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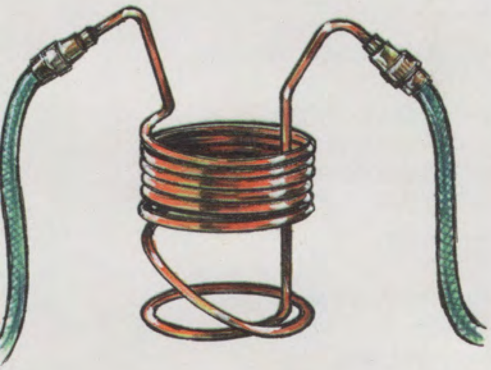
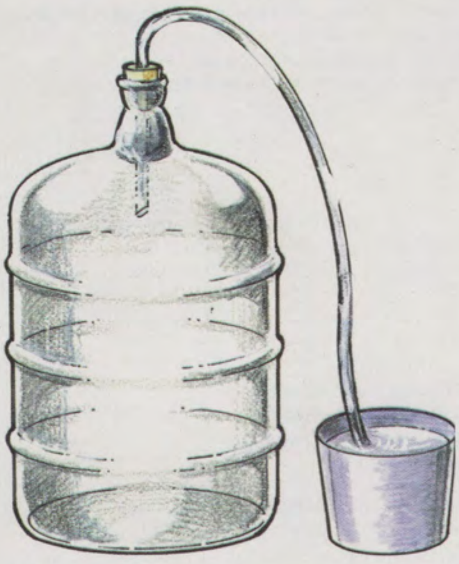
BEGINNER'S GUIDE to homebrewing





COVER PHOTOGRAPHY: Charles A. Parker

BYO RECIPE STANDARDIZATION

Extract efficiency: 65%
(i.e. — 1 pound of 2-row malt, which has a potential extract value of 1.037 in one gallon of water, would yield a wort of 1.024.)

Extract values for malt extract:
liquid malt extract (LME) = 1.033–1.037
dried malt extract (DME) = 1.045

Potential extract for grains:
2-row base malts = 1.037–1.038
wheat malt = 1.037
6-row base malts = 1.035
Munich malt = 1.035
Vienna malt = 1.035
crystal malts = 1.033–1.035
chocolate malts = 1.034
dark roasted grains = 1.024–1.026
flaked maize and rice = 1.037–1.038

Hops:
We calculate IBUs based on 25% hop utilization for a one hour boil of hop pellets at specific gravities less than 1.050.

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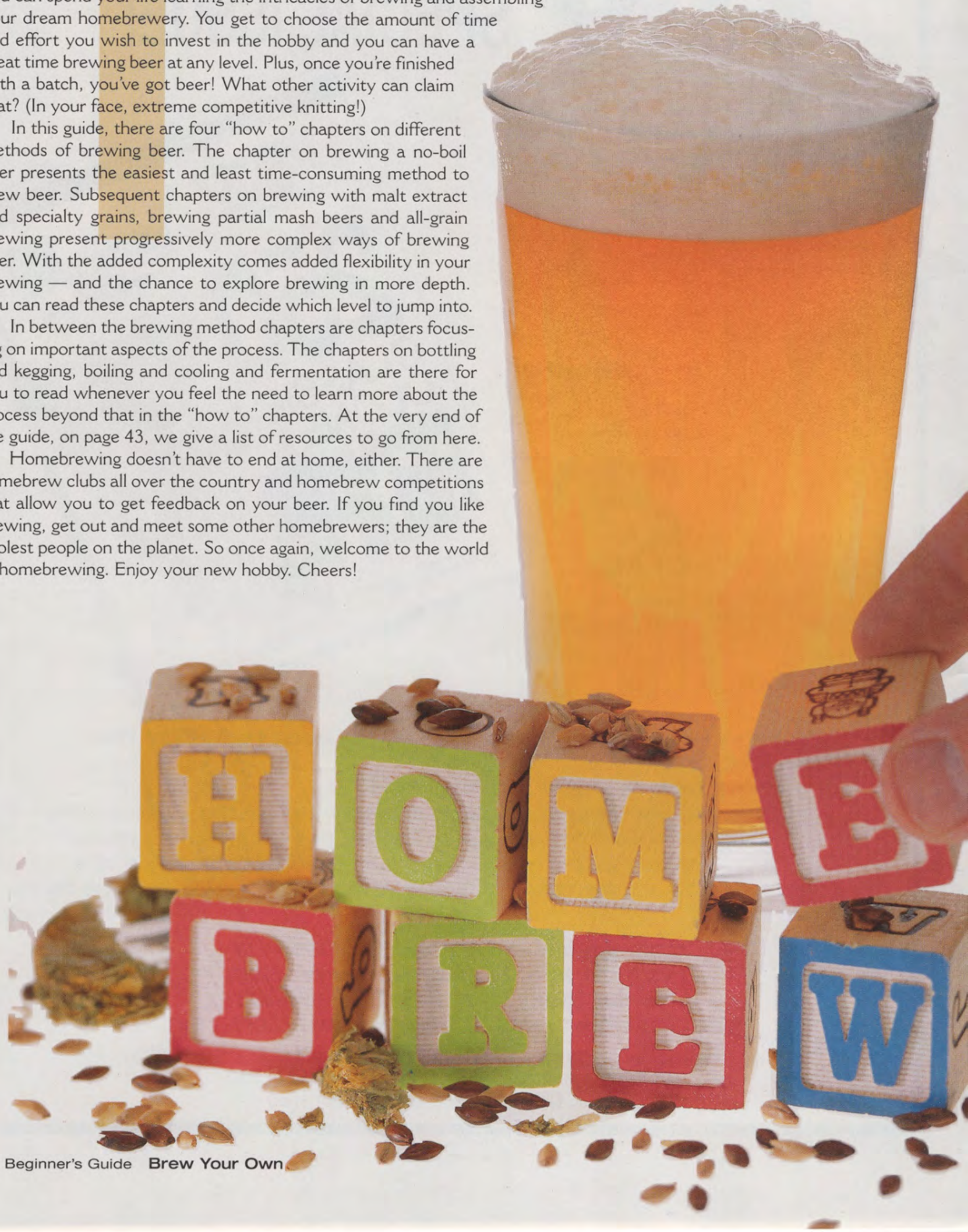
Welcome HOMEBREWERS!

This Beginner's Guide is meant to introduce you to the world of homebrewing. Making beer at home is one of the best possible hobbies you can imagine. You can brew good beer with a minimal amount of background knowledge and startup equipment. Conversely, you can spend your life learning the intricacies of brewing and assembling your dream homebrewery. You get to choose the amount of time and effort you wish to invest in the hobby and you can have a great time brewing beer at any level. Plus, once you're finished with a batch, you've got beer! What other activity can claim that? (In your face, extreme competitive knitting!)

In this guide, there are four "how to" chapters on different methods of brewing beer. The chapter on brewing a no-boil beer presents the easiest and least time-consuming method to brew beer. Subsequent chapters on brewing with malt extract and specialty grains, brewing partial mash beers and all-grain brewing present progressively more complex ways of brewing beer. With the added complexity comes added flexibility in your brewing — and the chance to explore brewing in more depth. You can read these chapters and decide which level to jump into.

In between the brewing method chapters are chapters focusing on important aspects of the process. The chapters on bottling and kegging, boiling and cooling and fermentation are there for you to read whenever you feel the need to learn more about the process beyond that in the "how to" chapters. At the very end of the guide, on page 43, we give a list of resources to go from here.

Homebrewing doesn't have to end at home, either. There are homebrew clubs all over the country and homebrew competitions that allow you to get feedback on your beer. If you find you like brewing, get out and meet some other homebrewers; they are the coolest people on the planet. So once again, welcome to the world of homebrewing. Enjoy your new hobby. Cheers!



what is BREWING?

Brewing is the process of making beer — a fermented, alcoholic beverage made from grains. The most commonly used grain for brewing is barley, but there are others (including wheat, rye, oats and sorghum). Brewing is similar in some ways to making wine, which is a fermented alcoholic beverage made from fruits (most often grapes) or mead, which is fermented honey. However, the brewing process has its own unique elements as well.

You can think of beer as a beverage made from (essentially) four ingredients using four main steps. The ingredients in beer are malt, hops, yeast and water and the four steps are malting, mashing, boiling and fermenting.

The Four Ingredients

Malt Malt is a grain that has been prepared for brewing (by a process called, not surprisingly, malting). Malted barley is the most common base grain used in beer, but malted wheat is also prevalent. In some beers, unmalted ingredients — including corn and rice — are used. Malt provides the sugar that the yeast consume during the brewing process and therefore determines the strength of the beer. More malt equals stronger beer. Most homebrewers, or professional brewers for that matter, do not malt their own grains. They simply purchase malt produced by maltsters or they use malt extract, a more highly processed form of malt.

Hops Hops provide the bitterness to balance the sweetness in beer. Compared to malt, hops are added in small quantities to beer, even in the most bitter IPAs. Most homebrewers use pelletized hops in their brewing as this is a convenient form to store and use.

Yeast Yeast converts the unfermented beer (called wort) that brewers make on brewing day into beer. They consume sugars from the malt and convert them to alcohol and carbon dioxide. Alcohol is, of course, what gives beer its "kick" and carbon dioxide is what gives beer its fizz.

Water Most beers are over 90% water by volume. And, quite a bit of water is used in the brewing process that does not end up in beer. A basic (although not infallible) rule of thumb in homebrewing is, if your water tastes good, it's suitable for brewing. If your tap water doesn't taste good, try using bottled spring water instead.

The Four Steps

Malting As mentioned before, malting is usually done by maltsters. However, malting begins the process of converting raw materials into beer and we'd be remiss if we didn't mention it. In malting, naturally-occurring enzymes in the grains are activated so they can be used for the next step, malting. Then, the grains are dried by heating (called kilning). Kilning dries the grains, which allows them to be stored for long periods of time, and also develops malt flavors and aromas that get extracted in the brewing process.

Mashing In mashing, malted grains are soaked in hot water. In the process, the starch molecules in the grains are dissolved in the hot liquid and the enzymes (activated by the maltster) chop the large starch molecules into smaller molecules of sugar. The main sugar produced in the process of mashing is maltose. Malt sugars from the mash are what fuel the yeast cells during fermentation.

For homebrewers who brew with extract, this process has been done for them. Malt extract is made from malted grains that have been mashed. The resulting liquid is then condensed into syrup or dried into a powder.

Boiling (and Cooling) The solution of water, malt sugars and other substances from the malt is called wort (or unfermented beer). Before wort can be fermented, it must be boiled. Boiling sanitizes the wort and helps to make the finished beer a more stable product. During the boil, the hops are added to the wort and bitter compounds are extracted from them. After the boiling, the wort is cooled so that yeast can be added.

Fermenting (and Conditioning) Once the wort is cooled, yeast is added to it. After a short time in which the yeast acclimate to the wort, fermentation begins. For homebrewers making average-strength ales, fermentation will last from a few days to a week. For brewers making stronger beers or lagers, fermentation can last longer, up to months. After the beer has fully fermented (and sometimes conditioned for awhile), it is ready to be bottled (or kegged) and served.

Homebrewing Equipment

In order to make homebrew, you will need a small amount of specialized equipment. Most homebrew shops sell starter kits, consisting of a bucket fermenter and some other basic equipment, starting at around $60 (US). In the "how to" chapters in this guide, the equipment you need is listed for each method. The more complex the brewing method the more equipment you will tend to need. You will also need a large pot to boil your wort in. A 5-gallon (19 L) stainless steel pot is a great one to start brewing in and these can be found starting at around $40 (US) in many homebrew shops.

Brewing a **NO-BOIL MALT EXTRACT BEER**

Vocabulary

cleaning
sanitizing
wort
malt extract
aeration
fermentation
specific gravity
patience
priming
racking

New Skills

cleaning
sanitizing
aerating
fermenting
priming
racking
bottling

Equipment list

large pot or kettle
large spoon
dial thermometer
plastic fermenter
airlock
hydrometer
racking cane
plastic hose
bottles
bottle caps
bottle capper

OBJECTIVE: Brew an ale with the least amount of effort and equipment

Some homebrewers may want to brew an easy-to-make beer during their first brewing session to build their confidence before trying more complicated brewing methods later. Others may want to take the simple approach and brew all their beers as quickly and easily as possible. In this chapter, we present the procedure and two recipes for no-boil beers. With a minimal amount of time and equipment, you can brew consistently good beer using the no-boil technique.

The Beers

Brown ales, such as Newcastle or Sammuel Smith's Nut Brown Ale, originated in Britain and are dark, malty beers. There are also US brown ales, such as Sierra Nevada's Tumbler brown ale. Canadian ales are often lightly colored and lightly flavored beers, such as Labatt Canadian Ale, and similar to the blonde ales or golden ales many brewpubs serve.

Equipment

To brew these beers, we'll use only malt extract and a minimum of equipment beyond what can normally be found in your kitchen. You may have to buy a large pot; if you don't already have one that can hold at least three gallons (11 L) of water. Any homebrew supply shop will carry plastic fermenters — buckets or carboys, usually between five gallons (19 L) and 6.5 gallons (25 L). You will also need an airlock, a racking cane, a hydrometer and bottling supplies. (For a complete equipment list, see box at left.) Most homebrew shops sell beginners kits with all the needed equipment. They start at around $60 (US) and go upward in price for more deluxe collections of equipment. Putting together this beer will only take a couple hours one day and then a couple hours another day when you bottle it. The bottling day will be 1–2 weeks from the initial brewing day. After bottling, your beer will need to sit another week or so to carbonate; then you'll be ready to taste the fruits of your labor. From brewday to your first sip can be as short as three weeks. So let's hurry up and get started brewing!

Cleaning and Sanitizing

There are many kinds of brewers, from extract brewers making their beer in five-gallon (19 L) buckets to commercial brewers making their beer in multi-story fermenters. The skills these brewers need and the procedures they use vary substantially. However, there are two skills that every brewer needs, no matter what size brewery they brew in: cleaning and sanitizing.

Cleaning and sanitizing your brewing equipment is the first step listed in the procedure on brew day. Your brewing equipment needs to be as clean and as free from biological growth as possible. The only organism you want growing in your fermenter is yeast. Growth of other organisms in unfermented beer (called wort) can spoil the resulting beer. Contaminated beer may turn out sour or develop other off flavors and aromas. In addition, the beer may overcarbonate and gush when opened. In extreme cases, your bottles may explode.

To clean your equipment, it's best to use a cleaning solution that's made for brewing equipment. (See the box on page 10 for a list of several cleaners and sanitizers.) You can use ordinary dishwashing detergent, but you will need to rinse thoroughly.

To clean your equipment, make up a cleaning solution, grab a clean sponge or scrub brush and scrub all the equipment thoroughly. Run the cleaning solution through your racking cane and fermentation lock. After cleaning, rinse the equipment with clean water. When you're done, visually inspect your equipment — especially those surfaces that will contact the wort. If you see any dirt or residue, no matter how small, repeat your cleaning procedures. Don't rely on your sanitizer to take care of any surfaces that are not completely clean. It doesn't work that way. You'll need your equipment to be spotless for the sanitizer to be effective.

To sanitize, soak any of your brewing equipment that will touch wort in your sanitizing solution. An easy way to do this is fill a bucket fermenter with sanitizing solution and soak all your cleaned equipment in it. Let the sanitizing solution work for the amount of time proscribed on the label. When you're done, rinse the equipment. (See the sidebar on page 10 for more information.) You can save some sanitizing solution in a small bucket or large measuring cup for sanitizing things — such as thermometers and spoons — during your brewing session.

The final step in keeping your beer free of contamination is prevention. Don't take this the wrong way, but you may be the biggest threat to your beer! Every day, you pick up bacteria and yeasts from every surface you touch and transfer these microorganisms to every surface you touch subsequently. On brew day, you will likely touch surfaces that harbor microbial growth and this growth could be transferred to your wort.

So, while handling your brewing equipment, try not to touch any surface that will touch wort, especially the inside of buckets and submerged parts of racking canes. In addition, wash your hands often while brewing. When you're done, clean your brewing equipment thoroughly and wipe down all surfaces that may have gotten spattered, like your kitchen counters, floor and stovetop.

No-Boil Wort Preparation

After cleaning, the next steps in the procedure involve preparing the wort — your unfermented beer. To make our wort, we'll use malt extract — a condensed form of wort. Malt extract is available in many different forms, including light and dark, hopped and unhopped, liquid and dried. We'll use hopped, liquid malt extracts for our no-boil brewing. As with any food product, using the freshest ingredients possible is important for success in homebrewing.

