Guide to All-Grain Brewing

By the Staff of Maryland Home Brew, Inc.

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1. Introduction

This guide assumes that you, the brewer, already have a good deal of experience in extract brewing. We have prepared the following information with our 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 mash. We hope that you will find it useful in making the transition from extract to all-grain as painless as possible.

2. All-Grain Brewing Terms

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.

Batch Size: The amount of wort in the brew kettle after it has been cooled from the boil but before it goes into the fermenter.

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

Conversion: The process of converting starch to sugar. Full conversion is achieved when all available starch is converted to sugar.

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 extract brewing, efficiency is 100% because all of the sugar in the malt extract goes directly into the kettle. 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.

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

Grain Bed: The grain in the lauter-tun.

Grist: The total amount of grain to be mashed.

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

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 drop of tincture of iodine. If the iodine remains red, 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.

Lauter:	The process of separating the sweet wort from the spent grain. This term is virtually synonymous with 'Sparge.'
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:	The process of mixing water and crushed grain at controlled temperatures to convert the starch in the grain to fermentable sugar. The term "mash" is also used as a noun to refer to the mixture of water and grain.
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°F. The mash-out stops enzyme activity and raises the temperature of the mash to a good level for sparging.
Mash-Tun:	A vessel, usually a large pot or picnic cooler, used to mash grains.
Saccharification Rest:	The process of allowing the mash to stay at a controlled temperature (usually 145-158°F) until all available starches are converted to sugar (usually 30-120 min.)
Sparge:	Rinse spent grains with hot water (liquor, in brewing terms) to extract fermentable sugar from the spent 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.
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.'
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.
Vorlauf:	The process of recirculating the first runnings of the mash back into the lauter-tun until the first runnings are clear.
Wort Chiller:	A piece of equipment used to rapidly cool the wort after the boil.

3. 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 instead of having a maltster do it for you.

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 as 'maltiness' are difficult, if not impossible to control with extract beers.

In all-grain brewing, most mashing is done between 145°F and 158°F. This wide temperature range allows the brewer to control body and alcohol level. There is an inverse relationship between these variables. A beer mashed at a low temperature will tend to have higher alcohol content and lighter body. A beer mashed at a high temperature will tend to have a lower alcohol content and heavier body. Also, the time for full conversion is inversely proportional to the temperature. Approximate times required for full conversion at various temperatures are: 15-25 min. @ 158°F; 45-90 min. @ 150°F; and 90-120 min @ 145°F. For example, a pilsner beer is relatively light in body. A mash at about 148°F would yield the correct body. Plan on this mash taking almost two hours. As a side note, most home brewers mash for at least 45 minutes regardless of the temperature. This does not harm the beer. We always mash for at least an hour.

Cost: All-grain brewing is generally much cheaper per batch than extract brewing. This is especially true if you buy your base grain in bulk. A 50-pound bag of pale malt is around $46.00-55.00. Even at modest efficiency, this amount of malt is equivalent to more than thirty pounds of malt extract, which would cost about $100.00. However, the capital investment in all-grain brewing is larger than that in extract brewing.

Time: Obviously, 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.

Scale: Many all-grain brewers tend to brew in larger batches than extract brewers. This is because it does not take much longer to brew ten gallons of all-grain beer than five gallons. With the increased time commitment, many all-grain brewers prefer to (or must) brew more beer less often. It is also because more people are coming around mooching your home brew! However, that increase in scale often means an increase in size of equipment. Whenever selecting equipment, it is usually better to go too big than too small.

Quality: Most brewers now agree that good beer may be made from extract. However, those brewers would also agree that, all other things being equal, all-grain yields the best beer.

4. Additional Equipment

Mash-Tun/Lauter-Tun: As mentioned above, most brewers use a large pot, picnic cooler or bucket as 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.

