All-Grain Brewing Guide

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Chesapeake Real Ale Brewers Society
MARYLAND

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Introduction

This guide assumes that you, the brewer, already have experience with extract brewing. The following information will focus on the differences between making extract and all-grain beers. By the end of this, you should have enough information and confidence to do your first single-infusion all-grain mash.

References

- John Palmer's How to Brew - http://www.howtobrew.com/intro.html
- Brew Your Own - http://byo.com/newbrew/all-grain
- BrewWiki - http://brewwiki.com
- American Homebrewer's Association - http://www.homebrewersassociation.org
- CRABS Homebrew Club - http://www.crabsbrew.org

All-Grain Brewing Terms

Equipment

Brew Kettle: The vessel in which wort from the mash is boiled with hops.

Grant: A pot or other vessel used to transfer the first runnings of the mash back to the lauter-tun during the vorlauf.

Hot Liquor Tank: The hot liquor tank is a large vessel that heats water for the different steps in the brewing process. The water that is released from the hot liquor tank is known as liquor.

Lauter-Tun: A vessel, usually a large pot, picnic cooler or bucket with a false bottom or other equipment used to separate sweet wort from spent grains. Many brewers use the same vessel as a combination mash-tun/lauter-tun.

Mash-Tun: A vessel, usually a large pot or picnic cooler, used to mash grains.

Wort Chiller: A piece of equipment, usually a copper coil, used to rapidly cool the wort after the boil.

Grain

Base Grain: Any malt that is used primarily as a source of fermentable sugar and that must be mashed to extract the sugar. For example, pale malt, wheat malt, and Munich malt are all base grains.

Specialty Grain: Grains that are used primarily for flavor, aroma, body or color. Generally, these malts do not require mashing for their purposes. The most common specialty grain is crystal malt. The name 'crystal' comes from the malting and kilning processes which crystallize the sugars in the grain. Therefore, the starch in the grain has already been converted to sugar. Other specialty grains include Special-B, chocolate malt, and roasted barley.

Grist: The total amount of grain to be mashed.

Grain Bed: The grain in the mash-tun/lauter-tun.

Mashing

Iodine Test: A test used by brewers to determine whether full conversion has been achieved. A small amount of wort is removed from the mash-tun and mixed with a small amount of iodine. If the iodine remains dark, conversion is complete. If the mixture turns blue, more time is needed.

Infusion Mash: A mash in which the temperature is controlled by using or adding hot (or cold) water to the mash. A single-infusion mash is one in which only one addition of water is used.

Mashing: The brewer's term for the hot water steeping process which hydrates the barley, activates the malt enzymes, and converts the grain starches into fermentable sugars.

Mash-In: The process of mixing the grain and water together in the mash-tun.

Mash-Out: The process of raising the temperature of the mash to 165 ºF. The mash-out stops enzyme activity and raises the temperature of the mash to a good level for sparging.

Strike Temperature: This is the temperature of the mash water when it is first mixed with the grain.

Stuck Mash: The unfortunate condition which occurs when water will not flow through the grain bed from the lauter-tun to the kettle. The lauter-tun becomes clogged or 'stuck.'

Sparging

Efficiency: The term, usually expressed as a percent, used to describe the amount of sugar extracted from the grain in a brew system relative to the maximum amount that can be extracted. In all-grain brewing, efficiency is always less than 100% because brewers cannot separate all of the sugar from the grain during sparging. It is useful in determining the amount of grain a brewer needs to mash to achieve a desired target gravity.

Lauter: The process of separating the sweet wort from the spent grain. This term is virtually synonymous with 'Sparge.'

Sparge: The process of rinsing spent grains with hot water (liquor, in brewing terms) to extract fermentable sugar from the spent grains.

Vorlauf: The process of recirculating the first runnings of the mash back into the lauter-tun until the first runnings are clear.

Boiling

Cold Break: Proteins and other material which coagulates and become solid as the result of cooling wort.

Hot Break: Proteins and other material which coagulate and become solid as the result of boiling wort.

Target Gravity: The Original Gravity of the final product.

Trub: All of the solid stuff left in the brew kettle after the boil. It consists of hot break, cold break, spent hops, etc.

