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MARCH-APRIL 2021, VOL.27, NO.2

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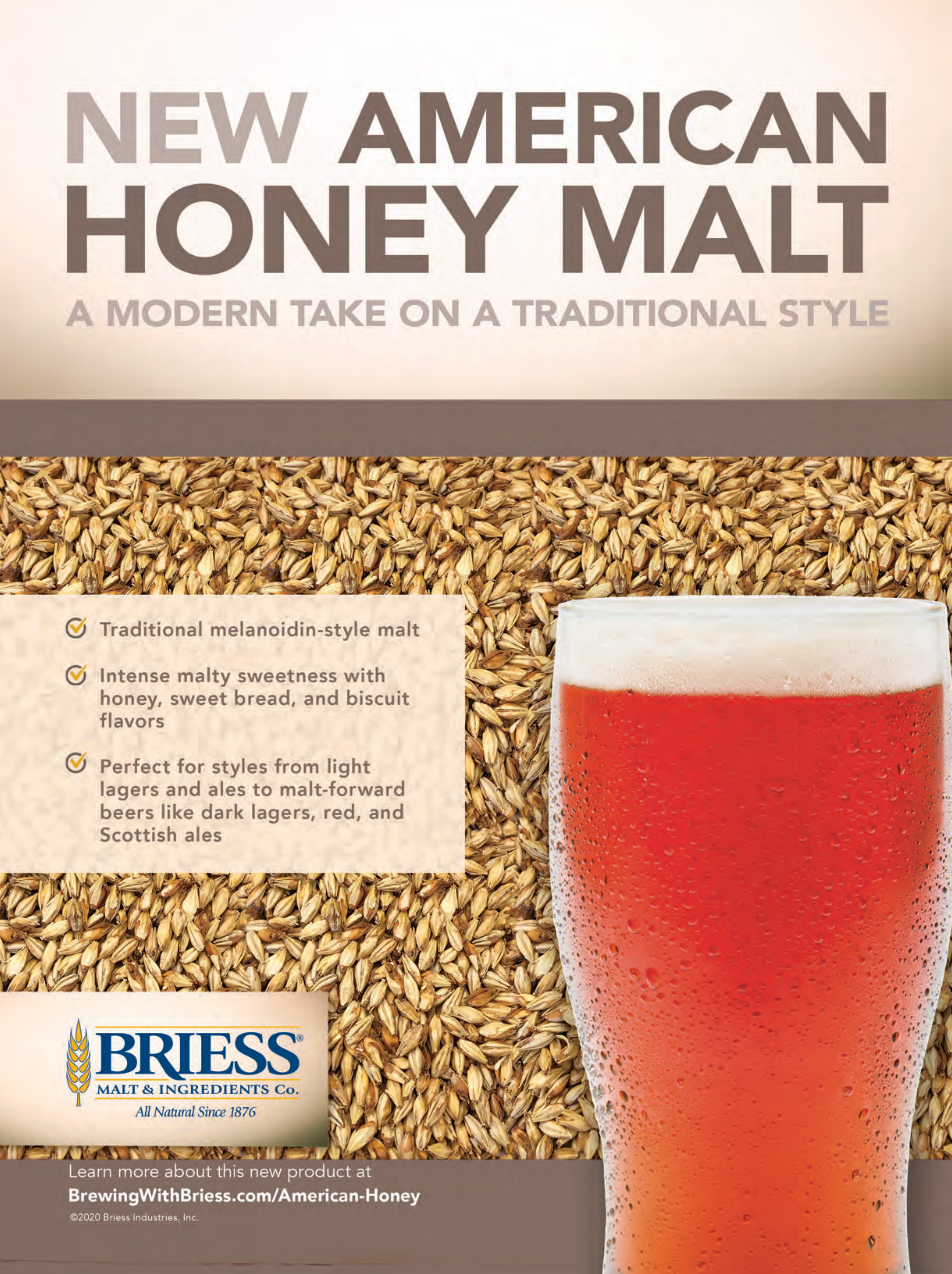
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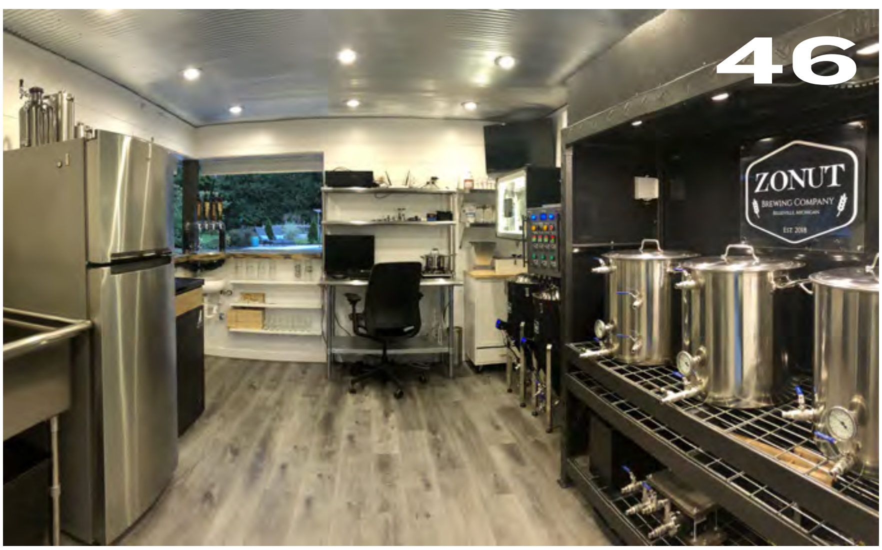
contents MARCH-APRIL 2021, VOL. 27 NO.2



features

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THE HOW-TO HOMEBREW BEER MAGAZINE

departments

24

where to find it

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.

Brew Your Own
THE HOW-TO HOMEBREW BEER MAGAZINE

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Cover Photo Illustration:
Charles A. Parker/Images Plus

Q

What was the first beer you fell in love with?

Leinenkugel's Octoberfest. 1975-ish. Long before this craft beer craze, there were craft beers being brewed by Jacob Leinenkugel — a fine little brewery in Chippewa Falls, Wisconsin. We would wait all summer to get a few in the fall.

In my discovering beer phase, I was constantly chasing new beers from all over the world. When I turned my attention to the beers of Belgium, I was gobsmacked when I took the first breath of Rodenbach Grand Cru. It was like no other beer I had ever poured. Nearly 30 years later, I still remember that bottle and how it shaped my new beer world.

Being 63 there was not much choice to be had in my early beer years. I have to thank my dad Willy for keeping Olympia stocked in the fridge but that first taste of Anchor Steam at the age of about 18 changed my world. Thanks Fritz Maytag for saving that old brewery. What a beautiful thing since then. Hop2it!

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New England IPA

The juicy, hazy, and aromatically hoppy beer continues to be the rave among craft beer lovers. While it is now omnipresent in the marketplace, it is still a difficult style to brew well. Learn from the master of style Gordon Strong how to do it right. https://byo.com/article/neipa-style-profile/

MEMBERS ONLY

Brewing With Maple

No matter where you live, maple syrup can be included in your lineup of brewing ingredients. For tips on making the most of this addition to your beer, we talked to three professional brewers who know how to handle their maple brews. https://byo.com/article/tips-from-the-pros-brewing-with-maple/

10 Tips For Beginners

Whether you're just starting out or helping a friend or family member get into the hobby, here are 10 simple tips/reminders that all brewers can abide by in their preparation and execution. https://byo.com/article/10-tips-for-beginners/

MEMBERS ONLY

LOX-less Malts

While still a fairly rare commodity, one way to reduce staling for beer that may not be consumed fresh is to use base malts where one of the chief culprits, the lipoxygenase or LOX enzymes, of the staling process have been bred out of them. https://byo.com/article/lox-less-malts-their-impact-on-staling-and-head-retention/

MEMBERS ONLY

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MAIL

KEEP AN EYE ON THE MILL GAP

I am writing to thank you for the "Techniques" article "Points Off?" (January-February 2021) written by Denny Conn and Drew Beechum. I had been having trouble with my gravity points and was not sure what the problem was. I had never previously really had any issues other than being off a point or so in my brewing. The last few that I did went progressively lower and I was not sure of the problem. I chalked it up to error on my part. After reading the article, one of their mantras hit me: Know your crush! I had changed over from a homemade two-roller mill to a Monster Mill. After reading this article I went to check my mill and I could see with my eye that the gap had opened up considerably. I set the gap back to where it belongs and am waiting to try it out. I'm sure this was my problem — thanks to Denny and Drew for giving me the direction to look.

Calvin Neubaum • *via email*

Author Drew Beechum responds: "Calvin, if the pain of my long-term failure to check my crush in a meaningful way helped you avoid the same problem, then I'm happy to have lived and written about it! Remember folks, gradual change — creeping change — can hurt you before you know it!"

CANDY CAP MUSHROOMS

I really enjoyed reading the article "Brewing with Mushrooms" (December 2020) and am glad people are reading about the benefits of umami in their beers. There isn't much information out there about mushrooms in beer and it was great reading about someone working with fungi.

I am a homebrewer living in Mendocino, California, and stumbled into an opportunity to brew with candy cap mushrooms after attending a meeting of the Foggy Coast Brewers in 2018 and tasting an excellent candy cap-infused barleywine made by Jeff Neumeier. As it turns out, there are quite a few foragers in the area and it wasn't long before I managed to acquire some of these incredible mushrooms. (Read more about my story in this issue's "Last Call" on page 72).

One thing I wanted to point out is that the author of the article makes no distinction of subspecies of candy cap mushrooms.

contributors

Adam Wirth is an Engineering Manager at Ford Motor Company, holding degrees in Mechanical and Automotive Systems Engineering. By day, he leads the development of suspension and frame components. By night, he is an automotive junkie, fabricator, and avid homebrewer. Adam started homebrewing in 2017 by walking into his local homebrew shop declaring, "How do I make beer?" Between then and now, he has progressed his brewing knowledge and brewing techniques and custom-built much of his homebrew equipment. He enjoys creating recipes in a wide range of styles and collaborating with his local homebrew club in Belleville, Michigan. You will never find an empty tap at the Wirth house!

In his first piece for *BYO*, Adam shares pictures and details about the homebrewing equipment and space he built to house Zonut Brewing Co. beginning on page 46.

Dr. Pattie Aron obtained a B.S. in Biochemistry from Elmira College and M.S. and Ph.D degrees in Food Science and Technology from Oregon State University. Pattie's passion for fermentation led her to conduct graduate research in wine chemistry and brewing science. Formerly, Pattie was the Senior Hop Chemist in the Applied Brewing and Research team at MillerCoors, now MolsonCoors. She currently manages Rahr Malting's technical research and innovation program at the Shakopee, Minnesota headquarters. The research group focuses on applied research and new product development for beer, wine, and spirits production.

Starting on page 38, Pattie digs into the science behind why New England IPAs are hazy, and what brewers can do to create a consistent, persistent haze.

Stephen Stanley's first homebrewing challenge was to reproduce Kloster Weltenberger's Barock Dunkel after a trip to Germany. He's still working on it ten years later. He is a founding member and Education Chair of the Aurora City Brew Club in Aurora, Colorado. Steve is a Lean Six Sigma Black Belt, an engineer, and a process geek. His love is German beers, from the classic Pilsners to the sour wheat beers of northeastern Germany. A native Kentuckian, Stephen won a silver medal at the Great American Beer Festival for his Kentucky common with Wade Malsen, then Head Brewer of Ironworks Brewery.

As a frequent commenter on homebrewing forums, Stephen sees those new to the hobby all too often focus on their recipes and overlook their process. On page 32, Stephen lays out what beginners should focus on if great beer is the goal.


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MAIL

My understanding is the *Lactarius rubidus* we get on the West Coast is significantly more potent than the *L. fragilis* that can be found in other parts of the country.

Thanks again for a great article and recipe. Maybe now others will be encouraged to work with fungi.

