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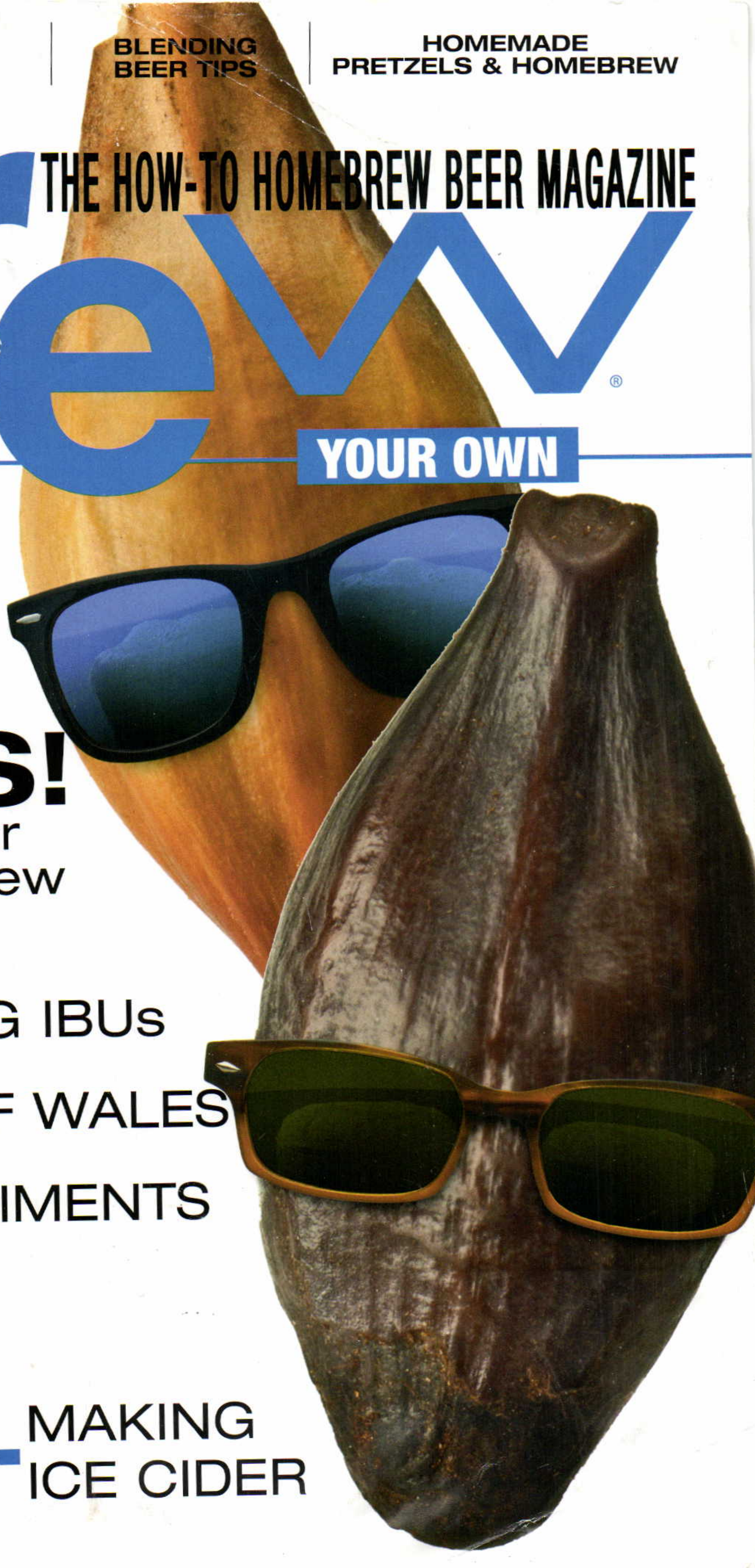
THE HOW-TO HOMEBREW BEER MAGAZINE

SEPTEMBER 2011, VOL.17, NO.5



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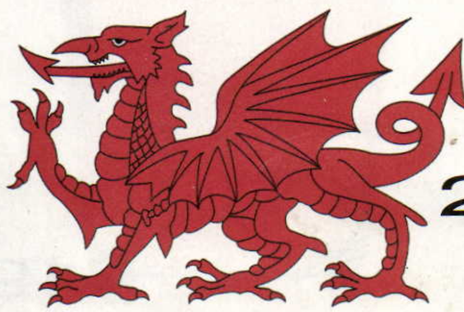

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BYO RECIPE STANDARDIZATION

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.

what's happening at **BYO.COM**

Grow Your Grains

Even though barley is most commonly grown commercially, you can easily grow your own. Chances are, there's a type of barley that will grow well in your backyard.

www.byo.com/component/resource/article/726

Make a Yeast Starter

Brewing better homebrew means pitching the proper amount of yeast. Make sure you pitch enough yeast cells in your next batch by making a yeast starter — it's easy, just follow the steps in this *BYO/Basic Brewing* video.

www.byo.com/videos/24-videos/1799-making-a-yeast-starter

Ask Mr. Wizard

Even the best brewers can run across a stubborn problem in the brewhouse. Thanks to *BYO*'s Mr. Wizard, Ashton Lewis, there are answers to nearly every sudsy situation. Check out *BYO*'s online collection of his questions and answers. (And if you can't find an answer, write to Ashton yourself: wiz@byo.com)

www.byo.com/stories/wizard

Cover Photo: **Charles A. Parker**

Brew Your Own — THE HOW-TO HOMEBREW BEER MAGAZINE

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Volume 17, Number 5: September 2011

Error in Mr. Wizard?

I just got the July-August *BYO* and read it cover to cover already! Thanks for such a well put-together resource for us homebrewers.

"Mr. Wizard" is always one of my favorite sections; it appeals to the nerdy engineer in me. However, I was a little confused by his response to Debbie Sellmeyer on brewing water. Referring to the table that accompanies the text, the note at the bottom indicates that the shown concentrations are for 18.9 GALLONS of water. He obviously meant liters (which equals 5 gallons), but this might confuse some people.

Also, his concentrations for Ca^{+2} and Cl^- coming from the addition of $CaCl_2$ don't match other references I've found. Most sources I find indicate that $CaCl_2$ comes hydrated ($CaCl_2+2H_2O$). The concentration of Ca^{+2} he indicates in the table matches with a non-hydrated version of $CaCl_2$. If you have some of that, send it my way. Assuming the non-hydrated $CaCl_2$ is right, the concentration of Cl^- looks like he may have only accounted for one Cl^- per Ca, instead of two (i.e., the number in the table should read something like 44.2).

Sorry to nitpick on this issue, brewing water chemistry is particularly interesting to me (don't ask me why). Again, great job with the magazine, and I look forward to when you switch to once a month!

Chris Holsonback
via email

Author and BYO's *"Mr. Wizard" Ashton Lewis responds: You are certainly not being nitpicky, you identified two [rare] mistakes in my column. Indeed, 18.9 gallons was a plain old brain-freeze that should have been 18.9 liters as you understand, but others who are not used to converting gallons to liters may not so quickly recognize the mistake.*

As for the second part of your question, at Springfield Brewing Company we purchase anhydrous calcium chloride from Brewers Supply Group and my calculations were based on the anhydrous form. Your question caught me by surprise since I have been using the same water calculations for a

contributors

Terry Foster was born in London, England and holds a PhD in chemistry from the University of London. He now lives part of every year near New Haven, Connecticut, where he often brews commercially with the brewers at BruRoom@BAR — New Haven's first brewpub.

Terry is known to many homebrewers as the author of the *Pale Ale* and *Porter* books in the Classic Beer Style Series (Brewers Publications) as well as many articles in *Brew Your Own*.

In this issue, Terry explores the often under-appreciated world of Welsh beers (page 26) and discusses calculating IBUs in homebrews in his "Techniques" column (page 57).

Betsy Parks is the Associate Editor of *Brew Your Own* and regular author of both the "Beginner's Block" and "Tips from the Pros" columns. She is a 1996 graduate of the New England Culinary Institute in Montpelier, Vermont and also holds a bachelor's degree in journalism.

In addition to her regular editing duties overseeing the magazine's columnists and our "Homebrew Nation" department, Betsy frequently contributes feature stories to *Brew Your Own*. In this issue, on page 50, she discusses the process for making ice cider, a dessert beverage that originates from Québec that is fermented from concentrated juice extracted from sweet cider.

Chris Colby is *Brew Your Own*'s Editor and an avid homebrewer. He learned to brew beer right around the same time that he discovered good beer — when he started graduate school at Boston University in 1990. As a grad student in biology he could have easily dug into the advanced homebrew literature at the time, but he figured he had enough things to study and just wanted a nice, easy hobby that ended up with him drinking beer. Since then Chris has gone on to be a regular contributor at *BYO*, the Associate Editor and eventually becoming the Editor in 2003.

In this issue, Chris scoured the world of maltsters to bring us a collection of new malts to try at home (page 38) as well as an experiment with Basic Brewing Radio's James Spencer on mashing (page 44).

long time, almost 20 years, and I do account for the four waters associated with calcium sulfate. I thought maybe I had been carrying around an old mistake, but I just confirmed the description on my supply of calcium chloride.

I did mess up my chloride calculations and only included one of the chlorides when I calculated the mole fraction. I confess to creating this table by doing the calculations by hand. Using 111 grams/mole for anhydrous calcium chloride the concentration should be 44.3 mg/l. The calcium is correct, however.

Summer, saison and Celis

Just in time for summer, the July-August issue appears in my mailbox! Your recommendation of cream ale and saison for summer are spot on. I already had planned to order ingredients for both the following week. I've been brewing on/off with my brother for 15 years now, but only recently got my own equipment. I had never heard of saison until maybe 6–7 months ago. I think this is a style on the rise. I've already made two batches (just ordered #3) and it is possibly the best beer that has ever passed my lips. I can't believe this stuff isn't more popular than it is.

Regarding Celis White, your story is in line with what I was told happened to it over 10 years ago. Celis White was among the best beers in America at the time. Blue Moon is the bilge left over from a batch of Celis (and I actually really like Blue Moon). Real shame what happened to it. Glad I was able to enjoy it while it existed.

Matt Nicholson
Charlotte, North Carolina

If that's how you describe a beer you really like, we'd hate to hear you describe one you don't. Glad you enjoyed the issue and keep on brewing saisons. (By the way, we think you're right, saison is experiencing a bit of an upswing, being a favorite of Belgian-inspired American craftbrewers. And it couldn't have happened to a nicer style.)

Very low gravity beer

As a recent kidney donor, I can no longer have more than one or two normal gravity beers a day anymore. Being an avid homebrewer for over two years now, though, I have no interest in giving up my hobby or passion for good beer. In the interest of still wanting to enjoy several pints over the course of a night on occasion, and realizing that as homebrewers we have complete control over our final products, I realized the possibility of making a very low gravity beer to satisfy my palate. I have yet, however, to start making my own recipes. I have noticed you have a wide variety of recipes and put several in to each issue. Do you know of any recipes that will result in a low ABV of around 2% but still remain quality ale?

William Devine
via email

We don't have any recipes on hand for beers with an ABV of 2% or below, but we could give you some advice. Any beer brewed in the normal way that ends up around 2% ABV is bound to taste a bit thin compared to other beers. To counteract this, you have a couple options.

As a starting point, look at recipes for session beers or other low gravity beers for a reference. A beer can be low in gravity, but still have plenty of flavor. If you are an all-grain brewer, mash your grains at a high temperature, mash out and keep your sparge water hot. You may also want to increase the percentage of specialty malt or add some CaraPils® to your beer; keep in mind this will change the flavor, so don't overdo it.

Finally, with a low starting gravity, be careful not to pitch too much yeast. In addition, with a comparatively short fermentation, you might need to adjust the pH of the beer downward to get the right amount of "zip" in it. You'd have to taste your beer and make the call for yourself on this aspect. It's doubtful you will be able to brew something that tastes like a full-strength beer, but — with some effort — you could likely brew something that is a worthwhile compromise. If you want to try brewing something with even less alcohol (non-alcoholic), visit www.byo.com/component/resource/article/265.

With less malt in your recipe, you may also want to dial back on the hops, to preserve some sense of balance. Take good notes on your brew days, and when you taste the beer don't be afraid to experiment (the ingredients for 2% ABV will cost less than for a regular strength beer).

Keg fermenter question

On page 65 of the July-August issue, Christian Lavender tells how to make an insulated keg fermenter. What I would like to know is what to do with the finished fermented beer (besides drink it). Can it be dispensed from the keg fermenter or does it need to be transferred to a Corny keg?

Dennis Anderson
via email

As with any fermenter, you will want to transfer the beer to another vessel before serving it. BYO

homebrew nation

READER PROJECT

Brewer: Lon DePoppe
Hometown: St. James, Minnesota

Liquid Lunchbox: *[lik-wid • luh-nch-boks]*: a tote for hand-crafted bottled beverages

Here's how you can build your own liquid lunchbox for transporting your beer. I built these boxes to cart five 12-ounce bottles, but you can always modify it to make it larger as well. These are simple to construct and inexpensive enough that I give them away as gifts.

Materials needed:

- Wood: 1 base, 2 ends, 6 side slats, 2 handle supports, and 1 handle
- Glue
- 4 screws
- Brads (small nails)

Tools needed:

- Ruler
- Saw (a table saw makes cutting easy)
- Hammer (or nail gun)
- Screwdriver

Planning and measuring

Because your bottles will likely have different dimensions than mine, you'll need to do some calculations to construct a box that's built for the bottles you have.

1. Measure the bottle(s) at their widest points. I made mine for five 12-oz. bottles in a single row; my row measures 14¼-inches (37 cm) long, 2¾-inches (6 cm) wide, and 7 ½-inches (19 cm) tall.

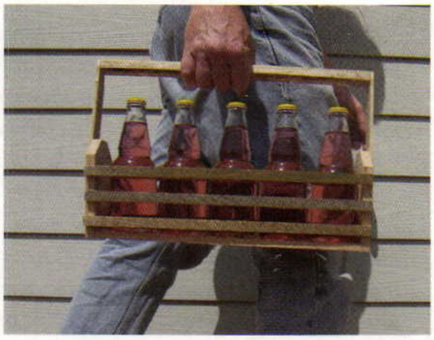
2. Base size: add ¼-inch (1.27 cm) to your measured length and width; mine comes out to 14½-inches (37 cm) long by 3 inches (8 cm) wide.

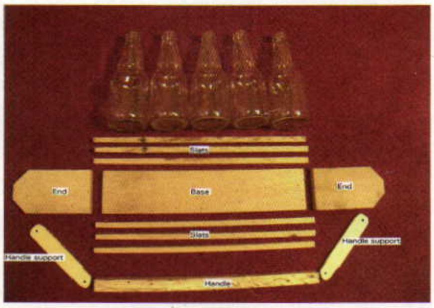
3. The ends are the same width as the base. The height of the ends will be approximately two-thirds the height of your bottles plus the thickness of the base. This makes my ends 5½-inches (14 cm) tall (two-thirds of 7½-inches is 5"), plus the thickness of the base [½-inch]). I cut off the top corners of my end pieces to give a finished look.

4. For the side slats, I first cut a piece of wood to the proper length. The length equals the length of the base plus the thickness of the two ends. So I'll need 6 slats that are 15 ½-inch (39 cm) long (14½-inches + ½-inch + ½-inch). I then make the individual slats by cutting the board into ½-inch- (1.27-cm) wide strips.

5. The handle supports are cut from thin plywood and are the same length as the ends. I pre-drill a hole in each end of the supports for the screws.

6. Lastly, the handle is the same length as the side slats. I drill a small pilot hole in each end of the handle. To assemble, simply glue and tack the ends to the base. Then glue and tack the slats to the sides and attach the handle with the support. Leave the handle support loose enough on the lunchbox so that it can swing out of the way for bottle removal.





byo.com brew polls

What do you do with your spent grains?

I compost 54%
I throw them away 32%
I reuse them for other things (bread, etc.) 13%
I don't brew with grains 1%

what's new?

Brewing Better Beer

Brewing Better Beer (Brewers Publications) is a comprehensive look at technical, practical and creative homebrewing advice from Gordon Strong, three-time winner of the coveted National Homebrew Competition Ninkasi Award. Discover techniques, philosophy, recipes and tips that will help you take your homebrew to the next level.
www.homebrewersassociation.org

The Ruby Street Brewery™

The Ruby Street Brewery is a complete direct fired 15-gallon (57-L) system that includes all stainless steel professional grade components — kettles, false bottoms, valves, sanitary tri-clamp fittings and dip tubes. Also includes magnetic drive pump, silicone tubing, 10-inch pneumatic tires, powder coated frame, and complete burner system with propane regulator. Unique storage option and large wheels make this system both convenient and portable. Plus, systems are shipped nearly completely assembled, and require no tools for final assembly.
www.rubystreetbrewing.com

calendar

September 17
DAI Oktoberfest Home Brew Contest
Dayton, Ohio
Judging for this homebrew contest includes a "German Style Winner" and a "Non-German Style Winner" (check website for entry rules). All entry fees support the Dayton Art Institute, and this event also features a "Best Label" contest. Winners will be announced during the DAI Oktoberfest, which runs from September 23 through 25.
Entry fee: $10 for one, $20 for three
Deadline: September 16
Contact: Jay Requarth, jay@daihomebrew.com
Web: www.daihomebrew.com

September 19
National Organic Homebrew Challenge (entry deadline)
Santa Cruz, California
Once a year, organic brewers compete head to head in a national competition that is professionally judged just for organic beers. Be sure to get your organic homebrews in before the deadline closes this year. Check the website for details, rules and entry forms.
Entry fee: $7 1st entry, $5 additional entries
Deadline: September 19
Contact: Jason Hansen, 7bridges@breworganic.com
Web: www.breworganic.com/Competition/index.html

September 23
Southern Vermont Homebrew Festival
Bennington, Vermont
This homebrew challenge is now AHA/BJCP sanctioned, but still includes a "people's choice" award where one lucky brewer can bring home a $200 cash prize.
Entry fee: $7
Deadline: September 2
Contact: Susan Strano, sstrano@benningtonmuseum.org
Web: www.benningtonmuseum.org/brew-fest-registration.html

homebrew drool systems

Little Dog Brewery

Allen Freeberg • Colorado Springs, Colorado

This setup is what Allen refers to as his "not so cheap" homebrewery. A self-confessed "gadget freak," his hot liquor tank is fully enclosed — except for a covered hole on the top — and fills and heats automatically.

Photo 1

As you can see the frame is made of red wood with Formica tops except for the bottom "pump" level which is stainless steel. I pondered for a long time between a one, two or three tier system. Each has its advantage and disadvantages and I settled on what you see. The HLT is the only gravity feed tank (except for the grant) in the system. There is no doubt I designed and built my brewery with looks in mind but it is also functional. I thought my first brew would be a Chinese fire drill but, in fact, the brew went very smooth. All of the problems were head space on my part, and best of all the beer turned out excellent. Even the clean up went well, which was of great concern because I cannot remove any of the tanks to empty and clean.

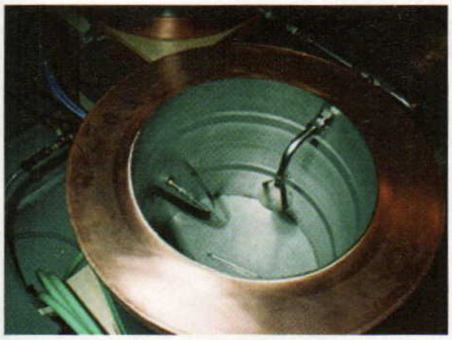


Photo 2

Here is a picture of the finished mash tun showing the vorlauf return tube, temperature sensor and false bottom. On the bottom of the vorlauf return tube is a diffuser plate to prevent the return stream from boring a hole in the mash bed. The vorlauf tube is removed and replaced by a sparge arm for sparging. You can also see a stainless steel bracket around the temperature sensor to protect it when I stir the mash. I made a cover out of red wood. I cut a groove in the cover to fit over the rim of the keg sticking just above the copper top. Two valves allow me to either run sparge water or wort return during vorlauf.

Photo 3

Here is the "brains" of my system. There is one difference between this picture and the final version, the two bottom temperature displays are now controllers and not just displays, not because I intend to automate the kettle and chilled wort temperature but because the original temperature display sensors would not register above 120 °F (~50 °C). Not adequate for the kettle but I just replaced them both (the controllers were in the $35 range). All switches and buttons are lighted for quick reference as to what is on.

HOT BREAK/COLD BREAK

by betsy parks

Whether you brew with extract or with grains, if you brew properly your first batch of beer will experience two phases: hot break and cold break. Hot and cold breaks are stages when proteins in wort clump together so much that you can see floating particles. These particles are not only normal, they are essential to brewing good beer. They are also visual signals that you have reached checkpoints in your brew day.

Hot break

The first break you will experience during brewing is hot break. Hot break occurs during the boil and precipitates when the wort reaches around 212 °F (100 °C). You can see the hot break forming when the foam (which is also coagulating proteins) stops forming and you start to see gelatinous-looking clumps floating in the pot. This happens because the proteins' structures change (or denature), much like a raw egg white becoming solid as it is heated. Depending on the amount of protein in your wort, this can take anywhere from 5 to 20 minutes. At the end of the boil, the hot break is allowed to fall to the bottom of the kettle as part of the trub, which is the material left behind when the wort is siphoned from the kettle to a fermenter.

Achieving a good hot break is important as it will encourage proteins to fall out of suspension. Too many of those proteins in your wort can cause the beer to become hazy, exhibit off flavors and can also lower the beer's long-term stability.

Cold break

After the boil, wort should be rapidly chilled to yeast-pitching temperatures to prevent contamination and oxidation. This rapid chilling process also causes cold break, which is the stage when another group of proteins precipitate from the wort. These proteins stick together, as well as to other particles (like tannins) still in suspension in the beer and fall to the bottom of the fermenter when they are allowed to settle. Cold break will look similar to the clumps created during hot break, and it starts to form at temperatures around 72 °F (60 °C).

Cold break is important for similar reasons that hot break is necessary. But also, cold break is important because it is your last chance to remove some of those proteins — anything left behind by not properly chilling your wort can create "chill haze." Chill haze happens when remaining proteins bind together when the beer is cold - when the beer warms up the bonds dissolve back into the beer. If the beer is heated and cooled too many times the haze can become permanent. (Read more about hazy homebrew in "Beginner's Block" in the May-June 2011 issue of *Brew Your Own*.)

Better breaks

Achieving a good hot or cold break is simple if you are patient, pay attention to what's going on in the brewpot and keep your eyes open on the wort for signs of the breaks forming. Hot and cold break also signal that you have done a good job boiling or chilling and are the points when you can move on to the next step of the brew day.

To get the best possible hot break, be sure to bring your wort to a hot, rolling boil. If you can't get your beer up to rolling boiling temperatures, upgrade your kettle heat source to something that can boil a full batch. Many brewers also add fining agents like Irish moss or Whirlfloc to the boil to help precipitate the proteins.

