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Plasticity of red wine sensory profiles: improved understanding through grape berry sugar loading profiles

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Reproducible aromatic red wine styles can be predicted based upon the measurement of grape berry sugar accumulation (corresponding to the quantity of sugar that accumulates per berry; mg/berry/day) and berry fresh mass. Distinct maturity stages, "Fresh Fruit" reminiscent of fresh/red fruits notes and "Mature Fruit" associated with dark fruit and plum characters could be correlated to berry sugar accumulation (mg/berry) and berry fresh mass evolution without any direct relationship with berry sugar concentration. After berry sugar accumulation plateaued, wine aromatic and phenolic maturity were uncoupled from technological maturity.

Context

A critical aspect in the role of a viticulturist or winemaker is to predict harvest dates in order to help to produce the desired wine style. Within the context of global warming, wine producers need, more than ever, objective indicators of grape maturity to inform and assist harvest timing decisions. Therefore, considerable interest in the progressive development of grape-derived flavour precursors during berry ripening has garnered the attention of researchers[1 2 3 4].

The decision to harvest grapes for wine production is often determined by measuring grape sugar concentration as total soluble solids and expressed as °Brix (technological maturity). °Brix may be the sole criteria for harvest decision or considered in combination with basic analytical parameters related to berry acidity (pH, titratable acidity)[4] and colour for red cultivars. Analysis of colour provides an indication of phenolic maturity and is assessed by the measurement of anthocyanin and tannin content in grape skins and seeds. Another common method, in particular for the assessment of flavour maturity, is the evaluation of berry maturity by tasting. While berry tasting is relevant, it can be highly subjective as the perception of flavours is influenced by the taster's personal experience and training[5]. Finally, while wine aroma is one of the most important components of wine quality, the methods mentioned above provide little objective information in regards to the grape juice aromaticity or the resulting wine aromatic profile. Van Leeuwen *et al.*[6] recently proposed an aroma wheel with increasing levels of aromatic maturity nuances. In the same time, the wine industry needs some objective indicators which are easy to measure to decide when to harvest. We propose a method for growers and winemakers to objectively predict wine aromatic profile evolution during ripening by measuring simple physiological grape parameters linked to vineyard growing conditions.

How to improve the choice of the harvest date for red cultivars?

A recent concept suggested that the speed of berry sugar loading or accumulation, corresponding to the quantity of sugar that accumulates per berry (figure 1), could be used as a physiological indicator of grape vine functioning to predict harvest dates 12 to 40 days in advance based on the possible wine aromatic profile[7]. Recent work using untargeted screening showed a coherent evolution of the wine volatome between Shiraz wines made from sequential harvest based on berry sugar accumulation model[8]. This investigation identified a total of 1276 compounds including; terpenoids, norisoprenoids, esters, acids, higher alcohols, sulfur compounds and ketones in Shiraz wines that were made from 4 different vineyards located in the same meso-climate. A total of 175 compounds were found to significantly contribute to the separation of samples according to the harvest date despite a temporal gap of a week between designated harvests and differences in various vineyard management strategies.

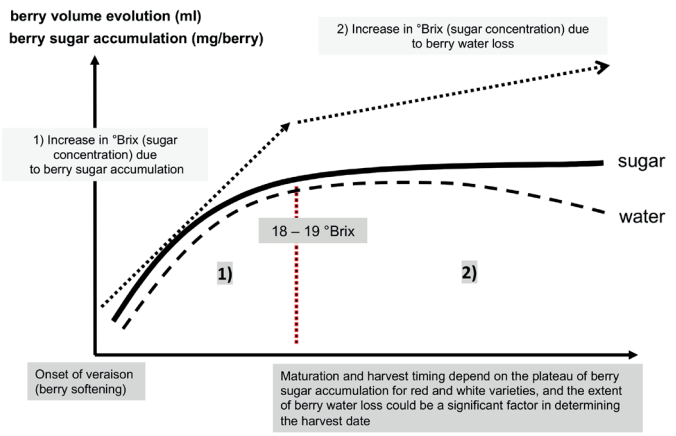


FIGURE 1. The "theoritical" principal of berry sugar and water accumulation (adapted from: Deloire, 2011)[9].