Drew Jackson • *Mendocino, California*

Story author Derek Dellinger responds: "Ahh, that's a good observation. To be honest, I haven't found much commentary on the differences between the American varieties, so I had not heard that L. fragilis *was considered less potent. From what I've seen,* L. rubidus *is almost always what you'll find online if you're buying them dried, so for most brewers taking the safe and easy way of acquiring the mushrooms, this is likely what you'd end up with anyway. (*L. rubidus *is what we used in the beer we brewed at Kent Falls Brewing Co. as well). Most online purveyors seem to be based in California or the Pacific Northwest, where the* L. rubidus *variety is prevalent. It is probably good to know that the* L. fragilis *is considered less potent, though, in case you are taking the step of foraging for these (one more consideration to keep in mind amongst the many others, for foragers).*

"Maybe worth noting also is that there is at least one other variety/subspecies called L. camphoratus, *which is most commonly found in Europe and Asia, but from what I've read can also be found in the Northeast of the U.S. as well. That variety is described as having a more "curry-like" character rather than maple syrup. I haven't seen it sold online in the U.S., but for any European brewers out there, they may find themselves with a different result if they're sourcing locally."*

THANKS, GORDON!

I have tried three new styles this year (in 2020) all because of the "Style Profiles" in the magazine, and have been pretty chuffed with the results. I would go so far as to say that Gordon Strong's series of style guides are my favorite aspect of the magazine, so a big thank you to Gordon and to *BYO* for making them a continuing feature.

Neil Andrew • *via email*

We second your opinion that Gordon's columns are tremendous. It's great to hear they are inspiring homebrewers to try new styles, too!

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. BYO

BEGINNER'S BLOCK

BY DAVE GREEN

IMPORTANCE OF SAFETY

While homebrewing isn't exactly one of the more dangerous hobbies in the world, hazards do abound: Emergency room visits from a shattered glass carboy, scaldings, hair set on fire, electrocutions, back thrown out, etc. The good news is that these are not common, and with some common sense and a few simple homebrewery SOPs (standard operating procedures), these can be further minimized.

1) Limit your consumption — Just because you're making a lot of beer, doesn't mean you should be simultaneously consuming a lot (especially if you're driving somewhere afterwards!). During my short stint as an assistant professional brewer, we never had a beer on brew day until the last kettle was drained. When we saw the trub at the bottom of the kettle, we did what we called the trub dance, then went and poured ourselves a pint. It makes the cleaning process a little more palatable. I still (for the most part) adhere to that to this day. Many homebrewers will wait until all clean up is done before having a drink, which I admire. I'm not that disciplined.

2) Closed-toed shoes are a must — I probably should say pants here too, but at the bare minimum, brewers should be wearing closed-toed shoes while brewing. Boots or other waterproof (or at least water resistant) shoes are preferred. A little boiling wort/liquid spilled on your bare skin is extremely painful. The same goes for whenever you are handling glass carboys: Washing, moving, or simply carrying while empty. Dropping a glass carboy (empty or full) can have life-changing consequences if you're in sandals or flip-flops.

3) Wear a good pair of brewing gloves — I always recommend wearing brew gloves whenever transferring, opening/closing valves, changing connections, scrubbing down kettles, or any other process where your hands are apt to touch hot, caustic, or acidic things. They're not expensive and a good pair lasts years (mine are twelve years old and still in good shape). To me they're essential to all beer brewers.

4) Simple electrical and gas considerations — Each carries their own risks but a few rules can eliminate most safety risks. When it comes to propane and natural gas, keep outdoor (high-powered) burners outside or in well-ventilated spaces indoors. I have heard reports from a homebrewer who sustained carbon monoxide poisoning when using his burners in a finished garage with a side door open. That's not ventilating . . . two doors open with a fan blowing air outside one of them is ventilating.

All DIY electrical builds should be reviewed and approved by a certified electrician. But even if you are simply plugging in a pump for a liquid transfer, you need to make sure all electrical components near your homebrew setup are protected by a GFCI (ground-fault circuit interrupter). Stand-alone GFCI plugs can be purchased at hardware stores and are not expensive. If you accidentally spill a bucket of water onto your pump, the GFCI will protect you from electrocution.

5) Minimize heavy lifting — The recent push towards brewing indoors has been a major upside for homebrewers' backs. Brewing and fermenting in the same space means a lot less hauling of large volumes of wort/beer. Add in the assistance of a pump(s), and pretty much all heavy lifting can be minimized if you plan well. Don't try to be a hero . . . be smart and be safe.

6) Zero bottle bombs — A bottle bomb is simply a bottle of beer that explodes . . . hopefully not close to anyone. It sends glass shards flying at high velocity in all directions (and causes a mess). For those that bottle their beers, there are five main causes of bottle bombs: Using the wrong bottle types, bottling too early, a miscalculation in priming sugar, unwanted microorganisms, or a phenomenon known as hop creep. Your standard 12 oz. (355 mL) crown-cap bottle is suitable for all beers except highly carbonated ones. If you are going for a Belgian tripel at say 3.5 volumes of carbonation, you should opt for Belgian-style or Champagne-style bottles. Also, make sure the beer is fully fermented and has had time to settle prior to bottling. The yeast should not be finishing primary fermentation in the bottle (unless you're an advanced brewer and this was in fact your intention).

I always recommend using a trusted priming calculator and that you double check all your work. Then it's a classic instance of: Measure twice, add once. If using a sugar other than glucose or sucrose, such as honey or maple syrup, make sure you are taking into consideration what percentage sugar by weight they actually are (although this is more often a source of under carbonation).

Poor sanitation is a common cause of bottle bombs. Be sure you follow a regimented cleaning and sanitation protocol for things like fermenters, racking canes, and reused bottles. Finally there's hop creep. To prevent this you can either not get super aggressive with dry hops on beers you plan to bottle or give the beer extra time in the fermenter. I personally say about 4 oz. (113 g) or less dry hops per 5-gal. (19-L) for beers you plan to bottle.

7) Protect Your Eyes — Finally, be smart about eye protection. If you're running beer line cleaner (a harsh caustic) through your taps, protect your eyes from possible spray. If you're using a counter-pressure bottle filler, wear some face protection. Weak bottles can fail under higher pressures and, just like with bottle bombs, send shards flying.

THE NOBLE HOPS OF GERMANY

There are four hops varieties that are considered noble . . . but what makes them noble? Basically it simply implies that they were the hop varieties that are old-school. They were the ones monks and brewers from continental Europe were using during the Middle Ages to flavor and preserve their fermented brews. There are four varieties from Germany (and now the Czech Republic) that are known as the noble hops: Hallertau, Saaz, Spalt, and Tettnang. They are named after the region where they were grown, the lone exception being Saaz, whose region is now known as Žatec, which is the Czech name for the area formerly known as Saaz. These fours varietals share many traits in common such as low alpha acid content and a strong aroma profile. They, or at least their slightly modified descendants, are still popular these days, especially among brewers of traditional continental-style lagers and ales.

HALLERTAU

Found in Bavaria in the southeast part of Germany, Hallertau is located just north of the city of Munich. It has a long tradition of growing hops and Hallertau hops date back too far to even find their genetic origin. Hallertauer Mittelfrueh is the classic Hallertau hop varietal but unfortunately due to its susceptibility to disease it was nearly wiped out. According to the *Oxford Companion of Beer,* its acreage was reduced to just 1.5% of total hop acreage of Hallertau by 1990. But due to the surge in craft beer and their need for quality aromatic hops along with improved farming techniques, Hallertau Mittelfrueh has roared back. It, along with its descendent Hallertau Tradition, continue to be the backbone of many Bavarian-style ales and lagers. Its complex aromatics of earth, spice, and citrusy nectar means that it will often be added near the end of the boil or after the boil by brewers.

SAAZ

Traveling northeast from Hallertau, you will cross the border into the Czech Republic, where just west of Prague and north of Pilsen you'll find the well-known hop region known as Žatec (Saaz is the German name), home of Saaz hops. Just like with Hallertau hops, Saaz hops are too old for geneticists to dissect its origins. Because this region was once part of the German empire, Saaz are often still considered a German noble hop. Saaz hop aroma has come to define the aromatic profile of Bohemian-style Pilsners, with its decidedly spicy and earthy oil components. Also having suffered from disease problems, new disease-free clones have been produced, which have helped boost yields of this hop.

SPALT

The region just to the northwest of Hallertau is the slightly lesser-known hop region of Spalt. According to the *Oxford Companion of Beer,* this region has been growing hops since at least the 14th century and was the first region to receive the German "seal of hop quality." Spalt hops display a mildly spicy note and are often associated with the hop profile of traditional Düsseldorf altbiers. Spalt hops are considered to be in the Saaz family genetically.

TETTNANGER

Travel southwest from Spalt, out of Bavaria and into the neighboring German region of Baden-Württemberg of southwestern Germany to find the last noble hop region of Tettnang. Hops have been cultivated here since about the mid-1800s according to the *Oxford Companion of Beer*. The namesake hop varietal takes the name Tettnanger and is often considered a very close match to Saaz hops in its profile, although it can take on a slightly more fruity or citrus quality, depending on the growing and harvest conditions. Just like Spalt, it is from the Saaz family and weissbiers can often be found with a Tettnanger hop profile in them.

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WHAT'S NEW

BREWER'S BEST® KOMBUCHA KITS

A new series of kombucha recipe kits by Brewer's Best® allows homebrewers to craft their own flavored kombucha at home. Each kit comes with the ingredients to craft one gallon (3.8 L) of fresh kombucha and is available in four flavors: Blackberry, hemp, passion fruit, and raspberry. Note that these kits do not include a SCOBY for fermentation, which needs to be purchased separately from a supplier. SCOBYs are not included since they can be reused time and again and don't need to be started fresh each time. First time making kombucha? Each kit comes with its own detailed, step-by-step instructions for a successful batch the first time and every time. http://brewersbestkits.com/kombucha.html

MANGROVE JACK'S HOPHEAD ALE

Fans of the hazy, juicy style of IPA have a new strain of dry yeast to try out. Mangrove Jack's has recently released a new strain in their lineup, M66 Hophead Ale. As the name implies, the yeast is ideal for hop-forward beers. Its combination of esters and increased aromatics from enzymatic activity means this strain should work well with New England, hazy, and fruit-forward IPAs. It exhibits medium attenuation and high flocculation. Learn more at https://mangrovejacks.com/collections/craft-series-yeasts/products/m66-hophead-ale-yeast-10g

BREWSCOUT

Needless to say, 2020 reshaped the current beerscape and how we as craft beer fans (and makers) make our selections. A new e-commerce platform called BrewScout has launched that caught our attention. They don't actually sell beer . . . but act like a matchmaker, by pairing beer consumers with breweries that are compatible based on the consumer's palate and the brewery's lineup. If this sounds like something you may be interested in, check out www.facebook.com/brewscoutapp/

Photo courtesy of Shutterstock.com

A THIOL TEST FOR BEER FINALLY APPROVED

The sulfur-containing class of compounds known as thiols have become synonymous with the tropical fruit aromas of New World hops. But they have remained shrouded in mystery due to their extremely low concentrations (ng/L) and highly reactive nature, making them difficult to assay. Using a technique used in the wine world, a team from the Research Institute for Beer and Beverage Analysis out of Berlin, Germany greatly increased sensitivity and tweaked the testing process in order to find what they were looking for . . . a way to reliably assess thiol levels in beer. Hopefully it's time to see what we've been missing. https://pubs.acs.org/doi/abs/10.1021/acs.jafc.0c06305

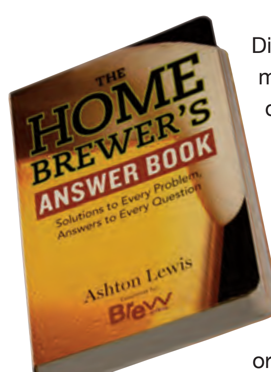
Upcoming Events

ALL-GRAIN BREWING ESSENTIALS ONLINE BOOT CAMP WITH JOHN PALMER AND JOHN BLICHMANN MARCH 26, 2021

This four-hour live online workshop covers all you need to know to successfully make great homebrews using both traditional and newer all-grain brewing techniques. *How to Brew* author John Palmer and equipment guru John Blichmann will take you through the all-grain process from milling, mashing, and sparging before going into the boil. https://byo.com/bootcamps/

HOMEBREW EXPERIMENTS ONLINE BOOT CAMP WITH DREW BEECHUM AND DENNY CONN APRIL 9, 2021

Learn how to conduct your own homebrew experiments. Without reliable results you rely on guesswork instead of facts to improve your brewing. Join two of the true leaders in experimenting with homebrews – podcasters and book authors Drew Beechum and Denny Conn from Experimental Brewing – as they walk you through how to properly conduct your own experiments at home. https://byo.com/bootcamps/



BY DAVE CLARK

DEAR REPLICATOR,

My wife and I went to Las Vegas, Nevada to visit her brother a few years ago. While waiting on our wives to finish one of their shopping sprees, my brother-in-law and I ducked into the nearest bar. On tap was Stone Brewing Co.'s Pataskala Red X IPA. One sip and I was hooked: Big hop nose with a caramel malt backbone to help support all those hops. But due to some work being done on our home, my brewery was out of service for an extended period. Now I'm ready to brew again and I'd like to share this seasonal brew from Stone with all my friends. Please help with a clone recipe.