To get the best cold break, always rapidly chill your wort (also known as "crash cooling.") This means cooling your wort from boiling temperatures (212 °F/100 °C) to yeast-piching temperatures (70 °F/21 °C) in 30 minutes or less. Slow cooling does not affect the cold break-sensitive proteins, so if you experience difficulty rapidly chilling your wort with your existing equipment, or if you are not already using a wort chiller, you may need to find a more efficient chilling method.

malt profile

BISCUIT MALT

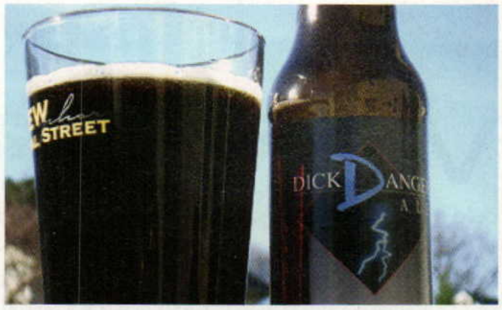
Aptly named for its biscuit-like flavor and aroma, biscuit malt is a Belgian specialty malt, which is most commonly lightly roasted to about 25–30 °Lovibond. Biscuit adds a toasty, bready — what some call a "Saltine" — character to beers without adding much color. Like all specialty malts, Biscuit is best used in moderation — often no more than 10% of the grist by weight. It is commonly used in Belgian ales (of course), but biscuit is also often used in many English and American ales.

homebrew nation

by marc martin

DEAR REPLICATOR, I HAVE FALLEN IN LOVE. IT'S QUITE A PASSIONATE AFFAIR BETWEEN MYSELF AND DICK'S DANGER ALE FROM DICK'S BREWERY IN CENTRALIA, WASHINGTON. HOWEVER, I REALIZED THAT I KNOW VERY LITTLE ABOUT MY LOVER. I DON'T KNOW WHAT GRIST GIVES HER THAT DARK AND MYSTERIOUS COLOR AND THE SMOOTH SILKY FINISH. I ALSO DON'T KNOW WHAT KIND OF HOPS OR HOPPING SCHEDULE GIVES THAT ALWAYS CRISP BUT NEVER TOO HEAVY HOP BITE. SHE'S A KEEPER, BUT I REALLY NEED TO LEARN MORE ABOUT HER SO THAT I CAN ENJOY HER IN THE COMFORT OF MY OWN LIVING ROOM. CAN YOU HELP ME OUT, REPLICATOR ?

CHRIS HILES
COLFAX, WASHINGTON



Like many others, Dick's Brewing Company is a brewery with strong roots in homebrewing. The founder, Dick Young, who owned a small business called Northwest Sausage and Deli, began homebrewing in 1984 and soon thereafter he combined the deli with a homebrew supply store. His passion for homebrewing then evolved into his dream of making beer commercially. He developed his recipes by 1990 and started the two-year application process to license a brewpub. Once approved, he opened with a homemade 2.5-barrel system producing less than 200 barrels of beer. Unfortunately, Dick passed away at the young age of 56. Many claim, "He is probably still brewing his Danger Ale in a better place on a system made of solid gold."

Dave Pendleton, Dick's Head Brewer, also began as a homebrewer in 1992 at the young age of 16. In 2000 he opened Rocky Top Homebrew Supply in Olympia, Washington. He was lucky enough to train for a year under Dick.

One of Dick's first beers was the Danger Ale and the recipe hasn't changed since the second batch. It was named after Dick's nickname "Dick Danger" for the way he used to ride his Harley. Dick didn't really try hard to emulate styles so this can best be described as a cross between a brown and a Scotch ale. This is definitely a malt-forward beer with just enough hops to offset the slight residual sweetness. Dave recommends a lower mash temperature and a highly attenuative English yeast strain to produce the dry finish.

For more information about Dick's Brewing Company visit the website www.dicksbeer.com or call the brewery at 800-586-7760. BYO

DICK'S BREWING COMPANY, DICK'S DANGER ALE
(5 Gallons/19 L, extract with grain)

OG = 1.053 FG = 1.010 IBU = 34 SRM = 28 ABV = 5.6%

Ingredients

3.3 lbs. (1.5 kg.) Briess light, unhopped, liquid malt extract
1.5 lbs. (0.68 kg.) dried malt extract
2.5 lb. (1.13 kg.) 2-row pale malt
7 oz. (0.19 kg.) crystal malt (80 (L)
9 oz. (0.25 kg.) Briess black malt (550 (L)
7.6 AAU Magnum hop pellets (60 min.) (0.55 oz./ 15.6 g of 13.8% alpha acid)
4.4 AAU Mt. Hood hop pellets (20 min.) (0.7 oz. / 19.8 g of 6.3% alpha acid)
½ tsp. yeast nutrient (last 15 min.)
½ tsp. Irish moss (last 30 min.)
White Labs WLP 007 (Dry English Ale) or Wyeast 1028 (London Ale) yeast
0.75 cup (150 g) corn sugar for priming (if bottling)

Step by Step

Steep the crushed grain in 2 gallons (7.6 L) of water at 151° F (66 ° C) for 30 minutes. Remove grains from the wort and rinse with 2 quarts (1.8 L) of hot water. Add the liquid and dry malt extracts and boil for 60 minutes. While boiling, add the hops, Irish moss and yeast nutrient as per the schedule. During the boil, thoroughly sanitize a fermenter. Now add the wort to 2 gallons (7.6 L) of cold water in the sanitized fermenter and top off with cold water up to 5 gallons (19 L).

Cool the wort to 75 °F (24 °C). Pitch your yeast and aerate the wort heavily. Allow the beer to cool to 68 °F (20 °C). Hold at that temperature until fermentation is complete. Transfer to a carboy, avoiding any splashing to prevent aerating the beer. Allow the beer to condition for one week and then bottle or keg. Allow the beer to carbonate and age for two weeks and enjoy your Dick's Danger Ale.

All-grain option:

This is a single step infusion mash using an additional 7.9 lbs. (3.6 kg) 2-row pale malt to replace the liquid and dried malt extracts. Mix the crushed grains with 3.7 gallons (14 L) of 170 °F (77 °C) water to stabilize at 151 °F (66 °C) for 60 minutes. Sparge slowly with 175 °F (79 °C) water. Collect approximately 6 gallons (23 L) of wort runoff to boil for 60 minutes.

Reduce the 60-minute hop addition to 0.45 oz. (12.8 g) Magnum hop pellets (6.2 AAU) and the 20-minute addition to 0.6 oz. (17 g) Mt. Hood hop pellets (3.8 AAU) to allow for the higher utilization factor of a full wort boil.

The remainder of this recipe and procedures are the same as the extract with grain recipe.

Beer Blending

Beyond black and tan

by Betsy Parks

WHEN ARE TWO BEERS BETTER THAN ONE? ALL THE TIME, OF COURSE! TWO (OR MORE) BEERS ARE EVEN BETTER THAN ONE, HOWEVER, WHEN THEY TASTE GREAT TOGETHER. BEER BLENDING IS A FUN WAY TO EXPERIMENT WITH YOUR HOMEBREWS, AND THESE THREE BEER BLENDING EXPERTS ENCOURAGE YOU TO GIVE IT A TRY.

Our beer menu at Sunset Bar & Grill features several "beertails" and "meadtails." Some of our most popular combinations are, of course, the old fashioned blends like a snakebite (cider and beer) or a Beery Mary (beer and bloody mary mix), but we have several of our own. We have "Black and Blue," which is Guinness and a blueberry ale, a "Black Velvet," which is cider and stout, a "Honey Moon Ale," which is Hoegaarden and mead and a "Peach Fuzz," which is Allagash White and Lindemans Pecheresse. We also play with all kinds of different versions of black and tan — for example, Dogfish Head's Worldwide Stout on top of their 90 Minute IPA. I like to think that when people come here and have the chance to get creative, they might order a better beer than they are used to — and then maybe move on to craft beer next time.

Getting ideas is kind of like coming up with peanut butter and chocolate. We come up with ideas on our own as well as from customers. A lot of the inspiration comes from coming up with a fun name — for example, a favorite here is the "Dirty Ho," which is a mix of Lindemans Framboise and Hoegaarden. We also mix beers for special occasions, such as when the Bruins were in the hockey playoffs this summer we made a "Bruins Town Black and Gold," which was Guinness and Blonde Cougar from Wormtown Brewing Company in Worcester, Massachusetts.

It's easy to come up with blend ideas when you have a lot of different beers — and different styles of beers — on hand, such as in our case where we have 112 beers on draft. It's all up to your imagination.

Photo by Derek Kouyoumjian

Marc Kadish, owner and executive chef of Sunset Grill & Tap in Allston, Massachusetts. Marc started his culinary career at age 15, working for hotels, inns and restaurants and today is considered by many to be one of the biggest beer experts in the Northeast. He opened the Sunset Grill in 1986.

At Cascade Brewing, we predominantly brew sour beers and barrel-aged sours, so that is what I blend. When we blend our beers, which are finished beers, we look at different flavor profiles as building blocks. We're looking to take the flavors and attributes of one mature beer and bring them together with another so that the sum is greater than the individual piece. It allows us to layer in flavors.

Our blending process is sensory oriented — somewhat like consulting the brewers' Ouija board. We don't use any quantified equations for our blending, it's all very organic, proportional blending. We also blend with aging in mind — we're not blending for our tastes now, but also for how they will taste in the future as we will often age our beers for up to three years.

If you're interested in blending at home, be bold — put some flavors together and experiment. Do as much blending at the tap or with bottles with finished beers that you can. Here at Cascade, we're constantly taking different beers that we have from the tap and blending them on the fly.

If you have the space, brew a little extra homebrew, or reserve a little bit of beer from each batch and start putting away a varied stock and inventory and library of blending components. Always, however, keep the beer away from O_2 as much as you can when you're blending — keep the oxygen exposure to a minimum.

Photo by John Foyston

Ron Gansberg, Brewmaster at Cascade Brewing Barrel House in Portland, Oregon.
Ron started in the brewing industry in 1986 and has been at Cascade Brewing for 13 years. Before brewing, he was a winemaker outside of Portland, and has made fruit wines and honey meads since he was a teenager.

Garrett Mead, Manager, Long Trail Brewing Company in Bridgewater Corners, Vermont. Garrett oversees the operations of Long Trail's pub and visitor center, which was inspired by the Hofbräuhaus in Munich, Germany.

I like to blend beers at Long Trail for a couple of reasons: to increase the variety of what's on tap, to enhance the flavors and/or qualities of each beer — and also to live recklessly!

To come up with our beer blend ideas, we (the staff in Long Trail's pub/visitor center) look at pairing contrasting styles. For example, pairing our Belgian White with a shot of Coffee Stout, which we named "Oreo" for its dark color, white head, and sweet palate.

We also sometimes blend beers to temper some of the extreme characteristics in a beer, like bitterness or alcohol levels. Once we come up with an idea, however, we simply go ahead and give it a try — usually after hours when the crew is sharing some shift pints.

Also, occasionally a guest will come in and surprise us with an idea to try. My absolute favorite beer blend so far is Long Trail's Double Bag (a strong ale) blended with our traditional IPA. We call it "Inda Bag."

The exploration of beer flavors when you are blending is the fun part. If you want to try blending, don't be shy — two different beers that may not seem compatible at first can often surprise you. Also, keep in mind that everyone's palate is different, and what may not appeal to one person may be heaven to another. If you're going to try blending, I say nothing is sacred. Remember beer drinking is about having fun, not being all stiff and snooty.

If you are focused on selling beer — or just getting your friends to try it — think of blending beer this way: if you give someone a blend and they like it, you have just sold two beers instead of one!

On the other hand, if you are in it for the heady joy of brewing only (pardon the pun), you can offer your guest or homebrewing friends a unique treat for their palate.

Finally, experimenting with beer blending can spur creativity in coming up with new brewing ideas. Exploring blends can inspire you to create a finished beer from the kettle that possesses the positive qualities of your blend. BYO

Fermentation Duration

Chill haze, sanitizing solution

by Ashton Lewis

Q WHENEVER I USE A YEAST STARTER I HAVE OVERLY ACTIVE FERMENTATION FOR ABOUT FOUR DAYS AND THEN ALMOST NO FERMENTATION AT ALL. IS THIS NORMAL?

DUSTIN PATTERSON
ALABAMA

A To answer this question I will assume that you do not have a chilly root cellar where you are fermenting lagers, and that most, if not all, of your homebrews are ales. I will also assume that you are fermenting your brews in your house at about 72 °F (22 °C).

So, given this information, you want to know if a four-day fermentation period for ales (assumed) is normal and the answer is unequivocally, "Yes!" I think too many descriptions of homebrew fermentations are based on using outdated methods where little packets of yeast were tucked beneath the lids of extract cans and often not used quickly enough.

The quality of yeast, both dried and liquid, is much better these days for a number of reasons — and I think the biggest reason is the strength of the homebrew market and the demand for such products.

Yeast starters increase yeast population and allow the brewer to pitch the yeast at high kräusen, or at least very shortly thereafter. This is the period in the growth phase when cells are actively growing and is named for the yeast froth (kräusen generally translates to ruffle or curly) on top of the fermenting beer. The result of pitching yeast at this stage of growth is what seems to many as abnormally vigorous fermentation that seems to terminate too quickly.

Historically this type of vigor during primary fermentation was extremely important since wort spoilage occurs quickly unless brewing yeast become the dominate microbiological population. When yeast begin to ferment the sugars found in wort, pH quickly drops, alcohol and carbon dioxide concentrations begin to increase and the environment becomes hostile to many aerobic wort spoilers. Sluggish fermentations, on the other hand, leave the wort vulnerable for a longer period and the chance of spoiled beer increases. The problems faced by brewers of the past still exist today, albeit to a lesser degree because of improvements in equipment design and our modern understanding of microbiology, and the benefits of vigorous pitching yeast are equally important today.

Aside from the argument presented above, rapid "normal" beer fermentations generally produce cleaner beer. Many of the off-flavors associated with fermentation, such as extremes with higher alcohols, esters, sulfur compounds, acetaldehyde and diacetyl, are associated with weak fermentations.

On a practical note, we use White Labs WLP001 American Ale for most of our ales at Springfield Brewing Company. Our primary fermentation period for ales with original gravities between 11–14 °Plato usually is complete in three days. There is nothing abnormal with seemingly-short four-day fermentations!

> "Rapid 'normal' beer fermentations generally produce cleaner beer."

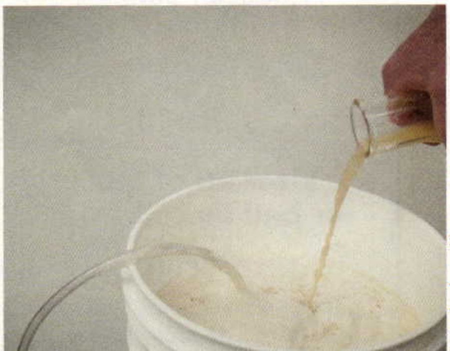


Photo by Les Jörgensen

Q I USE IRISH MOSS IN MY BEERS, BUT I STILL GET CHILL HAZE. COULD IT BE MY MASH TIME? TYPICALLY MY BEERS SPEND 20 MINUTES IN A PROTEIN REST AT 120–125 °F (49–52 °C) AND 40 MINUTES MASHING AT 150–160 °F (65–71 °C). THEN I LAUTER AND BOIL. I HAVE CHILL TIMES AROUND 30 MINUTES USING A COIL.

JESSE KUIPER
NORTH WALES, PENNSYLVANIA

A Chill haze is the product of protein and polyphenol (tannin) interactions in beer and occur when beer is chilled, hence the name chill haze. There are various methods aimed at chill haze reduction and they all either are based on reducing the content of chill haze proteins and/or polyphenols. The first thing brewers can do to minimize haze is to begin with low protein raw materials. This is one of the reasons that the protein content and degree of modification of proteins in malt are of importance. Although some brewers frown upon the use of adjuncts, protein dilution of wort is beneficial to a certain degree when higher protein barley is used for malting.

Irish moss added in the kettle reacts with hot break to form larger trub flocs that settle more quickly than smaller flocs. Many brewers today use silica gels prior to filtration to remove even more protein. Polyvinylpolypyrrolidone (PVPP) can be added alone or in conjunction with silica gel, and PVPP is used to remove the polyphenol component of haze. In all cases, a cold aging step prior to packaging allows chill haze to form and permits its removal by gravity sedimentation or filtration. Ale brewers often add isinglass finings to remove yeast, but isinglass also removes some haze forming proteins.

In my opinion neither mash time nor mash profile are significant contributors to chill haze. It is certainly true that longer mashes remove more protein in the mash than shorter mashes, but long mashes and those mashes using low temperature protein rests are not commonly used to specifically address chill haze.

I have a Teutonic view of chill haze control and it seems to work for most of our beers. We begin with high-quality 2-row malt that tends to be on the lower end of total protein (10.5–11%). In the brewhouse we use the mash profile that works for what we want in terms of beer flavor and no special concern is given to haze control. During boiling we evaporate about 6–8% of the kettle full volume and no finings are added. We use no finings before filtration, but we do hold our beers awaiting filtration at 30–32 °F (-1–0 °C) for several days to allow chill haze to form. This works for all of our beers except beers that are dry-hopped as well as those that begin with under-modified Pilsner malt. If I had to correct the haze in these two beers I would use PVPP to go after tannins in dry-hopped beers and silica gel for the haze forming proteins associated with under-modified malt. But a little haze is not a bad thing in some beers and I prefer to let the flavor express itself without excessive meddling.

Q HOMEBREWERS USE IODOPHOR TO SANITIZE BREWING EQUIPMENT, SO I'VE BEEN WONDERING IF I COULD USE AN IODINE DISINFECTANT SUCH AS A LIVESTOCK WOUND TREATMENT OR A DAIRY TEAT DIP? THE LOCAL DRUG STORES CARRY IODINE WOUND ANTISEPTIC WITH THE INGREDIENT POVIDONE IODINE AS ITS ACTIVE INGREDIENT AND I THINK THAT IT MIGHT WORK ALSO. WHAT SAY YOU ON THIS MATTER?

DOUG MCLENDON
CHICO, CALIFORNIA

A Oh the resourcefulness of homebrewers. Yes, iodophor is a commonly used sanitizer used by brewers. It is well known for its ability to kill a broad spectrum of bacteria and yeasts by oxidizing cellular membranes. Iodophors are also well known for the stains they leave behind on equipment. The name iodophor is a little odd, and some people think that they are the product of mixing iodine with phosphoric acid. While many chemicals have common names derived through contractions, the "phor" in iodophor refers to a chemical carrier that helps stabilize.

Poviodone is a contraction for polyvinylpyrollidone, also known as PVP and cousin of PVPP. PVP binds with iodine to form a stable complex known as povidone-iodine or PVP-I. According to Wikipedia, PVP-I was the first iodophor preparation and was first marketed as a medical antiseptic in 1955. Anyone who has ever used a surgical scrub is familiar with this type of iodophor. Iodophors are also used as teat dip by dairy farmers.

You ask what I say on this matter and I say I am being lead by the nose on this question . . . if I had to guess I would say that you are a rancher, dairy farmer, veterinarian or something related and know that surgical scrubs and teat dips have the same properties and similar approvals as iodophors sold to brewers. The key to any sanitizer used for food preparation, however, is knowing for certain that it is approved for use in food processing since it is assumed that non-rinse sanitizers will make it into the product. The other important thing to consider is anything that is added to the sanitizer that may impart flavor, for example lemon-scented bleach.

As a general rule I do not recommend using sanitizers marketed for use in applications other than food because it is not prudent to assume that all sanitizers can be ingested. Indeed, quite the opposite is safer.

Q I READ AN OLD MR. WIZARD RESPONSE ABOUT BEANO® REDUCING CALORIES AND CARBOHYDRATES BY TURNING SOME OF THE UNFERMENTABLES INTO FERMENTABLES AND THUS THE YEAST WILL CONVERT THOSE TO ALCOHOL. IN THE EXAMPLE OF AN EXPERIMENT WITH YOUR WHEAT BEER, YOU ESTIMATED THAT BECAUSE OF THE DROP IN FINAL GRAVITY WITH BEANO® THAT THE CALORIES HAD DROPPED AS WELL AS THE CARBS. I DON'T DISAGREE WITH

THE CARBS, BUT I QUESTION THAT THE CALORIES DROPPED WHEN CARBOHYDRATES PROVIDE 4 CALORIES PER GRAM AND ALCOHOL PROVIDES 7 CALORIES PER GRAM.

MICHAEL KILLGORE
BEAVERTON, OREGON

A There is an easy explanation of why converting unfermentables into fermentables reduces calories in beer. Indeed if this were not the case it would defy the First Law of Thermodynamics.

You are correct that one gram of carbohydrate contains 4 kilocalories (kcal) of energy and are also correct that the energy content of alcohol is 7 kcal per gram. The thing that is missing in your analysis is the complete conversion of glucose to ethanol. In simple terms fermentation can be described by the following equation:

$$C_6H_{12}O_6 \text{ (glucose)}$$
$$2\ C_2H_5OH \text{ (ethanol)} + 2\ CO_2 \text{ (carbon dioxide)}$$
$$+ 2\ \text{ATP}$$

This equation shows that one molecule of glucose is converted to two molecules of ethanol, two molecules of carbon dioxide and two molecules of ATP (adenosine triphosphate). Both ethanol and carbon dioxide are excreted by yeast during fermentation, while the ATP stays in the cell and is used as cellular fuel. For the purpose of demonstration let's assume we begin with 1 gram of glucose. This equates to 0.0056 moles since the molecular weight of glucose is 180 grams/mole. For every 1 gram or 5.6 millimoles (mmol) of glucose fermented, 1.1 mmol of ethanol and 1.1 mmol carbon dioxide excreted. The molecular weight of ethanol is 46 grams/mole and 1.1 mmol is equal to 0.51 grams of ethanol.

Converting these numbers into calories we can see that 1.00 gram of glucose is equal to 4.00 calories and that 0.51 grams of alcohol is equal to 3.57 calories. There are no calories associated with carbon dioxide and the yeast cells keep the ATP. This means that when beer containing unfermentable dextrins is treated with amyloglucosidase, the active ingredient in Beano®, the drier beer that follows is lower in carbohydrates, higher in alcohol and lower in calories. BYO

American IPA

A haven for hops

by Jamil Zainasheff

The BJCP divides the India pale ale category into three sub-styles: English, American, and Imperial. Some people further specify American IPAs as being a "West Coast" IPA. Count me among those who believe West Coast IPA is its own unique style, a creative out-growth from brewers and drinkers that love the character of American-type hops. There was a time, not long ago, where the only place you could get such extremely hoppy beers was on the West Coast. In the rest of the United States American IPA was decidedly mild in comparison. When I was drinking at a brewpub in the Midwest about five years ago they warned me about how hoppy their IPA was when I ordered it, but it did not even come close to what I considered an American IPA at the time. That has certainly changed. For example, I was in Cleveland recently and I was blown away by some fantastic IPAs, such as Fat Head's award-winning Head Hunter IPA. It is such a good example, it even won the West Coast IPA festival in 2009. So, as the trend continues, the term West Coast takes on more of a historic note than a geographic requirement.

You should think of all IPA sub-styles as "hoppy," but there is a vast difference in the level of hops between them. On the lower end is English IPA, which, while hoppy, does not have quite as bold a hop character as is found in American IPA. In an American IPA, the hop character should always be up front and the bittering obvious. The West Coast variant takes that hoppiness further and the hop character is almost overwhelming. In American IPA, the malt character takes a backseat, while in English IPA the bittering and hop character should not completely overpower the fermentation and malt character.

The malt character for American IPA is generally much less pronounced than in English IPA. This style is more about hops, so a clean, subtle malt character is all that is required. Some examples might include some toasty or caramel flavors, but that tends to detract from the hop character, so the use of specialty malts is less common in the West coast examples.

Mouthfeel is medium-light to medium-bodied and while there is a prominent bitterness, it is never harsh or astringent.

The BJCP style guide lists the color as medium gold to medium reddish copper, but I think the color has shifted lighter, maybe light gold to light copper. Many examples are hazy from high levels of dry hopping.

The base malt for American IPA is often domestic two-row, although use of domestic pale ale malt or even a British pale ale malt is acceptable. The slightly higher kilning provides a richer biscuit-like malt character that can help add balance to a highly bitter beer. Extract brewers should use the freshest light-colored domestic malt extract available.

