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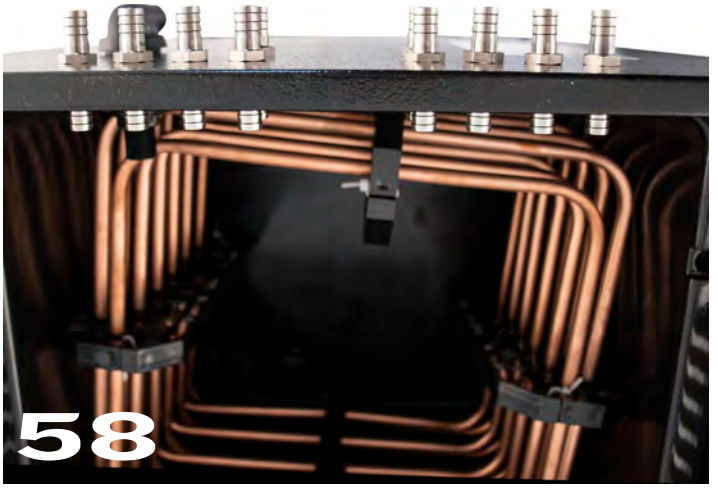

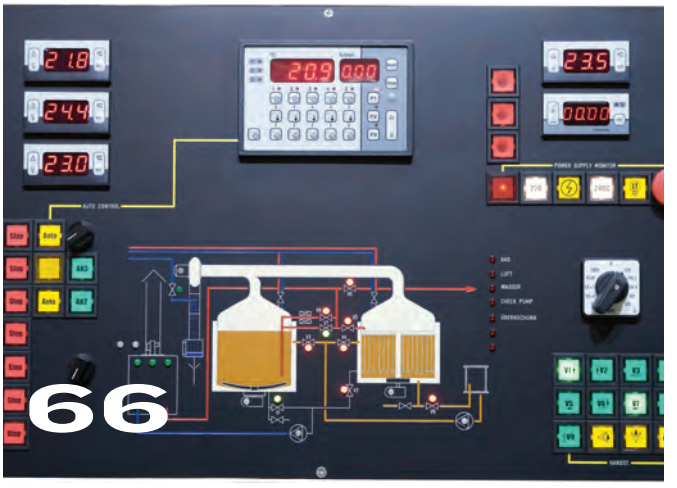

features

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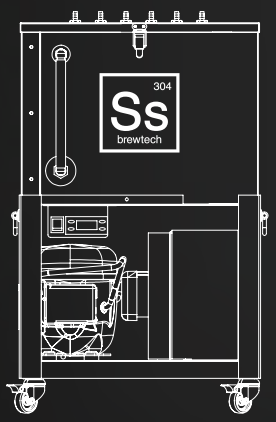
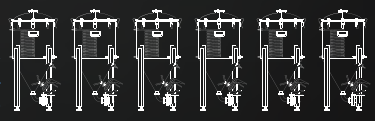
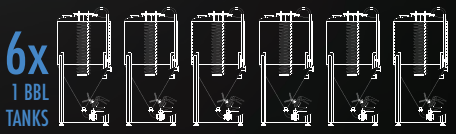
4.75 GAL RESERVOIR	10.0 GAL RESERVOIR	22.0 GAL RESERVOIR
3x 7 GAL TANKS	6x ½ BBL TANKS	6x 1 BBL TANKS







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RECIPE INDEX

RECIPE STANDARDIZATION

EXTRACT EFFICIENCY: 65%
(i.e. — 1 pound of 2-row malt, which has a potential extract value of 1.037 in one US 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. For post-boil hop stands, we calculate IBUs based on 10% hop utilization for 30-minute hop stands at specific gravities less than 1.050. Increase hop dosage 10% if using whole leaf hops.

Gallons:
We use US gallons whenever gallons are mentioned.

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Cover Photo Illustration:
Charles A. Parker/Images Plus

Q

Maibock seemingly is the only clear "spring style" of beer. Do you nominate any others?

Well, of course rye IPA is the right beer anytime! But early spring when it's still coolish could be time for an American brown or a dunkel. Late spring as it warms I'm thinking Belgian … maybe a tripel or golden strong works for me!

I drink all styles all year round, but I do have some preferences. Certainly, Irish styles come to mind (St. Patrick's Day) so Irish stout, Irish red ale, and similar styles are appropriate. Maibocks are moderately strong and malty, so styles with a similar profile could work. Scottish ales, Belgian dubbel, strong bitters, strong amber lagers, and similar beers all qualify. De Dolle's spring seasonal, Boskeun, is a strong pale ale with a Belgian flair. Beers that have a floral note could suggest spring. Just try something other than an IPA and you'll be fine.

Maibock is a great, traditional spring style beer. What other ones would be good? I think both hazy IPAs and kveik beers would be great. They are two of the most popular styles now, and each has a lot of room to be creative with ingredients to make something unique. Fruit can be used, and bacteria and *Brett* can also add unique characteristics. How about a Maibock made with a kveik yeast? Enjoy.

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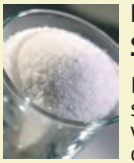
Electric Brewing Q&A

If the electric brewing bug has started to fester in you . . . be sure to check out this Q&A with two of pioneers in the field of electric brewing or e-brewing: Kal Wallner and Trent Neutgens. It has tons of practical information for those who are approaching this brewing format. https://byo.com/article/electric-brewing-q-a/



Brewing Sugars & How To Use Them

If you are looking at specific sugar types with an explanation on best practices for them, John Palmer breaks down the breadth of available choices and how they can impact the final beer. https://byo.com/article/sweetness-brewing-sugars-how-to-use-them/

Dynamics of A Glycol Chiller

So you got yourself a glycol chiller . . . but what temperature should you set the glycol? And how shall you run it efficiently and effectively? Find guidance and pointers from a seasoned pro. https://byo.com/mr-wizard/a-deep-dive-into-the-dynamics-of-glycol-chillers/

MEMBERS ONLY

Portable RO Water System

If you're ready to invest in a reverse osmosis (RO) system, but having trouble deciding how to best utilize it for your homebrewery, consider building your own portable RO system with water storage capacity and the ability to lift the water for transfers. https://byo.com/project/portable-ro-system-water-on-the-go/

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STEAM JUICING FRUIT

I'd like to add my two cents on the use of fruit in brewing. While I thought the "Mr. Wizard" column that featured a question about freezing fruit from the November 2019 issue was spot on in what it said, I'd add that there are other ways to add fruit to beers, ciders, and meads.

I live in a part of the country that has fruit available for foraging year-round, and I often pick more apples, prickly pears, peaches, pomegranates, grapes, etc. than I could ever use in a single batch of beer/mead/cider, which means I need to preserve it in some way. A simple $100 investment in a steam juicer makes quick work of processing fruit (with great yields), especially if frozen first to break the cell walls. The quality of the juice that I get from a steam juicer is much better than what I could get through other extraction methods. Additionally, the pasteurized juice can go right into mason jars to be capped, cooled, and pitched into whatever within just a few hours, or one could even can the juice in a water bath canner (if pH isn't low enough, either adjust with an acid, or use a pressure canner) for use at a later date. Canning is also a useful skill that requires a minimal investment to get started.

Should anyone be concerned about the volume of liquid that would be added through juice, I've successfully reduced many juices down to a fraction of their volume. Being careful not to scorch or burn the juice means that there isn't an impact to flavor.

As a cidermaker that picks apples by the bucketful from May through October, a steam juicer and canner means I can stockpile ½-gallon (2-L) jars of juice until I am ready to blend and ferment.

Elena Putman • *via email*

BYO*'s "Mr. Wizard" columnist Ashton Lewis responds: "This is excellent! I was not familiar with this method . . . very cool!"*

WORT PRIMING EQUATIONS

Thank you for publishing the recent "Advanced Brewing" column "Dose Carbing" by Colin Kaminski (November 2019 *BYO*). It was very informative and helpful. Unfortunately, there seems to be a problem in the equations that involve priming with wort. In brief,

contributors

Nicholas McCoy has been homebrewing for over a decade and has travelled the world in search of great craft beer. He owns FBS Printing Company in Dallas, Texas and is a father of two girls. He brews regularly with **Jeff Poirot**. Jeff has been homebrewing for 15 years. He has spent not only his vacations but any time he can spare reading about brewing, studying what others say about being a better brewer, and contemplating new batches to brew with Nick. Nick and Jeff are members of Draft Punk homebrew club and in 2017 the pair won the Ninkasi Award at the National Homebrew Competition with multiple first place awards.

Beginning on page 34, the pair share their tips for homebrew competition success.

Gordon Strong is the President and highest ranking judge of the Beer Judge Certification Program (BJCP), the organization that certifies beer judges for homebrew competitions and also registers qualifying homebrew competitions. In addition to his Grand Master Level V judge status, Gordon is a three-time winner of the National Homebrew Competition Ninkasi Award and the author of homebrewing books *Brewing Better Beer* and *Modern Homebrew Recipes*. He has been *BYO*'s "Style Profile" columnist since 2015 and is a frequent feature story author. He is also a past BYO Boot Camp Speaker, and will be leading the "Advanced All-Grain Techniques" Boot Camps in Denver, Colorado on March 26 & 28.

In this issue, Gordon explains the benefits of building up water profiles beginning with reverse osmosis water on page 50, and explores German weissbiers in his "Style profile" column on page 26.

Geoff Parkins is an American Boat and Yacht Council-certified marine electrician, with 20 years of experience in power distribution systems for large yachts. Frustrated with repeatability struggles on his propane rig, Geoff built a ½-bbl automated system that cured the repeatability blues and is now focused on recipe development. He's been able to move from the driveway to his garage, which he feels is a victory on his road to taking over the living room. For now, homebrewing is a hobby, but he's taking a hard look at trading in a long commute and a steady paycheck for the uncertainty of opening his own brewery.

Geoff makes his *BYO* writing debut beginning on page 66 as he shares what homebrewers need to know before beginning to build their own electric brewing system.

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Asheville Multisport & Brewery Adventure

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Set in the Blue Ridge Mountains, Asheville, North Carolina has a little something for everyone. With its gorgeous natural areas to explore, the most craft breweries per capita of any US city, a blossoming farm-to-table restaurant movement, and a booming art district, it's not hard to see why Lonely Planet named it the #1 Best US Travel Destination. We'll tour and taste at a number of craft breweries including well-known brewers such as the beautiful facilities at Sierra Nevada and New Belgium as well as smaller local brewpubs and small-batch breweries. In addition we'll visit White Labs to learn about their yeast production, and River Bend Malt House to check out their malting process. On this tour, we pair amazing hikes on the iconic Blue Ridge Parkway (and the surrounding areas) and a paddle down the French Broad River with a wide variety of Asheville's legendary craft beers. Come join us in Asheville for five full days of great local beer, hiking, and exploring all that Asheville has to offer.

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MAIL

the left side of this formula determines the total grams of CO_2 needed to achieve the desired level of carbonation. The right side is for the grams of CO_2 that can be produced from a gram of wort. Plugging in typical values from a 5-gallon (19-L) batch suggests over 200 liters of wort would be needed. That's a lot of wort! The critical change is that the left side of the equation (needed grams of CO_2) needs to be divided by the right side (grams of CO_2 from a gram of wort), not multiplied. The equation for $Liters_{krausen}$ also seems to need division rather than multiplication.

A second change that I recommend is to express the real degree of fermentation (RDF) as a decimal (that is, RDF/100) rather than a percentage. The resulting equation yields the grams of wort that are needed. The advantage is that it makes the formula easier to understand by keeping everything in gram units. Converting from grams of wort to liters is easy: Divide by 1,000. (1 g = approximately 1 milliliter wort).

Gary Fisk • *via email*

BYO*'s "Advanced Brewing" columnist Colin Kaminski responds:*

"Thank you for catching that error. I wish I could blame my patient editor but that one was my mistake. I was using three spreadsheets to check that equation and when I found the same error as you I corrected one and then when we went to publish I pulled the incorrect one. I prefer liters-to-liters, but it would be simple to adjust from liters-to-grams by making grams = liters / 1,000 to get grams as water and then divide by gravity in SG (of the source of new sugar) to adjust for the weight of the sugars.

"The corrected equations are then:

$$Liters_{wort} = (CO_{2desired} - CO_{2measured}) \times 1.969 \times Liters_{beer} / (0.5055 \times RDF \times (OG / 100)$$

and

$$Liters_{krausen} = (CO_{2desired} - CO_{2measured}) \times 1.969 \times Liters_{beer} / 0.5055 \times [(CG - FG_{expected}) / 100)]$$

Thank you again for reading so closely."

WRITE TO *BYO*

Have a question about something you've seen in *BYO*? Want to show off your latest DIY homebrewing gear or recipe? Write to us at: edit@byo.com, find us on Facebook: www.facebook.com/BrewYourOwn, Instagram: @brewyourownmag, or reach out to us on Twitter: @BrewYourOwn.

BEGINNER'S BLOCK

BY DAVE GREEN

MALTING VS. MASHING

These two terms, malting and mashing . . . what do they mean to you? The malting process is a fairly broad and generic term given to processing raw grains just as mashing can have a fairly broad definition as well. So let's delve in to investigate why these two terms can be so fluid and to use this understanding to your benefit as a brewer.

The malting process begins with the raw seeds of a cereal grain, sometimes referred to as berries of the grain. For brewing, the grain is typically barley but wheat, rye, and oats are commonly used as well. The malting process starts with steeping in water. This is simply to hydrate the seed. Next up, in the same way a gardener might start the seeds for the summer's garden, the maltster germinates the seeds in a warm and humid place allowing them to sprout. The germination step is vital for brewers since it gets a few key biological processes into gear in the grain including the formation of the enzymes that all-grain brewers are going to need during the mashing process. Without this key germination step, brewers would be unable to process all the starch that the grain contains . . . no starch conversion, then no sugar . . . no sugar, then no fermentation . . . no fermentation, then no alcohol.

All malted grain goes through this germination step, but once that happens the processes diverge, leading down multiple paths to end up with the cornucopia of malted grains we know. To start, how long the grain is allowed to sprout changes the proteins, enzymes, and starches. Next the malts will either be toasted/kilned, drum-roasted, or stewed. If they head off to be toasted, there are a few directions for them to go. They could be lightly toasted to halt those enzymes and create base malts. If they are toasted further, then the enzymes are destroyed, making it a specialty malt such as biscuit malt that requires base malts in the mash to work on the starch. Malts can also get heavily toasted in large rotating drums to become roasted malt. And just like coffee roasting, there is not one set way to toast the grains. Maltsters utilize unique roasting profiles with different times and temperatures to obtain the characteristics of the many specialty malts like pale chocolate, chocolate, and black.

Alternatively, grains could be stewed, which will land them in the class of grains we know as caramel/crystal malts. Stewing implies that these grains will be treated similarly to grains that are being mashed, but without the crush. In that case, the starch in the grain is converted to sugar, but instead of this happening in the mash, it happens inside the grain. Once the stewing is done and the starch is converted to sugar, the grain is then toasted to varying levels depending on what degree crystal the maltster is after. Again, different temperature and timing profiles apply. The fact that it is sugar in the malt and not starch is quite significant for the brewer as these crystal-type malts are much different taste-wise compared to toasted grains. The conversion of starches to sugars is also why these grains can be steeped to add flavor and a mix of fermentable and unfermentable carbohydrates.

By the time the brewer purchases their grains, all this has been done. The maltster has set the stage for the brewer. Now it's time for the brewer to set the stage for the yeast. The sugar profile of the wort, which is just a name for the sugar water produced by a brewer, will be set by the grain selection, the mash temperature profile, and duration of the mash. All this comes together as the enzymes created during the germination stage start to break down the highly complex starch molecules. The target mash temperature allows brewers to favor a specific enzyme, each of which works on the starch granules differently. Cooler and longer duration mashes create drier beer in the end since the enzymes can more finely chop up the starch molecules. Warmer and shorter mashes generally mean fuller-bodied, sweeter beer since the enzymes, figuratively speaking, are going to be randomly hacking at the starch and will produce more unfermentable carbohydrates, a class known as dextrins. And generally the more specialty grains that are added to the mash, the more unfermentable sugars are going to be found in the wort as well.

So what about malt extract? Well, in these products the maltster has completed the process just as they would do for standard malt. But then they actually employ a brewing team to make the brewer's wort in a huge mash. When the wort has gone through the mash phase, it is then vacuum boiled in order to concentrate the solution while minimizing the chemical reactions that typically happen in a brewer's boil kettle (like melanoidin and caramelization reactions). Once the wort is reduced down to syrup at about 80% sugar, then you've got liquid malt extract. The liquid can be further concentrated by a process known as spray drying, which will produce dried malt extract. Dried malt extract has all the water removed. The beauty of malt extracts are that they are brewer's wort . . . simply in concentrated form. The problem some folks have is that you lose control over the mash parameters mentioned in the previous paragraph. But with a skilled touch extract brewers can find ways to adjust these as well with things like sugar substitutions to dry the beer out or body building steeping grains to get a more full-bodied beer.

HOMEBREW DROOL SETUP

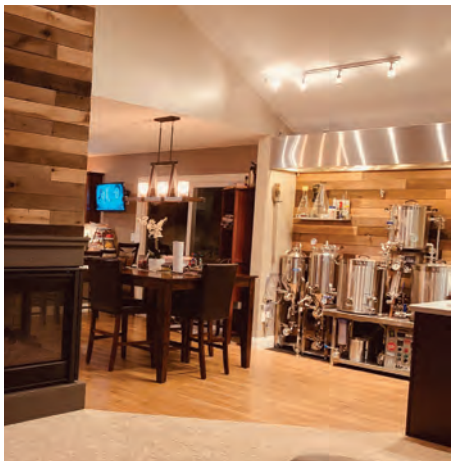
PATRIC LEUSCHKE • EAGAN, MINNESOTA

This brew space has been my pet project for the last eight years. I built the brewing rig five years ago but it wasn't until two years ago that we built an addition on our house to really showcase the brewery. The setup is built on the standard e-HERMS (electric-heat exchange recirculated mash system) principles. I decided to go with a 3-tier, pump-driven system for space savings. For the HLT (hot liquor tank) I repurposed my original 10-gallon (38-L) MegaPot kettle. I have recirculation ports to prevent stratification around the stainless HERMS coil and the water is heated using a Blichmann BoilCoil. This HLT is sized perfectly for 13-gallon (50-L) batches but we are looking at going up to a 15-gallon (57-L) kettle to allow for triple batches. We have a 20-gallon (76-L) mash tun with a Titan false bottom that in my opinion has the best edge seal and pickup, designed for minimal waste and grain disturbance.

For recirculation we use an Ss Brewtech manifold, which does a great job creating a uniform temperature while mashing. For sparge we utilize a three-way valve connected to an Ss Brewtech sparge arm, I built a custom mount that is bolted onto the back of the kettle. This not only provides a more secure adjustable mounting solution, it also doubles as a hook in the kettle for getting the mash manifold out of the way while doughing in. The boil kettle also has a 20-gallon (76-L) capacity, utilizing another BoilCoil for heat and a secondary port for recirculation and whirlpool. On the way to the fermenter the wort passes through a custom-made plate chiller that has a bypass port to prevent clogging. After chilling we have an in-line O_2 system in which we use a flow meter to reintroduce oxygen. Finally, for the bulk of our fermenting we use one of two appropriately-sized Ss Uni Tanks.

For the controller I was lucky to be able to fall back on my dad who happens to be an electrical contractor. The panel is scratch-built and has an added layer of complexity as it had to be childproof. Building out the space for the brewery opened up options that really allowed us to streamline the brewing process. We brought both hot soft water and cold RO water to a hose under the sink to make cleaning and filling the brewery a breeze.

The next challenge was brewing over a wood floor. Our solution was to plumb all brewery components to a drain manifold in the floor so we could CIP (clean-in-place) without getting the floor wet. The hood is also fully functional, it was built by Fast Hoods and connects to a 450 CFM (cubic feet per minute) fan mounted on the side of the house. All non-stainless-steel items such as the glycol chiller, keg fridge, and ingredients are forced to live in the closet adjacent to the brewery. We have videos on the build and brewing process at 8th Hour Brewing on Facebook and YouTube.



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BARTH-HAAS GROUP INCOGNITO™

If you have ever worked with hop extracts, you understand the viscosity of these extracts can be a challenge. The Barth-Haas group went back to the drawing board and came up with a new variety-specific hop concentrate they've named Incognito™, which is flowable at room temperature. It is currently available in Citra®, Mosaic®, Ekuanot™, Sabro™, and HBC 472 varieties and is a 100% all-natural hop product. Currently they come in 2- and 10-kg packaging, and dosing rate is recommended at 59–235 g/bbl or 2–7.6 g/gal. Maximum efficacy of the product is achieved when mixing Incognito™ with hot wort prior to or directly to the whirlpool. https://www.johnihaas.com/incognito/

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DRUNKEN GORILLAS?

A story that was featured in the publication *Popular Mechanics* struck our fancy, about a new book that Oxford University is publishing titled *Humans and Alcohol: A long and social affair*, which theorizes why humans can process alcohol. According to the book our ancestors, the great apes of Africa, would end up eating fruit that had fallen to the floor of the forest to meet the high demands of their daily caloric intake. Often these fruits would have started undergoing alcoholic fermentation. Our ancestors needed the energy found in the fruit and the researchers claim the fallen fruit were often the same alcoholic strength as a common small beer, about 1–4% ABV. So if only the apes that could tolerate the alcohol in the fallen fruits survived . . . well, that's natural selection! To read more about the upcoming book: www.popularmechanics.com/science/animals/a30139147/drunk-gorillas-alcohol-tolerance/

Upcoming Events

2020 WineMaker International Amateur WINE COMPETITION

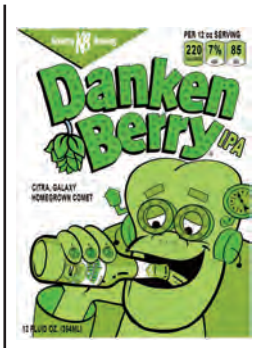
MARCH 17
WineMaker International Amateur Wine Competition is open to all homemade ciders, meads, and wine. Entry deadline is March 17 for the largest amateur competition of its kind in the world. Learn more at www.winemakermag.com/competition.

BrewYourOwn BOOT CAMP

MARCH 26–28
BYO Boot Camps are being held in Denver, Colorado. Join BYO for this unique learning experience, offering a range of in-depth, full-day, small-class brewing courses split over three days. Space is limited, so sign up now. Additionally, there are local craft brewery tours available. Learn more at BYOBootCamp.com.

Brew Your Own — THE HOW-TO HOMEBREW BEER MAGAZINE

25th Annual Homebrew LABEL CONTEST



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These are last year's top winners. Send your labels today for your chance to **WIN GREAT PRIZES!**

Label Contest Entry Form

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All original artwork? Y or N (circle one)

Mail your entry to:
BYO Label Contest
5515 Main Street
Manchester Center, VT 05255

OR

Email your entry to:
dave@byo.com

DEADLINE: April 30, 2020

Rules: Entrants can mail OR email labels to dave@byo.com. The judges say that labels can be attached to bottles full of beer. All rules are made up by the editors of ***BYO*** as we go along. Labels are judged in one category, open to graphic artists and amateurs alike, so ultimate bragging rights are on the line. When submitting your labels, tell us a bit about the artwork and its inspiration. Is it hand-drawn? Created on a computer? Send us your best labels, tell us how you made them, and good luck!

REPLICATOR

BY MICHAEL BURY

DEAR REPLICATOR, While out in Colorado on a business trip, I stumbled upon Knotted Root Brewing Company in the mountains just west of Boulder. I ended up chatting with Co-Founder and Head Brewer Chris Marchio who it turned out went to college just a few towns north of me in Vermont, at Green Mountain College. Tasting his beers, I felt like I was tasting the four best DIPAs coming out of my home state. While they were all delicious, Perpetually Unimpressed was exactly not that . . . it was incredible! While we chatted for a while about Vermont, we never really got into brewing. So if you can track down Chris' recipe, it would be greatly appreciated.

Jeff Sands
Dorset, Vermont

That must've been one enjoyable business trip. I wish I could've been there with you. Thankfully we can take readers on a little trip of our own to Nederland, Colorado, the home of Knotted Root Brewing Company.

Knotted Root stems from the inspiration of Chris Marchio, whose background provided him with the education and tools to pull off his dream. He attended Green Mountain College in Poultney, Vermont, where he developed his thirst for homebrewing that culminated with his senior thesis focusing on sourcing local ingredients and food at a locally-focused brewpub. From there, he went on to study Fermentation Science at Central Washington University in Ellensburg, Washington.

But school only generates bills; it doesn't pay them. Straight out of brewing school, Chris landed his first paid brewing gig at Anderson Valley Brewing Company in Boonville, California. From there he was offered a position to help start Fiction Beer Company in Denver, Colorado as their Assistant Brewer. After a few years at Fiction, he developed his approach to unfiltered IPAs. Through this exploration, he became one of the first brewers in Colorado to brew the style; the beer was named Cosmic Unity. From Fiction, he moved up in the brewing world and was awarded the title of Head Brewer for Joyride Brewing, in Edgewater. But in order to satiate the curiosity sparked from his years of brewing, he desired to own his own brewery. So, in late 2016, he left Joyride and focused solely on developing the brand and vision behind Knotted Root Brewing Company alongside Co-Founder and Operations Manager Chris Klein and Assistant Brewer Jordan Lanter. According to Lanter, "We will make beer with integrity." No compromises.

Knotted Root has a unique philosophy and approach to brewing and managing a brewery. They're located at the end of a dirt road in the small mountain town of Nederland, Colorado, which is situated ~15 miles west of Boulder at an elevation of 8,256 ft. (2516 m). On a 10-BBL brewhouse and 70-BBL fermentation capacity, they approach brewing with the necessary scientific prowess and rigor, but with more of an intuitive and artistic lens. To this end, they use these skills and aim to create nuanced, subtle, yet balanced and bold beers, ranging from unfiltered IPAs to fruited sours, traditional German Pilsners, and dessert-inspired stouts.

Some might ask, "Why start the brewery in Nederland?" It's not in the larger cities of Denver, Boulder, or even Fort Collins. Maybe it was the similarities to Vermont and Chris' beginnings. Or maybe it was simply that the town is colorful, zany, and completely not corporate at all; a perfect place to experiment on beers letting intuition guide them, all the while taking in the gorgeous vistas of the Rocky Mountains in Colorado.

Their brewing intuition leads them down numerous pathways. One of which includes the design and naming process of their beers. During the conception phase they try to get input from everyone involved to create a unique artistic connection to the beer. For example, currently on tap is Thick Strawberry Goo, a Berliner weisse with 420 lbs. (190 kg) of strawberry, raspberry, and passion fruit as well as Blue Light Rain, an unfiltered German Pilsner that employs the German Callista hops to provide a noble, grape-like character. But that's only a snippet of their line-up.

Perpetually Unimpressed is a double dry hopped, unfiltered double IPA whose flavors focus on one of Chris' favorite hops: Nelson Sauvin from New Zealand. The massive amount of dry hops and an English yeast strain produce intense fruit flavors and aromas such as grape must and peaches. The beer is dedicated to Chris' dog, Asa, who, ". . . internalizes the spirit of striving for more in life, as does this beer."

Despite the beer being quite hop-forward, you'd be shocked by a few of its attributes. First off, no hops are utilized during the actual boil. Although many calculators may render 0 IBUs due to how they handle post-boil additions, this beer does have supportive bitterness. Also, the hop bill is relatively straightforward with only two different hop varieties used over the course of three charges. Thirdly, the malt bill is more complex than one would presume from such a hoppy beer with flaked oats and wheat malt helping in the haze arena. The Golden Naked Oats® and honey malt both provide hints of additional sweetness to support the hops.

When I asked Chris if there are any aspects that one should take into account when brewing at 8,200 ft. (2,500 m), he commented saying, "The only considerations are a lower boiling point, less oxygen in the atmosphere for pitching yeast, and a slightly lower hop isomerization rate. More hops!" So, go ahead, take a walk on the hoppy haze side. I dare you to be "Unimpressed".

KNOTTED ROOT BREWING COMPANY'S PERPETUALLY UNIMPRESSED CLONE

(5 gallons/19 L, all-grain)
OG = 1.076 FG = 1.015
IBU = 80 SRM = 7 ABV = 8.1%

INGREDIENTS

6 lbs. (2.7 kg) Pilsner malt
5.5 lbs. (2.5 kg) Simpsons Golden Promise pale ale malt
1.6 lbs. (0.71 kg) flaked oats
1 lb. (0.45 kg) Rahr white wheat malt
1 lb. (0.45 kg) Golden Naked Oats® malt
7 oz. (200 g) honey malt
4 oz. (113 g) acidulated malt
6 oz. (170 g) Citra® hops (hop stand)
10 oz. (283 g) Nelson Sauvin hops (dry hop #1)
10 oz. (283 g) Nelson Sauvin hops (dry hop #2)
Wyeast 1318 (London Ale III) yeast or Omega OYL-052 (Conan) or LalBrew New England yeast
¾ cup corn sugar (if priming)

STEP BY STEP

Mill the grains, then mix with 4.9 gallons (18.5 L) of 167 °F (75 °C) strike water to achieve a single infusion rest temperature of 152 °F (67 °C). At this time add 50 ppm of gypsum. Hold at this temperature for 60 minutes. Mashout to 170 °F (77 °C) if desired.