Rob Sturgill
Williamsport, Pennsylvania

What does a small town in central Ohio have in common with one of America's biggest and most successful craft breweries? The answer is Greg Koch. Based out of Escondido, California, Stone Brewing Co. is currently listed as the ninth largest craft brewery in the United States. Its co-founder and craft beer pioneer, Greg Koch, came from a modest upbringing in rural Pataskala, Ohio, a town located about 30 miles east of the capital city of Columbus. As a former high school band member in Pataskala, Koch was involved with music long before beer became his calling card.

In 2015, the town was trying to pass a school levy to save extracurricular activities, including band. One enterprising student had an idea and wrote a letter to Koch at Stone Brewing Co. The letter asked Koch if there might be something he could do to influence a positive outcome for the upcoming levy vote. Remembering his days as a band student at the local public high school, Koch made a promise that his company would brew a beer dedicated to the citizens of Pataskala . . . if they would pass the levy. The promise also stipulated that 100% of the profits would go directly to the school's extracurricular programs. To make a longer story shorter, the levy passed, the beer was brewed, and the extracurricular activities were saved.

But there was more to this story, especially when it came to those who take an interest in beer and the brewing processes. A new, somewhat revolutionary malt played a key role in ensuring this story's happy ending.

Stone's brewmaster at the time, Mitch Steele, had just heard about a brand new malt from the German maltsters BestMalz called Red X®. With a diastatic power of over 200 °Lintner, (35 °L is the bare minimum for a base malt to be considered "self-converting") this malt could be used as 100% of a beer's grist. The malt's claim to fame was that it could deliver a bright red hue that was appealing, hard to achieve otherwise, and somewhat unusual.

For years, brewers seeking to craft a red-hued beer often struggled to find the right combination of malts that would deliver the desired color without ending up with a cloyingly sweet beer. BestMalz claimed that Red X® would deliver both the beautiful red hue and the rich malty character sought after by brewers without the heavily sweet character. In the eternal words of Van Halen, the best of both worlds. Under Steele's guidance, one of Stone's brewers, Kris Ketcham, took the lead on developing the recipe that was to eventually become Pataskala Red X IPA. It was a fairly straightforward process and malt bill considering that Red X® is the only malt used in the beer.

The real complexity of what Kris came up with was found in the hopping schedule, which includes a heavy dry-hopping schedule with Mosaic®, Cascade, and Amarillo® hops. The result was a noticeably citrus-forward aroma/flavor combination, rounded out with notes of biscuit and toffee on the palate derived from the Red X® malt. Pataskala Red X IPA was unlike anything on the market at the time . . . and still a rarity for that matter.

The beer's deep crimson color and brilliant clarity is an instant conversation starter. Tiny, off-white bubbles provide a creamy mouthfeel due to the generous helping of hops throughout the brewing process. Astringency-free, the beer finishes crisp, as one would expect from a 75 IBU IPA. An excellent palate cleanser, Pataskala Red X IPA pairs well with red meat of any kind, spicy food like Thai or Mexican, or with deep fried delicacies. It is recommended to serve the beer at 38 °F (3 °C), preferably in a nonic glass, that will help preserve the beer's dominant citrus hop notes.

Pataskala Red X IPA was intended to be a "one-off" to help the folks in Koch's original hometown . . . but what followed was an overwhelming response for more. The beer was added to the seasonal lineup for a period of time, and is currently being reborn to reappear in the Stone Classics series, the brewery's rotating series of Stone Brewing Co.'s classic beers.

The key to replicating a beer of this nature is to use the freshest hops possible and, as always with hop-forward beers, minimizing oxygen uptake during dry-hopping, transferring, and packaging processes. With five ounces (142 g) of dry hops and another four ounces (113 g) added during the brewing process, the hops are every bit as important as the integral BestMalz Red X® malt to brew this beer correctly. Prost!

STONE BREWING CO.'S PATASKALA RED X IPA CLONE

(5 gallons/19 L, all-grain)
OG = 1.068 FG = 1.012
IBU = 74 SRM = 15 ABV = 7.3%

INGREDIENTS

15 lbs. (6.8 kg) BestMalz Red X® malt
8.3 AAU Magnum hops (first wort hop) (0.65 oz./18 g at 12.7% alpha acids)
15.4 AAU Mosaic® hops (15 min.) (1.28 oz./36 g at 12% alpha acids)
4.3 AAU Cascade hops (15 min.) (0.65 oz./18 g at 6.6% alpha acids)
15.4 AAU Mosaic® hops (0 min.) (1.28 oz./36 g at 12% alpha acids)
4.3 AAU Cascade hops (0 min.) (0.65 oz./18 g at 6.6% alpha acids)
5.2 AAU Amarillo® hops (0 min.) (0.65 oz./18 g at 8.0% alpha acids)
2.56 oz. (73 g) Mosaic® hops (dry hop)
1.28 oz. (36 g) Amarillo® hops (dry hop)
1.28 oz. (36 g) Cascade hops (dry hop)
White Labs WLP007 (Dry English Ale), Wyeast 1098 (British Ale), or LalBrew Nottingham yeast
¾ cup corn sugar (if priming)

STEP BY STEP

Using 0.9 qts. of water per pound of grain (2 L/kg), mash in at 148 °F (64 °C), rest for 60 minutes or until conversion has been achieved. Increase temperature to 165 °F (74 °C) for 5 minutes to halt the conversion process. Considering the thick mash, you can achieve this by infusing boiling water. Recirculate your wort for 10–15 minutes or until clear. Begin your lautering process as you sparge to collect 6.5 gallons (24.5 L) while adding your first wort hop addition. Boil for 60 minutes and add the suggested hops during the last 15 minutes and at the end of the boil. Yeast nutrients and a kettle fining such as Irish moss or Whirlfloc can be added too. After the boil, give the wort a long stir to create a whirlpool, then let settle for 15 minutes.

Chill wort rapidly to 68 °F (20 °C), pitch your yeast and oxygenate. Ferment at 72 °F (22 °C) until final gravity is reached and clear of diacetyl (10 to 14 days is standard). Remove from yeast and add your dry hop additions to the fermenter. Let sit for 3 days. Chill the beer then rack into kegs and carbonate to 2.4 to 2.5 volumes or a touch higher if you intend to hand bottle from the keg. Otherwise, prime and bottle condition.

STONE BREWING CO.'S PATASKALA RED X IPA CLONE

(5 gallons/19 L, extract with grains)
OG = 1.068 FG = 1.012
IBU = 74 SRM = 15 ABV = 7.3%

While it may be hard to mimic the color and character of Pataskala Red X without a majority BestMalz Red X® base malt, we can try to mimic the color and toasted character with some playful substitutions. If you can utilize a partial mash in your setup, then go with as much Red X® as you can while proportionally cutting back on the Munich extract and Carafa® malt.

INGREDIENTS

3 lbs. (1.36 kg) extra light dried malt extract
3.5 lbs. (1.6 kg) Munich dried malt extract
3 oz. (85 g) Carafa® Special III malt
8.3 AAU Magnum hops (first wort hop) (0.65 oz./18 g at 12.7% alpha acids)
15.4 AAU Mosaic® hops (15 min.) (1.28 oz./36 g at 12% alpha acids)
4.3 AAU Cascade hops (15 min.) (0.65 oz./18 g at 6.6% alpha acids)
15.4 AAU Mosaic® hops (0 min.) (1.28 oz./36 g at 12% alpha acids)
4.3 AAU Cascade hops (0 min.) (0.65 oz./18 g at 6.6% alpha acids)
5.2 AAU Amarillo® hops (0 min.) (0.65 oz./18 g at 8.0% alpha acids)
2.56 oz. (73 g) Mosaic® hops (dry hop)
1.28 oz. (36 g) Amarillo® hops (dry hop)
1.28 oz. (36 g) Cascade hops (dry hop)
White Labs WLP007 (Dry English Ale), Wyeast 1098 (British Ale), or LalBrew Nottingham yeast
¾ cup corn sugar (if priming)

STEP BY STEP

Heat 2 gallons (7.6 L) of water, adding the Carafa® Special malt in a muslin bag and submerge while the water heats up. Once the temperature reaches about 165 °F (74 °C) remove the grains, giving a gentle squeeze to the bag. Increase temperature to near-boiling before turning off heat and adding the malt extract plus another gallon (3.8 L) of water. Stir continuously until all extract is dissolved. Put the pot back on heat, add the first wort hops, then raise to a boil. Boil for 60 minutes and add the suggested hops during the last 15 minutes and at the end of the boil. After the boil, give the wort a long stir to create a whirlpool, then let settle for 15 minutes.

Chill wort rapidly to 68 °F (20 °C). Add water to achieve a total fermenter volume of 5.5 gallons (20.82 L). Follow the all-grain recipe for fermentation and packaging instructions.

TIPS FOR SUCCESS:

Since Red X® is such a unique malt and doesn't have a true extract equivalent, brewing this beer all-grain is the ideal way to go. However, for those who haven't gone to all-grain brewing or don't have the space to do so, the extract recipe will give you a pretty great IPA that will be similar in color, even if it may lack some of the brightness and malt character of the all-grain version. Whatever you do, seek out this specific grain and do not substitute for something "similar" because nothing on the market will get you close enough to the character that Red X® provides . . . at least at this time. BYO

BY DAWSON RASPUZZI

HOW IMPORTANT IS KETTLE pH?

Mash pH gets most of the attention when it comes to pH measurement, but there are ideal pH levels at every step of the brewing process and they may get out of line after the mash. The boil pH affects protein coagulation, hot break, and hop isomerization (a higher pH results in a higher hop utilization, although also a harsher bitterness), among other things. So, how important is it to measure pH during or after the boil? We checked in with two pro brewers who know their way around lab equipment to get their opinions on whether homebrewers should sweat over the kettle pH.

We try to keep all kettle pH around 5.0–5.2. This promotes protein coagulation and lends a crisp, clean flavor and mouthfeel to the beers.

Cole Hackbarth is the Director of Brewing Operations at the regional, eight-year-old Rhinegeist Brewery in Cincinnati, Ohio. He has 14 years of professional brewing experience and holds a B.S. in Fermentation Science from Oregon State University.

We look at mash pH more closely than kettle pH as it has a big impact on enzyme activity and conversion. But also because mash pH translates to kettle pH consistently with a 0.2–0.3 pH drop. In fact, we don't generally measure kettle pH unless it's needed for the style (such as when we brew a Gose or a Berliner weisse). When we do track kettle pH it's measured at the end of boil (which is after a 5% boil-off rate on a 60-minute boil).

Brewing literature (including Kunze and Briggs) states that, when measured at room temperature, mash pH should be between 5.2–5.6 depending on style. When you hit that, the kettle pH will be appropriate. We try to keep all kettle pH around 5.0–5.2. This promotes protein coagulation and lends a crisp, clean flavor and mouthfeel to the beers. There is some evidence that higher pH will enhance bitterness and hop utilization, but we find it's not significant enough to outweigh the benefits of boiling at 5.2 pH.

We rarely acidify or deacidify in the kettle unless we are doing a historic style that used a non-traditional malt bill or intentionally soured wort pre-fermentation. Some lactic acid bacteria used in "quick" or "kettle" sours perform better if the wort is acidified before pitching bacteria. Usually around 4.9 pH; any lower and you start promoting diacetyl formation and creating stability issues.

In addition to calcium sulfate/calcium chloride or calcium carbonate, we use food-grade phosphoric acid to adjust pH. It has a good balance of acidification without being too dangerous. Sulfuric acid is stronger but also more hazardous. Lactic acid is also often used because of its availability and ease of use. One thing to note with phosphoric acid — it does release phosphates that will bind with and precipitate calcium. So, if you are battling low calcium concentrations in your water and see poor attenuation, flocculation, or trub formation, then lactic acid may be the better choice.