All-grain brewers should use a single infusion mash. A temperature in the range of 149 to 154 °F (65 to 68 °C) works well, although one fine commercial example, Lagunitas IPA, uses a mash temperature of 160 °F (71 °C). Use a lower temperature when using lower attenuating yeasts or higher starting gravities. Use a higher mash temperature when using the higher attenuating yeasts or lower starting gravity beers. If you are unsure, a great starting point is 152 °F (67 °C).

I like the clean, light malt character of American-style IPAs brewed with pale malt only, but some folks might prefer a richer character and will include specialty malts such as crystal. While some examples may have a touch of caramel character, I think caramel sweetness is best reserved for the smaller, less hoppy IPA versions. Do not try to balance

Continued on page 21

American IPA by the numbers

OG:	1.056–1.075 (13.8–18.2°P)
FG:	1.010–1.018 (2.6 –4.6°P)
SRM:	6–15
IBU:	40–70
ABV:	5.5–7.5%

Photo by Charles A. Parker/Images Plus

Hoppiness is an IPA
(5 gallons/19 L, all-grain)

OG = 1.065 (15.9 °P)
FG = 1.012 (3.1 °P)
IBU = 65 SRM = 8 ABV = 7%

Ingredients

11.5 lb. (5.2 kg) Great Western Northwest Pale Ale malt (or similar US domestic pale ale malt)
14.1 oz. (400 g) Great Western crystal malt 15 °L (or similar)
10.6 oz. (300 g) Best Malz Munich malt (or similar)
3.5 oz. (100 g) Great Western crystal malt 40 °L (or similar)
10.92 AAU Horizon hops (0.84 oz./24 g at 13% alpha acids) (60 min.)
7.56 AAU Centennial hops (0.84 oz./24 g at 9% alpha acids) (10 min.)
10.08 AAU Simcoe hops (0.84 oz./24 g at 12% alpha acids) (5 min.)
7.56 AAU Amarillo hops (0.84 oz./24 g at 9% alpha acids) (0 min.)
White Labs WLP001 California Ale, Wyeast 1056 American Ale or Fermentis Safale US-05 yeast

Step by step

Mill the grains and dough-in targeting a mash of around 1.5 quarts of water to 1 pound of grain (a liquor-to-grist ratio of about 3:1 by weight) and a temperature of 149 °F (65 °C). Hold the mash at 149 °F (65 °C) until enzymatic conversion is complete. Infuse the mash with near boiling water while stirring or with a recirculating mash system raise the temperature to mash out at 168 °F (76 °C). Sparge slowly with 170 °F (77 °C) water, collecting wort until the pre-boil kettle volume is around 5.9 gallons (22.3 L) and the gravity is 1.055 (13.6 °P).

Once the wort is boiling, add the bittering hops. The total wort boil time is 1 hour after adding the bittering hops. During that time add the Irish moss or other kettle finings with 15 minutes left in the boil and add the last two hop additions at 10 minutes remaining and at flame out. Chill the wort to 67 °F (19 °C) and aerate thoroughly. The proper pitch rate is 11 grams of properly rehydrated dry yeast, two packages of liquid yeast, or one package of liquid yeast in a 2.5-liter starter.

Ferment around 67 °F (19 °C) until the yeast drops clear. With healthy yeast, fermentation should be complete in a week or less. Allow the lees to settle and the brew to mature without pressure for another two days after fermentation appears finished. Rack to a keg and force carbonate or rack to a bottling bucket, add priming sugar and bottle.

Hoppiness is an IPA
(5 gallons/19 L, extract plus grains)

OG = 1.065 (15.9 °P)
FG = 1.012 (3.1 °P)
IBU = 65 SRM = 8 ABV = 7%

Ingredients

11.5 lb. (5.2 kg) US domestic pale ale liquid malt extract
14.1 oz. (400 g) Great Western crystal malt 15 °L (or similar)
10.6 oz. (300 g) Best Malz Munich malt (or similar)
3.5 oz. (100 g) Great Western crystal malt 40 °L (or similar)
10.92 AAU Horizon hops (0.84 oz./24 g at 13% alpha acids) (60 min.)
7.56 AAU Centennial hops (0.84 oz./24 g at 9% alpha acids) (10 min.)
10.08 AAU Simcoe hops (0.84 oz./24 g at 12% alpha acids) (5 min.)
7.56 AAU Amarillo hops (0.84 oz./24 g at 9% alpha acids) (0 min.)
White Labs WLP001 California Ale, Wyeast 1056 American Ale or Fermentis Safale US-05 yeast

Step by Step

If you can't get fresh liquid malt extract, use an appropriate amount of dried malt extract (DME) instead.

Mill or coarsely crack the specialty malt and place loosely in a grain bag. Avoid packing the grains too tightly in the bag, using more bags if needed. Steep the bag in about 1 gallon (~4 liters) of water at roughly 170 °F (77 °C) for about 30 minutes. Lift the grain bag out of the steeping liquid and rinse with warm water. Allow the bags to drip into the kettle for a few minutes while you add the malt extract. Do not squeeze the bags. Add enough water to the steeping liquor and malt extract to make a pre-boil volume of 5.9 gallons (22.3 L) and a gravity of 1.055 (13.6 °P). Stir thoroughly to help dissolve the extract and bring to a boil.

Once the wort is boiling, add the bittering hops. The total wort boil time is 1 hour after adding the bittering hops. During that time add the Irish moss or other kettle finings with 15 minutes left in the boil and add the last two hop additions at 10 minutes remaining and at flame out. Chill the wort to 67 °F (19 °C) and aerate thoroughly. The proper pitch rate is 11 grams of properly rehydrated dry yeast, two packages of liquid yeast, or one package of liquid yeast in a 2.5-liter starter. Follow the fermentation and packaging instructions for the all-grain version.

West Coast Style IPA
(5 gallons/19 L, all grain)

OG = 1.070 (17 °P)
FG = 1.014 (3.6 °P)
IBU = 100 SRM = 8 ABV = 7.4%

Ingredients

12.1 lb. (5.5 kg) Great Western US domestic two-row malt (or similar)
1.1 lb. (500 g) Bairds carastan malt 35 °L (or similar)
1.1 lb. (500 g) Briess Carapils® 2 °L (or similar)
28 AAU Simcoe hops (1.0 oz./28 g at 12% alpha acids) (90 min.)
3.5 AAU Columbus hops (0.25 oz./7 g at 14% alpha acids) (60 min.)
3 AAU Simcoe hops (0.25 oz./7 g at 12% alpha acids (60 min.)
3.5 AAU Columbus hops (0.25 oz./7 g at 14% alpha acids) (30 min.)
3 AAU Simcoe hops (0.25 oz./7 g at 12% alpha acids) (30 min.)
10.5 AAU Columbus hops (0.75 oz./21 g at 14% alpha acids) (15 min.)
9 AAU Simcoe hops (0.75 oz./21 g at 12% alpha acids) (15 min.)

6 AAU Cascade hops
(1.0 oz./28 g at 6% alpha acids)
(10 min.)
7 AAU Columbus hops
(0.5 oz./14 g at 14% alpha acids)
(1 min.)
6 AAU Simcoe hops
(0.5 oz./14 g at 12% alpha acids)
(1 min.)
7 AAU Columbus hops
(0.5 oz./14 g at 14% alpha acids)
(dry hop)
6 AAU Simcoe hops
(0.5 oz./14 g at 12% alpha acids)
(dry hop)
5 AAU Centennial hops
(0.5 oz./14 g at 10% alpha acids)
(dry hop)
4.5 AAU Amarillo hops
(0.5 oz./14 g at 9% alpha acids)
(dry hop)
White Labs WLP001 California Ale, Wyeast 1056 American Ale or Fermentis Safale US-05 yeast

Step by step

Mill the grains and dough-in targeting a mash of around 1.5 quarts of water to 1 pound of grain (a liquor-to-grist ratio of about 3:1 by weight) and a temperature of 152 °F (67 °C). Hold the mash at 152 °F (67 °C) until enzymatic conversion is complete. Infuse the mash with near boiling water while stirring or with a recirculating mash system raise the temperature to mash out at 168 °F (76 °C). Sparge slowly with 170 °F (77 °C) water, collecting wort until the pre-boil kettle volume is around 6.5 gallons (25 L) and the gravity is 1.054 (13.4 °P).

Once the wort is boiling, add the bittering hops. The total wort boil time is 90 minutes. Follow the hopping schedule and add Irish moss or other kettle finings with 15 minutes left in the boil. Chill the wort to 67 °F (19 °C) and aerate thoroughly. The proper pitch rate is 12 grams of properly rehydrated dry yeast, 2.5 packages of liquid yeast, or 1 package of liquid yeast in a 3-liter starter.

Ferment around 67 °F (19 °C) until the yeast drops clear. Transfer to another vessel and dry hop for one week at 62 °F (17 °C). Rack to a keg and force carbonate or rack to a bottling bucket, add priming sugar and bottle.

high levels of bittering with high levels of sweetness, which results in a heavy, less drinkable beer. The type of crystal malt also makes a difference. Darker color crystal malts add richer colors, as well as some dark caramel, toasty, roasted, and raisin flavors. Lighter color crystal malts add sweeter caramel notes. The crystal malt can range from 0 to 10% of the grist. However, the darker the crystal, the less you should use. An IPA with 10% 150 °L crystal malt may not be cloying, but it can be too intense a flavor for this style. On the flip side, an IPA with all light color crystal malt will tend to be sweet and lack depth of character. Just keep in mind, though, that American IPA is not about specialty malts, but rather clean malt flavor in the background and hop character up front.

If you are looking for more complexity or increased head retention, you can add other malts as well. Wheat malt, Munich, Vienna, Victory®, biscuit and more are common additions in many recipes, but restraint is important so that the beer does not become too malt heavy. In general, keep the total of all specialty grain additions to less than 15% of an all-grain grist.

To brew an American IPA you need hops with "American" flavor. Pretty much any hop that starts with a "C" is fair game, but there are a lot more that work well to produce that citrusy, piney, floral, resin, fruity and even dank character that people have come to love. Other hops that are frequently used in this style are Amarillo and Simcoe. Again, the most important aspect of this style is the character of the hops. The current version of the BJCP style guide mentions that the character is from American hops, but there are new hop cultivars from New Zealand and Australia that reportedly work quite well. I had an all-Galaxy hopped IPA at the Australian National Homebrewers' Conference several years ago and I was blown away by the "American" hop character.

The bittering level for American IPA is in the range of 40 to 70 IBU (and West Coast styles can be higher still). While the bitterness should be firm and obvious, it should not be harsh. Keep in mind that there are many factors at play in the final impression of bitterness for the drinker. The starting and final gravities, water sulfate levels, the character of malts selected, the type of base malt, the yeast strain, the pitching rate, and even the yeast cell size have an impact on the perceived bittering. For most American IPAs, a bitterness to starting gravity ratio (IBU divided by OG) between 0.75 and 1.0 gives the proper result. As a general rule of thumb in determining late hop amounts, include at least double the amount of bittering hops. If you are making more of a West Coast-style IPA, then use double what you would in an average IPA. Keep in mind this is just a generalization, since using very low or high alpha acid hops makes the equation faulty. For an American IPA, include two or more late hop additions using two different hop varieties, totaling around 2 to 4 oz. (28 - 85 g) for a 5 gallon (19 L) batch at 20 minutes or later. You can use more than two varieties, but do not go crazy. A couple of varieties creates an interesting complexity; ten different hop varieties creates an indistinct "hoppiness." Dry hopping and the use of a hop jack are also good ways to develop hop character for this style and dry hopping is almost required for a West Coast version. Dry hopping for a week at 62 °F (17 °C) is common.

The sulfate content of brewing water affects the character of hop bitterness to a significant degree. Brewing an IPA with water that has very low sulfate content results in a "flabby" bitterness. When brewing with low sulfate water you are forced to add a large amount of hop alpha acids to develop enough bittering. However, adding large quantities of hops to get a stronger bittering can result in a resin-like character. Cutting back on the hops and adding a moderate amount of gypsum (or "Burtonizing" the water), results in a sharper, crisper hop bitterness without the resin character. Most breweries add some amount of gypsum to their bitter beers, but it is easy to overdo mineral additions, resulting in a harsh character. Most water only requires a small amount of gypsum. If you do not know the sulfate content of your water, start low, with one gram of gypsum per gallon. Generally, you should need no more than three grams per gallon. It is usually better to add less gypsum than to add more, and it only takes a small amount to accentuate hop bitterness. You can add gypsum to the mash or, if you are brewing with extract, you can add it directly to your boil kettle water before you heat it.

The fermentation character for American IPA is usually clean, with restrained esters. Many brewers use a clean "Chico" strain for this style, but do not immediately rule out using the

American IPA Commercial Examples

60 Minute IPA
Dogfish Head Craft Brewery
Milton, Delaware
www.dogfish.com

Alpha King
Three Floyds Brewing Co.
Munster, Indiana
www.3floyds.com

Bell's Two-Hearted Ale
Bell's Brewery
Galesburg, Michigan
www.bellsbeer.com

Blind Pig IPA
Russian River Brewing Co.
Santa Rosa, California
http://russianriverbrewing.com

Head Hunter IPA
Fat Head's Brewery
Pittsburgh, Pennsylvania and Cleveland, Ohio
http://fatheadsbrewing.com

HopDevil
Victory Brewing Co.
Downingtown, Pennsylvania
http://victorybeer.com

Lagunitas IPA
Lagunitas Brewing Co.
Petaluma, California
www.lagunitas.com

Sierra Nevada Celebration Ale
Sierra Nevada Brewing Co.
Chico, California
www.sierranevada.com

Stone IPA
Stone Brewing Co.
Escondido, California
www.stonebrew.com

Titan IPA
Great Divide Brewing Co.
Denver, Colorado
www.greatdivide.com

West Coast IPA
Green Flash Brewing Co.
San Diego, California
www.greenflashbrew.com

more character rich English-style yeast strains. I would not use any of the very low attenuating strains or the ones with huge esters, but there are many of them that you can ferment cooler for a less estery character and they also attenuate really well. My favorites are White Labs WLP007 Dry English and Wyeast 1098 Whitbread. Both attenuate well and, when fermenting at lower temperatures, provide a cleaner, character with just a touch more esters that help punch up the character of the beer. If you need to use dry yeast, Safale US05 should produce good results.

At moderate temperatures (65–70 °F /18–21°C), the American yeasts produce low levels of esters. You can go higher and still get good results, but the levels of compounds such as acetaldehyde and fusel alcohols will increase with temperature and can result in a less than pleasant beer. I start fermentation in the middle of this range (68 °F/20 °C), letting the temperature rise a few degrees, slowly, over a couple days. This creates the expected level of esters, helps the yeast attenuate fully, and keeps the amount of acetaldehyde in the finished beer to a minimum. If your situation restricts you to using less attenuative yeast, you will need to take steps to ensure enough attenuation. You can lower the starting gravity, lower the mash temperature, or replace a portion of the base malt with simple sugar to aid in drying out the final beer.

When you serve your American IPA, experiment with different carbonation levels and different serving temperatures. Warmer temperatures will often allow the beer to express more of the hop aromatics. However, warmer is not always the answer. Depending on your blend of hops, cooler serving temperatures might suppress one hop character and let another shine, so don't be afraid to test. The same goes for carbonation levels. While 2 to 2.5 volumes of CO_2 is generally a good target, higher can help express hop aroma, but also can add an acidic sharpness that might not go well with the late hop character. If you have a draft system, you can start low and then try higher levels. You should be able to find the right level based on taste. While the perfect level may not be obvious the first time you try different CO_2 levels, it is pretty obvious when the beer slips from perfect to some other level. Have fun with it and you will be surprised how much difference it makes in an IPA. BYO

Jamil Zainasheff co-wrote the homebrew recipe collection, Brewing Classic Styles *(2007, Brewers Publications) as well as* Yeast: The Practical Guide to Beer Fermentation *(2010, Brewers Publications). He writes "Style Profile" in every issue. Follow his blog about opening his own commercial brewery, Heretic Brewing Company, in the San Francisco Bay area at www.byo.com/blogs/blogger/Jamil/*

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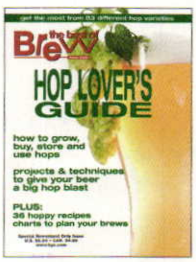

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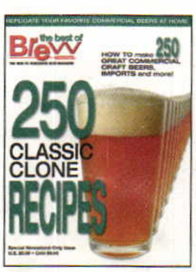

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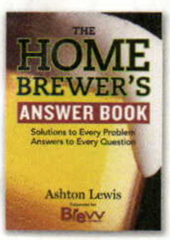

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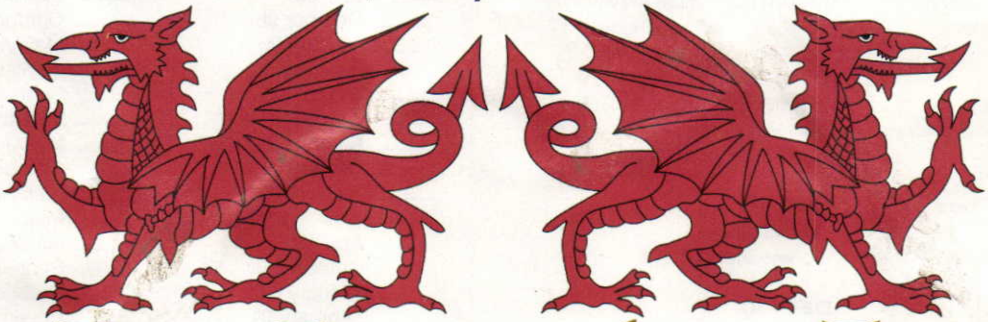
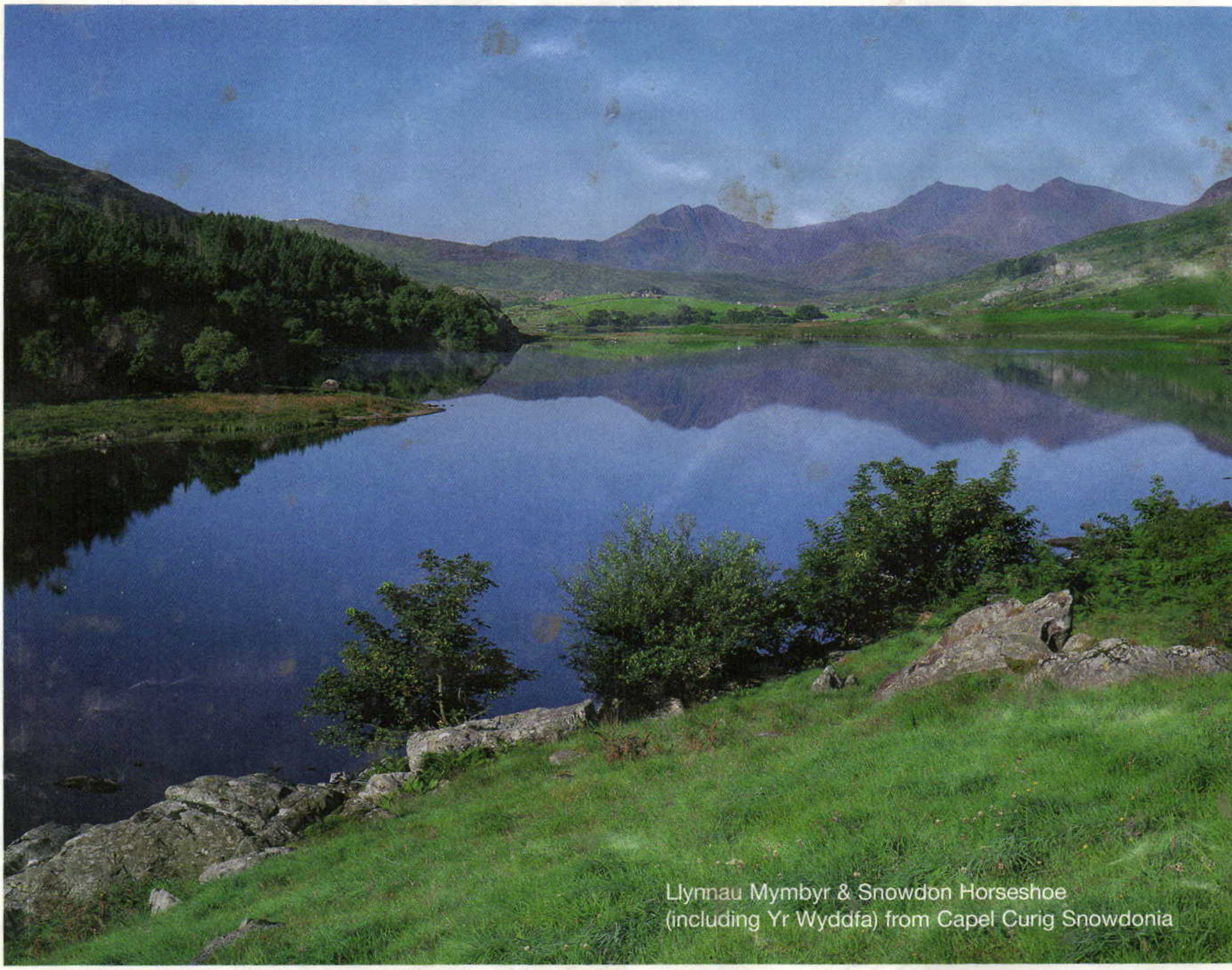


Welsh ALE

How to Brew Cwrw Cymru



Llynnau Mymbyr & Snowdon Horseshoe (including Yr Wyddfa) from Capel Curig Snowdonia

Wales, land of the Eisteddfod festivals of music and poetry, birthplace of Dylan Thomas, a country whose second religion is rugby, and whose symbol is the mythical Red Dragon. Wales, the country whose other national symbols are the daffodil, and the leek which Fluellen forced Pistol to eat in Shakespeare's Henry V. Wales, the home of Caerphilly cheese, laver bread (made with seaweed) and Welsh ales.

Home of what you say? We all know plenty about English, Scotch and even Irish ales, but I'll wager that you've heard little about Welsh ales. In fact, we hear so little in the USA about Wales that you may be forgiven for thinking that it is actually just a part of England. However, despite the fact that it was ruled by England for centuries, Wales is actually a principality and a country in its own right. Like Scotland and Northern Ireland, it partially devolved from Great Britain and established its own parliament or Assembly in 1998. And a 2011 referendum significantly increased that Assembly's powers, leaving only a few areas such as defense and taxes in the hands of the UK Parliament.

English is the most widely spoken language in Wales, but Welsh is still in significant use, and one of the aims of the Welsh Assembly is to promote the use of this Celtic language. That may be a daunting task as the language bears little resemblance to English. Indeed, it is joked that vowels would be the highest scoring tiles in Welsh Scrabble, since they occur much less frequently than consonants.

But what are the principality's claims to fame? Well, it's thought that Celts were the original inhabitants of England, and that they were displaced and pushed into Wales by the arrival of the Angles and Saxons around 450 AD, after the Romans departed Britain. When the Normans invaded and conquered England, they moved onto Wales, building many castles there in order to control the Welsh. There are more castles per square mile in Wales than in any other country in the world! Domination of the Welsh by their neighbors to the east was completed by the defeat of the rebel Owen Glendower by Henry IV and his son in the early 15th Century. Ironically, the son who became Henry V was actually born in Wales, in the town of Monmouth. In fact, Monmouth sits at the English-Welsh border, and has gone from Wales to England and back again several times over the years. It is where I am writing this, as I spend some time over here each year.

