ALL GRAIN CLASS

Mashing Defined: Mashing is using diastatic enzymes to break starches into sugars. Breaking starches into sugars is called **Saccharification.** **Enzymes** are biological molecules that change some molecules into others molecules.

The most important enzymes for creating fermentable sugars are **Beta and Alpha Amylase**. Beta Amylase can only work on the ends of a starch molecule and make one maltose molecule at a time. Alpha Amylase can break down molecules in random places. Think of Alpha as creating more ends for the Beta to work on. Also consider it may take longer if mashing at an optimum temperature for Beta and mash for 90 minutes if in the 140s range.

The **acid rest** is historically used to lower mash pH into the proper range. It takes a long time and is no longer required due to modern knowledge of chemistry and the ability to adjust water and malts.

The **peptidase** enzyme produces FAN which is essential for yeast health. The **Protease** rest breaks down large proteins that for haze. In fully modified malts, the malting process has done this work.

Mashing vs. Steeping. In extract brewing, you steep grains to extract flavor. Most steeping grains are a small portion such as crystal and roasted malts. The process to make these malts has already gone through saccharification and has converted starch to sugar. Base and flaked grains are inappropriate for steeping because you will merely release starch though in some cases some flavors will make it such as flaked oats. Mashing is done at a higher density of grain 1.25-1.5 qts per lb vs. 8+ qts per lb. In steeping, the enzymes are spread too thin to complete conversion in a timely manner.

Since a Beta rest produces very fermentable sugars and Alpha produces multiple sugars a long rest at a lower temperature produces very fermentable "dry" beers with low final gravity and a rest at a higher temperature produces less fermentable wort that finishes "sweet" with a higher FG.

Enzyme	**Optimum Temperature Range**	**Working pH Range**	**Function**
Phytase	86-126°F	5.0-5.5	Lowers the mash pH. No longer used.
Debranching (dough in)	95-113°F	5.0-5.8	Solubilization of starches.
Beta Glucanase	95-113°F	4.5-5.5	Best gum breaking rest.
Peptidase	113-131°F	4.6-5.3	Produces Free Amino Nitrogen (FAN).
Protease	113-131°F	4.6-5.3	Breaks up large proteins that form haze.
Beta Amylase	131-150°F	5.0-5.5	Produces maltose.
Alpha Amylase	154-162°F	5.3-5.7	Produces a variety of sugars, including maltose.

Note: The above numbers were averaged from several sources and should be interpreted as typical optimum activity ranges. The enzymes will be active outside the indicated ranges but will be destroyed as the temperature increases above each range.

How to Mash:

Multistep: You can still do a traditional mash with a Protein, Beta and Alpha Amylase rest. Many European brewers do. A Popular method is 40°C - 60°C - 70°C (104 - 140 - 158°F) with 30 minute rests at each step. This is tough as you need to be able to adjust your temperature with direct heat or by adding water.
Decoction: Decoction is a way to do a multistep without adding heat or water. A third of the mash (must be thick, little water), is removed and heated to conversion temp (150) then boiled and returned to the mash. This raises the temperature. This style produces melanoidin compounds which are red-brown flavors common in Oktoberfest, German Lagers and Hefeweizen.
Single Infusion Mash: Single infusion is possible with today's highly modified malts. Go to a single temperature and mash for 60-90 minutes. Usually done at 148-158. Go longer for lower temperatures. You can use iodine or idophor to check conversion as it turns wort black in the presence of starch.
Mash out: The temperature selections have creates a sugar profile. However, your enzymes are still active. As you transfer your wort it will cool and the enzymes may change the sugar profile. You can elect to raise the mash temperature to 170 for 10 minutes and denature (de-activate the enzymes) locking in your profile. Incidentally this will also make the wort more viscous reducing a stuck sparge scenario which is more common with wheat, rye and flaked grains.
Mash PH: Mash pH is absolutely important and has nothing to do with water pH. The mash will lower the pH and the hardness will resist lower. Harder water resists lowering (buffering power) more than soft water. Most mashes should be between 5.2 and 5.6. Darker malts lower the mash pH. Therefore a dark beer brewed with hard water will have a proper pH and a pale beer with soft water will as well. We encourage the use of water reports and software to make calculations. pH can be adjusted with brewing salts, acidulated malt, blending RO water, lactic acid, pre-boiling water, and 5.2 pH stabilizer.

Mashing will be done with 1.25-1.5 qts of water per lb of grain. Strike temperature is the temperature of the water to compensate for heat loss to the grain and the mash tun. It is usually 10-15 degrees warmer but you will need to learn your system. Add the water to the grain or the grain to the water then stir in all the clumps, cover and insulate as best as possible.