When it comes to the importance of monitoring kettle pH, what I would say is that I think it's important for each brewer to understand the composition of the water they are working with, and how it impacts the beer. No need to obsess over, but it is good to check from time to time or if you see haze or yeast performance issues.

Brewing water chemistry is one of the more complicated parts of recipe formulation and brewing. It's so much more than just pH. You have to look at hardness, residual alkalinity, calcium content, and how these interact with the other brewing ingredients. You can go crazy trying to create the perfect brewing water. But just like there is no single malt, hop, or yeast variety that should be used in all beers, neither does perfect water exist. It is essential to understand your water and adjust it, as a tool to create exciting flavorful beers.

Cole Corbin is the Director of Brewing Operations at Maine Beer Company, which was established in 2009 in Freeport, Maine.

I think mash pH, pH during lautering, and pH during fermentation is more important to monitor than kettle pH. That said, kettle pH is good to check to make sure things are in line before and after the boil. We do measure pH pre-boil and post-boil (with an evaporation rate of about 5% for a 60-minute boil). We're in the habit of spot checking pH throughout our processes; we grab a sample post-boil to record gravity, and while we have the sample we check pH. It's a quick check and another data point to verify everything is going as it should. While we do monitor the kettle pH, we never have needed to make adjustments based on the results of these samples.

Our ideal kettle pH depends on the brand being brewed, but we typically shoot for a pH of 5.2 post-boil when measured at room temperature for beers that are lighter in color. Just by the nature of the ingredients used, the darker beers (stouts and porters) naturally have lower pH because of the higher amount of roasted grains. They're typically below 5.0, in the 4.7–4.9 range. We monitor this and look for consistency between batches. We never acidify or deacidify in the kettle, nor do we use acid/base to alter pH. When pH adjustments are necessary in the mash and sparge phase we'll make those using brewing salts. Our water is fairly soft with a total hardness of 85 mg/L $CaCO_3$. This means pH buffering is fairly low and is not hard to adjust with just some salt additions.

My recommendation is to focus on using good-quality water first, then start making adjustments if needed. Monitor pH and don't over-sparge the grains during the lautering process. If you are using water from your tap, make sure you know your water profile and treat for any chlorines found in there. Reverse osmosis (RO) water is a great canvas to build a water profile if you are dealing with water high in TDS (total dissolved solids) or that displays other problems.

BY ASHTON LEWIS

MEASURING MASH pH

Also: Wort aeration temperature and beer in a bag

Q I LIKE TO BREW WELL-HOPPED ENGLISH-STYLE IPAS. DO I CHECK THE pH BEFORE OR AFTER THE ADDITION OF GRAINS? WHAT pH AM I AIMING FOR AND WHAT IS THE BEST METHOD TO ACHIEVE THE DESIRED RESULT?

CHRIS BENNETT
ALFRETON, ENGLAND

A Questions about pH and its relationship to brewing are very deep. So deep in fact, that the pH scale was developed and introduced to the world in 1909 by Søren Peter Lauritz Sørensen, head of the Carlsberg Brewing Laboratory in Copenhagen, Denmark from 1901 to 1938. Maltsters and brewers keep a careful watch on pH because of its influence on all biochemical reactions. Just a shallow scratch of the surface of this topic reveals malt color, enzymatic activity during mashing, color development and hop utilization during wort boiling, trub behavior in the whirlpool, microbial activity in unpitched wort and in fermented beer, and oxidative and colloidal stability of packaged beer, as examples of the myriad aspects of how beer is touched by pH. What follows will not be a rambling journey down this interesting rabbit hole!

Suffice to say, water pH is not very useful to brewers because mash pH is affected by stuff in water AND stuff in malt.

Photo courtesy of Shutterstock.com

BEFORE OR AFTER?

I have been spending much more time checking out homebrewing social media since life as we all knew it changed in early 2020. The question about when to adjust pH is perhaps one of the most common questions about this topic. I see my friend and fellow *BYO* contributor, Denny Conn, frequently posting short quips about this question. The answer is simple; check mash pH after malt is added and the mash is allowed to settle for a bit. A bit? Yeah, more on that in a bit.

Without getting bogged down into the specifics, the pH of brewing water tells a very incomplete story because there are three components in water that have a profound effect on mash pH (calcium, carbonate/bicarbonate, and magnesium), yet only one of the three, carbonate/bicarbonate, affects water pH. And that effect is not simple because carbonate/bicarbonate is a buffer system that opens up a chapter in organic chemistry titled "Buffers, Buffering Capacity, and the Henderson-Hasselbalch Equation." Suffice to say, water pH is not very useful to brewers because mash pH is affected by stuff in water AND stuff in malt.

When does a brewer measure mash pH? A little bit after mashing in, of course! Proteins, polypeptides, phosphates, and other organic molecules with carboxylic acid moieties react with calcium and magnesium and release protons into the mash; this lowers pH. The carbonate/bicarbonate buffer system is also busy doing its thing, which typically results in mash pH being pushed upwards. Since these reactions do not happen immediately upon mash-in, some time is required for the mash pH to stabilize. Like so many things in brewing, there is no magic time required for pH to stabilize; 15 minutes is usually long enough, but pH usually stabilizes after about 5–10 minutes. In the vernacular of non-specific direction, seasoned brewers say, "wait a bit after mashing in to check mash pH."

Let's assume we have mashed in for a nice hoppy, English-style IPA. The recipe is classic: 80% Golden Promise malt, 15% torrefied maize (a.k.a. corn), and 5% medium crystal malt. We wait for 15 minutes, and pull a mash sample. Now what? Well if the brewer is practical, they may have a pH meter with an electrode that doesn't mind hot measurements and the mash pH is measured. Others will cool the mash to 68 °C (20 °C) before a measurement is taken. So, 15–25 minutes later, we have our pH value. Drats! We discover that our pH is 5.6 and we really wanted pH 5.4. Does the practical brewer add acid? Well, that depends on the practical brewer. This practical brewer would make a note in the brewing log, play with the sample by determining how much acid would be required to adjust the pH, and use this information on the next brew. The problem that many homebrewers have is that the next brew may be an entirely different type of beer.

Target pH is another one of those things that depends on what you are aiming to do. The general rule is to have a pH in the 5.4–5.6 range (measured at 68 °F/20 °C).

ADJUSTING MASH pH

The three most common methods used to adjust mash pH are through water salt additions, for example, by adding gypsum (calcium sulfate) to your brewing water before the mash, malt selection, and acid additions. Your question was thankfully simple in that you asked for the methods, not a deep dive into the chemistry behind the method. Basic calculations are, however, required to estimate mash pH. Here is a method for estimating mash pH:

Estimated Mash pH = (wort pH from malt COA) + (RA x 0.03) – (% crystal malt x 0.025) – (% lightly roasted malts x 0.03) – (% darkly roasted malts x 0.05) – (% acidulated malt x 0.01).

Residual Alkalinity (RA) = (ppm carbonate/bicarbonate in water x 0.046) – (ppm calcium in water x 0.04) – (ppm magnesium in water x 0.03).

And here is an example:

Assume the grist bill is 95% base malt and 5% crystal malt (note this method does not have a spot for adjunct grains), and the water contains 60 ppm carbonate/bicarbonate, 120 ppm calcium, and 20 ppm magnesium. You need to check a "COA" (certificate of analysis) of the base malt used for this brew. That information is not always easy to find, but for this malt let's assume we know that the value is pH 5.9 at 68 °F (20 °C).

RA = (60 x 0.046) – (120 x 0.04) – (20 x 0.033) = -2.70

Estimated Mash pH = (5.9) + (-2.70 x 0.03) – (5 x 0.025) = 5.7 at 68 °F/20 °C

In the example above, the predicted mash pH is higher than the target. The options for mash pH adjustment are water chemistry, tweaking the grist bill, and adding acid. The equations above show the basics on using water and malt selection to adjust pH. What about adding acids? Definitely an effective, relatively easy, and common method, with lactic and phosphoric acids the most common food-grade acids used by brewers.

The general rules for these acids are that 0.66 grams of either 88% lactic acid or 85% phosphoric acid added to 1 kg (2.2 lbs.) of grist ("normal" mash thickness in the 3 liters water per kg malt is assumed) will reduce mash pH by 0.1 pH units. For my non-metric friends, this translates to 0.01 ounces of acid per pound of malt in a normal mash with a thickness of 1.4 quarts per pound.

BEER STABILITY, pH, AND DRY HOPPING

A topic that is likely to receive more attention in the near future is the relationship between beer pH and dry hopping. In general terms, dry hopping increases beer pH. Practical brewers and brewing scientists have noted that the very high dry hopping rates used for hazy IPAs have resulted in more packaged beers with pH > 5.0. Beer pH is usually in the 4.2-4.8 range and when beer pH gets into the 5s, oxidative and microbiological stability both take a dive. One technique that is really gaining some traction is wort pH adjustment after the boil to reduce pH going into fermentation to about pH 4.8. Brewers are also using post-fermentation acid additions to lower in-package beer pH to specifically address oxidative stability. Thanks for the great question about pH. Hope this information is useful in your quest for great beer!

Q JOHN PALMER STATES IN HIS BOOK *HOW TO BREW* "YOU SHOULD NOT AERATE WHEN THE WORT IS HOT, OR EVEN WARM. AERATION OF HOT WORT WILL CAUSE THE OXYGEN TO CHEMICALLY BIND TO VARIOUS WORT COMPOUNDS. OVER TIME, THESE COMPOUNDS WILL BREAK DOWN, FREEING ATOMIC OXYGEN BACK INTO THE BEER WHERE IT CAN OXIDIZE THE ALCOHOLS AND HOP COMPOUNDS PRODUCING OFF-FLAVORS AND AROMAS LIKE WET CARDBOARD OR SHERRY-LIKE FLAVORS. THE GENERALLY ACCEPTED TEMPERATURE CUTOFF FOR PREVENTING HOT WORT OXIDATION IS 80 °F (27 °F)."

SINCE I'M USING KVEIK YEAST (VOSS) THAT HAS AN OPTIMUM PITCH TEMPERATURE OF 102 °F/39 °C I'M A BIT WORRIED. AM I RISKING HOT WORT OXIDATION AT THAT TEMPERATURE?

DIRK KISSING
ALMELO, NETHERLANDS

A Several years ago, I was on a panel discussion at an annual MBAA (Master Brewers Association of the Americas) meeting held in Chicago. A question related to general suggestions about "stuff" was lobbed to the panel. Thanks moderator! Luckily, I waited to comment after the other panelists offered their sage advice about stuff. This gave me a little prep time to offer that brewers should avoid making absolute statements, especially when it comes to using process declarations as part of marketing. Seems like too many brewers make statements that are later backed away from as things change. This question kind of falls into that camp.

Many statements about process are often taken out of context. John Palmer's point about not aerating hot wort falls under the "best practices" umbrella. No argument with that general rule. But general rules are just that; they are general and not intended to be absolutes. A great example of aerating hot wort is when traditional brewers use coolships and/or Baudelot coolers . . . those cool looking copper washboard things that sort of resemble an art deco urinal that could be found at a fancy beer hall. Coolships and Baudelot coolers (falling film chillers) expose hot wort to air, allowing the wort to pick-up oxygen from the environment upon cooling. That's just part of the process with these devices, and commercial brewers who use them today for certain specialty beers do not have special rooms that are devoid of oxygen to prevent hot wort from being exposed to oxygen . . . although some brewer has probably done this or will be doing it after reading this jab!

Lines in the sand aside, you may want to consider if wort aeration is even required for what you are doing. There is a Voss Kveik dried yeast produced by Lallemand. Not sure of Lallemand's general suggestions about wort aeration and dried yeast these days, but Lesaffre Yeast (producers of the Fermentis line of dried yeast) has been educating brewers about when aeration is needed. As it turns out, many, if not most, dried yeasts are propagated under conditions resulting in lots of glycogen. This is different from how yeast grow in a typical brewery fermentation, making the oxygen requirements of these yeasts different from yeast that have been harvested from a previous fermentation or grown under conditions that push yeast into anaerobic metabolism even when there is ample oxygen added to the propagator; the latter happens when the Crabtree Effect is in full-effect.