When it comes to beer, the status of Wales is unclear. It is said that the Celts were great mead drinkers, while one historian at least states that cider is as close to being the

WELSH ALE RECIPES

Double Daffodil Ale

(5 gallons/19 L, all-grain)
OG = 1.042 FG = 1.009
IBU = 25 SRM = 9–10 ABV = 4.2%

Ingredients

7.8 lb. (3.5 kg) pale 2-row malt
5.0 oz. (140 g) medium crystal malt (50 °L)
1 lb. 4 oz. (0.57 kg) wheat malt
7 AAU East Kent Goldings hops (90 mins)
(1.4 oz./38 g at 5% alpha acids)
1.0 oz. (28 g) UK Fuggle hops (0 mins)
White Labs WLP002 (English Ale), Wyeast 1968 (London ESB Ale) or Wyeast 1099 (Whitbread Ale) yeast

Step by Step

Use a single infusion mash at 152–154 °F (67–68 °C) for 60 minutes. Sparge to collect about 6.0 gallons (23 L) wort. Boil 90 minutes, adding Goldings hops at start, and Fuggles hops as heat is turned off. Cool, pitch yeast (preferably as 1 quart (~1 L) starter), ferment 1 week, rack to secondary for 1 week and bottle or keg.

Partial mash option:

Replace pale 2-row malt with 5.5 lb (2.5 kg) Muntons pale or golden malt extract. Mini-mash the grains in 2.0 qt (1.9 L) water at 150–152 °F (66–67 °C) for 45 minutes. Strain off liquor, rinse grains with 2 qt (1.9 L) water at around 170 °F (77 °C), and dissolve malt extract in collected liquors. Adjust volume to 5 gallons (19 L), and boil for 60 minutes, adding the Goldings hops at the start, and Fuggles at the end. Top up to 5.0 gallons (19 L) with cold water, cool if necessary, pitch yeast, ferment and condition as above.

Dragon's Teeth

(5 gallons/19 L, all-grain)
OG = 1.060 FG = 1.014
IBU = 50 SRM = 60 ABV = 6.0%

Ingredients

11 lb. (4.9 kg) pale 2-row malt
12 oz. (340 g) medium crystal malt (50 °L)
4.0 oz. (110 g) chocolate malt
4.0 oz. (110 g) roasted barley
13 AAU German Magnum hops (90 mins)
(1 oz./28 g at 13% alpha acids)
1.0 oz. (28 g) German Hallertau hops (0 mins)
1.0 oz. (28 g) German Tettnang hops (0 mins)
White Labs WLP013 (London Ale), Wyeast 1028 (London Ale) or Wyeast 1318 (London Ale III) yeast*

Step by Step

Use a single stage infusion mash at 150–152 °F (66–67 °C) for 60 minutes. Sparge to collect about 6.0 gallons (23 L) wort, and boil 90 minutes adding Magnum hops at start, and Hallertau and Tettnang hops as heat is turned off. Cool, pitch yeast (preferably as 1 quart/1 L starter), ferment 1 week, rack to secondary for 1 week and bottle or keg as desired. *Wyeast 1187 (Ringwood Ale) yeast might be used to some advantage in this beer because of its tendency to produce estery/fruity flavors. But it can be tricky to use; you would need to hold the temperature below 70 °F (21 °C), and you will likely need a one to two day diacetyl rest at the end of primary fermentation.

Extract with grains option:

Replace pale 2-row malt with 6.0 lb. (2.7 kg) Muntons pale malt extract plus 1.2 lb. (0.54 kg) light dried malt extract. Steep the grains in 2.0 qt (1.9 L) water at 150–160 °F (66–71 °C) for 20–30 minutes. Strain off liquor, rinse grains with 2.0 qt (1.9 L) water at around 170 °F (77 °C), and dissolve malt extracts in collected liquors. Adjust volume to 5.0 gallons (19 L), and boil for 60 minutes, adding the Magnum hops at the start, and Fuggles at the end. Top up to 5.0 gallons (19 L) with cold water, cool if necessary, pitch yeast, ferment and condition as above.

Dragon's Revenge

(5 gallons/19 L, all-grain)
OG = 1.096 FG = 1.024
IBU = 90 SRM = 15–20 ABV = 9.6%

Ingredients

13 lb. (6.0 kg) pale 2-row malt
6 lb. 11 oz. (3.0 kg) amber malt
30 AAU Galena hops (90 mins),
(2.5 oz./71 g at 12% alpha acids)
1.6 oz. (47 g) English Fuggles hops (0 mins)
3 packets Nottingham Ale dry yeast

Step by Step

Mash at 148–150 °F (64–66 °C), for 90 minutes. Run off and sparge to collect about 9 gallons (34 L). Boil down to about 6 gallons (23 L), then boil 90 minutes adding Galena hops at start, and Fuggles as heat is turned off. Cool to 70 °F (21 °C), and pitch with the yeast (preferably as 3-qt./3-L starter), oxygenating for 3–4 minutes after pitching. After 7–10 days at 70 °F (21 °C) rack to secondary; Rack again after 2–3 weeks, let mature 1–2 months before bottling or kegging.

Extract-only option:

Replace grains with 10 lb. (4.5 kg) Muntons amber liquid malt extract plus 2 lb. 13 oz. (1.3 kg) light dried malt extract. Dissolve in 3.0–3.5 gallons (11–13 L), and boil 90 minutes, adding Galena hops at start and Fuggles as heat is turned off. Pitch the yeast (preferably as 3-qt./3-L starter), oxygenating for 3–4 minutes after pitching. Ferment at 70 °F (21 °C). See all-grain recipe for conditioning details.

Photo courtesy of Brains Brewery

Welsh national drink as anything. Quite a lot of cider is produced in this part of Wales, but that might be because it abuts the English county of Herefordshire, a very important cider-making area for centuries. There is evidence that the Celts established brewing in Northern Europe, so there is a possibility that they brought the art to Britain. There seems to be little record of Welsh ale brewing until medieval times, when — as was common throughout Britain then — abbeys and monasteries produced their own beer. They must have established some reputation by 901, for the Bishop of Winchester was required to provide "sweet Welsh ale" to King Edward as part of the payment for leasing land from the king. Brewing does not, however, appear to have become an industry on any scale in Wales, until the 18th Century as copper and coal mining became significant industries. Even into the 19th and early 20th Centuries, much brewing was either done at home, or at the local pub.

It is also worth pointing out that there has been some considerable antipathy to pubs and beer in Wales. Although there was never complete prohibition here, the "drys" did succeed in bringing about Sunday closing of pubs in 1882. This law was changed in 1963 to permit communities to decide by referendum whether they wanted Sunday closing or not, and these polls were finally scrapped in 1993. And during and after the First World War, Britain had a Welsh Prime Minister named David Lloyd George who was very much an anti-drink man. He succeeded in enacting legislation which severely restricted pub opening hours and remained in force until the 1990s. Under Lloyd George's rule, national pub ownership was established in certain areas, such as Carlisle on the Scottish border, where a good deal of munitions work was being carried out.

Welsh Breweries

The biggest brewery in Wales is at Magor in the south of the country and is not really Welsh. It was built by the English company Whitbread, which

was subsumed into Interbrew, which since became Anheuser Busch Inbev. A more interesting company was the Wrexham Lager brewery which began brewing a Pilsner style lager in 1883, by a small margin the second company in Britain to brew lager after the Austro-Bavarian and Crystal Ice factory in London. The latter did not last long, but the Wrexham brewery kept going despite many ups and downs and changes of ownership until 2001, when it was closed by the then current owners Carlsberg-Tetley.

Of the breweries established in the 18th and 19th Century only two remain — Brains and Felinfoel. These are the two biggest after Magor, and both were founded in the late 19th Century, although Brains came into being with ownership of a brewery built in 1713. Both companies deserve credit as having maintained their independence from marauding larger English companies. Brains is now the largest Welsh brewery, and is famous for its advertising slogan, seen on the sides of many buses in the Cardiff area – "It's Brains You Want." Felinfoel is famous for a technological innovation — they were the first company to introduce canned beer in Britain in 1936, less than a year after the Krueger Brewery in New Jersey did so in North America.

Today, in addition to the above, there are some 41 microbreweries in the Principality which have sprung up in the last 10–15 years as part of the modern craft brewing revival in Britain. They are fairly widely spread out over the whole of Wales, and as you might expect they are all quite small. Their products are not widely available in Wales, being generally sold close to the brewery — there is nothing like the American distributor system here and most of the breweries sell directly to the pubs. Some seven of these 41 are pub breweries, several of them are farm or cottage concerns, and no less than three of them are in Wrexham.

Modern Welsh Beers

But what about the beer they sell? A good number of them have Welsh names, mostly ending with the word "cwrw" which is Welsh for ale. (The words "Cwrw Cymru," seen in the subtitle of the article, are one way to say Welsh ale.)

Kingstone Brewery sits just inside Wales in the Wye Valley in Tintern, a village noted for its ancient Abbey. Its owner and brewer Ed Biggs pointed out that all the ingredients he uses come from outside Wales, and his beers were only Welsh in the sense that they are brewed in Wales. Indeed Ed's best beer is a re-creation from the first written English recipe for hopped beer in 1503.

I haven't had the opportunity to taste the offerings from all the micros, but it appears that the bulk of their offerings are pale brown beers in the range of 3.5–5.0% ABV. They do not bear much relation to the stronger Welsh ale of history, as we'll see later. A good part of the reason for that is that commercial Welsh brewers in the 19th Century substantially reduced the strengths of their beers as a counter to the negative publicity pouring from the temperance lobby. The result is that they fit exactly into the mold of most modern English ales, that is to say they are session beers. There is nothing wrong with that, for session beers are an important part of the beer spectrum, as I have written before, but there does not seem to be any defining Welshness about them. A number of the offerings from South Wales brewers emphasize malt flavors, and Brains notably still offer a dark mild ale. Despite the fact that these brewers are not far from the great hop-growing area of Herefordshire and Worcestershire, hop character is not significant and even bitterness is often very muted, especially by American craft brewing standards.

Welsh Beer Recipes

Two of the recipes in this article are for modern Welsh beers. I've opted first for a copy of a beer from West Wales, Felinfoel's Double Dragon, a "premium bitter," which is intermittently available in the US, and is billed as "The National Ale of Wales" by the brewery. It's not a clone because the original

used some invert sugar that is not generally available to us. The second recipe is based on a beer from North-East Wales, Plassey's Dragon's Breath, is billed as a strong bitter, and was 1995 Champion Beer of Wales.

But if modern Welsh ales are more English than Welsh, what do we know of earlier versions? There is not a great deal of information available from medieval times and before. Since there's very little written evidence from those times, we'll probably never know the answers to these questions.

I have come across one early 19th Century recipe with sufficient details to develop into a homebrew recipe. It was brewed entirely from amber malt, apparently taking only the first wort from the mash, with no re-mashing or sparging to collect further worts. Calculation using extract values from contemporary sources suggests an original gravity for the beer of around 1.100, although we don't know its final gravity. However, figures around 1.030–1.060 are given for other beers of similar OG; assuming FG of 1.045 that would give an ABV of around 9%. There weren't any figures given for the alpha acid levels of the hops, but — according to one English hop researcher — we might expect that in the early 19th Century hops would generally have been similar to modern aroma hops. So, taking a modest 3% alpha, I calculated that this beer would have a maximum of 90 IBU.

In putting the recipe together, I make some adjustments to make the recipe more modern. First, the grain bill contains pale malt along with the amber. Second, I do call for sparging the grains after mashing, and third I opted for a high-alpha US hop, so as to reduce the bulk of hops in the boil.

Summary

Wales is a country in the process of rebuilding its identity. If their language becomes fully re-established, perhaps Welsh beers may once again resume a distinct character. Lechyd da! BYO

Terry Foster is a frequent contributor to Brew Your Own *magazine.*

Beer & Pretzels

by **Richard Bolster**

My wife and I like to entertain — especially when we have a chance to showcase some of our homemade brews. A while back, we hit upon the idea of pairing homemade pretzels with our homemade beers. It seemed so natural a pairing (yeast for beers, yeast for pretzels), we were surprised we hadn't thought of it before. At our most recent pretzel party, we brewed two German styles to go with our pretzels, a hefeweizen and Kölsch.

As we geared up for our party, we did a little research (actually, we just called our German friend Sven) and discovered some interesting pretzel facts. For starters, according to Sven, the best pretzels (*brezel*, in German) are from Swabia (the southwest region that includes Stuttgart) not, as I always assumed, from Bavaria. And, despite its association with Germany, the pretzel may have come from Italy or France. Experts are divided over its origin, but it's likely they were invented by Christian monks about 600 AD.

Wherever they're from, I find it hard to shake the association with pretzels and Bavaria. And when I think Bavaria, I think of hefeweizen. So, for our pretzel party, I brewed a hefeweizen and a German (though not Bavarian) Kölsch-style ale.

Our pretzel party was in early spring and this crisp concoction, with its signature thirst-quenching combination of low alcohol and subtle complexity, was the perfect refresher for a sunny afternoon.

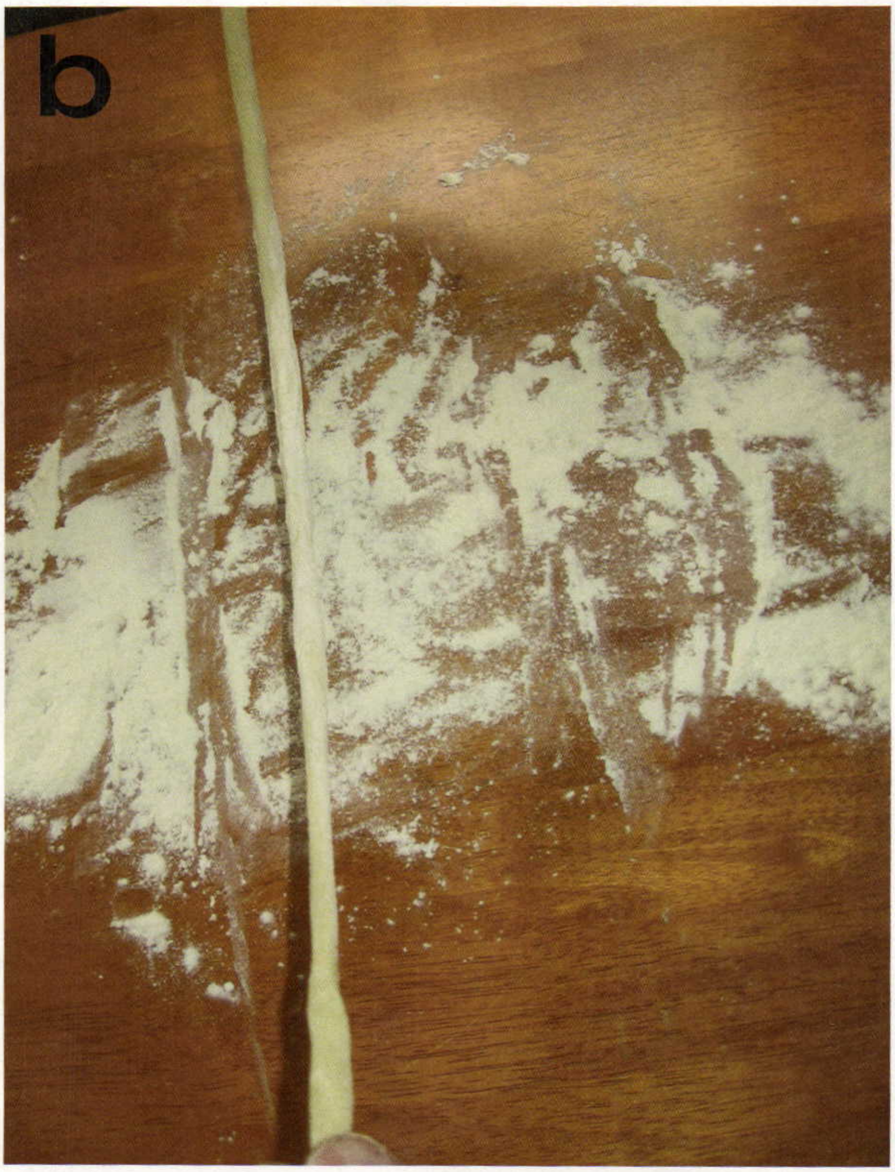
This triple play of yeasty creations is easy and fun to make. And with adventurous guests, you can give your own pretzel party a hands-on twist. To make sure your own pretzel party doesn't get tied in knots, we've worked out the kinks for you.

WHY NOT MAKE IT A PARTY?

Getting Started

First, make sure you have enough space to allow guests to shape their own pretzels. For 10 to 15 guests, set up three or four well-floured rolling areas so your friends can take turns shaping two or three pretzels each. Use the kitchen counter top, a butcher block cutting board, or create two rolling areas on your dining room table – well floured, of course.

Photo by IstockPhoto



Then, prepare the dough and divide it into about a dozen 2-oz. (57-g) lumps. Our recipe makes twelve to fifteen medium sized pretzels. They tend to be filling, so you can estimate two to three pretzels per person.

Dough needs time to rise, of course, so be sure to make yours at least two hours in advance of when your guests arrive. The guests then roll and twist their pretzels. The classic pretzel twist (described below) is easy to master, but encourage your guests to be creative with their pretzels — do a double twist, braid two lengths of dough together and always let the kids run wild with their own designs.

Prepare Your Pretzels

Once you and your guests have twisted the pretzels into shape, it's time to prepare them for cooking. Follow these steps to ensure the tastiest twist.

1. Dunk your proto-pretzels in a baking soda or lye bath to aid in browning. Ask for or appoint an assistant to help give each pretzel its baking soda bath. You can monitor the batches in the oven while your associate dunks each pretzel. This is an essential step, but you don't have to use lye – despite pretzel logicians who argue that lye is the secret to an authentic pretzel. In our house, there is no debate, we want our three year old involved as much as possible, therefore no lye. The stuff, while authentic is also caustic and involves rubber gloves, safety goggles and a

a. The pretzel dough ball is made and allowed to rise for about an hour. Then, it is punched down and allowed to rise again.

b. Your rolling area should be well-floured. This will allow you to easily roll the pretzels and not have them stick.

c. The dough is cut into 2.0-oz. (57-g) portions with a pastry scraper.

d. Roll the dough to the appropriately-sized "tube" and you're ready to twist.

e. The clasic pretzel shape is achieved through two folds of the dough.

Pretzel Recipe

Homemade Pretzels

(Yield = 12–15 pretzels)

The recipe calls for malted barley (in the form of malt extract) for an additional beery tie-in. The malt produces darker, slightly sweeter pretzels than those made with honey. Substitute honey for the malt extract, if you prefer.

Ingredients

3 cups bread flour
1 tbsp. liquid malt extract
1 tsp. salt
1 tsp. dry yeast
1 cup water (at 110 °F/43 °C) pretzel salt

For the bath:

6 cups water
¾ cup baking soda

Step by Step

Preheat oven to 350 °F (180 °C).

Place the flour, barley, salt, yeast and water in a stand mixer (or food processor) with a dough hook.

Knead using stand mixer or food processor until a smooth round ball forms, about 5 minutes. Place in an oiled bowl, coat and cover with plastic wrap and let stand at room temperature until doubled in size, about 1 hour. Punch down, cover and let stand 45 minutes or until doubled again.

Turn out onto floured surface and cut into 2 oz. (57 g) sections. Roll each section into 15-inch (38-cm) long tubes and twist. To twist: place the rolled dough at the top of your rolling surface. Bring the two ends down in an arc until they meet (think of a teardrop shape). Cross the ends and overlap them leaving two 1½-inch (3.8-cm) "ends." Twist these around each other so that you have a quarter-inch (~6 mm) nub remaining. Bring these nubs up to the top of the body of the pretzel and press firmly in place.

To bathe: Using a large spatula (a slotted spoon would work) gently place the pretzel in the rolling boil. Flip the pretzel at 30 seconds and boil for an additional 30 seconds for a total boil time of 1 minute. Remove to a cookie sheet pre-ared with parchment paper and sprinkle ith pretzel salt.

Bake for 16 minutes at 350 °F 0 °C). Turn out onto cooling rack.

option:

ice the boiling baking soda bath with solution of food grade lye (or, equiv- a 0.75 M NaOH solution.) Soak tzels in the lye batch for 30 sec- fore baking. This bath is not heat- el salt and food-grade lye (sodi- xide) can be found online.

degree of caution that is impossible to guarantee with a young child. If you have no such concerns, by all means go the lye route.

2. Don't undercook them. The pretzels should turn brown in the oven. They'll pass from pale beige to gorgeous golden to burnished brown. Though the golden color may look inviting, resist the temptation to pull them out at that point. They're not done.

And, never fear, they're not burning, that brown outer shell is crisp and flaky and contains the soft airy pretzel goodness inside.

3. Serve with condiments and get 'em while they're hot. Pretzels are best fresh out of the oven. Remove them to a cooling rack and eat them as soon as you can touch them comfortably. As for condiments, I prefer mustard. We offer a wide variety: from the tangy stuff usually slathered on hot dogs, to a ginger-infused blend, to grandma's own super-spicy horseradish mustard.

Party On!

For your guests who may just be getting acquainted, pretzels make great conversation starters. Do you prefer hard or soft, rod or twist? Which beer do they taste better with? How did they get their shape? We had much discussion on this topic: one guest claimed the shape is based on the position of hands crossed and laid against the chest in prayer; while others argued the holes serve the practical purpose of allowing them to be strung from twine and worn around the neck — see the Great American Beer Festival for proof of this convenience.

Toppings, too, were a hot topic of conversation, though that could have been due to the horseradish mustard. Although my German buddy Sven says all self-respecting Swabians swear by their buttered brezel breakfasts, let your creativity run wild. It's your party, your house, you set the rules.

That's what we do and will keep doing as long as we have friends and family to entertain — and beers to brew at home.

This is Richard Bolster's first artic for Brew Your Own *magazine.*

Beer Recipes

March on Köln

(5 gallons, 19 L, all-grain)
OG = 1.059 FG = 1.015
IBU = 22 SRM = 3 ABV = 5.7%

This is a beer that benefits from a short aging period. Two months in the bottle produced a dry, crisp, balanced ale.

Ingredients

6.6 lbs. (3.0 kg) Briess Pilsen Light dried malt extract
4 AAU Hallertau hops (55 mins) (1.0 oz./28 g of 4% alpha acids)
0.5 oz. (14 g) Hallertau hops (30 mins)
0.5 oz. (14 g) Saaz hops (5 mins)
1 tablet Irish moss (15 mins)
White Labs WLP029 (German Ale/Kölsch) yeast

Step by Step

Bring 3 gallons (11 L) water almost to a boil. Remove from heat and stir in extract. Return to heat and bring to boil. Add hops according to schedule. Add Irish moss for final 15 minutes of boil. After one hour remove from boil. Add cool water to make 5 gallons (19 L). Aerate and pitch yeast at 72 °F (22 °C). Ferment for two weeks then rack to secondary and move to cooler area for two weeks at 50 °F (10 °C), if possible. Prime, bottle, and condition at room temperature for one week.

WannaBeaSchneida

(5 gallons/19 L, all-grain)
OG = 1.058 FG = 1.014
IBU = 7 SRM = 27 ABV = 5.6%

An homage to Schneider Weisse.

Ingredients

6.0 lbs. (2.7 kg) Briess Bavarian Wheat dried malt extract
0.8 lbs. (0.36 kg) Carafa® III malt
2 AAU Hallertau hops (60 mins) (0.5 oz./14 g of 4% alpha acids)
Wyeast 3068 (Weihenstephan Wheat) yeast

Step by Step

Heat 3 gallons (11 L) water to boil. Remove from heat, add extract, hops and grain bag. Return to heat and bring to boil. Remove grains after 15 minutes. After 45 more minutes remove hops, top up to five gallons, cool, aerate and pitch yeast at 72 °F (22 °C). Ferment in primary at 68–70 °F (20–21 °C) for one week. Rack to secondary and condition for 10 days. Prime and bottle. BYO by **Chris Colby**

COOL NEW MALTS

Photo by Charles A. Parker/Images Plus

FALL IS BACK and for many brewers the cooler temperatures signal the return of brewing. Once again the smell of malt and hops will fill your kitchen or garage and the sound of gurgling carboys will lull you to sleep at night. For most brewers, their brewing schedule will contain a mix of old favorites and new brews they've never made before. When making your brewing plans this year, one thing to consider is experimenting with new ingredients. Every year there seem to be new hop strains coming on the market. Likewise, new yeast strains pop up at a regular frequency. And, over the past few years, malting companies have released quite a few new malts — it's possible that one of them might be just the thing for your next brew.