Generally, false bottom lauter-tuns require a separate mash-tun and lauter-tun (which could be an additional expense). This means that the hot mash must be transferred from the mash-tun to the lauter-tun. Many brewers use their brew kettle as a mash-tun, transfer the mash to the lauter-tun, then sparge back into the kettle for the boil. Additionally, many false bottom systems create a large amount of "dead space". Dead space is the space between the false bottom and the actual bottom of the lauter-tun. It is often impossible to get the sweet wort from the dead space into the kettle. False bottom type lauter-tuns also suffer from the inability to accept direct heat. With a false bottom in place, there is no way to stir the liquid at the bottom of the vessel. Therefore, if heat is added directly, scalding is a virtual certainty.

Maryland Homebrew carries the Torpedo Screens and Cooler Kits for making a cooler into a mash tun. The Torpedo Screens can also work with a pot if you get the weldless fitting instead of the Cooler Kit. Of course we are not limited to those — special ordering is available for the stainless and plastic false bottoms.

Digital Thermometer: For all-grain brewing temperature is very important. You may want to distinguish temperatures of one or two degrees very quickly.

Heat Source: Full-wort boils require a lot of heat. Also, you may want to heat more than one thing at a time. It's a good idea to look into a new burner.

Wort Chiller: If you don't already have one of these, you will need to get one. It simply takes too long for wort to cool by itself or by immersing the brew kettle in water. Most brewers use an immersion chiller. An immersion chiller is made from a coil of 25-50 feet of copper tubing in a coil tight enough to fit inside the kettle. It is attached to a garden hose or faucet adapter. The coil is placed in the kettle 5-10 minutes prior to the end of the boil to sanitize it. After the boil, cold water runs through the chiller cooling the beer. Another type of chiller is a counter-flow chiller. It is made of two coils of different diameters. The small coil is inside the large one. Many home brewers use a copper coil inside a garden hose of the same length. During cooling, the hot wort runs through the copper coil to the fermenter. Meanwhile, cold water runs the opposite direction through the garden hose. Counter-flow chillers are very efficient. However, many brewers avoid them because the inside of the copper coil must be sanitized.

Grain Mill: If you are going to buy grain in bulk, a grain mill is a necessity unless you are going to buy it then crush it back into the bag. Your grain will stay fresh longer if you crush it on an as need basis. To crush an entire bag of grain there is a $5 milling fee at Maryland Homebrew. If you are going to buy ingredients by the batch, your brew shop grain mill at home will probably serve you well enough.

5. Nuts & Bolts of Your First Single-Infusion Mash

First, we'd like to say that we are die-hard ProMash™ users. ProMash™ is brewing software which automates every phase of the brewing process from recipe formulation to conditioning. The only thing it does not do is drink the beer for you. However, because it is important to know how to brew without a computer, we will proceed as if we did not have computer assistance. For anyone interested in ProMash™, it is available on the web at www.promash.com. The program is only $25 and all upgrades are free.

Recipe Formulation

For a first all-grain beer, we recommend a red, brown or porter. These beers are mashed at relatively high temperatures. This will ensure that you don't have any conversion problems. The style guidelines for them are fairly broad, so if you shoot for the center of the guidelines you are sure to hit somewhere in the correct range.

From extract brewing, you know that you get about 45 points per pound per gallon (pppg or, more simply, points) from dry malt extract (DME) and about 35 points for liquid malt extract (LME). You might not have added any gravity contribution for crystal malt or other specialty grain. In all-grain brewing, it is more complicated. The gravity contribution of a specific grain depends on it's maximum potential multiplied by efficiency (expressed as a decimal). For example, many pale malts have a maximum potential of 35 points. This figure is also a good rule-of-thumb for unknown grains. However, this assumes the impossible efficiency of 100%. For a first brew, you can expect efficiency in the 60-80% range. Therefore, we recommend using 70% for your initial calculations.