Let's assume that you want to harvest and re-use your kveik yeast. Maybe you decide to use a traditional yeast stick or yeast ring, or maybe you use a glass flask equipped with a lid. Whatever the method, you plan to collect and re-use your yeast. Do you aerate your wort for subsequent worts? Brewing is all about pragmatism. Let's assume you don't aerate your wort and the yeast performs poorly. Your next move may be to aerate to see if aeration, or the lack thereof, affects fermentation. The way I see it, you don't have to worry so much about beer oxidation if your yeast are not happy and healthy.

Now let's go one step further. Assume that aeration does improve fermentation and beer flavor when re-using your yeast, but you discover that your beer is not so stable when stored. Now is the time to consider how aerating warm wort may be affecting stability. You could try aerating 79 °F/26 °C wort, pitching, and allowing the fermentation to warm up as action kicks in. The takeaway message is that general rules are never cast in stone and are intended as guidelines to help folks find success. Here's to great beer and never saying never!

"You could try aerating 79 °F/26 °C wort, pitching, and allowing the fermentation to warm up as action kicks in."

Q HERE IN ALASKA, BEFORE THE PANDEMIC, TWO BREWERIES SERVED REAL ALE FROM A BEER ENGINE. NOW IT'S JUST ONE, AND IT'S A FEW HUNDRED MILES AWAY, SO I'M ATTEMPTING IT MYSELF, CONDITIONING IN A BAG (BAG-IN-A-BOX STYLE). SO FAR, I'M NOT ACHIEVING WHAT I HOPED. I'M PRIMING WITH WORT, AND PUT SOME IN BOTTLES, SOME IN BAGS. THE BEER FROM THE BOTTLES IS FINE, BUT THE HAND-PUMPED BEER FROM THE BAGS LACKS PROPER CARBONATION. THE BAGS EXPAND QUITE A BIT, SO MAYBE THE ADDITIONAL HEADSPACE IS THE PROBLEM? SOME HAVE SUGGESTED I SHOULD VENT THE BAGS, BUT I WORRY THE VENTING WILL ALSO KEEP THE BEER FROM REACHING OPTIMAL CARBONATION; WE DON'T VENT BOTTLE-CONDITIONED BEER, RIGHT? PLEASE HELP.

JUSTIN HERRMANN
HOMER, ALASKA

A The bag-in-box method has never really been common among homebrewers, but is a technique used by many pubs around the world. The reason your beer is not carbonating is that a rigid vessel is required to house the bag. This allows the beer to be pressurized above atmospheric pressure and to become carbonated. The challenge with a bag-in-box type package for carbonated beverages is the seal required between the bag, the container, and the outlet to the environment.

The standard for this design uses stainless beer serving tanks to house specially designed liners equipped with an outlet spout that seals to the vessel with a special ring mechanism. These vessels are very common in Europe and are becoming more common in North America. Although it is possible to carbonate or condition beer in the bag, provided the tank pressure is high enough to prevent gas bubbles from forming, the standard method used with these tanks is to carbonate beer prior to filling. Since the liner separates beer in the bag from the atmosphere in the tank, high pressures can be used for beer dispense without affecting beer carbonation level. This same benefit also allows compressed air to be used for dispense without damaging the beer (shelf life varies by the type of liner). The liner also makes vessel cleaning much easier, and reduces water, cleaning chemical, and carbon dioxide consumption. Although the liners are recyclable, they are made from plastic and that is one of the few downsides to the general design.

Unfortunately for homebrewers, there are few small-scale choices of this type of container on the market. Mueller, Duo Tank, and Bier Drive are the primary suppliers of these vessels. Perhaps this idea could be explored as a new offering to the homebrewing market!

Your question is really more about producing cask-conditioned beer at home, versus how to serve beer from a bag. My suggestion is to use a soda keg to carbonate your beer if you are looking for the simplest approach. You can either rack your beer into your keg with some residual fermentables or rack into your keg after fermentation is complete and add priming wort or sugar. Whatever method you choose, a spunding valve (adjustable pressure relief valve) is a handy way to control the pressure in the keg. Although you can reliably dose sugar and carbonate without using a spunding valve, the method is not as easy. Conditioning method aside, you want relatively low carbonation if the plan is to serve something akin to cask ale.

I am a newer generation U.S. brewer, cutting my teeth in the late 1980s, and never really bought into the whole anti-bottled gas thing espoused by CAMRA (Campaign for Real Ales). If the idea is to serve beer with about 1.8 volumes (or whatever you want) of carbon dioxide using a beer engine, the easiest way to keep your beer fresh and the carbonation level consistent is to keep your keg pressurized. Beer at 50 °F/10 °C with an equilibrium carbon dioxide pressure of 9 psig contains 1.82 volumes of carbon dioxide. As long as you maintain this combination of temperature and pressure, your beer will be consistently carbonated at a pretty low level.

Although beer engines are simple to use, do interesting things to beer mouthfeel and foam, and look super cool, they are not designed for use with pressurized liquid because the design of the pump allows pressurized liquid to freely flow through the pump and out the nozzle. Two ways to prevent this from occurring is to either store the beer at a level that provides sufficient liquid head pressure to offset the keg pressure (in this example about 20 feet below the beer engine) or to simply install a check valve in the beer line. Check valves are normally designed to prevent back-flow, however, when used with a beer engine and a pressurized keg, check valves prevent flow out of the keg when the beer is not being actively pumped. Easy peasy!

If you do want to go old-school CAMRA, you can condition your keg, vent the keg to atmosphere, hook it up to your beer engine, and start pulling pints. The Achilles heel of cask ale is beer oxidation and the growth of aerobic beer spoilers, especially acetic acid bacteria. If you do decide to go without external gas, you will want to consume your beer in 3–5 days. BYO

BY GORDON STRONG

WITBIER

A hazy shade of summer

While some breweries claim linkages to the middle ages, this particular style most certainly died and was later re-invented in the second half of the 20th century.

WITBIER
BY THE NUMBERS

OG:	1.044–1.052
FG:	1.008–1.012
SRM:	2–4
IBU:	8–20
ABV:	4.5–5.5%

Photo by Charles A. Parker/Images Plus

A once-dead minor historical style, what is now known as Belgian witbier, can be traced definitively to the work of one man, Pierre Celis. Its popularity is probably due more to the fact that Celis sold the brewery and brand to Interbrew (now AB InBev) who heavily promoted and supported it. While some breweries claim linkages to the middle ages, this particular style most certainly died and was later re-invented in the second half of the 20th century.

Before the days of hazy IPAs, witbier was one of the few intentionally cloudy beer styles produced. The use of unmalted wheat, as well as its medieval heritage, meant that it was often described as having a complicated mashing program and difficulty in production. The use of rare or possibly secret spices led to its mystique. And the fact that it could be a bit fragile and subject to souring meant that it could be difficult to get a good example. Yet it became quite popular among homebrewers who are always up to a challenge.

Witbier means white beer in Flemish (Dutch), and is also known by its French name of the same meaning, *bière blanche*. So, Belgian white is an acceptable translation, and many consumers just call it a wit for short. White refers both to the color of the beer and the fact that it uses wheat, which produces whiter-colored beers than those made with barley (often called red beers). The reflective "shine" evident in a witbier simply reinforces its whiteness without having to ask to speak to the manager.

The Beer Judge Certification Program (BJCP) groups witbier in Category 24, Belgian Ales, along with Belgian pale ale and bière de garde (technically, a French-origin beer). These are mostly standard-strength, relatively balanced, non-sour beers without an aggressive yeast character. There are other style categories for higher-alcohol beer, sour beer, and beers of the type originating in monasteries. Witbier is Style 24A in the style guidelines.

HISTORY

Belgian white beers are a traditional family of styles produced in the Leuven area as early as the 14th century. The current-day Leuven district (arrondissement) is the eastern half of the Flemish Brabant province, which is located just to the east of Brussels in north-central Belgium. The modern witbier is not the only type of white beer, with Blanche de Louvain, Peeterman, and Hoegaarden types cited in Stan Hieronymus' *Brewing with Wheat,* which in turn cites Georges Lacambre's 1851 book *Traité complet de la fabrication de bières et de la distillation des grains*. Hieronymus' book devotes three chapters to this style and is a good reference for anyone looking to dig deeper.

These three "white" beers were different, with the Leuven type beer being fairly popular. Peeterman was described as a darker beer using calcium hydroxide and a long boil to darken the wort. Hoegaarden was described as local and rustic. Brewing professor Jean de Clerck found them to be often infected with *Lactobacillus* and of varying sourness. De Clerck's 1958 *A Textbook of Brewing* makes only the briefest mention of the styles as "old type," "very out of date," and "extremely complicated." The Hoegaarden brewery claims they first brewed in 1445 by local monks, but this is not the same brewery and not the same recipe as used today.

All of these styles died out before the modern craft era. They were fairly popular refreshing summer beers before World War I interrupted wheat supplies in Europe. The last brewery to produce the Hoegaarden-type, Tomsin, closed in 1957. But there is linkage to the older styles as the rebirth is well documented.

Pierre Celis, a milkman by profession, worked at Tomsin and later recreated the style in 1966 in his hometown of Hoegaarden. Michael Jackson's books describe these events in vivid detail. His *Great Beers of Belgium* devotes an entire chapter to the style.

Celis opened the De Kluis brewery and began producing a white beer called Hoegaarden, after the eponymous town. A small town of several thousand people, it had 30 breweries in the mid-1700s, but only six before World War I. Celis sold the brand to Interbrew in 1985, after expanding the brewery in the 1970s and later having a fire. The marketing muscle of a large brewing conglomerate led to the widespread availability of the style in modern times.

Celis later founded Celis Brewery in Austin, Texas in 1992 to produce a similar style in the U.S. As Interbrew had changed the recipe, he was brewing his original version. Celis eventually sold his brewery to Miller in 2000, which closed the brewery in 2001. Miller later sold the brand to Michigan Brewing, which went bankrupt in 2011. A new Celis brewery run by Pierre Celis' daughter Christine reopened in Austin in 2017.

The story of business dealings with large industry "partners" is a sad one for the original modern version of the beer, but it did serve as inspiration for many imitative products. So, the style was reborn and continues to live on, but the history is not exactly contiguous. Modern versions should not be taken to be surviving examples of medieval brews, despite some tenuous linkages. Of note, Pierre Celis did consult with St. Bernardus to create their version of witbier in Watou, Belgium. Van Steenberge also brews Celis White for the Belgian market. Modern Hoegaarden is definitely a big industry product, not a small-town craft beer.

Pierre Rajote wrote in the *Belgian Ales* style book in 1992 that there were only two breweries making the beer in the 1980s, but by 1990 there were more than 20 brands. He described the beer as being traditionally from Leuven, but now produced across Belgium. Consulting different references from various points in time has a way of showing various snapshots in history

WITBIER

(5 gallons/19 L, all-grain)
OG = 1.050 FG = 1.011
IBU = 12 SRM = 3.5
ABV = 5.1%

INGREDIENTS

5.5 lbs. (2.5 kg) German Pilsner malt
5 lbs. (2.3 kg) flaked wheat
8 oz. (227 g) flaked oats
3.1 AAU Sterling hops (60 min.) (0.5 oz./14 g at 6.2% alpha acids)
0.5 oz. (14 g) coriander seed, crushed
0.25 oz. (7 g) Curaçao orange peel
1.8 g chamomile flowers, dried
Wyeast 3944 (Belgian Witbier), White Labs WLP400 (Belgian Wit), or SafAle T-58 yeast
⅞ cup corn sugar (if priming)

STEP BY STEP

This recipe uses reverse osmosis (RO) water. Adjust all brewing water to a pH of 5.5 using phosphoric acid. Add 1 tsp. of calcium chloride ($CaCl_2$) to the mash.

This recipe calls for a step mash process. Start by mashing in the grains at 122 °F (50 °C) using a 1.5 qts./lb. (3.1 L/kg) water-to-grist ratio. Hold at this temperature for 15 minutes. Through either infusion with boiling water or with a recirculating mash system, raise the temperature to 148 °F (64 °C). Rest at that temperature for 45 minutes, or until saccharification is complete.

