# The Biochemistry of Winemaking: Why Is Must pH Not Stable

## Introduction

Common measurements taken by wine makers immediately following crush include the must's temperature, degrees brix, acidity, and pH. Retesting the must after it has rested for several hours can provide different readings.

*Why does the pH change in must?*

Angela Romo, a Sacramento Wine Club member, explains the reason for the change in pH. While somewhat a newbie home winemaker who is in the midst of her 4th harvest, Angela knows her science. She received her doctorate in Biochemistry and Molecular Biology from The Johns Hopkins University in 2005, and currently teaches chemistry at American River College in Sacramento, and biology online at The University of Phoenix.

## Angela's Explanation

First a little vocabulary to keep us all on the same page:

**H+**: hydrogen ions. The more of these you have, the more acidic your solution.

**K+**: potassium ions. The way the mineral potassium (symbol: K) exists in our body. If it existed as potassium metal, we'd all be dead!

**pH**: the negative log of the concentration of H+ ions (pH = -log[H+]). This is a log scale like the Richter scale for earthquakes, meaning that going from pH 4 to pH 3 makes the pH 3 solution 10 times as acidic as the pH 4 solution. Why did I go backwards there? Because it's a negative log scale, meaning the lower the number, the more acidic the solution.

**Cells**: the basic unit of life. All cells we'll be discussing have a cell membrane; a barrier to the outside word. Its function is to keep the inside of the cell separated from the outside of the cell.

**Pumps**: proteins in the cell membrane that let things into and out of the cell. Remember that we need to get nutrients into cells and waste products out of cells in order to live. Pumps are specialized as to what they move--the ones we're going to talk about move H+ and K+.

OK, now onto the explanation!

Let's get a little background about how things normally work in cells. Plants contain a special kind of protein pump in their cell membranes (called the H+/K+ pump; source: http://www.jbc.org/content/278/25/22453.full--it%27s in tomatoes, but they're plants too!). The job of this pump is to create energy for the cell. It does this the same way a dam allows us to create electricity--H+ are pumped out of the cell (like water stored in a dam) and then when they flow back through, they allow energy to be created (like when water from the dam flows through the turbine to create electricity). There is a cost for moving all of this H+ outside of the cell, however, and that cost is that something else has to be moved into the cell. In this case, in order to move H+ out of the cell, K+ must be moved into the cell to compensate. Think of going to the store to buy something. You can't just pick it up off the shelf and walk out with it; instead you have to pay money in exchange for it. The K+ is the money you pay in order to remove the H+. So the cell is the store, the K+ is the money, and the H+ is the good that you wanted to remove from the store and take home with you (or the good that the cell needs to move from the inside of the cell membrane to the outside of the cell membrane).

Another bit of background, cells need a certain pH in order to live. Human cells need a very narrow range from pH 7.3-7.5. Anything outside of this range and our cells start to die. Therefore, our cells work very hard to maintain this range. Grape cells are the same way--they need a narrow range of pH in order to properly function (typically around 3.50 source: http://www.pickyourown.org/food_acidity_ph_list.htm). Once things get out of this range, grape cells will work hard to get it back to normal!

As far as what's happening in your crushed grapes, the actual crushing process, well, crushes some of the cells and pokes gigantic holes in the cell membranes. This releases all of the H+, K+ and everything else that's inside of the cells. To top it off, the crushed cells are no longer using the H+ to make energy, so you get a buildup in your juice--this would be like continually filling a dam with water and never releasing any; the pressure would just build and build. In the case of the cells, the building pressure is seen by the increased acidity and lowering of the pH in the juice (which is why the pH falls when grapes are crushed).

However, not all of the grape cells are destroyed in the crushing process (look at all the intact skins that are still there!). The surviving grape cells don't realize that they are doomed. Instead, they go into survival mode. They know that the pH is falling into a range that will kill them, so they begin to try desperately to get the pH back where it should be. To do this, they throw that H+/K+ pump into reverse. Instead of removing H+ from the cell and bringing K+ in like it does when it's on the vine, now it starts to bring H+ in (to try to lower that pH) and pushes K+ out. It's like when you return something to the store that you don't want--you give them the goods, and they give you the money back.

Since you're removing the H+ from the solution, the pH starts to rise. This always takes a couple of hours, which is why we let the grapes rest overnight to stabilize. At the same time as the pH rises, you get more K+ into your juice, because that's the price the cell pays for removing H+ from the juice. So this is why you can see a rise in pH (because there are less H+ in the juice), but no change in total acidity (because the H+ is still there, but now it's inside of the cells instead of in the juice). Back in the 80s, a UC Davis researcher actually considered this and suggested calculating total acidity by adding pH to [K+] and [Na+] (because plants also have Na+/H+ pumps) (http://wineserver.ucdavis.edu/pdf/attachment/221%20relationship%20between%20K,%20Na,%20and%20pH.pdf). To be honest, that's a load of crap. All bacteria care about is the pH--they don't care what total acidity is.

So there you have it! That's why you guys saw a rise in pH when you let your juice sit overnight. The poor little grape cells were just trying to live!

Angela Romo September 2013