Vorlauf until your runnings are clear before directing them to your boil kettle. Batch or fly sparge the mash to obtain 6.5 gallons (25 L) of wort. Pre-boil pH should 5.2 to 5.4. Boil for 90 minutes.

After the boil, add 150 ppm of calcium chloride, cool the wort to approximately 190 °F (88 °C), and add the Citra® hops. Whirlpool for 40 minutes before further chilling the wort to 68 °F (20 °C). Pitch yeast. Maintain rough fermentation temperature but allow for a free rise to 72 °F (22 °C) by the end of primary fermentation for this beer.

Once primary fermentation is complete, rack the beer off the trub or drop the cone at ambient temperature. Add the dry hops sequentially as indicated and let them extract for 1 day each. During this time shake the carboy or degas with CO_2 to increase the rate of hop oil extraction. Cold crash for 24 hours before bottling or kegging the beer. Carbonate to approximately 2.3–2.4 volumes.

KNOTTED ROOT BREWING COMPANY'S PERPETUALLY UNIMPRESSED CLONE

(5 gallons/19 L, extract with grains)
OG = 1.076 FG = 1.015
IBU = 80 SRM = 7 ABV = 8.1%

INGREDIENTS

3.3 lbs. (1.50 kg) Pilsner dried malt extract
3 lbs. (1.36 kg) pale ale dried malt extract
0.75 lb. (0.34 kg) wheat dried malt extract
1.6 lbs. (0.71 kg) flaked oats
1 lb. (0.45 kg) Golden Naked Oats® malt
0.5 lb. (0.23 kg) honey malt
½ tsp. 88% lactic acid
6 oz. (170 g) Citra® hops (hop stand)
10 oz. (283 g) Nelson Sauvin hops (dry hop #1)
10 oz. (283 g) Nelson Sauvin hops (dry hop #2)
Wyeast 1318 (London Ale III) yeast or Omega OYL-052 (Conan) or LalBrew New England yeast
¾ cup corn sugar (if priming)

STEP BY STEP

Bring 5.5 gallons (21 L) of water to roughly 150 °F (66 °C). Steep both types of oats and the honey malt for 15 min before removing and draining. Add all the types of DME, with stirring, before heating to a boil. Add the lactic acid, then boil for 15 minutes.

Follow the remainder of the all-grain recipe instructions for post-boil and fermentation directions.

TIPS FOR SUCCESS:

With such a fruity, hop-forward beer, you could correctly assume that water chemistry is quite important. For the all-grain brewer, shoot for a 3:1 ratio of chloride-to-sulfate prior to pitching. Unfortunately, for the extract brewer, you're at the whims of the maltster. If you're feeling adventurous, add 50–100 ppm of calcium chloride to tilt the balance to chlorides. Personally, I'd err on the side of caution as too little will still make the batch drinkable but too much may cause it to leave a "chemical" taste on the tongue.

The other major consideration to concern yourself with is the yeast pitch rate. With an OG = 1.076, I'd recommend a fresh starter. A strong, healthy fermentation will afford a well-attenuated beer with proper biotransformation of hop oils. BYO

BY DAWSON RASPUZZI

H_2O ADJUSTMENTS

Treating water is the first step to great beer

Just because water is safe to drink doesn't mean it is ideal for making great beer. Changing the chemistry of water is the first step great brewers take when creating a recipe, and these changes have a significant impact on the final outcome. Two pros share the steps they take when it comes to adjusting water, and why homebrewers shouldn't dismiss beer's main ingredient either.

I start by trying to achieve the profile I want with gypsum and calcium chloride ($CaCl_2$). But this depends on your starting water.

Cesar Marron is a Founding Partner and Head Brewer of Sketchbook Brewing Co. in Evanston, Illinois. Before the brewery opened in 2014, Cesar was a homebrewer for five years, during which time he won the Samuel Adams Longshot American Homebrew Competition in 2013 with his smoked wheat Polish Grodziskie. Sketchbook will be opening a second, larger brewing facility in nearby Skokie later this year.

Located in Evanston, Illinois, our water source is Lake Michigan, which is so large that it makes for a very stable source of clean water. With larger volumes, changes in the profile due to rain or other sources that affect the numbers we care about are small. Evanston also pumps the water from a long distance in an effort to pull deeper, cleaner lake water. So here at the brewery we measure pH more regularly, and look at the city's yearly water report to see if anything changed dramatically.

We only filter for particulates and chlorine. We use a 1-micron particulate filter followed by a 0.5-micron carbon block filter.

Our philosophy on salt additions is "slow and careful." Spend the time researching what you want to achieve on the final product and if possible, start with a tried-and-true recipe. Don't add salts just because. I start by trying to achieve the profile I want with gypsum and calcium chloride ($CaCl_2$). But this depends on your starting water. If you are already too rich in calcium, you probably want to use something else to increase your chloride numbers without increasing your calcium.

Salt additions really depend on the starting water profile. I think it is safe to say that most breweries use gypsum, calcium chloride, and an acid. Magnesium chloride ($MgCl_2$) and Epson salt ($MgSO_2$) are the other salts I use in some recipes where I already have enough calcium. Sodium chloride (NaCl) in small amounts is great to accentuate roundness and flavors as well.

We do not treat for carbonates, per se. We do acidify the brewing water as part of each water recipe and to adjust the sparge water's pH.

Each of our beers has an SOP (standard operating procedure) that includes the water recipe as well as the malt, hops, etc. As for coming up with each water profile, you can start with the style you are targeting. An amber vs. yellow, malty vs. bitter. A good understanding of what each brewing salt does to your final product is important too. For example, calcium will help with precipitation of trub and oxalates from the wort, giving you a brighter final beer. Sulfate will increase the hop brightness, dryness, and sharpness on the beer, while chloride will accentuate fullness and sweetness. But be careful, there are ranges to follow, and ratios of salts you want to consider.

We use Bru'n Water to create water profiles. It's an Office Excel program and it works really well once you read and understand how it works. You will need your water report, or get your water tested in order to set up your starting water parameters.

I homebrewed for five years before turning pro and started digging into water chemistry when I was on my third year of homebrewing and brewed my Longshot-winning Polish Gratzer. My interest on that beer, initially, was to learn about water profile modifications. After I did that, I got hooked on the process and created water profiles for each individual beer style.

My biggest advice is "less is more." Start with a beer you know well and brew a test batch with your modified water profile and go from there. Sometimes no change is best. But I think most people will notice their beers will start differentiating from each other more and more.

Ryan Coker is a Certified Cicerone and the Owner/Head Brewer of Revelry Brewing Co. in Charleston, South Carolina, which opened in 2014. The brewery specializes in both clean ale and lager production as well as mixed fermentation styles. In five short years, the brewery has won four (3 gold, 1 silver) medals at the Great American Beer Festival and one gold medal at the World Beer Cup.

Our brewing water comes from two sources, the Bushy Park Reservoir and the Edisto River, before entering a water treatment facility. All in all, our water chemistry remains quite stable and requires little adulteration to make great beer. That said, we always check and balance our own measurements to those provided by our water utility company.

Our water has great chemistry for a wide range of brewing styles, although it is best suited for darker beers in its most naked form. Our only method of pre-filtration on the way to our hot liquor tank is an activated carbon filter to remove chlorine and chloramines that were added by the water treatment facility. If this isn't done, chlorophenols can form through the pathway of fermentation, and nobody likes to drink pool water!

At the moment, our only other treatment of our brewing liquor, prior to salt adjustments, is a parboil in the HLT. This does two things — it drops temporary hardness in the water and expels any remaining volatiles (chlorine, sulfur, etc.) that may have gotten past the activated carbon filter.

We work with about six different water profiles. We mostly build our water toward a general style rather than a unique profile for each brand. One exception might be with hoppy beers. If we want a more accentuated bitterness, our chloride-to-sulfate ratio changes toward higher sulfate content. If we want a softer "bite" and less perceived bitterness (i.e. hazy IPA), the ratio shifts toward higher chloride content.

Water chemistry in general isn't given the respect it deserves. Beer is mostly water and it should be a foregone conclusion that the water used to brew should be appropriate for the style you're brewing. It's really simple to run water through a carbon filter at the very least, and now there are many calculators that help you make adjustments based on information you can obtain from your local water utility. BYO

HELP ME, MR. WIZARD

BY ASHTON LEWIS

CURING SPARGING WOES

Also: Talking oxidation and the subtleties of beer gas

Q I HAVE BEEN MAKING A PUMPKIN ALE FOR THE LAST 7–8 YEARS. BECAUSE I PUT FLAKED OATS INTO THE GRAIN BILL, I HAVE ALWAYS USED RICE HULLS TO PREVENT A STUCK SPARGE; HOWEVER, 3 OUT OF THE LAST 4 BATCHES, MY FIRST RUNNINGS AND SPARGE HAVE BEEN VERY SLOW. DURING MY LAST BATCH, IT TOOK AN HOUR TO GET ALMOST 2.5 GALLONS (9.5 L) USING 7 GALLONS (26.5 L) OF STRIKE WATER. I SPARGED WITH ANOTHER 5–6 GALLONS (19–23 L) OF WATER AND IT TOOK ALMOST AN HOUR TO COLLECT AS MUCH AS I COULD. IN THE PAST, IT HAS TAKEN LONGER THAN OTHER STYLES TO COLLECT WORT BUT NOT THIS LONG. COULD I POSSIBLY BE USING TOO MANY RICE HULLS ON THE BOTTOM OF MY MASH TUN? I PUT THE RICE HULLS ON TOP OF MY FALSE BOTTOM AND MIX INTO THE GRAINS. I USE A 10-GALLON (38-L) WATER COOLER AS MY MASH TUN.

GRAIN BILL: PALE MALT, CARAMUNICH® MALT, MUNICH MALT, CARAMEL 40L, FLAKED OATS, WHITE WHEAT MALT, AND VICTORY® MALT FOR A TOTAL OF ABOUT 13 POUNDS (5.9 KG) FOR A 5-GALLON (19-L) BATCH. MY LAST BATCH WAS DOUBLE. I ALSO PUT ABOUT 30 OUNCES (850 G) OF CANNED PUMPKIN IN THE MASH.

MARK CONNELL
BEDFORD, MASSACHUSETTS

There are so many things about brewing raw materials that can cause brewers headaches because our raw materials are inherently inconsistent.

Photo by Marco Verch

The beta-glucans found in oats creates the gummy consistency of porridge and can lead to a frustrating brew day when the mash sticks up.

A The likely culprit to this problem, assuming that you have been using the same basic recipe over the last 7–8 years, is beta-glucan from the flaked oats. I am betting on this ingredient because the problem you describe is typical for how high-molecular weight beta-glucan gums associated with certain grains, most notably unmalted oats, rye, wheat, and barley, affect wort recovery. But why now?

There are so many things about brewing raw materials that can cause brewers headaches because our raw materials are inherently inconsistent. Crop variability can be classified into two big buckets; variability due to genetics and/or variability due to environment. Or, in the parlance of geneticists, G x E influences. Even when brewers select/purchase specific varieties of barley, for example, there is still considerable variability within and between crop years based on environmental variables such as growing region, temperature, rainfall, farming techniques, and harvest conditions. Add to this the different ways that cereal grains are processed and the permutations become huge.

So why am I focusing on the unmalted oats in your recipe? For starters, oats are a great source of beta-glucan gums that slow wort collection. The other reason is that the oats are the one "generic" ingredient in your grain bill. While oat variety and processing nuances, such as flake thickness and flaking conditions, can have a real influence on how oats perform in the mash, most brewers, including most commercial brewers, know very little about the flaked oats purchased for brewing.

Using rice hulls is a good start

to warding off wort collection issues associated with troublesome ingredients, like oats, but may not be enough for particularly gummy lots. The addition of beta-glucanase to the mash is an option that has increasingly become more common as the popularity of hazy IPAs continues to grow and brewers are exploring ways to minimize the bumps that come with using unmalted grains. And as a continuation of this approach, the use of malted oats, both naked and fully clothed (with hull), is also on the rise. The next time you brew this beer or another beer with oats, consider using a different flaked oat, adding beta-glucanase and a respective rest to the mash, and/or subbing malted oats for some or all of the flaked oats. Hopefully one of these suggestions works and you will not have to turn to Plan B; smashing pumpkins.

Follow-up to previous answer: *I answered a question from Scot in Chicago, Illinois that was published in the November 2019 edition of* BYO. *His question was about hop fade and why some of his recent New England IPAs lost hop aroma quickly after packaging. Scot let me know in his question that he was a very experienced brewer. Knowing that biased my answer because I did not think that he suddenly had a rash of oxidation problems. His question had me publicly scratching my head. Thanks to emails from Karl Helmstetter and Joe Walts (below), I now offer some more insight into the possible causes of hop fade.*

Q I REALLY ENJOYED YOUR ANSWER TO SCOT'S QUESTION ABOUT HOP FADE, ESPECIALLY YOUR HONESTY AS AN AUTHOR AND BREWING EXPERT. IT'S ALWAYS EASIER FOR ME TO BELIEVE AND ACCEPT PEOPLE'S ANSWERS WHEN THEY ACKNOWLEDGE THEIR OWN BIAS OR LIMITATIONS, EVEN WHEN THOSE COME FROM THE QUESTIONER!

I HAD A THOUGHT REGARDING SCOT'S SITUATION; HE SAID HE COLD CRASHES IN THE CARBOY, HOPS ARE BRIGHT WHEN ADDED, FADED A WEEK LATER. IF HE IS COLD CRASHING WITHOUT A CO_2 SOURCE, SUCK-BACK COULD EASILY ADD MORE THAN ENOUGH O_2 TO DULL THE HOPS, AND HAZY IPAS ARE ESPECIALLY SENSITIVE TO THIS. NO WAY TO KNOW WITHOUT MORE INFORMATION, BUT DOES THIS SEEM POSSIBLE?

KARL HELMSTETTER
CHARLOTTESVILLE, VIRGINIA

I WAS CATCHING UP ON BREWING MAGAZINES THIS MORNING, AND I CAME ACROSS YOUR MR. WIZARD RESPONSE TO A QUESTION ABOUT FADING HOP CHARACTER — WHICH GOT ME THINKING: COULD THE PROBLEM BE RELATED TO EITHER OXYGEN PICKUP DURING KEGGING, OR MIGRATION OF HOP AROMA INTO A TOO-LARGE (AND INCREASING OVER TIME) HEADSPACE IN THE KEG?

ON THE OXIDATION FRONT, I WOULD NOT EXPECT THIS TO BE AN ISSUE FOR TWO EXPERIENCED BREWERS. HOWEVER, MAYBE SOMETHING UNEXPECTED HAPPENED SUCH AS A LOOSE HOSE/TUBE CONNECTION OR EVEN A LOW-PURITY CO_2 CYLINDER. AND THE FACT THAT THEY COLD CRASH PRIOR TO PACKAGING COULD CAUSE ALL KINDS OF PROBLEMS IF THEY DON'T APPLY HEADSPACE PRESSURE BEFOREHAND.

ON THE HEADSPACE FRONT, IT WOULD BE INTERESTING FOR THE BREWERS TO PACKAGE ONE BATCH IN A KEG AND ONE BATCH IN BOTTLES TO SEE HOW THEY COMPARE OVER TIME — BUT THE ADDITION OF BOTTLE CONDITIONING COULD CREATE AN UNFAIR ADVANTAGE IN TERMS OF OXYGEN REDUCTION AND POSSIBLY EVEN BIOTRANSFORMATION. EVEN WITHOUT THIS INVESTIGATION, MAYBE THE BREWERS SIMPLY HAD A FEW LOW-YIELDING BATCHES THAT ACCELERATED THEIR NORMAL HOP FADE.

JOE WALTS
OCTOPI BREWING COMPANY
MADISON, WISCONSIN

A These emails are great and give me a little more fuel to expend on the topic of hop fade. For starters, as someone who really dislikes oxidized beer, why did I not consider oxidation as a possible cause of the problem? I dismissed oxidation as the probable cause because of Scot's experience. That is what is called a really bad assumption.

In the world of commercial brewing, brewers are obsessive about minimizing oxygen pick-up because oxygen quickly ruins beer. Even low concentrations of this potent molecule have a marked effect on reducing beer shelf life. Over the last 20 years or so, two technological changes have really been a game-changer when it comes to the general topic of oxidized beer. The first is the development of low-speed packaging lines that have dramatically reduced total package oxygen (TPO) in cans and bottles to levels that are on par with the fanciest, high-speed lines used by the largest brewers. The second real game changer is with dissolved oxygen (DO) meters. Today, DO meters are reliable, accurate, and widely used by brewers of all sizes (although not all breweries own these spendy instruments). Joe's reply about leaks and gas purity comes from his experience in commercial brewing where

brewing problems almost always include a question about equipment or raw materials . . . as in, what mechanical failure or out-of-spec [insert ingredient here] caused this problem? And Karl's question about suck-back is in the same vein of the original inquiry.

Let's start with suck-back. This happens when liquid from an airlock is sucked into the container it is intended to protect from the environment when the container headspace is cooled and a vacuum is formed. That sucks! And for a couple of reasons. One reason is that the airlock may contain "stuff" in the liquid barrier, such as microbes, cheap vodka, or bleach, that does not belong in beer. Even if the airlock contains nothing but pristine water, it offers no protection from the environment when empty. Picture a carboy that was bubbling slowly after primary fermentation. If a sample could be taken from the beer and the headspace and measured, there would be very little if any DO in the beer and in the headspace.

The second reason that suck-back sucks is air. Once the airlock has been gulped into the carboy, the headspace picks up oxygen from the environment, and headspace oxygen then enters the beer. A fallacy about carbon dioxide headspaces is that the density of the carbon dioxide protects the beer beneath. While a carbon dioxide gas blanket, especially during fermentation when the blanket is constantly flowing up and out of the fermenter, do help protect beer from oxygen, the blanket is not immune from gas mixing. Pesky principles like gas diffusion, convection, and Brownian motion work 24-7. An empty airlock needs to be re-filled pronto, and a full airlock is preferably never sucked into a carboy!

Joe's approach to this problem is open-ended and questions everything involving beer handling that can result in an increase in DO. A DO-meter-wielding commercial brewery experiencing hop fade and suspecting oxygen would be on this by methodically measuring beer DO before and after transfers, during storage, and right before packaging. After packaging, quality control (QC) pros vigorously shake packages to equilibrate sample headspaces with the beer before measuring TPO because inquiring minds want to know!

The point is that there are numerous, and often times invisible, sources of DO. Leaky gaskets, pump seals, and valve seats, DO in push water, low-purity carbon dioxide, vacuum pump failures (used on package lines for pre-evacuation before filling), inconsistent fobbing before capping, poorly purged bright beer tanks/kegs, below normal fill levels in tanks, and loose hose clamps can all lead to increases in DO.

The below-normal fill level is an interesting problem that can affect oxidation and/or aroma partitioning. Large headspaces contain more gas, and a headspace of a given oxygen content is less problematic when the headspace is small, for example in a normally-filled bottle or can. But large headspaces also provide a big, aroma-devoid gas space where aromas in beer can equilibrate.

Q I READ THE ARTICLE ON SERVING STOUTS WITH BEER GAS ON BYO.COM (HTTPS://BYO.COM/ARTICLE/NITROGEN-STOUT-FAUCETS/), AND I'M HOPING YOU HAVE SOME INSIGHT INTO A SITUATION I'M HAVING. I RECENTLY ADDED A BEER GAS LINE AND A STOUT FAUCET TO MY HOME KEGERATOR. I GOT A KEG OF BELCHING BEAVER PEANUT BUTTER MILK STOUT FROM A LOCAL STORE. THE BEER COMES OUT VERY, VERY FOAMY DURING POURING, BUT THE HEAD DISAPPEARS COMPLETELY AFTER A MINUTE OR TWO AND THEN THE BEER IS FLAT. IN THE AFOREMENTIONED ARTICLE, IT DESCRIBES A PERIOD OF TIME FOR CONDITIONING A KEG ON BEER GAS. I GUESS MY PRIMARY QUESTION IS: IS THIS STEP TYPICAL FOR A COMMERCIAL KEG OR IS THAT STEP NORMALLY ONLY HOMEBREW? DO ALL COMMERCIAL KEGS FOR NITRO STOUTS NEED TO BE CONDITIONED OVER A WEEK LIKE THIS? ANY INSIGHTS YOU HAVE WOULD BE HELPFUL AND APPRECIATED.

BOBBY SMALLMAN
SAN FRANCISCO, CALIFORNIA

A Years ago I was talking to a crusty dude named Larry who worked for a local beer distributor about the dirty draft beer tricks that can be played by competing distributors. Larry told me that he used to work for the local Coors distributor who also had Guinness in their portfolio. Larry would sell Guinness into his Coors accounts and then switch all of the beers at the account to "Guinness Gas," a blend of 75% nitrogen/25% carbon dioxide that is also known as beer gas, to make things simpler for the account. Anything to make serving draft beer simpler is the sort of customer service that bar-owners love from their beer distributors and Larry knew how to make his draft accounts happy!

But Larry's suggestion of simplicity was also his way to gain more business at his accounts because any slow-moving beer dispensed with beer gas will lose its carbonation over time and then customers complain of flat beer. Knowing that this would happen to some beer, Larry could later return and suggest a faster selling brand to take the tortoise's place. He was one clever rascal.

Your description of what is happening to your keg of Belching Beaver Peanut Butter Stout fits into Larry's gas trick. Belching Beaver Peanut Butter Stout is available in two versions. One is a normally carbonated beer and the other is nitrogenated. It sounds like you are using mixed gas to push normally carbonated beer through a stout faucet. The beer dictates the correct gas blend, equilibrium pressure, and temperature that fits the gas level set at the brewery. This one simple instruction, set the keg at the equilibrium temperature and pressure for the beer, is total Greek to most

people who deal with draft beer. And even when the idea is not obtuse, no keg that I have ever seen comes with carbonation specs or a suggested serving pressure and temperature. This is totally crazy because the brewery sure as heck knows the carbonation or mixed gas level in their beer.

Let's take a deeper dive into what may be happening in your keg of Belching Beaver Peanut Butter Stout. According to Belching Beaver's website, this brand is available as a normally carbonated and a nitrogenated beer in bottles. For the sake of thorough discussion that can benefit all readers of *BYO*, I am going to assume that two versions are also available in kegs. When a carbonated beer is dispensed with carbon dioxide, the gas' gauge pressure is usually about 12 psig (83 kpa) at 38 °F (3 °C). But when the same beer is dispensed with mixed gas at the same pressure, carbon dioxide in the beer moves into the headspace where the concentration of carbon dioxide is lower. Some nitrogen also moves from the headspace into the beer, but this is normally not obvious when the beer is poured. Over time, the beer in the keg begins to go flat, and the rate of change increases as the volume of beer in the keg decreases. Although this alone does not explain the initial foaming, it does explain the short-lived foam and may explain what is happening to your beer.

So what happens when a normally carbonated beer, or a carbonated beer that is slowly being flattened with beer gas, is served through a stout faucet? They usually foam like crazy because stout faucets have a flat disc with five small holes (if based on the Guinness tap design) that is designed to cause gas breakout from the beer. Without this special plate, nitrogenated beers don't do anything special when poured except produce a totally flat, and unexceptional looking pint. The very, very foamy pours you describe fit with how a carbonated beer poured through a stout faucet behaves. The short-lived foam is also consistent with this scenario because once most of the carbon dioxide has been stripped from the beer and the foam settles, there is not much gas left to keep the foam from collapsing.

Nitro beers, the flipside of this discussion, have very stable foam because the gas in the nitro beer bubbles is a mixture of nitrogen and carbon dioxide. Since the earth's atmosphere is 79% nitrogen and the nitrogen concentration in a bubble of nitro beer foam is typically 75%, there is no gradient "pulling" the gas out of the bubble. This makes nitrogen foams very stable. They do eventually collapse as the liquid in the bubble wall thins due to gravity and surface tension effects, but this takes much, much longer compared to carbon dioxide bubbles.

My point thus far is that it is possible that you have a keg of carbonated beer that you are attempting to serve on nitro. And to directly answer your question about needing to wait some time to allow the beer to condition to the mixed gas atmosphere, the answer is "no." When a keg of nitro beer

is put on tap, all that is needed is about 30 psig (207 kpa) pressure to push the beer from the keg and a stout faucet. Furthermore, if you are starting with a normally carbonated beer, you cannot morph this brew into a nitro beer by simply hooking the keg up to mixed gas, increasing the pressure, and waiting for 1–2 weeks. The reason this method is not effective is because of the carbon dioxide in the beer; nitro beers contain a much lower carbon dioxide content than normal beers. In order to convert carbonated beer into nitro beer, carbon dioxide must be removed and nitrogen must be added. This topic is a deep rabbit hole that I am going to avoid entering. Suffice to say, removing carbon dioxide to the right level is not easy.

Whether you are tapping a keg of nitrogenated beer produced at home or purchased from a commercial brewery, the dispense method is the same. The basic, short-distant, direct draw, set up consists of a source of mixed gas (75% nitrogen/25% carbon dioxide), about 4–6 feet (1.2–1.8 m) of $\frac{3}{16}$-in. (5 mm) beer line, a keg of beer stored at about 38 °F (3 °C), and a stout faucet. The standard-bearer for nitro beer is Guinness, because Guinness pioneered and perfected the technology. One of the interesting things about how stout faucets work is the need for velocity going into the tap. If nitro beer velocity is slowed by reducing the dispense pressure, gas break-out is reduced and the beer does not foam and cascade properly. For this reason, it is important to dispense nitro beers in the 30–35 psig (207–241 kpa) range. Not only does this pressure maintain the gas equilibrium established at the brewery, it provides the high velocity required by the faucet.

> **“Since the earth’s atmosphere is 79% nitrogen and the nitrogen concentration in a bubble of nitro beer foam is typically 75%, there is no gradient “pulling” the gas out of the bubble.”**

I will finish with a pragmatic suggestion. When all else fails, pick up the phone and call the brewery. I like asking simple questions and would begin with something like, “I just bought a keg of your peanut butter stout and want to make sure that I am using the correct gas pressure and temperature to match the gas specifications for your great beer.” It could be that you have a keg of beer that was not properly nitrogenated at the brewery, and that you are doing nothing wrong on your end. Cheers! BYO

BY GORDON STRONG

GERMAN WEISS

Weissbier in the south, Hefeweizen in the north

It's entirely correct to think about German wheat beer as a style family with variation by color, strength, and yeast presence.

WEISSBIER
BY THE NUMBERS

OG:	1.044–1.052
FG:	1.010–1.014
SRM:	2–6
IBU:	8–15
ABV:	4.3–5.6%

Photo by Charles A. Parker/Images Plus

When the Beer Judge Certification Program (BJCP) last updated its style guidelines in 2015, the name of this style was changed to weissbier from hefeweizen. I caught a lot of flak over that decision but the reason is sound. Sometimes the style was called Bavarian hefeweizen or (as the Brewers Association calls it) south German-style hefeweizen, which is where the style originated and is most popular. However, if you actually go to Bavaria, the beer is called weissbier (literally, "white beer"). Hefeweizen means "yeast wheat" which is probably more descriptive, but if you're going to acknowledge the origin of the beer, you might as well call it the same name the locals do.

The names weissbier, hefeweizen, and weizenbier are largely interchangeable. Understand that they all mean the same style, a pale wheat beer. As the style is popular in Germany, there are acknowledged variations such as kristallweizen (a filtered weissbier) and leichtes weissbier (a lower-gravity weissbier, maybe 2.5–3.5% ABV) in addition to the well-known cousins dunkles weissbier (a dark-colored weissbier), and weizenbock (a strong weissbier, often dark but sometimes pale). The Brewers Association (BA) also recognizes an amber-colored version, probably to account for the darker-than-typical Schneider Weisse Original.

It's entirely correct to think about German wheat beer as a style family with variation by color, strength, and yeast presence. The BJCP lists weissbier as Style 10A as part of Category 10, German Wheat Beer, which includes weissbier, dunkles weissbier, and weizenbock. The BJCP category doesn't include the lower gravity or filtered versions; it groups the amber-colored version in with the pale. The German wheat beer family generally is based on the type of yeast used, not just the content of wheat. There are several other well-known German wheat beers outside this family, including the tart Berliner weisse, the salty and tart Gose, the smoked wheat Grodziskie from neighboring Poland, and the sour and smoked Lichtenhainer.

