PANORAMA

VOLATILE ACIDITY

SEGUIN MOREAU / R & D department: oeno@seguin-moreau.fr

WHAT IS VOLATILE ACIDITY? WHAT IS ITS SIGNIFICANCE?

Volatile acidity (VA) is an important parameter of the quality of wine. This term refers to all forms (free and salified) of volatile acids potentially present in wine; but it concerns mainly **acetic acid**. The level of VA is measured in « grams of sulfuric acid per liter of wine ». Volatile acidity is a quality criteria used in French law: a wine is considered to be suitable for sale if volatile acidity does not exceed 0.9g per liter. Regulations governing wine making in other countries indicate comparable limits.

Even though the increase in concentration of acetic acid is an undeniable indicator of the drop in quality of the wine, it is not necessarily this molecule itself which leads to the most significant organoleptic flaws. A VA of 0.9g/liter results in an acrid and bitter finish, but at this level, the characteristic smell of acetic acid can hardly be perceived. On the other hand, the increase in VA is often accompanied by the development of ethyl acetate which is responsible for the sensation of bitterness (gradual acidification), burning and hardness. In red wine, these appear in low concentration: the threshold of perception of this molecule is 0.16g/L, but it can even begin to spoil the aromas of the wine below this level (loss of fruitiness).

HOW DOES VOLATILE ACIDITY DEVELOP IN WINE?

The causes for the development of volatile acidity are numerous, but the main sources are as follows:

A – Microbiological:

1. Formation of acetic acid by the yeast during the first half of primary fermentation (PF),
2. Transformation of citric acid and remaining sugars into acetic acid by the heterofermentary lactic bacteria during the last stage or after malolactic fermentation (MLF),
3. Transformation of ethyl alcohol into acetic acid by acetic bacteria

B – Physio-chemical: extraction of acetic acid from oak wood, in the case of wine being aged in barrel

Without wanting to be simplistic, we can conclude that the first source is the almost systematic formation of 0.2 to 0.3g/L of VA by yeasts during primary fermentation. This is valid; whatever the type of fermentation chosen, whether it be in vats or in barrels.
On the other hand, the three other sources need further explanation.

(SOURCES A.2, A.3)

Source A.2: metabolism of lactic bacteria .

The lactic bacteria are natural agents responsible for malolactic fermentation: their presence is indispensable for fermentation to take place normally. However, lactic bacteria can also adversely affect the quality of the wine as they are capable of breaking down the residual sugars and citric acid into large quantities of acetic acid. This explains why it is risky to carry out malolactic fermentation "on sugars" which can occur when the primary fermentation has been incomplete. In practice, to avoid this; it is advisable to ensure that the primary fermentation has been fully completed (no remaining sugars) and to add SO2 at the end of MLF.

Source A.3: metabolism of acetic bacteria.

Acetic bacteria can be found everywhere in nature and are naturally present on ripe grapes. Their amount varies depending on how healthy the grapes are: the less healthy the grapes, the higher the amount of acetic bacteria. These bacteria need oxygen to develop; this is why they are stressed and less active during primary fermentation (reductive environment, low in oxygen content). They become more active at the end of primary and malolactic fermentation, when the environment is more suited to their development (more oxidative, rich in oxygen)

At this stage, it is important to note that:

a. acetic bacteria are capable of producing ethyl acetate from ethyl alcohol and acetic acid. Therefore an increase in VA could cause the formation of ethyl acetate, whose organoleptic impact has been described earlier,

b. it is the ethyl alcohol, a component of the wine, which the acetic bacteria transform into acetic acid: the risk of VA increasing therefore persists after primary and malolactic fermentation, even if they have both been completed correctly.

In practice, acetic bacteria are not easy to eliminate when their level in the wine is high. Adding SO2 does not destroy them efficiently and the required amount in order to fully eliminate them is very high: from 0.45 to 0.6mg/L of active SO2 i.e. 15 to 20mg/L of free SO2 for a wine with a pH of 3.3 and 45 to 60mg/L for a pH of 3.8. The temperature seems to be a determining factor in the development of these bacteria: below 15°C their development slows down considerably but they are still not eliminated. The only real solution for limiting the risks of VA developing by acetic bacteria is to keep a very close eye on the sanitary state of the grape harvest, combined with good hygiene in the cellars and to respect good oenological practices (SO2, close control of PF/MLF, topping up etc.)

