All-Grain Brewing Instructions

Welcome to the world of all-grain, home-brewed beer! These instructions show you how to use a 3-tiered all-grain brewing system and assume that you are already familiar with the brewing process, sanitizing equipment, fermentation, and bottling procedures. If it’s been a while, or you’re new to brewing, we suggest you also pick up our “Beginning Brewer’s Instructions,” which cover these topics. Like our “Beginning Brewer’s Instructions,” the methods outlined below are drawn from decades of home-brewing experience as well as published sources such as Charlie Papazian’s *The Joy of Homebrewing* and John Palmer’s *How to Brew*.

**WHAT IS “ALL-GRAIN BREWING”**?

Brewing “all-grain” means that you’re brewing “from scratch,” that is, with raw ingredients instead of with syrup or powdered extract. When you brew with extract, you’re brewing with an already condensed wort: a malter has taken a batch of milled, malted barley, converted the starches inside the malt into sugar, and then reduced that sugar to a powder or syrup. Unfortunately, these processes make a portion of the sugar in the extract less fermentable. When we add this extract to water and boil it, we tend to increase the amount of these unfermentable sugars. This creates a sweeter, denser, and darker beer overall than what can be created when brewing all-grain. Of course, there are ways to get around this downside to extract brewing, and we’re not suggesting that extract beer is inherently lower quality than “all grain” recipes. But if you’re trying to brew a light, clean IPA, pilsner, or pale ale, you will have consistently better results brewing from malted barley than from malt extract.

Often, the biggest challenge in transitioning to “brewing from scratch” is the initial equipment expense. Buying a *mash tun*, a *hot liquor tank*, a *10 gal brew pot*, a *burner*, and a *wort chiller* can be quite expensive if purchased all at once. If you’re interested in spreading it out a little, we suggest you pick up our Brew-in-a-Bag (BIAB) instructions. BIAB methods only require a large pot, burner, and chiller, allowing you to make the switch to all-grain without having to buy any expensive equipment that you don’t immediately need. You can also pick up our “Going All Grain” pamphlet, which details other ways of managing an all-grain brew system by adding one piece of equipment at a time.

It should also be noted that “all-grain” brewing—BIAB or otherwise—is a significantly longer brew day: with an hour to mash, an hour to lauter, and an hour to boil, be prepared to crack open a home brew to pass the time!

Ready to make the leap? Read on!
**Overview:**

For thousands of years, mankind has been turning water and grains into beer, so there are many different ways to do it. As a brewer you will find that everyone has their own strategies to brewing beer, and over time you will develop (and jealously guard) your own secrets of the trade. The following instructions are a good place to start for using the common, 3-tiered all-grain setup, but remember that there’s always room for improvement. Beer is all about innovation: brew with friends, experiment, share your ideas, your success stories, and your abysmal failures. Every beer you brew contributes to the beer community!

**Process:**

1. **The Mash:** Milled grain is soaked at a stable temperature for an hour in order to allow naturally occurring enzymes to convert the starches in the malt into fermentable sugars. Known as “single-infusion mashing,” this is best accomplished using a mash tun: an insulated vessel (see illustration) with a false bottom and ball valve fitting.

2. **The Lauter:** Once the starches are converted, the liquid (sweet wort) needs to be separated from the grain (called “lautering”). This is why the false bottom and ball valve fittings are necessary. The liquid can drain from the mash tun through the sieve-like false bottom, leaving the spent grain behind.

3. **The Sparge:** Inconveniently, a significant portion of fermentable sugar will be retained in the mash tun; to get as much of that sugar as we can, we rinse (“sparge”) the grain. To do this, we use a second insulated vessel known as a hot liquor tank. We fill this with hot water and place it on a counter or shelf above the mash tun. By running this hot water gently over the mash as the wort lauters into our kettle, we will greatly increase how much sugar we extract from the grain.

4. **The Boil:** If you’ve ever made spaghetti, you probably have a working knowledge of boiling liquid, but a couple of points are worth mentioning here regarding volumes. In order to end up with 5 gallons in our fermentor, we have to plan ahead. Unlike extract brewing, you will not add water to your fermentor to top up your volume to 5 gallons. Instead you’ll be boiling down to 5 gallons. Since you will lose volume during your boil, you’ll need to start your boil with more than 5 gallons. Depending on how vigorously you boil your wort, around 8% will be lost due to evaporation, and (depending on recipe formulation) another gallon or so will be lost to the gunk\(^1\) that accumulates at the bottom. 6.5 gallons is a good volume to start with. At the end of an hour-long boil, you should have about 6 gallons, and when you leave the trub behind in the kettle, you should end up with 5 gallons in your fermentor.