Whirlpool: At the end of the boil, the wort is set into a whirlpool. The so-called tea leaf paradox forces the denser solids (coagulated proteins, vegetable matter from hops) into a cone in the center of the whirlpool tank.

Differences Between All-Grain and Extract Brewing

Mashing: The main difference between all-grain and extract brewing is that you mash your own grain in all-grain brewing to produce the wort. With extract brewing you are re-hydrating wort produced by a maltster.

Control: In extract brewing, you have limited control over the final product. Usually, this control is exercised by the use of specialty grains to develop desired malt characteristics. However, the control is not absolute. For example, it is very difficult to brew very light beers such as Belgian White with extract because of the dark color of even the lightest extracts. Similarly, body, mouth feel and what is often described at 'maltiness' are difficult to control with extract beers.

In all-grain brewing, crushed grain is mashed in hot water between 145-158 ºF. This mash temperature range allows the brewer to control body and alcohol level. A beer mashed at a low temperature will tend to have a higher alcohol content and a lighter body. A beer mashed at a high temperature will tend to have a lower alcohol content and heavier body.

Cost: All-grain brewing is generally cheaper per batch than extract brewing. This is especially true if you buy your base grain in bulk. However, the capital investment in all-grain brewing is larger than that in extract brewing.

Time: All-grain brewing takes longer than extract brewing. This is either good or bad depending on your point of view. Budget 6-8 hours on your brew day for all-grain brewing.

Quality & Creativity: Really good beer can be made from extract. However, all other things being equal, all-grain brewing produces better beer with more opportunities for creativity.

Additional Equipment

Additional equipment is needed for all-grain brewing. To start, a bigger brew kettle will be needed to accommodate a full-wort boil. Plus, A mash-tun/lauter-tun is also needed to mash and sparge the grain to produce the wort.

Mash-Tun/Lauter-Tun: Most brewers use either a large pot or picnic cooler a mash-tun/lauter-tun. Most lauter-tuns are fitted with either a false bottom or copper tubing with holes or slots in it. The false bottom or tubing acts as a strainer to separate the sweet wort from the spent grains. Each type has its advantages and disadvantages. Pots have the advantage of being able to accept direct heat. If the temperature of a mash is too low, the pot can be placed directly on a burner. However, pots do not hold heat very well. Conversely, picnic coolers hold heat very well but the only way to add heat is to add hot water.

Digital Thermometer: For all-grain brewing temperature is very important. A lab quality digital thermometer can distinguish temperatures of one or two degrees very quickly.

Heat Source: Most stoves do not have enough BTUs to boil the 6.5–7 gallons of wort needed to make a 5 gallon batch of beer. You will need to invest in an outdoor propane burner (or go with an electric brewery to remain indoors).

Wort Chiller: It simply takes too long for a full batch of wort to cool by immersing the brew kettle in ice water. Most all-grain brewers use an immersion chiller. An immersion chiller is made from a coil of 25-50 feet of copper tubing that is placed inside the brew kettle. After the boil, cold water runs through the chiller to cool the beer. Counter-flow and plate chillers are also used for colling wort as an alternative.

Grain Mill: Grain can be milled at Maryland Homebrew if you will be brewing within a few days of milling your grain. If you are going to buy grain in bulk, a grain mill is a necessity.

Single-Infusion Mash

Brewing Software

All-grain brewing requires formulating a mix of grain and water at specific temperatures to produce the beer you want. This can be done manually or with spreadsheets if you know the formulas, but why do this when there are several software programs available to help.

- Beer Smith
- Pro-mash
- Brew Toad (on-line)
- others...

Recipe Formulation

From extract brewing, you know that you get about 45 points gravity per pound per gallon from dry malt extract (DME) and about 38 points for liquid malt extract (LME). Therefore, 5 pounds of DME would have an expected Original Gravity (OG) of 1.045 for 5 gallons of beer.

In all-grain brewing, the gravity contribution of a specific grain depends on it's maximum potential multiplied by efficiency. For example, many pale malts have a maximum potential of 36 points per pound per gallon (assuming an impossible efficiency of 100%). Depending on your system, you can expect efficiency in the 60-80% range. We recommend using a 70-75% estimated efficiency until you you become familiar with your specific system.

The following formula is used to estimate how much grain is needed to end up with a target OG for a batch of beer. You only need to know this formula if you are doing your calculations manually. Brewing software will do this calculation for you.