HISTORY

Wheat beers are ancient; stories include ancient Egyptians, Sumerians, and Babylonians making beer from loaves of bread. However, these beers have nothing to do with modern German wheat beer. Wheat beer brewing in central Europe (modern southern Germany, Austria, and Czech Republic) traces to the late Middle Ages. The Degenbergers of Schwarzach, a Bavarian noble family, operated a weissbier brewery before the turn into the 16th century.

The Reinheitsgebot of 1516 prevented the use of wheat malt in beer (not because it was impure, but because it was needed for bread making), but the Degenbergers were allowed to keep brewing their existing beer. When the last of the Degenbergers died in 1602, the right to brew wheat beer was assumed by the ruling Bavarian royal family, the Wittelsbachs. Using their noble monopoly, a very profitable brewing empire was built. What began as a beer preferred by royalty became widely enjoyed by the public through the sale of wheat beer through tied pubs.

The royal monopoly lasted for nearly 200 years, when declining demand caused the nobility to offer licenses to commoners as a way of generating more revenue. The subsequent development of lagers hastened the style's demise as tastes shifted to the new type of beer.

In 1872, Georg Schneider gained rights to brew wheat beer without having a royal dispensation. Importantly,

the rights applied to everyone not just Schneider. However, wheat beer was not as popular as it once was. Demand continued to fall until the 1960s, when it regained popularity and grew throughout the rest of the century. It is still a very popular style in Bavaria, and has spawned not only imitations around the world but also derivative styles such as American wheat beer.

As of 2019, wheat beer accounts for about 9% of the total German beer market (Pilsner is by far the most popular style). However, weissbier is much more popular in Bavaria and neighboring southern state of Baden-Württemberg, with a market share more than double that in the rest of the country.

SENSORY PROFILE

The first thing you notice about a weissbier is the appearance. It normally is quite pale, light straw to gold, with a shiny haze from the wheat malt but also from suspended yeast in very fresh examples. The high carbonation level gives a very thick, rocky, mousse-like white head that is very long-lasting.

The aroma has a distinctive banana and clove character from the yeast. The intensity can be moderate to strong, and the balance between the two can vary. When fermented poorly, the beer can have an estery, bubblegum-like aroma (strawberry and banana), or even a smoky character. The "cleanliness" and purity of the banana and clove seems to degrade with warmer fermentations, like about 70 °F (21 °C). The warmer you go, the bigger risk you run for this degradation. The banana and clove does not need to be extreme; brewers who try to emphasize this character to the exclusion of other aspects usually create a sub-standard beer.

The high wheat malt content gives a breadiness to the aroma and flavor, not so much like uncooked dough but more like fresh whole wheat bread. A light impression of sweetness can often be noted, but not sugary. Hops are normally absent in the flavor and aroma so as to let the wheat and yeast character take center stage. Bitterness is low, often imperceptible, which can provide the impression of sweetness due to the absence of bitterness.

WEISSBIER

(5 gallons/19 L, all-grain)
OG = 1.050 FG = 1.010
IBU = 12 SRM = 3 ABV = 5.3%

INGREDIENTS

6.25 lbs. (2.8 kg) German wheat malt
4 lbs. (1.8 kg) German Pilsner malt
1 lb. (0.45 kg) rice hulls
3.1 AAU Sterling hops (60 min.) (0.5 oz./14 g at 6.2% alpha acids)
Wyeast 3068 (Weihenstephan Weizen) or White Labs WLP300 (Hefeweizen Ale) or Mangrove Jack's M20 (Bavarian Wheat) yeast
⅞ cup corn sugar (if priming)

STEP BY STEP

No starter is required. This recipe uses reverse osmosis (RO) water. Adjust all brewing water to a pH of 5.5 using phosphoric or lactic acid. Add 1 tsp. of calcium chloride to the mash.

This is a combined step and single decoction mash: Mash in both grains at 113 °F (45 °C) in 15 qts. (14 L) water. Hold at this ferulic acid rest temperature for 15 minutes, then raise the temperature to 131 °F (55 °C) for a protein rest. Maintain at this temperature for 10 minutes.

Pull a thick decoction (33–40% of mash with minimal liquid) and heat the decocted portion to 158 °F (70 °C) for 20 minutes, then boil gently for 10 minutes, stirring constantly. Meanwhile (during the decoction), heat the main mash to 147 °F (64 °C) and hold. Recombine the two mashes and rice hulls to hit 158 °F (70 °C) . Rest for 10 minutes. Raise the mash temperature to 168 °F (76 °C) for mashout. Recirculate for 15 minutes.

Sparge slowly and collect 6.5 gallons (24.5 L) of wort. Boil the wort for 90 minutes, adding hops at the time indicated in the recipe.

Chill the wort to 57 °F (14 °C), pitch the yeast, and ferment until complete at 62 °F (17 °C). Rack the beer, prime, and bottle (or cask) condition, or keg and force carbonate.

WEISSBIER

(5 gallons/19 L, extract only)
OG = 1.050 FG = 1.010
IBU = 12 SRM = 3 ABV = 5.3%

INGREDIENTS

5.5 lbs. (2.5 kg) Bavarian wheat dried malt extract
3.1 AAU Sterling hops (60 min.) (0.5 oz./14 g at 6.2% alpha acids)
Wyeast 3068 (Weihenstephan Weizen) or White Labs WLP300 (Hefeweizen Ale) or Mangrove Jack's M20 (Bavarian Wheat) yeast
⅞ cup corn sugar (if priming)

STEP BY STEP

Use 6.5 gallons (24.5 L) of low mineral or RO water in the brew kettle; heat to 158 °F (70 °C).

Turn off the heat. Add the malt extract and stir thoroughly to dissolve completely. Turn the heat back on and bring to a boil. Boil the wort for 60 minutes, adding hops at the time indicated.

Chill the wort to 57 °C (14 °F), pitch the yeast, and ferment until complete at 62 °F (17 °C).

Rack the beer, prime and bottle (or cask) condition, or keg and force carbonate.

TIPS FOR SUCCESS:

Decoction mashing is not an essential part of this recipe, but should help develop the proper mouthfeel. If time is short on brew day, you can just do the ferulic acid rest and a single saccharification rest at about 152 °F (67 °F).

If this is your first time attempting a decoction mash, a good tool to pull the grains out of the mash tun is a stainless steel colander (and gloves). This will help drain most of liquid back into the main mash. You want a little liquid with the grains, but not too much. By the end of the boil, there should be some Maillard reactions occuring in the decoction pot, but the grains should never scorch.

The body is somewhat light, lighter than many people expect, and the carbonation is very high (which also tends to lighten the body). The finish is dry and smooth with a refreshing spritz from the carbonation level. The beer should be easy to drink in quantity, and a high body and creamy mouthfeel would fight against that. Traditionally, the beer has a fair amount of alcohol, normally at least 5%, often more like 5.3%. But it shouldn't taste of alcohol or have noticeable warmth.

The impression of the beer on the palate is a kind of fluffy, or pillowy texture. With a heavy finish or sweet flavor, this beer could be oppressive. Yet the carbonation and fluffiness keeps it light, almost like the liquid equivalent of cotton candy in texture. Suspended yeast can give it some additional texture, and often a yeast bite in older examples.

I find this style of beer benefits greatly from freshness. I jokingly call it, "The New Car Beer" — you drive it off the lot, and it loses half its value. It can degrade quickly, so it really is best consumed fresh. As a judge, I almost never want to judge this style since they are almost never very fresh. As a brewer, this is one style I would definitely rebrew when entering the National Homebrew Competition.

"The current thinking is that under-pitching yeast and using shallow fermenters promotes ester development and can give a more prominent banana ester."

BREWING INGREDIENTS AND METHODS

The deceptive thing about making weissbier is that the recipe often looks simple. However, there are a few control points and recipe choices that make a big difference: The grist, the mash schedule, the yeast, and the fermentation schedule.

By German brewing tradition, wheat beers are made with 50% or more malted wheat, although this is often as high as 70%. The remainder of the grist is typically Pilsner malt. The use of wheat and Pilsner malt helps give the characteristic pale color. The use of other malts is unnecessary. Additional flavor or body malts will throw off the characteristic flavor profile of the beer, and often darken its color.

By now, some of you may be saying, but what about the Reinheitsgebot? Doesn't that say all beers are just made with barley malt? The German beer tax law (Vorläufiges Biergesetz of 1993) actually says that the original Reinheitsgebot limitations only apply to bottom-fermenting beers. As German wheat beers are top-fermenting, they are allowed to use other malted cereal grains, as well as brewing sugars, fining agents, and naturally-derived products.

Decoction mashes are traditional to help break down the wheat malt, which has a high protein content. Single and double decoction mashes could be used, although some modern brewers will use step mashes. Rests may vary but often include a protein rest and at least one saccharification rest. One unusual step in many mash schedules is the ferulic acid rest (113 °F/45 °C), which produces ferulic acid that is converted by phenolic off-flavor positive (POF+) yeast to 4-vinyl guaiacol (4VG). 4VG provides the clove-like phenol flavor in weissbier.

Weissbier is made with yeast that has a POF+ trait. The POF+ trait, as the name suggests, produces phenols in the finished beer (in this case, clove). When fermented too hot, the yeast can also produce smoky, burnt flavors in my experience. The weizen yeast strains also produce significant amounts of isoamyl acetate, which gives the banana ester character to the beer. In many styles, isoamyl acetate is an off-flavor, but in weissbier it's a requirement. Wyeast 3068 and White Labs WLP300 are the most common strains used, although other varieties exist.

The interesting thing about fermenting weizen yeast strains is that cooler fermentations seem to produce a cleaner-tasting beer. The yeast still produces banana and clove, but it doesn't produce other flavors that detract. Cloves that become burnt, bananas that become rotten, and fusels that are perfumy are all examples of yeast fermentation by-products that can be produced with warmer fermentations.

Eric Warner in *German Wheat Beer* says there is an old German rule that says the combination of pitching and fermentation temperature (in °C) should equal 30. If you do the math, that's pretty cold. I don't usually go quite that cold, but restraining temperatures seems to produce good results. I sat on a tasting panel that Harold Gulbransen did at the National Homebrewers Conference in 2011 where he compared cold fermentation against warm fermentation, among other variables. The cold fermentation beers were much better, and Harold was using 62 °F vs 70 °F (17 °C vs 21 °C).

Two other pieces of advice for fermentation come in the form of pitch rate and fermenter geometry. The current thinking is that under-pitching yeast (generally means not making a starter for these beers) and using shallow fermen-

The bready characteristic of wheat malt is one of the keys to weissbier, but dealing with it isn't always the easiest when it comes to lautering the mash. A little patience and rice hulls can go a long way with this gummy mash.

ters (generally what all homebrewers are utilizing already) promotes ester development and can give a more prominent banana ester. Sierra Nevada is among the breweries using this technique, and their Kellerweis is outstanding. Avoiding oxygenation (not to be confused with aeration) also encourages yeast growth and ester development. I think these methods are better for getting banana character than increasing the fermentation temperature, which can have some negative side effects.

Hops are almost non-existent in the finished beer profile. I tend to keep it simple and use a single bittering addition of German noble hops and avoid any finishing hops. The water profile is unobtrusive in a weissbier. I would use low mineral water with a little bit of calcium chloride, but avoid sulfates.

HOMEBREW EXAMPLE

I've been making this style of beer for a very long time; I think my first one was batch #4 for me. I've refined it over the years, as I've learned more and been able to add more controls to my system. A variation of this has won medals in the National Homebrew Competition.

I use around 60% wheat malt to make sure the flavor comes through. Pilsner malt is the rest, and I like to use German maltsters for both grains. I used to use Durst a lot, but have been using Best Malz recently. Weyermann is always a good choice. No matter which you choose, you really can't go wrong. Also, as insurance against a stuck mash, I typically use a pound (454 g) of rice hulls mixed into the mash.

I use a single decoction mash, which I think improves the mouthfeel of the beer. A ferulic acid rest is part of my normal process for German wheat beers, so I typically incorporate some step mashing before I pull my decoction. I don't boil the decoction for long since I don't want too much flavor or color development, just enough to improve the mouthfeel.

I have used Sterling hops here, but any noble-type hop is fine. Freshness matters, so choose freshness over specific variety. I'm aiming for about 12 IBUs and no flavor addition, so there is a lot of leeway.

I have always had good luck with the Wyeast 3068 strain, so I tend to pick that. I don't make a starter with this style. The fermentation temperature is kept cool at 62 °F (17 °C); I normally pitch at about 57 °F (14 °C). I don't oxygenate, but I do shake the carboy a bit. This yeast strain can be quite sticky, so it tends to cause some blowoff. Have a blowoff tube ready in case you need it, and use a fermenter with plenty of headspace. If you're really game, try it in an open bucket to see if you get a little extra banana. Just be ready to rack it into a closed fermenter once the kräusen starts to fall back into the beer so it doesn't get oxidized.

Serve this beer fresh, and don't worry about carrying over yeast from the fermenter into packaging. This yeast tends to degrade so I tend not to repitch it more than once. Don't overpitch this style of beer as the yeast needs a proper growth stage in the beer to give the characteristic flavor profile. BYO

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WEDNESDAY, MARCH 25, 2020

INSIDER TOUR OF DENVER-AREA CRAFT BREWERIES - You'll tour – and taste – at four different craft breweries in the Denver area during this pre-event optional offering. You'll have the opportunity to meet brewers and ask questions in addition to sampling their beers. Includes a beer-pairing meal. A great way to kick off your BYO Boot Camp experience and check out some of Denver's thriving craft beer scene.

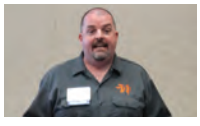
THURSDAY, MARCH 26, 2020 DENVER BOOT CAMPS

Each Boot Camp will run from 9:30 a.m. to 5 p.m. and is limited to just 35 people. Your Boot Camp will include lunch as well as a post-Boot Camp Colorado Beer Reception with local craft breweries pouring samples to wrap up your full day.

TROUBLESHOOTING HOMEBREW FAULTS & FIXES – ***with Ashton Lewis*** – Join *Brew Your Own*'s Mr. Wizard and Technical Editor Ashton Lewis as he walks you through the potential minefield of beer flaws and faults homebrewers can face. You'll learn how to troubleshoot – and fix! – your own homebrews with Ashton who has helped thousands of homebrewers over the last 20+ years troubleshoot common and not-so-common beer problems as *BYO*'s Mr. Wizard. You'll have a chance to experience many faults first-hand to better recognize them later. Plus as a special bonus, bring in your own troubled homebrews and Ashton will use your beer as a live example walking the class through the thought process as he figures out what might have gone wrong with your homebrew and what you can do to fix the problem moving forward.

ALL-GRAIN BREWING ESSENTIALS – ***with John Palmer and John Blichmann*** – Designed for intermediate to beginner homebrewers getting into all-grain brewing, this full-day workshop will cover all you need to know to successfully make great homebrews using all-grain brewing both with traditional and newer techniques. *How To Brew* author John Palmer and equipment guru John Blichmann will take you hands-on through the full all-grain process from milling, mashing, and sparging before going into the boil. You'll get to know the equipment, techniques, and ingredients first-hand and learn all-grain brewing by doing in a small-class environment. They'll also cover newer homebrew all-grain techniques such as Brew-in-a-Bag and No Sparge in addition to traditional mash methods and some advanced tips as well.

RECIPE FORMULATION ESSENTIALS – ***with Brad Smith*** – Learn the best ways to jump into creating your own signature recipes and understand the keys to developing a specific grain bill, hop schedule, and ingredient proportions to meet your homebrewing goals. Brad Smith, owner of Beersmith software and a *Brew Your Own* Contributing Writer, has helped thousands of homebrewers design their own beer recipes and now you'll learn first-hand from this recipe building expert how to use both artistic and scientific approaches to beer design to end up with the beer you had envisioned in your glass. You'll explore ingredients, techniques, and even your own brewing system during this practical boot camp that will get you on the right path to craft your own recipes for better beers at home. Please note Brad will also be offering an advanced recipe design workshop on Saturday as well.



CIDERMAKING – ***with Jason Phelps*** – Join professional Cidermaker Jason Phelps to learn all the steps you need to know to successfully craft your own hard cider, both still and carbonated, at home. Jason has taught many hobbyists about making hard cider in addition to making it himself at his New Hampshire Cidery every day. He'll have you roll up your sleeves and take you through the process of crushing, pressing, fermenting, all the way to bottling. You'll learn how to choose apples and get to know cidermaking equipment and the tests you need to run on your cider.

ADVANCED ALL-GRAIN TECHNIQUES – ***with Gordon Strong*** – Pull out the mash tun and get ready to learn advanced all-grain techniques hands-on with *Brew Your Own* "Style Profile" Columnist, book author, and President of the Beer Judge Certification Program, Gordon Strong. Gordon will walk you through a world beyond straight infusion mashing with keys to mastering step mashing, sour mashing, and decoction mashing. Plus you'll learn about playing with mash thickness and other ways to control your all-grain wort production. Please note this workshop will also be offered on Saturday as well.

ADVANCED YEAST TECHNIQUES – ***with Dr. Chris White*** – Join Dr. Chris White of White Labs as he discusses how to master different yeast-related techniques including harvesting yeast, figuring cell counts, the dos and don'ts of repitching including steps such as yeast washing, building up a proper yeast starter, storing your yeast samples, and much more. Here's your chance in a full-day seminar format to learn about getting the most from your yeast from one of the true leaders in the beer yeast field.

ADVANCED HOMEBREW HOPPING TECHNIQUES – ***with Dave Green*** – Join *Brew Your Own*'s Dave Green as he explores when and how to add hops to create awesome hop-forward brews. You'll explore the basics of hop biology (and why it matters to us!); techniques and timing of hop usage including mash hopping, boil hopping, whirlpool/knockout hop stand additions, and dry hopping; hop varietal choice strategies including hop pairing/blending; evaluating hops including hands-on hop rubbing and sensory training; and practical usage techniques including hop extracts, boil-hops "management" (bags, filters, free addition), and water adjustments for hoppy beers. By the end of the full day Dave will make sure you are making informed hops decisions and getting the most out of your hops – and into your glass!

FRIDAY, MARCH 27, 2020
BONUS BOOT CAMP SEMINARS
9:15 A.M. TO 5 P.M.

We are adding a third bonus day to our normal event schedule based on feedback we've received from past attendees who wished they had a chance to learn from all our assembled speakers beyond their Boot Camp workshops. So for 2020, we've scheduled a full day of seven different seminars led by our cast of brewing all stars who will share their knowledge with you on their area of expertise. It will be a full day packed with great tips and techniques from the best in the industry so get ready to learn. Plus you'll have even more time to check out the latest homebrew gear and ingredients with our Boot Camp sponsors located right in the meeting area.

9:15 A.M. – 10 A.M.
Brad Smith on Recipe Design

10:15 A.M. - 11 A.M.
Dr. Chris White on Yeast Propagation for Homebrewers

11:15 A.M. – NOON
Ashton Lewis on Avoiding Brewing's 5 Biggest Mistakes

NOON TO 1 P.M.
Lunch

1:15 P.M. – 2 P.M.
Gordon Strong on Evaluating Homebrew Like a Beer Judge

2:15 P.M. – 3 P.M.
John Blichmann on Layout Designs for Homebreweries

3:15 P.M. – 4 P.M.
John Palmer on Brewing Water Demystified

4:15 P.M. – 5 P.M.
Kara Taylor on Yeast and Fermentation Myths Busted

TURNING PRO & COMMERCIAL BREWERY START-UP: THREE-DAY BOOT CAMP

– with Steve Parkes – By popular demand, we're expanding our past two-day Brewery Start-Up Boot Camp to three full days to better cover more material in more depth for you. When you register for this class you will attend it for Thursday, Friday, and Saturday unlike our other offerings.

Opening up a commercial brewery is a far cry from just ramping up the amount of beer you brew. Steve Parkes, who has trained hundreds of pro brewers as lead instructor and owner of the American Brewers Guild, will walk you through the steps, planning decisions, and keys you need to know if you want to open a successful commercial craft brewery. Learn from his decades of expertise and wide range of experience to help you better achieve your goals of turning pro. Over three full days Steve will guide you in depth through all the various elements you'll have to know for the next big step toward starting a craft brewery.

SATURDAY, MARCH 28, 2020 DENVER BOOT CAMPS

Each Boot Camp will run from 9:30 a.m. to 5 p.m. and is limited to just 35 people. Your Boot Camp will include lunch as well as a post-Boot Camp Colorado Beer Reception with local craft breweries pouring samples to wrap up your full day.

ADVANCED RECIPE FORMULATION – ***with Brad Smith*** – Take your recipe creations to the next level by dialing in the specific grain bill, hop schedule, ingredient proportions, and water treatments to meet your brewing goals. Brad Smith, owner of Beersmith software and a *Brew Your Own* Contributing Writer, has helped thousands of homebrewers design their own beer recipes and now he's ready to get in-depth on the details of beer design so you end up with the beer you had envisioned in your glass. You'll explore ingredients, techniques, and understanding your own brewing system during this boot camp designed for advanced homebrewers that will help you craft your own recipes for better beers. This workshop can be taken in combination with Brad's Recipe Formulation Essentials class on Thursday that offers more of an introduction to intermediate and beginning brewers to the concepts of writing your own recipes.

ADVANCED YEAST LAB – ***with Kara Taylor*** – Join White Labs' Laboratory Operations Manager Kara Taylor for some hands-on yeast lab work to develop skills you can bring back home to help you make better beer. Learn how to accurately count yeast using a microscope, culturing yeast, using slants, harvesting yeast, washing and reusing yeast, propagation and determining growth rates, and more. Here's your chance to learn hands-on what you may have read in books and magazines, or listened to in seminars, and Kara's the perfect teacher to lead you through the world of yeast using lab equipment you can source for your home use.

HANDS-ON HOMEBREW SCIENCE – ***with Ashton Lewis*** – Get hands-on with pH meters, slants and loops, stir plates, centrifuges, and other brewing science gear with *BYO* Technical Editor and Mr. Wizard Columnist Ashton Lewis. Ashton will walk you through how to best use scientific gear at home to help you improve the quality of your beer. You will have the chance to understand not only how to use and care for the equipment properly, but also how to take the results and put that data into action to produce better beer in your glass. This workshop will focus only on those pieces of equipment suitable – and affordable – for your homebrewery.

BREWING WATER ADJUSTMENTS – ***with John Palmer*** – Water is the least understood ingredient when making great beer. John Palmer, who literally wrote the definitive book on the subject, *Water: A Comprehensive Guide for Brewers*, will help take the mystery out of water's role in brewing and how to make better beer as a result. You'll learn how to read water reports, understand flavor contributions, and how to adjust your brewing water to make different styles of beer. You'll leave with not only an understanding of the chemistry concepts of brewing water, but also the practical how-to aspects of getting the most from from this critical brewing ingredient.

MEADMAKING – ***with Jason Phelps*** – Interest in mead is on the rise throughout North America. Now you can learn all the steps you need to successfully craft your own homemade meads. Join professional Meadmaker Jason Phelps as he takes you through the keys to making a great mead at home including key techniques, yeast selection, fermentation strategies, and more. Learn how to select and work with different honey varieties as well as best practices for adding ingredients such as fruits and spices to your mead.

ADVANCED ALL-GRAIN TECHNIQUES – ***with Gordon Strong*** – Pull out the mash tun and get ready to learn advanced all-grain techniques hands-on with *Brew Your Own* "Style Profile" Columnist, book author, and President of the Beer Judge Certification Program, Gordon Strong. Gordon will walk you through a world beyond straight infusion mashing with keys to mastering step mashing, sour mashing, and decoction mashing. Plus you'll learn about playing with mash thickness and other ways to control your all-grain wort production. Note: This Saturday workshop is a repeat of the Thursday class and is offered twice due to its popularity.

HOME CHEESEMAKING – ***with Pamela Zorn*** – You make your own beer so now it's time to learn how to make your own cheese to pair with it! Pamela Zorn has been teaching people how to make their own cheese for years from her Colorado cheesemaking retail shop. You'll learn hands-on how to craft soft cheeses as well as be introduced to the world of making your own hard cheese plus understand the keys to making great cheese from a variety of different kinds of milk. Get ready to roll up your sleeves with this full-day introduction to the fun world of home cheesemaking – a perfect fit with your homebrewing!

SUNDAY, MARCH 29, 2020

INSIDER TOUR OF DENVER-AREA CRAFT BREWERIES

You'll tour – and taste – at four different craft breweries in the Denver area during this post-event extra offering. You'll have the opportunity to meet brewers and ask questions in addition to sampling their beers. Includes a beer-pairing meal. A great way to wrap up your BYO Boot Camp experience and check out some of Denver's thriving craft beer scene.

Three-Day and Two-Day Registration Options Available.
Full Event Details Available at: BYOBootCamp.com

BREWING FOR COMPETITION

Another step toward perfecting your craft

by Nicholas McCoy & Jeff Poirot

To some, homebrew competitions are overwhelming. To others they are a waste of good beer. But to us, they are serious business. The ability to brew up the perfect beer that nails the target style and is in its prime right as it's being judged truly shows mastery of our great homebrewing hobby. As challenging as that may be there are many other factors that go into winning medals. What was the size of the competition? What place was your beer in the flight? How qualified were the judges who sampled your beer? With so many variables and other factors, how is it the same people can consistently win awards?

There is one thing to be certain of; winning isn't just about making good beer. In this article we will go through our process for entering competitions. That process, after more than a decade of competing on both the local and national levels, has helped us reach a degree of predictable success that culminated in winning the Ninkasi Award at the National Homebrew Competition (NHC), which is given to the brewer who receives the most points in the final round.

Photo by Shutterstock.com

Photo by Annie Johnson

The larger the competition the more likely each entry is to be judged in a flight of the same beer styles — often resulting in more useful feedback.

SETTING GOALS AND MANAGING EXPECTATIONS

Someone recently asked us online, "What is the point of entering your beer into competitions?" It's a valid question that made us ponder why we, or other homebrewers, may want to enter homebrews into competitions. Is it some sort of ego trip or thrill of winning that keeps people entering or is it something else? For us, competing is about perfecting the craft of homebrewing. Sure, at first we were just trying to see how our beer compared to other homebrewers and maybe win a medal or two. But now we enter competitions to see how different ingredients and processes can affect our beer and give us a flavor profile that will help those brews stand out from the crowd. The thrill of winning isn't lost on us but scoring a 45 on a great beer is much more rewarding.

Like all other aspects of life, goal setting is crucial to success. If it's your first time entering, just have fun. The process of making beer, bottling and labeling them, dropping off, and going to the awards ceremony can be a lot to take in. Just having gone through that process is something to be proud of, winning should be considered "icing on the cake."

If you've entered a few competitions, awards aren't the only measure of success. Try setting some small goals like getting half of your beers to the second round (or mini Best of Show) or have all your beers score above a 30 in total score. Many brewers become discouraged — or even worse, cynical — about not winning. Don't fall into this trap! A lot can be gained from a competition even if your beer doesn't medal.

If you enter competitions regularly, see what percentage of your beers medal. Also see which entries achieve an excellent score over multiple competitions after several attempts of making the exact same beer.

No matter your level there are goals that can be set. Furthermore, managing your expectations and not getting too hung up on your medal count will keep you having fun and help grow your passion for this hobby.

CHOOSING COMPETITIONS

Probably the most overlooked factor in entering competitions is choosing the right competition(s) to enter. There is a little bit of reverse logic that we found helps us choose a competition if its medals we are after: The bigger the competition the easier it is for experienced homebrewers to medal.

I know that seems off but here's why. Let's say your local brewery is putting on a competition. No beer style requirements, just the best three beers medal and they cap the entries at 50 beers. With 34 different Beer Judge Certification Program (BJCP) categories and 120 styles, how are they going to judge these beers? Typically, they will group all the dark malty beers into one category, the hoppy ones into another, and a third category for the others.

For example, last year we entered a competition where, we were later told, barleywines were in the same category as double IPAs. Yes, both are high-alcohol beers, but the two styles couldn't be more different. It would take a great judge with an excellent range of experience to judge examples of both styles against each other. However, typically the judges are the brewers and most often, although they know beer, aren't experienced judges.

These factors make the results in smaller competitions

unpredictable. On the flipside, in large competitions beer styles can be judged individually and it allows the judges to really dive into the intricacies of a style and give you some great feedback. Also, the judges are typically certified and ranked Beer Judge Certification Program (BJCP) judges. You can read your score sheets and instantly see how much credibility you should give to the analysis. That's what we're looking for!