**Got it?** Alright, enough summarizing. Let’s just brew it.

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\(^1\) Known as “trub” (pronounced /ˈtroob/), this gunk includes broken down proteins and any hops added during the boil.
MASHING

1. **Measure and heat up your water.**

It’s important to use the right amount of water (about 1 quart water to every pound of grain; we’re shooting for roughly the consistency of oatmeal), but the key to a successful mash is precise temperature control.

The enzymes that convert starches to sugar are sensitive; if you stray too far out of the ideal temperature range, they won’t behave as you want. There are several different enzymes at work and many different ways of manipulating them. But we’ll start with the two most important ones and the simplest method of harnessing them:

- **Beta-amylase** (Ideal temp: 140-150F): breaks starches into small fermentable sugars
- **Alpha-amylase** (Ideal temp: 148-158F): breaks starches into larger, less fermentable sugars

We will be using “single infusion mashing,” which means that we’ll be picking one temperature to maintain for the whole mash. In order to utilize both enzymes, we will pick a temperature in the range of 148-158F. The lower end of that range will produce crisper, drier, cleaner-tasting beers (e.g. pilsners, IPAs, pale ales, etc.), while the higher end will yield denser, sweeter, maltier-tasting beers (e.g. Scottish ales, nut browns, sweet stouts, etc.). When in doubt, check your recipe; often enough, a recipe will suggest an appropriate mash temperature for you.

When heating up your mash water, it’s important to remember that you will need to compensate for two temperature losses: 1.) when you pour your mash water into your mash tun and 2.) when you pour your grain into your mash water. Since you’ll lose heat each time, you’ll want to heat up your water to 20 or so degrees above your target mash temperature in your kettle (for our example recipe, we’ll be heating our water to 165F before transferring it to the mash tun).

2 San Diego tap water has excellent minerals for brewing, but the chloramine from city water needs to be filtered out. You can use a standard carbon filter to do this yourself. Just be sure that 1) you don’t try to filter the water while it’s hot, which will damage your filter and 2) filter slowly; you want a flow rate of about 1 gal/min. to maximize the filter’s effectiveness.

3 If you’re the break-the-mold type, you may do some reading about other methods of mashing: Google “step mashing” or “partygyle” if you’d like to while away a few hours reading about saccharification rests and diastatic conversions. Or better yet, pick up John Palmer’s *How to Brew*. He will explain these things to you using a chainsaw metaphor. John Palmer is the man.

GENERAL PRINCIPLES OF MASHING

- A good mash ratio to start with is 1 quart of water per pound of grain; aim for oatmeal consistency.
- You will lose temperature every time you transfer water or add grain.
- Temperature range for the mash should be between 148F and 158F.
- Lower mash temperatures produce cleaner, drier beers; higher temperatures produce maltier, sweeter beers.

EXAMPLE RECIPE:

**Fermentables**
- 11.5 lbs. American 2-Row
- 1 lb. Munich Malt
- 1 lb. Wheat Malt
- 0.75 lb. Caravienne Malt

**Hops**
- 60 min: 0.75 oz Magnum 13.2%
- 30 min: 0.25 oz Magnum 13.2%
- 15 min: 0.50 oz Magnum 13.2%
- Flame out: 2 oz Chinook 11.2%
- Dry Hop: 6 oz Mosaic 12.8%

**Yeast:**
- White Labs - 001 California Ale

**Targets:**
- Mash Water: 13qts (3.25 gal)
- Strike Temperature: 160F
- Mash Temperature: 148F
- Mash Duration: 60 min
- Target Batch Size: 5 gal
- Target O.G.: 1.067
- Target F.G.: 1.013
- Target IBU: 60
- Target ABV: 7.2%
2. Mix water and grain together in your mash tun and seal with lid.

When your water is at the appropriate temperature, transfer it carefully into your mash tun. It should lose a couple degrees so that it’s hovering around our “strike” or “mash-in temperature” (160°F). At this stage, it’s better to aim for a couple of degrees higher; it’s easier to bring the temperature of your mash down a couple degrees with a small handful of ice cubes than it is to bring it up by adding quarts of boiling hot water.

Remember that grain should be milled prior to mashing (otherwise you’ll wind up with a fairly non-alcoholic and mostly husk-flavored beverage), but you don’t want to mill too early. If the grain sits too long after being milled, the starches will go stale and your efficiency will suffer. It’s best to purchase and mill your grain (most home brew shops will provide a mill) the day before or the day of your brew.