The qualities of individual malts are sometimes underappreciated by homebrewers. Most of us would scoff at a recipe that called for just "hops," instead of specifying a variety (and the alpha acid content), yet how many recipes have you seen that simply called for "2-row" as the most abundant ingredient in the beer? Different pale malts may be made from different strains of barley, be kilned to slightly different levels of color or have other differences that set them apart from other, similarly-labelled pale malts. Likewise, two different malts labelled "crystal 40" may impart discernibly different flavors in your beer. Getting to know the characteristics of specific malts can help you tweak existing recipes towards perfection or give you the inspiration to try something new. For this article, I've rounded up a variety of malts introduced in the last couple years.

What is Malt?

Malt is made from a variety of grains, most commonly barley, with wheat being the second most commonly malted grain. Rye, oats and other grains can also be malted. The process of malting transforms a nearly rock hard grass seed, that would yield almost no pleasant flavors when steeped in water, into a soft ingredient (chewable, and crushable by your grain mill) that imparts the malty notes we enjoy in beer.

The process of malting involves steeping the grain in water until it germinates and starts to grow. At this stage, the grain produces enzymes that would normally help the plant develop from a seed into a blade of grass. However, before much growth occurs, the maltster halts the process by drying the grain. Then, the malt is kilned and the heat applied darkens the husk (in grains with a husk). The malty flavors of malted barley come from the reactions that occur in the kiln.

Because the chemical reactions that occur in the husk are dependent on the molecules found in the husks, different strains of barley can yield different flavors (due to slightly different husk components), even when malted the same way. Likewise, small differences in the process of malting between maltsters can lead to differences in the flavor of the malt. 2-row is not just 2-row — each different maltster's 2-row pale malt will taste slightly different from the others. And the same thing goes for crystal malts, chocolate malts and any other malt style. If you have a beer recipe you really like, but are looking to tweak it, trying out another maltster's malt may be just the thing. (Or maybe you'll find that you can't tell the difference; either way you've learned something about brewing.)

Cool New Malts

In the past few years, a number of new malts have come on the market, including base malts, specialty malts and malt extracts.

The last few years have seen the introduction of some new Pilsner malts. Canada Malting Co. (CMC, based in Canada but with locations across North America), Bairds Malt (which operates five plants in the UK) and Great Western Malting Co. (with plants in Washington and Idaho) have all released new Pilsner malts. CMC's Pilsner malt is malted from Copeland 2-

Where Did All The Barley Go?

by Chris Colby

If you've only noticed one thing about malt in the past few years, the thing you've likely noticed is that it is a lot more expensive than it used to be. To find out the reason for this, plus ask for an outlook on malting for the near future, I talked to Dave Kuske, Director of Malting Operations at Briess Malt and Ingredients.

Kuske explained that barley prices were very volatile right now as a number of factors were contributing to a steady drop in worldwide barley production. But, it wasn't always that way.

The Good Old Days

As late as the early 1990s, there was an open market for barley and the number of acres planted far exceeded the amount required for malting barley. If barley met the demands of maltsters, the farmer could sell it for a nice profit. If it didn't meet malting standards, it could still be sold as feed. The price for feed barley was less than that of malting barley, but selling the crop as feed would not have been a disaster for the farmer. Also, many countries in Eastern Europe, despite being in prime barley-growing latitudes, were net importers of barley and the US exported a fair amount of barley every year.

In addition, there were parts of the US (such as North Dakota, Montana, Wyoming and Idaho) where farmers could grow barley but, due to their climate or short growing season, could not grow corn or soybeans.

Changes

Things started to quickly change in the 1990s, though. Corn and wheat were always more abundantly planted than barley, and when it came time to upgrade railroads and other infrastructure, agribusiness companies invested in ways to more cheaply move corn and wheat, but not barley. The feed lots in California, which used to buy barley as feed, found it less competitively priced and started phasing it out.

Likewise, political change in Eastern Europe brought capitalism to many countries and with it, investment in agricultural infrastructure. Countries that used to be importers of barley now became exporters.

In addition, genetic improvements in corn and soybeans expanded the geographic range where farmers could successfully grow them. Drought resistance and shorter times to maturity in GMO crops meant that farmers in the northern US no longer had to plant barley; they now had options.

And lucrative options they were. These days, with government subsidies for growing corn as a biofuel, and the greatly improved yields of GMO crops, farmers can earn significantly more money planting GMO corn or GMO soybeans compared to barley.

These changes have brought big adjustments in what the US farmer produces. In 1960, the US produced 5,500 billion bushels of feed grains; 64% of this was corn, 7% was barley. (The rest was oats and milo). In 2009, with overall US farm acreage shrinking, the US produced 13,400 billion bushels of feed grains — 94% of which was corn, 2% of which was barley. The total amount of barley produced in the US since 1960 has dropped by almost half.

Mother Nature hasn't been helping out either, although growing conditions in 2008 and 2009 were good, 2010 yielded a poor crop and the outlook for 2011 is just as bad. Flooding in the upper Midwest has left many fields unplanted or washed out.

Right Here, Right Now

Today in the US, corn is king. Although demand for corn as a food product is basically level, demand for use as a biofuel (and government subsidies for this) has pushed corn acreage to new highs, crowding out other grain crops. Barley has always lagged far behind corn and wheat in terms of acres planted. But today barley is basically a specialty crop, grown only for maltsters. The total amount of barley grown by US farmers will be enough to supply maltsters, but there will be little left over beyond a small bit of rejected malting barley that gets sold as feed. If trends continue, the already miniscule markets for feed barley and export barley will be gone in a year or so.

The overall acreage of 2-row malting barley grown in the US has remained roughly constant from 1985 to present, but plantings of feed barley and 6-row malting barley have decreased. Currently, basically all of the barley grown by US farmers is grown under contract to maltsters. There are no open or "spot" markets for barley.

The Future

If current trends continue, barley growing will become completely contracted and the only buyer of barley in the US will be maltsters. Competition with other crops for acreage will mean barley is pushed into other marginal growing areas in the northern US. More US barley acreage will be grown in irrigated fields (as opposed to farmland that usually receives adequate rainfall) and this may help improve consistency.

For Brewers

Unlike the hop shortage a few years ago, there is little chance that brewers will face a shortfall in the coming years. The factors affecting malt markets have been trending this way for many years and malt companies will contract for all the barley they need, and then some to cover for possible crop losses.

row barley, grown in Canada. Bairds claims their malt will give good yields and has a low potential for DMS while Great Western Malting's offering is certified organic. The company also has two other new organic malts, a Munich malt and a Caramel 60 malt.

Best Malz, from Germany, has a trio of new malts — melanoidin, acidulated and smoked malt. Their melanoidin malt is similar to a Belgian aromatic malt and they claim it most suitable for beers that are "malt bombs," such as doppelbocks.

Acidulated malt is malt that has been sprayed with lactic acid and is usually used to lower mash pH. Their smoked malt is smoked over beechwood and can be used for brewing Bamberg-style rauchbiers. Briess (from Wisconsin) has also released a new cherry wood smoked malt.

Canada Malting has also released two malts that fans of pale ales may be interested in — their Superior Pale Ale Malt and Rye Malt. The pale ale malt is kilned to a slightly higher color than the company's other base malts. Their rye malt is a high-protein, high glucan malt, without a hull and may cause lautering problems (as with all rye malts), but the reward is a spicy character not found in other malts.

New Malts

Malt	Moisture (%)	Color (°L)	Protein (%)	Extract (coarse grind dry min)	Usage (max %)
Baird's Pilsen Malt	4.5	1–2	10.5	80.0	100
Best Malz Acidulated Malt	4.0	1.8–3.1	11.5	-	5
Best Malz Melanoidin Malt	4.0	22–30	11.5	72.5	20
Best Malz Smoked Malt	4.0	2.5–4.0	12.0	78.0	100
Briess Blackprinz® Malt	6.0	500	-	-	-
Briess Carabrown® Malt	2.2	55	-	79*	25
Briess Caracrystal® Wheat Malt	4.0	45	-	78*	25
Briess Midnight Wheat Malt	6.5	550	-	-	10
Briess Smoked Malt	6.0	5	12.0	79.5	60
Canada Malting Rye Malt	4.1	1.8–3.2	12.0	81.0	100
Canada Malting Superior Pale Ale Malt	4.1	2.0–3.5	12.5	80.0	100
Canada Malting Superior Pilsen Malt	4.1	1.4–1.9	11.0	80.0	100
Great Western Organic Caramel 60	6.0	55–65	12.5	77.0	10
Great Western Organic Munich Malt	4.5	9.0–11.0	12.5	79.0	100
Great Western Organic Pilsner Malt	4.5	1.8–2.2	12.5	80.0	100
Muntons Brown Malt	<7	20–38	-	-	-

* fine grind, dry basis

Cool New Recipes

Purely Pils (Bohemian Pilsner)

(5 gallons/19 L, all-grain)
OG = 1.052 FG = 1.013
IBU = 39 SRM = 3 ABV = 5.0%

There are many beer styles for which a Pilsner malt is well suited. But if you are trying out a new variety of Pilsner malt — such as the new malts by Canada Malting, Great Western or Bairds (or any Pilsner malt that's new to you) — you can't do better than brewing a classic Bohemian Pilsner.

Ingredients

10 lb. 4 oz. (4.7 kg) Pilsner malt
0.25 lbs. (0.11 kg) CaraPils® malt (1 °L)
10.5 AAU Saaz hops (60 mins)
(3.0 oz./85 g of 3.5% alpha acids)
2.0 oz. (57 g) Saaz hops (0 mins)
Wyeast 2124 (Bohemian Lager) or White Labs WLP830 (German Lager) yeast (3 qt./3 L yeast starter)

Step by Step

For best results, use soft water with a carbonate content close to zero and calcium levels at about 50 ppm. As an option, you may want to swap 4.0 oz. (110 g) of the Pilsner malt for acidulated malt if your water is lower in calcium than this. Mash malts at 154 °F (68 °C) for 60 minutes. Mash out to 170 °F (77 °C), run off first wort and then sparge until final runnings drop to around SG 1.008 or pH climbs above 5.8. Boil wort for 90 minutes. As an option, you can add ¼ tsp. of calcium chloride ($CaCl_2$) to the boil after 15 minutes if your hot break looks poor. Ferment beer at 50 °F (10 °C). When the fermentation approaches its last few days, let temperature rise to 60 °F (16 °C). Hold there for a few days (or better yet, if you can safely sample the beer, confirm that there is no residual diacetyl.) Keg, carbonate and serve.

Schwarzschild Black IPA

(5 gallons/19 L, all-grain)
OG = 1.061 FG = 1.015
IBU = 64 SRM = 50 ABV = 6.0%

Formulated by Briess as a 7-barrel recipe to showcase their Blackprinz® Malt (dehusked black malt), here is BYO'*s homebrew-scaled version.*

Ingredients

9.75 lbs. (4.4 kg) Briess Pale Ale malt
8.0 oz. (0.23 kg) Briess Blackprinz® malt
8.0 oz. (0.23 kg) Briess Caramel 20L malt
8.0 oz. (0.23 kg) Briess Caramel 60L malt
8.0 oz. (0.23 kg) Briess Carapils® malt
11 oz. (0.31 kg) sugar
11 AAU Amarillo hops (60 mins)
(1.4 oz./39 g of 8% alpha acids)
0.66 oz. (19 g) Amarillo hops (10 mins)
0.66 oz. (19 g) Cascade hops (10 mins)
0.66 oz. (19 g) Centennial hops (10 mins)
0.66 oz. (19 g) Amarillo hops (1 min)
0.66 oz. (19 g) Cascade hops (1 min)
0.66 oz. (19 g) Centennial hops (1 min)
0.66 oz. (19 g) Amarillo hops (dry hop)
0.66 oz. (19 g) Cascade hops (dry hop)
0.66 oz. (19 g) Centennial hops (dry hop)
White Labs WLP060 (American Ale Yeast Blend)

Step by Step

Mash grains at 154–156 °F (68–69 °C) for 45 minutes. Heat to 170 °F (77 °C). Lauter. Boil with bittering hops and sugar for 50 minutes. Boil with second hop addition for 9 minutes. Boil with final hop addition for 1 minute. Cool to 66 °F (19 °C), oxygenate wort and pitch yeast. Ferment for 14 days at 66 °F (19 °C). Transfer to secondary for 14 days and add dry hops.

Extract with grains option:

Reduce amount of pale ale malt to 1.0 lb. (0.45 kg) and add 3 lb. 14 oz. (1.75 kg) Briess CBW® Golden Light liquid malt extract and 2.0 lb. (0.91 kg) CBW® Golden Light dried malt extract to ingredient list. Put the 3.0 lbs. (1.4 kg) of crushed grains in a large steeping bag, Steep in 4.1 qts. (3.9 L) of water at 154–156 °F (68–69 °C) for 45 minutes. Heat to 170 °F (77 °C). Lift bag into a colander over brewpot and rinse with 2 qts. (2 L) of 170 °F (77 °C) water. Add water to make at least 3.0 gallons (11 L) of wort. Boil, adding sugar and dried malt extract at beginning and hops at times indicated. Stir in liquid malt extract during last 15 minutes of the boil. Cool to 66 °F (19 °C), transfer to fermenter and top up to 5.0 gallons (19 L). Oxygenate wort and pitch yeast. Ferment for 14 days at 66 °F (19 °C). Dry hop in secondary for 14 days.

And Mirrors Rauchbier

(5 gallons/19 L, all-grain)
OG = 1.052 FG = 1.013
IBU = 22 SRM = 16 ABV = 5.0%

A rauchbier to evaluate smoked malts, such as Best Malz's new rauchmalz.

Ingredients

7.0 lbs. (3.2 kg) smoked malt
2.0 lbs. (0.91 kg) Vienna malt (3–6 °L)
1.0 lb. (0.45 kg) Munich malt (8–10 °L)
0.50 lbs. (0.23 kg) CaraMunich® malt (60 °L)
0.50 lbs. (0.23 kg) melanoidin malt
6.0 AAU Hallertau hops (60 mins)
(1.5 oz./43 g of 4% alpha acids)
Wyeast 2633 (Octoberfest Lager Blend) or White Labs WLP820 (Octoberfest/Märzen) yeast

Step by Step

Mash at 154 °F (68 °C). Boil wort for 90 minutes. Ferment at 52 °F (11 °C).

Canada Malting Co. Limited

Great Western Malting Co.

Muntons

Briess has recently released a series of malts in their Maltster's Reserve Series. Each of the four malts is seasonal. Their Caracrystal® Wheat is available January through March. Carabrown® malt is available April through June. Midnight Wheat is available July through September and their Blackprinz® malt will be available October through December.

Briess' Caracrystal® Wheat Malt is a caramel/crystal malt, with a color of 45 °Lovibond (°L), made from wheat. Carabrown®, at 55 °L, is a brown malt on the light side of the color range. Muntons has also released a brown malt, intended for session beers such as brown ales, dark milds and the like. Briess' Midnight Wheat, at 550 °L, is the darkest malt Briess makes and is the wheat equivalent of a black malt. This malt was especially designed for brewers who wanted to yield color from a malt, but little flavor, and is well-suited for brewing schwarzbiers or black IPAs. Midnight Wheat has been a successful offering for Briess and they are now making it year round. (Next year there will be a new malt in the seasonal rotation to take its place, but this malt has not been announced yet.) Their final malt in the series is another dark malt, called Blackprinz®. this is a dehusked black malt, with a twist — the hulls are removed before the grains are malted,

not after as is usually the case. At 500 °L, this is a dark grain, but the fact that it is huskless gives it a mellower feel than a regular black malt.

Briess also recently released CBW® Munich malt extract, made from 50% Munich malt and 50% Pilsner malt.

When brewing beer, every ingredient counts. You need active, healthy yeast, hops that are not stale or oxidized and of course, fresh malt. Evaluate the flavors of your ingredients closely, testing different options when possible, and your beers will improve. BYO

Chris Colby is Editor of Brew Your Own *magazine.*

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Brew Your Own — The How-To Homebrew Beer Magazine / Basic Brewing

colLABorative

When is Your MASH DONE?

Most homebrew recipes that specifiy a single infusion mash recommend mashing your grains for 60 minutes and most homebrewers follow these instructions . . . but why? Is 60 minutes the right amount of time to mash for all occasions? I almost always mash for 60 minutes and my reason for this is simple — that's the way I've always done it and it works. However, is it possible that mashing for a significantly shorter time, thus shortening your brew day, is feasible? (And, just to list all the options, is it possible an even longer mash brings more benefits?) James Spencer and I decided to test these questions in our *Brew Your Own*/Basic Brewing Radio Collaborative Experiment Series.

The original idea behind our experiment was simply to get all-grain homebrewers to do an iodine test every 5 minutes when they brewed their next beer. This would tell us how long, on average, before the test indicated that the level of starch in solution had fallen below the level of detection. Later on, we added the idea of performing a refractometer test every 5 minutes as well, to determine the amount of extract yielded from the mash over time.

In this experiment, we had 20 brewers participating, including ourselves, and 51 independent tests were performed. You can see the names of the participants in the chart on page 49, but a few need to be acknowledged for going beyond the call. Chris Wolfe and his two helpers from Kansas City, Missouri

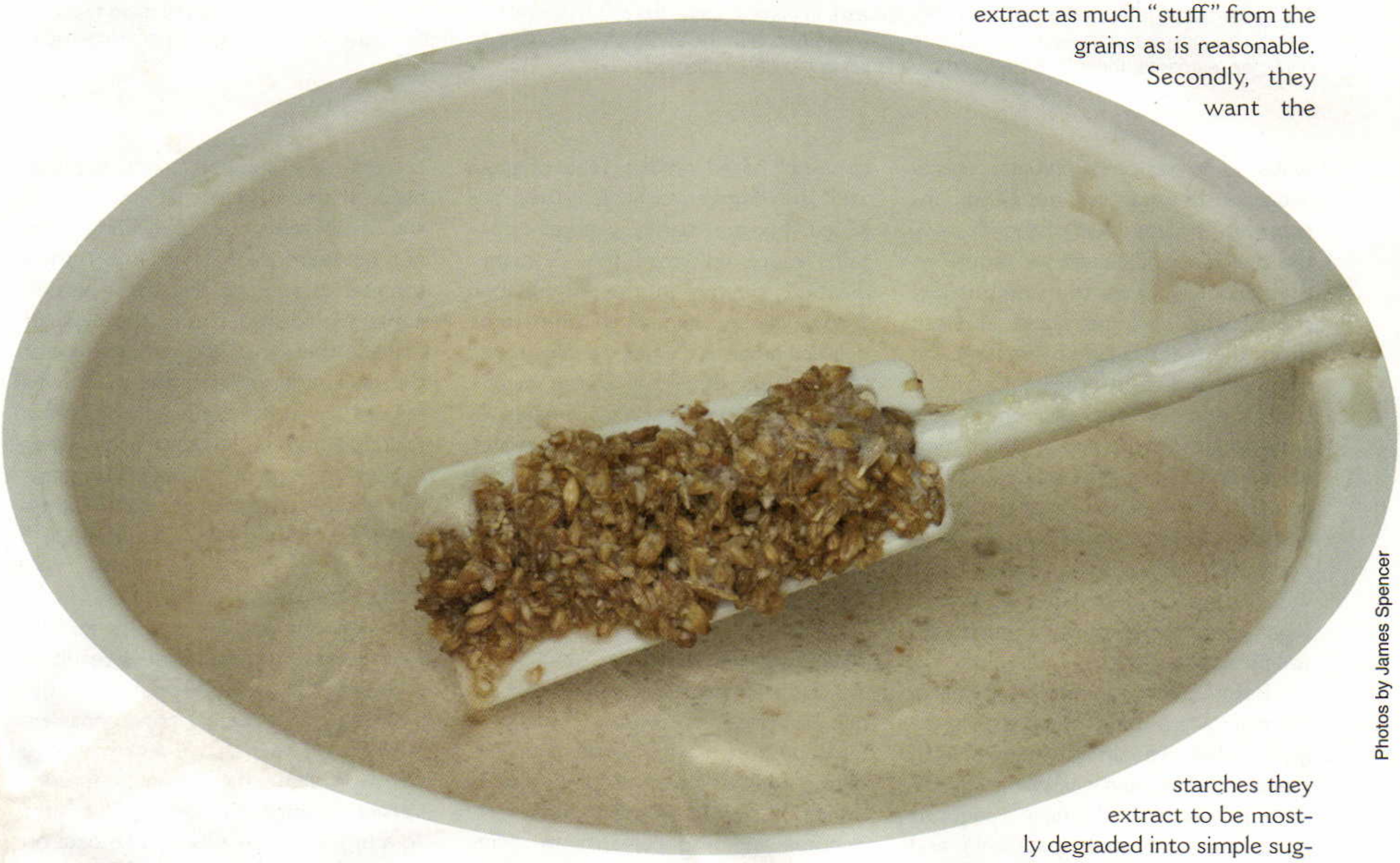
Story by **Chris Colby** and **James Spencer** tested five different base malts, each at two different temperatures and in the stirred and unstirred condition. (His data set can be seen at www.basicbrewing.com; click on the "radio" link and find the supplementary material for the March 3, 2011 show.) Brandon Dufala not only performed the experiments, but videotaped them and posted them to YouTube. (Links to this are

> "Although our experiment had a few subquestions in it, the overall question was fairly simple — when is a mash done?"

also on the Basic Brewing site.) Finally, Zot O'Connor and Kai Troester performed much of the data analysis as well as performing their own tests. (Zot O'Connor's blog, in which he mentions these experiments, can be found at exbeeriments.wordpress.com.)

What Goes On In the Mash?

Although our experiment had a few subquestions in it, the overall question was fairly simple — when is a mash done? Before explaining our experimental design, let's review what we believe happens in a mash and what brewers are trying to achieve. The point of a mash to make wort and, at a minimum, brewers want two things from their mash and wort. First, they want to extract as much "stuff" from the grains as is reasonable. Secondly, they want the starches they extract to be mostly degraded into simple sugars. This provides a source of fermentable sugars for the yeast. Also, if the wort has significant levels of starch, the beer made from it will be hazy and microbiologically unstable.



Photos by James Spencer

During the mash, starch granules in the crushed grains are exposed to hot

Unstirred

Starch iodine tests performed at 5-minute intervals by James Spencer on an unstirred mash. In the 5-minute and 10-minute tests, you see a strong blue/black color from the iodine reacting with starch. In later samples, the color is less pronounced. In his samples past 25 minutes (not shown), the wort remained the color of wort when the iodine was added.

Stirred

The same set of tests performed on a stirred mash. In James' case, the results were the same. However, all other head to head tests of stirred vs. unstirred mashes at the same temperature and with the same grain resulted in the stirred mash converting sooner. Within scientific experiments, there is always some variance in the data collected.

water. The starch is initially tightly packed in the granules, but — in contact with the hot liquid of the mash — the starch strands begin to "unfurl" as they dissolve. Once the starch is dissolved, the enzyme alpha amylase (from the malt) is able to contact the starch strands and break long starch strands down into smaller ones. Beta amylase attacks the end of starch molecules and "snips off" maltose molecules. Both the dissolving of the starch granules and its subsequent degradation take time . . . but how much time? Testing this on a homebrew scale is what our experiment (eventually) sought to test.