Here is a list of some of the competitions that we consider on that level, both in size and reputation:

Competition	Location	Date
Upper Mississippi Mash Out	Minneapolis, MN	Jan.
Kansas City Bier Meisters	Kansas City, MO	Feb.
Midwinter	Milwaukee, WI	Feb.
America's Finest City	San Diego, CA	Feb.
The Bluebonnet Brewoff	Dallas, TX	Mar.
Drunk Monk Challenge	Chicago, IL	Mar.
National Homebrew Competition 1st Round	USA	Apr.
Spirit of Free Beer	Washington DC	Apr.
Mayfair - Maltose Falcons	Los Angeles, CA	Apr.
Reggale and Dredhop	Boulder, CO	Apr.
World Cup	Bay Area, CA	Jun.
National Homebrew Competition 2nd Round	USA	Jun.
Indiana State Fair Brewers Cup	Indianapolis, IN	Jul.
Blue Ridge Brew Off	Asheville, NC	Sep.
Dixie Cup	Houston, TX	Oct.
New England Regional	New Hampshire	Oct.
Delafield Brewhaus Schnapp Hans Cup	Wisconsin	Oct.
FOAM Cup	Tulsa, OK	Nov.
Happy Holiday	St. Louis, MO	Dec.

COMPETITION CALENDAR

We sit down a couple times a year and choose the events we would like to enter. For example, this last year we chose the following competitions:

Competition	Location	Date
Upper Mississippi Mash Out	Minneapolis, MN	Jan.
Midwinter	Milwaukee, WI	Feb.
The Bluebonnet Brewoff	Dallas, TX	Mar.
National Homebrew Competition	USA	Apr./Jun.
Indiana State Fair Brewers Cup	Indianapolis, IN	Jul.
Labor of Love – Deep Ellum Brewing	Dallas, TX	Sep.
Iron Mash	Fort Worth, TX	Oct.
Dixie Cup	Houston, TX	Oct.

Many of them are in the early part of the year (when we are working on our recipes the most) and we can enter the same beers across multiple competitions. For example, the Mash Out, Midwinter, and Bluebonnet competition entry deadlines are all around the same time in December and January. This allows for a bunch of feedback in a relatively short amount of time. So, if we try something new to a beer, we can get definitive feedback from groups of judges and not let a single score sheet weigh too heavily.

Once we choose the event, more importantly, we talk through the beers we want to work on. We have a few tried-and-true recipes that we generally only enter for medal count and these go into competitions where we are trying to win a cumulative award, like Homebrew Team of the Year or the Ninkasi. These are beers that win consistently, and we are happy with (at least for now).

After choosing the beers we will enter we talk through the styles and work backwards from the entry deadlines to make a competition brew calendar. As a general rule of thumb we use these timeframes to determine when we make the beers so that they are at their best when the judges sample them:

Style	When to Brew
American, German, and English Ales	3–4 Weeks Before Entries are Due
Hoppy Ales	2–3 Weeks Before Entries are Due
Belgian Light Ales	4–5 Weeks Before Entries are Due
Belgian Dark Ales	3–4 Months or Longer Before Entries are Due
Light Lagers	5–6 Weeks Before Entries are Due
Amber and Dark Lagers	2–4 Months Before Entries are Due
Big Ales and Lagers	6 Months or Longer Before Entries are Due

It's also important to note when the beers are going to be judged versus when the entries are due. A few of the larger competitions take 4–6 weeks to judge entries. In that case we might brew ales where entries are going into competition bottles just a few days after being kegged for the most shelf life possible.

Brewing for a specific competition gives a huge advantage over the competitor that simply enters what they have sitting around. We don't want a beer judged before or past its prime resulting in poor feedback.

RECIPES AND INGREDIENTS

Ask any Kansas City Barbeque Society or competition BBQ pit master and they will tell you they don't make the same food for competitions that they do for their family and friends. Often this holds true for winning brewers as well. Bigger, bolder, and different flavors win competitions.

One strategy when brewing for competition success is to push the boundaries of a given style or make them stand out in some way. If you haven't judged before, entries are typically placed in flights of 10–15 beers and the

Photo by Paul Peng Wang

As judges sample anonymous beer after anonymous beer in a flight, giving your entry something that makes it stand out — whether it be an ingredient or process difference — may help bring home the medals.

judges choose medal winners or a few to advance to a second round from each flight. After the judges have tasted a handful of the same style, flavors begin to run together and the beers with a little "something extra" seem to stand out.

This doesn't always mean brewing over the style to win. Sometimes making a lager on the bottom end of the style can make it seem more delicate and balanced. Additionally, adding ingredients that might not be typically in the style can make a beer stand out. For example, maybe try adding a little honey malt to your Belgian wit or make a pale ale with Maris Otter as opposed to regular 2-row to give your recipe a slight edge.

TRAIN YOUR PALATE AND JUDGE FOR YOURSELF

One thing we often do before entering and always do the first few times we try a new recipe is drink that beer in a blind lineup of other beers in the BJCP style guidelines. If you make an Oktoberfest, when you think its ready, get a few friends together and do some blind side-by-sides with your favorite examples and the ones listed in the guidelines. Seeing how your Oktoberfest stacks up against Hacker-Pschorr and Paulaner is a fun experience and gives you instant results.

Remember the judges are using those example beers as mental guides to help evaluate your entry. Why not cut out the middleman and train your palate a little in the process? After a while you'll be able to taste a beer for yourself and know the chances it has in an upcoming competition. If your beer misses the mark maybe choose to rebrew it and enter it into another competition later that year.

OTHER ADVANTAGES

This article isn't intended to talk too in-depth about brewing process (for more information on our process read our article "The Little Things" in the May-June 2019 issue of *Brew Your Own*). However, there are some points related to recipe formulation and the brewing process that you can try to improve your beer's quality and chances that we would like to mention:

Water

Either adjusting your water with mineral additions or building it from scratch with reverse osmosis water will make a huge difference. At bare minimum you should have your water tested to know what is in your water and which beer styles it may favor. For more information on the subject, we'd recommend you refer to John Palmer and Colin Kaminski's *Water* book.

Sourcing Ingredients

Don't overlook ingredient quality and selection. Sometimes just having fresher hops can make all the difference between a 30-point pale ale and a 40-point winner. Please support your local homebrew stores but if you notice the hops, yeast, or malt are a little past their prime try sourcing from online vendors with a reputation for fresh ingredients and turning their inventory on a regular basis. Or maybe select a yeast that is a little different but is fresher from the source.

Lesser Used & New Ingredients

We mentioned earlier about adding ingredients that are a little out of the norm for a given style. Furthermore, maltsters are always releasing new malts like Briess Caramel Rye or Simpsons Double Roasted Crystal that many homebrew stores don't even carry. If you are making a pale ale, why not try a few experimental hops for something the judges have a hard time picking out. Maybe try a yeast that is a seasonal-only release to give it a different mouthfeel or attenuation than might be expected. Many brewers make the same recipes with the same ingredients that have been around for decades — and it is likely many of the beers in your flight will use the same yeast strain as well — try something new for an edge!

Brew Day Process

Sometimes the difference in a first and second place beer can be a small process change, like using a step mash or whirlpool hop additions. Some people swear by decocting their German beers for this exact reason. For example, we stray from our usual process and use a no-sparge technique when brewing our English mild, and the prac-

tice seems to being paying off as the beer won 2nd place at NHC in 2018.

Carbonation and Bottling

We can't overstate how important it is to have the proper level of carbonation in your entries and normally we even slightly over-carbonate our beers. The reason is these entries are poured and sit out for a while when being judged. Additionally, because we keg all of our beers and then bottle entries using a counter-pressure bottle filler, we tend to lose a little bit of carbonation in the bottling process. So, to get this right we always keg our beers, get them just above the ideal level of carbonation, and then bottle them. We use a Blichmann BeerGun to purge the bottles of oxygen and slowly fill to the proper level.

Lady Luck and Number of Entries

No matter how good a brewer you are, there is an element of luck to winning. The quality of the beer right before or after yours can make a huge difference. And even though biases aren't supposed to be a part of judging, they can often creep into the equation. Maybe the person judging your flight likes pale ales that are a little more malty than you do.

Getting things to line up you need to enter as many beers as you can. Some of the best brewers only place on 30–40% of their entries, unless they get lucky. If it is the medals you are after, it's much better to get up for a few competitions than to enter a bunch of different ones lightly throughout the year.

Double Entering Beers

We realize everyone has a day job and you can't sit around making beer all day (although we wish that were the case). So, to help get the number of entries up in a competition consider double entering beers into multiple categories. Some examples would be entering an IPA in both imperial and single IPA categories. Porters and milds can be very close and double entered. Also, some styles have subcategories that are very similar like English bitters and Scottish ales.

EVALUATING RESULTS AND REBREWING

Hopefully you've taken our advice and entered your beer in some of the better competitions or at least a BJCP-certified event, meaning you will get a uniform score sheet and certified judges. When you get back your score sheets the first thing to look for is the judge and their ranking. If they are a certified (or higher) BJCP judge or cicerone, you will usually get good and precise feedback. However, sometimes even good competitions must use judges that are unranked or haven't judged before. Hopefully they

Photo by Gordon Strong

Winning medals shouldn't be the only end-all be-all to determining success at a homebrew competition. A lot of factors, including many that are out of your hands, go in to determining the winners. Other goals may include advancing to the second round of judging, improved scoring compared to previous entrants of the same beer, or cumulative point averages from all of your entries.

Photo courtesy of Nicholas McCoy & Jeff Poirot

will at minimum place these judges with more experienced ones to make a two-person team. This will be your frame of reference when evaluating the sheets.

The one thing you shouldn't focus on too heavily is your actual score. Yes, a 40-point beer is almost always a great beer and a sub 30-point beer needs improvement, but many times a beer in the high 30s can be a winner. This is because every judge has their own scale and without knowing that scale it's hard to go off the number. Also be sure to notice the amount of entries in your flight and what order your entry was sampled. You don't want to be too early or late in the flight as sometimes these judging sessions can take some time. Again, this will come down to luck.

Mainly you should be looking for any major or minor points that the more experienced judges suggest. Maybe they suggest upping your mash temperature, trying a less attenuating yeast, or the dreaded "watch your sanitation." Sometimes the feedback is more subtle like "good beer but misses the style a bit." Whatever the comments may be, try and read between the lines and understand what the judge is implying. These are unbiased and experienced opinions that can help make a good beer into a great one. Furthermore, entering the same beer in several competitions in a relatively short amount of time can create a consensus that will lead to more precise adjustments when you rebrew.

FINAL THOUGHTS

No matter what results you get entering competition, the process should be fun. We really suggest entering the ones you can attend. Building camaraderie with fellow brewers and enjoying your successes in person can't be overstated. Once you have the competition itch it can drive you to be the best brewer you can be. BYO

RELATED LINKS:

- Looking for more opinions on how to bring home the bling from a competition? Digital members have access to this "Tips from the Pros" column where three brewers who won medals at the Great American Beer Festival give us the inside scoop to competing in—and winning—homebrew competitions: https://byo.com/article/winning-competitions-tips-from-the-pros/

- One of the biggest advantages a homebrewer can have when entering competitions is being a capable judge of the beer they enter. *BYO* digital members can learn more about becoming a BJCP beer judge here: https://byo.com/article/become-a-homebrew-judge/

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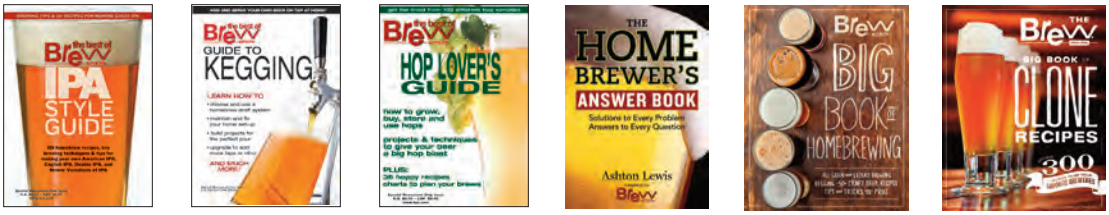

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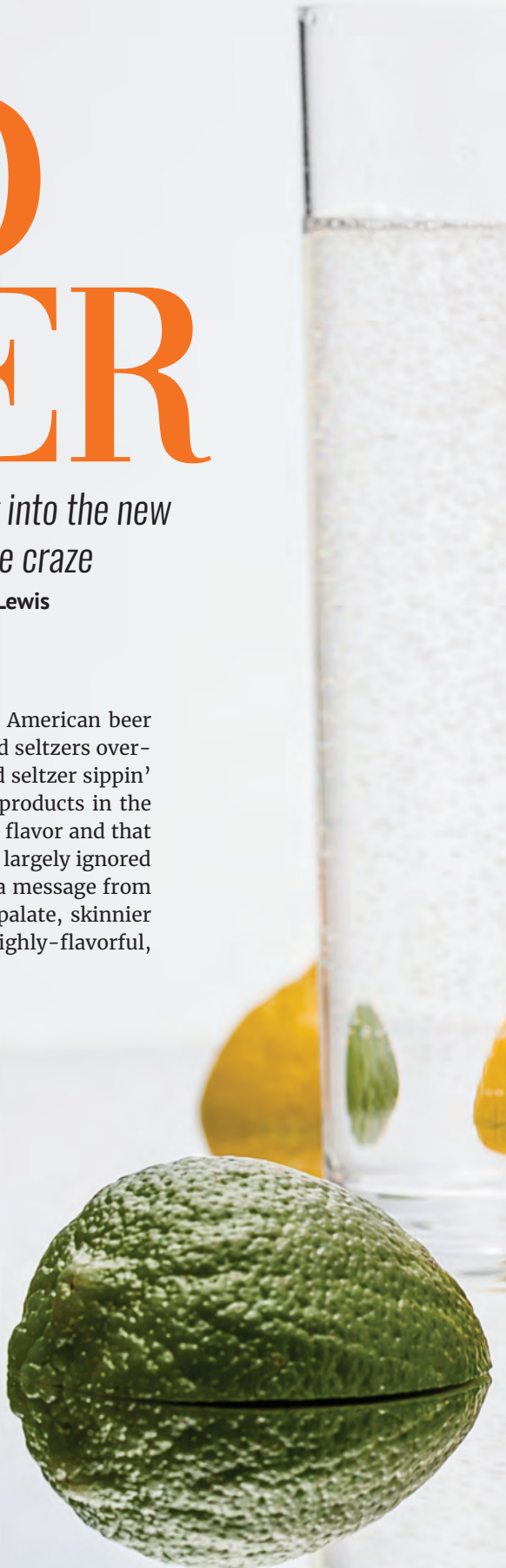
HARD SELTZER MADE EASY

Clawing into the new beverage craze

by Ashton Lewis

The summer of 2019 may go down in the annals of North American beer history as *The Summer of Hard Seltzer*, and not because hard seltzers overtook beer volume or converted bearded beer bros into hard seltzer sippin' hipsters. The real significance of the popularity of these products in the market may be the mere fact that they exist in a sea of big flavor and that the category has done so well by appealing to a demographic that was largely ignored by so many of the arbiters of beer style. Hard seltzer's popularity is a message from the market signaling demand for beverages that are lighter on the palate, skinnier on the calories, and less challenging to consume than big-bodied, highly-flavorful, calorically-rich beers.



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The hard seltzer business has taken off in recent years as some consumers look for lower-calorie alcoholic beverages. Shelf space at beverage and grocery stores dedicated to hard seltzers continues to grow and many craft breweries are also getting into the business.

THE NEW, OLD CRAZE

Popular trends are interesting to analyze when the "new thing," be it food, music, or beverage, is looked at without the bias of a name. Many "new things" are simply "old things" that have been tweaked, repackaged, and given a new name. In the case of hard seltzers, the new thing has more to do with process and taxation than it does with the liquid itself. Strip away the peripherals, and what is left is a simple cocktail similar to something like a vodka tonic.

There is one key difference, however, between a canned vodka tonic and a canned hard seltzer; tax classification. In the United States, alcohol taxation has much more to do with the source of the ethanol in a beverage than it does strength. In fact, there is no difference in the federal excise tax levied on beer based on beer strength, and only 16 states collect higher tax rates on "strong" beers, a distinction that varies by state. Another nuance of US alcohol taxation is the different licenses, and associated restrictions, required by beverage makers to legally produce and pay tax on various alcoholic beverages. For example, a licensed brewery cannot produce wine or distilled spirits without having a separate license. And when a producer does hold multiple licenses, special rules apply to how the facility is operated to help ensure that the different tax rates levied on alcoholic beverages are properly paid. What does all of this have to do with hard seltzer?

The popularity of bottled water and coffee drinks has been hard to ignore over the past decade. The price difference between something like a can of flavored seltzer and beer is pretty staggering when the cost of production is considered. To make a common non-alcoholic seltzer, filtered water is flavored with a dash of flavor essence, carbonated, and put into a can. Not much different than making soda, but the ingredient costs are lower because there is not much of anything in these drinks. Beer, on the other hand, is much more expensive to produce in terms of equipment, ingredients, labor, energy inputs, effluent treatment, cleaning chemicals, inventory costs related to fermentation and aging time, and taxation. Most brewers cannot help doing mental math when noting that something as simple as a cup of coffee at the local café costs about half as much as a pint of craft beer. So the idea of adding a shot of alcohol to these common and popular drinks has crossed the mind of many a brewer, but the taxation thing was an obstacle.

Back to the old thing with a new name topic. Zima was arguably the first malternative to make the big leagues when Coors introduced its clear concoction to the market in 1993. Zima, like malt-based wine coolers that were all the rage in the 1980s, was taxed as beer but had little else in common with other beverages in this tax class. Maybe it was the sweetness, the funky name, or the clear and cool package, but for whatever reason Zima floundered in the market and was officially retired in 2008 . . . and then un-retired in 2017. The key to producing a beverage like Zima is removing malt color and flavor. The easiest way to begin this process is to start with as little color and flavor as possible by maximizing the non-malt adjunct allowed for an alcoholic beverage to be taxed as beer. Flavorless beers have been the butt of many a joke about mainstream beers, but the truth is that producing very lightly flavored beer is not easy. And producing colorless beer requires special processes.

There are numerous patents from the past related to color removal from beer using ultrafiltration, reverse osmosis, and activated carbon. Many of these processes were specifically developed to remove malt colors from wort or beer, not necessarily flavor, because the inventors wanted to produce beer without color. Today's brewer may not quite get the point of this quest, but we can learn by reading patents from the past. One of the obvious takeaways from looking at these

patents is that color removal requires special methods, and that an easier way to begin is to simply leave out the color compounds from the mix. If the objective is to reduce flavor and color, starting from a malt-free base seems logical, except for the pesky tax laws that require a certain amount of malt and hops in a "malt beverage." It's worth noting that these same rules do not apply to "beer" because malt substitutes are permitted and there is no hop requirement.

Hold the phone! What is this thing about a malt substitute? We all know that beer must contain malt because, well, that's just how beer is made. Don't ask; this is about taxation and not conformance to brewing tradition.

So, what is a malt substitute? According to the US Alcohol and Tobacco Tax and Trade Bureau (TTB) *". . . the definition of a 'beer' under the IRC [Internal Revenue Code] differs from the definition of a 'malt beverage' under the FAA Act in several significant respects. First, the IRC does not require beer to be fermented from malted barley; instead, a beer may be brewed or produced from malt or 'from any substitute therefor [sic].' Second, the IRC does not require the use of hops in the production of beer. Third, the definition of 'beer' in the IRC provides that the product must contain one-half of one percent or more of alcohol by volume, whereas there is no minimum alcohol content for a "malt beverage" under the FAA Act.*

"Accordingly, a fermented beverage that is brewed from a substitute for malt (such as rice or corn) but without any malted barley may constitute a 'beer' under the IRC but does not fall within the definition of a 'malt beverage' under the FAA Act. Similarly, a fermented beverage that is not brewed with hops may fall within the IRC definition of 'beer' but also falls outside of the definition of a 'malt beverage' under the FAA Act."

Believe it or not, sugar (sucrose) as well as dextrose/glucose are considered malt substitutes by the current TTB definition of malt substitute. This has the fingerprints of a company with lobbying power written all over it, but I am more of a science writer than investigative journalist. What I do know is that breweries can produce hard seltzer, pay tax as if seltzer were beer, and sell these products without much ado about mashing.

A FOOD SCIENCE, HOME-APPROACH TO HARD SELTZERS

Not to take the pizazz away from hard seltzers, but when viewed for what they are as opposed to how they are made, hard seltzers are basically garden-variety flavored seltzers plus about 5% ABV. The basic flavor palate of most hard seltzers I have tasted are mildly fruity, with little to no sweetness, a little acid zip, and no obvious hints of alcohol.

A convincingly "authentic" hard seltzer at 5% ABV can be made by the following recipe:

- (4) 355 mL (12-ounce) cans of carbonated water
- 0.2 mL lime extract
- 0.2 mL lemon extract
- 30 mL pulp-free orange juice (single-strength, not from concentrate)
- 1 g citric acid (powder)
- 210 mL vodka

Note: *Some recipes are best-suited to metric-only units. Converting tenths of a mL or 1 gram into teaspoon or ounce equivalents is not particularly practical. No conversions to English units are used in this article. If you want to make*

Photo by Ashton Lewis

Homebrewers who don't need to worry about TTB regulations can make a simple hard seltzer starting with sparkling water and adding flavor extracts, citric acid, orange juice, and vodka.

seltzers, you must suffer through metric as penance!

This is a pretty basic beverage and not the type of thing that can be improvised on before all variations on them have been tried. Obvious permutations are the use of different fruits, but we are still left with a pretty basic beverage. This is the main critique of hard seltzers, but one that may not be a major deal breaker in a beverage market filled with different brands of water, carbonated water, and mildly flavored carbonated water. Just a reminder that creative marketing can always make up for the lack of real differentiation. Perhaps the most tempting variation on the basic seltzer theme is adding some sweetness. Definitely something to consider if looking for a tasty beverage, but not so tempting if keeping caloric content under 100 calories per 12-ounce (355-mL) serving. In the world of low-calorie marketing, the 100 calorie threshold seems to be the barrier to not cross.

It's pretty easy to see how the basic vodka seltzer morphs into cocktails using different spirits, mixers, fruits, garnishes, sweeteners, bitters, and all of the other stuff that is used to stock a bar. Funny how quickly beer brewing pops into one's mind when considering all of the excitement of the home-approach to hard seltzers. Of course that means the addition of vodka is out of the question. So, how would a commercial brewer go about making a hard seltzer that can legally be sold using a brewer's license?

HARD SELTZERS MADE IN BREWERIES

While the logical approach described in the last section works great at home and in commercial facilities licensed for cocktail production, breweries must use a variant on the malternative theme. And thanks to the giant loophole in the legal definition of beer, breweries can ferment sugar water into what the tax collector defines as beer. The problem is that sugar water lacks the nutrients that make wort an ideal solution to ferment into beer. Sure, sugar water can be fermented by yeast to produce a crude mixture of water and alcohol, but the resulting flavor is not clean and is not the sort of product that can be enjoyably consumed without further processing. Distillation is the most common method to remove impurities from these rough washes, but breweries are not distilleries, so the old still in the back 40 is not the answer. Perhaps this is one of the reasons that Herr Rein H. Gebot penned his now-famous beer purity law back in 1516.

This is where yeast nutrients enter the picture as a crucial ingredient required for the production of any fermented beverage using a high proportion of simple sugars. Winemakers and meadmakers are much more familiar with the practical uses of different nutrients than brewers and taking lessons from their playbooks is a pretty handy start. The term yeast assimilable nitrogen, or YAN (where YAN = nitrogen from ammonia + nitrogen from amino acids), is used by winemakers and meadmakers to quantify the amount of nitrogen compounds in must — for example grape juice — that can be metabolized by yeast. Brewers use the term free amino nitrogen, or FAN, to describe amino compounds whose "free-amino" group reacts with ninhydrin stain (the same stain used in finger printing). YAN and FAN differ in the fact that not all FAN can be metabolized by yeast because proteins and polypeptides (not assimilable by yeast) have one free amino group. The takeaway message is that by knowing the YAN concentration of must, or sugar water in the case of hard seltzers, nutrient adjustments can be made by referring to tables relating nutrient addition scheme to YAN concentration.

Must containing less than 50 ppm

Keeping a neutral base hard seltzer on tap and then adding flavored syrups is an easy way to make available an array of flavored seltzers without tying up multiple taps.

of YAN is a high risk environment for yeast and a combination of organic nitrogen (amino acids), inorganic nitrogen (ammonia), and micronutrients, such as zinc, manganese, and B-vitamins, is recommended for healthy fermentations. The most common nutrient blends are proprietary and contain varying concentrations of lysed yeast cells and diammonium phosphate (DAP). Lysed yeast cells provide amino acids and micronutrients, and DAP is a ready source of ammonia. This all becomes quite the science project when brewers begin playing around with different yeast strains and nutrient combinations because of the vast number of combinations that can be used. Since the objective is to produce a neutral finished product and because yeast and nutrient blends can be purchased that have been specifically developed to cleanly ferment sugar solutions, many commercial producers of seltzers turn to these ready-made blends and skip the R&D project. A final thing to note about yeast nutrients is they will add a yellowish tinge to the sugar-fermented seltzer, which is one reason many brewers use carbon fining or carbon filtering.

The recipe and instructions provided to the right puts this information to use to produce the same basic hard seltzer described in the previous section, but this time the alcohol base will be produced by fermentation. Note the low starting gravity of the sugar solution. Sugar is completely fermentable by yeast, so this means that fully attenuated hard seltzer base will have little to no fermentables left at the end of fermentation. If you use brewing software or online apps to approximate alcohol in beer, be aware that these tools use regression models to predict alcohol based on large data sets collected from normal beer; these calculators do not work for sugar water mixtures.

BEYOND THE BASICS AND INTO THE FUTURE

The easiest way to flavor a neutral hard seltzer base is by adding unfermentable flavorings and organic acids to the finished and carbonated base

HARD SELTZER

5.25 gallons/20 L
OG = ~1.031 FG = ~1.000
ABV = ~ 5%

NEUTRAL BASE INGREDIENTS

21 L reverse osmosis (RO) or distilled water
4.5 g gypsum (adjusts calcium concentration to 50 ppm)
1.65 kg cane sugar
11.5 g packet SafAle US-05 or other neutral yeast strain
2.5 g Yeastex 82 yeast nutrient added with yeast pitch
2.5 g diammonium phosphate (DAP) added with yeast pitch
2.5 g Yeastex 82 yeast nutrient added 36–48 hours after yeast pitch
2.5 g diammonium phosphate (DAP) added 36–48 hours after yeast pitch

FLAVORINGS

2.8 mL lime extract added after CO_2 bubbling (if used) and carbonation
2.8 mL lemon extract after CO_2 bubbling (if used) and carbonation
420 mL pulp-free orange juice (single-strength, not from concentrate) after CO_2 bubbling (if used) and carbonation
14 g citric acid powder after CO_2 bubbling (if used) and carbonation

STEP BY STEP

Add water and sugar to kettle, turn on heat, and stir to dissolve sugar. Check solution strength and adjust as necessary; the pre-boil gravity should be ~1.031 OG (7.6 °Plato). Continue heating until solution is boiling and boil for 20 minutes. Check solution strength and dilute as necessary with RO or distilled water. Cool to 64 °F (18 °C) and transfer to fermenter. Add yeast and first addition of nutrients. Aeration is not required for first use of most dried yeast strains, including US-05, due to high glycogen content related to propagation conditions (https://fermentis.com/en/tips-n-tricks/questions-and-answers/). Feel free to aerate as normal if this suggestion seems too unusual. Other common yeasts that are popular for seltzer production are Champagne yeast and distillers yeast.

Fermentation should begin within about 12 hours. The second nutrient addition is added once fermentation has really kicked off and the gravity has dropped by about 0.008 OG; this should be about 36–48 hours after yeast pitching. When fermentation is complete (5–7 days after yeast pitch — FG will depend on yeast and nutrients but should be around 1.000), cool to 32 °F (0 °C) (or as cold as possible at home) and hold cold to permit yeast sedimentation.

Commercially-produced seltzers are clarified by filtration and/or centrifugation, but most homebrewers do not have filters. Part of the seltzer appeal is clarity, therefore, filtration is recommended when going for a facsimile of the real McCoy. The good news is that hard seltzer is easy to clarify using a cartridge filter. But you could also go the *Cloudy Claw* route and skip this step. Whatever you decide with respect to filtration, transfer the seltzer into a keg and carbonate to 2.8–3.0 volumes. Bottle or keg conditioning is not typical for hard seltzer. Taste the seltzer base to determine if aroma stripping is needed.

Sulfur off-flavors are fairly common with hard seltzers. Carbon dioxide bubbling can be used to strip these unpleasant rotten-egg and burnt-match aromas from hard seltzer. Just make sure to vent the keg during bubbling to allow these volatiles to escape. Nutrient adjustments and/or yeast strain selection on future batches can be made to help dial in the process. The trial and error nature of this process is the primary reason that many commercial seltzer producers select a yeast/nutrient blend designed for these intentionally bland bases.

