The pH-issue in winemaking

Communication for the Pennsylvania Quality Association

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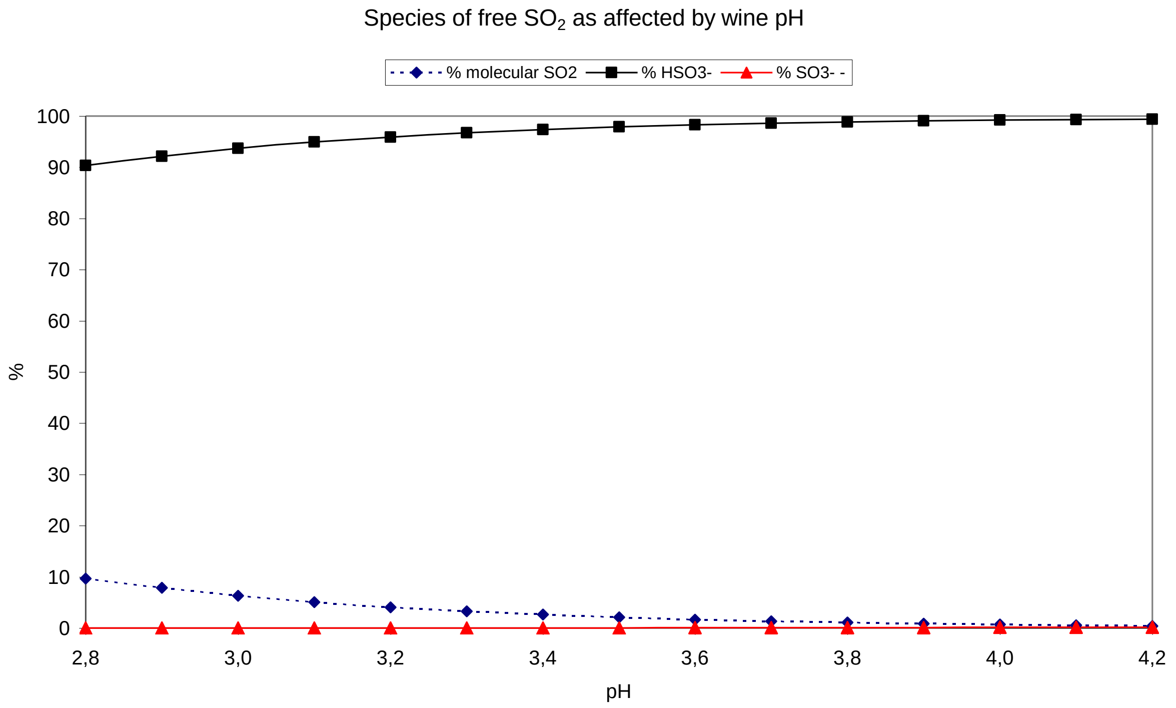
Abstracts: High pH is a major concern in winemaking since it affects SO_2 effectiveness and microbiological stability. Lowering pH by acid additions generates drastic alterations on the palate that frequently distort the desired wine style. Filtration and sterile bottling are efficient means of high pH-winemaking.

Sulfur dioxide, when added to wine, will bind with aldehydes, predominantly acetaldehyde, as well as with anthocyanins. Whatever is left over is called "free SO_2", existing simultaneously in three forms and distributed according to the wine's pH**:**

$$SO_2 \text{ (molecular)} \leftrightarrow HSO_3^- \text{ (bisulfite)} \leftrightarrow SO_3^{2-} \text{ (sulfite)}$$

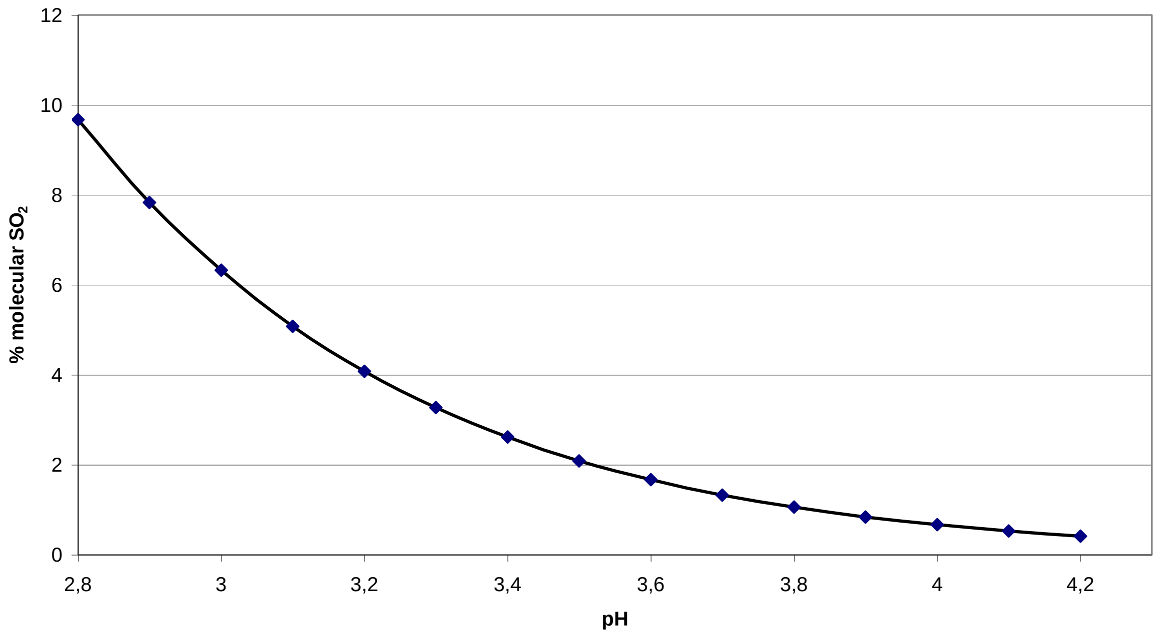


Bisulfite (HSO_3^-) is the predominant species comprising 92 to 99 % at pH 3.0 and pH 4.0, respectively. It inhibits oxidative browning, binds to acetaldehyde, and combines with monomeric anthocyanins in red wines, bleaching them in a reversible reaction. These reactions are not pH-dependent.

