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Effect of matter other than grapes on quercetin evolution and key wine parameters

Shuyan Liu[1], Daniele Pizzinato[2], Celine Sparrow[3], Simone Vincenzi[1]✉

[1] Interdepartmental Centre for Research in Viticulture and Enology (CIRVE), University of Padova, via XXVIII Aprile 14, 31015 Conegliano, Italy
[2] Oenofrance Italia, via Vigazzolo, 112, 36054 Montebello Vicentino (VI), Italy
[3] Sofralab Group, 79 avenue A.A. Thévenet, 51530 Magenta, France

Quercetin instability is a practical concern in red wines because low-solubility quercetin aglycone can form haze or crystals during storage. This study evaluated whether sub-threshold levels of matter other than grapes (MOG; < 3 % w/v), as encountered during mechanical harvesting, differentially affect quercetin evolution and key wine parameters, depending on MOG origin. Micro-vinifications were performed in triplicate at 18 °C using synthetic must and Merlot must supplemented with 1, 2, or 3 % (w/v, fresh weight) grape leaves or stems. Quercetin-3-glucuronide, quercetin-3-glucoside, quercetin aglycone, fermentation kinetics, pH, and catechin were monitored. Leaves markedly increased quercetin glycosides and the overall quercetin precursor pool, whereas stems contributed little to quercetin enrichment but more strongly affected pH and catechin, and tended to accelerate fermentation. These results show that, even at low levels, leaf-derived MOG is the main concern for quercetin-related instability, whereas stem-derived MOG has a stronger impact on catechin, pH, and fermentation kinetics.

Introduction

Quercetin instability, expressed as haze or crystal formation, remains a practical risk in red wines because quercetin aglycone has limited solubility in the hydroalcoholic matrix. During fermentation and ageing, quercetin glycosides, particularly quercetin-3-glucuronide and quercetin-3-glucoside, may undergo hydrolysis and release quercetin aglycone, thereby increasing the risk of precipitation and loss of visual stability[1,2]. During mechanical harvesting, matter other than grapes (MOG) is often kept below 3 % (w/v), a threshold generally regarded as acceptable for quality wine production[3]. However, even within this sub-threshold range, it remains unclear whether different MOG, particularly leaves and stems, contribute equally to quercetin precursor loading and related changes in wine composition. In this study, micro-vinifications were carried out in synthetic must and Merlot musts with 1–3 % leaf- or stem-derived MOG to compare their effects on quercetin forms, fermentation kinetics, and key phenolic parameters, with the aim of providing practical recommendations for winery decisions.

Why it matters

Quercetin haze or crystals are a practical quality defect in wines because they reduce clarity and stability. This risk is associated with the formation of low-solubility quercetin aglycone, which can be derived from the hydrolysis of quercetin glycosides during fermentation and ageing. Therefore, practices that increase the quercetin precursor pool may also increase the long-term risk of instability. In mechanically harvested grapes (Figure 1), this makes it important to distinguish the effects of different MOG, such as leaves or stems, so that MOG management can be better aligned with wine stability objectives.

What we tested

Micro-vinifications were carried out in two fermentation matrices, a synthetic must and a Merlot must, to compare MOG effects under controlled and realistic winemaking conditions. The synthetic must was prepared according to Delfini and Formica[4] (2001). Treatments included a control without matter other than grapes (MOG) and additions of leaves or stems at 1, 2, or 3 % (w/v; fresh weight) (Figure 1). Fermentations were performed at 18 °C in triplicate, with MOG maintained in contact throughout alcoholic fermentation. Fermentation kinetics were followed by daily weight loss as a proxy for CO_2 release. Quercetin-3-glucuronide, quercetin-3-glucoside, and quercetin aglycone were monitored during fermentation, and the final wines were also evaluated for selected parameters related to acidity and phenolic composition. Data were analysed by ANOVA followed by Tukey's HSD test ($P < 0.05$).



FIGURE 1. Study overview: mechanical-harvest MOG and micro-vinifications with 1–3 % leaves or stems in synthetic and Merlot musts.

Key findings 1: Leaves drive quercetin precursor loading

As shown in Figure 2A, leaves were a much richer source of quercetin glycosides than stems, with quercetin-3-glucuronide as the predominant form. In contrast, stems contained much lower levels of quercetin glycosides, while quercetin aglycone was absent in leaves and detectable only at trace levels in stems. These data indicate that leaves are the primary source of quercetin precursor input in the two MOG fractions considered.

During fermentation, leaves caused a much greater increase in quercetin derivatives than stems in both matrices. In the synthetic must, leaf addition produced substantial accumulation of quercetin-3-glucuronide, quercetin-3-glucoside, and quercetin aglycone, whereas the contribution of stems remained minimal (Figure 2B). This difference is consistent with the much higher quercetin content measured in the leaf material before fermentation.

In Merlot must, quercetin extraction from leaves was lower than in the synthetic must, indicating a matrix effect. Even so, leaves still produced clearly higher quercetin derivative levels than stems in the final wines (Figure 2C). The estimated release of leaf-derived quercetin glycosides decreased in Merlot must compared with synthetic must (from 89 % to 55 % for quercetin-3-glucuronide, and from 81 % to 12 % for quercetin-3-glucoside), suggesting that the grape matrix constrains extraction dynamics without changing the overall ranking between MOG types (leaves > stems).

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Overall, these results indicate that leaf contamination is the most relevant contributor to quercetin precursor loading under low-MOG conditions. From a practical perspective, reducing leaf-derived MOG in harvested fruit and limiting leaf must contact during early winemaking stages represent effective preventive strategies.