The last step is to add the flavor additions. Dissolve the citric acid powder in the orange juice and add it along with the lemon and lime aromas. Slowly release the pressure on the keg, open the top while flushing the headspace with CO_2, and add the flavorings. Quickly closing the lid and re-pressurizing the headspace will minimize loss of carbonation. The orange juice in this recipe is intended to provide a slight haze, so if you choose not to filter, the juice will complement the haze of the seltzer.

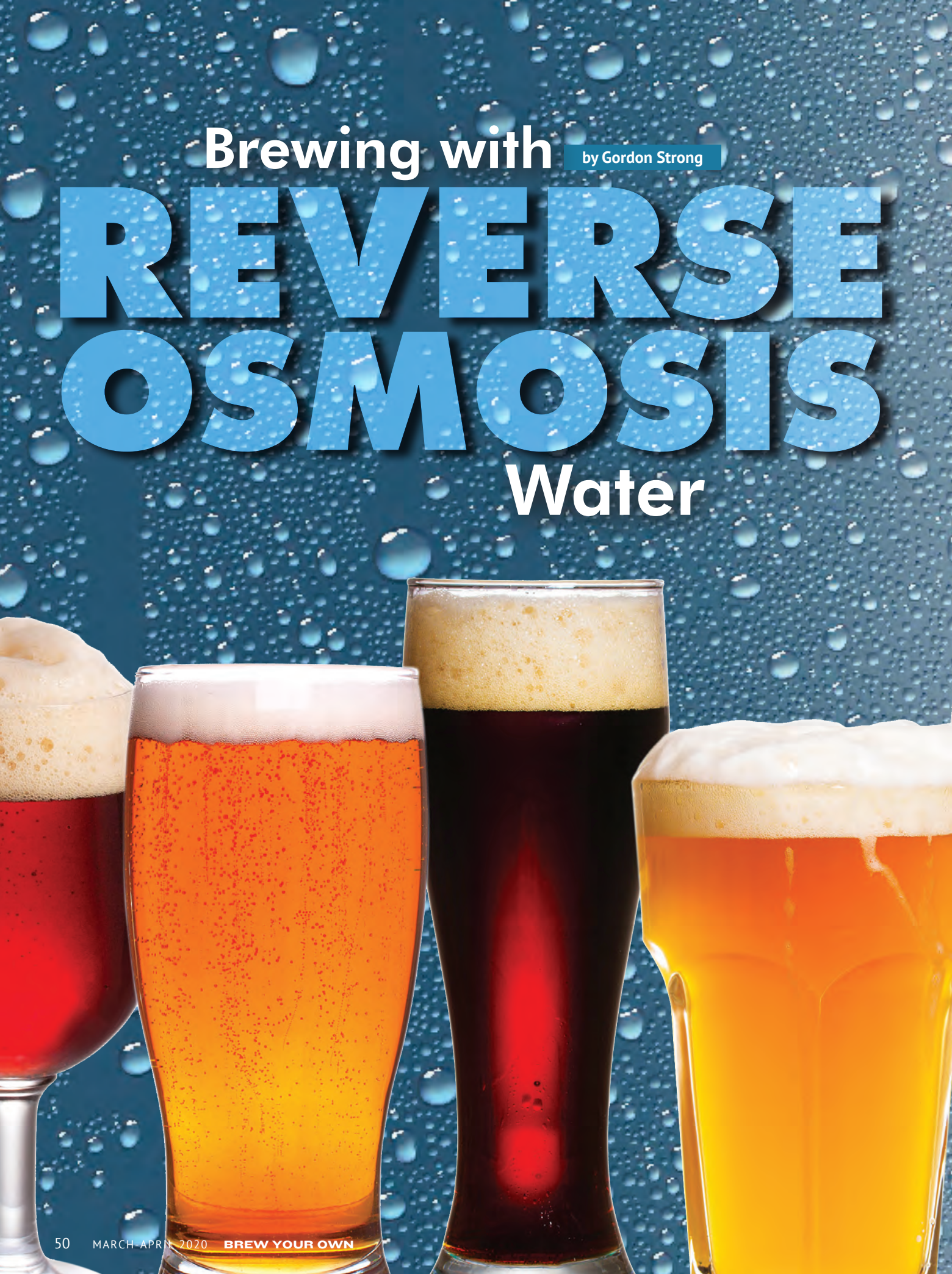
produced from the method described in the recipe on page 47. Another simple way to make variants from a single batch of neutral base is to add flavored syrups, a la Berliner weisse, immediately before serving. This is especially appealing for commercial brewers (as well as homebrewers) who don't want to tie up multiple taps for seltzer.

Neutral hard seltzer bases can be envisioned as the base of a cocktail where sweetness, fruitiness, color, and body are layered onto the base. The challenge becomes product stability; brewers **must consider** methods to prevent re-fermentation when hard seltzers are packaged. The best method, unavailable to homebrewers and most craft brewers, is tunnel pasteurization following packaging. The addition of potassium sorbate or potassium metabisulfite and/or flash pasteurization prior to packaging are alternates to tunnel pasteurizers. These last points are being directed to any commercial brewers who are reading this article. Whatever is decided, just make sure that unstable product is not packaged and sold.

The summer of 2019 may or may not go down in brewing history as the summer of the one hit wonder known as hard seltzer. In my opinion, I think this style is just getting started and that creative brewers will find interesting and exciting ways to push the envelope. Sugars with flavor, such as honey, agave nectar, brown sugar, Belgian candi sugars, and fruit juices, are the tip of the iceberg. Forrest Gump is my inspiration for the future of seltzer with his monologue about shrimp variants. There will surely be cloudy seltzer, kettle-soured seltzer, barrel-aged seltzer, nitro coffee seltzer, imperial seltzer, triple-double seltzer, PB&J seltzer, zero IBU seltzer, CBD seltzer, herbal seltzer, herbed seltzer (TTB got nothin' on homebrewing), spiced seltzer, high-calorie, gluten-unfriendly, pastry seltzer, and even peach-mint, orange-hued seltzer. The sky is the limit and homebrewers will certainly be searching for the outer limits. Have fun with this style and don't take things too seriously. BYO

Brewing with REVERSE OSMOSIS Water

by Gordon Strong



SIMPLICITY IS THE ULTIMATE SOPHISTICATION

"You can't trust water: Even a straight stick turns crooked in it."
– W.C. Fields.

Over the years, I've probably had more discussions, debates, and arguments with other brewers over water than just about any other topic. And I think I know why. It's a fairly advanced topic that requires some scientific understanding, but also significant brewing experience to apply. So those of us who write about beer invariably try to create simple models and descriptions to make the subject understandable to a wider audience. And in doing so, we create advice that people misinterpret as rules, and misapply in situations that were never envisioned.

In the more than 25 years I've been brewing, my goals have been to understand what's going on in my process, to apply controls in places that matter, and to enjoy making great beer. My switch to using reverse osmosis (RO) water has probably been the single largest change I've made that allowed me to achieve these goals and to greatly simplify my brewing process while still crafting medal-winning beers.

Photo by Shutterstock.com

WHAT IS RO WATER?

RO water is basically filtered water with greatly reduced mineral content. It's produced using the reverse osmosis process that uses high pressure and a semi-permeable membrane to remove minerals. The membrane is like a filter that will only allow molecules of a certain size or smaller to pass through. Under normal osmosis, liquid would flow across the membrane in the direction of lowest salt concentration to highest. But in reverse osmosis, the high pressure causes the liquid to flow in the opposite direction, forcing water from the mineral-rich side of the membrane (the water being treated) through the membrane while the concentrated feed water is rejected, thus producing low-mineral water (see the illustration below).

RO water is not the same as deionized (DI) water or distilled water. Those use different processes, although they will also produce water with reduced mineral content. RO water is not mineral-free, but can have 95–99% less minerals than the source water. The source water is often pre-treated to help with the mineral removal. In the RO machine I use, there is a five-stage process: Active carbon filtering, micron filtering, reverse osmosis, post carbon filtering, and ultraviolet (UV) irradiation. These other steps help remove chlorine, metals, organic matter, viruses, bacteria, and other undesirable content. While these steps aren't part of the RO process, getting water in this condition simplifies my brewing, and is what I mean when I talk about using RO water.

If you think all of this processing is expensive, it's not. I can buy 5 gallons (19 L) of RO water at my local supermarket for about $1.95.

ADVANTAGES OF RO WATER

RO water is a blank slate; it has very few minerals, so you can use it as a starting point for building brewing water for your purposes. It has very little alkalinity (dissolved carbonates and bicarbonates), so it doesn't buffer acids much — this means acid additions can easily change pH rather than having to first neutralize these buffers. And (assuming the RO machine is working properly), it is extremely consistent from batch-to-batch. This means you don't have to worry about variability in your water source, or get water reports to analyze.

If the RO water is processed as I described, it also has any chlorine removed and has other objectionable substances removed. Your water should be good to go for brewing without pre-boiling, filtering, or any other modifications. I normally just do a quick check of total dissolved solids (TDS), which is built into my pH meter. If it's low, I know the RO machine is working and the water will respond as with previous batches.

I've mentioned pH twice but haven't defined it. Loosely, it's an expression of how acidic or basic a solution is, with 7 being neutral, lower numbers being acidic, and higher numbers basic. Higher concentrations of hydrogen ions (H+) make a solution more acidic. The scale is logarithmic, so moving one number means the solution is ten times more acidic or basic. pH is an open-ended scale, although most measurements fall within the 0 to 14 range. Most beer-related measurements are even more constrained — for example, most finished beer is in the range pH 4.1–4.5.

That is a primer on pH, but if you want to dive deeper into the subject check out this story from the *BYO* archives: https://byo.com/article/the-role-of-ph-homebrew-science/

HOW WATER IMPACTS THE BREWING PROCESS

I see the three main worries about water during the brewing process as:

1. Does the water taste good?
2. Can I achieve a proper mash pH for enzymatic activity?
3. Does the beer taste right for its style?

To achieve the first goal (good

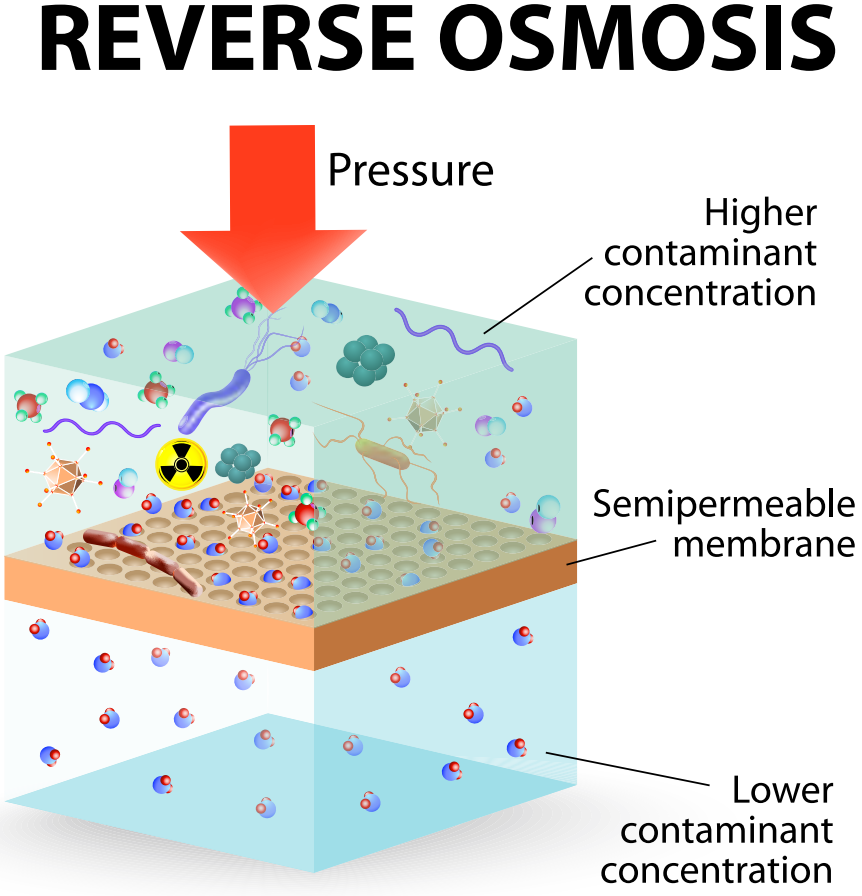


Photo by Shutterstock.com

In reverse osmosis, the high pressure forces water from the mineral-rich side of a membrane (the water being treated) through the membrane while the concentrated feed water is rejected, thus producing low-mineral water.

tasting water), breweries often pretreat their water by carbon filtration or pre-boiling. Municipal water suppliers can do some of this work for you, but breweries with their own wells or private supplies must treat their own water. Buying RO water allows you to skip all these steps. Your water is ready to use.

To meet the second goal (a proper mash pH for enzymatic activity), you typically have to lower the pH of the mash to a desired range. References vary on this goal, but I usually shoot for a pH of 5.2 ± 0.1 (Kunze in *Technology Brewing and Malting* says 5.1 to 5.2 is the goal; he stresses a lower mash pH helps avoid enzymatic oxidation of the mash, which causes premature staling of the beer).

When taking pH readings, understand that pH is expressed as 77 °F (25 °C) by convention, regardless of the temperature of the reaction. pH does vary by temperature (pH can be about 0.3 lower at mash temperature than at reference temperature), but the pH is normally written at the standard reference temperature unless otherwise stated.

Breweries typically adjust their brewing water to remove or offset alkalinity (carbonates) through boiling, acid additions (mineral acids, biological acids, or acid malt), or lime (calcium hydroxide). Then harden the water through additions of calcium salts (calcium chloride and/or calcium sulfate). Finally, the calcium in the water reacts with phosphates in the malt to reduce the pH. If all of this was calculated properly, the target mash pH is achieved.

With RO water, some of these steps are simplified. Removing alkalinity should already have been done. Salts can be added to reach a target calcium level (which we will discuss later), and the mash reactions are still the same. Some additional pH adjustments may be required with acids or malts.

The final goal (a beer that tastes right for its style) involves making any small adjustments to the flavor profile of the water to better support the style of beer being brewed. This is what I call adjustment of *stylistic ions* or chemically-inactive ions in the water. These salt additions don't affect the mash chemistry but can affect the taste of the beer. Adjusting these salts is the same regardless of the use of RO water or water from another source.

Photo by Charles A. Parker/Images Plus

There are fewer steps required to achieve a proper mash pH for enzymatic activity when using reverse osmosis water as the alkalinity has already been removed.

EFFECTS OF WATER IONS ON BREWING

Water is often called the universal solvent due to its ability to dissolve so many things, including salts. Salts are solid compounds formed of positive- and negative-charged components. Water readily disassociates salts (causes them to break into separate charged particles or ions), although some salts are more soluble than others.

The various ions from disassociated salts have pH and flavor effects in beer. Let's run through them:

Calcium (Ca^{+2}) — Is perhaps the most important ion for brewing. It's an

important cofactor for mash enzyme activity, helps in protein coagulation (hot and cold break, for those brewers who still remember that clarity is important), and helps lower mash pH by interacting with phosphates in the malt. Excessive amounts can taste metallic and have detrimental effects on yeast performance.

Magnesium (Mg^{+2}) — Has some of the same effects as calcium, but less so. It can also lower mash pH but has a disagreeable bitterness and sourness in higher concentrations; it also has laxative effects.

Sodium (Na^{+2}) — Has no effect on the brewing process but has some flavor effects, such as palate fullness. It can taste salty in high concentrations and has been linked to causing high blood pressure.

malts, however I don't use carbonate as I add any dark grain additions after the mash (more on this later).

Other ions present in brewing in smaller concentrations include trace elements important for yeast nutrition, such as zinc (Zn^{+2}), copper (Cu^{+1}), and manganese (Mn^{+2}). Metals such as iron (Fe^{+2}) and nickel (Ni^{+4}) are undesirable and can cause metallic flavors.

I resist making specific recommendations for concentrations of ions in brewing since sources vary so much. For example, Palmer and Kaminsky in *Water: A Comprehensive Guide for Brewers* recommend 50–150 ppm (parts per million, same as mg/L) of calcium; Fix in *Principles of Brewing Science* recommends 50–100 (although his cited source recommends 40–100), Briggs in *Brewing: Science and Practice* recommends 20–150, and Noonan in *New Brewing Lager Beer* suggests 5–200. Yet the water in Pilsen has less than 10 ppm of calcium, and I don't think Pilsner Urquell is a problematic beer . . . so hard and fast guidelines don't always work in real life, or there is more to the story than you think.

For people who dogmatically apply water profiles, I ask the simple question: Who says all of these minerals must come from water? Did malt suddenly become mineral-free when I wasn't looking? The mineral content of beer does not exclusively come from water, so we should stop pretending that the other ingredients have zero mineral content.

ter into literally any style. You don't have a huge range of alternatives to deal with — your options are limited. Some of my methods allow the brewer to limit them even further, which makes brewing very repeatable, consistent, and easy.

Sometimes there are multiple solutions to a brewing problem. When lowering the pH of the mash, you can let the calcium and magnesium (hardness) interact with the malt, you can add liquid acids, or you can add acid malt to the grist. The hardness interaction will always happen, but is often insufficient to reach a target mash pH. Malts are tested with a procedure called a *congress mash*, which is a very standardized process using deionized water. The mash pH for base malts generally settles at 5.8–6.0, which gives an indication of what other acidification is necessary when brewing.

> **The mineral content of beer does not exclusively come from water, so we should stop pretending that the other ingredients have zero mineral content.**

Chloride (Cl^{-}) — Adds to the fullness and roundness of beer on the palate. It can contribute to salty flavors when combined with sodium. It is an important flavor ion.

Sulfate (SO_4^{-2}) — Adds to the dryness of the beer on the palate and can accentuate the sharpness of bitterness. It can be harsh and sulfury in larger concentrations. It is an important flavor ion.

Carbonate (CO_3^{-2}) — Increases mash pH and provides the alkalinity in water. At mashing pH it mostly exists as bicarbonate (HCO_3^{-}). It causes problems in brewing by raising pH, and has a chalky flavor. Reducing alkalinity is a major goal of brewers when dealing with water. Carbonate can balance acidic raw materials like roasted

RECIPE AND PROCESS CONSIDERATIONS

When you use RO water, you aren't trying to turn literally any kind of wa-

If you are using RO water, mashing base malts should result in a fairly consistent pH that you can measure and use as part of your recipe planning. I recommend using a good-quality, calibrated digital pH meter for this purpose. You can then measure how much acid you need to add to your mash to lower the pH to the desired range. Use your pH meter to monitor the pH change, and record the amount of acid needed.

I acidify all my RO brewing water to a pH of 5.5, which is a trick I learned years ago at Sierra Nevada's Beer Camp. This prevents tannin extraction during sparging and also helps me prepare for mashing. Even if you handle your mash pH calculations differently, I recommend acidifying your sparge water and keeping the temperature below 176 °F (80 °C).

If you don't acidify your mash with (liquid) acids, you may find that you need to add 2–3% *sauermalz* (acidulated malt) to your grist to achieve your desired mash pH.

When I brew, I try to have consistent mash performance every time. So, I tend to only mash base grains and starchy adjuncts — things that actually need to be mashed. I leave out roasted and crystal malts from the mash since they are already converted. I add these grains during wort recirculation, after the mash is over. The pH during the mash thus becomes very predictable without the use of recipe software or water calculators.

If you do include crystal malts and roasted grains in the mash, you may need to use the water calculators to adjust your mash chemistry and reach a desirable pH. The mash pH should settle within the first 10 or 15 minutes of the mash, so that's when the pH can be tested (by first cooling a small sample to room temperature).

With my process, I stopped measuring mash pH because it was always where I expected it to be. With good process control and consistent use of ingredients, that kind of performance is possible. I occasionally spot-check the pH of my mashes, but that's more like performing a random audit than a process control.

Not all salts in the mash carry over to the boil (one source estimates it at 40–60% of salts are filtered by the mash). If the final mineral profile is important to the flavor of the beer style being produced, I will make another addition of salts to the kettle.

MY METHOD FOR WATER ADJUSTMENTS

There are a wide variety of salts, acids, and bases that can be used in brewing, but I find that I use a very limited subset when using RO water. Many of the options are redundant, or only useful in specialized situations. Others have side effects that I would rather avoid.

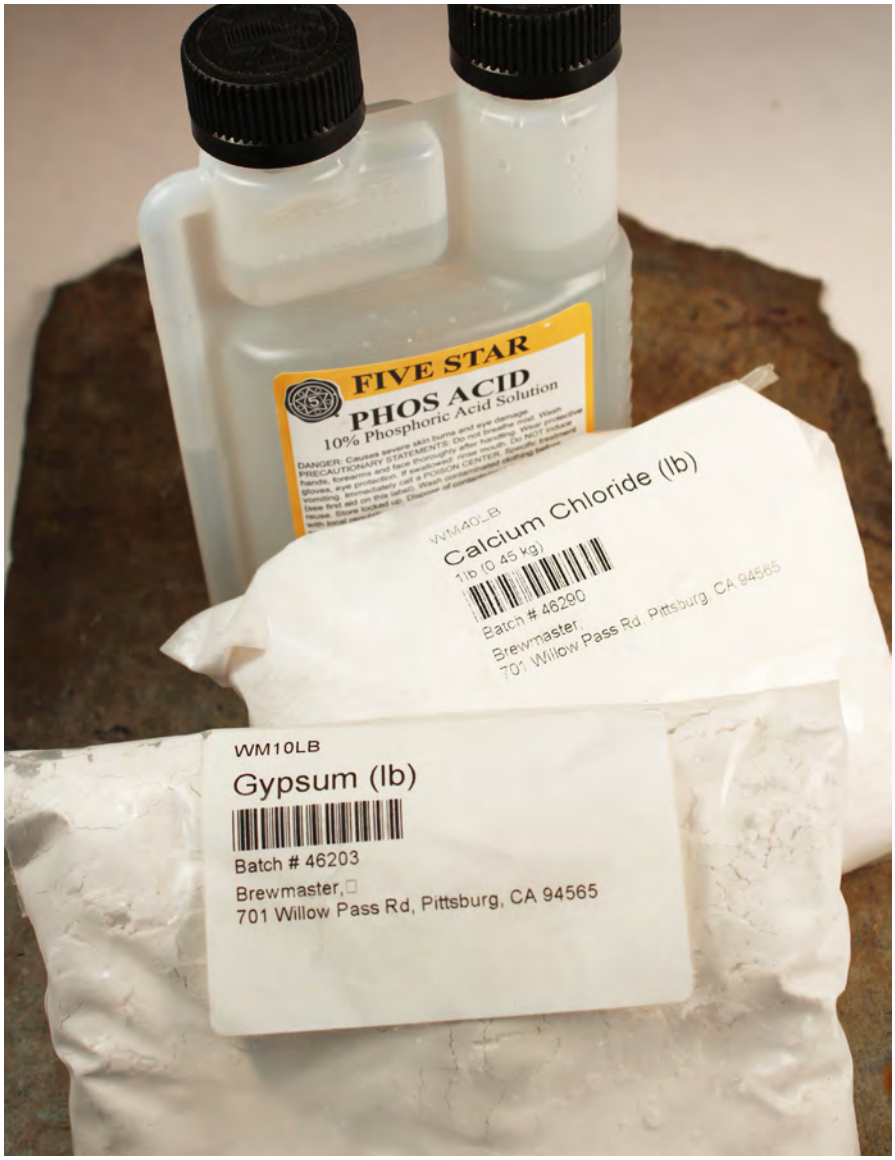
The three most important additives for me are:

Calcium chloride ($CaCl_2$) — Adds calcium in the most flavor-neutral way. Chloride adds a soft, wet, round, fat, sweet, or full impression to beer that often favors malty styles.

Calcium sulfate (gypsum, $CaSO_4$) — Adds calcium but also sulfates that may have a negative flavor impact with noble-type hops or cause a harsher, sharper bitterness.

Phosphoric acid, 10% solution — My primary way of adjusting acid in the most flavor-neutral way. Using the more dilute solution makes it safer and easier to handle, as well as measure.

I generally don't want to add magnesium due to its laxative and souring effects, but if I did, I would use Epsom salts (magnesium sulfate). Likewise, I rarely want to add sodium due to its blood pressure effects, so I avoid using kosher salt (sodium chloride) and baking soda (sodium bicarbonate) (admittedly, the amount of sodium that would be added to beer is minimal, but I still try to avoid unnecessary sodium additions). If I did want to raise mash pH for some reason, I would use either pickling lime (calcium hydroxide) or potassium hydroxide, but these can be a bit dangerous to handle. Lactic acid can also adjust pH like phosphoric acid, but the flavor can mimic beer faults (generally not in the concentration used to adjust pH, however).



Calcium chloride, calcium sulfate (gypsum), and 10% phosphoric acid are the three most important water additions in my brewing method.

I can perform my measurements with two or three instruments: A good set of kitchen measuring spoons, a digital pH meter, and a TDS meter. These, plus a hydrometer or refractometer, and a quick-read digital thermometer, are my basic brewing instruments I keep handy.

I start by checking my source RO water with a TDS meter. If it reads low, I know it is really RO water and will respond as I have tested. If not, I know that I have to take additional readings and possibly adjust my measurements.

I then adjust all my brewing water with phosphoric acid to pH 5.5 at room temperature. I use a pH meter the first few times I do this to measure how much I am adding. For my water, it's about ¼ tsp. per 5 gallons (19 L) of RO water. But you should measure and test your own water. It's important.

This brewing water is then used for mashing, sparging, and whatever other utility tasks I have, such as cleaning.

I measure water salts I am using in my recipe using a teaspoon. These salts are added to the mash, not the hot liquor. I generally add the milled grain, then the salts, then underlet my mash with the hot liquor. Measure your mash pH about 10 minutes after you have mashed in. If it's off, wait another five minutes and try again. Only then consider making adjustments (which is something I almost never do).

Some recipes may use kettle salts (for example, I might add some calcium sulfate during the boil to adjust the flavor profile of English IPAs without overly affecting the mash chemistry), but this is a distinct minority of brews for me.

WATER PROFILES

When I first began brewing, many recommendations involved creating water profiles based on classic brewing cities that were associated with certain beer styles. There are several problems with this approach, however. First, is accuracy — are the profiles actually representative of the cities? Did they come from the sources used by breweries, or are they simply local to the area? Are they from modern times or from when the styles were developed?

While I don't keep a library of water profiles, I have general guidelines I stick to. For instance, New England-style IPAs favor chlorides to help soften the finish, while West Coast-style IPAs go heavier on the sulfates to provide a sharper finish.

Second, are those profiles actually what brewers used? Did the brewers perform any pre-treatment? Is it the profile of what is in the mash tun? I don't think so. Even the premise of famous cities and styles makes no sense in some cases. Consider Munich, London, and Edinburgh. What styles originated there? Munich dunkel or helles? London brown or porter, or bitter? Scottish wee heavy or IPA? Those styles require very different water, yet are from the same cities.

Finally, the profiles often don't make sense from a chemistry standpoint. They are either incomplete or could not exist at typical water pH ranges. This is probably because multiple sources of data were averaged or that numbers were just made up. Either way, they often don't represent actual targets.

However, generalities about the local brewing water in classic brewing cities is relevant and often does inform choices — just not at the level of precision that published water profiles imply. Statements like, "Pilsen has low mineral water" or "Burton has high sulfate water" are useful for understanding the historical basis for styles.

I don't really have a library of water profiles for each style of beer, rather I have some general guidelines. I tend to think of beers by their major characteristics and then decide if I want to accentuate certain flavors through the use of flavor ions. The nice thing about this approach is that the flavor ions can also be added to the finished beer. So, if you aren't sure about the flavor profile you want, you can run some tests with your completed beer and decide what you want to incorporate into your next batch. Just run those tests as bench trials on a small glass, not a full keg, and scale up when you find what you like. Here are my general guidelines:

- For most beers, I use one teaspoon of calcium chloride per 5 gallons (19 L) of finished beer. This should provide about 60 ppm of calcium and 107 ppm of chloride, per Korzonas' *Homebrewing: Volume 1*. I find this provides ample calcium for the mash, and al-

lows the flavors of the beer to come through cleanly.

- For some hoppy styles (like pale ales), I instead use one teaspoon of calcium sulfate per 5 gallons (19 L) of beer. This provides about 59 ppm of calcium and 141 ppm of sulfate, per Korzonas.

- For some more balanced styles (like Kölsch), I'll use a half teaspoon of both calcium chloride as well as calcium sulfate.

- British beer tradition often mentions the ratio of sulfate-to-chloride, so I sometimes will try to play with the ratio while keeping the total quantity of salts to about a teaspoon. Briggs recommends sulfate:chloride of 2:1 to 3:1 for Burton ales and 2:3 for mild ales, for instance. West Coast-type American IPAs use a lot of sulfate, but New England-type IPAs favor chlorides. Think about the difference in how those beers finish to give you an idea of the range of adjustment.