(Target OG pts.) * (Batch Size) / (Points Per Pound) * (Efficiency) = Pounds of Grain

How much pale malt would be needed for 5 gal of beer with a target OG of 1.050?

(050 pts. * 5 gal.) / (36 * 0.75) = 9.25 Pounds of Grain

Hops are basically the same for all-grain and extract so we won't go into them much here. However, if you have been doing concentrated wort boils and then topping off with cold water, consider using about ten percent less hops. This is because you get less hop utilization from a concentrated boil typical with extract brewing. Hop utilization is also built in to brewing software.

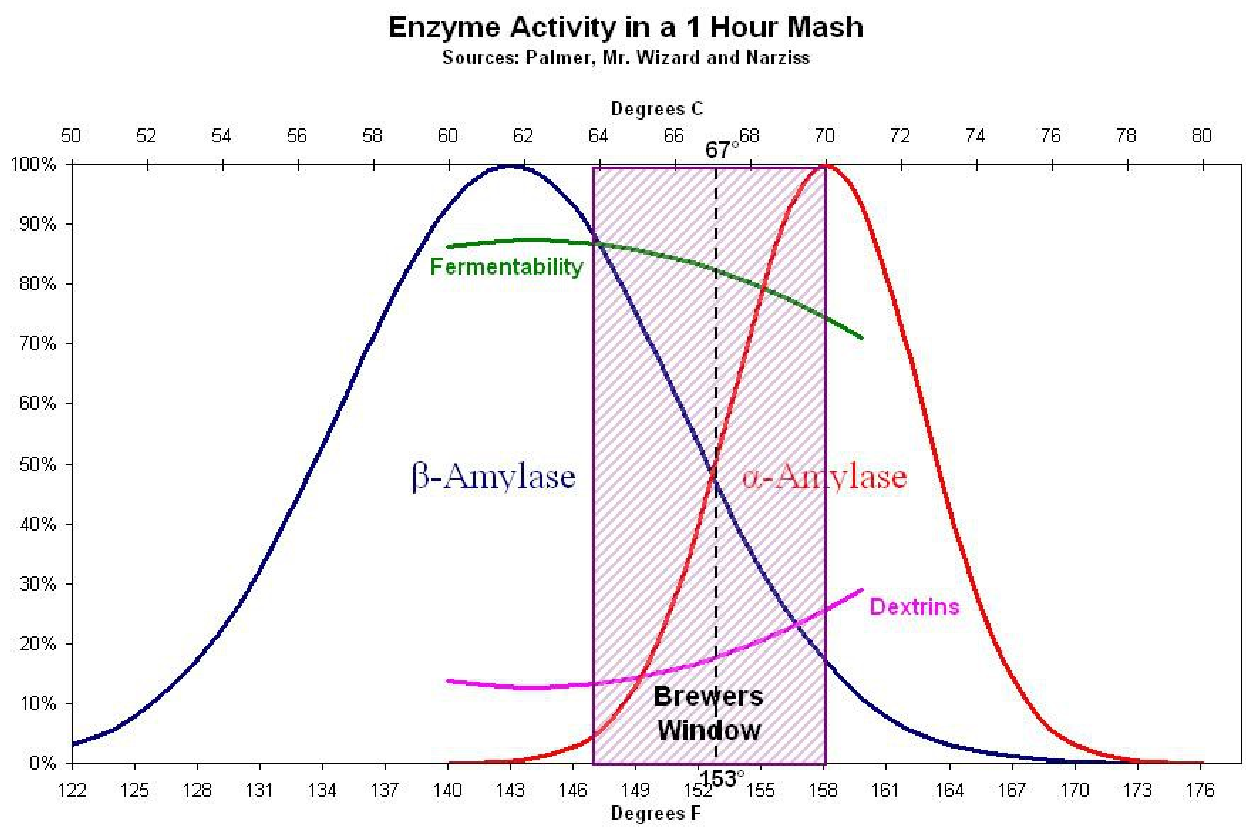
Grinding Grain

Maryland Homebrew has a grain mill that can be used. For almost all brews, the mill settings there are fine for all-grain brewing. The general rule is that the grain should be cracked, not crushed, and most of the husk should be intact. If the grain is ground too finely, it begins to look pulverized and dusty. This can lead to stuck mashes and harsh flavors associated with the extraction of tannins from the crushed husks. If it is too coarse, some of the fermentable material will not be converted.