Sparge slowly and collect 6.5 gallons (24.5 L) of wort. If lautering is difficult, adding a pound (0.45 kg) of rice hulls can help.

Boil the wort for 90 minutes, adding the single hop addition 30 minutes after the start of the boil. Put all three of the spices in a tight mesh bag and add when boil is complete, stirring; remove after five minutes.

Chill the wort down to 64 °F (18 °C), pitch the yeast, and ferment until complete.

After a short conditioning, rack the beer, prime and bottle condition, or keg and force carbonate.

WITBIER

(5 gallons/19 L, extract only)
OG = 1.050 FG = 1.011
IBU = 12 SRM = 3.5
ABV = 5.1%

INGREDIENTS

5.3 lbs. (2.4 kg) Bavarian wheat dried malt extract
3.1 AAU Sterling hops (60 min.) (0.5 oz./14 g at 6.2% alpha acids)
0.5 oz. (14 g) coriander seed, crushed
0.25 oz. (7 g) Curaçao orange peel
1.8 g chamomile flowers, dried
Wyeast 3944 (Belgian Witbier), White Labs WLP400 (Belgian Wit), or SafAle T-58 yeast
⅞ cup corn sugar (if priming)

STEP BY STEP

Start with 6.5 gallons (24.5 L) of water in the brew kettle; heat water 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. Put the spices in a tight mesh bag and add when boil is complete, stirring; remove after 5 minutes.

Chill the wort down to 64 °F (18 °C), pitch the yeast, and ferment until complete.

After a short conditioning, rack the beer, prime and bottle condition, or keg and force carbonate.

TIPS FOR SUCCESS:

This is one of those styles that is hard to duplicate the pillowy mouthfeel that the flaked wheat and oats provide by substituting with extracts. With the advent of the brew-in-a-bag systems, this is the perfect brew to give that type of system a try if you don't currently brew all-grain. Just take it slow and steady through the temperature step and don't worry if the resting temperatures are off some. We're sure you'll still be happy with the results. And be sure to use fresh spices.

that can build a story when pieced together.

Americanized versions exist and remain popular. Coors Brewing developed Blue Moon in the 1990s (which outsold all craft brewing combined at one point), although it uses different types of oranges than the original style. Allagash Brewing Co.'s White was developed around the same time and is well-regarded in the brewing community, but is a bit more bitter than the Belgian versions. I see these versions as inspired by the original, but with American twists.

SENSORY PROFILE

Witbiers are a pale wheat beer with spices accenting the yeast character. Despite some American versions being aggressive with the spicing, the beers should have a restrained, delicate character where the spicing doesn't overpower the other flavors. The suspended proteins and yeast make the beer have a milky white sheen that is characteristic, and the high wheat content gives it a bready flavor.

The classic spice profile is dried Curaçao (bitter) orange peel and coriander seed. Used in liqueurs like Triple Sec and Cointreau (as well as some gins), Curaçao orange is very aromatic. Fresh coriander seeds have a lemony, slightly earthy character. This citrusy complexity adds to the general fruitiness of the yeast fermentation profile. A light spiciness is desirable, but not a heavily clove-y character. Restraint is desirable when using spices. Spices should be fresh; old or oxidized versions can have an unwanted celery, ham, or soapy quality.

Witbier doesn't have a strong hop character. Rajotte writes that "hop aroma has no business in white beer" and many examples seem to have around 12 IBUs, so this is not a bitter beer either. Yet it is also not a sweet beer; the finish should be dry. The impression some have of sweetness comes from the low bitterness and the fruity aromatics.

Because of the unmalted grains, there tends to be some moderate body to the beer. The combination of body and dryness, along with high carbonation, leads to a refreshing character without seeming thin. The high carbonation and protein content of the beer gives a very rocky, creamy head. The color of the beer is very pale, straw to pale yellow, but the cloudiness gives it a whiter appearance.

The wheat and barley give the beer a slightly bready flavor, but often with a lightly honey-sweet quality. As an approximately 5% ABV beer, this is a standard-strength product that doesn't have big bold flavors or noticeable alcohol.

Some mention of a lactic sourness is noted in older versions of the style, although it is not clear that this is intentional. The older methods of production could introduce this, and many note that the beer is best enjoyed fresh. Some sources mentioned the beer being pasteurized to remove this character, so I tend to think it was an unintentional rustic element that just happened sometimes. As a dry, low bitterness, high carbonation beer, sourness is not really needed to make it refreshing. A light tartness is allowable because of the historical nature, but it isn't really a part of the modern style.

BREWING INGREDIENTS AND METHODS

The white beers of Belgium are principally characterized by their use of unmalted (raw) wheat, which causes some issues in brewing that must be addressed. Wheat is frequently 30–60% of the grist. Other unmalted grains such as oats or spelt may be used as part of the grist, but are typically only a small percentage (typically 10% or less), if used at all. In his book *A Textbook of Brewing*, Jean De Clerck mentions 5% oats, for instance. Pale barley malt is the remainder of the grist, not necessarily Pilsner-type malt but it should be low color. Some sources say that the wheat doesn't have to be raw, but most examples do use unmalted wheat.

"The coriander and orange peel are highly aromatic, so use them late in the boiling process or at the end of the boil."

Since the style began hundreds of years ago before brewing processes and science was well-understood, many of the processes for dealing with the wheat were long and complex. Modern methods can certainly reduce these times, but many traditional methods were based on trial-and-error rather than solving particular problems. De Clerck described cereal mashes and mixed mashing methods with wheat boiled separately and multiple mash rests. Much of these processes seem to be dealing with making sure the wheat is properly gelatinized before it is converted, and then to avoid scorching of the viscous mash.

Modern approaches can use pre-gelatinized flaked wheat (and oats) to avoid the laborious mashing processes. Some flavor could be compromised by using these ingredients; in his book, *Radical Brewing,* Randy Mosher recommends performing a cereal mash to better preserve that character. It's definitely a trade-off, but I consider it to be a very advanced method. I wouldn't use it on my first attempt at the style; better to understand the fermentation and spicing first. Most commercial breweries today seem to be using a step mash process. Homebrewers can use rice hulls if working with the huskless wheat makes lautering difficult.

The coriander and orange peel are highly aromatic, so use them late in the boiling process or at the end of the boil. Avoid excessive contact times to keep from extracting too much astringent qualities from the spices, since those are not desirable in the finished profile. Some experiment with different types of citrus or orange varieties, and also with coriander of different origin (Moroccan versus Indian). These experiments are interesting, but remember the classic profile as a reference. Curaçao orange peel is always dried, never fresh. If using fresh citrus peel, take care to avoid any white pith.

There are several Belgian witbier yeast strains available. Wyeast 3944 (Belgian Witbier), Wyeast 3942 (Belgian Wheat), Wyeast 3463 (Forbidden Fruit), White Labs WLP400 (Belgian Wit), and White Labs WLP410 (Belgian Wit II) among liquid strains while SafAle T-58 and Mangrove Jack's M21 (Belgian Wit) can be used for dried strains. The water of the Hoegaarden region is described as being hard and calcium-rich; I don't find the beer to have a minerally profile, so I think you have some latitude here.

HOMEBREW EXAMPLE

I'm not a fan of cereal mashes at the homebrew scale, so I'm going to use flaked wheat and oats rather than the raw grains. Pilsner malt is the rest of the grist, because the flavor is less grainy and the color is less dark than many other pale malts. While I call for German Pilsner malt, if you have Belgian malt (like Dingemans) use that instead. I want the final beer to be as pale as possible. A step mash helps break down the starches in the flaked grains, using a short protein rest and then a conversion temperature on the low side to encourage attenuation. I skip a higher temperature rest I normally use to build body since I know I have some oats in the grist, and they will provide mouthfeel.

Hops are minimal in this recipe. I keep the bitterness at the bare threshold level and omit any finishing hops since I don't want them to clash with the spices and yeast. Noble-type hops are mellow in the flavor, so I use what is freshest for me (Sterling, in this case). Feel free to substitute another smooth hop to get the same IBUs.

A classic yeast strain with a cool fermentation temperature builds some yeast flavor without getting too extreme. Higher fermentation temperatures can make the beer seem less clean, in my opinion. The spices are traditional with the optional chamomile that some speculate is the secret ingredient in Hoegaarden. A short steep period post-boil extracts the flavor and aroma without too many tannins and unwanted characteristics.

The beer should ferment dry but not seem bitter because of the low IBUs. This should increase drinkability, as long as it is carbonated well. The spices shouldn't be heavy, but if you find yourself wanting more, you can always make a quick "tea" of the parts you want to increase and blend it in post-fermentation. That is how I always fine-tune my spiced beers for competition since the freshness and intensity of spices can vary greatly.

Like a German hefeweizen, this beer can be fairly delicate and not hold up well over time. So enjoy it fresh and young, and make it again if you run out; this isn't really a vintage style. If you make it right, it can be a very enjoyable summer beer. BYO

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WEDNESDAY, NOVEMBER 3, 2021

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, NOVEMBER 4, 2021 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.

SIMPLIFY YOUR BREWING – ***with Drew Beechum and Denny Conn*** – As a homebrewer progresses through the hobby there comes a temptation to feel you need to keep adding more equipment, more techniques, more ingredients, and more of everything. At a certain point you can find yourself wondering how it all got so complicated and even less fun than it was at the beginning. BYO Techniques Columnists, book authors, and podcasters Drew Beechum and Denny Conn will spend the day making sure you still produce great beer, but with less headaches, worries, and time. From streamlining your brewing process to simplifying your recipes without sacrificing beer quality, Denny and Drew will free up your time to brew more often and have more fun and success as they remind you why you fell in love with homebrewing in the first place.

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, NOVEMBER 5, 2021
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 2021, 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, NOVEMBER 6, 2021 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.

HOMEBREW EXPERIMENTS – ***with Drew Beechum and Denny Conn*** – Developing your own recipes, refining your own brewing techniques, and tweaking your equipment set-up all require the know-how to conduct your own homebrew experiments. Without reliable results you rely on guesswork instead of facts to improve your brewing. Join two of the true leaders in experimenting with homebrews – podcasters and book authors Drew Beechum and Denny Conn from Experimental Brewing as they first walk you through how to properly conduct your own experiments at home including structured blind evaluation techniques, and then walk you through some real life homebrew case studies to show how these experiments can play out. Get ready to roll up your sleeves and get your science on!

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, NOVEMBER 7, 2021

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

Photo by Shutterstock.com

Brewing Priorities *for* Beginners

Focus on the Fundamentals

by Stephen Stanley

Beer is easy to make. People brewed beer for thousands of years without the benefit of computers, digital wireless hydrometers, or PID controllers — or, for that matter, even basic thermometers and hydrometers. Because we do not have direct control over the biological processes that make beer, we rely on production procedures to make wort for yeast to ferment to produce the results we desire. All brewers follow the same process for converting grain to beer. A recipe is simply a list of inputs to the process. Yet when I read forum comments from beginning homebrewers, most of the questions revolve around recipes (it is a very close race between "will this recipe make beer x?" and "what went wrong?").

After more than 9,000 comments on Brewer's Friend, my first piece of advice to beginning brewers is to brew a simple beer with a grain bill of 90% pale ale malt, 10% medium crystal such as C60, a single clean bittering hop such as Magnum, and a single flavor hop — brewer's choice but I'd go with something unobtrusive like Crystal or Willamette. For extract beer, light dried malt extract (DME) or liquid malt extract (LME) and C60 for steeping. Keep it reasonable, an original gravity (OG) of 1.050–1.055, around 30 IBUs and keep the yeast neutral, one of the Chico strains, SafAle US-05 for example, is a good choice. This formula makes a respectable pale ale recipe, by the way. Then brew that one recipe until it tastes the same every time. If you can't wait that long to try your own version of the imperial kveik-fermented Belgian dark IPA, at least brew the pale ale a few times. Here's why:

While there is creativity involved in combining flavors and predicting outcomes, to brew consistently requires rigorous procedures and process controls. Attention to detail makes the difference between drinkable beer and great beer. It's very tempting to try to make that New England IPA you had at a local brewpub but that's a very difficult beer to make well. Beginners, start with something simpler and more forgiving. Full disclosure, I'm still trying to perfect the first beer I was challenged to brew, a German schwarzbier. It, too, is a very demanding style.