- If I'm making a beer style that is known for a minerally profile, like Dortmunder export or English IPA, I'll double the level of salts — 2 tsp. per 5 gallons (19 L), using half of them in the kettle and half in the mash. I've tried making IPAs with high amounts of sulfates and I just don't like the flavor as much as I do with less. Your palate might think otherwise.

- If I'm brewing a Czech Pilsner or other very low mineral beer, I'll halve the standard amount — ½ tsp. of salts.

- I try to avoid using sulfate salts in conjunction with noble hops, because it creates a clashing flavor to my palate.

- I often rely on yeast nutrients to provide trace elements for fermentation; I don't try to add those directly. I prefer Wyeast brand yeast nutrient.

These additions assume that you are following the process I have outlined in this article — that you have treated your RO brewing water to pH 5.5 with phosphoric acid, and that you are adding your crystal malts and dark grains after the mash has finished. If you follow other processes, you will have to account for adjustments needed to hit your target mash pH.

Remember that you can adjust flavor ions after the beer is finished, as well as the finished pH. Lower pH makes the beer thinner and sharper, higher pH makes the beer rounder and fuller. Finished beer pH shouldn't be above 4.5 in order to protect it against infections. I don't think these post-fermentation treatments are normal; however, I sometimes use them to play "what if" games and think about future recipe development. It does help you fine-tune a recipe to your test, and could help put the finishing touches on your competition beers too.

I can't stress enough how important it is to taste your beer. Not *drink* it — taste it. Think about it like a judge. Are you tasting minerals or the ingredients? If it tastes too minerally, make adjustments in future batches. How is the finish? Is it too sharp or too flabby? Adjusting the amount of chlorides and sulfates can help soften or sharpen the beer. Experimentation on a very small scale with your finished beer helps you avoid brewing many larger test batches.

It's interesting; while researching different author's positions on water additions, I found a quote in *Dave Miller's Homebrewing Guide* from 1995, "One tsp. of either $CaCl_2$ or $CaSO_4$ is the most you should need (per 5 gallons/19 L of mash water)." So it seems I wasn't the first to make this observation. I'm in good company.

ON MEASUREMENT

I'm an engineer, so I'm comfortable with judicious use of approximations. There is a point where good enough is, well, good enough. Adding extra precision doesn't always give you better results; it just consumes time and distracts you from important tasks. Fiddling with water is one area where this extra precision doesn't add significant results.

> **Remember that you can adjust flavor ions after the beer is finished, as well as the finished pH.**

Yes, using volume measurements for water salts is less precise than weights. But what does that extra precision buy you if your other quantities are unknown or are approximates themselves? If your source water is unknown, why add a highly precise addition? If your target profile is at best a guess, why must you hit it exactly?

I trust my palate to tell me when my beer is good, not an equation. And I know a volume measurement is a reasonable approximation of a weight measurement in normal brewing conditions.

FINAL THOUGHTS

Brewers made great beers for hundreds of years without gram scales or spreadsheets. You can too. RO water is the key to not worrying about precise water adjustments. Embrace the elegance of simplicity, and begin enjoying the fruits of your labor.

I would like to acknowledge the teachings and friendship of A.J. deLange over the past 20 or so years, and all that he has done to further the understanding of water. He helped me understand the science behind the practical observations that I made about brewing and to validate my methods.

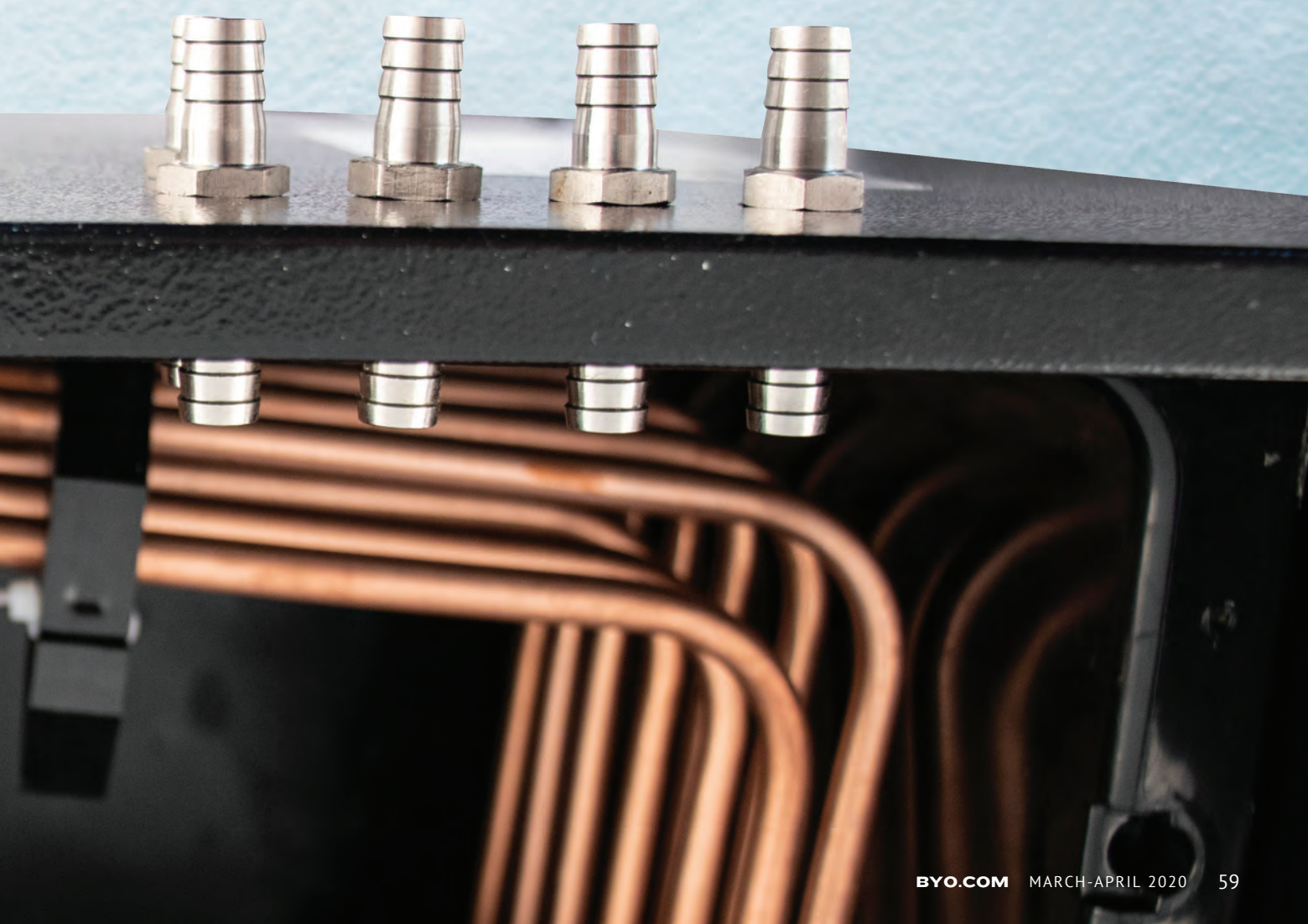
HOMEBREW GLYCOL SYSTEMS

Photo courtesy of MoreBeer!

Cool rundown on 7 set-ups

Everyone who brews beer knows that fermentation temperature control is one of the most critical aspects to consistent, flawless beer. When the fermentation temperature gets too warm, off flavors are sure to follow. Even if you have a cool spot in the house, daily temperature swings during fermentation can still wreak havoc on beer flavor. There are many methods homebrewers use to control fermentation temperature — from water baths and heat wraps to fermentation chambers and pumping ice water through cooling jackets or immersion coils. Each method works, to a degree, but they also have major drawbacks from having to constantly monitor the temperature and replace ice water, only being able to set one temperature for multiple batches, and space constraints, to name a few.

Over the last couple of years a new method has flooded the homebrew market: Glycol chilling systems. Similar to what is used on the professional scale, these homebrew-sized units solve nearly all of the drawbacks from other temperature control methods. Of course, the cost is greater than most of these other methods as well, so glycol cooling systems are generally intended for the more dedicated homebrewers who brew often (with multiple batches fermenting at a time) and those who brew large batches where temperature control presents greater challenges.



While each unit available offers unique features and different designs, the nuts and bolts of how glycol chillers work is simple. Fill the chiller's reservoir up with a glycol/water mixture, which will be cooled down around freezing temperature. Then set the desired fermentation temperature on the thermostat (with some units the thermostat, as well as pumps and hoses are sold separately). A temperature probe is placed in the fermenter and whenever the temperature of the beer rises above the set temperature a pump kicks on and sends the glycol mixture through coils in or around the fermenter until it is within the correct temperature range. Additional insulation wrapped around the fermenter is often recommended to hold the temperature longer.

With multiple controllers and pumps, the ability to keep multiple fermenters at various set temperatures is also made easy. Want to lager one beer while another ferments at ale temperatures? Easy. Want to raise the temperature for a diacetyl rest on one beer but not the others? It just requires a push of a button.

Even chilling wort down to yeast-pitching temperature is made easier with a glycol chiller. Cooling those final 10–20 degrees can be difficult, especially if your tap water isn't cold enough with a standard wort chiller. Just chill the wort down close, say to 100 °F (38 °C), then allow the glycol chiller to do the rest of the work in a fraction of the time.

There are a number of factors to consider when deciding which glycol chilling system is right for you. Is it powerful enough to get the job you need it for done efficiently? Can you control all of your fermenters with the unit? Is it in your price range? How easily compatible is it with your brewing system, and does all of the equipment you'll require come included or will there be additional costs? Are there space constraints or aesthetic issues to be considered based on where it will be housed?

We aren't here to tell readers which unit is the best or which you should buy. Indeed, that decision will differ depending on what each homebrewer is after. Instead, we believe there is a benefit to laying out the options in a concise way for comparisons and allowing each homebrewer in the market for a glycol unit to make an informed decision. So across the following pages we provide the manufacturer-stated specifications for seven glycol systems designed specifically for homebrewers, and put many of the key specs together side-by-side in a chart on page 64 for easy comparison.

No matter which one you choose, the addition of a glycol system is sure to make your brewing easier. And if you haven't already found a reliable way to ferment your beers at a set temperature, adding a glycol system will also noticeably improve the quality of your brews!

Blichmann Engineering Glycol Chiller

Just released in December 2019, the Blichmann Glycol Chiller features a ⅜ horsepower compressor and an 8-gallon (30-L) glycol reservoir, with an advertised 3,400 BTU/hour cooling capacity. The reservoir temperature control range is from 23 to 50 °F (-5 to 10 °C). It is compatible with up to six fermenters at a time (Blichmann Fermenator™ Pump & Controller Kits sold separately for $99.99). The unit features a convenient plug-and-play temperature controller dock and is designed to keep the cables and hoses tidy and out of the way. It also has locking casters for easy mobility.

It has the capability to cold crash six 14-gallon (53-L) fermenters at a time, or two 1-BBL fermenters. For maintaining temperatures it can handle up to six ½-BBL fermenters or four 1-BBL fermenters at a time (results based on vessels equipped with insulation at an ambient temperature of 75 °F/24 °C).

The Blichmann Glycol Chiller runs on 120VAC with a power consumption of under 500W. The unit measures 16" W x 17" D x 29" H (40.6 x 43.1 x 73.7 cm)

MSRP: $899.99

Web: https://www.blichmannengineering.com/glycol-chiller.html

BrewBuilt IceMaster 100 Glycol Chiller with Stainless Bulkheads

The BrewBuilt IceMaster 100 can control the temperature of up to four tanks that have a glycol jacket, added Coolstix, or submersed cooling coil/rod. The unit has a glycol reservoir capacity of 8 gallons (30 L) and has a ⅜ horsepower compressor. It comes with 10 stainless bulkheads with ⅜ OD barbs and includes wheels. A submersible pump and digital controller will need to be purchased separately (the 5-gallon/19-L BrewBuilt Chiller Pump Kit retails for $99.99 and the 10-gallon+/38-L+ kit is $109.99). Cold crashing capacity at 75 °F (24 °C) with neoprene insulation (double for fermentation temperature control) is advertised at 4+ tanks of up to 14 gallons (53 L), or up to four ½-BBL tanks, or two 1-BBL tanks.

The IceMaster 100 runs on 110V and has a cooling capacity of 950W/3,200 BTUs. The unit measures 16.1" W x 16.1" D x 26" H (41 x 41 x 66 cm).

MSRP: $749.99

Web: **https://morebeer.com/products/brewbuilt-icemaster-100-glycol-chiller-stainless-bulkheads.html**

BrewBuilt IceMaster Max 4

The newest release from BrewBuilt, the Max 4 is nearly identical to the IceMaster 100 with the exception that it includes four built-in submersible pumps with independent digital temperature controllers, allowing users to separately control the fermentation temperature or cold crashing of four tanks at a time. At just $150 more than the IceMaster 100, it delivers a significant cost savings for homebrewers who are looking to add on up to four pumps and controllers. The Max 4 has a glycol reservoir capacity of 8 gallons (30 L) and has a ⅜ horsepower compressor. It comes with labeled "in" and "out" stainless bulkheads with ⅜ OD barbs and includes wheels.

It runs on 110V (36 amps) and has a cooling capacity of 950W/3,200 BTUs. The unit measures 16.1" W x 16.1" D x 26" H (41 x 41 x 66 cm).

MSRP: $899.99

Web: **https://morebeer.com/products/brewbuilt-icemaster-max-4.html**

Grainfather Glycol Chiller

The Grainfather Glycol Chiller includes a pump with four connections to make it possible to connect and control the temperature of up to four 8-gallon (30-L) Grainfather Conical Fermenters at a time. It features a 1.6-gallon (6-L) glycol tank that has the ability to cold crash, lager, and control fermentation temperatures of up to four fermenters with 6-gallons (23 L) of wort down to 40 °F (4 °C).

The glycol chiller comes with everything needed to hook up to a single Grainfather including two 6.5-foot (2-m) insulated silicone hoses and an LED touch display. Additional cooler connection kits must be purchased separately for each additional conical fermenter (connection kits retail for $64.99 and include two 6.5-foot/2-m insulated hoses and two cooling connection couplers).

This system works with the Grainfather Conical Fermenters as the cooling sleeve is located in between the two stainless steel walls of the fermenter, which is then hooked up to the Glycol Chiller. With the chiller comes a two-part conical insulation jacket (one to wrap the body, another to wrap the cone) to insulate the conical fermenter. The unit comes with a two-year warranty.

The unit measures 15" W x 17.7" D x 25.8" H (39 x 45 x 66 cm). Electricity compatibility is 110–120V, 60 Hz.

MSRP: $998

Web: **https://grainfather.com/grainfather-glycol-chiller**

Penguin Chillers ⅓ HP Glycol Chiller

This is the smallest of a wide range of glycol chillers made by Penguin Chillers, all of which are built in America. The ⅓ HP model features a 5-qt. (4.7-L) glycol reservoir and can be used with up to four fermenters of any kind. It features four inlet and four outlet ⅜" tubing fittings on the lid of the reservoir along with an additional hole to run the power cord for each pump. Pumps, controllers, and tubing must be bought separately. Descriptions of the model indicate it runs quietly at 56 dBA. The chiller comes with a one-year warranty.

The unit weighs 48 lbs. (22 kg) and has a cooling capacity of 2,200 BTU/hour at 28 °F (-2 °C). It runs on 115V / 3.7 A / 420 W and has a 6-foot (1.8-m) power cord. It measures 18" W x 16" L x 13.25" H (46 x 41 x 34 cm)

More powerful models from Penguin Chillers are also available for homebrewers and nanobrewers, from a ½-HP unit (starting at $999.99) up to 1 HP (starting at $1, 599.99).

MSRP: $879.99

Web: **https://penguinchillers.com/product/1-3-hp-glycol-chiller**

Ss Brewtech Glycol Chiller ⅕HP

The Ss Brewtech Glycol Chiller ⅕HP will maintain lager temperatures for up to three vessels, and enable cold crash cooling for one vessel at a time. It has a 4.75-gallon (18-L) glycol reservoir with a sight glass to keep an eye on the glycol level. It integrates seamlessly with Ss FTSs kits. Since each FTSs kit includes a temperature controller, pump, and tubing, each vessel can be connected to the glycol chiller with no additional equipment necessary. However, the Glycol Chiller does not come with a controller, pump, or tubing, so those must be purchased separately if using with other vessels. It can cool up to three 7-gallon (26.5-L) conicals or unitanks, or three 10-gallon (38-L) Brite Tanks, or two ½-BBL vessels.

This unit comes with casters and measures 14" W x 11" D x 27.5" H (36 x 30 x 70 cm). It runs on 120VAC and outputs 1,450 BTUs/hour.

If you want to cool more (or larger) batches at a time, Ss also has larger units with more horsepower, including a ⅜-HP unit that chills up to 6 fermenters (sized from 7 gallons/26.5 L to ½ BBL) and retails for $1,295, as well as a ¾-HP unit that chills up to six vessels up to 1 BBL in size, which retails for $2,495. These larger sizes pack more BTUs/hour and house larger glycol reservoirs, but generally have the same features as the ⅕-HP unit.

MSRP: $899

Web: **https://www.ssbrewtech.com/products/glycol-chiller-1-5hp**

Stasis

The Stasis from Craft A Brew is the first glycol chiller to feature internal pumps and thermostats that come standard. The Stasis can be integrated with the cooling system of any fermenter. Digital controls allow you set independent temperatures for two different beers so you can ferment two 10-gallon (38-L) batches side-by-side. The glycol tank capacity is 2.1 qts. (2 L) — which is smaller than its competitors but since it is well-insulated and moving glycol in a closed loop, it is big enough to get the job done. The minimum set temperature is 36 °F (2 °C) (keeping one beer at this temperature while fermenting a second at ale temperatures would require 5-gallon/19-L insulated fermenters).

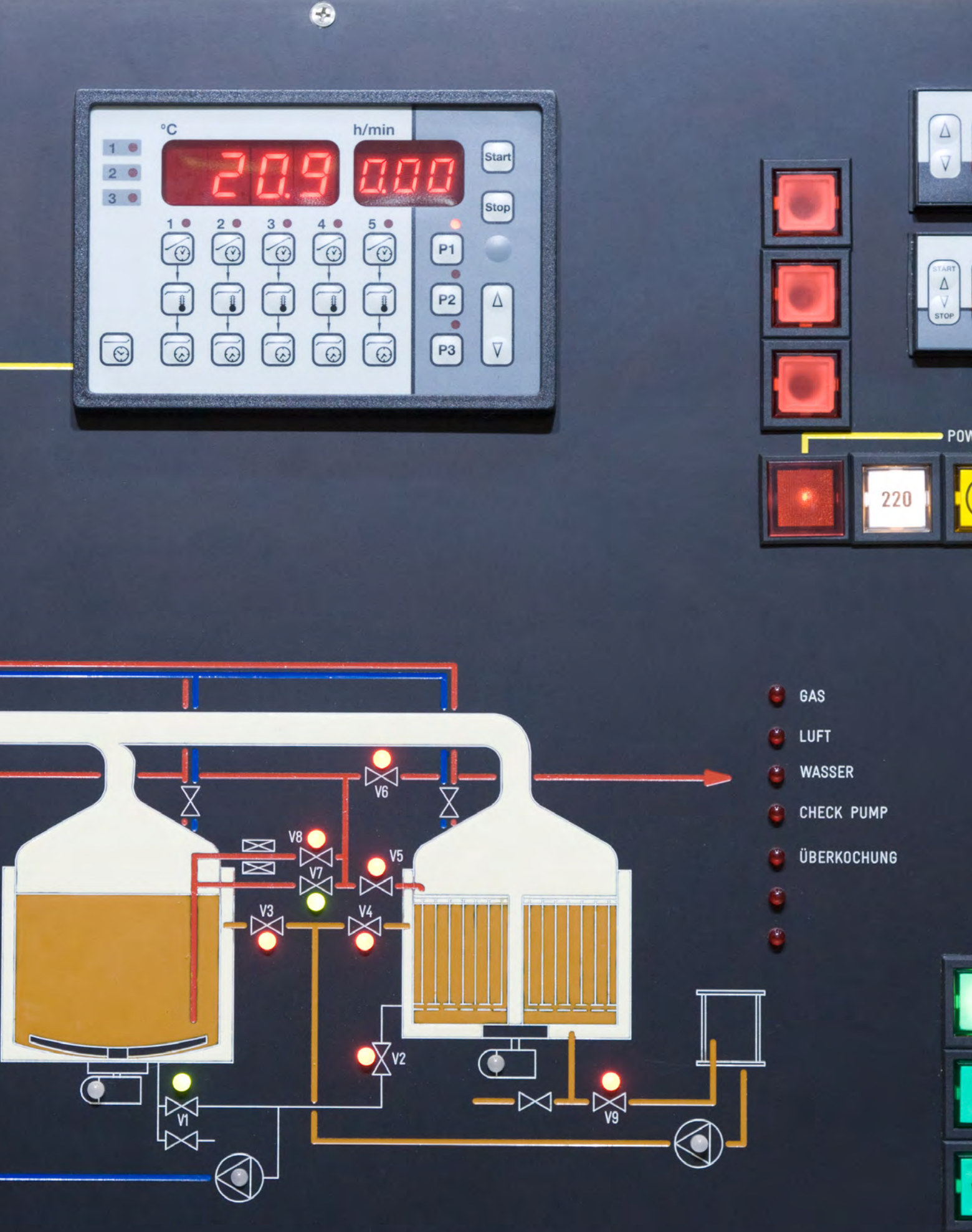
The Stasis runs on 120V with a ⅕-HP compressor. It has a cooling capacity of 1,700 BTU/hour. The maximum dimensions are 21.1" W x 10.4" D x 11.5" H (56.7 x 26.4 x 29.2 cm).

MSRP: $659

Web: **https://craftabrew.com/products/the-stasis-glycol-chiller**

GLYCOL SYSTEM COMPARISON CHART

GLYCOL SYSTEMS	PRICE (US)	PUMPS/ CONTROLLERS	HORSEPOWER	BTU/HOUR RATING	MAX FERMENTER COMPATIBILITY	RESERVOIR CAPACITY	POWER (VOLTAGE)	DIMENSIONS (W X D X H)
Blichmann Engineering Glycol Chiller	$899. 99	Sold Separately	⅜ HP	3,400	6	8-gallon (30-L)	120VAC	16 x 17 x 29 in. (40.6 x 43.1 x 73.7 cm)
BrewBuilt IceMaster 100 Glycol Chiller with Stainless Bulkheads	$749.99	Sold Separately	⅜ HP	3,200	4	8-gallon (30-L)	110V	16.1 x 16.1 x 26 in. (41 x 41 x 66 cm)
BrewBuilt IceMaster Max 4	$899.99	Included	⅜ HP	3,200	4	8-gallon (30-L)	110V	16.1 x 16.1 x 26 in. (41 x 41 x 66 cm)
Grainfather Glycol Chiller	$998	Included	¼ HP	Unknown	4	1.6-gallon (6 L)	110–120V	15 x 17.7 x 25.8 in. (39 x 45 x 66 cm)
Penguin Chillers ⅓ HP Glycol Chiller	$879.99	Sold Separately	⅓ HP	2,200	4	1.25-gallon (4.7-L)	115V	18 x 16 x 13.25 in. (46 x 41 x 34 cm)
Ss Brewtech Glycol Chiller ⅕HP	$899	Sold Separately	⅕ HP	1,450	3	4.75-gallon (18-L)	120VAC	14 x 11 x 27.5 in. (36 x 30 x 70 cm)
Stasis	$659	Included	⅕ HP	1,700	2	0.5-gallon (2-L)	120V	21.1 x 10.4 x 11.5 in. (56.7 x 26.4 x 29.2 cm)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Start
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P1
P2
P3
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GAS
LUFT
WASSER
CHECK PUMP
ÜBERKOCHUNG
V1
V2
V3
V4
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V9

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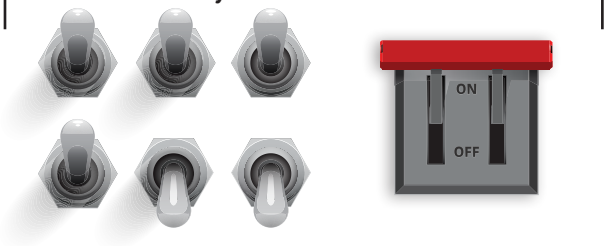
DIY ELECTRIC BREWING

WHAT YOU NEED TO KNOW FIRST

by Geoff Parkins



Many homebrewers start their adventure with the kitchen stove or a turkey fryer pot and propane burner, coupled with a cooler converted into a mash tun. It worked for Charlie Papazian, it worked for John Palmer, and it has worked for thousands of homebrewers across the country. These systems are often cobbled together from this, that, and t'other. Some look very nice and finished, while others are quite crude. They do, however, share some common drawbacks: An open propane burner loses 50–80% of heat to the atmosphere; propane cannot be used indoors due to carbon monoxide issues; it is difficult to keep a consistent mash temperature without constant fiddling; and gravity is not the most convenient way to move a batch from here to there if it's larger than 5 gallons (19 L). Over the years, a large body of shade-tree wisdom has been shared that alleviates many of the symptoms, but the core issues remain.

Necessity, mothers, and invention collaborated, and electrically-powered tools entered the homebrewing scene. The introduction of a small centrifugal pump meant that brewers could start planning for bigger batches without having to consult with a structural engineer to design a safe three-tiered tower that would allow for half-barrel kettles to all flow downhill. Pumps also accelerated the development of recirculating wort during the mash. Development proceeded in dribs and drabs until 2009, when Kal Wallner developed and published his design for a PID-controlled system at TheElectricBrewery.com that used specialized water heater elements installed in a kettle. To put it mildly, Kal pretty much started a revolution among homebrewers singlehandedly. His book, *The Complete Guide to Building Your Brewery* sparked

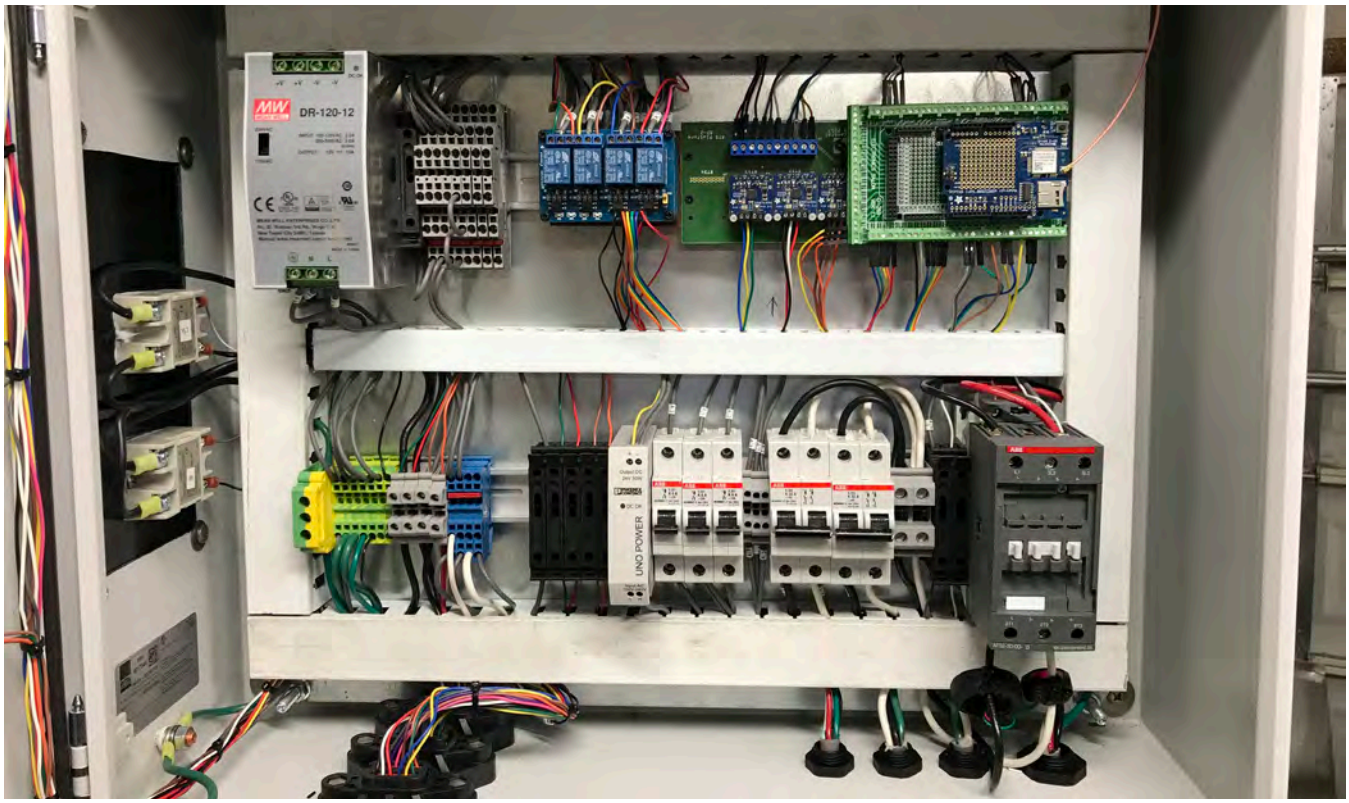


Photo by Geoff Parkins

Inside a completed brewstand control system enclosure.

a forum dedicated to electric brewing on HomebrewTalk.com (HBT), which at the time of this writing, has over 145,000 messages in over 8,500 threads. Hopheads around the country started talking about SSRs (solid-state relays), GFCIs (ground-fault circuit interrupters), and PIDs (proportional–integral–derivative controllers) as much as they were talking about IBUs, ABV, and pH.