Mashing-in

Single rest infusion mashing is the easiest method for producing an all-grain wort. The most common homebrewing mash schedule consists of a water-to-grain ratio of 1.25-1.5 quarts water per pound of grain, and holding the mash between 148-158 °F for 1 hour. The temperature of the mash determines which enzymes are active to convert grain starches to sugars and impacts the final body of the beer.

- Lower mash temperatures favor conversion of more simple sugars that are more easily fermented by yeast – yielding a lighter bodied beer.
- Higher mash temperatures favor conversion of more complex sugars that are more difficult for yeast to ferment – yielding a fuller bodied beer.



The initial temperature of the mash-in depends mostly on the temperature of the strike water, the temperature of the crushed malt, and the temperature of your mash vessel. There are equations that can help you calculate the temperature of your strike water, and brewing software does this for you. If you want to wing it, this generic recommendation works fairly well if your grain and equipment are in the vicinity of "room temperature," and you use a water-to-grain ratio between 1.25 and 1.375 quarts per pound. Heat your strike water to 12 °F above your target mash temperature. This assumes no, or minimal, heat loss when transferring your water to your mash-tun. (Add another 4 °F to account for a plastic cooler mash-tun).

Once you have reached strike temperature, you are ready to mash-in the crushed grain. Many home brewers start with the mash water in the mash-tun then add the grain to the water (but it can be done the other way). Add the grain to the water and stir constantly to break-up all clumps.

This is especially important at the beginning. As you add more malt, the thickness of the mash will help to break up any clumps. Once the grains are fully mixed and uniform, take a temperature reading. A couple of degrees high or low are fine. If you are way too low or too high, add cold or boiling water to adjust the temperature. Then, set your timer for the desired mash time. Also, if you are mashing in a steel pot, you may want to wrap it in a towel to conserve heat.

The Mash

It is best not to disturb the mash once the water and grain are thoroughly mixed and you are at your desired mash temperature. After 30 minutes, you can stir the mash (it will be warmest at the center) and take a temperature reading, but this is optional. You can also adjust the temperature with some boiling water, if necessary. This is also a good time to get your sparge water started. Once you are nearing the end of the mash, you can do an iodine test to verify full conversion. Remember that this test is not infallible. In fact, if you are using wheat malt, the iodine test may never show complete conversion.

Mash-Out

At mash-out, boiling water is added to the mash to raise the temperature to 165-170 °F. This stops the enzymatic activity and prepares the grain bed for sparging. The amount of water needed depends on the amount of mash water used and its temperature. As a general rule (for mashes at 152-154 °F), the amount of boiling water used is 40-50% of the amount used at mash-in. Use more or less water according to your mash temperature. Brewing software will perform this calculation for you.

The Vorlauf

After the mash-out, you are ready for the vorlauf. Assuming that you are using a mash-tun/lauter-tun with a false bottom, open the valve and begin running the wort into the grant (a 1-2 quart pot is sufficient). At this point, the wort will not be clear, and you will see lots of grain husks and other large particles. Because you want the wort to be clear, you will need to recirculate it back to the top of the grain bed.

When the grant is almost full, quickly move the hose to another grant (without closing the valve) and return the wort to the lauter-tun. Repeat this process several times (about four or so). As you do, larger particles will cover the holes or slots in your system and act as a strainer. Let the wort recirculate until it is fairly clear, then move the hose to drain into the brew kettle. Now you are ready to sparge.

Sparging

Sparging is the process of running hot water through the grain bed to extract sugars. The sweet wort exits the lauter-tun through a valve and passes through a hose into the kettle. A hose is used to prevent hot-side aeration. Before you brew, you will need to decide how to address the problems associated with sparging in a gravity feed system. Assuming that you are using gravity to move your wort, your kettle must be lower than your lauter-tun.

Sparge water is typically 168-172 °F, erring on the low side. You will need enough sparge water to be able to fill the brew kettle with ~6.7 gallons of wort (for a 5 gallon batch). It is better to have more sparge water than needed. ~75% of the batch should be sufficient. Brewing software will more precisely estimate how much sparge water is needed.