We'll make our wort by dissolving the malt extract in hot water and allowing it to sit for 15 minutes. To dissolve the malt extract, heat 2 gallons (7.6 L) water to 180 °F (82 °C) in a large pot. Turn off the heat and add the malt extract and yeast nutrient. A (clean) spatula will help you scrape the thick extract from its container. Stir the extract into the water with a large spoon. Your spoon should be clean, but it does not need to be sanitized. Once the extract is dissolved, which may take a couple minutes, check the temperature with your (sanitized) dial thermometer. If it is below 160 °F (71 °C), raise the temperature to this point. If you overshoot your temperature mark, don't worry, it won't affect the outcome. Let the dissolved malt extract sit for 15 minutes at 160 °F (71 °C) or higher, then proceed to the next step.

Holding the temperature of your wort at 160 °F (71 °C) for 15 minutes should kill all the unwanted microorganisms in your wort. In later chapters in this guide, you will be instructed to boil your wort. However, since the wort used to make hopped liquid malt extract was boiled before it was condensed, and it already contains the bitterness from hops, there is no reason to boil it a second time. There are also a few benefits to not boiling an all-extract wort. For one thing, the wort will darken less if less heat is applied to it. In addition, boiling the wort will drive off any volatile compounds from the hops in the extract. These compounds give beer the aroma of hops.

EXTRACT ONLY recipes

Ignatious J. Reilly Ale (Brown Ale)

(5 gallons/19 L, extract only)
OG = 1.044–1.049
FG = 1.011–1.012 ABV = 4.2–4.7%

Ingredients

3.3 lbs. (1.5 kg) Muntons Hopped Dark liquid malt extract
3.3 lbs. (1.5 kg) Muntons Hopped Amber liquid malt extract
¼ tsp. yeast nutrient
2 11.5-g packages of DCL Safale 04 dried yeast
162 Primetabs or 54 Coopers Carbonation Drops

A Handmade Ale (Canadian Ale)

(5 gallons/19 L, extract only)
OG = 1.040–1.045
FG = 1.008–1.009 ABV = 4.2–4.7%

Ingredients

5.0 lbs. (2.3 kg) Coopers Canadian Blonde light malt extract (hopped)
1.0 lb. (0.45 kg) corn sugar
¼ tsp. yeast nutrient
2 11-g packages of Danstar Nottingham Dried Yeast or 3 7-g packages of Coopers Dried Yeast
Carbonation drops for priming

Use a thermometer to make sure your wort is held at least 160 °F (71 °C) for 15 minutes to kill off unwanted microorganisms.

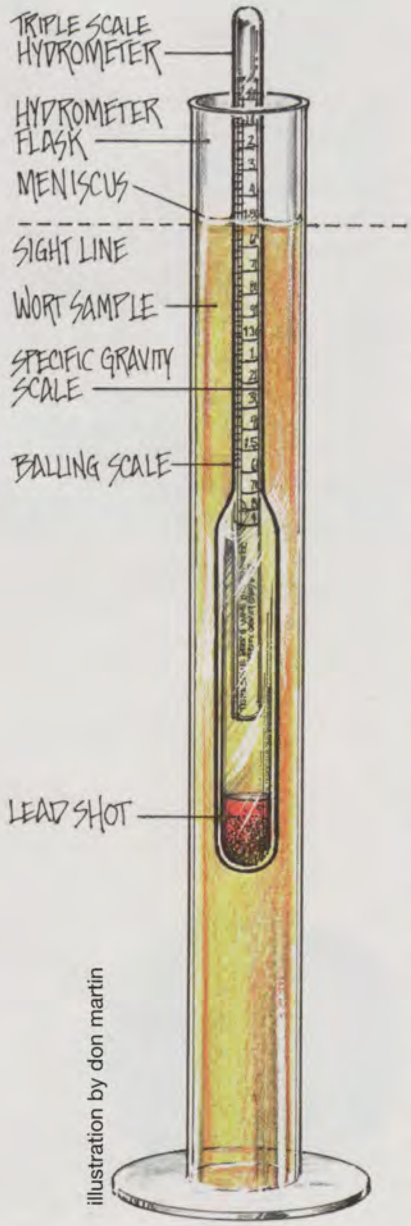
Wort Cooling and Aeration

Another benefit of no-boil wort preparation is that less wort cooling is needed compared to worts that have been boiled. Your wort needs to be cooled before the yeast is added (or pitched, in the brewer's lingo). If your yeast is pitched into hot wort, the heat can kill or stun the yeast. Different yeast strains prefer different temperatures, but for this beer, the wort needs to cool to at least 72 °F (22 °C). The best way to do this is by cooling the wort a bit while it's still in your pot (or brew kettle), then finishing the job by adding cold water to the wort in your fermenter.

To begin cooling, put the lid on your brewpot and set it in a sink full of cold water. After a couple minutes, let the (now warm) water out of the sink and refill the sink with cold water. Continue doing this until the outside of the pot is no longer warm to the touch. (In later chapters of this issue, we'll introduce you to a piece of equipment called a wort chiller, which greatly speeds the cooling of wort. If you have one, use it here instead of cooling the wort in your sink.)

When done cooling, pour or siphon your wort into a sanitized fermenter. When moving the wort, let it splash as much as possible at this stage. Once the wort is transferred, add cold tap water to your fermenter until it is full to the 5-gallon (19-L) mark. (If your tap water is very cold, you may want to check the temperature of the wort when you reach the 4-gallon (15-L) mark and adjust the temperature of your tap water so the final wort temperature is 68–72 °F (20–22 °C). Stir the wort with a sanitized spoon to completely mix the wort and the water. Make sure your thermometer is sanitized before measuring the temperature of the wort. As when adding the wort to the fermenter, pour the water such that it splashes as much as possible (without allowing foam to spill over the side of the fermenter).

Your wort needs oxygen so that the yeast can multiply quickly after they are pitched. This is why you splashed the wort and water when adding it to the fermenter. Splashing encourages oxygen from the air to dissolve into your wort. Another easy way of aerating is to sanitize two fermenting buckets and pour the wort (after the water has been added) between the buckets a few times. You can also take a sanitized whisk and whip the surface of the wort for 3–4 minutes. (In later chapters, we'll show you better ways to do this, but these ways also require some extra equipment. For now, this will work adequately.)



Learning how to properly take a hydrometer reading is a valuable brewing skill.

Fermentation

Next to cleaning and sanitation, the most important step in brewing good beer is conducting a good fermentation. A good fermentation will proceed quickly and yield a beer free from odd flavors and smells. Encouraging yeast growth by running a good fermentation is also an anti-contamination measure. Yeast growth changes wort conditions and protects against growth of many other microorganisms. In addition, beers made from good fermentations finish at an appropriate level of dryness, not sticky sweet as poorly fermented beers can be. Not only does a too-sweet beer not taste like a proper beer, but unfermented sugars in a too-sweet beer can also support bacterial growth.

In order to run a good fermentation, you need to understand a few things about yeast. Yeast are microscopic fungal organisms. In brewing, they consume the sugars in your wort to obtain the energy to live and multiply. As a byproduct of fermentation, they give off ethanol (the kind of alcohol in alcoholic beverages) and carbon dioxide (the gas that makes beers fizzy). Minor fermentation byproducts given off by yeast also play a large role in the taste and aroma of beer.

Pitch Enough Yeast

In the procedure, you are instructed to pitch 2 to 4 packets of dried yeast. You need to pitch this much yeast because pitching too few yeast cells means the yeast would have to multiply many times before there were enough of them to ferment the wort. Beers made from underpitched worts start slower and finish fermenting at a higher specific gravity (i.e. with too many sugars remaining unfermented, and hence with a too-sweet beer). Beers made from underpitched worts also have more esters than beers from adequately pitched worts. So, always pitch plenty of yeast whenever you ferment your beer.

Pitch Healthy Yeast

You should also proof the yeast before pitching it. Proofing yeast is some-thing done by both bakers and brewers who use dried yeast. The dried yeast is placed in warm water before it is used. The warm water quickly rehydrates the yeast cells and brings them back to functionality. Pitching the dried yeast directly into the wort is not as effective at quickly reviving them.

Read the instructions on your yeast packet — different yeast strains have different proofing times so giving generic instructions may be misleading. Pay close attention to both the times and temperatures — yeast are living organisms and must be healthy and unstressed in order to ferment your beer properly. Be kind to your yeast and they will reward you with good beer. Once proofed, the yeast should not sit in water for long. Pour them into your cool wort and stir the wort briefly with a sanitized spoon.

Try a Little Patience

Once the wort is in the fermenter and the (proofed) yeast has been added, seal your fermenter and affix the airlock that has been filled up halfway with water. Now, it's time to wait. If you aerated the wort sufficiently and pitched enough yeast, everything should be fine. You should see signs of fermentation within 24 hours, sometimes much sooner. Keep your fermenter in a place where the wort temperature will remain between 68–72 °F (20–22 °C) and leave it undisturbed.

A common complaint of beginning homebrewers is that their fermentation never started or was delayed. Sometimes, they're right. If they did not pitch enough yeast or aerate their wort, it may take a few days for fermentation to start. However, the fermentation may have gone fine and they just don't know it. It's not uncommon for bucket fermenters to seal incompletely. Fermentation can be taking place while little or no activity is seen in the airlock. So try a little patience. The best course of action is to assume the fermentation went well and wait 4–5 days before checking your specific gravity.

To test the specific gravity, you'll

Cleaners and Sanitizers

It takes two steps to get your brewing equipment ready: cleaning and sanitizing. For these steps, you can use household products — dish soap for cleaning and bleach for sanitizing — or you can use cleaners and sanitizers designed for brewers. You can buy these at any homebrew shop.

Cleaning

When cleaning your brewing equipment, you can use dish soap and water, but this has drawbacks. Unless rinsed very thoroughly, soap residue can interfere with head retention in beer. Two popular cleaning products for homebrewers that work better for cleaning homebrew equipment are TSP (tri-sodium phosphate) and PBW (Powder Brewery Wash). Use 2 tsp. of TSP per gallon (~2 g/L) of warm water. Use 1–2 oz. (28-56 g) of PBW per gallon of hot water. Both TSP and PBW can be used safely on stainless steel.

Sanitizing

Bleach is a cheap and effective sanitizer. 2½ tablespoons of bleach in 5 gallons (19 L) of water makes a working solution that sanitizes with a 30-minute contact time. However, bleach can corrode stainless steel and can be absorbed by plastic, leading to off-flavors. If you use bleach on glass or plastic fermenters, as many homebrewers do, empty any plastic containers immediately after the sanitizing period is over and rinse thoroughly.

Two brewery sanitizers are iodophor and Star San. Just 1 ounce (30 mL) of iodophor in 5 gallons (19 L) of water makes an effective sanitizing solution. Likewise, 1 oz. (30 mL) of Star San in 5 gallons (19 L) of water works well as a sanitizing solution. When used in these low concentrations, neither of these sanitizers needs to be rinsed from your equipment.

need a measuring cup (clean and sanitized inside and out), your hydrometer and a test cylinder. Open your fermenter and scoop out about 3 to 4 ounces of wort. Seal the fermenter immediately. Pour the wort into the cylinder and read the specific gravity. To do this, float the hydrometer in the test jar. Hold the test jar at eye level and read the scale at the level of the liquid. Discard the sample. If the sample is below a specific gravity of 1.020 and doesn't change for three days, you're ready to bottle. If your beer is still cloudy, let it sit for a few more days before bottling.

Bottling Your Batch

To bottle your beer, you need to clean and sanitize 54 twelve-ounce (355 mL) bottles. You also need to clean and sanitize your plastic hose and racking cane. This is a rigid plastic tube that bends at the top. You use it to siphon or "rack" beer from one container (your fermenter) to another (your bottles).

You don't really need to sanitize your bottle caps, just be sure not to touch the side of them that will be facing the beer. If you choose to sanitize them, boil them for 15 minutes.

The next step is priming your beer. This means adding a small amount of fermentable sugar, usually corn sugar, to the batch. This "wakes up" the yeast and starts a renewed fermentation in the bottle, and the resulting carbon dioxide carbonates your beer.

The simplest way to prime beer is to use carbonation drops, which are premeasured corn-sugar tablets. You can buy these at many homebrew shops. Drop 2 to 5 of these tablets in each bottle, depending on the level of carbonation you want (3 yields an amount of carbonation that is fine for most beers). Once all the bottles have been primed, rack the beer into each bottle. Try to leave behind as much of the sediment at the bottom of the bucket as possible.

To start a siphon, fill the racking cane with water, making sure there are no air bubbles. Hold the two ends at same level so water does not run out. Quickly put the stiff arm of the racking cane in the beer and the hose in a large glass or little bucket. The glass or bucket should be below the level of the bottom of the fermenter. Gravity will get the beer flowing, so get ready to fill your bottles! Use a hose clamp to pinch the hose to stop the flow of beer, then-place the outflow end at the bottom of a bottle. Let the beer fill to the very top, then remove the hose. This will leave about an inch of headspace in the neck of each bottle. Fill all the bottles as quickly as is feasible and with a minimum of splashing. Place a bottle cap on top of each bottle as you fill it. Then, when all the bottles have been filled, use your bottle capper to crimp down the caps and you're done!

Conditioning

Your beer will need to sit and condition for at least about a week at room temperature before it is ready. (Some beers require longer conditioning times, so be sure to read your recipe thoroughly.) During that time, yeast will "eat" the priming sugar and give off carbon dioxide, carbonating your beer.

After that week, take one bottle and let it sit in your refrigerator overnight. Open the beer the next day and see if it's carbonated. If so, you can refrigerate the rest of the batch. Often, your beer will get clearer the longer it stays cold. If you can wait, give it at least three days in the fridge before you start drinking it.

SUMMARY

- Clean your brewing equipment thoroughly
- Sanitize any surface that will come in contact with wort
- Run a good fermentation by: pitching enough yeast aerating your wort
- Check specific gravity with a hydrometer
- Bottle and enjoy your beer!

BOTTLING AND KEGGING

There are two popular options when it comes to packaging homebrew — bottling and kegging. For many, choosing between the two is a classic case of time vs. money. Bottling is fairly time-consuming, but costs next to nothing. Kegging requires you buy some equipment, but saves you time at the packaging stage.

The basic idea in bottling is to move beer from one big container (your fermenter) to numerous small containers (the bottles). In the process, you want to avoid introducing any oxygen, bacteria or wild yeasts to the beer. Oxygen introduced after fermentation will cause the beer to go stale faster. Bacteria or wild yeasts can lead to off flavors in the beer or gushing bottles. For bottle-conditioned beers, you also want to prepare the beer so it will carbonate to the right level in the bottle. There are four steps to bottling: cleaning, sanitizing, preparing the beer and filling the bottles. The equipment you'll need is: a bottling bucket, a racking cane, a large spoon, tubing to move the beer from the bucket, a tubing clamp or a bottle filler, bottles, sugar, bottle caps and a capper.

You'll need a capper to bottle up your homebrew.

Bottle Selection

You can modify how much work bottling is by selecting bottles of different sizes. The chart on page 13 shows the number of bottles of various sizes needed to bottle a five-gallon (19 L) batch. If possible, use brown bottles and store your bottles in a dark place. Clear or green bottles offer less protection from UV rays and beer can get "skunked" quickly if exposed to sunlight.

Cleaning the Bottles

Cleaning bottles can be the worst part of bottling, especially if you leave the job until bottling day. You can save yourself a lot of time if you clean your bottles as soon as you empty them. Hot water will rinse out any yeast, bacteria and residual beer. Then you can clean the bottle with a small amount of TSP (trisodium phosphate) or PBW (powdered brewery wash).

Store your clean bottles dry and upside-down. Many homebrew shops sell drying racks for bottles. Some of these "bottle trees" also have a sanitizer sprayer built in.

If you waited until bottling day to clean your bottles, you'll need two things to clean your bottles — a jet-washer and a bottle brush. A jet-washer is a tube that connects to your faucet and releases a stream of water that blasts the bottom of the bottle. Jet-washers are inexpensive and greatly reduce the time it takes to wash or rinse bottles.

Any remaining yeast that is not blasted out by the jet-washer can be removed with a bottle brush. Once the bottle is visually clean, use a little bit of water with TSP or PBW and the bottle brush to remove the stuff you can't see. Really nasty bottles can be soaked in a bleach, TSP or PBW solution overnight before cleaning.

Sanitizing the Bottles

Clean bottles need to be sanitized before they are filled. Most homebrewers sanitize their bottles by soaking them in a sanitizing solution. Bleach is a cheap and effective way to sanitize bottles. Bottles can be soaked for 30 minutes in a bleach solution of 1/2 cup of bleach per five gallons of water. Iodine solutions provide more killing power and the soak time is shorter. You can soak your bottles for 2–3 minutes in a iodine solution made from one ounce of Iodophor to 5 gallons (19 L) of water.

It really saves time if you soak all your bottles at once. A 100-quart cooler holds sixty 12-ounce bottles, more than enough for a 5-gallon (19 L) batch of beer.