Before performing the experiment, there are a few things we might expect given what we already know about grains, mashing and chemistry in general. In general, chemical reactions (including enzymatic reactions) and physical processes (such as a solid dissolving into a liquid) speed up at higher temperatures. Also, we know that different malts have different enzymatic contents based on the type of grain and the degree to which they are kilned. Six-row barley generally contains more enzymes (has a higher diastatic power, in the lingo) than 2-row barley kilned to the same degree. Since enzymes are destroyed by the heat of kilning, more highly-kilned (darker) malts typically have less diastatic power than lighter malts. Likewise, if a grain bill contained specialty malts (which would be expected not to contain any enzymes) this would dilute the amount of enzymes in the mash.

The Experiment

So, our proposed experiment was simple. Participating brewers would simply take any brew day, mash as usual, but take a refractometer reading (if they owned a refractometer) every five minutes and also perform an iodine test every 5 minutes. In a starch iodine test, the brewer takes a small sample of wort and adds a drop of iodine (iodophor works for this). If starch is present, the solution turns a bluish black. If there is minimal starch (or if starch is absent), the color change cannot be seen. Along with the refractometer and iodine test data, participants would also report the type of malts in their grist, the temperature of the mash and whether the mash was stirred or not. Some participants, including myself, did test mashes using a single base grain (no specialty grains mixed in) and other participants (James) collected other data as well.

The Results

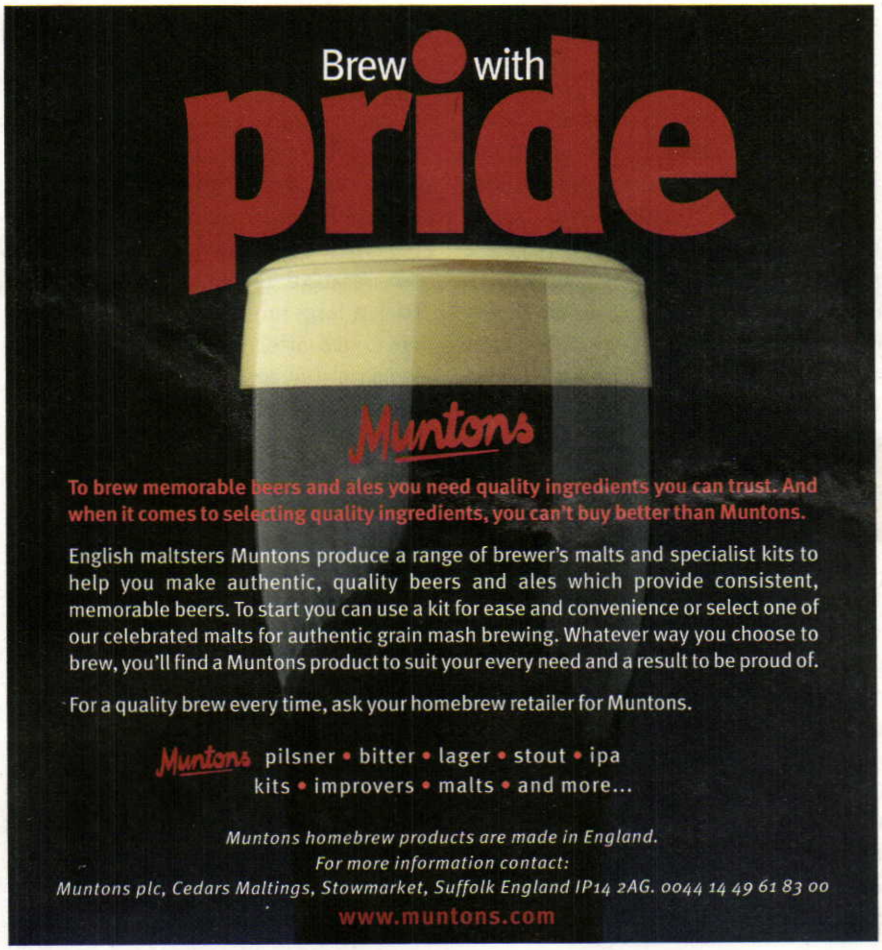
The amount of time it took for the iodine test to show a negative result — indicating that the level of starch in the wort was minimal — varied considerably. If you look at the chart on page 49, you will see that the time until conversion varied from a low of 10 minutes to a high of 50 minutes. (The data on page 49 omits Chris Wolfe's data. Since half of his data was collected at 142 °F (61 °C), outside the usual temperature range for a single infusion mash, and the other half showed unusually long conversion times, we will temporarily set aside this data.) Seventeen of the 30 tests showed an iodine negative result in 20 minutes or less, with an average time to conversion of 24.8 minutes. This average covers a wide variety of grist compositions, mash temperatures and differences in stirring.

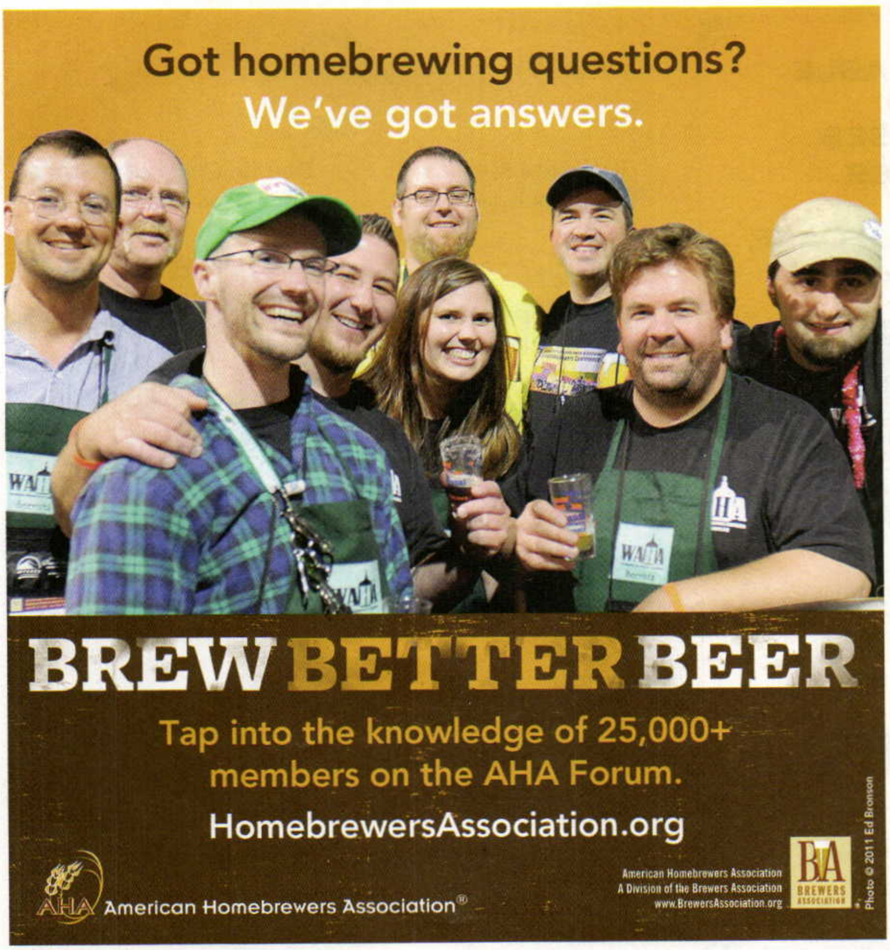
Conversion time was generally faster at higher mash temperatures, in mashes with fewer specialty malts and with mashes that were stirred. One of the longest times (50 minutes) until a negative iodine test occurred in a beer with a starchy adjunct (sweet potato ale). Even though these trends were clear, there was a lot of variability and it is not hard to find data points that don't fit the general trend. This is not unexpected as these mashes were all conducted under different conditions. Within my (Chris Colby's) data and Chris Wolfe's, there is some paired data that highlight these differences more clearly. For example, in a test I did of 2-row malt vs. 2-row malt at different temperatures, but with all other variables held constant, the higher temperature mash yielded a negative result sooner. (So, did — probably — my 6-row test, but after initially showing a negative result at 10 minutes, I got a positive result at 15 minutes. This was probably due to a small piece of starch granule in the sample, but I put an asterisk by this data point. See my blog at www.byo.com for a little more about the data I collected.)

If you add Chris Wolfe's data into the analysis, the average time to conversion goes up considerably. This is partially because half of his tests were done at 142 °F (61 °C), below the temperature that a single infusion mash is normally carried out at and seven degrees Fahrenheit (3.9 °C) lower than the lowest temperature in any of the other tests. The addition of his data clearly shows the effect of temperature on mash time, especially since he tested 5 different malts head to head at two different temperatures. (Wolfe's data also shows clear differences in stirred vs. unstirred mashes in head to head tests.) However, even in his high-temperature tests, many of his tests took a long time to convert and some never did after 90 minutes. This may indicate that some other factor was at work since none of the other 19 participants reported such results.

James Spencer also collected mash temperature data in his stirred vs. unstirred. He found little difference in conversion time (which was unusual) but that the mash temperature dropped more in the stirred mash. His unstirred mash dropped less than 1 °F (~0.5 °C) over the 60 minute mash time whereas his stirred mash dropped 14.5 °F (8.1 °C). This would be expected in most homebrew set-ups.

Taken as a whole, the data shows that, under a wide variety of common mash variables (including grist, temperature and stirring as well as mash thick-





ness (data not shown)), an iodine test will give a negative result in under 60 minutes. In many cases, conversion occurred more quickly, but in a few it took as long as 50 minutes. A 60 minute mash schedule could be characterized as a "safe" mash schedule, meaning that you can be fairly certain that conversion will occur somewhere in that time frame. Given the fact that conversion occurred many times in much less than 60 minutes, it is reasonable to ask if homebrewers could perform mash rests less than 60 minutes, using the iodine test as an indicator of when to start running off the wort.

Only a subset of the participants took refractometer readings, but the results in this part of the experiment were clear. In mashes that were stirred, wort gravity initially started low, but climbed steadily as the mash progressed. Wort gravity continued to increase even after a negative result was obtained in a starch iodine test. This was seen in my (Chris Colby's) data, James Spencer's data and Chris Wolfe's data.

This might seem like a non-sensical result to some as you often hear people say that a negative result on the iodine test means that "all the starches have been converted to sugars," but that isn't true. What the starch test shows is that (nearly) all of the starches *in solution* have been converted to sugars. Iodine doesn't penetrate unhydrated starch granules, so there can be significant "chunks" of starch in the grain bed while the free wort can test iodine negative. Given that we see continued iodine negative results as the wort gravity increases, we can infer that once the enzymes convert the starch that dissolved early in the mash rest, they can degrade the late dissolving starch as fast as it enters the solution (or at least at a rate quick enough to keep the iodine test negative).

This last inference is testable. If you were to take clear wort that was recently run off from a mash, tested iodine negative and held at mash temperatures, you should be able to stir a small amount of crushed malt into this liquid (enough to cause an iodine positive result in water if you used

Starch Iodine Test Data

Name	Location	Beer Style	Stirred	Time	Temp °F (°C)
John T Welbourn	Wirral UK	English pale ale	N	15	151 (66)
John T Welbourn	Wirral UK	English pale ale	?	20	?
Brian Davis	Lyle, MN	Classic American Pilsner	N	30	149 (65)
Nate Muller	Seattle, WA	Cream Ale	Y	20	153 (67)
Dennis DeWalt	Fayetteville, PA	Irish Red	N	25	153 (67)
Jeff Karpinski	Elizabeth, CO	Red Ale	Y	15	156 (69)
Ron Evans	Verdigris, OK	Schwarzbier	Y	15	153 (67)
Ken Valley	Iowa City, IA	Red	N	30	158 (70)
Ken Valley	Iowa City, IA	Pale Ale	Y	20	156 (69)
Sean Terrill	Silverton, CO	Test	?	15	144 (62)
Sean Terrill	Silverton, CO	Test (Reverse)	?	15	144 (62)
Peder Hoyum	Pipestone, MN	IPA	Y	40	153 (67)
Mark Grier	Nashville,TN	Cream Ale	N	15	153 (67)
Chad Schaefer	North Port, FL	Irish Heavy	N	45	153 (67)
Ron Harmsen	Owasso, OK	Schwartzbier	?	20	153 (67)
Tony Milner	Wallasey, UK	Robust Porter	N	25	153 (67)
Brandon Dufala	Greenville, SC	Base-Malt Ale	N	50	153 (67)
Brandon Dufala	Greenville, SC	Base-Malt Ale	N	45	153 (67)
Erich Streckfuss	Washington, DC	Sweet Potato Ale	Y	50	153 (67)
Zot O'Connor	Seattle, WA	Red	Y	10	151 (66)
Zot O'Connor	Seattle, WA	Pale Ale	Y	20	151 (66)
Zot O'Connor	Seattle, WA	Pale Ale	N	30	151 (66)
Zot O'Connor	Seattle, WA	Pale Ale	N	30	151 (66)
Chris Colby	Bastrop, TX	6-row Test	Y	10(*)	158 (70)
Chris Colby	Bastrop, TX	6-row Test	Y	15	151 (66)
Chris Colby	Bastrop, TX	2-row Test	Y	20	158 (70)
Chris Colby	Bastrop, TX	2-row Test	Y	30	151 (66)
James Spencer	Prairie Grove, AR	Pale Ale	N	20	154 (68)
James Spencer	Prairie Grove, AR	Pale Ale	Y	20	154 (68)
Kai Troester	Pepperell, MA	Test	Y	30	154 (68)

* There may be some problems with this value. See story text.

"cooked" malt — malt that was heated to inactivate the enzymes) and still get an iodine negative result. This would be because enzymes from the malt would attack the starch as soon as it dissolves.

In stirred mashes, the gravity continued to rise in most cases as long as data was being collected, but the rise in gravity diminished over time.

In unstirred mashes, wort samples climbed very slowly in wort gravity and ended up with a lower finishing gravity than stirred samples. This is almost certainly due to stratification within the grain bed. The liquid on top of the mash would have a low gravity because the bulk of the dissolved sugars would be inside the grain bed. James Spencer's data showed that, in his unstirred mash, although his refractometer samples indicated a very low gravity, the actual first runnings of the wort tested significantly higher. (In other words, he was doing an iodine test on thin wort floating above the grain bed, which harbored thicker wort.) He did, however, find that the first runnings of his stirred batch had a higher gravity than the unstirred batch.

Conclusion

Our overall question in the experiment was, when is your mash done? Our results showed that neither the starch iodine test nor a measure of wort gravity alone would give you an answer. In the majority of cases, the wort showed iodine negative results in 20 minutes or less. However, in cases where refractometer readings were also taken, wort gravity continued to increase after this point. If a brewer decided to start running off his or her wort based on a negative starch iodine test alone, he could leave a significant amount of extract behind. Conversely, in a few cases, it took awhile for the iodine test to become negative and a brewer may reach a reasonable wort gravity before this happens (although this is less likely than the converse).

Although wort gravity continues to rise at longer mash times, there is a point where the return for more time spent is minimal. Taking refractometer readings can help you decide when to start running off your wort. BYO

Chris Colby and James Spencer are always planning new experiments. Watch James' website and Chris' blog for updates on new experiments.

MAKING ICE CIDER

by **Betsy Parks**

Photos courtesy of Eden Ice Cider

For my first ever taste of ice cider, I picked up a bottle at the local liquor store during a typical all-day New England snowstorm on my way home from work. I was intrigued — I like icewine and I like hard cider, so ice cider seemed like the best of both worlds. The label on the bottle instructed me to "serve well chilled," so, like a typical Vermonter, I slid the slim 375-mL bottle up to its neck in a snow bank and let it cool down as I headed inside to make dinner.

After dinner, my roommate and I rescued the bottle from the blizzard, uncorked it and poured two small tastes. "It looks a lot lighter than I thought," she remarked at the bright amber-gold color. "Smells like a cold apple orchard," I responded. We took a sip. It was tart but sweet, the chilled dessert drink burst with a complex apple cider flavor that permeated my mouth and lingered on my palate. "Yum," my roommate said with a smile. "Yum, indeed," I answered. And with that first sip, I had to learn more about ice cider.

Originally from Québec, where it is known as *cidre de glace*, ice cider is made from sweet juice extracted from frozen cider, just as icewine is made from the juice from frozen winegrapes. Christian Barthomeuf, the owner of Clos Saragnat and the cidermaker at Domaine Pinnacle, both located in Frelighsburg, Québec, is credited with making the first ice cider in the early 1990s.

Unlike hard cider, which is simply fermented fresh-pressed apple cider, ice cider is fermented from the sugary solution of the fresh-pressed apple juice that has been separated from the water in the juice by freezing it. This can be done either naturally by leaving the fruit on the trees to freeze and then pressing the juice from the frozen fruit, or by freezing juice and separating the concentrate from the ice (known as cryoextraction). The concentrate, because of its sugar content, has a lower freezing point than water. When the cider is frozen, the concentrated juice is separated from the ice crystals, warmed, inoculated with yeast and fermented.

Ice cider is similar in many ways to apple jack — hard apple cider that is frozen and concentrated by removing the ice crystals. The difference between the two is that, when making ice cider, the apples or juice is frozen first, then fermented. Apple jack is fermented first, then frozen.

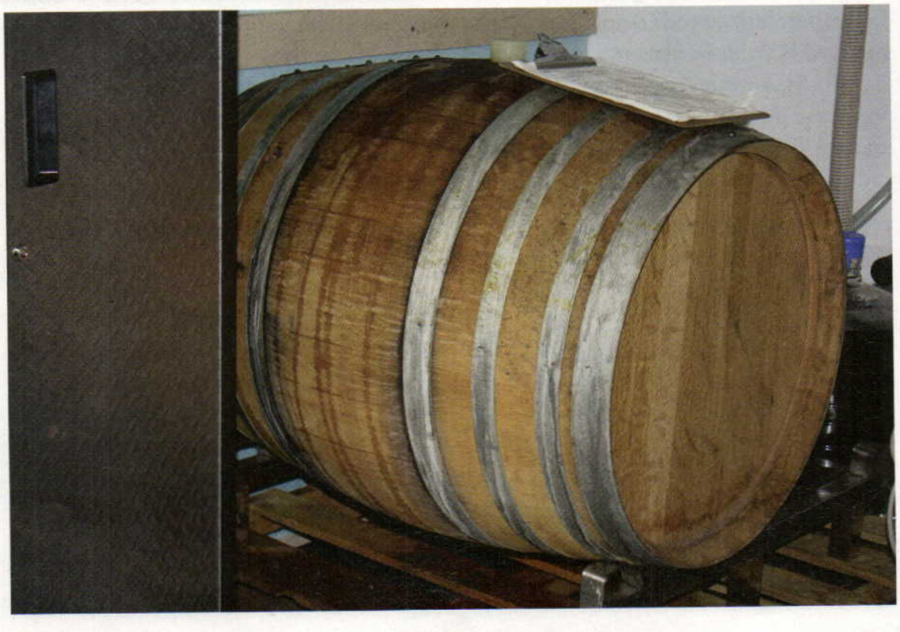
To figure out the process for making ice cider on a home scale, I contacted Eleanor Leger, co-owner and cider maker at Eden Ice Cider Company in West Charlestown, Vermont for some advice. Eden's first ice cider trials were made using 5-gallon (19-L) polyethylene terephthalate (PET) carboys, which they filled with cider, left out in the Vermont winter to freeze, and flipped upside down to extract the concentrated juice.

Start with Cider

First and foremost, for homebrewers' purposes, the easiest way to make small batches of ice cider is to freeze fresh-pressed cider since not many homebrewers are equipped to press apple cider, especially from frozen apples. Eleanor explained that you can make ice cider from any kind of cider apples, but you don't need to overthink the varieties.

"For hard cider aficionados, it is tempting to use lots of cider apples," she explained, referring to some of the heirloom varieties that go into commercial artisan hard ciders, "but I would use those judiciously in ice cider as it would make it bitter, and that's something you really want to avoid." Whatever your local orchard is pressing into their sweet cider should work

> "Originally from Québec, where it is known as *cidre de glace*, ice cider is made from sweet juice extracted from frozen cider . . ."



for your own ice cider. You can always experiment later with different varieties if you would like. One caveat — be sure that the cider you use is not pasteurized — you don't want it to be heated. Heat will change the character and flavor of the juice. A local orchard will very likely be willing to sell you fresh-pressed or UV-pasteurized cider if you contact them ahead of time.

Equipment and Space

For every 5 gallons (19 L) of cider, you will yield about 1.25 gallons (4.7 L) of cider concentrate, so plan your fresh cider processing and equipment accordingly. For example, if you want to make 5 gallons (19 L) of finished ice cider, you will need to start with 20 gallons (76 L) of fresh cider. Not everyone has that much space, enough carboys or the right equipment for that amount of raw product, so keep that in mind as you plan your first batch. Your home brewery may be better suited to make smaller batches. In addition to PET carboys or plastic buckets for freezing the cider, you will need a primary fermenter with an airlock that can accommodate your concentrate with a minimal amount of headspace. You will also need a refractometer that can measure from 20 to 60 °Brix (which can be a challenge to find. Two refractometers that can cover that range works, too) as well as a hydrometer, a racking cane and tubing, a means to test for sulfite and total acidity (TA), and a supply of 10% sulfite solution. (All of the necessary items are likely readily available in the winemaking section of your local homebrew shop.) To make the sulfite solution, dissolve 10 grams of potassium metabisulfite, into about 50 milliliters (mL) of distilled water. When it is completely dissolved, dilute to 100 mL total with distilled water. You may also want

Top photo: Better Bottle PET carboys, filled with slowly-melting frozen cider, are releasing a thick, syrupy solution. When the bulk solution drops to near 30 °Brix (~1.130 SG), it is time to stop collecting the runoff.

Bottom photo: Aging ice cider in oak can add some tannins and other notes.

some kind of inert gas — such as nitrogen, CO_2 or argon — to keep your container topped off and prevent oxidation. Cleanliness and sanitation are also just as important here as in any brewing project.

Freezing the Cider

Space and equipment is also an issue for freezing the fresh cider. Probably the easiest way to freeze the cider is in a PET carboy, which will be the easiest to lift and handle so that you can turn it over and collect the extract in another container as it comes out of the neck. (Be sure to leave space for the juice to expand when it freezes. Somewhere around 4.5 to 4.75 gallons/17 to 18 L should be fine). Therefore you will need a means to freeze at least one 5-gallon (19-L) carboy — or more if you plan to make a batch larger than 1.25 gallons (4.7 L). In cold climates this is easy, and the obvious reason why people make ice ciders in these parts of the world — you can put the carboys outside to freeze. If you aren't in that kind of climate, you will need to find a way to freeze the cider solid — such as a chest freezer. According to Eleanor, a typical 5-gallon PET carboy filled with cider will freeze solid in a week at 25 °F (-4 °C), and a chest freezer will be much colder and faster. To be sure your cider is frozen, move or shake the carboy to see if there is any liquid movement. If there is no movement, the cider is frozen.