When adding your grain to the mash tun you’ll want to pour slowly into the water while constantly stirring (this is one of the many instances where having a friend around is handy). The key here is to ensure that every ounce of your grain is wetted and thoroughly mixed into the water. Any dough balls that form can harbor dry pockets that will decrease the efficiency of your mash.

Once your mash is evenly mixed, check the temperature again. Be sure to check multiple places to detect any warm or cool spots. If it’s too hot, add 2-3 ice cubes, stirring them into the mash and checking the temperature each time. If it’s too cool, add a quart of boiling water at a time and stir until you reach the desired temperature (148°F for our example). Once you do, lock the lid on your mash tun tightly and set a timer for an hour.

A note on efficiency: When it comes to brewing, “efficiency” refers to the percentage of sugars absorbed and extracted during the mash, lauter, and sparge of a brew day. If you were to calculate the maximum amount of sugar possible to extract from a recipe, your “efficiency” would be the percent of that amount that you succeed in extracting (e.g. 70% efficiency means that you converted and extracted 70% of the available sugar in a mash). You shouldn’t expect to ever reach 100%; you would need to reduce the malt to powder and press it like apple pomace to get 100% of the sugars. An efficient home brewer will average somewhere between 72% and 75%; most recipes (like our example recipe) will assume you’re achieving at least 70%. There are tools like BeerSmith™ available to help you improve, track, and adjust the efficiency of your system. If you’re working with a system that is consistently less efficient, you can adjust your recipe by increasing the base malt to hit the same OG/FG targets.

AN EFFICIENT BREWER

- “Efficiency” measures the percent of sugar extracted compared to the amount of sugar available.
- Most recipes will use a grain bill that assumes you will achieve 70-72% efficiency.
- You can increase the base malt portion of your grain bill to compensate if you expect a lower efficiency.

CHECKING GRAVITY:

You can use a refractometer to check your gravity throughout your brew day instead of waiting until the end. Refractometers use much smaller samples than hydrometers and are much more convenient to use (though they’re only accurate before fermentation).

Checking the gravity at these stages will allow you to adjust your brew day to be more efficient.

- Pre-boil and final volume: initial reading should be between 5 and 10 pts lower than your target OG; if it’s not, you can add water to dilute or prepare to boil longer to concentrate your wort so that your final reading will be right on your target OG.
Lautering and Sparging

After an hour at a stable temperature, the enzymes will have completed their conversion, so now it’s time to separate the liquid and rinse the grain (“lauter” and “sparge” respectively) to extract as much available sugar as possible.

1. Set up your hot liquor tank and sparge arm.

Milled, malted barley is so absorbent, you will need a total of 10 gallons of water between the mash and sparge in order to extract fermentable sugar in your mash tun and reach 5 gallons in your fermentor. We already used a portion of this total in our mash; the rest we will use for the sparge. The mash will often call for 3 or 5 gallons, which means you will need between 5 and 7 gallons for your sparge. You’ll want to follow the same steps for filling your hot liquor tank (HLT) as for your mash tun. Heat your sparge water to 180F in your kettle so that when you transfer the water to your HLT, it’ll be around 175F.

In a continuous sparge, which is what we recommend for maximum efficiency, the lauter and the sparge happen simultaneously. We rely on gravity to accomplish this, so you’ll need three tiers in descending height. At the top, your HLT; below that, your mash tun; at the bottom, your kettle. Be sure each tier will be supported on a stable surface and you can reach the top tier without the use of a ladder. It is dangerous to lift large amounts of hot water above your shoulders or up a ladder.

2. Recirculate your wort.

Even with a false bottom installed in your mash tun, your first runnings will be full of small particles from your mash. If these grain particulates get into your boil, it’s not the end of the world. However, to avoid cloudiness and bitter astringency in your beer, it’s better to filter these out the best you can through recirculation.

The easiest way to do this is to have two pitchers or large measuring cups at the ready. First, open the valve partway so that a moderate stream of wort begins to flow into one of the pitchers. Once the first pitcher becomes full, you will swap it out for the empty and carefully pour the first pitcher into the top of the mash tun; the particulates in this wort will be trapped by the grain in the mash which will now act as a natural filter bed. This is best done by gently pouring against the wall of the mash tun so as not to disturb the grain bed. Pouring vigorously can potentially mix up the grain again, dislodging more small particulates and necessitating more time spent recirculating.

EXAMPLE RECIPE:

- **Total Water:** 10 gallons
- **Mash water:** 13qts/3.25 gal
- **Sparge water:** 6.75 gallons (10 gallons – 3.25 gallons)
- **Sparge water temp:** 175F
- **Target Boil Volume:** 6.5 gal

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5 A simpler method of sparging called “batch sparging” is described in our BIAB instructions.