To sanitize your bottles, fill the container with water, add the sanitizer and mix. Submerge the bottles for the appropriate amount of time. Remove and rinse thoroughly with your jet-washer. I triple-rinse to ensure that no sanitizing solution is left although some sanitizers can be used without rinsing.

Bleach is also effective in cleaning bottles. It's tempting to think about combining the cleaning and sanitizing steps, but don't — you run the risk of infecting the entire batch.

Preparing the Beer

Before you can fill the bottles, you need to siphon the beer from the fermenter to the bottling bucket and prime it so it will carbonate. The bucket and the racking cane should be cleaned and sanitized first.

Try to minimize the amount of splashing or agitation, which can introduce oxygen into the beer and accelerate staling. Place the end of the racking tube at the bottom of the bottling bucket, below the liquid level as the bucket fills.

Most homebrewers use corn sugar to prime their beer. Between ⅔ and 1 cup per 5-gallon (19-L) batch is enough to carbonate it. Two-thirds of a cup of corn sugar will provide a soft carbonation suitable for some English ales. A full cup of sugar will produce a more fizzy brew.

Measure the sugar into a small sauce pan and add water until the sugar just dissolves. Boil the sugar solution for 15 minutes, cool, then add it to the beer in your bottling bucket. Gently stir the beer and sugar with a sanitized spoon.

There are times when adding fresh yeast at the bottling stage is a good idea. If beer is left in secondary fermentation for an extended amount of time, almost all of the yeast drops out of solution. After a high gravity fermentation, the yeast may be tired. Beer may take a long time to bottle condition when few yeast cells are present or the yeast are not in good health. Adding a bottling yeast will help your beer to condition faster.

Sometimes, the yeast doesn't flocculate well or has other undesireable characteristics. A bottling yeast that is flocculant (it clumps together well during fermentation and sinks to the bottom) can help pull down some of the less-flocculant yeast in the bottle.

If you are using bottling yeast, use a cleanly-fermenting strain that flocculates well. The bottling yeast only ferments a small amount of sugar, so its impact on the flavor of your beer should be minimal. Be sure to choose a compatible yeast strain for your beer style. Don't pick a highly attenuative yeast if your main yeast was not as it will ferment sugars left by your main yeast. This can result in overcarbonation, changing a sweet beer into a dry beer. If you use a yeast with decent flocculation and don't let your beer sit in secondary for an excessive amount of time, you don't need to use bottling yeast. Most homebrewers don't.

To use a bottling yeast, add about a teaspoon or less of dried yeast to your bottling bucket.

Filling the Bottles

Next you need to move the beer from the bottling bucket to the bottles. Some homebrewers use a racking cane to siphon their beer into bottles. If you have a bottling bucket or plastic carboy with a spigot, this stage is easier because you don't need to start another siphon. To minimize spillage, use a tubing clamp to stop the flow of fluid between bottles.

To begin filling, set the bottle on a white background such as a paper towel. This will help you see the liquid level as the bottle fills. Put the end of the tube in the bottom of the bottle. Open the clamp and let the beer start flowing. As the liquid level rises, slowly retract the tube from the bottle while keeping the end below the level of the liquid. The proper fill level is the level most commercial beers are filled to — about an inch (2.5 cm) below the top of the bottle.

When the bottle is filled, close the clamp. Remove the tube and place a blank cap on top of the bottle. When you're done filling your bottles crimp the caps on with your bottle capper.

Kegging

The most obvious advantage of kegging is the simplicity of cleaning and filling a keg. A 5-gallon (19 L) batch forces you to handle 50 or more 12-ounce (355 mL) bottles. With a keg, you clean and fill one.

You can also use your kegging system to force carbonate your beer; that is, carbonate without adding priming sugar. Force carbonation results in less sediment and a quicker-clearing beer, as well as the option to carbonate and serve the beer within a few hours.

If you want to precisely control the level of carbonation in your beer, kegging is the only way to go. Force carbonating with a keg and CO_2 tank allows you to set the level of carbonation to any level you desire.

Another potential reason for kegging is that most filtration systems require a keg system. Likewise, having a kegging system will allow you to use a counter-pressure bottler.

There are some drawbacks to kegging your beer, however. A kegging setup costs more than bottles. You need the keg, a CO_2 tank and regulator, fittings, hoses and some sort of dispenser. Bought new, this can cost well over $200. Most homebrewers will buy a reconditioned keg and CO_2 tank, but with new fittings, hoses and regulator; they will end up spending $120–160.

When you keg your beer, you also have to figure out a way to cool the beer. While a bottle or two of beer can be put in the family fridge, a keg cannot. Most people who keg their beer have a dedicated cooler and that's the best way to go.

Equipment

The first and most obvious piece of equipment that you need is a keg.

Number of Bottles in a Five-Gallon Batch

Bottle Type	# of Bottles
5 gallon Cornelius keg	1
2 L "growler"	10
1 L "torpedo"	19
22 oz. bottle	29
16 oz. bottle	40
12 oz. bottle	53
6 oz. bottle	107

Volumes of CO_2

Temp. (F)	1.5	1.7	1.9	2.1	2.3	2.5	2.7
40	1.9	3.9	5.8	8.0	10.0	12.3	14.5
45	3.4	5.6	7.9	10.2	12.5	14.9	17.2
50	5.0	7.4	10.0	12.5	15.0	17.6	20.0
55	6.6	9.1	12.1	14.9	17.6	20.3	23.0

If you want to precisely control the level of carbonation in your beer, kegging is the only way to go.

Most homebrewers use 5-gallon (19 L) stainless steel kegs that are made for holding the syrup used in soda dispensers. These are commonly called "Corny" kegs, after one of their major manufacturers, the Cornelius Company.

Corny kegs come in two varieties: ball-lock and pin-lock. The difference between them is the type of fittings they have and the kind of disconnects they use. Since they use different connectors, you will have to have duplicate sets of quick-disconnects if you mix keg types. Get at least one "in" and one "out" quick-disconnect once you settle on a keg type to purchase. Also, get some food-grade lubricant, such as "keg lube," to use sparingly on the lid gasket and disconnects.

Next you need a CO_2 tank. For this you have two options: buy or rent. Welding supply and fire extinguisher businesses are the usual places to get a CO_2 tank filled and many will rent you a tank. Or you can buy a tank of your own. These are available either new or reconditioned, in steel or aluminum. The most common tank sizes are 5, 10 or 20 lbs. (2.3, 4.6 or 9.1 kg). Larger tanks obviously last longer, but they're bigger and heavier.

You will need a regulator for the CO_2 tank. You can buy either single-gauge or double-gauge regulators. Single-gauge regulators have one gauge showing the pressure being applied to the keg, with an adjustment knob to set that pressure. Double-gauge regulators have an additional gauge showing the tank pressure.

Next you need equipment for dispensing the beer. Here again you have two basic choices: a picnic tap or a faucet. A picnic tap (also called a cobra tap) attaches to the end of a hose and is held in your hand. A faucet is the kind of tap you see at your local pub. Picnic taps are cheaper and easier to set up, but I prefer the look and feel of a mounted faucet. Having a picnic tap as a backup is a good idea if you ever want to take a keg with you to a party.

You also need hoses to connect the CO_2 tank to the keg and the keg to the tap or faucet. Either ¼-inch (0.64 cm) or 5/16-inch (0.79 cm) inside diameter hose can be used from the regulator to the gas-in disconnect. The tubing used for gas should be rated to withstand at least 50 PSI (2590 Torr). Use small hose clamps to secure the hose to the fittings.

For the hose going from the beer-out disconnect to the tap, I recommend 3/16 inch (0.48 cm) inside-diameter, food-grade tubing. In this case the pressures will be low, so the psi rating doesn't matter.

Filling Kegs

When you're ready to fill your keg, start by putting CO_2 into it. This will prevent oxidation of your beer during transfer. Release the pressure, take the lid off and rack 5 gallons (19 L) of your beer into the keg under the "blanket" of CO_2. Now "purge" the keg. This is the process of removing air from the headspace and replacing it with CO_2. You can do this by pressurizing the keg with CO_2 then letting the air out through the relief valve on top of the keg two or three times.

Carbonating

The easiest way to carbonate a keg is simply to let it sit with CO_2 pressure on the beer. The table on the bottom of page 13 shows the equilibrium pressure for different temperatures and volumes of gas in beer. Find the serving temperature on the right and the volumes of CO_2 you desire on the top; where they meet in the table shows the equilibrium pressure (in PSI). For instance, if the beer is cooled to 45 °F (7.2 °C), and you want it to contain 2.1 volumes of CO_2, you would pressurize it to 10.2 PSI and let it sit with the tank connected to the keg until as much CO_2 as possible had dissolved into the beer; this process should take about a week.

Kegs give you the option of serving your beer much quicker, though. Cool the beer first, turn the pressure up to 20 psi (1040 Torr) or higher and shake the keg to make the CO_2 dissolve quickly. When the CO_2 stops hissing out of the tank, let the keg settle for an hour or so. Then, turn the CO_2 pressure down to your serving pressure during this time and pour away. The drawbacks to carbonating with this method are that you lose the benefits of aging and you won't know how many volumes of CO_2 are initially dissolved in your beer.

The final method for carbonating beer in kegs is to prime and condition. Priming in kegs is essentially the same as priming bottles; you just treat the keg like one big bottle. The difference is that you use proportionally less priming sugar; ⅓–½ cup for a five-gallon (19 L) batch is all you need; any more and you'll get excessive foaming. The drawback to this method is that you end up with yeast sediment in the bottom of the keg. This sediment will mostly be drawn out with the first glass or two that you pour. After you start pouring, connect your CO_2 tank to maintain the level of carbonation and push out the rest of the beer.

Dispensing

The objective is to dispense your beer with enough foam to give it a nice head, but not too much foam. The dip tube in the keg, the fittings, the hose and the tap — everything between the beer and your glass — will restrict the flow of beer out of the keg. When pouring, the amount of restriction needs to match the pressure in the keg. Three feet (91 cm) of 3/16-inch (0.48 cm) ID hose between your keg and your tap will provide 9 PSI of restriction. This is just right if you have the regulator on your CO_2 tank set to around 9 PSI.

Although there is some initial expense, most homebrewers who have taken the plunge into kegging say they will never go back to bottling.

Brewing an **EXTRACT with GRAINS BEER**

OBJECTIVE: Learn how to use specialty grains, pellet hops and liquid yeast to brew an extract with grains beer

Vocabulary

specialty grains
kilning
crystal malt
chocolate malt
roasted barley
pellet hops
alpha acids
secondary
fermentation
flocculation

New Skills

steeping specialty grains
boiling pellet hops
conducting a secondary fermentation

Equipment list

nylon grain bag
nylon hop bags or large tea balls
carboy
airlocks

This chapter builds on the basic brewing skills learned in chapter two "Brewing a No-Boil Extract Beer." Here, you'll learn how to use steeped grains, pellet hops and liquid yeast to modify a wort made from a malt extract base, opening up your horizons as a brewer. Brewing with specialty grains, your own choice of hops and liquid yeast takes a few additional pieces of equipment and some added work. However, using the techniques described here, you can modify an extract-based beer to brew virtually any style of beer you want. This is the way most homebrewers make their beer.

We'll examine the recipe and procedure for brewing a West Coast pale ale or a porter (see page 17). Pale ale is one of the most popular styles of ale for homebrewers. The best pale ales are refreshing beers in which the flavor of malt is balanced by the hop bitterness. West Coast pale ales have more hop bitterness and hop flavor than their East Coast (or British) counterparts. Full Sail Pale Ale and Red Seal Ale are two excellent examples of this style. Porters — such as Samuel Smith's Taddy Porter, Sierra Nevada Porter or Anchor Porter — are dark beers with a taste of roasted malt.

In our recipes, we'll add some sweetness and color with the use of specialty malts. In addition, we'll bitter the beer by boiling pellet hops in our wort. And finally, we'll use a liquid yeast strain for fermentation.

Specialty Grains

When brewing an extract-only beer, you must find a malt extract formulated to yield your desired style of beer. When brewing an extract beer with specialty grains, most homebrewers start with a base of unhopped light malt extract. From this starting point, they can add malt flavors, colors and aromas by adding one or more specialty grains. Likewise, you can add hop bitterness, flavor and aroma by boiling pellet hops.

Specialty grains are grains that add color and flavor to a beer. They also add a small amount of fermentable sugars. There are many different kinds of specialty grains and adding them singly or in combination yields a large range of possible flavors and colors. Specialty grains are steeped (soaked in hot water) to extract their color and flavor. Base grains — the grains that provide the bulk of the fermentable sugars in a beer — cannot simply be steeped; they must be mashed. More on that later. (In an extract beer, the base grains are replaced by malt extract.) Specialty grains are usually darker in color and are added in smaller quantities than base grains.

There are two basic types of specialty grains, those that have been prepared by stewing and those that have been produced by roasting. Stewing and roasting are two ways of adding heat to darken the grain. The process of heating malted grains in the malting process is called kilning. Stewed grains are heated such that the liquid inside them cannot escape. In contrast, roasted grains are heated so they are dried quickly.

The upshot is that in the center of a stewed grain most of the starch has been converted to sugar. The most common types of stewed grains are called crystal malts. Crystal malts lend the red or amber color to most pale ales. They also add sweetness with a caramel edge to it, which is why crystal malts are sometimes called caramel malts. These malts also add a small amount of fermentable sugar to your beer, boosting its strength slightly.

Different crystal malts are kilned to different degrees. The more kilned the malt is, the darker the color. The color of a crystal malt is usually expressed in degrees Lovibond (°L). Commonly available crystal malts vary from 10–120 °L. For our pale ale, any crystal malt in the 30–40 °L range will suffice. We'll use crystal malt in both the pale ale and porter recipes.

Common roasted grains include chocolate malt, roasted barley and black patent malt. These malts give the brown or black colors in porters and stouts. They contribute a roasted flavor to the beer, ranging from the mild, "chocolatey" flavor of chocolate malt to the roasted, sometimes even burnt, flavors of roasted barley or black patent. In a roasted grain, the starch in the center of the grain has been mostly destroyed by the high heat, so few fermentable sugars are present. We'll use chocolate malt and roasted barley in the porter recipe.

Using Specialty Grains

Specialty grains must be crushed before they are steeped. Most homebrew stores either sell crushed grains or have a grain mill and will crush the grains for you. To do it yourself, simply use a heavy rolling pin and a fairly light touch. You want to crack the grain and open the husk, not pulverize it.

Specialty grains can be steeped at a wide range of temperatures. However, to quickly extract the desired amount of color and flavor, most homebrewers steep their specialty grains in hot water around 140–170 °F (60–77 °C). If you steep the grains at higher temperatures — for example, if you boil them — you risk extracting too much tannin from the grain husks and ending up with an astringent beer.

Limiting the amount of water you steep your specialty grains in will lead to better extract beers. Many, perhaps most, homebrew recipes instruct brewers to steep their specialty grains in their brewpot as they are heating their 2–3 gallons (7.6–11 L) of brewing water. This works well at extracting a lot of color and flavor from the grains, but also extracts harsh tannins. If, however, you steep your specialty grains in a smaller amount of water, you will be able to produce a better tasting beer. Use 2–3 quarts (~2–3 L) of steeping water for every pound (0.45 kg) of specialty grain you steep. You can steep your grains in a smaller pot while heating your brewing water in your bigger brewpot.

To steep the specialty grains, place the crushed grains in a nylon or muslin grain bag. If the bag has a drawstring, close it. If not, tie off the end of the bag. Heat the water to about 10 °F (5 °C) above your planned steeping temperature, then turn off the heat. Place the grain bag in the water. (This should drop the temperature to your target.) Stir the water a few times while you steep, and stir the water one final time before you remove the grain bag. Stirring will cause water to flow through the bag and release col-

When adding malt extract to your brewpot, turn off the heat and stir the pot until it is thoroughly dissolved. If you don't, the extract will sink to the bottom of the kettle and scorch, causing burnt flavors.

EXTRACT with GRAINS recipes

Bottler's Row Red (West Coast Pale Ale)

(5 gallons/19 L, extract with grains)

OG = 1.049–1.051
FG = 1.012–1.013
IBU = 40 SRM = 9
ABV = 4.7–5.0%

Ingredients

3.5 lbs. (1.6 kg) Briess light liquid malt extract (unhopped)
2.5 lbs. (1.1 kg) Briess light dried malt extract (unhopped)
0.66 lbs. (299 g) crystal malt (40 °L)
10 AAU Willamette hops (60 min) (2.0 oz./57 g of 5.0% alpha acids)
0.50 oz. (14 g) Cascade hops (15 mins)
0.50 oz. (14 g) Cascade hops (0 mins)
Wyeast 1056 (American Ale) or White Labs WLP001 (California Ale) yeast
Carbonation drops for priming

Heart of Darkness Porter

(5 gallons/19 L, extract with grains)

OG = 1.048–1.051
FG = 1.012–1.013
IBU = 32 SRM = 41
ABV = 4.6–4.9%

Ingredients

3.5 lbs. (1.6 kg) Muntons Light liquid malt extract (unhopped)
2.0 lbs. (0.91 kg) Muntons Light dried malt extract (unhopped)
0.75 lbs. (0.34 kg) crystal malt (60 °L)
0.50 lbs. (0.23 kg) chocolate malt
6.0 oz. (0.17 kg) roasted barley
8 AAU East Kent Goldings hops (bittering) (60 minutes) (1.6 oz./45 g of 5.0% alpha acids)
0.33 oz. (9 g) Fuggles hops (flavor) (15 minutes)
Wyeast 1968 (London ESB) or White Labs WLP002 (English Ale) yeast
Carbonation drops for priming

BOIL OPTIONS

Extract brewers have a variety of wort-boiling methods to choose from, depending on their equipment and amount of time they want to spend brewing.