Extraction

Once the cider is frozen solid, you can begin to slowly melt it to separate the ice from the extract. This is easily achieved by inverting your carboy over a sanitized container to collect the extract. This is where you will need your refractometer, and you will also need to know your target Brix before you start melting. Brix is a measure of the amount of sugar in solution, much like specific gravity. (One degree Brix is equal to roughly 0.004 specific gravity "points" above 1.000, although this approximation get progressively worse at gravities over 1.040.) Since you will be working with samples that are too small to measure with a hydrometer, it is easier to work in Brix as this is the standard scale for winemaking refractometers. Eleanor explained that Eden follows Québec's guidelines for making ice cider, which requires the pre-fermentation sugar concentration must be at least 30 °Brix (~SG 1.130). (See the sidebar on page 56 for Québec's guidelines). At home, shoot for a range of somewhere between 30 and 40 °Brix (~SG 1.130–1.180), depending on what style of finished ice cider you would like to make. Eleanor explains that, just like making beer or wine, higher sugar means greater potential alcohol. "The higher the starting Brix level of the cider concentrate, the greater the residual sugar and alcohol potential of the final product. Using the rule of thumb that 1% sugar by

"As the ice melts, the Brix levels will drop, so shoot for the range of 30 to 40 °Brix (1.130 to 1.180 SG) in the bulk sample."

weight converts to 0.55% alcohol, 30 °Brix (~1.130 SG) means that an ice cider with the minimum 13% residual sugar will have at most (30-13)*.55 = 9.35% alcohol. Starting with higher Brix means you can produce an ice cider with more residual sugar and/or more alcohol."

However, know that even though you will measure a high potential alcohol, the yeast will start struggling and stop fermenting anywhere between 9 and 12% alcohol, depending on the initial Brix. The high sugar content causes a lot of osmotic stress on the yeast. This is important because if you are considering shooting for something like 12%, you might not be able to achieve that. Usually anything over 36 °Brix (1.160 SG) is asking for trouble.

When the cider starts to melt, begin taking samples with your refractometer as it flows into the sanitized collection container. As the ice melts, the Brix levels will drop, so shoot for the range of 30 to 40 °Brix (1.130 to 1.180 SG) in the bulk sample. You can collect extract into the high 20s in Brix (1.080+ SG) as long as you have a sufficient amount collected in the 40s (1.200+ SG). Keep measuring the average of what you have collected in the bucket with a hydrometer to be sure you are meeting your target. You can also test for acidity at this point with a home winemaking acidity testing kit. Eleanor says that Eden shoots for a higher total acidity in their finished ciders than most — 1.2 to 1.4% — but because apples are high in acidity, they don't have to add acid. Regular sweet cider from your local orchard will have a lower acidity than Eden's because Eden uses a specific blend of higher-acid apple varieties, but you as the cider maker can decide what acid level you prefer based on taste. You can add acid if you so choose, but it is not necessary.

> "According to Eleanor, a typical 5.0-gallon PET carboy filled with cider will freeze solid in a week at 25 °F (-4 °C) . . ."

Fermentation

Once you have your extract collected and tested, you are almost ready to ferment. Eleanor explains that you can use a variety of yeasts for ice cider — Eden uses a Riesling wine yeast strain, and Champagne yeasts also work well. She cautions strongly, however, against using any strains of *S. bayanus* yeast, which are commonly used for cidermaking. This is because unlike making hard cider, you are going to stop the fermentation at a certain point to retain some residual sugar. Hard cider, in contrast, is fermented to dryness. *Bayanus* strains, she says, are notoriously difficult to stop, and can even restart after you have purposely stopped fermentation. Also, be sure to allow your extract to warm up to pitching temperatures before adding your yeast. The extract is colder than freezing, and it is not unusual to measure extract temperatures at around 22 °F (-5 °C) when it is first collected. Let it warm up to just over 55 °F (13 °C) before adding any yeast, otherwise you risk inhibiting the yeast. If your extract is not already collected in a sanitized primary fermenter that will accommodate the liquid with a minimal amount of headspace, transfer it.

Canadian Rules for Ice Cider

The United States currently does not have rules governing the production of commercial ice cider. However, the province of Québec, Canada, where ice cider originated, is working to develop a reserved designation for Québec ice cider. Read more about their efforts at (www.cidredeglace-.com/cidredeglace_en.html). The rules for Québec ice cider are as follows:

1. No chaptalization.
2. No added alcohol.
3. During the production of the ice cider, the use of artificial cooling is only permitted for purposes of malic precipitation and only if the temperature is not lower than -4 °C (25 °F).
4. No artificial flavors or colors.
5. Ice cider producers must cultivate the apples required for the production of this alcoholic drink and press the apples as well as carry out the subsequent steps in the production process at their own facility. However, holders of a manufacturer's license can produce ice cider using a maximum of 50% of apples that they did not grow.
6. Ice cider can be infused artificially with carbon dioxide provided that the volume of dissolved carbon dioxide per volume of finished product is 1.5 to 2.5 or 3.5 to 5.5.
7. The present regulation came into effect on December 4, 2008.

A note before pitching the yeast: apples don't tend to have a lot of yeast available nutrient (YAN), so adding yeast nutrients is very important. Eleanor recommends using Go-Ferm Protect from Lallemand (not to be confuse with the similarly-named Go-Ferm. Go-Ferm Protect is specifically designed for difficult fermentations). Follow the manufacturer's instructions. This is a rehydration nutrient, so it needs to be hydrated, then the yeast is added to it, then it is all pitched into the juice. Also, some cidermakers add pectic enzyme to their cider at this point to prevent haze in the finished product. Eleanor says that she does not use pectic enzyme in Eden's ice ciders because of the long, slow process of fermentation, followed by filtering, but you may choose to add pectic enzyme if you would like.

Once the yeast is added to the cider extract, monitor the temperature of the fermentation to maintain a range of 55 to 60 °F (12 to 16 °C). It should take around three or four days to see signs of fermentation. If the temperature of the fermentation gets too warm — more than 62 °F (17 °C), cool it back down. If the fermentation gets too hot it will ferment too fast, which will not only change the flavor characteristics of the finished cider, it will also make it more difficult to stop the fermentation.

Take measurements from your fermentation every few days. Once the lag period is over and fermentation is underway, the cider should fall one to two degrees Brix (.005 to .010 SG) per day — you don't want the gravity to fall too far too fast. For example, if you read 35 °Brix (SG 1.154) one day, you want to see something in the range of 33–34 °Brix (SG 1.144–1.149) the next day. If it is falling faster than that, cool the fermentation down a few degrees. Since the fermentaion will slow as it progresses, it will take at least six to eight weeks to reach the point where you will want to stop fermentation, so you will need to find a place in your home winery where you can maintain a constant temperature for that amount of time. Be sure to prevent oxidation by topping up with inert gas, and always use sanitized equipment to test.

Once your readings come into range for the amount of residual sugar (RS) you would like (for example, Eden's flagship ice cider is 14% RS, 11% ABV), it is time to stop the fermentation. Eleanor says, in her opinion, the best way to stop it at this point is to add some more sulfite solution and make it cold again. When the ice cider is at this point, the environment is pretty hostile for yeast, so a cold temperature like 25 °F (-4 °C) with a dose of sulfite to protect the wine (around 2.5 to 3 mL of the 10% solution per 5 gallons/19 L) should stop the yeast within a day. The yeast will fall to the bottom and you can rack it off the yeast that has dropped to the bottom of the fermenter. After that first racking, keep the ice cider in the cold temperatures for another two or three days and rack it again. You will also filter before bottling and aging, which will further stabilize the cider. Again, be sure to prevent oxidation at this end stage.

Bottling and Aging

At this point you are ready to filter your cider and bottle, or you can age in oak before bottling. Commercially, ice ciders are frequently sterile filtered before they are bottled to be sure they are stable. Without filtration, you run the risk of refermenting in the bottle. Most homebrewers are not equipped to sterile filter. Your best bet, if you don't normally filter your homebrews, is to borrow filtering equipment from a local home winemaker or rent from a local homebrewing supplier. Filter the ice cider down to the lowest possible pad rating you are able to get for your home filter. You can filter at home either with the small plate filters, such as those made by a company called Buon Vino, or you can use a vacuum-style filter, which can also help degas the finished ice cider. It is not a bad idea to add sorbate (2–4 g per 5 gallons/19 L) before bottling. This will prevent any remaining dormant yeast from becoming active agin. Be sure to prevent oxidation by topping up with inert gas if you age in a small barrel or top up your carboy if you use an oak alternative. Once your cider is in the bottle, if you did a good job of preventing oxidation, your ice cider should be good for about five years, and will be best in the first two to three years.

Serving and Pairing

Ice cider is an excellent dessert beverage. In Québec they are commonly served with a cheese course, and pair very well with aged cheddars and blue-veined cheeses. Ice cider is excellent paired with apple-based desserts, crème brûlée or even savory dishes such as duck or pork terrine, and of course . . . *foie gras*. And don't forget, serve your ice cider well chilled! BYO

Betsy Parks is the Associate Editor of Brew Your Own *magazine. For more information about Eden Ice Cider, visit www.edenicecider.com.*

All About Bitterness

IBU calculations

by Terry Foster

Craft brewing these days seems to be all about BIG! Beers have to be over the top in every sense of the word — more flavor, more malt, more hops and more alcohol. Something that caught my ire recently was a beer that quoted a bitterness level of "150 IBU" on the label. That is so unlikely, because that bitterness level exceeds the limit of iso-alpha-acid solubility in beer, especially as this particular one was relatively high in alcohol at around 8% ABV. That means that the number given was probably not a measurement but a calculation. Brewers can make calculations to determine hop bitterness, and I recommend that homebrewers do so. But, a number determined in this way is only informative and useful if you understand the limitations of such calculations. Let's look those calculations and learn how to use them to our advantage.

Definitions

First let's look at what the term IBU really means. IBU is determined by extracting a sample of acidified beer with iso-octane (2,2,4-trimethylpentane) under specified conditions. The ultraviolet absorbance of the extract at a frequency of 275 nanometers is measured, and International Bitterness Units are defined as:

(equation 1)

$$\text{IBU} = \text{absorbance} \times 50$$

If you are interested in the details of this method, they are given in various publications of the American Society of Brewing Chemists, such as *Laboratory Methods for Craft Brewers*. The concept behind this is that this procedure measures total hop iso-alpha acid content of the beer (in mg/L, or ppm), making no allowance for differences in the proportions of the isomers of these compounds. With fresh hops this is approximately true.

This will not necessarily be the case if old hops or various forms of hop extract are used. However, it is generally accepted that this measurement gives a reasonably good correlation with bitterness as perceived by sensory methods (that is by tasting it!), which is why it is widely used by large, medium and small breweries.

Obviously, to determine IBU in this manner, you would need to have the services of a well-equipped and staffed laboratory, or to have the number determined for you by a consulting laboratory. In either case, expense would be involved. And that is where the calculation of IBUs comes in.

IBU calculation

The first assumption is that IBU does measure iso-alpha acid concentration:

(equation 2)

$$\text{IBU} = \text{mg/L iso-alpha acids}$$

We know that this is more or less true for fresh hops, so if you want to use this calculation you should use the freshest hops you can get — which you should be doing anyway!

We know how much alpha acids have been added, from the weight (in grams, G) of hops used and their alpha-acid content (α, %). If we then know how much of the isomerized form of the alpha acids survives through to the finished beer (volume V in liters), which is usually called utilization (U %), we can put together the following expression:

(equation 3)

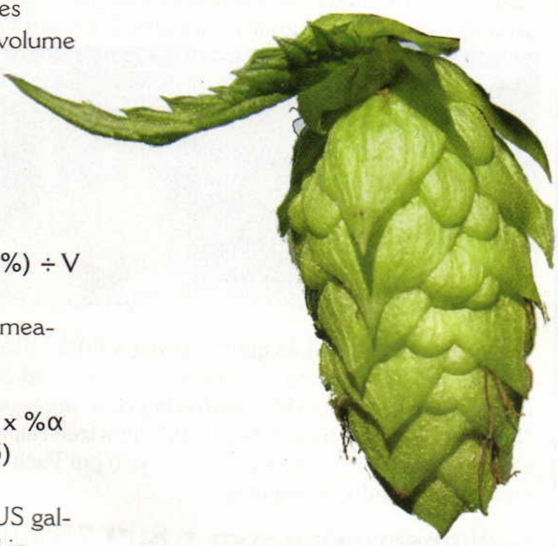
$$\text{IBU} = (G \times 1000 \times \%\alpha \times U\%) \div V$$

Putting this into common US measurements we have:

$$\text{IBU} = (W \times 1000 \times 28.35 \times \%\alpha \times U\%) \div (BV \times 3.785)$$

Where BV = beer volume in US gallons and W is the weight used in

"Brewers can make calculations to determine hop bitterness, and I recommend that homebrewers do so."



ounces.
Reducing this we get:

(equation 4)

$$IBU = (W \times \alpha \times U \times 0.749) \div BV$$

Where α and U are in whole numbers.

Utility of IBU calculation

This equation can be a very useful tool in formulating beer recipes, especially if you have a target IBU in mind, as in cloning a favorite beer. For example, if you want to obtain 35 IBU in a 5-gallon (19 L) brew, by adding Citra hops at 11% alpha-acid, and your utilization is 25%, then:

$$35 = (W \times 11 \times 25 \times 0.749) \div 5$$

Or:

$$W = (35 \times 5) \div (11 \times 25 \times 0.749) = 0.85 \text{ oz } (24 \text{ g})$$

If that is an awkward number and you want to round it up to 1 oz (28 g), what difference would that make to your IBU number?

$$IBU = (1 \times 11 \times 25 \times 0.749) \div 5 = 41$$

That's enough of a difference to be noticeable, but is probably marginally so in a beer with sufficient body to balance the bitterness.

But suppose your recipe calls for 41 IBU with 1 oz. Citra at 11% alpha-acid, yet you only have Northern Brewer at 8.4% alpha-acid and you really have to brew today, how much should you use?

$$41 = (W \times 8.4 \times 25 \times 0.749) \div 5$$

So:

$$W = (41 \times 5) \div (8.4 \times 25 \times 0.749) = 1.3 \text{ oz } (37 \text{ g}) \text{ Northern Brewer}$$

In fact, you could have done this more easily and more accurately without referring to IBU:

$$\text{Citra} = 1 \times 11 = W \times 8.4 \text{ N. Brewer}$$
$$\text{So } W = 11 \div 8.4 = 1.3 \text{ oz } (37 \text{ g}) \text{ N. Brewer}$$

We'll come back to this subject later on in this column.

Downsides of IBU calculation

There are two parameters in Equation 4 (on this page) that are sources of inaccuracy in using it to calculate hop requirements. These are hop alpha-acid and utilization.

Taking the former, there will be errors that we cannot determine. The number given by the supplier will be that which was measured soon after harvesting the hops, and the level of acid will have decreased by the time you actually use them in a brew. By how much will they have decreased? That depends upon a number of factors, firstly that some hop varieties degrade more than others on storage. Secondly, the method of storage will have a big effect. Both heat and oxygen will accelerate hop deterioration, so packaging needs to be air tight, and the package needs to have been stored at low temperature (such as in a freezer). Remember equation 2 (on page 57) only holds true for fresh hops. I've said it before and others have said it many times, but I'll say it again use the freshest hops you can find! Ideally your supplier will have stored the hops separately and will be able to tell you when they were harvested. Always test them yourself — rub a flower or pellet in your palm and smell it. If you get a good clean aromatic odor, with no hint of cardboard or cheese, then you're probably fine. Also, if the sample is discolored, especially if it looks a dark brown color, find a fresher sample.

Then there's the problem that alpha-acids are heterogeneously distributed in the hop flower, and the analysis you have been given is an average value for a sample taken in such a manner as to ensure it is representative of the whole. And the package from which that sample was taken has been broken down into smaller and smaller lots before it reaches you, so it's likely that what you weigh out will not be at all representative of that analysis. This may be a picky point, perhaps, but it is another argument for proper hop selection. Pelletized hops are homogenized in the manufacturing process and the risk that the 1 to 2 oz. sample you take for a brew is non-representative has been minimized. Hop pellets are also usually vacuum-packed, and are much easier to store than flower or cone hops.

Secondly, we come to the thorny question of utilization (U in equation 4). How do we know what value to use for this? There are several factors that influence utilization, starting with the specific gravity of the wort. Put simply the higher the wort gravity the lower the utilization of α-acid. There is also significant loss of iso-alpha acid from the wort during fermentation, some adsorbed by the yeast, some lost to the walls of the vessel as a result of being carried up into the yeast head. It's very difficult to determine how much iso-alpha acid is lost, however, as it will vary with yeast strain, amount of yeast pitched and the vigor of the fermentation. The biggest problem is that alpha-acid utilization depends upon the time of boil as well as the specific gravity of the wort. A consequence of this is that late-added hops can contribute to bitterness, but will do so to a lesser extent than hops added at the start of the boil. Various attempts to quantify these variables have been made, notably by Jackie Rager, Mark Garetz and Glenn Tinseth. The formula produced by the latter appears to have been based on significantly more data than the others, and is generally reckoned to give predictions that are closest to actual IBUs as determined by UV spectrometry. It is however a complicated equation:

$$IBU = (1.65 \times 0.000125^{(Gravity - 1)}) \times \frac{1}{4.15}$$

$$(1 - e^{-0.04xt}) \times \frac{1}{V} (\alpha\ \%/100)\ (W \times 7490)$$

Where t = boil time in minutes, W = weight in oz and V=volume in gallons, and e is a mathematical constant (= 2.71828).

Note that in the case of multi-hop additions you would have to work this out for each addition and sum the results. This is not as difficult as it sounds, since several websites have worked out values for this equation over a range of gravities and boiling times so that you can just read the required number from a table. Search the Web for hop bitterness, for example www.realbeer.com/hops/research.html. Computer brewing programs will also often do IBU calculations for you.

None of these more sophisticated approaches make allowance for errors in alpha-acid levels or for losses during fermentation. What is more they were all worked out on the basis of using hop flowers, not pellets, and it is generally held that pellets give better utilization than flowers, though there's little formal information on this available. The only way to really determine utilization is to measure the IBU in the beer using the prescribed method.

Is it worth the effort?

It is if you want to brew in a consistent manner, especially if you are trying to replicate beers. I believe in keeping things short and simple, so I stick to Equation 4, making the assumption that I have a 25% utilization (as we do in formulating *BYO* recipes). That does not really give an IBU figure, but does give a good comparison from brew to brew. Couple that with careful tasting and you will get a good feel for what it means in your own brewery.

If you really want to keep it simple, all these equations contain the term (oz x α%), where α is in whole numbers. That is also called AAU, or alpha-acid units. It must be used with a little care, for you need to make allowances for changes in beer volume — adjust downwards for 3 gallons (11 L) from 5 gallons (19 L) for example. But it is a simple calculation to do, does not involve assumptions and is a reasonable approximation when you want to compare additions, or to substitute one hop for another. BYO

Terry Foster writes "Techniques" in every issue of BYO.

Boil Physics

What happens to wort

by Chris Bible

Boiling the wort is a very important step in the brewing process and can dramatically affect the properties of the finished beer. The changes that occur within the wort during the boil include:

- Sterilization of the wort
- Destruction of enzymes
- Protein precipitation (hot break)
- Color and flavor development (Maillard reactions)
- Isomerization of α-acids
- Removal of volatile components from the wort
- Concentration of components within the wort (via the removal of water)
- Oxidation of components within the wort

How boiling happens

As thermal energy is added to a liquid, the molecules within the liquid vibrate faster and faster in direct proportion to the amount of energy absorbed. As the vibration of the molecules within the liquid becomes more and more vigorous and the average speed of the molecules increases, the molecules eventually reach a point where they are able to overcome the attractive forces within the liquid and also overcome the external pressure of the gas-phase atmosphere above the liquid. As the liquid is heated, its vapor pressure increases until the pressure equals the pressure of the atmosphere. Bubbles of gas-phase molecules form within the liquid, then rise to the surface and escape from the liquid into the gas-phase atmosphere.

Boiling point definition

A liquid that is boiling is undergoing a phase transition from the liquid phase to the gas phase. The temperature at which this occurs is the temperature at which the vapor pressure of the liquid equals the pressure of the atmosphere above the liquid. This is called the boiling point of the liquid. The normal boiling point of a liquid is the temperature at which its vapor pressure is equal to one standard atmosphere (14.7 PSIA or 760 mmHg). For water, the normal boiling point is 100 °C (212 °F). Figure 1, below, presents an illustration of boiling water.

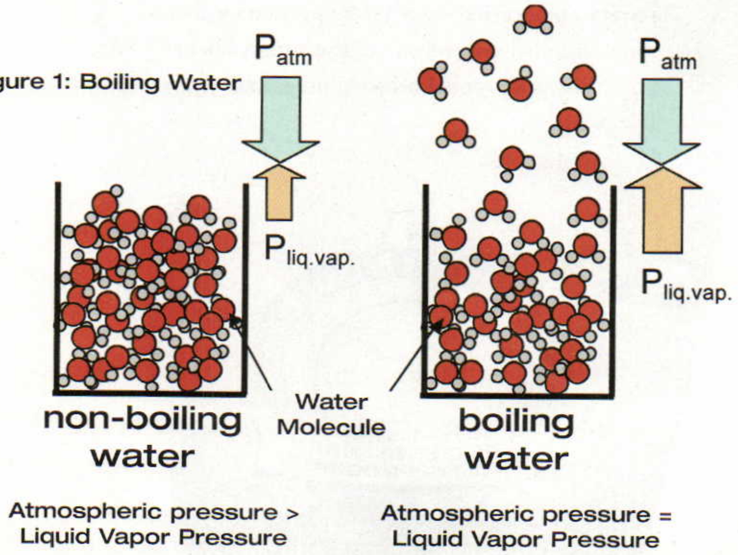
Bubble nucleation

In order for a liquid to boil, bubbles must form. It is possible for bubbles to form within the bulk of the liquid (homogeneous nucleation) but, from a thermodynamic perspective, this is energetically unfavorable even when the liquid is heated to the boiling point. It is much more energetically favorable for bubbles to form at nucleation sites within the system where there are already-existing phase differences (heterogeneous nucleation).

Bubble nucleation sites within a boiling system are typically tiny crevices or imperfections on the surface within the heating vessel, or spots on the heating surface with lower wetting properties. Solids that are suspended within the liquid can also act as nucleation sites. At nucleation sites, the effective surface energy for the gas-phase molecules is lower and therefore the free energy barrier to bubble formation is reduced.

“The temperature at which this occurs is the temperature at which the vapor pressure of the liquid equals the pressure of the atmosphere above the liquid.”

Figure 1: Boiling Water



Heterogenous bubble nucleation can also be observed in a less-than-clean (or purposely etched) glass filled with beer. Carbon dioxide bubbles within a glass of beer will tend to form around impurities or imperfections within the glass. Figure 2, on page 63, illustrates the concept of bubble nucleation sites.

Effect of dissolved solids on boiling point

The boiling point of a liquid is affected by things that impact either the vapor pressure of the liquid, or the pressure of the gas-phase atmosphere above the liquid. The vapor pressure of the liquid is impacted by the presence of dissolved substances within the liquid. Dissolved substances within a liquid effectively reduce the vapor pressure of the liquid in proportion to the concentration of the dissolved substance. The dissolved substance can be thought of as "getting in the way" of the molecules that are trying to push out and escape from the bulk of the boiling liquid. In order to overcome this "extra" resistance, the molecules need more energy, so the boiling point of the liquid will increase.