6 This is often referred to as “the vorlauf” or “vorlaufing.” It’s German. German words are cool. Only call it “the vorlauf” if you’re prepared to sound cool.
3. **Begin lauter and continuous sparge.**

Once you observe that there are very little or no particles coming through the valve, you can attach a heat-resistant transfer tube (silicone is best) and begin draining the wort into your kettle. Position your sparge arm above the mash tun and open the valve on your hot liquor tank so that, as your wort drains from the mash tun, you are rinsing your grain from above at the same time. Shoot for a fairly slow rate of flow from your HLT and your mash tun. The longer the lauter, the more time your mash has to convert and the better your extraction will be. A quick rule of thumb is: an hour mash, an hour lauter, an hour boil.

It is important that the rate of sparge remains the same as your lauter. You should maintain about an inch of water above the level of grain in your mash tun. Much more than an inch and the pressure may compact your filter bed and create a stuck mash, where little to no water can escape from your mash tun. If the flow rate from your mash tun is too rapid, and the level of liquid falls below the top of the mash, you risk disturbing the grain bed or creating flow channels through your grain, which can negatively affect the efficiency of the sparge.

As you near your target boil volume in your kettle, you may run out of sparge water in your hot liquor tank. Don’t worry; you should have enough water still draining through your mash tun to bring you up to your target boil volume of 6.5 gallons.

**BOILING**

For anyone that has ever boiled a pot of spaghetti, this section may seem superfluous. However, there are unique challenges to boiling 6.5 gallons of wort, and we really do not want to stumble on the last lap.

1. **Getting your brew volumes right**

This is going to take some practice. Everyone’s equipment is different, every recipe is unique, and a “rolling boil” is pretty subjective. Accurately predicting how much will evaporate during your boil and how much will be left behind with the trub is something that you’ll improve with each recipe.

For evaporation, assume you’ll lose around 8-10% with a moderate rolling boil, bringing us down to 5.75 - 6 gallons. The more vigorous your boil, the more you will lose to evaporation. If you find after your first recipe that even with a modest boil, you lost a gallon or more, you’ll want to use less heat or a larger boil volume.

You can also assume that you will leave behind at least ½ gallon with the trub. Remember that IPAs will have a lot more hop additions to the kettle, so you’ll have to be prepared to either leave a lot more wort behind, or start thinking about investing in a hop spider (*see “Dealing with the trub”*).

By the end of the boil, we should be at about 5 to 5.5 gallons.
2. Cooling down 6.5 gallons

When you have 6.5 gallons in an 8 or 10 gallon pot, the ice bath method of cooling down your wort pretty much goes out the window. It’s time to upgrade to a wort chiller.

An immersion wort chiller is a copper coil that you connect to a water source and submerge in your pot. Water runs through the copper coil, absorbs the heat from the liquid, and carries it out again, thereby cooling the wort. It is important to immerse the coil while the wort is still above 190F (it needs to be this hot so the surface of the wort chiller is sanitized by heat). Some people choose to dunk it in while the wort is still boiling (15 min mark), some wait until after the boil is complete so that they have the chance to perform a whirlpool (see “Dealing with the trub”), and some put it in right at flame out and perform the whirlpool with the wort chiller present. That part will be up to you, but we highly recommend that you connect the chiller to your hoses before immersion. Copper is an excellent conductor of heat; you do not want to try to handle those fittings while they’re literally boiling hot.

Once you’re ready to cool, you will begin running water through your chiller. This water will absorb heat and carry it out your hose (ideally into a collection bucket for your garden, washing your dishes, or your car—we are in a drought after all). You don’t want to turn it on full blast, either. A modest flow rate will do the best job. You’ll know it’s the ideal rate if the water exiting the wort chiller is steaming.

You will notice that the first 100F will pass quite rapidly, especially if you stir the wort with a sanitized metal spoon. The home-stretch between 90F and 70F can take much longer depending on the temperature of your ground water, but you can accelerate this part by using a pre-chiller. This is a second coil of copper spliced into the hose between your water spigot and your kettle, then placed in a tub of water. Be sure that the length of hose from your pre-chiller to your wort chiller is as short as possible to prevent temperature change in the hose. Once you’re down to 100F, you can add ice to the water in this pre-chiller tub to cool the ground water before it reaches your kettle. This will greatly lessen the time spent waiting for those last few degrees, especially on summer days when the groundwater is warmer.
3. Dealing with the trub

Dumping your entire batch, trub included, into your fermentor would not make your beer undrinkable. However, it’s an inevitable truth that the more crud gets into your beer, the more likely you’ll taste crud in your beer. Here are a couple recommendations we have for keeping the crud out:

- **Hop Spider:** For especially hoppy beers, it can become difficult to contain all of the sediment from hop pellets. Consider investing in a stainless mesh hop spider or fine nylon steeping bag (see Fig. a.) to contain your boil additions. Hops can be added to the spider or to the bag during the boil, and when the boil is complete, the spider or bag can be removed along with all of the residual hop sediment (see Fig. b.).