Sulfite (SO_3^{2-}), though present at less than 0.1 % in the wine's pH range, is the species able to act as a reducing agent and to protect the wine against oxidation. It does not react with dissolved oxygen in a direct way, however.

The molecular form (SO_2) is the gaseous species responsible for the known, stinging and tickling irritation in the nose as well as for preserving the wine against microbiological spoilage. The percentage of free sulfur dioxide that occurs as molecular SO_2 varies tenfold over the pH-range of wine, being close to zero in high-pH wines. This effect becomes more apparent in the following graph**:**

Percentage of molecular SO_2 out of free SO_2.



It is obvious that a measured level of 40 ppm free SO_2, for example, at a high wine pH of 3.8 is approximately four times less effective than at pH 3.2. Accordingly, an extensive part of enological teaching focuses upon the importance of pH in winemaking, and winemakers are worried about the microbiological preservability and stability of wines with a pH they consider high. As a consequence, tremendous amounts of tartaric acid are used to lower allegedly high pH readings regardless of the sensory outcome. Alternatively, even sulfuric acid was used in former times.

Since tartaric acid produces insoluble potassium bitartrate, the addition of 1.0 g/L of tartaric acid removes 262 mg/L potassium (K^+) and increases the total acidity (TA) by 0.5 g/L when precipitation is completed. Simultaneously, pH is decreased by approximately 0.15. High pH-wines frequently may require more than 2 g/L of tartaric acid to achieve a final pH considered "safe".

What is a low or a high pH?

While pH-measurement is a standard procedure in any winery and easy to perform precisely, the definition of "high" and "low" pH is rather arbitrary, depending on the educational background each winemaker has had. That's why so many decisions upon pH-adjustment are driven by emotions rather than by understanding. However, this issue is of paramount importance. Taking a Central European look at commonly occurring pH-data of representative varieties and wine types will help to clarify the question.

Red wines without any pH-correction rarely display a pH lower than 3.6, with frequent peaks as high as pH 4.0 when grown under cool-climate conditions and after reduction of total acidity to what is considered harmonious on the palate. Traditionally, these wines are aged in cold cellars before they are sterile-filtered (0.45 µ) prior to bottling. Conscious that free SO_2 at tolerable levels performs only limited protection, cool storage and / or careful filtration are the common means to ensure microbiological stability.

Riesling wines are found at the lower end of the scale at around pH 3.2 due to their intrinsically low potassium content and traditionally higher TA. Most other white cultivars like Chadonnay, Pinot gris, and Pinot white are found in an intermediate range around pH 3.5 to 3.6. This is what is commonly considered a natural watershed dividing winemaking into low- and high pH-regions. However, current practice accommodates pH 3.6 to 4.0 which some winemakers might consider high.

Importance of filtration and sterile bottling

Indeed, pH > 3.6 is high and critical if the basic approach to high pH-winemaking – temperature control during storage before filtration – is ignored. Especially filtration and sterile bottling are essential tools in high-pH winemaking. It’s easy to understand that when there are no germs, no microbial alterations will be possible.

Of course, there is also a stage when wine cannot be filtered or stored at low temperatures, i.e. during fermentation. That’s the moment viable yeast cells, even long after fermentation ends, come to our rescue: They consume all dissolved oxygen in a way that there is not any more available to nourish harmful, oxygen-dependent bacteria.

Lowering pH affects taste dramatically

Why can pH-adjustment through addition of tartaric acid, or any other acid, not always be the perfect solution for high pH-winemaking, and why is it frequently even detrimental to what we consider perceived quality on the palate, particularly under cool-climate conditions? Because any addition of acid brings about a significant increase of sourness many wines do not bear without a loss of quality or typicity. The sensory difference threshold of TA is approximately 0.1 to 0.2 g/L TA depending on the individual wine and its buffering capacity.

The use of tartaric acid, without any doubt a powerful means to lower a high pH, generates an additional loss of potassium which plays an important, but barely understood role in what we perceive as weight, volume, or body of the wine. The potassium difference threshold has been shown to be 250 ppm K^+ for a constant TA level. All in all, aiming at an often intended decrease of pH by 0.3 through the addition of 2.0 g/L tartaric acid, one has to accept a 1.0 g/L increase of TA and a loss of approximately 500 mg/L potassium. The wine that results will very probably be more stable from the microbiological point of view, but it might be very different from the wine we intended to achieve. However, this is what happens frequently when winemaking is centered one-sidedly on pH considerations.

Summarizing, uncontrolled acidification with the only objective of lowering pH can generate a serious lack of perceived quality due to elevated sourness and loss of potassium.

The production of great wines may require running a limited risk due to high pH. This risk can be considerably reduced by adequate filtration. Post-bottling stability is guaranteed by well-established techniques of sterile bottling.

Conclusion

In an effort to ensure microbiological stability in sensitive beverages, intelligent people have invented sterile filtration about one century ago. Use should be made of that instead of acidifying an impeccable wine out of fear of high pH and thereby transforming it into something unharmonious. In a germ-free environment, any worries about microbiological stability are for no reason.