Concentrated Wort Boil

Most homebrewers add all of their malt extract to their brewpot and boil 2–3 gallons (7.6–11 L) of wort for 60 minutes. This concentrated wort is then diluted in the fermenter to 5 gallons (19 L) before pitching the yeast. Although this is a time-tested way of making homebrew, it has a few disadvantages. First, boiling a "thick" wort can lead to carmelization of the sugars in your beer-to-be, potentially making it darker than you want. Secondly, "thicker" worts limit the amount of hop bitterness that is extracted in the boil, potentially leading to beer that lacks bitterness (or requires the brewer to add more hops to reach the target bitterness).

Full Wort Boil

If you have a 7-gallon (26- L) brew pot, which will hold 6 gallons (23 L) of wort without boiling over, you should do a full wort boil. Boil a volume of wort such that you add no dilution water when you transfer the wort to your fermenter. For a one-hour boil, beginning with 5.75–6 gallons (22–23 L) of beer will yield 5 gallons (19 L) of wort after boiling and cooling. (The precise amount starting varies depending on how much water you evaporate during the boil.) A full wort boil solves the problems of wort carmelization and hop utilization, allowing extract brewers to get the same performance in these respects as all-grain brewers get. The only drawback is that you will need to get a wort chiller to cool your wort quickly enough.

Texas Two-Step

If you don't have a large brewpot, but still want to do a full-wort boil, there is a way. If you split your brewing into two separate sessions and make half of your wort (2.5 gallons/9.5 L) each time. To do this, begin by making 2.5 gallons (9.5 L) of wort from half of your malt extract and hops. Boil it at working strength and pitch all of your yeast to this half-batch. The next day, brew the remaining wort (using the second half of your malt extract and hops), cool it and add it to the previous day's wort. You now have 5 gallons (19 L) of wort made using a full-wort boil. (For more on this technique, see "The Texas Two Step" in the October 2003 issue of *BYO*.)

Extract Late

The biggest drawback of the Texas Two-Step is the extra time involved. If you'd like to get the major advantages of a full-wort boil, but without the extra time expenditure, try adding your extract late. In an extract late beer, you add ½ or less of your malt extract (dried or liquid) at the beginning of the boil. You then boil the 2–3 gallons (7.6–11 L) of wort as you normally would, making your hop additions at the appropriate time. Then, near the end of the boil, you stir in your remaining malt extract. (For best results, use liquid malt extract for late additions.) You can add the late extract with 15 minutes left in the boil or you can add it at knockout (when the boil is over and you turn off the heat) and let the wort sit for 15 minutes prior to cooling. To finish up, cool and dilute your wort to 5 gallons (19 L) as you normally would. (For more on this technique, see "Boil the Hops, Not the Wort" in the October 2002 issue of *BYO*.)

ors and flavors from the grain.

After the grains have been steeped, pull them out and let the liquid from the bag drip into your steeping pot. Once the runoff slows, discard the grains. The grains will be hot, so be careful. It's a good idea to take a small kitchen strainer and remove most of the "floaties" left in the water. Don't worry if you can't get them all; a few stray husk pieces won't hurt your beer. The strainer should be clean, but don't bother sanitizing it, as you will boil the wort later.

If you like, you can rinse your steeping grains with hot water (up to 170 °F (77 °C)). This will extract more color and flavor from the grains. However, as before, better color and flavor extraction may come at the price of extracting unwanted tannins. So, it's best to either not rinse your specialty grains or to rinse with only a small amount of water — less than half the volume of steeping water. If you do rinse your grains, the easiest way to do so is to lift the grain bag out of the steeping pot with a large kitchen strainer. Lay the strainer across the top of the pot and pour your hot water over the grains.

Once you're done steeping the grains, add the steeping water — your "grain tea" — to the water heating in your brewpot. Then heat the liquid in your brewpot to a boil.

Hop Varieties

Your local homebrew shop probably has a large variety of hops. To a beginning brewer, the variety can seem overwhelming. Hops come in three basic forms: whole hops, plug hops and pellet hops. Pellet hops are the most widely used form of hop among homebrewers (and commercial brewers for that matter). Pellet hops are made by compressing shredded hop cones into small, cylindrical pellets. We'll use this form of hops in all of our recipes in this guide.

We'll use Cascade hops in our West Coast pale ale. Cascade has a citrus/floral smell that is prominent in most West Coast pale ales, including Sierra Nevada (the quintessential West Coast pale ale). In our porter, we'll use a pair of English hops — East Kent Goldings and Fuggles.

When you buy hops at your homebrew store, you will notice they have numbers printed on the bags. Hops are rated for their bittering strength and this is given in percent alpha acids. In most homebrew recipes, the amount of hops required is often given in AAU (alpha acid units) or HBU (home brew units). AAUs (or HBUs) are the alpha-acid rating of the hop times the weight of the hops in ounces. To calculate how many ounces of hops you need for a recipe, divide the value of AAU given in the recipe by the alpha-acid rating. For example, if the recipe calls for 12 AAU of hops and you choose hops with a 4% alpha acid rating, you need (12/4 =) 3 ounces of hops. You may have seen a beer's bitterness described in terms of IBUs (International Bitterness Units). The amount of IBUs a beer has depends on how much hops were used, their alpha rating, how long they were boiled and many other factors.

Boiling Hops

Hops must be boiled to extract their bitterness. The bitterness of a beer is primarily determined by how many AAUs of hops are used and the length of time these hops are boiled. The longer hops are boiled, the more bitterness is extracted from them. Bittering hops are often boiled for around an hour. Some hops may be added later in the boil and these are often called flavor or aroma hops.

Another factor that influences how much bitterness gets extracted from hops is wort concentration. The more concentrated a wort is, the less bitterness gets extracted from the hops. Extract brewers can keep their wort concentration in a reasonable range a few different ways. One way is to boil your wort at, or near, "working strength" — start the boil at 4–6 gallons (15–23 L) for your 5-gallon (19 L) batch and top up as needed. Alternately, you can boil as much wort as your brewpot will allow, but add much of the malt extract late in the boil. Adding roughly half (or more) of the malt extract in the last 15 minutes or at the end of the boil will allow you to boil the hops at a reasonable wort concentration. (See the sidebar on page 18 for more detail.)

Conducting the Boil

Heat the water in your brewpot, including the "grain tea," to a boil. Once the water starts boiling, turn off the heat and add the dried malt extract. Stir well to ensure the extract is completely dissolved. Turn the heat back on and bring the wort to a boil. Wort will foam a lot at the beginning of the boil, so always leave some room in your brewpot for this foam. A couple quick stirs with a clean spoon should calm the foaming down. If it doesn't, lower the heat until the foam subsides. Add the first charge of hops (called the bittering hops) right after the wort comes to a boil. Throw the pellets directly into the wort. These hops will boil for an hour and add most of the bitterness to your beer.

Try to maintain a vigorous, rolling boil. If your wort is only simmering, cover the pot partially with a lid. If the wort is boiling fine, leave the cover off. Never cover the pot completely no matter how weak the boil is.

Add the remaining hops when the recipes direct them. If you are adding your liquid malt extract late, stir it into the wort with 15 minutes left in the boil. At the end of the boil, put a lid on the brew pot and begin cooling it in your sink. Once the wort is cool, use a racking cane to transfer the wort to your fermenter, leaving behind the solids at the bottom of your brewpot. Add cold water to your fermenter to make 5 gallons (19 L) of wort. Pitch your yeast and let it ferment.

Secondary Fermentation

After fermenting for a week, our procedure calls for a secondary fermentation. The term secondary fermentation is a bit of a misnomer as it is really just a settling stage. The fermented beer is racked off the layer of dead yeast from the primary fermentation. Yeast and other particles still in suspension are allowed to settle out. Removing the beer from the yeast ensures that it doesn't pick up any off-flavors from these materials.

To conduct the "secondary fermentation," clean and sterilize a glass or Polyethylene terephthalate (PET) carboy and a racking cane. Rack the beer from your primary fermenter (bucket) to your secondary fermenter (carboy). Splash the beer as little as possible to avoid oxidation. When racking, keep the outflow end of the cane beneath the surface of the beer in the receiving carboy. A benefit of a glass or plastic carboy is that you can see what's going on with your beer.

Secondary fermentation takes about a week for an average-strength ale. After it is finished, bottle the beer as you did in the all-extract chapter. The only difference is that you will be bottling out of your secondary fermenter instead of your primary. Your beer should be a little clearer as a result of the secondary fermentation.

Brewing beer by boiling a malt extract wort is the way most homebrewer make their beer. Extract brewers can modify the color, flavor and bitterness of their extract wort by choosing different specialty grains and hops. In the partial mash chapter, we'll learn how to get a portion of your fermentables from base grains. We'll also present a slightly more advanced procedure for bottling as well as how to make a yeast starter. (Either of these two procedures can, and frequently are, used when making an extract beer with the methods used in this chapter.)

SUMMARY

- Specialty malts add color and flavor to beer
- By boiling hop pellets you can add hop bitterness, flavor and aroma to your beer.
- A secondary fermentation leads to a clearer beer

BOILING AND COOLING

Homebrewers employ a variety of equipment to boil their worts, ranging from pots on a kitchen stovetop to modified commercial kegs heated by propane burners. Most homebrew setups involve a "simple" kettle — one with no internal structures for heating or circulation — heated by an external heating source.

Concentrated vs. Full Wort Boils

Most extract brewers perform concentrated wort boils. A "thick" wort is boiled then diluted with water to working strength prior to fermentation. The smaller the volume of wort boiled, the higher the specific gravity of that wort in the kettle. For example, 7 lbs. (3 kg) of liquid malt extract (LME) dissolved in 5 gallons (19 L) of water yields a specific gravity of 1.051. The same amount of LME in 3 gallons (11 L) yields a specific gravity of 1.086. To calculate your boiling gravity, multiply your target original gravity (OG) times your batch size divided by the amount of wort you are boiling. For example, if you make a 5-gallon (19 L) batch of porter with a target OG of 1.060 and boil 3 gallons (11 L) your boiling gravity is 60(5/3) = 100 (a specific gravity of 1.100).

In a full-wort boil, the entire wort is boiled at working strength. At the beginning of the boil, the volume of wort is greater than the batch size and more dilute. Boiling condenses and concentrates the wort to working volume and concentration. A 5-gallon (19-L) brewer will typically start with 5.5 gallons (21 L) of wort and boil it down to just over 5 gallons (19 L). After cooling, they can transfer 5 gallons (19 L) of wort to the fermenter, leaving the trub and hop debris in the kettle.

Hop utilization increases in full wort boils compared to boiling a concentrated wort. In other words, you get more bitterness out of your hops as your wort gets thinner. The table to the left shows a typical hop utilization vs. specific gravity curve.

Hop Utilization vs. Specific Gravity

°Plato	SG	Hop utilization (%)
12	1.048	25.0
13	1.052	24.7
14	1.056	24.4
15	1.060	24.0
16	1.064	23.8
17	1.068	23.4
18	1.072	23.0
19	1.076	22.7
20	1.080	22.3
21	1.084	21.9
22	1.088	21.6
23	1.092	21.2
24	1.096	20.9
25	1.100	20.5
26	1.104	20.2
27	1.108	19.8
28	1.112	19.5

* for pellet hops boiled for one hour

A full-wort boil also leads to less wort darkening. The more concentrated the sugars are, the more likely they are to react with each other or amino acids in the wort.

A full-wort boil also promotes better break formation. When heated, proteins, carbohydrates and tannins in the wort react and form what brewers call break material. Some of this break material appears as solids while the wort is boiling. This is called hot break (or hot trub). Other break material only becomes insoluble in cold wort and is called the cold break (or cold trub). If proteins or lipids don't get formed into break, they can carry over into the finished beer and cause problems with chill haze and invite bacterial growth.

The advantage of a concentrated wort boil is the convenience while the advantages of a full-wort boil relate to beer quality. Extract brewers should therefore seek to boil as much wort as the size of their brewpot, power of their stove and time constraints allow. Many extract recipes give specific amounts of liquid to boil the malt extract in. These recipes are meant to be quick and simple to brew and the recommended wort volume reflects this. Boil larger volumes if you can.

Boil Times

All brewers must decide how long to boil their wort. These days, many homebrew recipes call for a one-hour boil. However, an even longer boil may help improve beer clarity and stability.

The longer that wort is boiled, the more break material is formed. More break material removed from your wort will ultimately yield clearer beer. Also, your beer will be more stable. So, if you have the time on brewing day, try extending your boil times and see if that makes a difference in your final beer. Note that you will need a larger initial volume if you are boiling for 90 minutes. For 5 gallons (19 L) of beer, you should start with 6.5 gallons (25 L) of wort compared to 6 gallons (23 L) for a 60 minute boil. You can add 0.25–0.33 gallons (1–1.2 L) to that to account for the hops and trub that settles to the bottom of the kettle. Traditionally some of the lightest-colored beers were boiled the longest.

For extract brewers, there is one further variable to consider. Many liquid malt extracts are already boiled. So, when making beer from LME, you can boil for as little as 15 minutes, just long enough to sterilize the wort. Beers made from dried malt extract (DME) still need to be boiled for at least 45 minutes.

What Happens During the Boil?

A lot happens during the boil, even though brewers don't do much during this period. Let's tour the boil and find out what's going on and what, if anything, we can do.

Wort Expansion: Wort expands when heated. A five-gallon (19 L) brewer is unlikely to notice this, but larger-volume homebrewers may notice the volume shrinkage upon cooling. At 68 °F (20 °C), ale fermentation temperature, wort occupies about 4% less volume than it did at boiling (~215 °F/102 °C for most worts). For a 5-gallon (19-L) batch, this amounts to just over two "lost" (12 oz./355 mL) beers.

Evaporation of Water: When wort boils, water evaporates from it. One consequence is that the wort volume will shrink. This shrinking more than counteracts the expansion due to heating, which stops once boiling starts and the temperature is no longer rising.

One way to determine the vigor of your boil is to measure the evaporation rate. To calculate this, measure your wort volume at the beginning of the boil and again at the end of the boil. Your evaporation rate is calculated as:

Evaporation percent = 100 – (post-boil volume x 100 ÷ pre-boil volume)

For example: Say you collect 5.5 gallons of wort and boil it down to 5 gallons. This would be 100 - (500 ÷ 5.5), or 100 - 90.9, which equals an evaporation rate of 9.1 percent.

For most homebrews, a 10% evaporation rate is a good wort vigor. Anything less than this and your hop extraction and break formation suffers. Greater evaporation can yield too much darkening.

Another consequence of evaporation is that the concentration of sugars will increase in the wort. You can estimate how the gravity of your wort will change by using the formula $C_1V_1 = C_2V_2$. In the equation, C_1 is the concentration of wort at the beginning of the boil and V_1 is the volume at the beginning of the boil and C_2 is the unknown concentration of wort at the end of boil, when the wort will have a volume of V_2.

Let's say that you have 6 gallons (23 L) of wort at a specific gravity of 1.040 and plan to boil it down to 5 gallons (19 L). Substituting the numbers into the equation, we get 6(40) = 5(X), where X is our unknown specific gravity. (Notice that you only use the decimal portion of specific gravity — i.e. 1.040 becomes 40.) Solving for X, we get 6(40)/5 = 240/5 = 48. So our expected specific gravity would be 1.048.

This formula will, however, consistently overestimate your final gravity. Your early reading of specific gravity will be inflated by soluble proteins and other molecules in the wort. These will cause your hydrometer to float higher. Late in the boil, these substances will have precipitated out and will not affect the gravity. My estimate is usually off by three or four gravity points when I use this formula.

A third consequence of the evaporation of water is that color-bearing molecules will become more concentrated, darkening the wort.