Electric brewing can be done indoors as long as you have an exhaust fan of some kind. The heating elements are surrounded by wort, so every kilowatt-hour consumed is directly applied to the job at hand. No more forking out $25 for a Blue Rhino tank in an attempt to heat Duluth, Minnesota in January. Perhaps the biggest benefit is that mash temperatures can now be held to +/- one degree, across the entire mash rest period, and it can be done with very little intervention from the brewer. The benefits to electric brewing are tremendous. It gets even better when you have a digital thermostat controlling your fermentation temperature. No more sketchy batches because someone left the blinds open in the living room.

Most of today's electric brewing is centered around a 2–3 vessel system with electric heating elements and some kind of mash recirculation system. There are plenty of variations, but we'll spend the balance of this article focusing on the most common system design.

As with all stories, it's never all sunshine and roses. A loss of control over electricity can hurt or kill you, and it's not as polite as propane, with its lovely sulphur-based alarm smell. You can't see electricity coming. Without proper grounding and circuit protection, you could wake up in an ambulance, or worse. If you turn your back to it, it will find every resistive connection it can and start making copious amounts of heat in that connection. Enough to start a fire and turn your brewery into a smoking ruin.

Mixed in the 145,000 messages in the Electric Brewing forum on HBT is Forrest Gump's box of chocolates. There is some outstanding information, some recycled information, and some information that came out of the south-facing end of a northbound intact bovine creature. Navigating the rocks and shoals of information on electrical safety in the brewhouse requires information, a little understanding, and a lot of caution. That's not to say that the subject is unapproachable without a heavy theoretical background. There are some basics that are important to know (grounding, wire sizing, breaker selection, etc.) and some techniques that need to be used (proper crimping, separating power and signal wires, etc.). Most importantly, you need a decent common sense filter and a healthy dose of caution. If, after reading the rest of this article, your gut still tells you that you are not destined to be the next Nikola Tesla, you can still enjoy the benefits of electric brewing, but the most important technique to learn is the preferred method for writing a check for a standalone system like Picobrew or Grainfather, or a turnkey system from a reputable manufacturer like Blichmann Engineering or Ss Brewtech.

What we're going to do for the remainder of this article is take a look at the steps involved with getting ready to DIY an electrical brewery, and a closer look at some of the important

things that are most often overlooked or done just flat wrong. Towards the end, we'll lift up a corner of the curtain, and take a quick peek at the next revolution — automation. The subject of electric brewing is, of course, much more complex than can be laid out in one article, and Kal's book mentioned earlier is a great reference to dig deeper on the subjects we'll address here.

PLANNING

Without a doubt, this is the most important part of your journey to becoming an electric brewer. Not only do you have to make some decisions about what your new rig needs to be able to do, you have to learn about the parts you're going to need to build with, how to build something safe, and how you're going to go about fixing it later. There's really a lot to learn before your wallet comes out. In broad strokes, these are the steps needed:

1. Learning
2. Specification, round 1
3. Block diagram/functional description/flowchart
4. Detailed schematic
5. Bill of materials
6. Sourcing/purchasing

The first thing you need to do is some research. Start with learning about the various kinds of brewing rigs that are suited for electric brewing on the homebrew scale. By "homebrew scale," the implication is a rig somewhere between 2½ to 31 gallons (9.5 to 117 L). Any smaller, and you might as well use your kitchen stove or a countertop appliance-style machine. Anything bigger than a 1-bbl rig is going to mean a substantial dedicated electric supply and a matching cash layout. You will need to decide whether to use a BIAB (brew-in-a-bag [basket]), HERMS (heat exchange recirculating mash system), or RIMS (recirculating infusion mash system). There are arguments for and against all three systems. Educate yourself and make an informed decision about which will best fit your brewing style. The "show us your rig" threads on the Electric Brewing and Automated Brewing forums on HBT are a great source of inspiration and *BYO* has published many articles over the years on the advantages and disadvantages of each.

Next, you're going to need to know more about the kind of control system you want to use. A lot more. There are some starter links at the end of this article, so grab a bag of carrots and start going down some rabbit holes. Learn about PID controllers, SSRs, PWM (pulse-width modulation), hysteresis, 4-20mA control, and a host of other terms that you'll discover. PID controller-based systems like Kal's design depend on individual components to perform the various functions. Automated systems use a low-cost microcontroller and some software to emulate the functionality of the standalone equipment. Another type of automated system uses a small computer called a Raspberry Pi. There are advantages and disadvantages to each type of system that you'll have to take into consideration and make a decision about how you want to control the various controllable bits in your system.

Save some energy, because you'll need it for your deep dive into single-phase household AC power and how to use it safely. Depending on the basic batch size of your new rig, you'll need somewhere between 20-65A of single-phase 120/240VAC power. That's more than enough juice to help you meet your ancestors if you're not careful. Again, there are some starter links at the end of this article, but the first step is to understand the four basic measurements, and how they relate to each other. They are: Volts, Amperes, Watts, and Ohms. There is math involved with this bit of learning, but it's the kind of math you probably finished up with by the time you finished your sophomore year of high school. Here's a quick preview:

- A **Volt** is the basic measurement of electric potential. If electricity was water, voltage would be the pressure. Volts (V) can measure direct current (DC) or alternating current (AC). Your car uses 12VDC from a battery, and an outlet in your living room uses 120VAC provided by your local electric company.

- An **Ampere** is the basic measurement of how much electrical current is flowing through a circuit. More current at a test point means that more electrons are flowing past that point. If electricity were water, amperage would be the rate of flow. A typical living room outlet can support up to 15 Amperes (15A, or 15 Amps) of current. A household dryer uses about 30A of current.

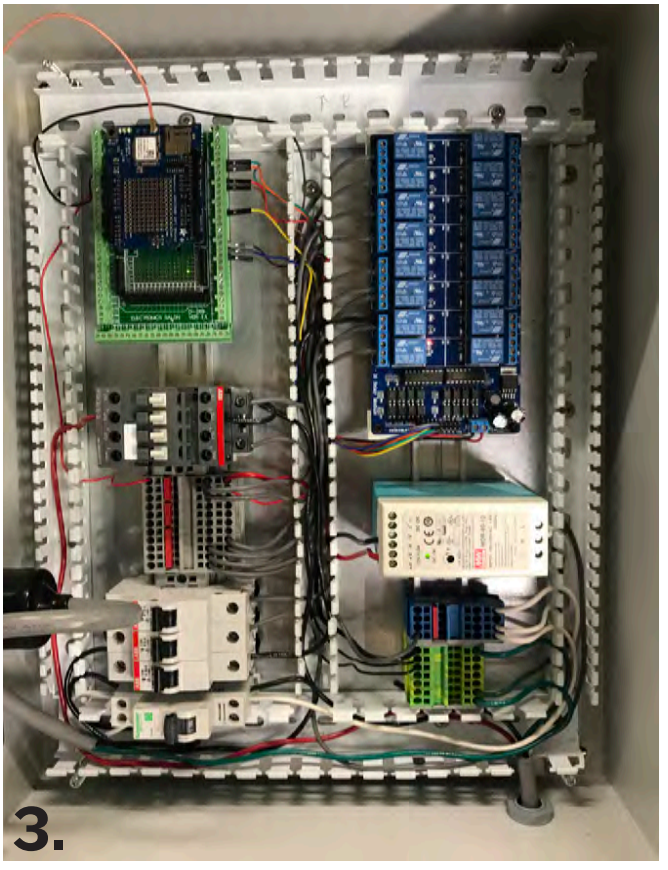
- A **Watt** is the basic measurement of electrical work, or power. Multiplying the number of Volts by the number of Amps will tell you the number of Watts (W). A 15A, 120VAC circuit is capable of delivering 1800W of electrical work. The math holds true in reverse. A 100W, 120VAC light bulb uses 1.2A of current.

- An **Ohm** is the basic measurement of electrical resistance. It's the drag that slows the flow of electrons through a circuit. More Ohms (Ω) of resistance means less current flow. The restriction of the flow creates heat, which is really a number of Watts of work that are lost instead of doing the work that you want it to.

That is a very basic view of the fundamentals and is not enough information for you to begin planning a system. You still need to learn about safety, grounding, overcurrent protection, ground fault protection, conductor sizing for a given load and distance, and many other things. Most big box home improvement stores sell books that cover DIY electrical improvements; one of those books is a good place to start.

WARNING: Unless you are a documented, certified electrical expert, you should have a documented, certified electrical expert review your entire design before you start building, and again before you plug it in.

Once you feel you have a clear understanding of brew rigs, control systems, and electrical fundamentals, you are ready to move on to developing your preliminary specification. Start with a blank sheet of scratch



Photos by Geoff Parkins

Fermenter and dispenser control enclosure, under construction. ***1)*** *Just mounted the tray and rail.* ***2)*** *Arduino shields with WiFi board and relay board are mounted. Power supply, breakers, and terminal blocks are installed next.* ***3)*** *Wiring is almost complete. Starting to neaten and finalize.* ***4)*** *Finished and installed on the dispensing cooler.*

paper and a pencil. Draw your kettles and begin adding the pumps, valves, chillers, heating elements, hoses, temperature sensors, and any other hardware you'd like to incorporate into your system. Make sure you understand the flow of liquids and try to anticipate everywhere the liquid can possibly go, depending on the various valve configurations. Get a good eraser. Play with the sketch until you think you have everything sorted out, then take the time to make a more careful drawing. Once you have the drawing refined, write a description of the system to help keep your design work on track. It could look something like this:

"A 30-gallon/114-L three-vessel HERMS system, with two 120VAC pumps and six 24VDC electric 3-way valves. There is a 5500W stainless ripple element in the hot liquor tank and boil kettles. There is a temperature sensor in each kettle, and a fourth sensor in the output of the HERMS coil. A counterflow chiller is plumbed into the output of the boil kettle. The system is controlled by an Arduino MEGA microcontroller with WiFi connectivity to a PC running BruControl as a front end. The heater elements are controlled by SSRs and the valves and pumps are controlled by a bank of 10 SPDT relays with 12VDC coils. All plumbing connections are via ½-inch NPT TC fittings connected via ½-inch silicone tubing."

Now that you have a pretty clear idea of what it is that you want to build, it is time for you to start in on the most difficult part of the project. You need to take your idea from the concept stage to a detailed plan from which you can build your system. Whoever coined the phrase "the devil is in the details" was a smart fellow and deserving of a hoist of the glass when you pour the first pint from your new rig. Now is the time for you to specify and source every single piece of your system, from the casters on the stand to the last bit of hose. There are three documents that you will need to create. The first is a detailed plumbing diagram (also called a Piping and Instrumentation Diagram, or P&ID) that shows every single connection in the system. It has to be complete enough for you to count each component, right down to the last o-ring and hose clamp.

The second document you will need is a schematic diagram of the electrical system. Each connection on each component has to be accounted for. Everything you will be sourcing has diagrams available on the internet that shows all of the part's connections and what they are for. Your job is to draw a picture of each and every connection in the system. It's easier if you break it into two separate drawings; the first for the main 120VAC power and how it will be connected, controlled, protected, and grounded. The second is for the low-voltage control wiring that will handle the temperature sensors, relays, and microcontrollers.

Unless you are a credentialed electrical engineer or journeyman electrician with several years of experience in process control, GET HELP! There are lots of online forums with experienced guys that are pretty open to helping, and a few bucks to a local licensed electrician to look over the safety aspects of the design wouldn't hurt, either. It will take a lot of time to get it right, but it's essential to get it right. Troubleshooting a problem a year after you finish the project will be nearly impossible without a detailed schematic.

The last of the three documents you'll need is a detailed bill of materials (BOM). The BOM is your shopping list. Every part number, the quantity of each part, and where you will buy it from needs to go on that list. An Excel spreadsheet is a good way to build your BOM. It's also a good place to build your budget and track the money that you're spending.

A final note on materials: There is a very clear correlation between price and quality. When you are sourcing electrical components, be aware that cheap components available from some overseas sources can have internal bits that are not rated for the current they claim to be able to carry or are an outright counterfeit of a quality manufacturer. Make sure you allow enough room in your budget to get suitable, rated, UL-listed components.

ASSEMBLY

When all of your parts arrive, the temptation to grab a drill and get busy will be strong. That would be a mistake. The old carpenter's adage about measuring twice and cutting once applies here. Set up a mockup of the mounting panel from your enclosure on your workbench. Take some time and test fit all of the equipment before you start making shavings. Make sure you have enough room for the bend radius of your larger wires. Make sure you have enough clearance inside the enclosure for all of the stuff that will protrude into the back panel area. One trick is to cover your workbench with brown kraft paper and sketch the dimensions of the enclosure and door on the paper. The components you want to use will have the dimensions available online.

When it comes to the part where you need to cut holes, either in your kettles or in the enclosure, you might consider taking the pieces to a local sheet metal fabricator. They will have all of the proper cutting tools that will punch the right size hole without distorting or chewing up the metal. If you have the experience and the proper tools, by all means have at it.

The same holds true for the main electrical outlet for your new rig. A licensed electrician will be able to specify the correct equipment, pull a permit, run the feed cable, install the proper GFCI protection, and leave you with a nice outlet that's just the right size. This is one area where DIY-ing it is not recommended. Without a permit, there can be problems with Code Enforcement, selling your house, and even home owners/renters insurance if there is ever an accident (even without being the source).

The rest of the build will be up to you. Take your time, especially when routing and securing wires. The time you spend at this stage will pay huge dividends when you go to make a change later or try to isolate an intermittent problem.

When you have finished assembling everything and have made notes

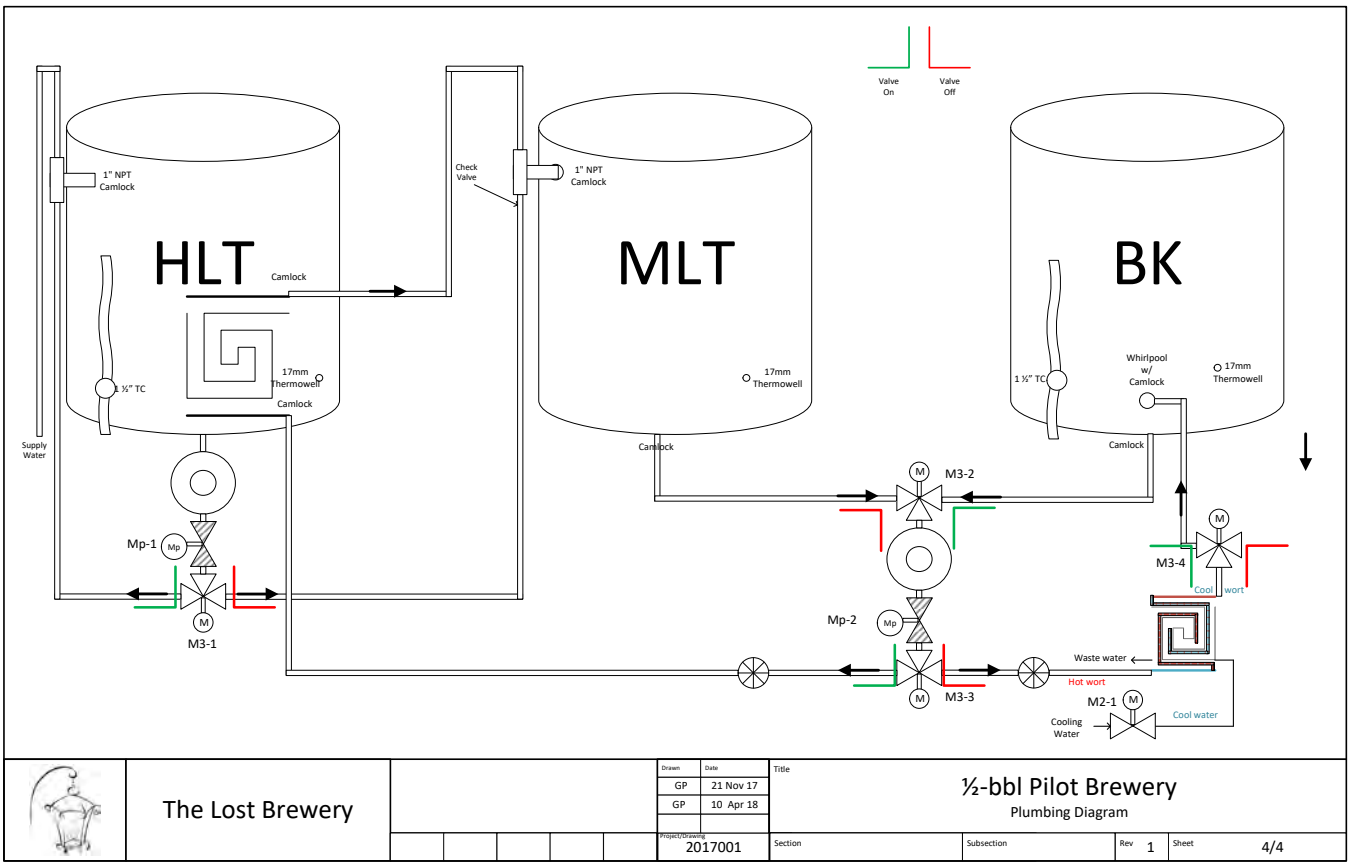


Illustration by Geoff Parkins

An example of a homemade P&ID drawing. The green and red lines show the direction of flow depending on whether the valve is on or off.

and corrections so that your schematics reflect what actually exists, you are still not quite ready to plug it in and start brewing your first batch. You need to do a final quality check. Use a multimeter to test continuity on all of the high voltage and low voltage wiring. Something that is supposed to be hot should not have any continuity to ground. Also test to verify that every piece of metal in the system from the enclosure to the kettles to the stand has continuity to ground. Test as much as you possibly can before you plug it in. Your final set of checks should be to brew a couple of batches of water. This will test all of your plumbing connections and liquid flow assumptions.

Now it is time to tighten everything up and enjoy the first brew. By being careful and documenting along the way, you will be enjoying more consistent, accurate brews than you ever thought possible.

AUTOMATION

Over the last ten years, accessible automation has grown by huge amounts. It has also reached homebrewing and is quickly becoming the next step for many electric brewers. The benefits of automation are easy to see: Precise temperature control and recipe progression is all handled by easy-to-develop scripts. Timing of rests is dead-on accurate from batch-to-batch, and the brewer's time is freed up during the brew day, which very often leads to improvements in domestic bliss. Perhaps the biggest improvement is that since every brew is consistent and repeatable, it allows for documentation of the effects of a single, controllable change in the recipe. Being able to change just one variable at a time leads very quickly to improvements in the quality of the product. Anyone considering adding automation to their process should take a look at what BruControl offers. The flexibility and capability of that system is far ahead of any other automation product.

CONCLUSION

Brewing with electricity opens up the possibility of tremendous improvements in the quality of your homebrew. However, it is not a simple undertaking, and can be hazardous. Take your time with research and planning, and get help when you get into an area where you're unfamiliar.

HELPFUL RESOURCES

- Homebrew Talk Electric Brewing: https://homebrewtalk.com/forum/forums/electric-brewing.170
- Homebrew Talk Automation: https://homebrewtalk.com/forum/forums/automated-brewing-forum.235
- The Electric Brewery: https://shop.theelectricbrewery.com
- Electric Brewing Supply: https://ebrewsupply.com
- Reddit Homebrewing: https://www.reddit.com/r/Homebrewing
- Adafruit: https://www.adafruit.com
- Auber Instruments: https://auberins.com
- Brewhardware.com: https://brewhardware.com
- BruControl: https://brucontrol.com BYO

BY DREW BEECHUM & DENNY CONN

BREWING SUGARS

Finding your sugary zen

Possibly one of the most often repeated myths in homebrewing is to never use sugar. The main rap you'll hear is that sugar makes your beer taste cidery. That's the real myth. You'll hear other negatives about sugar — "it doesn't add any flavor to your beer"; "it cheapens your beer"; "it's bad for the yeast"; "real beer doesn't use sugar."

It's all a part of the same puritanical purity that derides anything that moves away from the four blessed beer ingredients of the past 500 years. Don't let malt machismo dissuade you from discovering the power of sugar. We see value in using sugar in our beer and see no value in setting it aside!

Let's take a look at what brewers get wrong about sugar before we focus on the available types of sugar and what they can bring to your beer. The first thing to remember about sugar — it's a modern miracle. Until the 1800s sugar was a remarkable luxury. Today, thanks to industrialization, we are awash in free flowing sugar crystals. Whether or not that's the best thing for our health, we'll leave to others.

Don't let malt machismo dissuade you from discovering the power of sugar.

Photo by Tori Avey

Invert sugar can easily be made on the stovetop with sugar, water, and a little acid.

THE MIRACLE AT OUR TABLES

When you think sugar, you probably think of that industrial, snow-white crystalline product called table sugar. Refined from sugar cane or sugar beets, it's the stuff that makes the world sweet. In beer making it's primary purpose is to raise the gravity and thin the body of your beer.

Ok, you get why it's a good thing to raise the gravity, but thin the body? Why would you do that?!?

For that, you need to look to the Belgians. Belgian beer is often driven by a notion of "digestibility." In the US, we might use words like drinkability — same idea. It just means you can drink these beers without getting filled up, the way you might from a high-gravity all-malt beer. Like most solid (non-liquid) sugars, table sugar comes in at about 45 ppg (points/pound/gallon), which means that adding one pound (0.45 kg) to 5 gallons (19 L) of wort will raise the gravity by 9 points.

The sugar can be either added to the boil (which is what we usually do) or added to the fermenting beer. Some people claim that adding sugar after fermentation helps to get the yeast off to a good start so it can easily deal with the added gravity of the sugar. And while it is true that yeast prefer to uptake simple sugars and adding sugar to the boil "could" lead to stalled fermentations we've found that if you pitch an appropriate amount of healthy yeast, waiting on the sugar additions isn't necessary. One exception might be if you're brewing a very high gravity beer and have big sugar additions. Otherwise the benefits are basically negligible.

Sugar also plays into people's mistaken rescue strategy for a stuck ferment. "Add sugar, it will dry your beer out!" Wrong! "Wait, didn't you just say that above?" Yes, but in terms of a planned addition that replaces part of your malt. If your fermentation is stuck — nothing about adding sugar will magically dry it out. If you're lucky, the yeast will start to ferment again, but sugar doesn't have the nutrients that yeast that have stalled really need. (Usually a ferment stalls from yeast health issues including a lack of sufficient nutrients and glycogen.)

About this cidery thing — this idea seems to come from the "bad old days" of "kit and a kilo" brewing. This is in reference to recipe kits of old that contained a 3.3-lb. (1.5-kg) can of hopped

Photo courtesy of Michael Tonsmeire

Homemade brewing sugar can be done on the stovetop with a few specialty ingredients. Be sure to check out Michael Tonsmeire's "Advanced Brewing" column "Brewing Sugars & Syrups" in the May-June 2016 issue if you attempt to make some of your own.

liquid extract to which you added a kilogram of table sugar. The sugar was an important addition as the extract was created to leave residual body because they assumed you'd add the sugar to add gravity to the small amount of extract and thin out the beer. This is less of a concern today.

Informal testing done in the late 90s showed that the real culprit was the extract, not the sugar. These kits sat on shelves for quite a while and the liquid extract went stale. Because the sugar was tasteless it didn't cover the stale off flavor and the sugar got the blame. Even today, if you're using extract, make sure you get the fresh stuff! A great and busy homebrew store will buy in bulk drums and run through it before it gets stale.

Experienced (read old and crusty) brewers in the know would say that you should use more extract rather than sugar. That made a certain sense. The fresher extract helped cover the flavors from the stale extract. But that isn't appropriate for every style — particularly ones that you want to finish dry like a saison or a Pilsner. If you have fresh ingredients to start with it's also unnecessary.

LOOKING BEYOND THE TABLE

Don't stop at the regular bags of white sugar or corn sugar, start hunting in other parts of the grocery store (or even other stores all together!) Other types of solid sugars that you can find in your local grocery store include brown sugar, demerara sugar, and raw sugars like piloncillo (a Mexican sugar in a cone shape) or jaggery.

Regular brown sugar is simply the white sugar with a measured amount of molasses added back in. The slight molasses flavor seldom lasts through fermentation. We find it of little value and recommend to just use white sugar in its place. The exception here is if you're using a lot of brown sugar in a very light beer without a lot of other flavors in it. In that case, you may be able to detect the brown sugar. If you really want to use brown sugar — go find the good stuff — particularly true molasses brown sugars. Those flavors will lend an interesting punch.

Piloncillo is a raw sugar that is often referred to as Mexican sugar. It's made by boiling cane juice into a thick syrup and pouring it into a mold to cool. It has a rich, caramel, and molasses type of flavor, even though no molasses is added to it. Piloncillo has a deep, complex flavor. Caveat: Denny has seen some piloncillo that has oil added to it to help it maintain its shape. Check the label before you buy (really you should be doing this anyway.) Jaggery sugar has a similar sweet, earthy flavor profile and is made from palm, coconut, or java plants.

Other sugars that you might want to check out for brewing include demerara, which has toffee notes (think Sugar in the Raw in the US), sucanat (made from crystallized cane sugar with a high proportion of molasses with an intense, slightly burnt flavor), muscovado with a strong molasses flavor, and turbinado with a light caramel flavor, which is made from the first pressing of the cane and retains more molasses than brown sugar.

While we're on the subject of solid sugars, let's mention rock candi sugar. There's a reason we left it until the end of this section — we've never found that it does much, if anything, for your beer that table sugar doesn't do. Even the darker ones add little to no color to your beer.

Years ago, Denny did a blindfolded taste test to see what he thought about rock sugar. He couldn't tell one type from another. We consider it a waste of money. But if you've used it before and like it, be our guest. (Note — Drew has seen rock candi sugar at some very well known Belgian breweries, but really it's still no reason to use it.)

GOING LIQUID

Candi syrup, on the other hand, can have a huge impact on your beer's flavor, especially in Belgian styles. The first time Denny used candi syrup to make a Belgian dark strong ale, his reaction was "this is what's been missing!" There's a whole world of liquid syrups, and we're starting with our favorite and easiest to procure.

What makes candi syrup unique? It's an invert syrup (more on that later) that's a leftover of the sugar-making process, like molasses. It really shouldn't surprise you that a waste product with a ton of sugar ended up in the brewing process. It's a cheap and flavorful boost, because the real stuff carries flavors over from the violent process of creating beet sugar. (It's a seriously nasty bit of chemistry.)

Prior to the importation of proper candi syrup in the US (by Dark Candi, Inc. – now part of Country Malt Group), brewers trying to recreate the potent magic of a Belgian quad like Westvleteren 12 threw massively complex grain bills at the problem. With Dark Candi's introduction, the creation of a proper Belgian quad become an act of simplicity – some pale malt, some dark candi syrup and proper yeast management. It's truly astonishing stuff.

These days other competitors have risen, including Candi Syrup Inc., which sells syrups by color impact from clear to 45 to 180 to the potent 240. Any of these syrups we've tried deliver a punch and a half for so little effort. Drew, when brewing a big batch of beer, will often split the wort in two and dose one part with a candi syrup to change the color, boost the gravity, and send it to a different place altogether from the first one.

The important part about these syrups is that, well, they're syrupy — they flow like honey (a topic for another day) instead of binding up. It's not just a matter of water content. It's a matter of crystallization. If you mixed table sugar into water, boiled it to a syrup consistency and let it sit — it will slowly recrystallize. The sugar molecules will do their best to take a nap in their favorite low energy state.

If the sugar molecules have been "inverted" — which is chemistry shorthand for an orientation shift in the arrangement — the molecules can no longer align into their crystalline state and remain free flowing. Also importantly, from a brewer's perspective — invert sugar syrups are easier to use and more available to the yeast. (Regular sugar molecules require some enzymatic work on the part of the yeast before they chomp down — think like how you cut a piece of meat for a young kid.) Inverting sugar is a matter of heating the sugar in syrup form, lightly acidifying and letting it ride in temperatures like you're making candy. A little time, heat, and magic works wonders. (Again, we find that healthy vital yeast obviates the need for this step since the yeast can utilize non-inverted sugar just fine, but some brewers swear by it.)