GETTING YOUR PRIORITIES STRAIGHT

I seldom respond to beginning brewers' requests for feedback on their recipes. The reason is simple: The recipe is a low priority when it comes to brewing good beer as long as the proportions of ingredients are reasonable. I've provided a pale ale recipe on page 35 designed to be a good introductory beer; a quick Google search will turn up thousands more of them. I will almost always respond to questions about how to make the beer (or the inevitable, "Did I do this wrong?" question). Great beer is made through using solid procedures, the recipe simply describes the inputs to the process.

To brew well, here are the priorities that I have come up with after nine years of homebrewing:

1. ***Sanitation:*** As a brewer, in everything you do, cleanliness and sanitation should be your number one priority, especially once the wort is chilled. Sanitation errors ruin your beer. All you can do with an infected beer is keep it cold and drink it quickly before it becomes too unpalatable. A beginner working with new equipment can often get away with sanitation errors for a few brews because new equipment is relatively clean and wort-loving microbes have not yet multiplied in your brewery. But make no mistake, they are already there. Beginner's luck never lasts. If your sanitation regime is not solid, infected beers are inevitable and rarely come out tasting pleasant.
2. ***Fermentation temperature control:*** Yeast ferments wort across a wide range of temperatures but will generally not produce desirable results at the extremes (kveik yeasts are an exception as they do produce good results at extreme temperatures). Being able to keep your yeast operating within a couple of degrees of its optimum temperature, particularly during the first half of fermentation, will increase the quality of the beer immensely.
3. ***Proper yeast management:*** This refers to pitching enough healthy yeast cells into a wort rich in nutrients, including oxygen. Liquid yeast manufacturers claim their yeast packages have enough healthy cells to ferment 5 gallons (19 L) of a medium-gravity (1.050) wort. If your original gravity or volume is much above that, you'll need more cells, meaning propagating the yeast, commonly called making a yeast starter. Likewise, shaking your fermenter vigorously before adding yeast will dissolve some air into the wort, enough for most beers I'd recommend for beginners. You can eliminate two process steps by using dry yeast — a single sachet is sufficient to ferment a 5-gallon (19-L) batch of medium gravity wort without aeration, two sachets normally cost about the same as a single package of liquid yeast and will ferment a higher-gravity beer. (Thank you to Denny Conn and Ashton Lewis for finally convincing me I do not have to rehydrate dried yeast, nor do I have to add oxygen for moderate-gravity worts when using dried yeast.)
4. ***Removal of chlorine/chloramine:*** Chlorine or chloramine in your tap water can lead to harsh medicinal or plastic-like flavors due to formation of compounds called chlorophenols. If you are using municipal water, it usually has chlorine or chloramine added as a disinfectant. Chlorine can be removed easily by letting the water stand or by boiling it; however, chloramine is far more persistent. Refer to your water report or call your water office to find out what disinfectant is being used. The easiest way to remove chlorine and chloramine is to crush a Campden tablet (metabisulfite, either of sodium or potassium) and add it to the brewing water, assuming 5-gallon (19-L) brews using 10 gallons (38 L) total water used. One tablet is enough to dechlorinate 20 gallons (76 L) of water. Once in your beer, chlorophenolic flavors won't come out. If you're on well water or other non-municipal sources, your water likely does not contain chlorine or chloramine.
5. ***Process considerations:*** This refers to how you move wort around when

Expert Tip:

MIX STAR SAN WITH DISTILLED WATER

If you mix your Star San or similar sanitizing products with distilled water, they will last practically forever. I mix mine four gallons (15 L) at a time using distilled or reverse osmosis water in a cheap plastic bucket and leave it covered. Once in a while I'll measure pH to ensure it is still good – look for a pH of 3.5 or lower.

Expert Tip:

SIMPLE TEMPERATURE CONTROL

Here are some things you can try, short of tricking out a refrigerator, to keep your fermentation temperature within a few degrees of the yeast's optimum temperature:

- If you have a place in your basement or house that stays at or below your fermentation temperature, ferment your beer there.
- If you don't, you can always drape your fermenter in moist towels. Extra points for directing a box fan at the towels or for putting the fermenter and towels in a water bath so it will wick upward and keep the towel moist.
- Place the fermenter in a container of cool water and add ice or ice packs to keep the water at the proper temperature.

it's hot and cold, stirring, control of splashing, measurement, and other procedures used to make your wort. I'll specifically mention oxygen, measurements, and record keeping: Oxidized beer is seldom pleasant. There are two ways it can go, one way tastes like wet cardboard and the other, cooking Sherry. Oxygen also dulls malt flavors and contributes to haze. At the beginner level, simply avoiding splashing wort will help prevent oxidized flavors in your beer. Measurement is also a process consideration: You should be able to measure weight, temperature, volume, and specific gravity fairly accurately. Finally, keep good notes. If you brew a great beer you will want to be able to brew it again and you will forget what you did by your next brew day.

6. ***Ingredient freshness:*** Old hops can smell of Parmesan cheese or smelly feet. Old malt can taste dull and lifeless and yield less extract (gravity) than expected. When sourcing ingredients, try to taste malt or buy from vendors that keep fresh stock. Smell hops — they should smell bright and fresh and not like a

BEGINNER'S LUCK PALE ALE

(5 gallons/19 L, all-grain)
OG = 1.054 FG = 1.012
IBU = 32 SRM = 10 ABV = 5.5%

INGREDIENTS

10 lbs. (4.5 kg) pale 2-row malt
1 lb. (0.45 kg) crystal malt (60 °L)
6 oz. (170 g) acidulated malt (optional)
7.5 AAU Magnum hops (60 min.) (0.5 oz./14 g at 15% alpha acids)
7.5 AAU Centennial hops (10 min.) (0.75 oz./21 g at 10% alpha acids)
1 oz. (28 g) Amarillo® hops (0 min.)
1 Whirlfloc tablet (10 min.)
LalBrew BRY-97 (West Coast Ale), SafAle US-05, or Mangrove Jack's M44 (US West Coast) yeast
4.7 oz. table sugar (if priming)

STEP BY STEP

Mash in with 4 gallons (15 L) of water at 163 °F (73 °C). Rest one hour at 152 °F (67 °C). For simplicity, this recipe uses a batch sparge: Start by running off all the wort into your kettle. Then add 4.5 gallons (17 L) of water at 170 °F (77 °C) to the mash tun, stir, rest 10 minutes, drain the wort. Bring to boil and add hops per schedule while doing a 60-minute boil. After the boil is complete, add the Amarillo® hops and give the wort a long stir to create a whirlpool. Let stand for 10 minutes.

Chill to 68 °F (20 °C), run off to a sanitized fermenter, add yeast (aeration or rehydration not required). Ferment at or near 68 °F (20 °C) for two weeks. At bottling, make a syrup of two cups of water and table sugar, boil, stir gently into wort in bottling bucket to prime. Keep bottles in a warm-ish (room temperature) but dark place for at least 10 days to carbonate. Alternately, if you use 16-oz. (470-mL) PET bottles, you may prime the beer with one standard (3 g) sugar cube per bottle.

BEGINNER'S LUCK PALE ALE

(5 gallons/19 L, extract with grains)
OG = 1.054 FG = 1.014
IBU = 32 SRM = 13 ABV = 5.3%

INGREDIENTS

6 lbs. (2.7 kg) light dried malt extract
1.5 lbs. (0.68 kg) crystal malt (60 °L)
6.5 gallons (24.5 L) reverse osmosis or distilled water
7.5 AAU Magnum hops (60 min.) (0.5 oz./14 g at 15% alpha acids)
7.5 AAU Centennial hops (10 min.) (0.75 oz./21 g at 10% alpha acids)
1 oz. (28 g) Amarillo® hops (whirlpool)
1 Whirlfloc tablet (10 min.)
LalBrew BRY-97 (West Coast Ale), SafAle US-05, or Mangrove Jack's M44 (US West Coast) yeast
4.7 oz. table sugar (if priming)

STEP BY STEP

This recipe uses the extract and steep method to produce a concentrated wort. Rehydrate malt extract in 3.5 gallons (13.2 L) of reverse osmosis (RO) or distilled water, bring to a boil, and add Magnum hops at the beginning of the boil. While the reconstituted extract is heating, place the crushed crystal malt in a grain bag and separately steep in 2 quarts (2 L) cool RO or distilled water, which you want to heat to 170 °F (77 °C) and hold for 30 minutes. At 15 minutes remaining in the main boil, remove the grain bag from the steep and drain the liquid from the bag. At 10 minutes remaining, pour the liquid from the steep into the main boil, return to a boil, add the Whirlfloc and Centennial hops, and boil for 10 more minutes. Follow the remainder of the all-grain recipe instructions, being sure to top up the fermenter to 5.5 gallons (21 L) with RO or distilled water prior to pitching yeast.


Photo by Charles A. Parker/Images Plus

Great beer starts with fresh ingredients. Malt should be fresh tasting, crisp, and crunchy.

cheese monger's shop. Malt should be fresh tasting, crisp, and crunchy. Yeast should be used before its sell-by date and should not be dark brown or smell like soy sauce or bouillon when opened. Stale, old ingredients do not make good beer.

7. ***The boil:*** How and when you add hops and other ingredients can make a large difference in the beer's outcome. Hop oils are volatile, hop compounds react with other compounds in the boil, so when you add hops can make a huge difference in the flavor of your beer. Another important instruction: Don't cover the boiling wort. One reason beer is boiled 60 minutes or longer with the lid off is to drive off bad-tasting volatile compounds that can leave your beer tasting of cooked cabbage.
8. ***And finally, the recipe:*** Recipes are everywhere. Google any style or even many commercial beers and you can find hundreds of variations of recipes that will supposedly make that beer. There are many ways to make a given beer style and with experience, you'll learn to judge recipes by the ingredients listed. Recipes simply tell you the inputs to the brewing process, not how to make the beer. Your procedures are far more important.

I'll mention one more process factor only because it comes up so often in forum discussions: Water. Yes, despite how much you may have read or heard about water in brewing, unless your water is very bad it really is one of the lower brewing priorities. Water is a low order contributor to beer quality if it is clear, not excessively hard, and tastes good. Brewing salts have an impact on beer flavor and mouthfeel but you can't fix a poorly made beer with them. Get a water report or test your water, make sure you're in the 50–100 ppm range for calcium and your beer should be fine. Extract should be rehydrated with soft or pure (distilled or reverse osmosis) water — the minerals needed for flavor and yeast health are already in the extract. You can buy reverse osmosis (RO) water in many grocery stores, there are dispensers or pre-filled jugs, or you can buy jugs of distilled water. But until you nail the basics, water can be put on a backburner.

Brewing can be as simple or complex as you want to make it. Knowing what is important to making beer helps you decide where to spend your time and money to improve your brewing. Would you benefit more from a larger brew pot or an RO filtration system (generally decided by cleaning up a boilover or two)? Should you ask the forum about your recipe or suggestions on ways to control your fermentation temperature? Armed with knowledge of the priorities in brewing, a beginning brewer can pinpoint where to improve, what to ask, and what to buy.

