IVES Technical Reviews vine & wine

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How can the water regime and nitrogen status of the vine influence aging aromas in red wines?

>>> This study looked for a possible link between the water and nitrogen regimes measured in the vineyard and the aromatic compounds responsible for the aging bouquet of red wines. The wines studied for this purpose were produced in the Bordeaux region and aged for between 10 and 20 years. The levels of aromatic compounds such as tabanones and dimethyl sulfide (DMS) were found to be influenced by the supply of water and nitrogen to the vine. The residual nitrogen composition of the wines was also consistent with the nitrogen status of the vines and suggests potential for aromatic precursors and microbiological instability. <<<

Whatever the terroir of origin, the quality of a fine wine is always associated with its aptitude for aging. Within this concept of terroir, the water regime and nitrogen status of the vine are well-known parameters that affect the functioning of the plant. Measurable agronomic variables such as, for example, the yield and the chemical composition of the grapes (sugar, polyphenols, acids, aromas) are closely linked to the supply of water and nitrogen to the soil. Considered as important parameters for grape and wine quality, links were sought between these viticultural factors and levels of the aromatic constituents of the aging bouquet. Forty-four Bordeaux wines were studied, produced during the 1997 to 2007 vintages from three grape varieties, Merlot, Cabernet Franc and Cabernet Sauvignon, and planted on different soil types. The wines were produced by micro-vinification and analyzed in 2014.

The sensory definition of the aging bouquet of red Bordeaux wines revolves around several odors (Figure 1). Measurements were made of two families of molecules that correspond to some of these odors: DMS (Figure 1, No. 1) and tabanones (Figure 1, No. 2). In the work of Picard *et al.* (2015)[1], the DMS content of red Bordeaux wines was positively correlated with the typical sensory characteristics of the aging bouquet. This compound can produce various sensory effects in wines depending on its concentration and the composition of the volatile and non-volatile matrix in which it acts. Involved in perceptual interactions, it can have the effect of enhancing fruit aroma at low concentration, while at higher levels it brings out truffle and undergrowth notes.

■ Relationship between the nitrogen status of the vine and dimethyl sulfide (Figure 1, No. 1)

The yeast assimilable nitrogen (YAN) contained in the musts at harvest was measured and used as an indicator of the nitrogen nutrition level of the vine[2].

The measured nitrogen status was compared with the DMS concentration (Figure 2). The old wines with the highest DMS content came from the juices that had the highest YAN values. A positive and significant correlation (R^2 = 0.7) links the DMS content of old wine to the YAN content of the must, according to the equation [$DMS_{(\mu g/L)}$ = 0.3 × $YAN_{(mg/L)}$ - 2.7]. These observations are consistent with knowledge of DMS precursors, the main one being S-methyl methionine which is synthesized in the grape. S-methyl methionine is an amino acid derivative that represents a major part of the YAN indicator.

This study also showed that the soil type could not directly explain the variations in DMS levels in aged wines. However, soil type could have an indirect effect through the variations in water regime and nitrogen status that it induces in the vine. Furthermore, no varietal effect could be observed under the study conditions.

A positive contributor to the aging bouquet of wines, DMS is positively linked to the nitrogen status of the vine. It depends on the soil type, the climatic conditions and the plant material. The addition of fertilizers or soil improvers to the vineyard could favor the synthesis of its precursor. These practices must be applied judiciously, however, in order to avoid excessive increase in yields and vine vigor, which could lead to a dilution effect or increased sensitivity to gray rot.

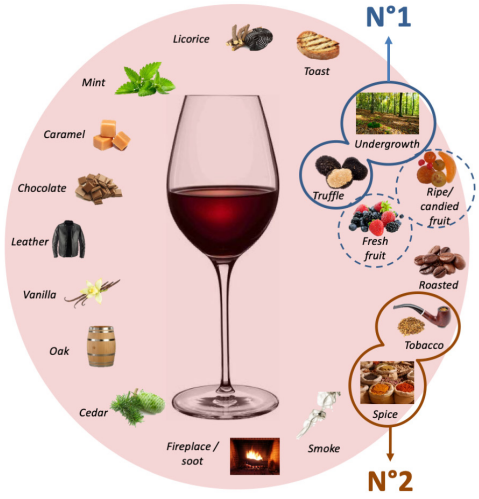

Figure 1. Aromatic sensory areas of the aging bouquet of red Bordeaux wines. The odors grouped and labeled in aromatic classes No. 1 and No. 2 are linked, in wine, to the presence of volatile compounds: No. 1, DMS; No. 2, tabanones.

■ Relationship between the water status of the vine and tabanone, (aromatic class No. 2, Figure 1)

"Tabanone" refers to a mixture of 5 isomers of megastigmatrienone (TAB1, TAB2, TAB3, TAB4, TAB5), of which TAB2 is exclusively detected in wines that have had contact with oak wood. In accordance with the micro-vinification protocol applied to the red wines studied, TAB2 was not detected.

The tabanone levels were positively correlated with the ages of the wines. Following this first result, the concentrations were divided by the age of the corresponding wines to allow the effect of the water status in the vineyard to be studied, by stripping out the aging effect. In addition, the leaf water potential (LWP) values were categorized into different levels of water status[3].