There is one place where invert syrups are impossible to dismiss and Drew would argue that makes it impossible for American brewers to really recreate the low-gravity, full-flavor magic of British ales. The British have a whole series of Brewer's Invert Syrups that, like the Belgian Candi Syrups, range from the pale (think Lyle's Golden syrup) to "How is that not burnt"? These carry a different set of flavors than the Belgian Candi syrups.

These British syrups are unique and unfortunately, not available in the US at the homebrewer level. Ask "Dr. Google" to give you results on "British Brewing Invert" syrup to get a few articles on how to daredevil your own or cheat with blackstrap molasses and pale sugar! (And trust us when we say — it's another world of difference.) We've seen a lot of recipes to make your own candi syrup, and tasted more than a few beers made with homemade syrups. None that we've tried have the depth of flavor that the commercial candi syrups have. There are reports of good homemade versions of the British syrups, so look around for recipes if you have time on your hands! To get you started, here's a link to one recipe: http://www.unholymess.com/blog/beer-brewing-info/making-brewers-invert.

So if you've been avoiding sugar or trying to figure out how to use it, give it a go. It just could be the ingredient you need to perfect your next batch. BYO

BY COLIN KAMINSKI

IT'S COMPLICATED

Understanding oxygen in brewing

"Minimizing the formation and activity of ROS (O_2-, HOO , H_2O_2 and HO*) in beer and wort, must be a first step for improving beer flavour stability." — Bart Vanderhaegen.*

As brewers we get lots of conflicting information about the roles of oxygen in brewing. The reason there are so many opinions is that it is one of the most difficult and most important parameters to control. Until you have control over oxygen in your brewing process you won't be able to make a high-quality beer. Oxygen is the primary parameter to control when concerned about shelf life.

Oxygen is a pesky molecule that can bond strongly to many compounds. While O_2 is relatively stable, it is easily converted by iron and copper ions into much more reactive oxygen species (ROS), also known as free-radical oxygen. However, beer also contains antioxidants that will protect beer for the beginning of aging. Making this antioxidant effect outlast the expected shelf life is the goal of most beer styles. These antioxidants include melanoidins and reductones, or compounds that negate free-radical oxygen, from the malt. Melanoidins and reductones are more prevalent in darker malts and darker beers have a better shelf stability when compared to the lightest beers (this is true with roast malts, but crystal malts can lead to instability). Polyphenols from malt and hops will also bind to oxygen. While there are flavor changes associated with polyphenol reactions not all are considered detrimental. Interestingly, analysis of famous hazy IPAs shows both lots of polyphenols and lots of total package oxygen (TPO). The short shelf life of these beers suggests that lowering oxygen is more important than having lots of polyphenols.

Oxygen can also be bound enzymatically to linoleic acid from barley creating the famous wet paper staling flavor from trans-2-nonenal (T2N). While some new varieties of malt cannot produce this enzyme it is still important to eliminate oxygen ingress in brewing processes. For more on this topic, see my "Advanced Brewing" column titled "LOX-less Malts" in the January-February 2019 issue. Flavors that can be attributed to oxygen are Sherry, wet paper, cheesy (from improper hop storage), woody, ribes, black currant, catty, green apple, winey, and soapy.

It is convenient to think of different stages of the brewing process separately. We are going to go sequentially, first covering hot-side aeration, then onto post-chilling wort oxygenation, then the most critical to control: Post-fermentation oxygen pickup. After the yeast has metabolized the oxygen present at pitching all further oxygen sources should be eliminated. We say this is at the end of the lag period but the line is a little blurry.

HOT-SIDE AERATION

Nothing has gotten more interest in brewing in my career than hot-side aeration (HSA). When the first HSA paper came out linking staling flavors to aeration on the hot side of the brewery it was a shocking revelation. Oxygen can be introduced on the hot side in many places. The hot liquor can have dissolved oxygen. Milling the grain can entrain oxygen into the grist with the husks. Splashing during recirculation (vorlauf). Splashing into the grant. Exposure of the surface of the kettle during boil and whirlpool are all potential sources of hot side aeration.

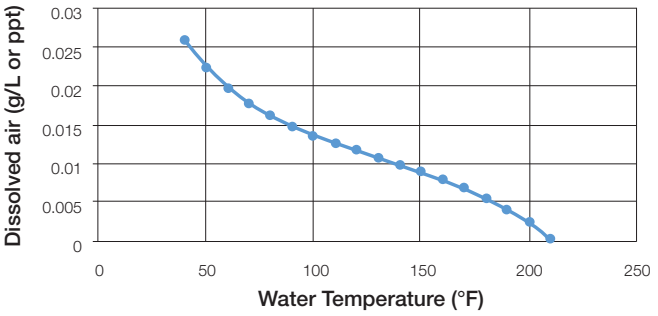
With all of these possibilities and the difficulty of eliminating the sources of oxygen it begs the question: How important is HSA in my brewery? HSA has

Oxygen is the primary parameter to control when concerned about shelf life.

Photo courtesy of Scott Janish

Beer darkening is one sign that beer has seen oxygen ingression. Signs of oxidative reactions can be seen in the beer on the right, which was in a fermenter with a leaky lid and too large a headspace.

Graph 1: Solubility of Air in Water at 1 atmosphere of pressure



been linked to staling in packaged beer. There is no question about this. The question is how much and when will it occur. Even in the best of storage conditions the delicate flavors of a fresh beer are fragile. We can speed up a beer's demise by storing it warm or cycling it between hot and cold and find out how our packaged beer might fair over time.

Obviously there are other gasses than oxygen in air, only about 21% of the atmosphere is comprised of oxygen. As you can see in Graph 1 above, as water is heated the gas is forced out. You will see this as you heat water in a pan. Bubbles of gas will start to form. However, we need to drive the gasses out of the water in order to remove them from the system or we end up with a supersaturated state. Boiling provides enough motion to remove dissolved gasses on our scale but a larger tank would need to provide other methods of agitation. While boiling will lower the O_2 level of water, it will not eliminate the oxygen entirely and utilizing a dissolved oxygen (DO) meter is useful in finding the best process to remove O_2.

The big debate in the beer world is: If my beer is going to be consumed within a month or two, how much concern do I need to pay to HSA? Charlie Bamforth and I have spoken at length about HSA. While his words are: Don't worry about it as a small brewer. But when you ask him for specifics like, "can I just splash wort during recirculation?" His reply would be something along the lines of, well I wouldn't. Sierra Nevada goes to great lengths to eliminate HSA. They do so by oxygen reduction, and minimizing any ions that might activate oxygen, in every step of their process. I find their product to be consistently high quality with a strong shelf life.

I follow a few homebrewing threads around the world and for some brewers going to the extremes of a pro brewer are appreciated. I have heard of brewers who claim that on day one their beers have a better malt presentation and are brighter than beers that have suffered HSA. In my brewing I do what I can to avoid HSA but I don't go crazy. Chart 1 on page 79 provides some options. I have never heard of anyone, except lab workers, going to all of the extremes listed here. The one paper I have read that did go to all of the effort to completely eliminate HSA claimed that some of the necessary flavors were not created. Fortunately for us, we cannot ever eliminate all sources of HSA.

WORT OXYGENATION

We go through all of this effort to eliminate air in all places except for one. After we cool the wort, we add oxygen as a yeast nutrient. This is extremely important if we don't have healthy yeast. The oxygen allows a pathway that provides more energy to the cell and allows it to replenish depleted sterol reserves. It also prepares the cells to multiply, increasing our cell count. Big brewers traditionally use air to provide this oxygen as it is hard to over-oxygenate, but setting up sterile air is more difficult for the homebrewer than pure O_2. But without an O_2 meter you have to guess at the proper oxygenation level. A good test is to measure the amount of yeast added and make sure you recover 4x as much after fermentation. This is a pretty good indicator of proper oxygenation.

It is very important that we separate as much trub as

During the technical review process tangential conversations can break off between reviewer and author that can be interesting and may at times become folded into the story. We thought this back and forth between "Advanced Brewing" columnist Colin Kaminski and Technical Editor Ashton Lewis was worthy of its own space.

Ashton Lewis: Graph 1 is a great depiction, but it includes an assumption that I cannot prove or disprove with references . . . and I have searched for a long time in the past. The assumption is that boiling water contains no oxygen. The problem with this argument is that the boiling water is still exposed to atmospheric pressure and the absolute pressure is not zero. If I understand Henry's Law, the system is still under pressure and gas solubility should be more than zero. Water deaeration in a commercial brewery is more extreme than simply heating to 212 °F/100 °C.

Colin Kaminski: While visiting a highly successful 15-bbl brewery and talking water, they had a scaled down copy of an expensive commercial deaeration system. The brewer had been using an old boil kettle to boil and cool water before the system. After months of work, the kettle was still better at lowering the O_2 level for hot liquor than the deaeration system, but you are right, neither could get to 0. The final data point in Graph 1 is dissolved air/water ratio at 210 °F (99 °C) = 0.0004 g/L.

Ashton Lewis: 0.0004 g/L (ppt) x 1,000,000 x 35% O_2 = 140 ppb. (35% is the approximate calculated from Henry's Law level of O_2 dissolved from a nitrogen, O_2, CO_2 blend matching the atmosphere.) This is a very low value but is not zero. If beer with 0 ppb of oxygen is diluted with water at a ratio of 1 part water to 4 parts beer, the resultant concentration is 28 ppb. This may be considered low for packaged beer, but it's not very low for beer out of a fermenter. Interesting stuff!

Colin Kaminski: This is important for anyone looking to add water to beer post-fermentation. It is hard to see on Graph 1 but heating the water to 210 °F (99 °C) will not completely eliminate the O_2 and this water would not be suitable for dilution of finished beer.

Chart 1: Sources and solutions of hot-side aeration (HSA)

Source	Traditional Method	Easy Solution/My Solution	Extreme Solution
Hot Liquor	Heat to temperature	Pre-boil	Run CO_2 gas strippers on all brewhouse water
Mill	Mill dry		Mill wet with deaerated water
Recirculation/ Vorlauf	Sprinkle in from the top	Submerge the sparge arm into the top of the wort	Seal the mash and replace the air with nitrogen
Grant	Splash in from the top	Extend the arm to only have a small gap from the top of the wort	Seal the grant and provide a vacuum breaker to protect the mash screens
Lauter	Fill from the top	Fill from the bottom	Seal the kettle and replace air with nitrogen
Boil	Boil vigorously		Boil under nitrogen and use a heat exchange column to extract volatiles, condense them and remove them from the system

possible before adding oxygen and lower the temperature to as close to pitching temperature as we can. Oxygenating trub can create off-flavors reported to be soapy and unpleasantly bitter. If we want to eliminate this step entirely it is possible if you multiply your yeast up to a fermenting cell count as opposed to a pitching cell count and make sure the yeast's sterol reserves are maximized. Then you can eliminate the yeast oxygen step from the brewing process. Dry yeasts are typically dried at a point of very high sterol reserves and many brewers use them without adding wort O_2.

POST-FERMENTATION OXIDATION

On the cold side of brewing it is worth every effort to eliminate oxygen ingress. Even exposing the surface of beer to air is sufficient to pickup oxygen. In professional brewing where dissolved oxygen is often measured, levels are controlled in the parts per billion (ppb) range. Bottling lines that have less than 6 ppb DO pickup and canning lines that have less than 30 ppb DO pickup are commonplace. The only way to maintain the low levels of oxygen is to have strong quality control and quality assurance programs in place.

Before we move beer from one vessel to another it is important we make every effort to avoid splashing and purge the vessel of oxygen as much as possible. For transferring to a bucket we can only fill gently from the bottom with a hose.

Chart 2: Sources and elimination of cold-side oxidation

Source	Method for elimination
Fermentation	• Don't open your fermenter • Provide back gas when lowering fermentation temperature
Racking from fermentation	• Fill from the bottom • Pre-purge with CO_2
Bottling	• Bottle condition • Purge and counter pressure
Kegging	• Purge with water • Purge with CO_2 • Keg condition • Fill from bottom
Dry Hopping	• Purge hops with nitrogen • Purge head space with CO_2 • Dry hop while yeast is active

When transferring to a keg we can pressurize and vent a few times or if we have water to waste we can fill with water and purge with CO_2.

One of the best ways to deal with oxygen is bottle/keg conditioning. This is the process of adding sugar and yeast to the final package and encouraging a final fermentation to carbonate the beer while scavenging oxygen. In normal homebrewing there is enough yeast in the beer at the end of fermentation to eliminate the yeast addition and one only needs to add sugar.

Last week I was cleaning up and had two special bottles of beer. They were 100% Maris Otter and wet hopped with Centennial that I bottled 260 Champagne bottles of in 2006. Because the tank had been clarified, I added dried yeast and sugar individually to each bottle before filling it. The bottles were sealed with a Champagne cork and hand numbered and two extra bottles were numbered 0/260 and 261/260. I saved the two extras. Thirteen years later I had no hope for the beer having survived but I also no longer had room for sentimental bottles so I opened them.

Surprisingly, the beers were delicious. The malt had become more toffee-like, there was no hop character at all and a phenolic-producing yeast had made a very slight clove character. Neither the pitching nor the bottling yeast have the gene to produce phenolics so this was a contamination. The beer was crystal clear and golden. The dry fermentation and the sweetness from aging balanced well to make a very refreshing and drinkable beer. We will call those lucky bottles and I would not expect to be able to repeat these results.

I have had many private conversations with Quality Assurance personnel at many breweries and I have included their advice without attribution to protect the proprietary processes of the breweries involved. It has helped me to refine my beers and hopefully it can help you as well. BYO

REFERENCES:

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PROJECTS

BY GARY SCHWARTZ

THE WASHALL SYSTEM

Not your everyday keg washer

I started brewing 5-gallon (19-L) batches about 15 years ago. One of the best things about a system that size is that cleaning it is for the most part pretty easy. Over the years I expanded my system to do 10-gallon (38-L) batches, switching to all-electric and upgrading to a heat exchange recirculating mash system (HERMS). I expected cleaning to be a bit more work than cleaning the 5-gallon (19-L) equipment, but the reality was the upgrade made the task much worse. Now I have expanded even more to 20-gallon (76-L) kettles and a 15-gallon (57-L) fermenter and, without a doubt, the cleaning effort and time has gone up exponentially rather than linearly!

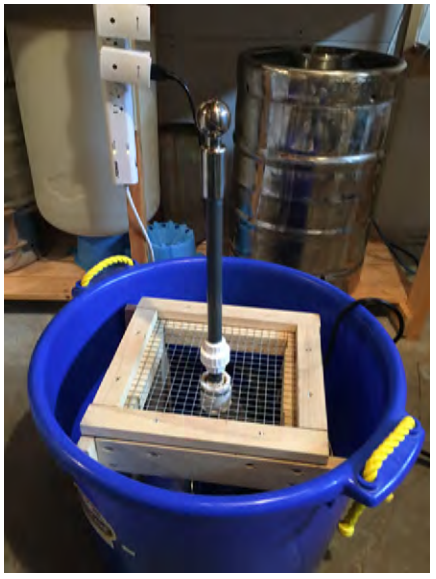
I had seen numerous single-purpose corny keg cleaning projects, both homemade and commercial, and decided to build one that increased its capabilities exponentially as well — to help match my efforts. This design can clean large kettles, fermenters, corny kegs, picnic taps, hoses, pumps, chillers, buckets, and my HERMS coil just by changing a few "cleaning tools," built with common ½-inch NPT landscape irrigation fittings including unions. The unions make tool change out quick and easy.

In use, I save all my used chiller water in the muck bucket, other plastic buckets, and my hot liquor tank (HLT). I start by removing as much of the spent mash as possible from my mash tun by hand. I find a large square recycled plastic food container works the best since it gets into the corners and also works well on the flat false bottom. Then I wash the mash tun on the WashAll with no sprayball connected, just the open plastic riser. If you use the sprayball right away it will get plugged with small pieces of mash that you missed. I do the same with the boil kettle. Once they are partly cleaned I pump the muck bucket out and clean it to get rid of all those particles of mash and boil kettle hops and break. I refill the bucket with fresh hot cleaning solution and run with the sprayball attached. The pump is connected to an inexpensive wireless remote control switch for AC power to make turning on/off quick and easy.

You can clean carboys and flasks with just the open PVC riser, with no sprayball attached, since it's too large to fit through the opening. But care is needed for this task since carboys will also fill faster than they drain. You will need to cycle the pump on and off. You can also place smaller items on the hardware cloth while a pot is getting cleaned. It's also an ideal time to clean, and dry by hand, the exterior of any equipment such as kettles, fermenters or corny kegs while they are upside down on the washer.

After everything is clean, all the WashAll parts fit into the muck bucket and it's stored away. You should be able to build one for less than $200 and after that it's like having an extra unpaid helper on brew day!

You should be able to build one for less than $200 and after that it's like having an extra unpaid helper on brew day!



Photos by Gary Schwartz

Tools and Materials

- Sump pump (½ HP or larger recommended)
- PVC adapter for pump outlet to ½ inch NPT threads
- Muck bucket
- Wood for frame
- Hardware cloth or wooden slats for the top
- Sprayball with ½-in female NPT threads
- (3) ½-inch PVC NPT Unions
- ½-in. PVC NPT tee
- ½-in. PVC NPT elbow
- (2) ½-in. NPT to barb for corny cleaning assembly
- PVC risers (mine are 10 in./25 cm), adjust depending on your pump and kettles)
- Keg gas and beverage fittings

STEP BY STEP

1. PUMP

I started by buying a stainless steel sump pump rated at ¾ HP, 24-ft. (7.3-m) head and up to 2,250 gallons/hr (8,520 L/hr). The pump will also handle particles up to 0.2 in. (5 mm) in diameter. The ratings sound impressive but the way the specs are defined is if you try to pump up to 24 ft. (7.3 m) you'll have zero pressure at the top and flow-rate is rated for zero head. You'll end up using the pump somewhere in between those maximums and also likely need to reduce the pump outlet size down to ½-in. NPT. If you can't get threaded fittings to make the reducer you may have to use PVC primer and glue and use "slip" fittings.

This pump has a top outlet, which makes it a bit easier to center in the tub. It also has a float switch, which allows it to shut off if the water/solution level gets too low.

2. MUCK BUCKET

The next key item to buy was a large plastic "muck bucket" to put the pump in and to easily accommodate my kettles and fermenters. Mine is 70 qts. (66 L) with a top inside diameter of 20 in. (51 cm) and it's 15 in. (38 cm) tall.

I usually only fill it ¼ to ⅓ full with water then add a brewery cleaner such as PBW™ or substitute with T.S.P. and OxiClean™ combined.

3. STAND

The wooden stand sits a few inches lower than the top of the muck bucket (to help contain the dripping solution). It has a hardware cloth top to let the liquids through and also support corny kegs or other small items for cleaning. I cut a square opening in the hardware cloth for the risers and sprayball to get through. You could also just use wood slats or some other grill instead of hardware cloth. The stand has short arms that go right to the inside edge of the muck bucket since it has sloped sides. Stand dimensions are about 12 in. (31 cm) x 12 in. (31 cm) x 14 in. (36 cm) high, not including the short arm extensions.

My 20-gallon (76-L) kettle handles rest on the rim of the muck bucket. You should check where your handles might rest before you build the stand. The top of my 15-gallon (57-L) fermenter rests on the stand.

4. SPRAY BALL ASSEMBLY

This is good for cleaning my mashtun, boil kettle, fermenter, immersion chiller, cornies, and buckets. My PVC riser is 10-in. (25-cm) long using the top outlet pump. You can adjust that length depending on your kettle dimensions.

To clean my immersion chiller, I put it on the stand and cover it with a large plastic bucket after switching to just a short 2" riser on the sprayball.

Depending on what cleaning chemicals you use you will get some foaming after running the WashAll sprayball for a while. Don't go have a long lunch and leave it running unless you also want to wash the floor!

5. CORNY KEG DIP TUBE ADAPTER

I usually start cleaning my corny kegs with the sprayball then switch to the dip tube adapter to clean the dip tubes.

To clean a picnic tap attached to the "beverage out" post I connect the grey corny fitting from the pump to the "gas in" on the corny, which is sealed and vertical on the floor. I run the pump briefly to pressurize the corny with cleaning solution and get the level above the bottom of the diptube, then open the picnic tap into the muck bucket.

6. PUMP OUT/CLEANOUT ASSEMBLY

To clean my hoses, pump, and HERMS coil I attach them in series to my "pumpout" tool, which is just a union, riser, and garden hose adapter to tubing and a male quick connect since my hoses have female quick connects. There is a fair bit of pressure so hold on to the end of the last hose (I learned the hard way)!

You may occasionally get an airlock in the pump. To clear it just shut off the pump, unscrew the union a bit, then retighten. This breaks the airlock and gets enough liquid back into the pump to prime it.

Because the muck bucket is quite heavy when full you can pump it out with this tool when done. The sump pump will pump down to about ¼ inch of liquid remaining in the muck bucket. BYO

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BY SUZI MORALES

DROP AND GIVE ME TEN . . . GALLONS

How and why to fit in exercise while brewing

Brew day is quite the workout. Incorporating some intentional exercise into the day could not only help earn some extra beer calories, it could also give you a longer and safer homebrewing career. Let's be honest, for most of us, there is a lot of downtime during a typical brew day. Why not take advantage of this for your mental and physical well-being?

"You want to continue to do your hobby for as long as possible," says Chris Gagliardi. He is a Medical Exercise Specialist, Group Fitness Instructor, Personal Trainer, and Health Coach certified by the American Council on Exercise (ACE). "It doesn't require you to put on running shoes and athletic shorts," Gagliardi says. Wear whatever you'd normally wear to brew.

Your exercise might depend on where you brew. For example, Gagliardi notes that exercises like leg raises and countertop pushups can be done by holding yourself on the inside corner of a kitchen counter. A portable table in your garage might not hold your weight but maybe a keg will. Gagliardi says you will not need additional weights. Use your body weight, brewing equipment like empty kettles, kegs, bags of grains, or any other items you might have in your brewing space. Of course, do not use hot or breakable equipment.

Gagliardi recommends a warmup, a slightly more difficult active workout, and cool down/stretching. Mimic the movement you are doing while you brew, like bending, pulling, and lifting. For the warmup, you can use your body weight. If you want weight, lift something light like a small empty kettle or a bag of grains while the strike water heats up.

Once you've started moving, do a few sets of harder exercises. Carry over exercises from the warmup. For example, if your warmup included lunges without weight, you can do the same move while holding a bag of grains. What about adding a pull-up bar nearby your brewing space? Gagliardi says you might decide, "I'm going to do ten burpees and then I will need to check my water temperature." This may actually mentally speed up your brew day in the end.

If you don't exercise regularly, Gagliardi recommends starting with your own body weight. Try ten reps of an exercise. If it's too hard, reduce it to eight. If you'd like more challenge, add weight. When adding weight, make sure you can do the exercise with good form ten times in a row.

"Pay attention to your body," Gagliardi says. If there are areas that are normally sore when you're done with brew day, choose exercises to strengthen those areas. If you don't know what kind of exercises to do, Gagliardi recommends the ACE exercise library, available at https://www.acefitness.org/education-and-resources/lifestyle/exercise-library.

Include some stretching in your cool down. Hip flexors are a common problem area and can lead to lower-back pain. Exercises for the hips include lunges and standing on one leg while holding the opposite foot behind you to stretch the hamstring.

Here's the rub: Gagliardi recommends that brewers do not drink alcohol during the workout for safety reasons. While some may bemoan this fact, the reality is that you really shouldn't be drinking while brewing in the first place. Handling boiling hot liquids while under the influence is not a good recipe. The good news is you're in charge of the workout. It can be as long as you want it to be. After that, relax and have a homebrew.

If there are areas that are normally sore when you're done with brew day, choose exercises to strengthen those areas.

Image courtesy of Suzi Morales

A keg can actually be a great workout tool across many routines for an inventive brewer to make the best of downtime during brew day.

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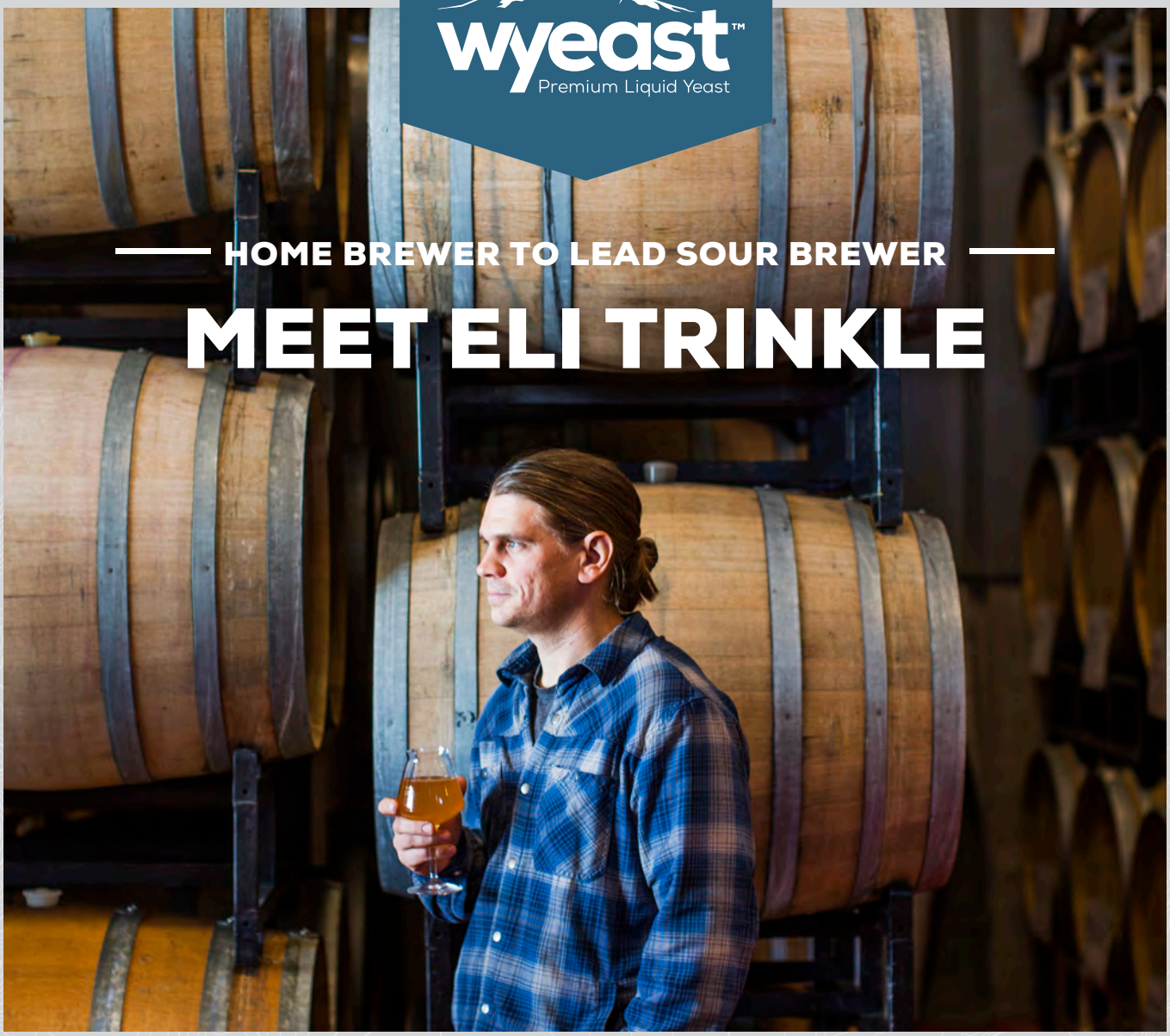

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MEET ELI TRINKLE

Eli Trinkle of Upland Brewing Co. was immediately drawn to home brewing after being introduced to it by his neighbor. After just one month of owning his own home brew setup, Eli was brewing all-grain with Wyeast smack-packs and kegging his own beer. He admits he was so intrigued by the process, it consumed his life. He spent countless hours researching and experimenting–he even worked as an assistant brewer while finishing his degree in engineering technology. Post-graduation, Eli decided that instead of pursuing more education, he'd turn his passion for brewing into a career.

Today, Eli has crafted a diverse portfolio of award-winning sours for Upland. He attributes his present-day brewing devotion to his colleagues at Upland, to the people of Bloomington, IN and the pride associated with pioneering a quality fermentation product. At Wyeast we share these same values, which is why we're pleased to toast the work of Eli and the rest of the Upland Brewing team.

See **wyeastlab.com** for homebrewing recipes from Eli and other commercial craft brewers.

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