Water III – Chemicals In Our Beer And Other Conspiracies

By Greg Hackenberg

“Not all chemicals are bad. Without chemicals such as hydrogen and oxygen, for example, there would be no way to make water, a vital ingredient in beer.” - Dave Barry

I know it’s been a while, but I’m back and I know if you’ve been playing along at home, you should be ready for the next installment where we were going to delve into the eternal mysteries of mash pH. “Ready”, of course, could mean ready to skip this part altogether, but I hope you’ll bare with me and see that it’s not so complicated. Really, this part is simply about understanding what’s going on in the mash you’ve got going. We’ll work into what you can do about it later…remember, local water is going to work reasonably well for nearly all beers, but “reasonably” is a bit subjective. Anyway…

In our first installment, I described the three major roles water plays in brewing. The first and most important was in determining the pH of the mash. Before we begin I have to point out that our good friend and Hopline contributor Mike Retzlaff, covered this topic in his article “pH - What is it and where can I get some?” and is available on the CCH website. It covers a lot of the same ground, but in a different way. I’ll be going at it in a bit more round-a-bout way.

Now, to begin, we have to get a few terms straight. Tops on the list is **pH**, which is a numeric scale used to specify the **acidity** or **alkalinity** of a solution. It measures activity of Hydrogen ions, which you really don’t need to know. What you do need to know is that it goes from 1-14, the low end being **acidic**, 7 being **neutral** and the high end alkaline or **basic**. It is a logarithmic scale so each numeric increase represents a 10 fold increase. But that’s that math stuff, don’t worry about that.

A tad bit confusing in this is that **alkalinity** in water actually expresses the ability of a substance to resist a change in pH. To keep things simple and to make Chemists and other science types cringe, from here out this ability to resist a change will be called the **Buffering Capacity**, a **Buffer** is something in the water that provides that ability, and **alkalinity** will refer solely to refer to things pushing us to the higher end of the pH scale. This will help it all make sense; at least I hope it will.

On to mash pH. When we mash we are employing a number of enzyme functions to convert starches to sugars. As you know, temperature plays a huge role in the outcome. But pH, while not quite as important, plays a pretty big role, too. But unlike temperature you are pretty much aiming for one target. That is a pH between 5.2 and 5.6 at mash temperature. As long as the pH remains in the ballpark, the mash functions will proceed without issue. However, if the pH falls too far outside this range, there can be a significant impact on the quality of the beer.

A pH of 6 or higher (more basic) can increase the extraction of tannins, produce harsh hop bitterness and produces beers with malt character often described as "dull". Further, low PH carried into the kettle can reduce hop utilization.

A pH of 5 or lower (less alkaline) can impair beta amylase functions, impairing conversion, and produces beers with malt character often described as "grainy" and one-dimensional. <snark on> Yum! <snark off>

So what about water determines the mash pH? Well, there are three of those buffers I mentioned at play that shake out to give us the mash pH.

As counterintuitive as it might appear, the pH of the water is of little importance. It is the **buffering capacity** of the water that is the critical factor that serves as the first of those three. The buffering capacity is determined by the **carbonate** content of the water. This is expressed in water reports as **Bicarbonate** (HCO_3) or as **calcium carbonate** ($CaCO_3$). They measure the same thing, just in different ways. The greater the amount, the greater the buffering capacity, and is it is an **alkaline** buffer. So the more you have the higher your final mash pH is going to be.

Our second buffer is the available calcium and magnesium, the "hardness" of the water. You probably have heard of water described as "**hard**" or "**soft**". This is a crude term for the Calcium and Magnesium content of water, which actually refers to how easy or how "hard" it is to produce soap lather; "soft" water having low mineral content and "hard" having high content. On its own it has no effect on the pH.

But it’s not on its own, at least not in your mash, we have the grain. The grain provides phosphates which react with the hardness and through several resulting reactions serve to **acidify** the mash, thus lowering the pH of the mash. Water with low hardness will produce a weaker buffer and higher hardness a stronger buffer. It is the interaction of the two buffers that determines what we call the **Residual Alkalinity**. Now our third buffer comes into play, and we can begin to see how certain water leads to certain beer styles.

There’s more to gain than just reacting to the hardness. Our third buffer is found when we add darker malts to the mash, your toasted and roasted ones, especially. These malts, due to Maillard reactions in the kilning and roasting processes, provide an additional acidic buffer which serve to lower the residual alkalinity and lower the mash pH, hopefully into our 5.2 to 5.6 range.

Now this is the money part here: beer made where Residual Alkalinity is high, the addition of darker malts or an acid would be necessary to keep the mash pH in the desired range. Lower Residual Alkalinity would favor lighter beers without the darker malts. This is largely what we see when we examine historic beer cities, the water and the styles of beer that arose there. Here are a few examples:

<u>Pilsen</u>: Extremely low hardness and low alkalinity allows optimal mash pH to be reached with only lightly kilned base malt. Pilsners

<u>Munich</u>: With only moderate hardness, but higher bicarbonate levels, additions of darker Munich and other malts are required. Oktoberfest and Dunkel

<u>Dublin</u>: Moderate hardness with extremely high bicarbonate levels, the resulting alkalinity requires the addition of significant amounts of highly roasted grains. Stout

<u>Burton-on-Trent</u>: Extremely high hardness and extremely high bicarbonate levels serve to largely cancel each other out allowing pale beers. Pale Ale

<u>Orleans/Jefferson:</u> With fairly low hardness, and moderate bicarbonate levels, addition of some darker malts is required. Amber or Brown ale

<u>Houston</u>: Extremely low hardness and extremely high bicarbonate levels, even the darkest stouts will be difficult to brew without significant water treatment. Failure

That’s it folks. It really comes down to the interplay of those three elements…that’s it, really. If you stick to the 9-15 SRM range, you’ve got nothing to concern yourself with…well, maybe a few things, but that’s the more advanced stuff.

So next up, “Thank God I don’t live in Houston, but I don’t want to make a Brown Ale, what can I do?”