Wort darkens for two reasons. Primarily, the wort gets darker because it is getting more concentrated and secondarily because chemical reactions are forming colored molecules from colorless precursors. The carmelization of sugars is one example of this type of reaction. Maillard reactions are another. Carmelization occurs when (colorless) sugars react with other sugars and form color-bearing polymers. Maillard reactions occur between sugars and amino acids. If you want to differentiate between the effect of wort concentration and direct color development in your wort, try this experiment. Take a sample of wort immediately after the hot break then take a second sample at the end of your boil. You


photo by michael pollio

can compare the two to see the extent of wort darkening. To estimate how much of the darkening was due to color-developing reactions, dilute your final wort back to the concentration it was when you took the first sample. Comparing the early and late worts, corrected for loss of water, should show you how much wort color comes from Maillard reactions and sugar carmelization.

Other things that affect color are going on as well, including the effect of the precipitated break material. However, this is a good, quick check for extract brewers whose beers are too red. You can check if the color is developing during the boil or if your extract was simply carrying too much color to begin with.

Evaporation of DMS: Other volatile chemicals, including dimethyl sulfide (DMS), are also evaporated during the boil. DMS is a molecule that leads to a cooked corn smell in the beer. Precursors to DMS are found in lightly kilned malts. A good, rolling boil — followed by fast wort cooling — will minimize DMS.

Chemical reactions: Wort is a complex mix of water and biochemical molecules, including carbohydrates, proteins, lipids and other molecules. When you heat this mixture, many chemical reactions occur. I've already mentioned two important reactions — those that form Maillard products and those that form break material.

The chemical reactions involving hops and their bittering compounds are of interest to brewers. In the boil, alpha acids in hops are converted via heat to iso-alpha acids. Alpha acids are insoluble in wort and are not bitter. Iso-alpha acids, however, are both soluble and bitter. The amount of alpha acids converted to iso-alpha acids depends on how long the wort is boiled and the specific gravity of the wort. Most brewers boil their bittering hops for at least one hour. On average, a homebrewer will convert 25% of the alpha acids in their hops to iso-alpha hops in a one-hour boil.

In the boil, calcium ions in the water and phosphates derived from the grain react and drop out of solution. This results in a drop in pH. The wort should drop from a pH of 5.4–5.6 to a pH around 5.2. If your wort pH is too high, the resulting beer may taste dull and lifeless. Adding a small amount of calcium — about ¼ tsp. gypsum or calcium chloride per 5 gallons (19 L) — can help the pH get to the right point.

Convection currents: Wort is not heated evenly. When temperature differences within a volume of liquid exist, convection currents result. In commercial kettles, the shape of the kettle — and the presence and placing of internal heating elements — are designed to induce currents in the kettle. Convection currents help mix the wort and help with break formation. Homebrewers don't need to worry about convection currents. Stirring the wort a few times during the boil should ensure adequate mixing. Cessation of biological activity: Boiling will kill bacteria and yeasts. Some bacteria and fungi can form spores and survive a boil, but there are no common wort or beer spoilers that do this. Boiling will also inactivate the enzymes you utilized in the mash.

Kettle additions: The boil is also a time for kettle additions such as Irish moss, which helps clear break material, and yeast nutrients.

Cooling your Wort

Once you've boiled your wort, you need to cool it. Wort cooling is a procedure that is conceptually simple, yet very important to beer quality. Unfortunately, since wort cooling is straightforward and comes near the end of the brewday, many homebrewers pay little attention to this step.

Reasons to Chill Wort

After the boil, wort needs to be chilled for a variety of reasons. The wort needs to be cool enough for the yeast to survive and perform well at making beer. Most ale yeasts work best between 68–72° F (20–22° C); most lager yeasts work best at 45–57° F (7–14° C). In addition, to prevent shock from a rapid change in temperature, the temperature difference between your yeast culture and wort should be less than 10° F (-12° C) at pitching.

There are reasons other than yeast health for wort chilling. Wort cooling causes solids, called the cold break, to form and fall out of solution. When wort is transferred from the kettle to the fermenter, this break material is left behind.

Wort cooling also slows DMS production. DMS is a volatile substance produced in some worts, mostly those made from lager malts. DMS smells like cooked corn and is usually considered a beer fault, although it is noticeable and intentional in some commercial beers.

Quickly cooling the wort also slows growth of some wort contaminants. Once the wort drops below 160 °F (71 °C) or so, there are many bacteria — known as wort spoilers — that can quickly grow and produce off flavors in wort. Quickly moving the wort to fermentation temperature and pitching the yeast minimizes the impact of these bacteria on your beer.

Starting Warm

Some homebrewers start their fermentations "warm." Instead of cooling the wort all the way down to fermentation temperature, they stop cooling 5 to 10 °F (3 to 6 °C) short of the target temperature and then pitch their yeast. The usual reason given is that a warm wort provides for a fast start, which will help the yeast colonize the wort faster and crowd out any stray bacteria. When deciding whether to start warm or not, there are a couple things you should consider.

Warm wort will lead to a faster start for the yeast, but it will also propel bacterial contaminants to grow faster as well. Bacteria can divide faster than yeast, so you really aren't gaining leverage by starting warm. Many flavor-active molecules are produced early in the fermentation while the yeast are multiplying. These molecules are produced in much smaller numbers later when the yeast cells have reached their maximum density and are fermenting, but not dividing. Thus, starting a fermentation warm can lead to more fermentation by-products in your wort. If you are striving to make a "clean" tasting beer, starting at fermentation temperature is more advisable. Starting warm also means that more potential cold break material remains dissolved in the wort. This material can contribute to chill haze in your finished beer.

Topping Up With Cold Water

Extract brewers typically boil a concentrated wort, a wort smaller than the volume of the batch. After the boil, water is added to make the batch full-size. For example, the brewer may boil three gallons (11 L) of wort, then add two gallons (7.6 L) of water to make a 5-gallon (19 L) batch of beer.

The water used for topping up can absorb a good deal of heat. To increase the "cooling power" of this water, it can be refrigerated overnight. Make sure the water containers are clean and sanitized and that the containers can be sealed. Water stored in a refrigerator can pick up flavors from food if it is not in a sealed container.

Before mixing this water with your wort, aerate the water thoroughly. You can do this by vigorously shaking the container for 45–60 seconds, or you can use a fish-pump aeration device or oxygen tank. Cold liquids can hold more gas than warm liquids, so aerating your cold topping-up water can help greatly with overall aeration.

When mixing cold water and hot wort, add the cold water to your fermenter first, then slowly add the hot wort. Stir the wort with a clean, sanitized spoon as you mix the two. Never add hot wort to a carboy before the cold water, as the heat can crack the carboy.

One of the disadvantages of transferring hot wort into cold water without chilling it first is that you carry all the potential cold break into the fermenter. If you want to get rid of this break material, you can initially transfer the wort to cold water in a sanitized bucket and wait for 15 minutes or so for the break material to settle out. After that, you can siphon the clear wort over to your primary fermenter.

In the Sink

A five-gallon (19 L) or smaller wort can easily be cooled by submerging your brewpot in a sink. This transfers heat from your wort to the water. To do this, put a cover on the brewpot after the boil, place the pot in a sink and fill the sink with cold water. To speed cooling, swirl the water in the sink every couple of minutes and change the water in the sink every five to seven minutes. Also, stir the wort with a clean, sanitized spoon every time you change the water. These two things will keep cold water

Immersion wort chiller

An immersion wort chiller is a metal coil — usually copper — that uses cold water running through the tubing to cool.

Counterflow wort chiller

A counterflow wort chiller has one tube inside a second tube. Hot wort travels one way in the inner tube. Cold water travels the opposite direction in the outer tube.

next to the outside of the pot and hot wort next to the inside of the pot.

Once the brewpot has cooled to the point where you can comfortably touch it for a few seconds, put some ice in the sink and fill it with water. The exact amount of ice you need depends on how cold your wort is when you begin icing it. Keep changing the cooling water and adding more ice every time the ice melts. Begin checking the temperature of your wort — with a clean, sanitized thermometer — once the brewpot is cool to the touch. Once the wort is cooled to your target temperature, transfer it to your fermenter.

Even if you add some cold topping-up water to your wort, cooling the brewpot in a sink or tub is a good idea. If hot wort is splashed around, it can darken significantly. This can occur even if you are pouring the hot wort into cold water, especially if you're pouring it through a funnel. Whatever you do, don't pour hot wort through a strainer — this will definitely darken the wort and leave your beer prone to quick staling. And finally, hot wort can cause scalding — so anytime you cool it before moving it anywhere, the better off you will be.

I always cool any wort — even the wort I make for yeast starters — before transferring it. This ensures that my light-colored worts (or starter worts) stay light-colored and I don't risk scalding myself. Cooling the wort before transferring also allows you to separate the wort from some of the cold break material.

If you are cooling your wort in the sink plus adding topping-up water, you don't need to cool the wort all the way down to fermentation temperature. Simply cool the wort to the point where you can touch the brewpot for a few seconds, then transfer the wort to your fermenter.

Immersion Wort Chiller

It's possible to cool 5 gallons (19 L) or more of wort in a sink or bathtub, but it would take awhile. Plus, you would need to carry the wort to the water and this could be dangerous. Luckily, homebrewers have an effective way of cooling a wort without having to move it — with an immersion chiller.

An immersion chiller is a metal coil — usually copper — that is placed in hot wort. It has tubing or hoses running from both ends. Water running through the coils absorbs heat and carries it out of the wort. When used correctly, an immersion chiller will cool your wort much faster than cooling the brewpot in a kitchen sink.

To use an immersion chiller, place the clean chiller in your wort about 15 minutes before the boil is done. The heat from the wort will sanitize it. Hook one end of the chiller tubing to your water source and place the other end anywhere that can accept hot water. You may need to weigh down the "out" end so it stays put.

After the boil, turn on the water to the chiller. Using a clean pot holder or barbecue mitt, grab the top of the chiller and swirl it through the wort a few times to start the wort circulating. The circulating wort will flow past the chiller coils and keep cold wort from collecting around them. Swirl the wort every five minutes or so. Putting a lid on the kettle slows the cooling slightly, but it prevents airborne contaminants from falling into your wort. Once the outside of the kettle is cool to the touch, take the temperature of the wort every five minutes or so with a sanitized thermometer. When your wort is cooled, transfer the wort to your fermenter.

Counter-Flow Chiller

Another way to cool your wort is with a counter-flow chiller. A counter-flow chiller is essentially a tube within a tube. Hot wort flows into the chiller and travels through the inner tube. Cold water flows in the opposite direction through the outer tube. As the wort moves through the chiller, it encounters ever-colder water and continually transfers heat to this water.

Counter-flow chillers are commonly attached to a valve on the kettle. After the boil, the water is turned on and the valve is opened. Hot, clear wort flows into the chiller and cooled, cloudy wort exits the other end. A counter-flow chiller will quickly cool your wort down to pitching temperature, but the wort that comes from it will be cloudy. The wort is cloudy because it contains all the precipitated cold break solids. To get rid of this, you can direct your wort from the chiller to a sanitized bucket first. Once the break material settles to the bottom of the bucket,transfer the wort to a fermenter and pitch the yeast.

The temperature of the wort exiting the chiller depends on a number of factors. Colder water temperatures, longer chiller lengths, more turbulence within the chiller and a slower flow rate of the wort increase the "chilling power" of the chiller. If you measure your wort temperature as it exits the chiller, you can change the wort flow rate with a tubing clamp to hit your target temperature.

One concern with counter-flow chillers is that you cannot see the inside of the chiller to see if it's clean. Running hot water through the wort line of the chiller immediately after use will help keep it clean. Follow the hot water with a cleaning solution. To sanitize, you can run sanitizing solution through the wort line or boil the entire chiller. If you boil, fill the chiller with water first, place it in your kettle and heat the water to boiling.

Following cooling, you will need to aerate your wort and pitch your yeast. Some brewers have built aeration stones into the wort outflow tubing on their chillers for aeration.

Quick wort chilling — followed by cold break separation, if needed — will give your yeast cool, clear wort to live, grow and ferment in.

Related Links:

•For more information about building your own counterflow wort chiller at home, visit: http://www.byo.com/component/k2/item/362-build-a-counterflow-wort-chiller

• For more info about boiling better wort at home, visit: http://www.byo.com/component/k2/item/341-bubble-bubble-boil-and-trouble

Brewing a **PARTIAL MASH BEER**

OBJECTIVE: Learn how partial mashing allows you to brew a beer in which some of the fermentables come from grain.

Vocabulary

partial mash
base grains
full-wort boil
wort chiller
aeration stone
yeast starter

New Skills

partial mashing
conducting a full-wort boil
using a wort chiller
aerating with an aquarium pump
batch priming

Equipment list

large kitchen strainer
8-gallon kettle
wort chiller
aquarium pump and aeration stone
bottling bucket

In the chapter on extract with grains brewing, you learned how to alter a malt extract wort by steeping specialty grains and boiling pellet hops. In this chapter, we'll show you how to create a wort with flavors and a substantial percentage of its fermentables from malted grains.

Making a partial mash of base grains allows you to add the characteristics of some base grains — such as pale malt, Pilsner malt, Munich malt, Vienna malt or wheat malt — to an extract beer. The base malts also contribute fermentable sugars to your wort and also give you greater flexibility in determining the fermentability of your wort.

In this chapter, we'll also introduce the procedure of a full-wort boil, give the instructions for making a yeast starter and show you how to use an aquarium pump and aeration stone to aerate your wort more thoroughly. For the full wort boil, you'll need a few new pieces of equipment — a bigger brew kettle to hold the entire volume of wort and a wort chiller to quickly chill your hot wort to pitching temperature.

In this chapter, we'll focus on brewing a Belgian ale (a dubbel) and a German weissbier (wheat beer) similar to the hefeweizens made by Paulaner, Weihenstephan or Franziskaner.

Mashing & Partial Mashing

In order to brew a full mash (or all-grain) beer, you will need special vessels — called mash and lauter tuns, or a combination mash and lauter tun — to make your wort. For a partial mash beer, however, all you need is a large grain steeping bag.

In our recipes (found on page 27), approximately two-thirds of the fermentable sugars will come from malt extract. The remaining one third will come from malted grains. Mashing is a simple process, but one that is often made to seem overly complex in some homebrewing texts. The essence of mashing is simply soaking crushed grains in water. As the grains soak, the hot water dissolves the starch in them. Enzymes from the grain attack the starch and chop it up into its building blocks. Once the starch is fully converted, the sugars are rinsed from the spent grains. The mix of water, sugars and other substances extracted from the grains is wort (or unfermented beer).

As far as starch-conversion goes, a partial mash works exactly like a full mash. However, since less grain is used in a partial mash, handling the soaking and rinsing of the grains is simpler and requires no special equipment beyond a mesh grain bag and a measuring cup. Performing a small partial mash is thus very similar to steeping specialty grains. Gaining some experience with partial mashing often encourages brewers to go on to try making an all-grain beer.

Performing a Partial Mash

In a partial mash, you want to steep the grains in a volume of water sufficient to cover them completely, but not leave a lot of excess volume. In general, you can mash grains in 1.0–2.0 quarts (~1.0–1.9 L) of water for every pound (0.45 kg) of grain. The ratio of 1.25 qts. (1.18 L) of water per pound (0.45 kg) of grain is a commonly used consistency for homebrew full mashes. For our recipes, we'll steep 3.0 lbs. (11 kg) of grains in 1.5 gallons (5.7 L) of water. This is on the thin end of the scale with regards to mash thickness, but it works well when doing a partial mash.

To begin the partial mash, gather the crushed grains and place them in the nylon steeping bag. Tie the bag off very loosely and give the grains plenty of room to swell when they absorb water. The consistency of the crush is more important when mashing than when steeping, so you should get your grains crushed at your homebrew shop if you don't own a grain mill. Crushing your malts with a rolling pin or heavy can works when crushing grains to be steeped, but the results are too variable to be useful when mashing (partial or otherwise).

In a full mash, the mash is usually held at a relatively steady temperature somewhere between 148–162 °F (64–72 °C) during the starch conversion step (or saccharification rest). The temperature may drop a few degrees during this rest, but generally not more than this.

In a stovetop partial mash, you should expect the temperature to vary quite a bit during this step as the volume of the mash is fairly small and contained in an uninsulated pot on your stove. If you keep your mash temperature within a 5 °F (2.8 °C) window during your partial mash, you will be doing a good job.

In a single infusion mash, the temperature of the mash determines the fermentability of the resulting wort. High mash temperatures, 156–162 °F (69–72 °C), yield a less fermentable wort, resulting in a more full-bodied beer. Low mash temperatures 148–152 °F (~65 °C), yield a more fermentable wort, resulting in a drier beer.