- **Cool down rapidly:** This is the first step to separating the trub from your wort. The faster you can cool down your wort, the more of that gunk will sink to the bottom of your pot, allowing you to easily leave it behind.

- **Whirlpool:** Vigorously stirring your wort in order to create a “whirlpool” (see Fig. c.) will suck the crud into the center and bottom of your kettle, making it easier to leave behind during the transfer to the fermentor. Don’t forget to give the trub ample opportunity to settle. Put the pot somewhere stable for 10-15 min; any jostling of the pot can shake the trub back into suspension.

- **Rack it out:** Some brew pots come equipped with a ball valve port on the side of the pot near the bottom. Carefully opening this valve will allow you to slowly drain your kettle into your fermentor, leaving the trub at the center and bottom of the pot.
  - If you don’t have a ball valve, or are having poor luck using it, you can use an auto-siphon or old-fashioned racking cane. Treat the kettle like your fermentor and siphon the wort off the trub as you would off the dead yeast in your carboy.

**OXYGENATION**

Every fermentation goes through stages, the first and most important of which is “respiration.” During this stage, yeast will consume oxygen in order to fuel yeast cell reproduction. The more yeast cells in your wort, the healthier your fermentation will be and the better your beer will taste. However, since you boiled your wort for an hour, you have effectively removed most if not all of the oxygen from the liquid. So, in order to have the best possible fermentation, it’s time to put the $O_2$ back in:

- **Shaking the carboy:** Low tech and cost-efficient, shaking the carboy has been a common homebrew practice for generations. By shaking the carboy for 5 min, you can manually introduce oxygen into your wort from the atmosphere. But, since the atmosphere is only 21% oxygen, and shaking can only absorb a portion of that 21%, this will not yield the ideal oxygenation for your yeast.

- **Using Pure Oxygen:** Your best option is to invest in an oxygenation system. This consists of a regulator and a sanitary air filter (necessary for anything other than medical grade $O_2$) connected to a porous, gas diffusion stone. With this system, you can grab a $13$ tank from Home Depot, spray pure $O_2$ into your wort for 30 sec and have as much oxygen as you could possibly want for your fermentation.
Measuring gravity

Here it is. The moment of truth. The moment when you find out if your mash was as efficient as you hoped. You have mashed, recirculated, lautered, sparged, boiled, cooled, racked, and oxygenated. Be brave. Grab yourself a sample—with a sanitized thief, of course—and drop in that unsympathetic hydrometer. Remind yourself that whatever happens, you have created beer, and beer is awesome.

Pitching yeast

The very last step, ye road-weary traveler, is adding your yeast. Remember that when it comes to yeast, more is almost always better. When using White Labs Pure Pitch, one package is usually enough for a 5 gallon batch. However, there are certain circumstances that recommend, if not require, the pitching of multiple packages or of a yeast starter:

- Recipes with an original gravity higher than 1.065
- Recipes that call for low fermentation temperatures

Remember to sanitize the package and your scissors before cutting into any yeast pouch and to follow fermentation recommendations according to the yeast that’s used.

That’s pretty much it! Remember that we’ve been doing this for millennia. Remember that, though there are many different methods to brewing, the chemical processes to brewing have remained the same for thousands of years and if you understand the principles, and model your own methods to suit them, you’ll make great beer every time!

Cheers to good, cold beer!
3-Tier All Grain System

- **Mash Tun with Stainless Steel False Bottom**
  - $170.95 w/out Thermometer
  - $229.95 w/ Thermometer

- **Hot Liquor Tank with Sparge Arm Assembly**
  - $160.95 w/out Thermometer
  - $229.95 w/ Thermometer

- **10 gallon Brew Built Kettle**
  - $224.99

- **9 gal Kettle w/ fittings**
  - $140.84

- **Kettle Spider**
  - $39.99

- **Wort Chiller**
  - $74.99 25ft Chiller
  - $139.99 50ft Chiller

- **Refractometer**
  - $49.95

- **Fine Mesh Bag**
  - $19.99