There was a positive correlation between the intensity of water stress and the age-corrected tabanone concentrations (Figure 3).

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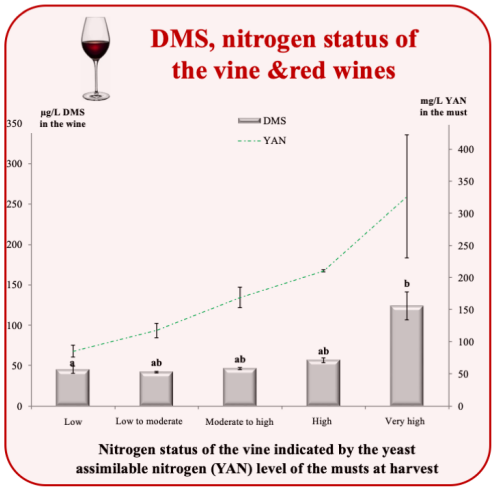

Figure 2. Influence of the vine's nitrogen status on the DMS level measured in red wines after aging. The letters indicate the significant differences. Error bars indicate the standard error.

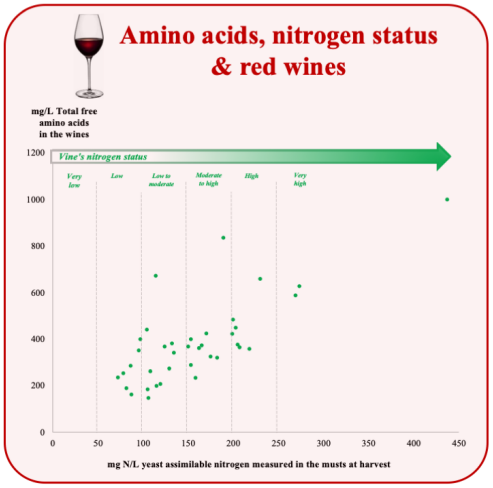

Figure 4. Correlation between the vine's nitrogen status and the total free amino acid content measured in the corresponding red wines after aging.

Severe water stress in the vine favored the appearance of tabanones during aging. These observations can be linked to the origin of the tabanones. Described as non-volatile glycosylated precursors derived from C_{13}-norisoprenoids, the latter are known to be influenced by the water regime of the vine[4].
Contributing to spice and tobacco notes in aged wines, tabanones are linked to the water regime of the vine. Severe water stress in the vineyard contributed positively to the presence of the tabanone precursor in grapes and tabanones in aged wines.

■ Relationship between the nitrogen status of the vine and the nitrogen status of the wines

Free amino acids were quantified in aged red Bordeaux wines and compared with the nitrogen status of the corresponding vines evaluated by the YAN content of the must (Figure 4). This observation demonstrates a link between the nitrogen status of the vine and the nitrogen status of the wines, even after fermentation and aging. A high nitrogen content in musts seems to induce a higher and/or more easily released organic nitrogen content in the wine.
From an aromatic point of view, the combination of high levels of free amino acids and aging time can favor the production of heterocyclic aromatic compounds resulting from the Maillard reaction[5].
Described as aromas belonging to the cooking register, with toasty, nutty and roasted notes, they fit well with the sensory definition of the aging bouquet (Figure 1) and, moreover, without oak. The quantification of aromatic heterocycles in the red wines in this study did not, however, show any significant differences for these compounds, contrary to what was observed in a study on Champagne reserve wines. One possible reason is that the levels of free amino acids were much lower than in Champagne reserve wines.
Furthermore, other studies have shown that the aromatic precursors of volatile thiols[6], or substituted acid precursors of substituted esters[7], can be favored by high nitrogen levels in the must.
However, it should be noted that excess residual nitrogen in wines promotes microbiological instability during storage. Although a recent study has shown the limited effect of residual nitrogen on the development of *Brettanomyces bruxellensis* in a model wine medium[8], there are many strains with different needs evolving in a more complex matrix.
In the vineyard as in the cellar, it is thus necessary to be judicious in making nitrogen additions. ■

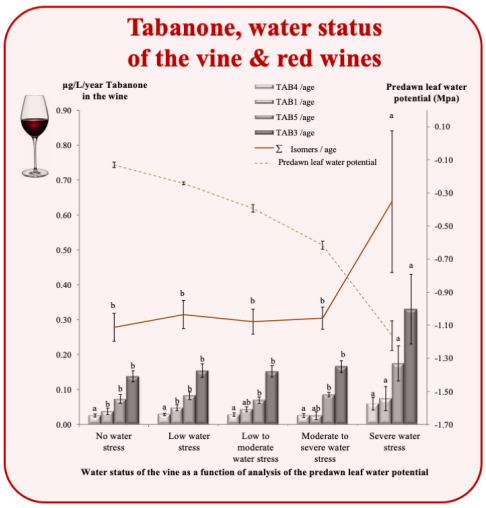

Figure 3. Influence of the vine's water status on the levels of the 4 tabanone isomers measured in the aged red wines.

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