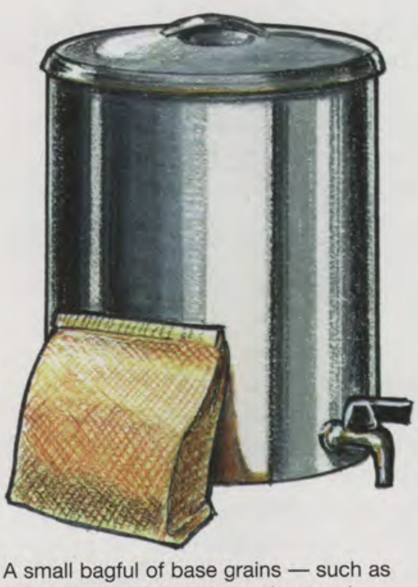
For our recipes, we will try to hold the temperature of the mash at 155° F (68 °C). So, we will initially need to heat the water to 166 °F (74 °C) because the temperature of the mash will drop once the grains — which are at room temperature — are added to the liquid. When you add the grain bag to your partial mashing pot, take a clean spoon and poke around at the bag a bit to ensure that all the grains come in contact with water. Break up any dry clumps that are sticking together. Once the grain bag has been submerged for a couple minutes take the temperature of the water in the pot. As with the steeped specialty grains, you should shut the bag and tie it to the handles of your brew pot.

Try to hold the temperature between 150–155 °F (66–68 °C) for 45 minutes. To adjust the temperature of the partial mash, add heat in short (~45 second to 1 minute) bursts of heat from your stove. Then stir and retake the temperature. It's easy to overshoot your temperature mark, especially when heating, so don't rush.

As you heat a pot, it takes time for the heat to travel through the metal and equilibrate. Thus, if you heat the mash continuously until the thermometer reads 150 °F (66 °C), then turn off the burner, the temperature will keep rising as heat from the pot is transferred to its contents. To avoid this, heat in short bursts, stir while heating, and wait a couple of minutes before checking the temperature again. It's not going to hurt the beer if it takes you a little while to adjust the temperature, so be patient.

Rinsing the Grains

After the partial mash period has elapsed, take a large kitchen strainer



A small bagful of base grains — such as pale malt, Munich malt or wheat malt — can spice up your homebrewed beer if you do a partial mash.

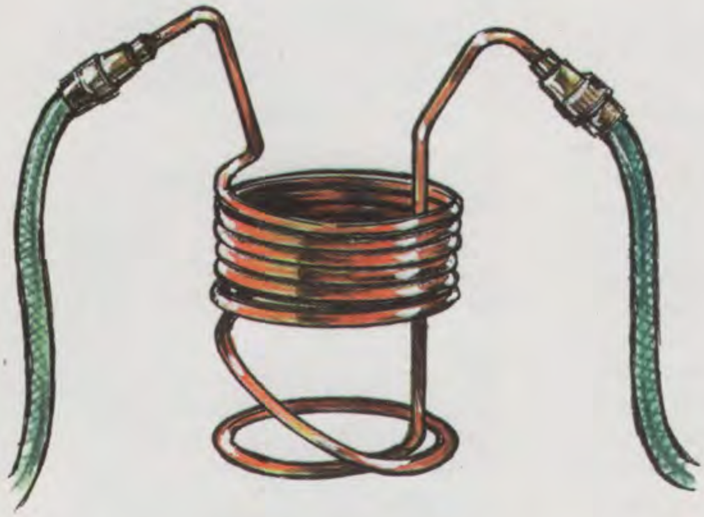
PARTIAL MASH recipes

Durden's Double
(Belgian dubbel)
(5 gallons/19 L, partial mash)
OG = 1.055 FG = 1.011
IBU = 20 SRM = 11 ABV = 5.6%

Ingredients
4.0 lbs. (1.8 kg) dried malt extract
2.33 lbs. (1.1 kg) Belgian pale ale malt
0.33 lbs. (0.15 kg) crystal malt (60 °L)
0.33 lbs. (0.15 kg) Belgian aromatic malt
1.0 lb. (0.45 kg) dark Belgian candi sugar
5 AAU Styrian Goldings hops (1.0 oz./28 g of 5.0% alpha acids)
0.25 oz. Saaz hops (15 mins)
0.25 oz. Saaz hops (0 mins)
1 tsp. Irish moss (15 mins)
Wyeast 1214 (Belgian Abbey) or White Labs WLP530 (Abbey Ale) yeast
0.75 cups corn sugar (for bottling)

Surfin' Wendigo Wheat
(German weissbier)
(5 gallons/19L, partial mash)
OG = 1.048 FG = 1.012
IBU = 27 SRM = 10 ABV = 4.6%

Ingredients
4.33 lbs. (2.0 kg) wheat dried malt extract
1.0 lbs. (0.45 kg) 2-row pale malt
2.0 lbs. (0.45 kg) wheat malt
6.7 AAU Tettnanger hops (1.7 oz./47 g of 4.0% alpha acids)
0.5 oz. Hallertau hops (15 mins)
0.33 oz. Hallertau hops (0 mins)
1 tsp. Irish moss (15 mins)
Wyeast 3068 (Weihenstephan Weizen) or White Labs WLP300 (Hefeweizen) yeast
0.75 cups corn sugar (for bottling)



A copper immersion wort chiller can quickly cool 5 gallons (19 L) of hot wort. Cool water runs through the coils, submerged in the wort and heat is transferred from the wort to the water, which exits the kettle. Swirling the chiller speeds cooling.

and lift the grain bag out of the water. Let the liquid drain into your partial mashing pot. This liquid is wort, just like reconstituted malt extract is. Unlike wort from malt extract, however, it probably has little "floaties" in it — bits of husk and other solids.

By simply letting the partial mash "drip dry" into the partial mashing pot, you are leaving some of the sugars in the grains behind. However, attempting to rinse them from a "dry" grain bed could lead to tannin extraction. One way to strain out the floaties and safely rinse a few more sugars from the grains is to add some water (amounts given below) to your partial mash wort and pour the whole mixture through the grain bag.

To do this, move the large strainer holding the grain bag to a position over your brew kettle. Slowly pour your diluted partial mash wort through the grains. The grains will act as a filter bed and will strain out most the solids from your wort. And, because you thinned out the wort a bit with some water, you'll be able to gently rinse a few extra sugars from your grains. You don't want to thin out your partial mash wort too much, however. You can extract tannins if you pour very thin wort — or plain hot water — through the grain bag.

It's best to use about half the volume of your partial mash wort as a water addition. For example, in our recipes we'll add 0.75 gallons (2.8 L) of water — half the volume of our "steeping" water — to our wort, then pour it through the grain bag. Once you are finished, discard the grains and proceed with brewing as you did before. (The grain bag will be hot; you may want to let it cool awhile before dealing with it.)

Full-Wort Boil

In your large brewpot — it should hold at least 8 gallons (30 L) of liquid —add water to your partial mash wort to make 5.5–5.75 gallons (21–22 L) of wort. Bring this to a boil, then add the malt extract. Although we are trying to make 5 gallons (19 L) of wort, we need more wort initially because some liquid will evaporate during the one-hour boil. The amount that evaporates is dependent on the amount of heat applied to the kettle. If you're boiling on the kitchen stove, the evaporation may be minimal; if you're using a propane burner outdoors, it may be considerably more.

Boiling 5 gallons (19 L) of wort is a large task for most home stoves. A gas stove can probably bring this volume of wort to a rolling boil. An electric stove may have problems developing more than a sustained simmer. Also, the amount of time it takes for the wort to come to a boil may be quite long. You may wish to begin heating your brewing water while you are performing the partial mash. If your kitchen stove is having trouble boiling this volume, close the lid partially. Another option is to move your homebrewery outside and use a propane burner for the boil.

Once the wort comes to a boil, it will likely foam for a few minutes. Once the foam subsides, add your bittering hops and begin timing the boil. In our recipes, the wort is boiled for 60 minutes. Add the hops, Irish moss and yeast nutrients at the times specified in the recipes.

Two benefits of boiling the entire wort are increased hop utilization and less wort darkening compared to boiling a concentrated wort. When brewing a beer using a full-wort boil, you need to add fewer hops to get the same level of hop bitterness. This is because more hop bitterness is extracted in more dilute worts. With a full-wort boil, you can also brew beers that are much lighter in color than beers brewed from a concentrated wort. In thicker worts, the sugars carmelize much easier, darkening the wort and sometimes contributing burnt flavors.

Cooling Your Wort

Another change that a full-wort boil will bring is the need for a wort chiller. Cooling 5 gallons (19 L) of wort in a sink (or bathtub), even with ice, is a lengthy process. Also, since you've boiled the full volume of wort, there's no diluting the wort with cold water in the fermenter to bring the temperature down.

Most homebrewers who perform full wort boils use a submersible wort chiller to cool their wort. A submersible wort chiller is a spiral of copper tubing connected to tubing on both ends. The chiller is submerged in hot wort and cold water is run through it (the tubing usually has hose attachments on it). Heat from the wort transfers to the cold water being run through the chiller and is carried out. Cooling speed depends on the temperature of the cooling water and how fast it is run through the chiller.

You can speed chilling by gently whirlpooling the wort. If the immersion wort chiller is left undisturbed, the wort next to the copper coils will quickly cool. However, the wort farther away from the coils will cool much more slowly. But, starting a whirlpool will greatly enhance the amount of hot wort passing by the copper coils and greatly enhance your cooling rate.

If you move your immersion wort chiller in a circular motion, you will start the wort moving. As the wort moves by the cool chiller, it cools. Induce a slow, steady swirling motion by moving the wort chiller in a circle. Repeat this motion every five minutes. Keep in mind that the tubing on the side of the chiller where the hot water is exiting is very hot. Handle the chiller by the "cold side" (where the cooling water is entering the chiller) only.

The wort chiller is usually sterilized by submersing it in the wort for the final 15 minutes of the boil. During this time, there is no water flowing through it. Don't connect the tubing until after you have turned off the heat to the kettle. Note: Connecting the tubing to your sink faucet will probably require an adapter, since most wort chillers are threaded to screw onto a garden hose connector.

Aerating the Wort

In the previous chapters, we aerated the wort by letting the cooled wort and dilution water splash around when we added it to our fermenter. This works, but there are much better ways to get oxygen into your wort. The more oxygen the yeast have (before fermentation begins), the better they will perform in the fermenter.

One of the simplest ways to aerate cooled wort is by using an aeration stone attached to an aquarium pump. For more details on this, see the section on aeration on page 34.

Making a Yeast Starter

You need to plan ahead when you use liquid yeast. There are not enough yeast cells in liquid yeast containers to pitch directly into 5 gallons (19 L) of beer. So, you must build a yeast starter. A yeast starter is essentially a little batch of beer used to grow up yeast for your big batch of beer. For a full rundown on making a yeast starter, see page 32.

Bottling by Priming with Sugar

After your beer ferments for a week or so in your primary fermenter, and then settles for another week in your secondary fermenter, it's time to bottle. We'll try a new bottling procedure this time. Instead of priming each bottle individually, we'll use batch priming in a bottling bucket.

To bottle this way, you need to siphon your wort from your secondary fermenter into a sanitized bucket. Try to minimize the amount of splashing when you transfer the beer. You don't want to oxidize it.

For 5 gallons (19 L) of beer, use a sanitized spoon to stir a solution of sugar water into your beer. Make the sugar water by boiling ¾ cup of corn sugar in 2 cups of water. (You can add more or less sugar — from ½ cup to 1¼ cups — to vary the amount of carbonation.) Boil for 15 minutes, then cool the solution to about room temperature and stir it into the beer. Now, siphon the beer into bottles and cap them as before.

The sugar provides a new source of fermentable sugar, which causes fermentation in the bottle and creates carbon dioxide. After a week at room temperature, put the bottles in the fridge for a week. Then, invite some friends over and impress them with the beer you made with your new brewing skills.

So that's how to make a partial mash. In the final techniques chapter, we'll move up to full mashing and brew an all-grain beer. A full mash works just like a partial mash, but you will need get some added equipment and learn a few new skills to handle the larger volume of grains required.

SUMMARY

- Partial mashing with grains adds more control to your extract homebrew.
- A full-wort boil increases hop utilization but requires that the wort be cooled.
- A submersible wort chiller can cool wort quickly
- Aerating cooled wort with an aquarium pump and stone is simple and effective.

STEEPING OR MASHING: What's the Difference?

Steeping is the process of soaking grains in hot water to extract flavor and color components. In mashing, color and flavor extraction also occurs but, in addition, starches in the grains (if present) are converted into sugars. Grains that can be steeped can also be mashed (along with base grains). However, grains that need to be mashed cannot be steeped. Steeping and mashing are similar, of course, but mashing requires tighter control over the temperature and volume of the mash.

Whether or not a grain can be steeped depends on how it was malted. Grains that can be steeped are ones that have been stewed during malting until the starches are converted to sugar inside the grain hull. Depending on how long this lasts, and at what temperature, some or all of the sugars will be caramelized. The extent of the caramelization, and any toasting of the hull, determines the color rating of the malt (typically given in degrees Lovibond). The most commonly steeped malts are the crystal malts (also called caramel malts).

Other grains are kilned at higher temperatures or for longer periods and the sugars in these roasted malts end up charred instead of caramelized. Roasted malts tend to be darker than crystal malts and give a sharper flavor.

Malts that are not stewed or kilned enough to convert the starches must be mashed. These malts are typically called base malts. Base malts require mashing to convert their starches to simpler sugars. The bulk of the fermentables in a beer come — directly, or indirectly through malt extract — from the base grains. If these grains are not mashed, unconverted starches are released into the wort and eventually wind up in the beer. The result is excessive haze and the potential for a "starchy" flavor.

See the sidebars on pages 30 and 31 for more information.

SPECIALTY GRAINS

Steep Me!
Maltsters have already converted the starches in these grains to sugars. Steep them to dissolve the sugars and add color to your brew.

Crystal malt (10–120 °L)
Crystal malts are malts that have been malted and then stewed — a process in which the malt is initially kilned without drying it. Crystal malts lend a reddish color to beer as well as a caramel flavor. For this reason, they are sometimes called caramel malt.

The color of crystal malts are described in degrees Lovibond (°L). The rating of most crystal malts falls in the 10–120 °L range).

Of all the specialty malts, crystal malt is probably the most frequently used. They give the red or amber colors in most pale ales. They are also frequently used in combination with other malts in darker beers. In these beers, they often comprise between 5 and 15% of the grain bill.

Special B malt (180 °L)
Special B is a very dark type of crystal malt. It can be used in many types of beers, but shows up most frequently in certain Belgian styles.

Chocolate malt (~300–350 °L)
Chocolate malt is a dark roasted grain. It is kilned dry, not wet as in the stewed crystal malts. Chocolate is the lightest of the commonly used roasted malts. Chocolate can be used in a wide variety of beer styles, where it lends a brown color and somewhat chocolate-like flavor. Many porters feature chocolate malt prominently. As with crystal malt, they can be comprise up to 15% of the grain bill.

Roasted barley (300–500 °L)
Roasted barley is a specialty grain that is not a malt (i.e., the barley is roasted without first being malted). It can be found in a rather wide range of colors. Roasted barley is sometimes used in very small amounts simply to add a little color to a beer. This is common in Scottish ales. In larger quantities, it makes a beer that is very dark and has a distinct roasted quality. This can be coffee-like and may have a burned edge to it. The flavor of roasted barley is featured prominently in stouts, where it may comprise up to 10% of the grain bill.

Black malt (500 °L)
Black malt is another very dark malt. It is very similar to the darker versions of roasted barley, but is made from malted barley. Because black malt lends a somewhat bitter, drying character, it is typically not used in over 5% of the grain bill. Black malt is sometimes called black patent malt.

BASE GRAINS

Mash Me!

These grains are malted such that they, unlike specialty malt, still contain large amounts of starch. It is this starch that, once converted to sugar in the mash, gives beer the bulk of its fermentable sugars. Because starch renders beer hazy and less biologically stable, these grains should not be used unless they are mashed (including partial mashing procedures).

2-row pale malt (~2 °L)

A lightly kilned base grain made from 2-row barley. If it is mashed without any specialty grains added for color, it makes a very light colored beer. 2-row pale malt makes up the bulk of the grain bill in many different beer styles.

2-row pale ale malt (~3 °L)

A base grain made from 2-row barley, that is kilned to a slightly higher color than pale malt. It gives a little more color and malt flavor to beer and is frequently used in British-style ales, especially — as the name implies — pale ales.

6-row pale malt (1.8 °L)

This is a base grain made in a manner very similar to 2-row pale malt, only it is made from 6-row barley. The use of 6-row malts is more common in brewing in the United States than elsewhere. 6-row has smaller kernels, but more enzymatic power than 2-row malts. It is frequently used when large amounts of corn or rice are used in the mash. The flavor is similar to 2-row pale malt but, because 6-row has proportionally more husk, it is slightly "grainier."

Pilsner malt (1.0–1.6 °L)

A very light-colored base malt. Pilsner malt is the base malt in many German lagers, including — as the name suggests — Pilsners. It is also the base malt, sometimes the only malt, used in making a Munich-style helles. Pilsner malt is also used in many Belgian beers.