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HOW DOES VA DEVELOP MICROBIOLOGICALLY?

Note:
It should be noted that the transformation of acetic acid into ethyl acetate simply through a chemical channel (without any bacterial catalyst) is possible, but extremely slow: it can in no way be the only explanation for a high increase in concentration of ethyl acetate in the wine

CAN WOOD RELEASE HIGH QUANTITIES OF ACETIC ACID? (SOURCE B)

It has been shown that oak wood, especially after toasting, can contain a certain quantity of acetic acid. This amount depends on the type of toast carried out because two phenomena occur simultaneously during this operation: the formation and evaporation of acetic acid. However, the level remains very low: it can explain the increase in VA from 0.1 to 0.15g/L in the case of wine stored in new barrels. The role of the wood in creating volatile acidity can therefore be considered to be a minor one.

Moreover, wood never contains ethyl acetate.
So, even if it can release a small amount of acetic acid, this will not transform into ethyl acetate, unless there are signs of acetic bacteria being present.
So we can easily conclude that the presence of large quantities of ethyl acetate completely excludes the possibility of acetic acid being caused simply by a barrel. The increase in VA, in that particular case, is certainly of microbiological origin.

WHY IS IT CONSIDERED THAT THE RISK OF DEVELOPMENT OF VA IS HIGHER IN THE CASE OF WINE BEING AGED IN BARRELS RATHER THAN IN STAINLESS STEEL VATS?

The barrel in itself is not a source for lactic or acetic bacteria, for wood has a low level of nutrients and does not attract these micro-organisms.
On top of this, the wood of a barrel undergoes high temperature treatment during the toasting phase which excludes the possibility of there being any bacteria on its surface. A barrel can however become a source of bacteria when it contains a wine which has been "contaminated" by the bacteria in question. Any doubt that may exist can therefore only concern second hand barrels.

In any case, once the wine is contaminated, it is more complicated to control if it is stored in barrels as opposed to stainless steel vats. Barrels have a much larger surface contact with wine than stainless steel vats and their surface is fairly rough. Consequently, colonies of bacteria have statistically more chance of sticking to the inside surface of a barrel than that of a stainless steel vat. They penetrate inside the wood by several millimeters which makes it more difficult to eliminate them properly when cleaning.

Using second hand barrels therefore requires special equipment and/or special products to eliminate bacteria after the barrels are emptied: steam cleaners, hot water under pressure etc.
It is important to emphasize that oak has high thermo-insular properties: to ensure an efficient treatment it is advisable to choose a method which can reach sufficiently high temperature to destroy the bacteria present on the inside surface of the barrel but also within the wood. Should the treatment be insufficient, the bacteria which have developed in the barrel will grow by feeding off the wine which has soaked into the wood. The acetic bacteria continue in this way to transform the ethyl alcohol into acetic acid and ethyl acetate. This is why a smell of vinegar and bitterness can sometimes be found in second hand barrels, even after a long period of storage.

Moreover, the contribution of oxygen to the wine is higher in barrels than in closed vats, which encourages the development of acetic bacteria. The conditions which suit oxygenation best are created in the upper empty area of the barrel where the wine and the atmosphere interact. In the most extreme cases, a film of bacteria can form on the surface of the wine.
Regular topping up of the barrel can help limit this phenomenon. It is of course imperative to use a perfectly healthy wine when carrying out this operation in order to avoid any accidental contamination.

Lastly, a barrel that has contained a sour wine can have absorbed a large quantity of acetic acid and ethyl acetate. If these compounds are not fully eliminated, they can be extracted from the wood by the wine which has been used to top up the barrel. In this way, even if the bacteria have been fully eliminated between two successive aging periods, the wine can nevertheless deteriorate if these undesirable molecules are released.

CERTAIN PEOPLE THINK THAT NEW BARRELS CAN RELEASE NUTRIENTS WHICH CAN SERVE AS A POTENTIAL MEDIUM IN WHICH BACTERIA CAN DEVELOP AND CONSEQUENTLY INCREASE THE RISK OF DETERIORATING THE WINE. IS THIS TRUE?