For a dilute, ideal solution the degree to which a dissolved substance will cause boiling-point elevation is directly proportional to the molal concentration of the solution. For a non-ionic solution in which no molecular disassociation occurs in solution, this relationship is expressed as:

$$\Delta T_b = K_b \cdot mb$$

Where:
ΔT_b = boiling point elevation (°C)
K_b = a constant. (For water K_b = 0.512 °C per moles/liter of dissolved solute)
m_b = concentration of dissolved substance (solute, expressed in moles/liter)

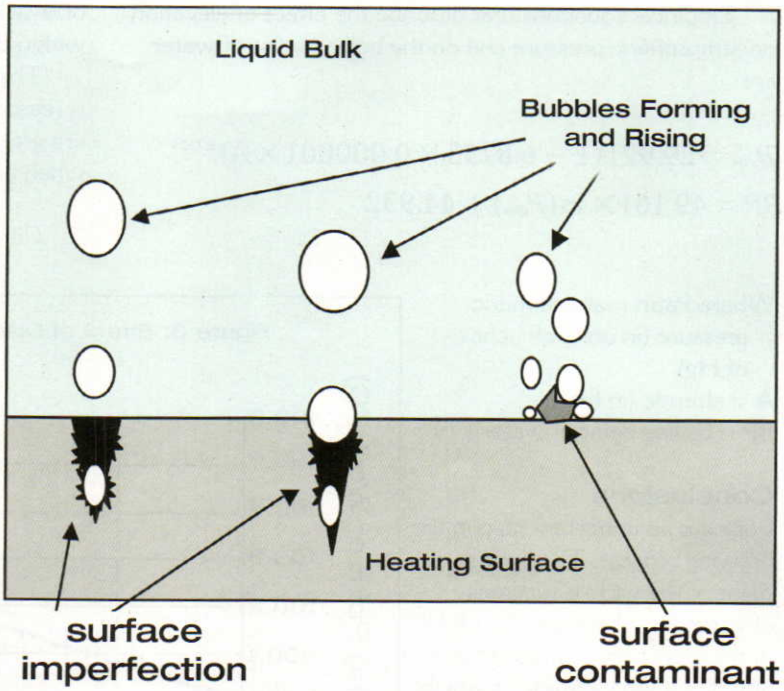
The presence of dissolved substances has little impact on the boiling point of wort because the concentrations of dissolved sugars in the wort are relatively low. Figure 3 (page 64) illustrates the impact of dissolved maltose sugar on the boiling point of wort for concentrations in the range of interest to brewers.

Effect of atmospheric pressure on boiling point

The boiling point of a liquid is affected by the pressure of the gas-phase atmosphere above the liquid. At higher atmospheric pressures more energy (higher temperature) is required for the molecules within the bulk of the liquid to escape into the gas phase. Increasing the pressure over a liquid increases the boiling point of the liquid. It is this property that is exploited when we use pressure cookers. Conversely, lowering the pressure over the liquid reduces the amount of energy that is required for the molecules to escape from the liquid. Lowering the pressure over a liquid reduces the boiling point of the liquid.

The pressure of the atmosphere is affected by elevation. At higher elevation there is less air "pushing down" on any particular point. At lower elevation there is more air pushing down on any given point. As an analogy, recall a time when you were swimming and dove down into the water. The deeper you dove, the more pressure you felt from the water pushing down on your body. We can think of our atmosphere as an ocean of air. If we are at sea level, then we are at the bottom of the ocean of air. If we are on a mountain top, we are less deep within the ocean of air.

Figure 2: Illustration of Bubble Nucleation Sites



Empirical equations that describe the effect of elevation on atmospheric pressure and on the boiling point of water are:

$$P_{atm} = 29.921\,(1 - 6.8753 \times 0.000001 \times A)^{5.2559}$$

$$BP = 49.161 \times \ln(P_{atm}) + 44.932$$

Where Patm = atmospheric pressure (in units of inches of Hg)
A = altitude (in feet)
BP = boiling point of water (°F)

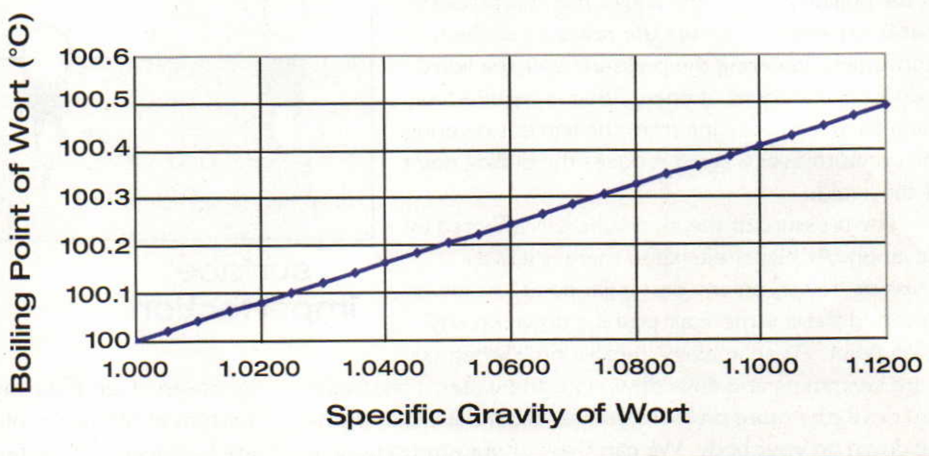
Conclusions

Boiling is an important step in the brewing process. The boiling point of the wort is minimally affected by substances dissolved in the wort, but is more strongly affected by the altitude at which the boiling is done. Temperature within the boil impacts several important things including hop utilization, rate of isomerization of α-acids, color formation and hot break development within the wort.

The impact of boiling temperature on these parameters is reasonably small at lower elevations, but these impacts are greater at higher elevations and should be considered when brewing beer at high altitude.

Chris Bible is BYO's *"Advanced Brewing" columnist.*

Figure 3: Effect of Dissolved Sugar on Boiling Point of Wort



Fermentation Conversion

A kegerator and fermentation chamber

by Christian Lavender

Modifying your kegerator for use as a fermentation chamber is useful and can be an easy task to accomplish. You can make your kegerator an ideal storehouse for lagering at different temperatures or for your open/closed fermentations with the installation of a temperature controller and an airlock.

A kegerator fermentation chamber lets you keep your beer's fermentation temperatures stable. I modified my kegerator to let CO_2 escape and monitor temperature with a temperature sensor. The modification will especially come in handy when brewing some of my wheat beers where open-air fermentation is the preferred method. The positive pressure of CO_2 that collects inside the kegerator from active fermentation is adequate for keeping the beasties out during primary fermentation.

Additional benefits for using a kegerator chamber for your fermentations include a more controlled sterile environment, reduced UV light exposure (sun, fluorescent, halogen, etc.) and my personal favorite benefit . . . it doubles as a kegerator!

There are many different methods of building a fermentation chamber using manufactured or homemade kegerators, but the following method was created with economics in mind. If your kegerator is already a freezer conversion, using an inline power flow regulator as a temperature controller (such as the Johnson Controls Manual Thermostat Control Unit), will make your conversion fairly simple. Most freezers have an airtight chamber, so you may want to install a one-way valve that will enable the CO_2 produced from the fermentation process to escape. You will need to make a one-way vent or airlock and install it somewhere in your freezer's chassis. The door or hatch is usually the best choice as it is free of coolant lines.

The simplest way to install a one-way gas vent is to use a hole saw bit to drill a hole big enough for a rubber stopper and install an airlock. If the freezer is a chest freezer, this can be done in the top of your kegerator hatch. If your kegerator opens out, you can build or re-purpose a small box out of wood or metal and install the same system by drilling through the top of the box, or by fabricating a lightly spring-loaded vent system utilizing "accordion technology." To make an exit valve vent in this way, you will need a helical torsion spring, or a lightly spring-loaded hinge, thick felt, very thin suede, screws, white glue and a small piece of thin wood.

First, drill a hole into the door of your kegerator using a 1 to 2-inch paddle bit or hole saw bit. Next, cut your piece of wood to fit over this as a flap. Finish your wooden vent flap and then use the white glue to attach the felt to the wood and then the suede to the flap. While the glue is drying, mount the wooden flap with the hinge and spring or spring-loaded hinge. The spring tension should be enough to hold the flap shut except when pressure causes it to open from the inside.

"A kegerator fermentation chamber lets you keep your beer's fermentation temperatures stable."

Parts and Supplies List

(To make one kegerator fermentation chamber)

- Kegerator (I used a Haier Brewmaster Kegerator)
- Power drill
- 5/32 inch drill bit
- 5/16 inch drill bit
- 1 1/8 inch Speedbor bit
- Thermowell stopper
- Airlock
- LOVE temperature control switch TS-13010
- Temperature sensor (Thermister) with M8 disconnect cable

Make your kegerator work double duty with this easy project to convert it into a fermentation chamber.

1. GATHER YOUR TOOLS

Before I started the assembly I needed to take inventory of my tools and supplies to make sure I had everything I needed to get the job done. A quick run to the hardware store left me the proud new owner of a set of Speedbor drill bits, which are perfect for drilling down through the first layer of plastic and the second layer of particle board top of the kegerator. I used a LOVE Temperature control switch, but you could use a Ranco, Johnson or Auber temperature controller to achieve the same results. I got the Thermowell stopper with airlock assembly from MoreBeer! and the temperature sensor thermister with M8 disconnect cable from Brewers Hardware.

2. PREPARE THE KEGERATOR

Not a ton of prep work needed here, but you need to clear the top and inside of the kegerator to make sure you don't hit anything like the CO_2 tank or kegs of beer when drilling. The top will most likely have no refrigerant lines running through it, but always carefully look at those hinges for lines running to the top. If you are using a side door model unit with a tower-style beer dispenser, you will have to remove the inner plastic lining to see where the refrigerant lines run. You must be able to see the refrigerant lines to determine where to drill your pilot hole. Once the lines are revealed, choose a spot where you will have at least a ¼-inch clearance around the hole that the thermowell will be mounted through.

3. DRILL THE PILOT HOLE

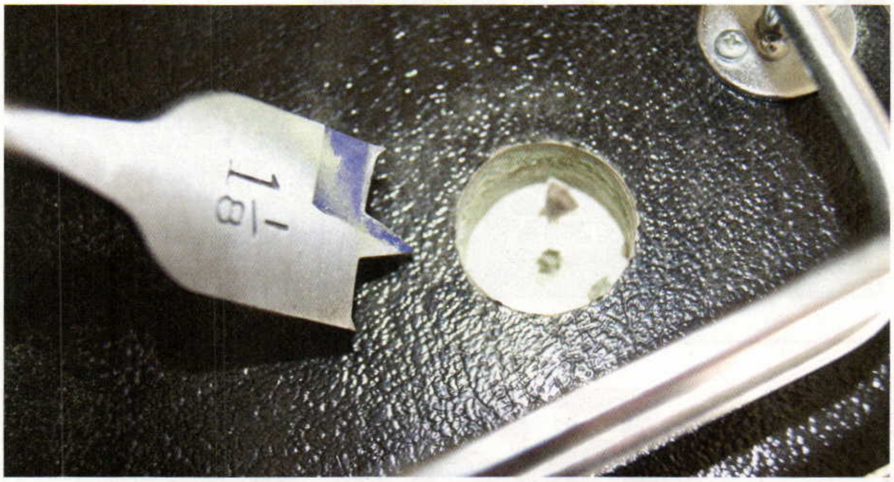
There were no coolant lines on the top of the Haier Brewmaster kegerator that I chose to use for the project, so it was time to start drilling. Using the 5/32-inch drill bit I started the pilot hole 2 ¼-inches from the right edge and 2 ¾-inches from the back edge. There are five layers you need to drill down through, including the thin top layer of plastic, wood particle board, plastic water barrier lining, foam insulation layer and then the inner plastic lining. You should see the drill bit exit through the inner kegerator lining leaving a small hole in the back right corner.

4. HOLE FROM THE INSIDE

Place the larger 5/16-inch drill bit in the drill and repeat the steps to widen the pilot hole. I am drilling in steps with different sized drill bits so as to not split or tear any of the materials in the kegerator top. The key is not to rush the drilling process - you only have one shot at this, so take your time and make nice smooth cuts until the hole is wide enough that your thermowell fits through and has a tight fit.

5. DRILL THE STOPPER HOLE

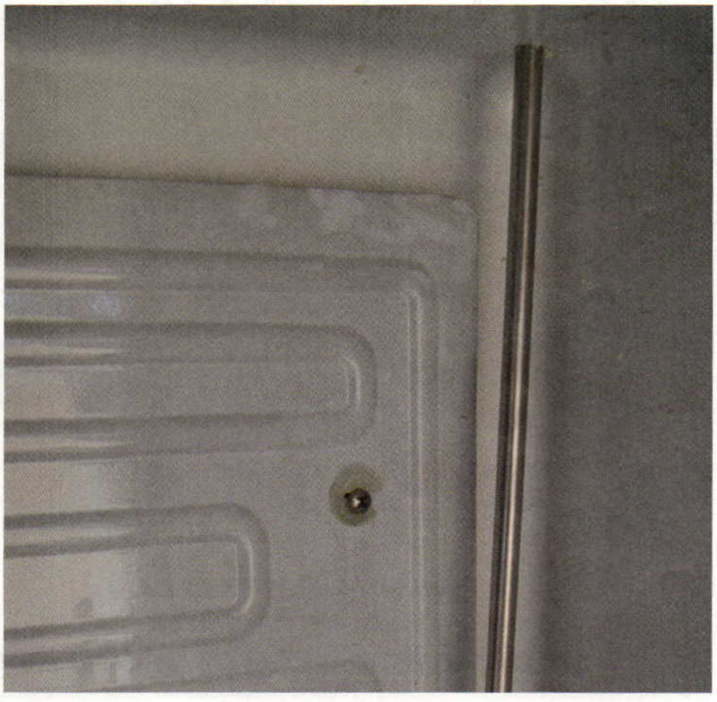
Next, ready your 1 1/8-inch Speedbor bit and start drilling down through the top plastic and particleboard top of the kegerator. You have to drill through the plastic top coat and particle board slowly until you reach the foam insulation layer and then stop. DO NOT drill all the way through. Again, drill down slowly and try to make the cut as accurate as possible. This is the hole the rubber stopper will fit into.

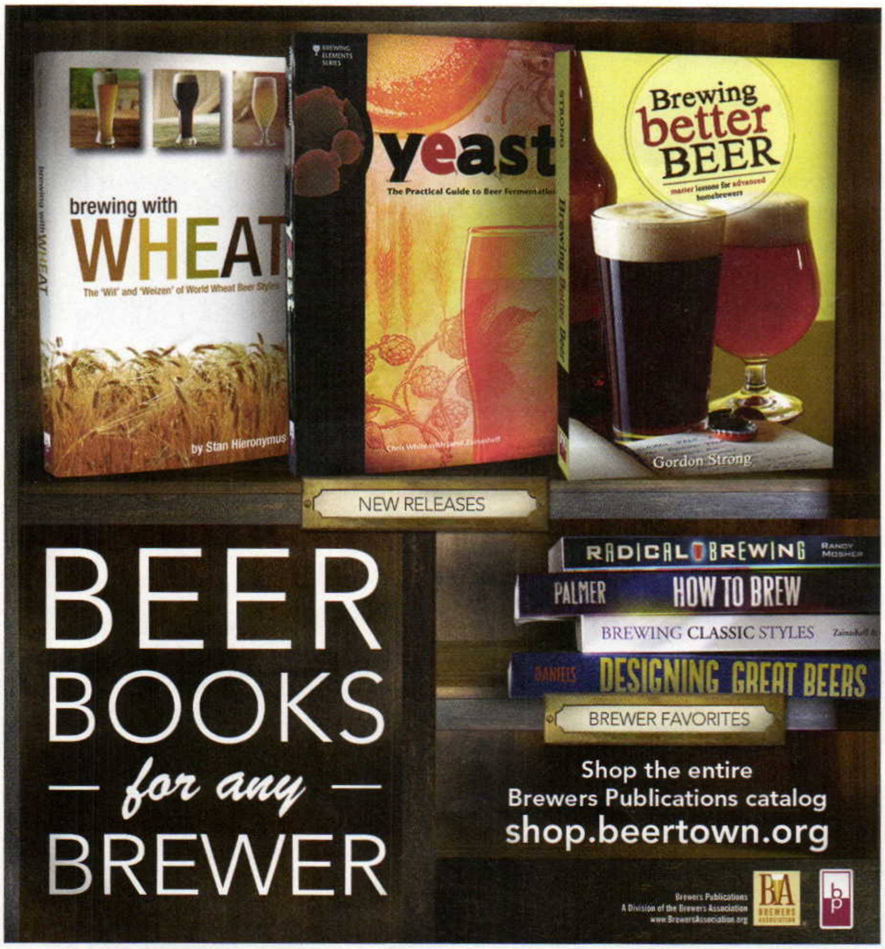


6. MOUNT THE THERMOWELL AND CONTROLLER

Give your new stopper hole a quick sanding and then slip the thermowell tube and stopper down through the drilled holes until the stopper fits tightly in place. The picture shows the thermowell rod in the back right corner of the kegerator. Make sure the location you choose does not get in the way of your kegs or CO_2 tanks. Next, pop your airlock into the stopper and mount your temperature controller in the location of your choice. I used a zip tie on the railing of the kegerator. Finally, wire your temperature sensor into your temperature control switch (use the manufacturer's directions on this and use caution when doing anything electrical). Slide the thermister probe into the thermowell and you are ready to monitor your fermentation temperatures inside the kegerator. BYO

Christian Lavender is a homebrewer in Austin, Texas and founder of Kegerators.com and HomeBrewing.com.





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Grains to Treats

Make spent grain dog biscuits

Ron Dorsey • Scotts Valley, California

Like probably every other homebrewer out there who has ventured into all-grain brewing, I found myself wondering what to do with my spent grains.

After searching the Internet for more information, it seemed that the majority of brewers were A) throwing them out, B) using them as compost, or C) using a small portion of them in a bread recipe. I liked the idea of using them to make bread, but it just didn't require enough grains to use them up. Then one day I stumbled upon somebody who wrote about mixing up treats for their dog using the spent grain. I have two German Shepherds at home, so that idea sounded like a great way to re-use the grains while saving some money on dog snacks. I looked into the idea a bit, experimented with different ratios of ingredients and found a simple recipe that was quick and easy to make, which was important since whatever meager brewing skills I possess do not transfer over to baking!

> "Before diving in with a full-scale batch, I whipped up a small test batch to see if my dogs would like them — check."

Before diving in with a full-scale batch, I whipped up a small test batch to see if my dogs would like them — check. I then gave some to my in-laws for their dogs to test — check (although they eat anything, so that didn't exactly confirm anything). I gave a few to friends who have dogs — check. Finally, I gave a few to friends who had dogs that were deemed "picky eaters" and they snatched them up, too.

Once I passed the "taste-test'" phase, I decided to take my treats one step further: instead of just making round shapes I decided to press them into dog bone-shaped biscuits. All I needed was a cookie cutter in the shape of a dog-bone, which my wife found at a local bake shop. I then spent the next night making a few batches while the dogs went crazy with the smell of "beer biscuits" wafting through the house. Now, whenever I'm mashing, I have two faithful companions who lay as close to me as possible . . . hoping for more treats!

I am currently in talks with my local feed store to carry the biscuits. The best part of this arrangement is that I cannot only reuse more of the grains from my brews, but also make enough money to pay for the grains themselves which equals free beer!

Notes:

- Do NOT add hops to the grain as hops have been shown to be toxic for many breeds of dogs!
- Save the spent grains in a large bowl/pot after mashing.
- If you are not using the grains within 24 hours of mashing, refrigerate them to avoid spoilage. BYO

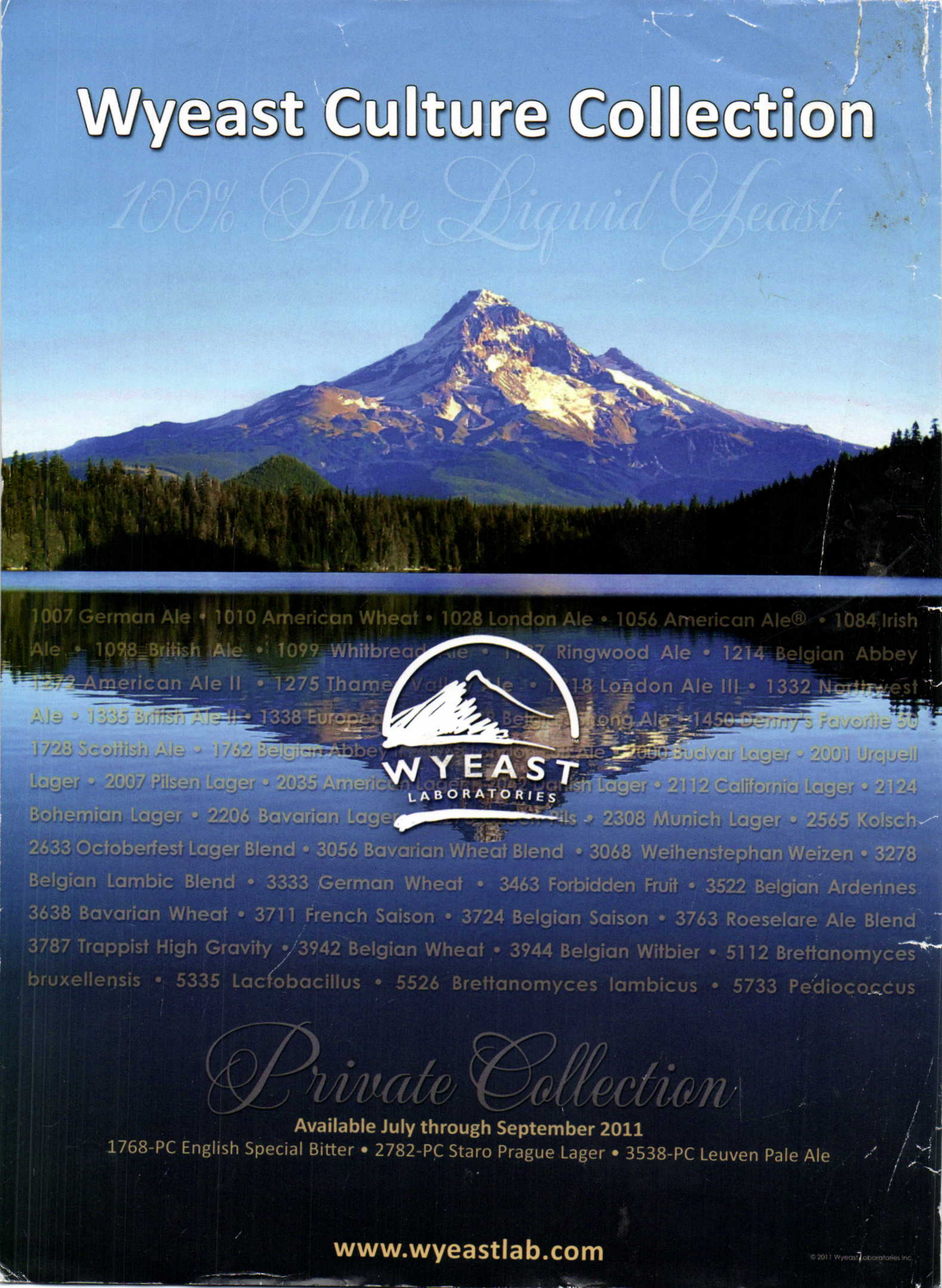
Photo courtesy of Ron Dorsey

Ron Dorsey uses his spent grains to make dog biscuits for his two German Shepherds.

Dog Biscuit Recipe
(yields 40 medium-sized biscuits)

Ingredients
4 cups spent grain
1 cup peanut butter
2 cups flour
2 eggs

Step by step
1. Mix the ingredients together and press the dough onto parchment or wax paper, about ¼ thick.
2. Cut the pressed dough into shapes with a cookie cutter or using a knife.
3. Place the treats onto parchment paper on cookie sheet and place in a 350 °F (177 °C) oven.
4. Bake at 350 °F (177 °C) for 30 minutes.
5. After 30 minutes, drop the oven heat to 225 °F (107 °C) and bake for two hours. When the treats come out they should be dry and crunchy so they do not spoil/mold. If they are not dry after two hours, increase time at 225 °F (107 °C). You want to dry them, but not cook them to the point where they are hard to break.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