Table 16 - Salts for Water Adjustment

Brewing Saltand Common Name	Concentration at 1 gram/gallon	Grams per level teaspoon	Effects	Comments
Calcium Carbonate ($CaCO_3$) a.k.a. Chalk	105 ppm Ca^{+2} 158 ppm CO_3^{-2}	1.8	Raises pH	Because of its limited solubility it is only effective when added directly to the mash. Use for making dark beers in areas of soft water. Use nomograph and monitor the mash pH with pH test papers to determine how much to add.
Calcium Sulfate ($CaSO_4$*2 H_2O) a.k.a. Gypsum	61.5 ppm Ca^{+2} 147.4 ppm	4.0	Lowers pH	Useful for adding calcium if the water is low in sulfate. Can be used to add sulfate "crispness"

	SO_4^{-2}			to the hop bitterness.
Calcium Chloride ($CaCl_2*2H_2O$)	72 ppm Ca^{+2} 127 ppm Cl^{-1}	3.4	Lowers pH	Useful for adding Calcium if the water is low in chlorides.
Magnesium Sulfate ($MgSO_4*7H_2O$) a.k.a. Epsom Salt	26 ppm Mg^{+2} 103 ppm SO_4^{-2}	4.5	Lowers pH by a small amount.	Can be used to add sulfate "crispness" to the hop bitterness.
Sodium Bicarbonate ($NaHCO_3$) a.k.a. Baking Soda	75 ppm Na^{+1} 191 ppm HCO_3-	4.4	Raises pH by adding alkalinity.	If your pH is too low and/or has low residual alkalinity, then you can add alkalinity. See procedure for calcium carbonate.

Sparging: Sparging is the process of rinsing the remaining sugars from the grain. Without sparging, we would need enormous amounts of grain. There are two main types.

Vorlauf: This is the process of building a grain bed which will be done before directing wort into the kettle. Your Mash Tun will have some method to drain through the bottom into the boil kettle. Using a pump or pitcher, slowly run off worth until a grain bed sets as a filter and bits of grain are not coming out. Return the wort carefully to the top of the mash tun. This may take a gallon or so.

Batch Sparging: This is the easiest method. Simply vorlauf, then run all of the wort to the kettle. Close your mash tun valve, add all the sparge water to the mash tun, stir, then wait 10 minutes. Vorlauf again and run the wort to the kettle. We prefer a double batch sparge for best results. Simply cut the calculated sparge water in half and do this process twice. Regardless, run the wort at a medium or slow pace to keep from channeling in the grain bed. You want to rinse and not allow the sparge water to find a path of least resistance.

Fly Sparge: Fly sparging is slowly draining wort while rinsing at the same time. This will require a pump or 3 tier system to use gravity. Complete the vorlauf and slowly allow the wort to drain into the kettle. Slowly drain the sparge water through a sparge arm on top of the grain bed. The object is to keep about 1 inch of water above the grain bed and to sparge slowly. This works very well with deep grain beds.

Calculating water. You will need to learn your system to get this exactly right, but there are some general calculations. Here is an example based on 10 lbs of grain for a 5 gallon batch:

Mash Water = 1.25 qts x 10lbs = 12.5 qts we will use 3.25 gallons
Water left in Grain = .1 gallons per lb = .1*10= 1.0 gallons
We can expect 2.25 gallons in the boil kettle

Boil Off: every kettle is different and most advice says 10-15% per hour. Learn your system, but we would expect about 1 gallon on a 5 gallon batch. Knowing we want 6 gallons of wort to end with 5 gallons, we know we need 6 - 2.25= 3.75 gallons more water.
Sparge water = 3.75 gallons (If you are fly sparging, you can easily heat more and not use it)

Brew House Efficiency: Calculate this every time you brew. This is the actual sugar extract as a percentage of the potential sugar yield in the grain. Higher efficiency means you can brew the same beer with less grain, and less costs. 70-80% is normal for homebrewers.

All grain has a potential extract per pound and it varies (check chart in out store or on the web). You will need to add them up. Here is a simple example of 10 lbs of pilsner malt, with a potential extract of 1.037 SG per lb. For ease of math, we will make 1.037 written as 37 points.

10lbs x 37 points equals 370 points of potential.

We yielded 5 gallons of wort after boil with a SG of 1.055 or 55 points

5 gallons x 55 points equals 275 points of extract

Brewhouse Efficiency = extract / potential = 275/370= 0.74 or 74%

Now use this number in any brew software to build your recipe to meet your needs. Keep in mind it may take a few brews to get this consistent and you will likely have lower efficiency with bigger beers.