The objective of our study on Shiraz/Syrah and Cabernet-Sauvignon was to highlight the existence of reproducible aromatic wine styles using sequential harvests. This was achieved by the measurement of grape berry sugar loading and berry mass integrated with a subsequent quantitative grape and wine compositional and sensory approach. Wines were made from grapes sourced during two consecutive vintages from six characterised vineyards located in three different mesoclimates of Australia. Wines were evaluated using sensory descriptive analysis and a comprehensive set of grape and wine chemical analyses were determined. The evolution of wine sensory profile-wine composition-grape composition nexuses was also investigated[10].

1. Berry Sugar loading measurement to predict harvest date

Berry sugar loading and fresh mass curves were determined on a berry population for all plots and the results are described in Antalick *et al.* (2021)[10]. The model of berry sugar accumulation studied on a per berry basis[11] suggested that the plateau of berry sugar accumulation is reached at 1 M (18 - 19 °Brix). The model proposed by Shahood *et al.* (2020)[11] for individual berries is certainly the most appropriate for addressing the molecular, metabolic and compartmentation events that regulate fruit development in a grapevine at a single fruit level. On the other hand, the evolution of sugar per berry of a population of berries is a more relevant physiological indicator to determine the plateau of sugar accumulation and harvest date for specific wine styles as previously suggested[7 8]. In our study from a population of berries, the plateau was reached around 20 ± 1 °Brix. From that level onwards, any sugar gain is mostly due to berry water loss and ultimately shriveling.

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From the plateau of berry sugar accumulation two harvest dates were determined according to the proposed method (figure 2): the first date for the fresh fruit wine (FF) and the second date for the mature fruit wine (MF).

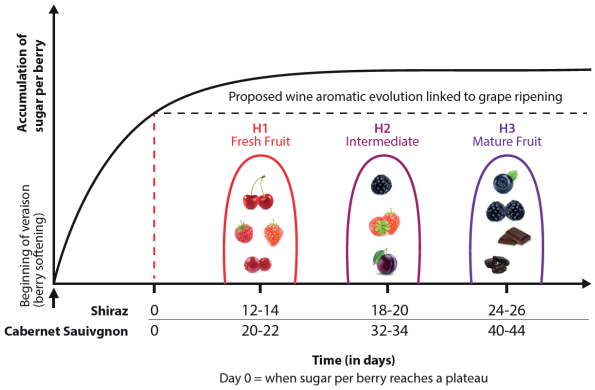


FIGURE 2. Proposed method for determining optimum harvest dates in relation to the potential wine style based on sugar accumulation per berry for Shiraz and Cabernet-Sauvignon.

2. Wine sensory analysis

In 2014, a similar aromatic evolution was observed for Shiraz and Cabernet-Sauvignon wines from the Griffith region. "Fresh Fruit" wines (FF) were associated with red fruit and herbaceous attributes such as tomato leaf, green olive and specifically capsicum for Cabernet-Sauvignon. In Shiraz, FF wines were perceived as more acidic, a finding that was not obvious for Cabernet-Sauvignon. Conversely, "Mature fruit" wines (MF) were characterised by dark fruit, plum characters, higher astringency and were perceived as more alcoholic. In 2015, an intermediate harvest was performed between FF and MF stages. Wines showed a similar pattern of aromatic evolution between FF and MF irrespective of the variety, site and climatic conditions across regions and vintages[10]. Descriptors such as red fruit, dark fruit and plum consistently discriminated "Fresh Fruit" from the "Mature Fruit" stages. In contrast, wine sensory profiles from the intermediate harvest date could not be distinctively defined (Figure 3).