Wheat malt (2–2.5 °L)

Wheat malt is malt made from either red or white wheat. It is used at 30–70% of the grain bill for many styles of wheat beer including German hefeweizens, Belgian wits and lambics. It is often added in smaller amounts — around 5–10% — to add head retention in other beer styles.

Munich malt (10–20 °L)

Munich malt is a more highly kilned malt that adds a malty character to beers in many German lagers. It is also used somewhat frequently to add a malty element in India pale ales.

Vienna malt (~6 °L)

Vienna is similar to Munich, but lighter.

FERMENTATION

What's the simplest way to improve your homebrew? Well, for most homebrewers, it's running a good fermentation. One of the biggest factors in this is pitching an adequate amount of yeast. Pitching a single packet of yeast into a 5-gallon (19 L) batch does not give your beer enough yeast cells to efficiently ferment the wort. Beers made from underpitched worts start slower, and this slow start can leave the wort open to the growth of bacteria or wild yeast. Underpitched beers also stop fermenting at higher final gravities, resulting in a beer that may be too sweet. Finally, an underpitched wort may lead to high concentrations of esters and fusel oils, which can yield off-flavors and smells.

How Much Yeast?

A general rule of thumb for pitching ale yeast is that you need one million (1.0 x 106) cells per milliliter of wort per degree Plato. An average-strength ale weighs in at 12 °Plato (1.048 SG). So, for 5 gallons (19 L) of this beer, you would need to pitch about 228 billion (2.28 x 1011) yeast cells. You would need more cells for higher gravity beers or for larger volumes of beer.

Wyeast says its XL packs contain 40–60 billion cells and White Labs says its tubes contain 30–60 billion cells. Using the pitching rule above, 60 billion cells is only enough to pitch to 1.3 gallons of wort. You would need almost four packages of yeast to pitch to a standard five-gallon batch of homebrew. Fortunately, there's an easy way to get from 60 billion (or fewer) cells to 228 billion (or more) — making a yeast starter.

A yeast starter is simply a small batch of beer. The yeast from this small batch is used to inoculate your main wort. In addition, if you pitch the yeast around the peak of fermentation (called high kraeusen), they will be active and healthy. Some calculations can show you how large a starter you need to raise the required 228 billion yeast cells.

At high kraeusen, yeast density reaches about 100 million cells/mL in a normal-strength beer. So, to raise 228 billion cells, you'd need 2,280 mL — just over two liters — of starter wort. To calculate the starter volume needed for any number of cells, just divide the number of cells required by 100 million (1.0 x 108) cells/mL.

Another rule of thumb relating to pitching is that the size of the starter should be at least 1/10 the volume of the wort. Using this rule, a 5-gallon (19-L) batch of beer would need a 0.5 gallon (1.9 L) starter. As you can see, our two estimates of starter volume are pretty close.

These numbers assume your starter wort is of average strength, around 12 °Plato (1.048 SG). They also assume your wort is well-aerated and has all the proper nutrients. And they assume that your wort is at high kraeusen and that your yeast strain of choice actually has a maximum density of 100 million cells/mL. Any deviation from these things may alter your cell count.

Without actually counting yeast cells — a procedure that requires special equipment — you'll never know your exact cell count. However, the calculations above are a rough guideline for making an adequate starter. Even if your actual cell counts are off by as much as 20%, which is unlikely, you'll be fine.

Materials Needed

Making a yeast starter for 5 gallons (19 L) of ale requires only the following materials: a two liter (or larger) container with cap, a fermentation airlock for the container, dried malt extract (light, unhopped), a pot and your yeast package. Glass gallon jugs, or many brewpub growlers, can also be used.

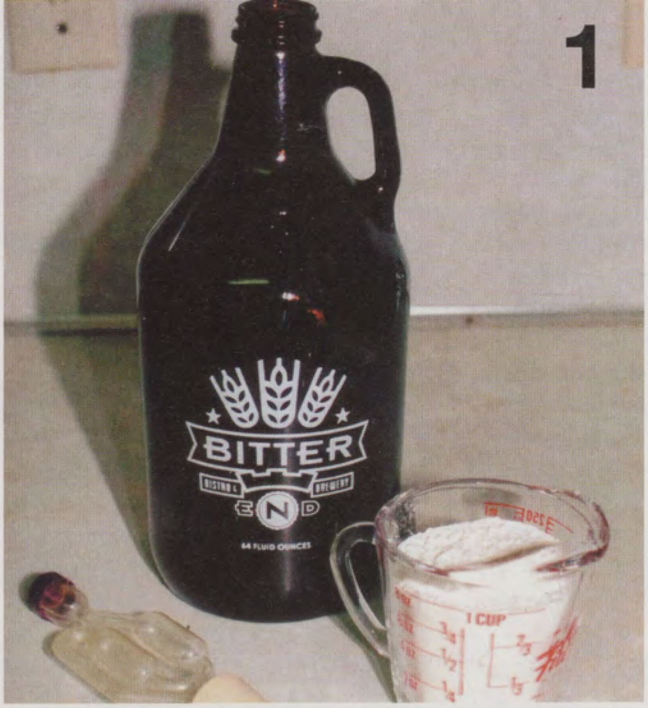
Making a Yeast Starter

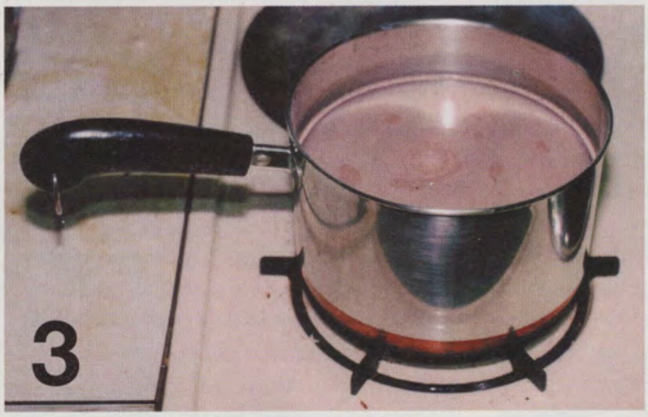
Measure out enough dried malt extract (DME) to make a wort with a specific gravity of 1.040. Dried malt extract yields 45 gravity points per pound per gallon; in other words, one pound of DME in one gallon of water makes a wort with a specific gravity of 1.045. So, to calculate the amount of DME you need, take your target gravity (in "gravity points") times the volume of your yeast starter (in gallons) and divide this number by 45. A beer with a specific gravity of 1.040 has 40 gravity points, and two liters equals 0.52 gallons, so we need about 0.46 lb. (0.2 kg) of DME to make a yeast starter for an average-strength ale.

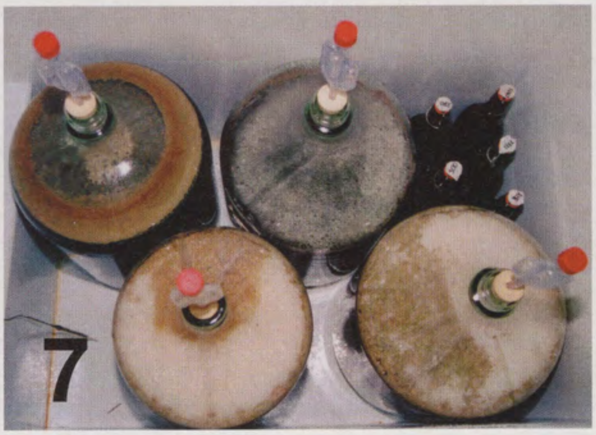
Bring two liters of water to a boil on your stovetop, then turn off the heat. Add the malt extract and stir until completely dissolved. Expect some foaming when you add the extract. Turn the heat back on and boil the starter wort for 15 minutes. Keep the pot partially covered with a lid during the boil. When the boil is over, put the lid on and cool the starter in your sink.

Cool the wort until it is at room temperature or below. This may take 15 minutes or so. To cool the wort as quickly as possible, fill the sink with ice water and place the pot in it. Every minute or so, lift the pot out of the water and swirl the wort gently by moving the pot in a circular motion. Keep the lid on to keep out microorganisms. Swirl the ice water in the sink around and return the pot to the water. If the water is getting warm, replace it with cold water. At room temperature the side of the pot will feel cool to the touch.

During the boil and cooling, clean and sanitize your starter container and fermentation airlock.







To ensure a healthy fermentation, **(1)** measure out 1-1.5 cups of dried malt extract, **(2)** boil 64 oz. (~2 L) of water, **(3)** turn off heat and add malt extract to hot water, **(4)** boil for 15 minutes, **(5)** cool starter wort to approximately 70 °F (21 °C), **(6)** transfer to a sanitized container and pitch yeast to the starter wort and **(7)** pitch starter wort to main wort on brewing day. Making a starter allows for faster starts, cleaner fermentations and lower finishing gravities.

Remember that this "little batch of beer" is going into your big batch of beer, so pay close attention to cleaning and sanitation. Any contamination of your yeast starter will be magnified in your main batch of beer.

Once the wort is cool, quickly pour the wort into the container and cap the starter. Shake the starter vigorously to aerate the starter wort. Once the foam has subsided, pitch the yeast into the starter. If you keep the starter between 72–80 °F (22–27 °C), it should be ready to use in two days.

Fermenting the Yeast Starter

Treat your yeast starter like you would a batch of beer. Keep the starter between 72–80 °F (22–27 °C) while it's growing, slightly higher than normal ale temperatures. The yeast will grow quickly and happily in this temperature range. Also, keep it away from bright light.

On brewing day, you can pitch your entire yeast starter or pour off the liquid and only pitch the yeast sediment. Pitching the entire yeast starter ensures that the yeast are active when they enter your wort. Pitching the sediment only is preferred when pitching the whole starter would dilute the color or strength of your beer.

Once you've pitched your yeast starter, fermentation should start in 6–18 hours. You shouldn't have any problems with fermentations that wouldn't start or with "stuck" fermentations when using a yeast starter.

In order to provide the yeast from your starter a healthy environment to grow in, you will need to aerate your wort.

Why Aerate?

Aeration is any process that introduces air into the wort. Before fermentation, chilled wort must be aerated in order to introduce oxygen. Since air is 21% oxygen, aerating wort also oxygenates it. This oxygen is absorbed by the yeast within a few hours and is used to synthesize sterols, molecules that are important to yeast's health.

A well-aerated wort promotes yeast health. And you can't have a good fermentation without healthy yeast! Three indications of a good fermentation are minimal lag time, low ester levels and proper attenuation.

Keep in mind that the only time you should aerate your wort is after it has been chilled and before the onset of fermentation. Oxygen is detrimental at all other stages of beer production and can contribute stale, cardboard-like flavors and smells. Before fermentation, the oxygen is absorbed by the yeast within a few hours and isn't in contact with the wort for that long.

How Much?

The amount of oxygen your yeast requires depends on wort gravity and the amount of yeast replication that will occur. Yeast in higher-gravity worts require more oxygen. Yeast's demand for oxygen increases steadily with gravity until about 1.060. Above this gravity, the need for oxygen increases sharply. Under-pitched worts also need more oxygen. The less yeast you pitch, the more they need to replicate before reaching a density high enough to ferment the wort. Yeast generally need between 4 and 14 ppm of oxygen for a healthy fermentation. Since the vast majority of homebrewers don't have a dissolved oxygen (DO) meter to measure this with, you must rely on a variety of clues to indirectly gauge if aeration is sufficient.

The best way to assess efficiency is by noting the lag time until fermentation starts, ester levels in the finished beer and the final gravity of the beer. A brew that starts fast, and yields a dry and clean finished beer, received enough oxygen during aeration. A sluggishly fermenting beer that yields a sweet and estery concoction might not have received enough oxygen.

When & What to Aerate?

The oxygen you introduce into your wort isn't the only source of oxygen for your yeast. Wort oxygen also can come from oxygen in the starter wort and, for extract brewers, oxygen in the dilution water. Also, trub (sediment) can substitute for oxygen.

If you use starter wort, aerate it well. Thorough aeration will lower the amount of oxygen you need to introduce to your main wort. Aerating both the starter wort and the main wort is a good way to satisfy the oxygen demands of your yeast.

Retaining a bit of trub in the bottom of your fermenter decreases the need for oxygen. Trub doesn't contain oxygen, but it helps yeast with sterol synthesis. Still, homebrewers should attempt to minimize the amount carried over from the kettle as too much trub can cause off-flavors.

The efficiency of aeration depends on wort gravity, wort temperature and aeration techniques. Higher-gravity worts hold less oxygen at saturation. Unfortunately the yeast in higher gravity worts need more oxygen. So, for higher-gravity beers, you should aerate until the wort can't hold any more oxygen.

How you aerate your wort is also important. The techniques fall into three general classes: shaking, splashing and injecting. When choosing your aeration technique, you should consider your yeast oxygen needs, starter size and the temperature of the wort.

Method One: Shaking

Shaking a container of wort will aerate it. Shaking is not very effective for large volumes of wort, but works great for smaller volumes.

If you use your foot for support, you can rock a carboy back and forth vigorously until you have raised some foam. Be sure to get a good grip on the carboy and work up to speed slowly. A sloshing wort wave can jerk or twist the carboy from your hands.

Though a great way to get exercise, shaking is not the most effective way to aerate a carboy. The top of the wort will pick up air, but the bottom doesn't get any.

The starter wort can be refrigerated overnight before it is pitched. When it's cold, a vigorous shaking will aerate the starter wort far beyond what shaking a carboy full of room-temperature wort will. The agitation is greater and the wort will hold more oxygen at the lower temperature.

Method Two: Splashing

You can aerate your chilled wort by splashing it around. This is more effective than shaking. But there are also greater opportunities for the wort to become infected when splashing wort in the open air.

To do this, you'll need two sanitized buckets and, optionally, a large sanitized kitchen strainer. Pouring wort back and forth between two buckets will aerate it. Get a friend to hold a kitchen strainer above the receiving bucket. Straining the wort will further agitate it.

When splashing, care must be taken to avoid contamination. Don't transfer the wort between buckets in the same area where you crushed your grain. Grain dust harbors all sorts of bacteria and wild yeast that will spoil your wort. Also, don't touch the inside of your buckets or the wort itself. Remember to brace the receiving bucket. An empty bucket can tip or slide suddenly when hit with a "wort waterfall."

Method Three: Injecting

The most effective way to aerate your wort is by injecting air or oxygen directly into it. Injecting minimizes the chances of contamination.

The most common homebrew aeration set-up includes an aquarium pump, tubing with an in-line filter and an aeration stone. An aeration stone can also be connected via tubing to an oxygen tank.

Injecting air or oxygen into wort is simple. First, sterilize the tubing and aeration stone (usually made of a porous stainless steel). As the chilled wort transfers to the fermenter, air (or oxygen) is bubbled through the aeration stone and dissolves into the wort. Continue bubbling air through the stone until a layer of foam covers the wort. This takes 5 to 15 minutes.

The filter takes out dust and microorganisms in the air that could potentially contaminate the wort.

If a high level of aeration is desired, pure oxygen can be used. However, high levels of oxygen can over-stimulate the yeast, resulting in foul-tasting fermentation byproducts.

If you've pitched an adequate amount of yeast and aerated your wort properly, all you need to do is ferment your beer.

Fermentation

On brew day, you make your wort. Then you unleash an army of yeast cells to turn the wort into beer. During primary fermentation, your main goal should be to maintain a relatively constant temperature, within the yeast's recommended range, and let the fermentation proceed without distrubing it. You should also protect your fermenting wort from strong light. Many homebrewers perform a "secondary fermentation" of their beers. Secondary fermentation simply means the beer is racked to another vessel (a secondary fermenter) and allowed to age prior to packaging.

The advantage to secondary fermentation is that the beer is racked off the trub and yeast from the primary fermentation. If the beer remains in contact with these materials for too long, it may pick up off-flavors. A second benefit is that it helps the beer clarify faster. Some homebrewers use secondary fermenters that are smaller than their primary fermenter to minimize the headspace in the secondary.


1

2


3

1. A glass carboy is the fermenter of choice for most homebrewers. Although breakable, the glass won't absorb odors and is impermeable to oxygen. New plastic models are now available that also keep out odor and oxygen.
2. Cylindro-conical fermenters allow you to perform primary and secondary fermentations in the same tank.
3. Fermentation buckets are the old homebrewing standby. Buckets are cheap, easy to clean and block light from your beer.

Brewing an **ALL-GRAIN BEER**

OBJECTIVE: Brew an all-grain IPA and American Pilsner from malted barley

Vocabulary

all-grain brewing
single-infusion mash
fearless
sparging
propane cooker
mash tun
recirculation
lauter tun

New Skills

single-infusion mashing
recirculation
sparging

Equipment list

mash-lauter tun
propane burner
sparge arm

In the previous chapters, we made our beers using malt extract for some or all of the fermentable sugars. In this chapter, we'll brew a beer in which the fermentables come entirely from malted barley or other malted grains. This is called all-grain or full-mash brewing. We'll perform a single-infusion mash, the simplest kind of full mash.