For a pale malt at 35 points and an efficiency of 70%, the gravity you can expect is: 35 x 0.70 = 24.5 points. Rounded up, you can assume about 25 points per pound for your first beer. This means that one pound of grain mashed to yield one gallon of wort will yield an OG of 1.025. Of course, you want to make five gallons. Also, your OG is not going to be 1.025. You may want to make a brown ale with a target OG of 1.050. For the math, use only the last two digits of the OG and points. The equation for this is:

$$\frac{\text{(Target OG)} \times \text{(Batch Size)}}{\text{(Points Per Pound)}} = \text{Pounds of Grain}$$

OR

$$\frac{50\text{ (pts.)} \times 5\text{ (gal.)}}{25} = 10\text{ Pounds of Grain}$$

Now you know that you are going to need ten pounds of grain for your brown ale. However, you still need to figure out how to divide this amount between your base grain and specialty malt. The best way to do this is to use someone else's all-grain recipe and adjust the amount of pale malt in the grist so that the total grain bill is ten pounds. Also, if you have your own extract recipe, you can probably substitute the pale malt for your malt extract and get good results.

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.

With regard to color, you probably won't have too much trouble getting a brown ale right. However, color for other beers is often determined by your own experience, judgment and trial and error (and those of others).

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. Assuming you are not going to buy a grain mill right away, keep an eye on the consistency of the grain ground at the home brew shop and match that consistency when you buy a mill. Then, you can adjust as necessary.

Strike Temperature

In your first single-infusion mash, you will mix hot water with cool grain in hopes of hitting your target mash temperature. As we said above, you can mash a brown ale at a high temperature. Mashing at 155°F will give you a quick conversion. It will also give you a little buffer zone before your mash gets too hot. The question now is how to calculate strike temperature. In other words: How hot do you have to get the mash water so that an equilibrium temperature of 155°F is reached? Many home brewers use a water/grain ratio of one quart of water per pound of grain. Using the above recipe as a guide, you are going to use ten quarts of water for ten pounds of grain. The very general rule is that the addition of the grain to the mash water will cause a 17°F drop in the water temperature. Therefore, you just need to add 17°F to 155°F to get a strike temperature of 172°F.

For your first couple of mashes, keep a quart or two of boiling water on hand at mash-in in case your mash temperature is too low. Add water as needed to raise or lower the temperature. Also, once you have hit your strike temperature, it is a good idea to hold the water there for a few minutes to make sure all of the water is at the correct temperature.

Mash-In

Once you have achieved strike temperature, you are ready to mash-in. We, like most home brewers start with the mash water in the mash-tun then add the grain to the water. Add the grain slowly stirring constantly to avoid 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. In our example, one hour should be sufficient. 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 to disturb the mash as little as possible. We usually wait at least thirty minutes before checking it. After that time, you may want to stir the mash (it will be warmest at the center) and take a temperature reading. You can adjust the temperature, if necessary. This is also a good time to get your sparge water started. Once you are nearing the end of the mash, do an iodine test. Remember that this test is not infallible. In fact, if you are using wheat malt, the iodine test may never show complete conversion. Also, periodically taste the mash water. As the mash progresses, the liquid will become noticeably sweeter as the starch is converted to sugar.

Mash-Out

At mash-out, boiling water is added to the mash to raise the temperature to 165°F. The amount of water needed depends on the amount of mash water used and its temperature. The general rule is that a 1:1 mash at 155°F will require an additional 1/4 of the original mash water volume. In our example, we used 10 quarts of mash water so we will need an additional 2.5 quarts of boiling water to mash-out. In simpler terms, if you used 2.5 gallons to mash, use 2.5 quarts to mash out. Use more or less water according to your mash temperature.

The Vorlauf

After the mash-out, you are ready for the vorlauf. First, you need to carefully transfer your mash from the mash-tun to the lauter-tun if you are using separate vessels. Then, attach a heat resistant hose (keg line is ideal for this) to the valve on the lauter-tun and run the hose into a saucepan or Pyrex cup (a pot of a quart or two is sufficient). Hopefully, liquid will flow from the lauter-tun into the grant (the brewing term for the pot you are using). However, you will see lots of grain husks and other large particles. Because you want the liquid but do not want the other stuff, you will need to recirculate it back to the lauter-tun.