This idea is indeed widespread in the wine industry: certain specialists refer to cellobiose, one of the sugars in wood which can be released during the contact of wine and wood. According to them, this sugar is extracted by the wine and represents a nutrient for bacteria; it therefore helps them to develop.
We have carried out analyses to find cellobiose and other sugars in the wood which can potentially be extracted by wine on toasted and non toasted wood. The results obtained by ion chromatography (LAREAL Laboratory) show that the quantity of cellobiose that can be released does not enable this compound to increase its concentration by more than 5mg/L.

The analysis of other sugars shows similar results (<10-20mg/L). This amount of sugar brought by the wood is therefore tiny compared to the sugars naturally present in wine.
We know that even a « very dry » wine (total primary fermentation, using up all the sugars, which is difficult to achieve in practice) contains at least 100mg/L of sugar (trehalose resulting solely from the autolysis of yeasts).

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In the most realistic cases of well controlled primary fermentation, wines contain from 300 to 500mg/L of residual sugars, whereas when fermentation is stopped, or the fermentation is incomplete/slow, wines can reach 2 to 5g/L of sugar.

We can therefore conclude that the quantity of sugar brought by the wood is totally insignificant compared to the sugars in the wine; the sugars in oak can therefore under no circumstance be the element which encourages the development of volatile acidity.

CAN BARRELS WITH BLISTERS ON THE INNER SURFACE OF THE STAVES BE MORE AT RISK THAN BARRELS WITH NO BLISTERS?

As explained earlier, a new barrel cannot be the source of contamination of wine by bacteria, nor a source of nutrients which can help their development. This is true for all new barrels whether with or without blisters, so the risk is not higher either in one case or the other.
On the other hand, if we are dealing with a barrel in which one or several wines have aged, and which has contained a wine contaminated by bacteria, this is a different matter: the inside surface of a barrel with blisters is larger than that of a barrel without blisters and can therefore hold these micro-organisms more easily. This being said, if the rules of hygiene are respected, especially during cleaning procedures, barrels with blisters should not pose any more problems than those without blisters. The wine impregnated in wood leaves traces of its compounds (colorants, polyphenols) even after good washing. In contrast, good washing coupled with disinfection allows removing nutritive compounds coming from wine and which could be a source of contamination.

IS GOOD HYGIENE IN THE CELLARS AND BARRELS A NECESSARY AND SUFFICIENT CONDITION TO AVOID THE DEVELOPMENT OF VOLATILE ACIDITY?

Good hygiene in the cellars and with the barrels is of course necessary to prevent the risk of bacteria developing but unfortunately it is not enough: the development of volatile acidity can occur, even in a clean cellar.

Let us take the case of a very slow and long malo-lactic fermentation in barrels. This is a risky time for the potential development of acetic bacteria, because:

- the wine is only slightly protected by SO2,
- its temperature is fairly high,
- the barrels are not full and conditions can therefore be oxidative.

If the primary fermentation has not been fully completed, the presence of residual sugars will increase the risk.

. WHY CAN WE OBSERVE THE DEVELOPMENT OF VOLATILE ACIDITY AT THE END OF MLF WITH CERTAIN BARRELS AND NOT OTHERS, WHEN THE CONDITIONS ARE APPARENTLY IDENTICAL?

MLF in barrels is a phase which varies from one barrel to another in terms of length of completion, microbiological development, presence of nutrients etc. Therefore, in certain barrels, MLF is already finished while with others it is not finished at all.

With regard to volatile acidity, as with other molecular compounds of wine, we can observe, for a given period, a higher or lesser concentration depending on the barrels. In the case of VA; this cannot in any circumstance be put down to possible differences between the barrels themselves (toasts, or different suppliers for example). We can look for the cause in:

- Microbiological factors (level of presence of bacteria),
- Composition of the wine itself (level of sugars, alcohol, fermentable acids or S02, pH, turbidity)
- Environment of cellars (temperature gradient between the various barrels, circulation of air causing higher level of evaporation of the wine with one barrel compared to another, etc.)

SEGUIN MOREAU
R & D department
oeno@seguin-moreau.fr