Although a full mash works on the same principles as the partial mash, the increase in the amount of grain used requires us to alter our procedures slightly. In the partial mashing chapter, we put our entire grain bill in a mesh bag and later lifted this bag out of the pot, leaving behind wort. In all-grain brewing, lifting a grain bag containing all the necessary grain would be highly problematic due to its weight. So, in all-grain brewing, the grain bed stays in place during the wort separation process (called lautering). For this, you will need some additional equipment, specifically a combination mash-lauter tun (for more on these, see page 37).

Advantages and Disadvantages of All-Grain Brewing

Brewing beer from a full mash takes significantly more time than brewing an extract beer. Some of the extra time comes from added steps in the procedure, such as the mashing, recirculating and lautering. (We'll explain these terms later.) More time is also needed to heat the larger volumes of water needed to brew an all-grain beer. You also have to clean the additional equipment used in brewing an all-grain beer.

Although it takes more time, there are many advantages to brewing "from scratch." All-grain brewers can manipulate the conditions of the mash to make their wort exactly as they want it. They can, for example, adjust the fermentability of the wort. In this chapter, we'll incude recipes for a big, full-bodied beer — a hoppy, Northwest-style IPA — and a somewhat crisper, drier beer — a classic American Pilsner (or CAP). (See page 38 for the recipes.) In the CAP recipe, we'll learn another benefit of all-grain brewing — the ability to brew using starchy adjuncts.

In the long run, brewing all-grain beers is more economical. When you buy malt extract, you are paying not only for the malted barley, but the expense of mashing the grains, separating the wort from the husks, and condensing the wort into extract. So, malted barley grains cost about half as much as an equivalent amount of malt extract. Of course, the start-up cost for brewing an all-grain beer can be substantial. At a minimum, you need a mash-lauter tun to hold the grains.

A homebrewer contemplating switching to all-grain brewing may be intimidated by the amount of information out there. Homebrewing books and online homebrewing forums are filled with talk of appropriate mash thicknesses, stepped temperature regimes, pH and mash efficiencies. These are all important theoretical considerations. However, in most cases a practical brewer can brew without worrying about all these variables. And keep in mind that, although there are many varieties of stepped-temperature mashes, many commercial brewers and homebrewers use a single-infusion mash for their beers. For your first all-grain beer, you should be fearless —just jump right in.

Heating the Water

Although some of the later steps may be intimidating to a first-time all-grain brewer, an all-grain brew day starts with a simple task — heating water. When mashing, you need a large volume of hot water to mash the grains. About an hour later, you will need another large volume of water for rinsing the grains, or sparging. You will need about 10 gallons (38 L) of water to brew 5 gallons (19 L) of beer.

If you begin heating all your water first, you can clean and set up your brewing equipment while it heats. Having a reserve gallon or two of cold or room-temperature water will come in handy on brewing day. Likewise, having a reserve gallon or two of boiling, or near boiling, water will also come in handy.

Heating all the water needed for an all-grain batch can literally take hours on a kitchen stove, especially an electric stove. Most all-grain brewers eventually switch to a propane cooker to heat their water and boil the wort. These cookers will decrease the amount of time it takes to heat water and will give you the power to bring your full wort to a nice, rolling boil.

Mashing In

To begin the mash, or to mash in, you combine your grains with the hot water (called strike water). If your grains are roughly at "room temperature," you will want your strike water to be roughly 11 °F (5 °C) hotter than your target mash temperature. You will need from 1.0–2.0 quarts (~1-2 L) of strike water per 1.0 lb. (0.45 kg) of grains, with 1.25 lbs/gallon (0.15 kg/L) being a common ratio.

To begin the mash (or mash in), place the crushed grains in your mash-lauter tun. With a large measuring cup or a beer pitcher, add your strike water to the grains a few quarts (liters) at a time. Stir the mash each time you add water to break up any clumps of grain. These clumps can form a ball that seals liquid away from their dry core. Having dried clumps in your mash lowers the amount of fermentables you extract from the grain. It may also add starch to your beer.

As you ladle water onto the grains, work quickly. As you are working, heat is escaping from your mash into the environment. You don't need to rush, but work at a steady pace. Once there is enough water in the mash tun to barely cover the grains, take the mash temperature — it should be close to to your target temperature. If the temperature is much higher, stir in cool water from your reserve until you hit the right temperature. If the temperature is too low, stir in some near boiling water. When you stir in this water, make sure to stir the mash enough that the temperature is even throughout the mash. Once you've added the full volume of stike water, and your mash is at the correct temperature, you're ready to let the grains mash.

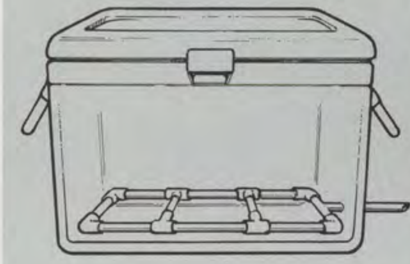
When mashing in, you also have the option of adding your strike water to your mash-lauter tun first then stirring in the grains. If you do this, try to stir the grains as quickly as possible into the water. As before, there's no need to rush, but work as quickly as is feasible. Once you've added all your grain to the strike water, check the temperature. Adjust with hot or cold water if needed.

For your first all-grain brew session, do not sweat the details too much. If your mash temperature is off by a couple degrees, don't worry. As long as you are within 148–162 °F (64–72 °C), you'll be making wort. Take good notes on how much water you added, how hot it was and what your mash temperature ended up at and you will be able to tweak your procedures next time you brew.

The Mash

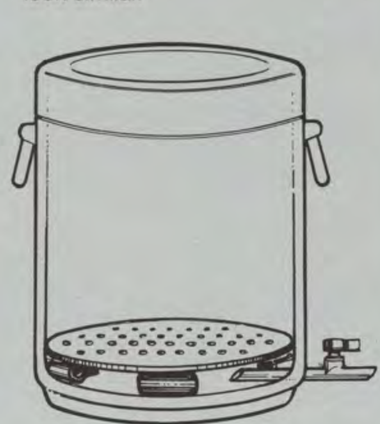
At this point, seal your mash tun. If you are mashing in a modified picnic cooler, shut the lid. If you are mashing in a brew-pot or modified brewpot, put on the cover and insulate with towels or a mash-jacket. Let this mash sit for an hour. If your mash tun is insulated well enough, the temperature should stay roughly constant. It

MANY WAYS TO MASH YOUR MALT



Most homebrewers use one of two arrangements for mashing grains and draining the wort. One set-up involves modifying a picnic cooler to hold a framework of copper pipes on its bottom (see diagram above). The copper pipes are cut with slots that allow wort to flow through but are too narrow for the grain. The pipes channel wort outside the cooler. A valve allows the homebrewer to control the flow of wort out of the cooler when draining the wort. Picnic coolers are well insulated and can hold the mash at a steady temperature for the entire duration of the mash.

The second common type of mash tun is a large brew pot with a "false bottom" inserted. The false bottom sits an inch or so above the kettle's floor and is perforated, so the grain stays behind but the wort can flow through. A valve below the false bottom is used to drain wort once the mash is complete. An advantage of this type of mash cooler is that it can be directly heated. The diagram below shows a picnic cooler mash tun with a false bottom, but a brewpot mash tun would look similar.



ALL-GRAIN recipes

Inverted IPA (India Pale Ale)

(5 gallons/19 L, all-grain)
OG = 1.069 FG = 1.016
IBU = 69 SRM =12 ABV = 6.9%

Ingredients

11 lbs. 14 oz. (5.4 kg) 2-row pale malt
2.0 lbs. (0.91 kg) Munich malt (10 °L)
0.66 lbs. (0.30 kg) crystal malt (30 °L)
16 AAU Magnum hops (60 mins) (1 oz./28 g of 16% alpha acids)
4 AAU Amarillo® hops (30 mins) (0.5 oz./14 g of 8% alpha acids)
0.66 oz. (19 g) Amarillo® hops (15 mins)
Wyeast 1028 (London Ale) or White Labs WLP013 (London Ale) yeast

Step by Step

Mash crushed grains at 158 °F (70 °C) with 4.5 gal (17 L) of water. Boil for 90 minutes. Ferment at 70 °F (21 °C).

Night CAP (Classic American Pilsner)

(5 gallons/19 L, all-grain)
OG = 1.053 FG = 1.011
IBU = 30 SRM = 6 ABV = 5.4%

Ingredients

5.0 lbs. (2.3 kg) 6-row pale malt
4.0 lbs. (1.8 kg) 2-row pale malt
0.33 lbs. (0.15 kg) CaraPils® malt (6 °L)
2.0 lbs. (0.91 kg) flaked maize
7 AAU Northern Brewer hops (60 mins) (1.0 oz./28 g of 7% alpha acids)
1.65 AAU Cluster hops (30 mins) (0.33 oz./9 g of 5% alpha acids)
Wyeast 2007 (Pilsen Lager) or White Labs WLP840 (American Lager) yeast

Step by Step

Mash crushed grains at 148 °F (64 °C) with 3.5 gal (13 L) of water. Boil for 90 minutes. Ferment at 52 °F (11 °C).

may drop a few degrees, but that's nothing to worry about. While the grains are mashing, heat a couple gallons (~8 L) of water to the boiling point. We'll use this later in a step called the mash out.

A lot occurs in the mash. Hot water soaks into the center of the grains and dissolves the starch. Starch is a large molecule found in great abundance in the barley kernels. Starch molecules are chains of simpler sugars. The starch is cut up by enzymes, called amylases, present in the grain. The starch molecules are thus gradually reduced to smaller sugar molecules, mostly maltose.

Note that the enzymes from your grain may also degrade starches from adjuncts — such as corn and rice — added to the mash as well as their own starches. When adding starchy adjuncts, keep the amounts under 30% of the grain bill or your grain may not be able to supply enough enzymes to degrade all the starch in the mash.

Although a lot is going on in the mash, the brewer doesn't need to do anything. If you'd like, you can stir the mash occasionally. You may increase the efficiency of mash by doing this, but you will also lose heat every time you open the mash tun. If you do open it, you will likely need to stir in boiling water to boost the temperature back to your target. If you just let the mash sit for an hour, you can be cleaning brewing equipment used in later stages. In any case, you will need to heat the water used to rinse the grains — the sparge water — towards the end of the mash.

The Mash-Out

After an hour of mashing, open your mash tun and take the mash temperature. Then, raise the temperature of the mash to 168° F (76 °C). To do this, stir in boiling water a few cups at a time. Take the temperature each time. Once you reach 168° F (76 °C), seal the mash tun again and wait for 15 minutes. Boosting the temperature to 168 °F(76 °C) will make the sugary wort less viscous and easier to drain from the grain bed. You can skip this step if you'd like. Due to limitations of their equipment, many brewpubs do. But, it can increase the amount of fermentables you extract from your grains. It will also stop the enzymatic action in the mash.

Recirculating

Once the grains have been mashed, your wort needs to be separated from the spent grains. Your mash lauter tun will have either a false botton or a manifold, depending on the type you choose. Opening the valve to your mash-lauter tun will allow the wort to drain, leaving the grains behind. However, the first bit of wort you collect will be very cloudy and have a lot of solids dissolved in it. To clarify the wort, brewers recirculate their wort, letting the grain bed act as a filter.

To begin recirculation, open the valve on your lauter tun. Once you open the valve, cloudy wort should start flowing. Collect this wort in a large measuring cup or beer pitcher. Once the container is full, pour this wort on top of the grain bed. As you continue recirculating, you will notice the wort clearing. For a 5-gallon (19 L) batch of beer, 20 minutes of recirculating is usually sufficient.

While recirculating a 5-gallon (19 L) batch, you want the wort to drain from the grain bed at a rate of about 2–3 qts. (~2–3 L) every five minutes. At this rate, a standard beer pitcher should fill in about 3–5 minutes. To control the rate that the wort drains, you may need to adjust the valve on your mash tun frequently. (Don't worry if you're draining the mash a little faster or slower here, especially if it's your first all-grain batch.) At the end of twenty minutes, you will have recirculated the entire volume (or nearly so) of wort in the grain bed. The wort should now be much clearer and free from large husk pieces or other large grain particles.

The Run-Off

Once the recirculation period is over, continue draining the wort from the grain bed. However, this wort should go now to the brew kettle. You can begin heating the wort as you collect it, but don't bring it to a boil. During the run-off period, you should be draining wort at about 2 qts. (~2 L) per five minutes or slightly less. The run-off period will be relatively short; it ends when the liquid level in the lauter tun falls to the level of the grain bed. Once the grain bed is about to be exposed, it's time to start sparging, so be sure your sparge water is ready.

The Sparge

During sparging, you continue running off clear wort at the same rate as in the run-off. However, you add hot water to the top of the grain bed at the same rate as wort is being drained off. As a result, as you collect the remainder of your wort there will always be a little water on top of the grain bed.

There are a couple different ways to add sparge water. You can ladle a quart (liter) or two of water on top of the grain bed when the level gets low. Alternately, most homebrew stores sell sparge arms to deliver the water at a steady rate. Sparge arms are like little lawn sprinklers for your mash. Hot water drains from a container (often the homebrewer's bottling bucket) through nylon or plastic tubing to the sprinkler. The rate of water can be adjusted either by opening or closing the valve on the bottling bucket or by partially clamping the nylon tubing leading to the sprinkler.

However you deliver it, the sparge water should be heated to 170 °F (77°C) — or a bit higher if you skipped the mash out. The heat from the sparge water should keep the temperature of the grain bed just under 170 °F (77 °C). At this temperature, the thick, sugary wort will flow freely through the grain bed.

If the grain bed cooled substantially, your flow of wort would slow down. On the other hand, at temperatures higher than 170° F (77 °C), tannins could be leached out of the grains. So, avoid overheating your sparge water. (This is another detail not to stress overly much about on your first brewing session.)

Remember to keep checking the rate at which the wort is draining. You should be collecting wort at a rate of about 2 qts. (~2 L) every 5 minutes. Faster run-offs are less efficient, and you run the risk of collapsing the grain bed, slowing or stopping the flow of wort. Slower run-off rates give better yields, but take longer. At the rate given above, you should be able to collect your wort in 60–90 minutes (depending on the size of your grain bill) and get a good yield of fermentables from the mash. As you continue collecting wort, the valve may become progressively blocked with small particles from the mash. If the rate of wort drainage drops too low, or stops altogether, open the valve all the way for a few seconds until the flow resumes. Then slowly close the valve to the proper flow rate.

It can be difficult to get the wort to drain at a constant rate. You will probably need to fiddle with the valve quite a few times. As long as your rate is in the right ballpark, you'll be fine. If you finish collecting your wort in less than 45 minutes, you've gone too fast. If it takes over 2 hours, you're going too slow. Keep collecting wort until the specific gravity of the runnings drops below 1.010. At this point, there is still a small amount of sugar that could be rinsed from the grains, but you'd also extract a lot of tannins at the same time. (You might also have to boil your wort longer to reduce its volume.)

Once you've stopped collecting wort, adjust the volume of your wort to around 6 gallons (23 L) by adding water, if necessary. With a rolling boil, you should be able to boil off a gallon (3.8 L) of liquid in an hour and hit your target volume of 5 gallons (19 L). If you have more wort collected than six gallons, you may have to boil your wort longer than 60 minutes. Likewise, some recipes call for 90-minute (or longer) boils; in this case you will need around 6.5 gallons (25 L) or more of wort to begin with.

Boiling, Cooling & Fermenting

You will finish brewing this beer as you would any other beer made with a full-wort boil. You will boil and cool the entire wort. The cooled wort will be siphoned to your fermenter, aerated and pitched. Please review earlier chapters for details on boiling, cooling, aerating and pitching.

You may get a larger hot break from an all-grain wort than from an extract wort. Very soon after the boil commences, you will see little light-colored flakes in your wort. This is the hot break. Break material will settle to the bottom of the kettle while the beer is cooling. If all goes well — and with a good rolling boil, it likely will — there will be 5 gallons (19 L) of clear wort sitting atop a few quarts of break material. This clear wort will be siphoned to the fermenter, leaving behind as much of the break material as feasible. In an extract wort, the hot break may have already been left behind in the process of making an extract (although procedures for making extract vary).

Is That It?

If you've thought about all-grain brewing before, you may have read a lot about water chemistry and pH. These factors are of great theoretical interest and can adversely effect your beer if they are out of whack. However, on the practical side, you will likely be able to brew good beer without worrying about them. Homebrewers considering all-grain brewing should not be scared off by the seeming complexity of these issues. If you do switch to all-grain you may wonder why you waited!

SUMMARY

- It takes a lot of water to brew an all-grain beer, so start heating it early.
- When mashing in, stir water into the crushed grains.
- Mash for an hour.
- Recirculate for 20 minutes.
- Run off wort from grain bed, begin sparging just before grain bed is exposed
- Don't sweat the details the first time around.