When the grant is almost full, quickly move the hose from the full pot to an empty pot (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. Soon, the liquid will be free of large particles although it will be cloudy. Let the wort recirculate until it is fairly clear. When you are finished, let the hose drain into the 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. If you are going to use your stove top to brew you will either need to lift the lauter-tun above stove level or lift the kettle to the stove after sparging. The advantage of sparging directly into a kettle on the stove top is that you can begin heating the wort as soon as it reaches the kettle. However, lifting a forty pound lauter-tun at 165°F two feet above the stove is no thrill ride. Ah, the joys of brewing.

For a long time, the conventional wisdom has been to use sparge water at 165°F-170°F, erring on the low side. However, more recently, we have read of brewers sparging with water in the 180°F range. At any rate, we still recommend the 165°F-170°F degree range. The question now is how much sparge water to use. We recommend sparging with an amount of water equal to about half of your batch size. For a five gallon batch, this is 2.5 gallons of water. If you under-sparge a batch, you will get low efficiency. However, if you over-sparge, you will extract husk tannins and end up with an astringent and very unpleasant beer. Also, remember that the amount of sparge water you can use is limited by the size of your kettle and may be affected by the OG of the beer you are brewing. To calculate the amount of water you can expect in the kettle after sparging, add all the water you used in the mash. Then, subtract 0.5 quarts per pound of grain you used. Then add your sparge water for the total volume to kettle.

In our example, we used 10 quarts of water to mash and 2.5 quarts for mash-out for a total of 12.5 quarts. The grain will absorb about 5 quarts of water, leaving us with 7.5 quarts which is a little less that two gallons. If we sparge with 2.5 gallons of water in our example, we can expect about 4.5 gallons initial volume to kettle.

When sparging, be careful when pouring sparge water into the lauter-tun. Maryland Homebrew sells a sparge arm that helps to sprinkle the water so that the grain bed does not get disturbed. 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.

The speed of the sparge is a matter of personal taste and can be controlled by adjusting the flow through the exit valve. Many brewers believe that a rapid sparge creates channels in the grain bed which deliver the sparge water through the grain bed without any rinsing of sugars. Others believe that a slow sparge causes the extraction of husk tannins which contribute to astringency. We believe that a thirty minute sparge is sufficient. Finally, some brewers advocate taking periodic hydrometer readings and stopping the sparge when the runnings have a gravity of less than 1.010. The last method requires repeated starting and stopping of the flow to the kettle. This releases the suction on the grain bed and can lead to husks in the boil kettle.

Once you have used all the sparge water and the water drains below the top of the grain bed, look for air bubbles in the exit hose. This means that the system is sucking in air and sparging is near the end. If you are so inclined, you can try to compress the grain bed to squeeze out every drop of wort. We don't do this because of the risk of extracting husk tannins. At this point, you should be heating the wort in the kettle. Now you can adjust the batch volume for gravity if you wish.

Adjusting Gravity

After sparging, you will have a good deal of wort in your kettle. If you wish, you can adjust the volume of wort to hit your target gravity. In our example, you are making a brown ale with an OG of 1.050. If you are not concerned about your gravity, skip down to the Boil section below. Otherwise, read on. Hopefully, you have a dipstick or other way to measure the amount of wort in your kettle. Make a note of your volume and take a gravity reading. We take a sample from the kettle with a saucepan and swirl it around in the sink with some cold water until it has cooled off a little so we don't crack our hydrometer. We take the gravity with a hydrometer and take the temperature with our digital thermometer. If you do not have a hydrometer correction chart, a good rule-of-thumb is that gravity needs to adjusted 0.001 for every 7°F the temperature is from 60°F. For warm liquid, you will be adding 0.001 for every 7°F above 60°F. Another useful rule is that for normal gravity beers, the addition of one quart of water to a five gallon batch of beer will lower the OG of the wort by 0.002. Finally, remember that most home brew systems boil off about one gallon of wort per hour of boil.

