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Aromatic ripeness may be the type of maturity that impacts red wine typicity the most. Part I: the aromas involved in aromatic ripeness

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Harvesting grapes at the appropriate maturity is key to the production of high quality red wines. Viticulturists, oenologists and winemakers define several types of maturity: technological, phenolic and aromatic. Aromatic maturity is probably the most important for determining wine quality and typicity, including terroir expression. This article (part I) reviews the state-of-the-art of compounds underpinning aromatic maturity; the influence of terroir factors and management practices are addressed in a follow-up article (part II).

Different types of maturity

Quality and typicity are much valued attributes of wine, both contributing to the consumer's willingness to pay. As perceived in sensory assessments of wine, typicity is the result of complex interactions between numerous molecular compounds, and involves the collective knowledge about the sensory characteristics of the product[1]. Wine composition is known to be related to grape composition at the time of harvest. Grape ripening is a dynamic process that takes place between veraison (the onset of ripening) and harvest, a period during which berry composition dramatically changes with respect to both primary metabolites (sugars and organic acids) and secondary metabolites (phenolic compounds, aroma precursors and aromas). The level of maturity at which grapes are harvested has a major impact on berry components and, as a result, on wine typicity. Maturity is influenced by viticultural management choices and the harvest date, as well as by the terroir - that specific combination of variety, soil type and climatic conditions[2].

Unlike other phenological stages, such as budburst, flowering and veraison, maturity is not an easy stage to distinctly define. Viticulturists, oenologists and winemakers recognise different types of maturity: technological, phenolic and aromatic. They strive to find the best possible compromise between these types of maturity, depending on the style of wine they want to produce. Technological maturity has been defined by Carbonneau *et al.* (1998)[3] as the point when sugar reaches a plateau and acidity is low. Phenolic maturity is considered optimal when anthocyanin concentration in the skins reaches a maximum and tannin concentrations have decreased after veraison in both skin and seeds. Their structural evolution, however, is more important than their quantitative evolution, being responsible for trigeminal sensations which are appreciated by tasters. However, reliable metrics to precisely measure phenolic maturity in a production setting are not easy to define, as phenolic compounds in grapes and wines are extremely diverse[4]. Aromas are strong drivers of wine typicity; they can be classified according to the chemical family they belong to, or alternatively to the level of maturity they are associated with[5]. Depending on level of maturity, wines can be perceived as green, herbal, spicy, floral or fruity, with the scale of fruity aromas being very broad - ranging from fresh fruit to cooked fruit (Figure 1). Over the past few decades, the understanding of the molecular basis of aromatic maturity in wines has significantly increased. Some of these compounds are present in grapes and transferred to wine without transformation (e.g., methoxypyrazines and (-)-rotundone), while others are present as odourless precursors and transformed into aroma compounds during the wine making process (e.g., volatile thiols).

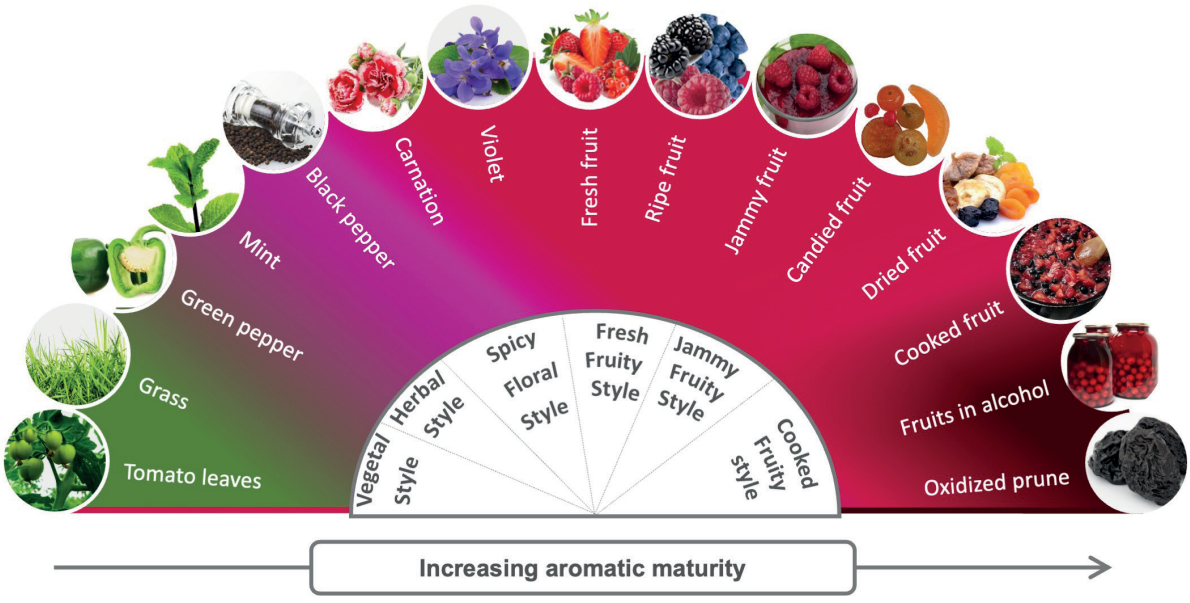


FIGURE 1. Aroma wheel with increasing levels of aromatic maturity nuances.

