Is Your Wine Slowly Turning Into Vinegar? Basic Information About Volatile Acidity

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In 1857, Louis Pasteur was asked to investigate why some fermented beers would sour while others would ferment into good, quality products. Pasteur discovered that beers, wines and many other fermented products were fermented by microorganisms called yeast. However, when a spoiling effect would take place, he found that the microorganisms present in the beverage were much smaller than the yeast cells. Pasteur concluded that it was these bacteria that caused wine to spoil into a vinegar-like product. Fast-forward over 150 years later, and winemakers still deal with these spoilage microorganisms in wine today.

Volatile acidity (VA), specifically the measurement of the wine's volatile acids, can be a challenging issue in many young and old wines. In wine, the primary acid that contributes to volatile acidity is acetic acid, which is also the primary acid associated with the smell and taste of vinegar. In my experiences traveling throughout the Mid-Atlantic, I have found many winemakers assume that they will be able to taste acetic acid before it becomes a problem in the wine. However, I would like to make the argument that by the time a winemaker tastes acetic acid (or vinegar) the problem has already gone too far. This blog post explains that perspective.

The sensory threshold for acetic acid is between 0.7 – 1.2 g/L for most individuals, and many are surprised at how challenging it can be to smell acetic acid before the levels rise near legal limits. As defined by the Standards of Identity in the Code of Federal Regulations (27 CFR), "the maximum volatile acidity, calculated as acetic acid and exclusive of sulfur dioxide is 0.14 g/100 mL (1.4 g/L) for red wine and 0.12 g/100 mL (1.2 g/L) for white wines." There are some allowances for higher maximum VA concentrations for wines produced from unameliorated juice up to 28°Brix.

The wrong assumption many winemakers make is that they will be able to smell or taste acetic acid (vinegar) before it reaches the legal limit, as vinegar is easily recognized by most people. However, commercial vinegars generally contain 3 – 9% (30 g/L) acetic acid concentrations, which is ***much*** higher than 1) the associated threshold and 2) the legal concentration allowed in wines.

Additionally, the smell and taste of VA is also composed of acetic acid's oxidative breakdown product, ethyl acetate. Ethyl acetate has an aroma that is similar to nail polish or nail polish remover. Its threshold is much lower than acetic acid at 100-120 mg/L (0.10-0.12 g/L). While it is not necessary for high VA wines to contain the ethyl acetate aroma in addition to a high acetic acid concentration, both usually go hand-in-hand. In some instances, the detected concentration of acetic acid can be under the 0.7 g/L threshold with a high (>100 mg/L) concentration of ethyl acetate, contributing to the "high VA" nature of the wine in question.

Enologists measure acetic acid concentration simply because it is easier and more affordable than measuring the ethyl acetate content in the winery. Additionally, legal limits for volatile acidity are defined by the acetic acid concentration.

Where does VA come from?

The primary sources of acetic acid in wine are from several spoilage yeasts and bacteria. While some strains of yeasts (*Kloeckera*, *Brettanomyces*, *Candida*) and lactic acid bacteria can contribute to the acetic acid concentration, many wines suffering from VA spoilage is due to the presence of acetic acid bacteria. To a winemaker's dismay, acetic acid bacteria are relatively ubiquitous in the vineyard and winery.

Wetter vintage years or fruit with rot can be prime sources of spoilage microorganisms.

In the vineyard, higher concentrations of acetic acid bacteria have been affiliated with poor quality fruit and wetter growing seasons. Sour rot, which typically makes grapes smell like vinegar while hanging on the vine, is of particular interest. *Zygosaccharomyces* and *Hanseniaspora* are two additional spoilage yeast genera that may also contribute to the volatile acidity of wine produced from sour rotted grapes.

Biofilms of acetic acid bacteria are also common in the cellar. Drains, exterior surfaces of tanks (especially those that have dripping juice or wine on them), barrels, vents, and floor surface crevices have all been isolated as harboring sites for acetic acid bacteria growth. The lack of adequate equipment/cellar repairs, cleaning, and sanitation can increase the risk for acetic acid bacteria contamination in the cellar.

Volatile Acidity during Winemaking

Acetic acid bacteria are obligate aerobes, indicating that they need oxygen to grow and proliferate. Many considerations can be taken during wine processing to control oxygen exposure.

Like many other microorganisms affiliated with wine production, acetic acid bacteria can be managed with proper sulfur dioxide treatments, adequate temperature control, thorough sanitation practices, and appropriate oxygen management strategies. As acetic acid bacteria need oxygen to grow, reducing oxygen in the wine is a good way to minimize potential growth.

Many winemakers experience acetic acid bacteria growth during barrel aging. However, if barrels are properly topped off every 1-2 months (more often for smaller barrels) to minimize oxygen in the headspace, and wines are treated with sulfur dioxide (according to the wine's pH), acetic acid bacteria growth can be managed through this oxidative processing step. It is important to note that winemakers should avoid topping barrels too frequently, as this practice breaks the natural vacuum created by evaporative loss in the barrel. The vacuum minimizes oxygen availability for microorganisms that may be present in the wine.

Other winemaking practices have been affiliated with enhancing acetic acid bacteria growth or increased levels of VA in the finished wine. These include:

- **Cold Soaking**
- **Natural or Native Fermentations**

- **Sluggish or Stuck Fermentations**
- **Prolonged Headspace (Oxygen) or Ullage in Tanks and Barrels**

These processes are affiliated with higher incidences of high VA wines because they open opportunities for acetic acid bacteria or spoilage yeast growth. This may contribute to increased acetic acid or ethyl acetate concentrations due to prolonged exposure to oxygen. Yeast selection can also play a role in this. It is well documented that *Saccharomyces cerevisiae* contributes minimal quantities of acetic acid (<0.5 g/L) to a wine by the end of primary fermentation. This concentration is less than threshold, and often provides "lift" or "enhancement" of the fruity aromas and flavors in the wine.