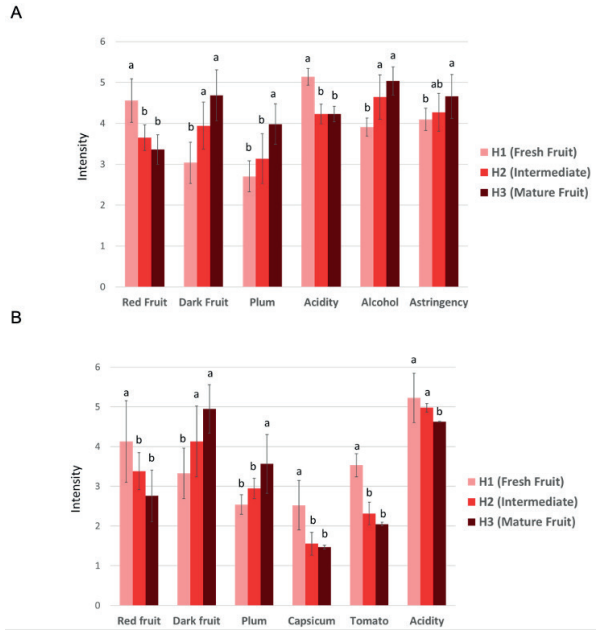


FIGURE 3. Mean rating ±SD of sensory attributes intensity showing significant differences assessed in 2015 Shiraz wines (A: n =18 per harvest date) and Cabernet-Sauvignon wines (B: n = 6 per harvest date) between harvest dates (H1, H2, H3). One-way ANOVA was used to compare data. Different letters above bars indicate significance at $p < 0.05$ (Fischer's LSD). All quoted uncertainty is the standard deviation of 18 Shiraz (A) and 6 Cabernet-Sauvignon (B) wines respectively.

Therefore, performing a simple sequential harvest based on grape sugar concentration alone does not provide a guarantee of the aromatic attributes in the final wine. Instead, sugar loading per berry was found to be more synchronised with aromatic characteristics perceived in the respective wines.

The investigation on the wine volatile composition/sensory nexus revealed that both grape and yeast-derived compounds were affected by grape maturity. A few individual compounds could be considered as maturity markers common to both Shiraz and Cabernet-Sauvignon wines. The contribution of dimethyl sulfide (DMS) to dark fruit aroma specific to Mature Fruit wines was the most relevant marker to discriminate Fresh Fruit from Mature Fruit stages. Some cultivar specific markers with potential sensory contribution were also identified. In particular, (Z)-3-hexenol appears to contribute to fresh fruit aroma in Shiraz wines. The evolution of terpenoids seemed overall to be uncoupled from sugar accumulation during late ripening. In contrast, ester composition was significantly different in Shiraz and Cabernet-Sauvignon wines, however a consistent trend was still observed between the maturity stages. The complex nexuses between grape composition, wine composition and the wine sensory profile were difficult to define. The relationships are complicated due to a number of possible factors including; other compounds that were not analysed, effects of yeast metabolism and sensory interactions influencing wine perception.

Conclusions

The present study has highlighted the existence of a predictable aromatic sequence during ripening for both Australian Shiraz and Cabernet-Sauvignon from different mesoclimates. Two distinct maturity stages, namely "Fresh Fruit," reminiscent of fresh/red fruits notes and "Mature Fruit," associated with dark fruit and plum character were consistently evident. The dynamic of the aromatic evolution could be correlated to berry sugar loading and berry fresh mass evolution without any direct relationship with berry sugar concentration. Therefore, sugar loading and berry fresh mass could be used as additional physiological indicators to assess vineyard functioning. After berry sugar accumulation plateaued, wine aromatic and phenolic maturity were uncoupled from technological maturity. ■

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Sources : *Sourced from the research articles: "Performing sequential harvests based on berry sugar accumulation (mg/berry) to obtain specific wine sensory profiles" (OENO One, 2021) and, "Unravelling wine volatile evolution during Shiraz grape ripening by untargeted HS-SPME-GC × GC-TOFMS" (Food Chemistry, 2019). .*

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