- Caution: over-sparging (running too much sparge water through the grain) will tend to extract husk tannins that could add an astringent and unpleasant taste to the beer.
- Adjusting the pH of the sparge water to match the pH of the mash will minimize the risk of extracting tannins while sparging. Mash pH is acid (~5.2). Tap water pH is usually alkaline (7-8). Adding a small amount of lactic acid (1ml/4 gal) is usually sufficient to adjust MD tap water to a 5.2 pH.

When pouring sparge water into the lauter-tun be careful not to disturb the grain-bed. You do not want to stir or disrupt the grain so having the water flow gently is best. Try to keep the entire grain bed under water until you have used all of the sparge water. There are various methods used to control the flow of sparge water over the grain bed. For example, Maryland Homebrew sells a sparge arm that helps to sprinkle the water so that the grain bed does not get disturbed.

The speed of the sparge is a matter of personal taste and can be controlled by adjusting the flow through the exit valve. A rapid sparge may create channels in the grain bed which would reduce the amount of sugars rinsed from the grain (lowering efficiency). A slow sparge may cause the extraction of husk tannins which contribute to astringency. A 30-40 minute sparge should be sufficient.

The Boil

The main difference between an all-grain and extract boil is that the amount of wort that needs to be boiled and the amount of trub – both are greater with an all-grain boil.

With extract brewing the boil is typically concentrated and water is added in the fermenter. This reduces the heating demands and allows most extract beers to be boiled on the kitchen stove. With all-grain brewing, you must have the ability to boil at least 6.7 gallons of wort for a 5 gallon batch. Most stoves do not have enough BTUs to boil this amount of wort and an outdoor propane burner is needed.

There is also less trub with extract brewing. Most maltsters filter the wort before making extract out of it. Therefore, there is little solid material other than spent hops in an extract boil. With all-grain brewing, there will be a large amount of both hot-break and cold-break left in the brew kettle after the boil. The use of Irish Moss (1 tsp / 5 gallons) helps precipitate out these solids and is added in the last 15 minutes of the boil. With more trub in the bottom of the brew kettle, there will be ~2 quarts of wort that cannot be transferred to the fermentor.

The amount of wort needed for a batch of beer will be system dependent and needs to factor for: expected boil-off, cooling shrinkage, and loss to trub. Brewing software will do this estimate for you, but here is an example:

5 gallon batch + 1 gal/hr boil-off + .20 gal cooling shrinkage + .5 gal trub loss = 6.7 gallons wort

Chilling the Wort

Most extract brewers cool their wort in an ice bath. This method is not optimal for all-grain brewing since it would take too long to cool 5.5 gallons of wort. A more effective cooling method is needed for all-grain brewing and this is typically a copper coil immersion chiller. An immersion chiller must be sanitized since it will be in contact with the finished wort. This is done by soaking in a sanitizer solution or by placing the chiller in the wort during the last 10 minutes of the boil.

When the boil is complete, cut the flame and begin the flow of water through the immersion chiller. Remember that the first water out of the chiller will be close to boiling so be careful that the effluent hose is secure. During cooling, stir the wort every few minutes to keep it moving over the chiller. Take periodic temperature readings with a sanitized thermometer, and once the wort is cool, you are ready to whirlpool.

Whirlpool & Racking

Using a sanitized spoon, stir the wort for a few minutes until you have a nice whirlpool. The whirlpool action will force the solid material in the kettle to settle at the bottom center of the kettle forming the trub cone. Let the wort settle for 15-20 minutes prior to transferring the wort to the fermentor. If your kettle does not have a valve, be careful not to disturb the trub cone when racking. Once you get to the trub cone, you will see that it is made of two layers. The top layer is very light in color and thin. The bottom layer is darker and thicker. The top layer of trub will not hurt your beer (and may be beneficial) so do not worry if some of this gets picked up during the transfer. However, always try to leave the bottom layer of trub in the kettle. Once you have moved the beer to the fermenter and pitched yeast, proceed with fermentation as usual.

Conclusion

There is an old brewer's axiom: "Brewing is easy . . . until something goes wrong." We hope that this document has helped you to make sure that things go right and prepared you for when things go wrong. Thank you very much. Please e-mail us if you have any questions or comments about this document.