In our example, assume that your post-sparge volume is 4.5 gallons, that your hydrometer reading is 1.049 and that your temperature is 100°F. Using the hydrometer correction formula, you need to add (100-60) or 40 ÷ 7 = approx. 6. You need to add 0.006 to your gravity reading for an actual reading of 1.049 + 0.006 = 1.055 OG. At this point, you will need to decide how you want to adjust volume for gravity. From the above paragraph, you know that if you add two quarts of water, you will lower the gravity of the beer by 0.004 and that you will have five gallons of beer at 1.051 OG. This means, that your efficiency was a little better than expected. If you want, you could add another pint of water and get a little more beer at the target gravity of 1.050. If you are going to increase your batch size, remember to adjust you hop schedule for the increased volume. Finally, top-off with an extra gallon of water to compensate for the boil.

The Boil

The main difference between an all-grain and extract boil is that the amount of trub in an all-grain boil is much greater. 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. However, there will be a large amount of both hot-break and cold-break in an all-grain batch of beer. Once the boil begins, hydrate your Irish moss if you use it (one teaspoon per five gallons). Add it to the boil for the final thirty minutes. With ten minutes left in the boil, put the wort chiller in the kettle to sanitize it. We usually take a gravity reading during the final minute of the boil to minimize the possibility of contamination. Also, we leave a spoon in the kettle throughout the boil and during cooling. This way, the spoon is sanitized and may be used to circulate the wort during cooling and to whirlpool the wort.

Chilling the Wort

When the boil is complete, cut the flame and begin the flow of water through the wort chiller. Remember that the first water out of the chiller will be close to boiling so be careful that the effluent hose is secure. If you are taking periodic temperature readings with a thermometer, it's a good idea to sanitize it in iodophor before using it. Also, once the beer has cooled a good deal, you can use one of the temperature strips used for fermenters to approximate the temperature. During cooling, stir the wort every few minutes to keep it moving over the chiller. Once the wort is cool, you are ready to whirlpool.

Whirlpool & Racking

Using a sanitized spoon, stir the wort in a clockwise direction until you have a nice whirlpool. After about five minutes, stop whirlpooling and let the trub settle. 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 20-30 minutes (don't cover the kettle) and you are ready to move the wort to the fermenter and pitch yeast. 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. It is made up mostly of spent hops and other gunk.

Some brewers believe that allowing part of the top layer of trub into the fermenter is beneficial to your beer. Others believe that this material does not help but will also not hurt your beer. 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.

6. 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.

You might want to try the India Pale Ale (IPA) recipe on the next page for your first effort.

7. Oak Hall Red Ale Recipe

Style: American Amber Ale (6B)

Ingredients for 5 gallons:

- 10 lb. — Pale Ale Malt
- 1 lb. — Munich Malt
- .75 lb. — CaraVienne Malt
- .25 lb — Chocolate Malt
- 0.50 oz. — Columbus Hop Pellets (Bittering) 12.2%
- 0.50 oz. — Columbus Hop Pellets (Flavor) 12.2%
- 0.5 oz. — Amarillo Hop Pellets (Aroma) 8.0%
- 0.5 oz. — Amarillo Hop Pellets (Aroma) 8.0%
- 0.5 oz. — Amarillo Hop Pellets (Dry) 8.0%
- 1.00 tsp. — Irish moss
- Starter — White Labs California Ale Yeast WLP001

Procedures: Single Infusion — Boil Time: 60 min.

1. Heat 13.2 qt. Water to 166°F and add grain.
2. Hold at 152°F for 90 min. (or until complete conversion).
3. Add 5 qt. boiling water and mash out at 165°F.
4. Sparge with 2.5 gal. Water at 170°F.
5. Adjust O.G. to 1.066 (if desired).
6. Add bittering hops to pot after recirculating initial runoff.
7. Hydrate Irish moss at start of boil.
8. Add hydrated Irish Moss along with flavor hop for final 30 min.
9. Add aroma hops for final 5 min.
10. Add second aroma hops at knockout (directly before cooling).
11. Cool wort, pitch yeast and ferment for 6 days at 66°F.
12. Transfer to secondary and dry hop for 5-7 days at 55°F.