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Different types of aromas depending on perceived level of ripeness

In the following subsections, grape and wine aromas are presented in increasing levels of perceived aromatic maturity.

Green aromas

Undesirable green aromas in wines are reminiscent of tomato leaves, freshly mowed grass or green pepper (induced by methoxypyrazines). The latter are generally not appreciated in red wine when their presence is well above the olfactory detection threshold.

Fresh minty and herbal aromas

1,8-cineole and 1,4-cineole can contribute to fresh green aromas like menthol, mint and Eucalyptus in red wines[6]. These cineoles can originate from the proximity of vineyards to Eucalyptus trees[6] or have a varietal origin[7]. Recently, a series of terpenes resulting from limonene degradation and lactones were identified as providing fresh and minty aroma nuances in aged wines[8].

Spicy aromas

(-)-rotundone is a sesquiterpene, responsible for black pepper notes. It was first identified in Syrah, but it is also present in several other varieties like Mourvèdre[9]. In addition, megastigmatrienone (often referred to as tabanone) is a C_{13}-norisoprenoid with a smell of spices and tobacco, while dimethyl sulfide (DMS) can contribute to the expression of truffle and undergrowth nuances at moderate concentrations[10].

Floral aromas

Many compounds contributing to floral aromas in wines have been identified. These compounds can have a varietal origin or be produced during alcoholic fermentation due to yeast metabolism. Several monoterpenes (e.g., linalool, geraniol and citronellol) are responsible for flowery-muscat-like or iris flower aromas. Among norisoprenoids, β-ionone contributes to violet aromas[11]. 2-phenylethyl acetate and 2-phenylethanol are compounds associated with the smell of roses.

Fresh fruit aromas

Many compounds belonging to several chemical families contribute to fresh fruit aromas, including several types of esters, in particular substituted ethyl esters (red fruit and black fruit) and volatile thiols (grapefruit). DMS enhances fruitiness in wines at low concentrations, as does β-damascenone.

Ripe fruit aromas

Furaneol and homofuraneol, which have the aroma of strawberry jam and caramel, have been found to affect the perception of ripe red fruit notes in young red wine. Like for fresh fruit aromas, DMS can enhance ripe fruit aromas, in particular notes of blackcurrant liquor.

Dried fruit, cooked fruit, and oxidized prune aromas

Several compounds have been identified as contributing to dried and cooked fruit aromas, including 3-methyl-2,4-nonanedione (MND), massoia lactone, 1,5-octadien-3-one, γ-nonalactone, and furaneol. Oxidized prune aromas, which are not desirable in red wine, are associated with the presence of MND.

Assessment of aromatic maturity

Excessively green or overripe aromas diminish the quality of red wine. In the spectrum of aromas comprising herbal to dried fruit aromas (Figure 1), aromatic maturity contributes to the typicity of wine. The influence of terroir factors and management practices on this aromatic typicity is addressed in a follow-up article (Part II). Growers, oenologists, winemakers and consultants need to have a precise idea about the desired level of aromatic maturity in relation to the wine style intended. To a certain extent, aromatic maturity can be assessed by the sensory evaluation of grape berries, although this requires intensive training of the technical staff to obtain homogeneous results. Sensory evaluation works reasonably well on green and cooked fruit aromas, which can both be detected in grapes and young wines. The associated aroma compounds have been identified as IBMP (3-isobutyl-2-méthoxypyrazine) for green and MND for cooked fruit aromas. IBMP is transferred from grapes to wines without chemical transformation, whereas the precise origin of the synthesis of MND is still under investigation. Hence, this sensory approach can be completed with chemical analysis. Many aroma compounds, however, are present in grapes in odourless bound forms and released during either fermentation or ageing. Other compounds, including esters, are formed during alcoholic fermentation. Hence, it is not possible to assess the level of aromatic maturity that will be exhibited in the wine by only tasting the berries. To obtain the desired level of aromatic ripeness, harvest decisions should be based on (1) the analysis of primary and, if possible, some key secondary metabolites, (2) the sensory assessment of berries, and (3) experience gathered over previous vintages on the same site of production. ■

Sources: *Sourced from the research article: "Aromatic maturity is a cornerstone of terroir expression in red wine" (OENO One, 2022).*

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