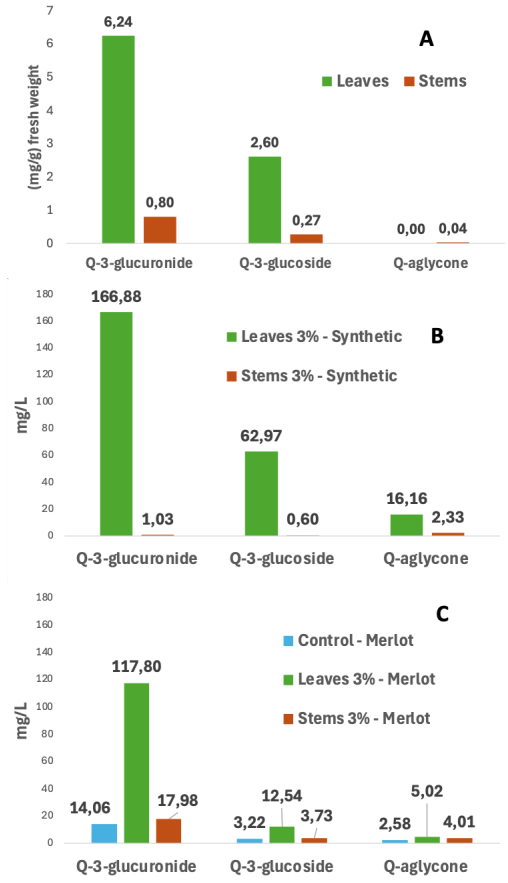


FIGURE 2. Quercetin forms in leaves vs stems (A) and in final wines after 3 % additions in synthetic (B) and Merlot musts (C).

Key findings 2: Stems more strongly affect pH and catechin

At the end of fermentation, stems showed a stronger effect than leaves on pH, particularly in the Merlot matrix. In Merlot must, pH remained essentially unchanged with leaf additions (control 3.73; leaves 3 %: 3.75), whereas the 3 % stems increased pH to 3.93. In the synthetic must, both MOG types increased pH relative to the control, but stems again reached the highest value (control: 3.08; 3 % leaves: 3.27; 3 % stems: 3.32). This behaviour is consistent with previous reports indicating that stem can increase wine pH through potassium release, thereby promoting tartaric acid precipitation as potassium tartrate[5 6].

The stronger stem effect was also evident for catechin. Before fermentation, stems already contained much more catechin than leaves on a fresh-weight basis (21.79 vs 3.81 mg/g) (Figure 3A), which helps explain the subsequent enrichment observed in the wines. In synthetic must, catechin increased significantly with both MOG types, but the response was far greater with stems: at 3 % addition, leaves increased catechin by +380 % relative to the control, whereas stems increased it by +2096 %. In Merlot must, the effect was smaller due to the higher baseline catechin content of the grape matrix; however, 3 % stem addition still produced a statistically significant increase, while the increase with 3 % leaves was not significant (Figure 3B).

Overall, under low MOG conditions, stems exert a stronger influence than leaves on pH and catechin enrichment, whereas leaves mainly affect quercetin precursor loading.

Key findings 3: Fermentation kinetics can be modified by MOG

In both synthetic and Merlot musts, MOG addition accelerated alcoholic fermentation relative to the control, with a stronger effect from stems than

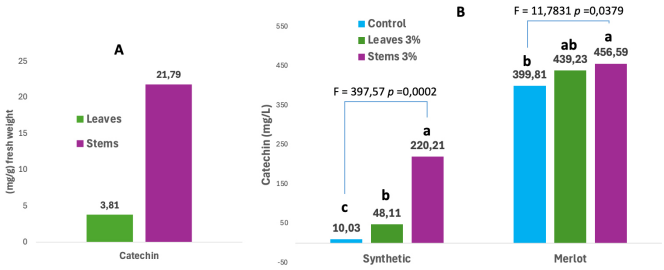


FIGURE 3. Catechin content in leaves vs stems (A) and in final wines after 3 % additions in synthetic and Merlot musts (B). Statistical analyses were performed separately for the synthetic and Merlot musts. Within each matrix, bars with different letters differ significantly (Tukey's HSD, $P < 0.05$).

from leaves. This pattern was consistent across both matrices. By Day 10, the greatest weight loss was observed in the 3 % stem treatments, followed by 3 % leaves and the control (stems > leaves > control). These results indicate that, even at sub-threshold levels, MOG can modify fermentation behaviour, with stem-derived material having the clearest effect. A possible explanation is that stems may provide additional nutrients, such as nitrogenous compounds, and/or confer physical advantages, such as improved heat dissipation, which support faster fermentation kinetics[7].

Conclusion

Even at sub-threshold levels (<3 %), matter other than grapes (MOG) can modify wine composition and fermentation behaviour according to its origin. Leaf-type MOG is the main source of quercetin glycosides and therefore enlarges the precursor pool that may later contribute to quercetin aglycone precipitation and loss of visual stability. By contrast, stem-derived MOG contributes little to quercetin enrichment but has a stronger effect on pH and catechin, and it also tends to accelerate alcoholic fermentation. From a practical perspective, MOG management in mechanically harvested fruit should distinguish between leaves and stems: limiting leaf-derived MOG is most relevant for reducing quercetin-related instability risk, whereas stem-derived MOG requires closer attention to acid balance, phenolic extraction, and fermentation performance. ■

SOURCE: *Sourced from the research article: "Influence of matter other than grapes on quercetin evolution and wine polyphenols" (OENO One, 2025).*

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