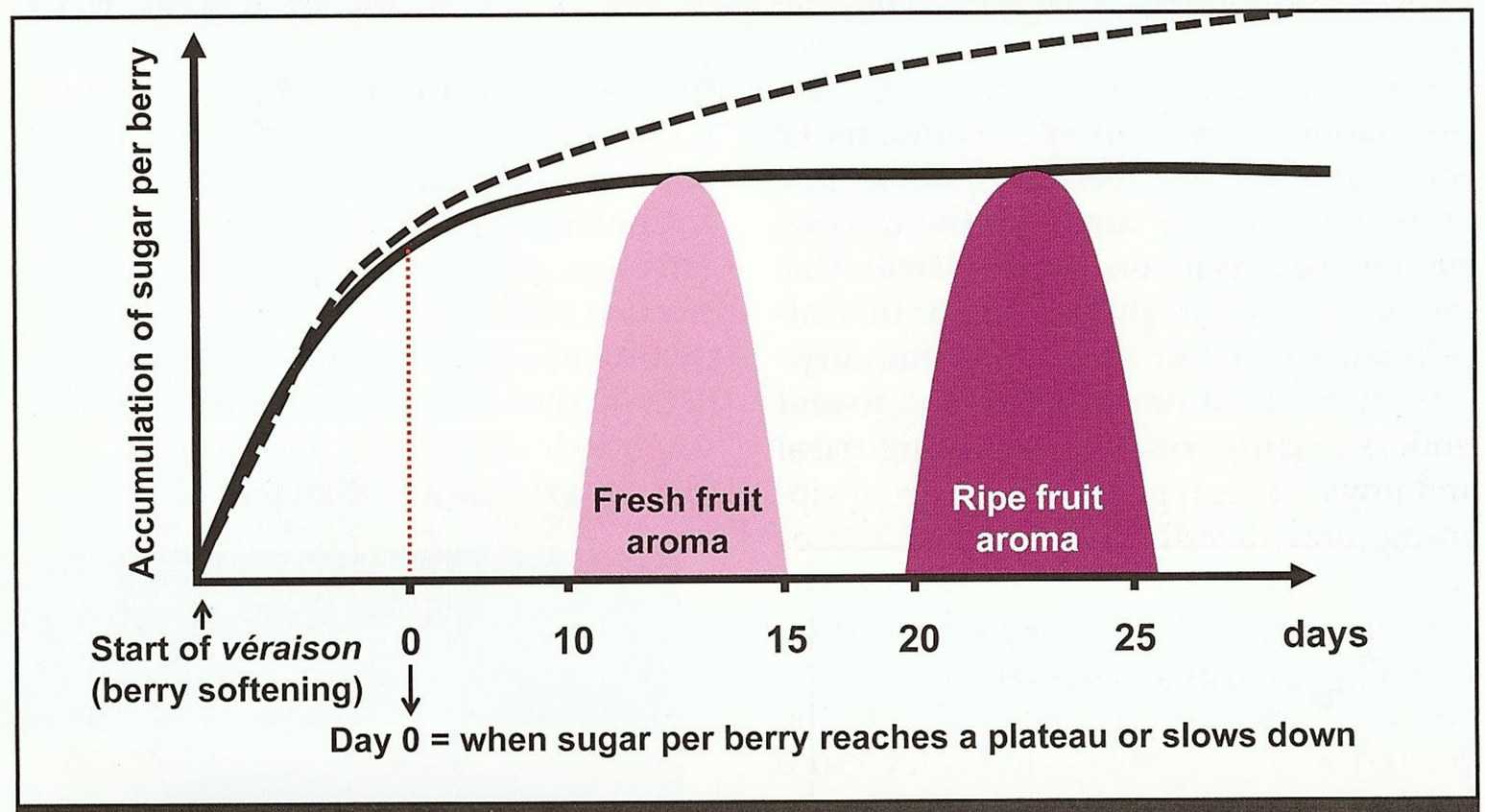


Figure 3 — Sugar loading and wine style: Example of relationships between berry sugar loading curve and potential related wine styles for Merlot. After "Day 0," three successive main periods have been determined: a fresh fruit period, a "neutral" or pre-ripe period and a mature fruit period. In terms of harvest dates, these periods have been determined according to the number of days after "Day 0," which correspond to the sugar-loading "plateau," or slowing down and not directly to a calendar date. This introduces the concept of a "physiological clock."

3. Sugar loading presents a plateau phase — Vines showing this tendency present a phase of active sugar loading in the berry (ripening), followed by a plateau representing a cessation of sugar loading (or a slowing down of sugar accumulation), and corresponding to maturity.[9] In some cases, there is a third phase corresponding to a possible decrease of the quantity of sugar per berry (over-ripening). To date a probable explanation for the occurrence of this phase has not been identified.

Theoretical berry sugar loading curves (accumulation of berry sugar content over time) are presented in Figure 1. The implications of this curve in terms of defining the finished wine are important. Depending on whether grapes are harvested in the early, mid-, or later stages of the plateau phase, the wine will be characterized by fresh fruit, neutral-spicy/pre-ripe or mature fruit flavors, respectively (see Figure 2).

Berry Aromatic Sequence (BAS)

The curve in Figure 2 demonstrates that selection of a harvest date according to the quantity of sugar per berry in conjunction with other indicators (titratable acidity, malic and tartaric acids, pH, berry volume, berry tasting, tannins, anthocyanins, etc.) enables different wine styles to be produced. Hence, for a balanced red wine, complete ripeness will be achieved between one and five weeks after the cessation of sugar loading (see Figure 3).

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