Research pertaining to cold soaking has shown no impact and increased concentrations of volatile acidity. Some of these conflicting results may pertain to the way cold soak is executed. Those using refrigerated environments may find spots throughout the tank or bin that are warmer than the surrounding fruit. These hot spots can encourage acetic acid bacteria or spoilage yeast growth at a time when the wine is generally unprotected by sulfur dioxide and exposed to oxygen. Even if winemakers treat crushed fruit or must with sulfur dioxide, it is often less effective due to the increased amount of surface area affiliated with all of the unfermented berries.

Cold soaking that includes adequate mixing in temperature controlled tanks to drop the temperature quicker appears to have a more positive effect on the volatile acidity of the finished wine. The use of dry ice into the center of a fermentation bin has more frequent positive outcomes as well. Not only does dry ice adequately cool the grapes/must, but it also displaces some of the oxygen available for acetic acid bacteria growth.

Natural or native fermentations can encourage acetic acid bacteria or spoilage yeast growth before primary fermentation takes off, but this practice is unpredictable and inconsistent. Stuck or sluggish fermentations run the risk of acetic acid spoilage due to the fact that little carbon dioxide is given off during the later stages in fermentations. Without adequate gas displacement, the surface of the wine is exposed to oxygen, which can support spoilage yeast and bacteria growth. Additionally, spoilage microorganisms will compete for nutrients with the struggling yeast populations trying to finish the fermentation.

Contamination in the Winery

The other issue wineries should be aware of is sustaining biofilms throughout the winery and cross contamination. While contaminating a wine with spoilage yeast or bacteria may not result in a spoiled wine (through proper fermentation management), it increases the risk for potential spoilage.

Avoid potential sites for spoilage microorganism growth. The exterior or interior of tanks are good places to clean regularly, especially during fermentation.

Winemakers should watch for biofilm sites that can harbor spoilage microorganisms:

- Exterior surfaces of tanks, valves, barrels, etc.
- Drains, especially drains that are not regularly cleaned
- Crevices or cracks in floors
- Wooden equipment, including barrels
- Hose lines or connecting points
- Use of unsanitized wine thieves

When taking barrel samples, winemakers should carry a bucket of no-rinse sanitizer (e.g. citric-sulfur dioxide solution, 70% ethanol) to soak the wine thief in ***before*** it enters a barrel. The thief should be sanitized before and after each sample is taken from a barrel. In fact, any vessel that will hold a solution or addition to be added to the wine should be pre-cleaned and pre-sanitized ***before*** it touches the material that will go into the wine. This is a common food sanitation practice that is carried out by commercial food productions, and wine is no exception to this rule.

Cleaning and sanitizing the wine thief is one of the easiest ways to ***avoid*** cross contamination of spoiled wine into clean wine. Additionally, minimizing bacterial growth in a barrel ensures better cleanliness of the barrel. Barrels that contain higher populations of bacteria in a wine are more difficult to clean and rid of bacteria once the barrel is emptied. Given the investment associated with barrel purchases, it is within the winemaker's financial interest to ensure proper sanitation techniques are utilized by all cellar personnel.

Measuring Volatile Acidity

Luckily, most small commercial wineries can invest in a cash still to monitor the volatile acidity concentration from post-primary fermentation through bottling. In fact, monitoring VA is a good and easy way for winemakers or enologists to monitor spoilage through the life of the wine during its stay in the winery.

I have found that many people are initially intimidated by the cash still, but it is a rather simplistic piece of equipment to use once properly trained.

The cash still is used to carry out a steam distillation process, which separates the acetic acid from the wine. Wine and an anti-foam agent are poured into the interior bulb of the cash still. Distilled water is boiled in the exterior bulb, which surrounds the interior bulb. The boiling water slowly heats the wine in the interior bulb, and as the wine heats up, various volatile components (i.e., water, aroma compounds, acetic acid, etc.) are released into the headspace of the interior bulb. These gases, some of which include the volatile acid, acetic acid, are condensed into a liquid as it cools while traveling up the interior bulb and into the condenser. This condensed liquid is collected from the condenser tube, and a titration is used to determine the concentration of acetic acid in the liquid.

A good cash still will cost the winery ~$900. For an adequate protocol, please click here.

During the winemaking process, volatile acidity should be evaluated, at minimum:

- After primary fermentation
- After malolactic fermentation
- Periodically through storage
- When a film is found on a given wine
- Pre-bottling

Fixing High VA Wines

Why all of this information about volatile acidity?

This is one wine defect that is *much easier* to prevent than to remediate. In lower VA-issue wines, blending with a non-contaminated and lower VA wine is often selected. It is important for winemakers to ensure that the high-VA wine is sterile filtered (confirmed by analysis) and moved into a properly sanitized storage vessel until it can be blended.

Higher VA wines (>0.7 g/L) are a greater issue, and it may be challenging to blend them away or they may have to be blended away in small quantities over time. The only practical option for wines with a very high VA is the use of reverse osmosis (RO), which can often be contracted out to various wine technology companies. RO can be costly and depending on the company, it may not be a practical solution to minimize ethyl acetate concentrations.

Ignoring the flaw is not recommended, as VA is regulated by the TTB and limits are set for various wine styles. Please visit the TTB website here for more information on volatile acidity regulations [27 CFR 4.21(a.iv.)]