Beer Mashing

By: Douglas Wright, President

Mashing in is the process by which grains and malt are added to hot water in order to extract fermentable sugars for conversion to alcohol. This process is highly dependent on temperature.

The hot water dissolves starches from the grains and enzymes present in grains naturally break the starches down into fermentable sugars. That's the simplified explanation but in reality precise control of all parameters here is like an award winning chef mixing up the ingredient and cooking a 5 star meal precisely. Too much, too little too hot or too cold and you will not get what you want.

Here are the tests that should be done and how they will affect your brews:

Temperature

The temperature range in which extraction of the fermentable sugars occurs is quite wide. The higher the temperature is, the more starches will be extracted. But if the temperature is too high, above 77°C, tannins are extracted from the grains giving the beer a harsher bitter flavor. Even higher and an unpleasant flavor evolves due to burning of grains in the mash.

The enzymatic breakdown of starches is much more temperature specific.

α-amylase, works over 66°C - 72°C. and produces many non-fermentable sugars that will give the finished beer more Mouthfeel and less alcohol.

β-amylase works over 57°C - 68°C produces more fermentable sugars, resulting in a drier and more alcoholic beer.

β-glucanase works best around 45°C to 60°C.

Above these temperature ranges the enzymes denature and no longer break down starches to sugars. By varying temperatures between 55°C and 72°C one can vary the amount of each enzyme and the time at each point you can change the flavor of beers even if the mash is exactly the same.

Mashing temperature is also important for developing good foam quality in the finished product. The temperature at which mashing occurs will affect what proteins will be in the finished product. Foam stability is largely dependent on the balance protein and lipids in the final product. Most proteins are foam promoters, meaning they make more stable head. Lipids, on the other hand, can rapidly decrease foam stability.

At temperatures lower than 55°C foam promoting proteins are neutralized and as temperatures increase, the amounts increase.

At temperatures lower than 55°C enzymes promoting fatty acids that destroy foam stability are activated.

There is a very fine balance here!

A problem that occurs in Mash tanks is that temperature distribution may not be even and that due to process requirement hardwired thermowell might not be in the ideal locations. Even with good mixing hot and colds spots can occur. Depending on the beers you are trying to produce you may want higher temperatures, but too high and you get bitter flavors from grains in the hot spots and deactivation of some enzymes leading to less sugars or the wrong balance. It's here where some of our expertise comes in. We can supply dataloggers and wireless systems that can work independent of your controls or in some instances be integrated with your controls. These devices are battery powered and can be placed on moving mixing paddles to allow temperature monitoring in areas you cannot check currently.

In summary the temperature and its duration will affect the amount and types of sugars produced, which will influence the alcohol content, the body and overall flavors. Your temperature control at this stage should be precise to control this process. It ensures that beer will have your desired foam stability, flavor, Mouthfeel, and alcohol levels. Temperature should be kept between 55°C and 72°C as a rule of thumb but for consistent beers the more precise the temperature the more consistent will be your beers. Varying the temperature within this range will affect the final product also. The process can be fine-tuned to achieve the desired flavor profile. Cooler temperatures will result in more fermentable sugars, leading to higher alcohol and lower foam stability. As temperature is increased the finished beer will have more Mouthfeel, less alcohol, and greater foam stability.
Monitoring for temperature during the mashing process can be done using the following methods:

A) Handheld Thermometers- Still an invaluable tool for spot checks they do however only give you the temperatures at the time they are used. They do have the advantage of allowing readings "not next" to the process probe. Also custom built probe are simple to build.
B) Data Loggers or Smart thermometers, are compact device that take  temperature and log it to their memory until downloaded. These are ideal for special process applications such as Pasteurization, Shipping but are also cost effective for sort tem studies. These leave the mystery out of the between readings times that might occur with display type thermometers or non-logging control systems. These can display alerts and data can be downloaded to produce reports. Combined the reports can show trends helping you to trouble shoot otherwise insignificant changes.
C) Wireless Systems are the ultimate dataloggers. They continually record and do alarming if incorrect conditions occur. Alarms can be sent to your smartphone if you wish. They can be remotely monitored via computer or cell phone anywhere and we can monitor dozens of other critical functions to make one extremely cost effective monitoring/alarming/control system. If your time is valuable, then this has a payback in weeks or months. This option is just an example but we can also offer a wide range of sensors and different probe designs to monitor (and even control) a huge range of needs. Call us with your ideas and specific needs.

D) Integrating Sensors with your Current System. If you already have current PLC or control based system these can be expensive to upgrade, repair or expand. We can integrate controllers and wireless system with most systems. This allows you to marry the advantages of our systems and any specialized features of your current brewing systems.

pH

The pH during mash making is important because it controls the extraction of proteins and sugars from the malt as well enzymatic activity. During mashing enzymes such as α-amylase, β-amylase, and β-Glucanase break carbohydrates into fermentable sugars. Enzymes all have specific pH ranges that they work over. If the pH is too high or too low then they might not work and there will not be enough sugar present for fermentation to take place.

Ideal pH Ranges:
α-amylase 5.3 - 5.7

β-amylase 5.1 - 5.3
β-glucanase 4.0 - 6.0
Proteases 4.2 - 5.3

The type of malt used will influence the pH of the mash. Darker malts are usually more acidic whereas Paler malts are usually less acidic.

If the mash pH is too high the addition of gypsum, inorganic or organic acids can be added until the pH is in the desired range. Malt containing lactic acid, known as acid malt can also be used to lower the pH. If the pH is too low the addition of CaCO3 can raise it to the desired range.
The addition of some acids or buffering salts may take some time to reach final pH so it is critical to do this slowly and incrementally while using a good pH meter and fast response probe. Also since the Mash may vary in temperature it is critical to use a probe with ATC (automatic temperature compensation) to get valid pH readings. If you make additions and take readings too quickly you can overshoot the target pH. This can be ensured by adding a small amount of the adjusting substance stirring thoroughly and waiting a few minutes before measuring again.
Ideally a small test lot can be taken and adjusted to see how much acid or base is required to change the pH to the desired value then scale up this quantity. Even then as you near the end point additions should be done slowly and pH checked continually so as not to overshoot.
In addition, the pH of the mash will also affect the taste, body and malt character. pH testing can be conducted at this stage to ensure stability. Our pH testers shows readings in an extended range from -2.0 to 16.0 pH (pH56 has a 0.01 pH resolution). They compensate automatically for temperature for precisely accurate measurements.

Oxygenation

During the heated mashing stage extra care needs to be taken in monitoring and controlling oxygen, because increased temperatures tend to increase the rate at which chemical reactions take place.. If too much oxygen is allowed to contact the brew during mashing the result is the formation of aldehydes which result in wet cardboard-like flavors in the finished product.
Acetic acid can also be formed by oxidation resulting in sherry-like flavors at low concentrations and vinegary flavors at higher concentrations.
See for options here: dissolved oxygen meter
Even if possible, the question arises. Should you eliminate all oxygen from the mashing process?
Studies are variable here: Some show that completely eliminating oxygen during mashing and wort boiling decreases the beer’s colloidal stability and tends to induce chill hazing.
Others show that by increased oxygen during sparging can increase the colloidal stability of the finished beer. During traditional batch sparging the water is completely drained from the mash leaving the solids behind exposed to air. This causes oxidation between batch sparges. During continuous sparging the solids in the mash are constantly covered by water minimizing exposure to air and oxidation. The method you use will determine O2 levels and whether you have any real control over it.
This just stresses the importance of conducting tests, so that you will have repeatable benchmarks to follow in subsequent batches.