If I could tell my beginning brewing self one thing it would be to know the priorities in brewing, to concentrate on one recipe until I knew what my system was doing and why, and then branch out to more complex styles and equipment. BYO

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From Juicy to Crazy Hazy

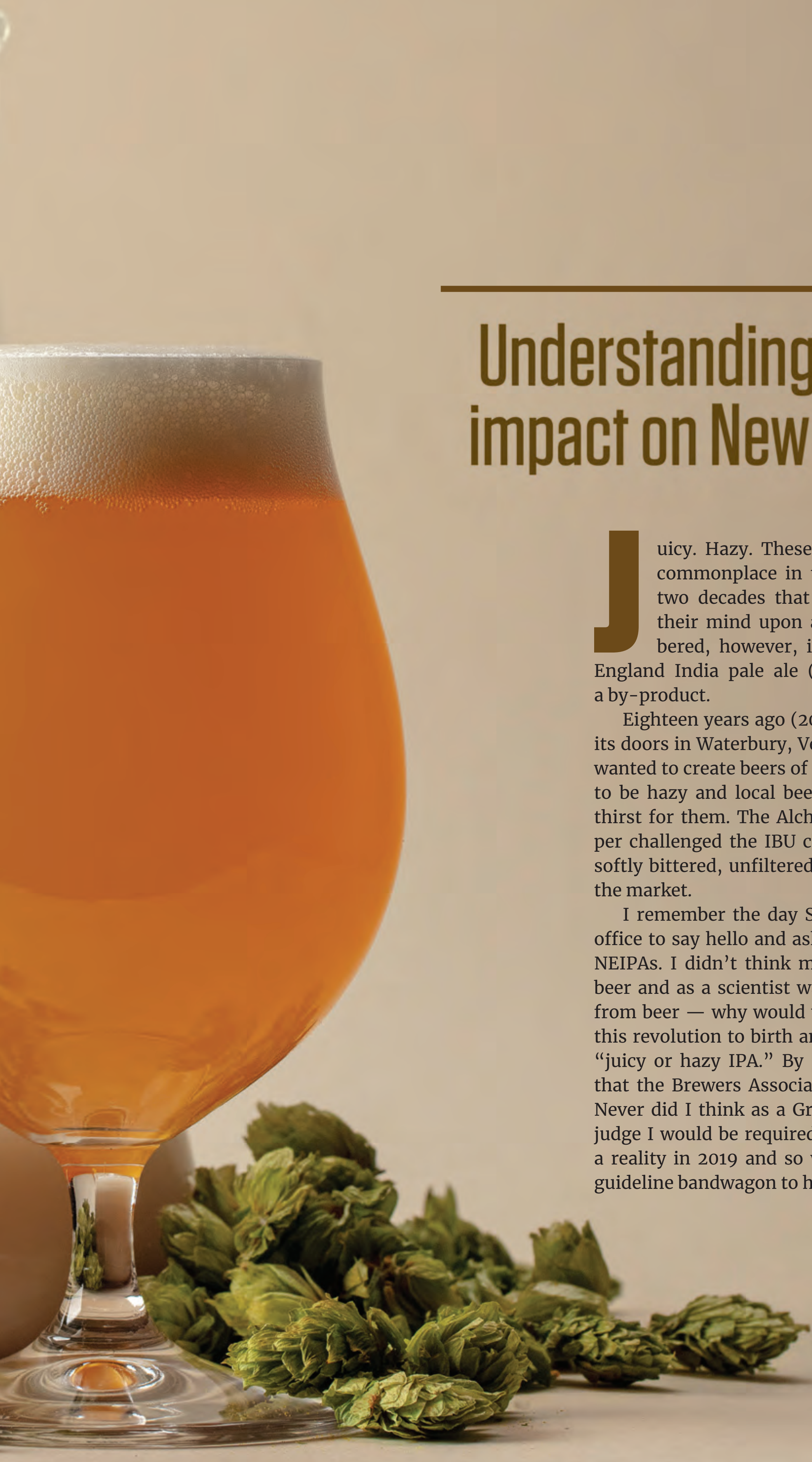


Photo by Charles A. Parker/Images Plus

Understanding raw material impact on New England IPAs

by Dr. Pattie Aron

Juicy. Hazy. These style descriptors have become so commonplace in the craft beer world over the past two decades that everyone can picture the beer in their mind upon a single word. It must be remembered, however, it was flavor that started the New England India pale ale (NEIPA) revolution, and haze was a by-product.

Eighteen years ago (2003) the Alchemist Brewery opened its doors in Waterbury, Vermont. Co-Founder John Kimmich wanted to create beers of intense flavor.[1] The beers happened to be hazy and local beer drinkers developed an insatiable thirst for them. The Alchemist's haze-forward Heady Topper challenged the IBU craze of the mid-2000s, bringing a softly bittered, unfiltered, fruity, and juicy aromatic beer to the market.

I remember the day Stan Hieronymus stood outside my office to say hello and asked me what I thought about these NEIPAs. I didn't think much of it. My entire experience in beer and as a scientist was focused on how to remove haze from beer — why would we want it? Wow. We didn't expect this revolution to birth an entirely new beer category — the "juicy or hazy IPA." By 2018, the style became so popular that the Brewers Association developed a style description. Never did I think as a Great American Beer Festival (GABF) judge I would be required to judge hazy IPAs, but it became a reality in 2019 and so we all literally *hopped* on the style guideline bandwagon to honor our industry.

JUICY

While the original intent for these beers was to create a flavorful and harmonious hop-forward beer, the haze aspect is what caught the attention (both positive and negative) of the industry. My inner hop queen must address the hop flavor aspect first, because despite the present day industry obsession with creating a "colloidally stable, er, persistent" haze, the flavor is really what birthed and thus brought this style to fame.

While hops get the attention, yeast is as important in these styles and here's where I must reference the article "Biotransformation" that I wrote for the May-June 2020 issue of *BYO*. You see it's not just the hops, it's the interaction of hops and yeast that lead to a fruit-forward, juicy beer. Today's hazy-juicy beers tend to include varieties such as Citra® and Mosaic®. However, Citra® wasn't released until 2007 and Mosaic® wasn't released until 2012 (both are proprietary varieties of the Hop Breeding Company). So what was going on in these beers at the start?

The brewers at Alchemist Brewery and subsequently Hill Farmstead Brewery use a yeast strain named "Conan" (VPB1188). This strain is a medium- to low-flocculating yeast that leaves a slight to persistent haze and provides a lush mouthfeel. Conan is known for a clean fermentation at temperatures of 65 to the low 70s °F (18–22 °C) to produce an estery stone fruit profile (cherry, apricot, plum), as well as apple, pineapple, floral, and sub-tropical notes. Legend has it that it came from the United Kingdom and is likely a descendant of the Whitbread B strain — known as Wyeast 1098, White Labs WLP007, and SafAle S-04.[2] For a longer list of commercially-available yeast strains that are appropriate and popular to brew NEIPA, see Table 1.

When a yeast strain such as Conan comes into contact with hops that are high in geraniol (such as Cascade, Centennial, and Bravo™) the majestic biotransformative yeast produce fruity, floral, and "juicy" flavors.[3,4] Yeast can transform terpenes such as geraniol into linalool and they can also aid in the release of terpenes that were once bound to a glucose molecule (glycosidically bound). Yeast can also release glycosidically bound thiols, highly potent sulfur-containing compounds found in both hops and malt.[5] Thiols can exist as free molecules as well, variety dependent, so depending on hop addition timing, form, and amount, thiol character can be manipulated. Thiol aromas such as grapefruit, catty, orange rind, tangerine, and so on released during fermentation or during dry hopping on active yeast can augment a beer's juicy character. Combine Conan's fruity and haze-forward yeast with citrusy (thiol-forward) hops like Citra® and Mosaic®, now that's wicked juicy potential.

This sought-after flavor is typically derived from shifting the hop additions of a West Coast IPA in the front side of the kettle toward the end of boil or whirlpool hopping. Additions are targeted to reduce iso-alpha acid formation and maintain fresh hop oil character (less woody, earthy, oxygenated sesquiterpenes). Dry hopping tends to be targeted toward active fermentation, 24 to 48 hours after yeast pitch. This allows the magic of biotransformation to augment fruity and floral character through transformation as well as terpene and thiol release from glycosides.

So this highlights the basic origins of juicy. But how about the hazy part?

Table 1: Yeast strains recommended for NEIPAs

East Coast Yeast **(ECY29)**
Escarpment Labs Vermont Ale
GigaYeast Vermont IPA **(GY054)**
Imperial Barbarian **(A04)**
Lallemand LalBrew New England
Omega DIPA **(OYL-052)**
RVA Yeast Labs Hoptopper Ale **(RVA-104)**
SafAle English Ale **(S-04)**
SafAle German Ale **(K-97)**
White Labs Dry English Ale **(WLP007)**
White Labs London Fog **(WLP066)**
White Labs Burlington Ale **(WLP095)**
Wyeast London Ale III **(1318)**
Wyeast British Ale **(1098)**
The Yeast Bay Vermont Ale **(WLP4000)**

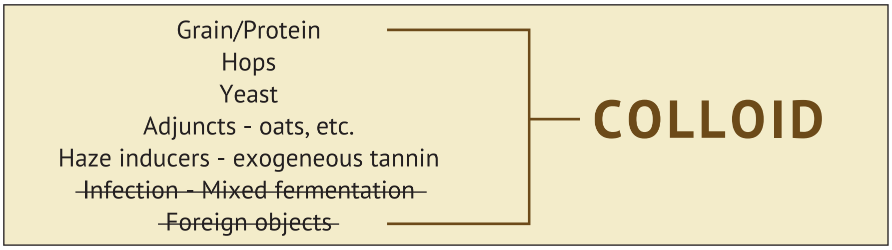
HAZY

What was originally just a cloudy side effect turned into a really big craze. Not only is there now a hazy-juicy style, there are also sub styles: From lush balanced juicy IPAs to milkshake IPAs (lactose inclusion), to muddy, chalky, chunky thick IPAs. In the 2000s we experienced near-death-by-bitterness, why not near-crazy-by-hazy? For the sake of science and for the sake of my own sanity this article focuses on how to best achieve a colloidally stable and persistent haze that doesn't settle or form pasty chunks within a reasonable time period. The term *best* applies because we are still attempting to understand what makes a haze persist.

In chemistry, a **colloid** is a mixture in which one substance of microscopically dispersed insoluble or soluble particles is suspended throughout another substance. To qualify as a colloid, the mixture must be one that does not settle/precipitate or would take a very long time to settle appreciably. So this is the goal for hazy beers: Disperse particles in beer so that they remain suspended for an appreciably long time.

The old-school (targeted haze removal) model of beer haze has a few pathways toward haze production, thus several targets for haze removal. Raw materials combined with brewing process, or perhaps an infection or a foreign object like glass or partially removed fining agents, can all lead to haze formation. While we still apply the old-school model for identification of problematic hazes, it doesn't necessarily help us with targeted development of stable hazes. For this we need a new-school model that takes into account raw materials and process as targets to form the best possible colloid (Figure 1).

Figure 1: New haze model



Some pathways to (unwanted) haze in beers from years ago such as infections and foreign objects do not play a part in the haze of NEIPAs. Instead, we look to things like raw materials and process.

The new-school model of haze takes into account raw material input such as starch and protein source (grain), hop variety and hopping technology and technique, yeast strain, use of adjuncts, and use of exogenous haze inducers such as tannins and pectin.

To understand haze and haze potential let's start at the fundamentals. Classically we categorize haze into two types: Chill (temporary) haze and permanent haze. Beer is considered bright if no haze forms when chilled to 40 °F (4 °C) or below. Chill haze appears when the beer is chilled and re-dissolves upon re-warming. Chilled beer forms a haze at 32–40 °F (0–4 °C) and is largely attributed to protein and polyphenol interactions. This cyclic warming and cooling leads to permanent haze that does not re-disperse upon warming. Removal of chill haze via prolonged cold storage at 28–30 °F (-1 to -2 °C) can be effective as long as chilling occurs at low temperature over duration. Haze-forming complexes that form can then be removed by filtration or with chill proofing treatments while the beer is still cold. Permanent haze can also form during packaging as covalent bonds begin to form between proteins and polyphenols to form insoluble complexes that do not re-disperse. Insoluble complexes can thus form that sediment, flake, or even chunk out in packaged product.

Somewhere between chill haze and permanent haze there is a middle. How do we create a "stable haze?" What we know right now is that it's a story of solubility, hydrophobicity (water fearing tendencies), and particle size. If we solubilize the right raw material particles through intentional process and create a harmony of hydrophobic molecules, a colloid can form. Although we know that the inclusion (or non-exclusion) of yeast can make for hazy beer, surprisingly in New England IPAs, residual yeast are not necessarily the key players. Recent research by Maye and Smith evaluated commercial hazy IPAs and determined that most of the beers tested contained less than 1 million yeast cells/mL. The authors contest that yeast was "not even a minor contributor to haze" and confirmed that protein and polyphenol interactions are likely the major contributors.[6]

NATIVE GRAIN PLAYERS

The native players in haze formation are well known: Proteins, polyphenols, carbohydrates, oxygen, hop resins, melanoidins, and metal ions.[7] The majority of protein comes from the grain bill and can account for 40–70% of haze. Carbohydrates (starch, beta-glucans, and arabinoxylans) also derive largely from the grain bill and can make up 2–15% of haze particles. According to Karl Siebert, carbohydrate's role in haze formation often goes underestimated.[8] Polyphenols derive both from malt and hops with longer chains playing a role in both chill and permanent haze formation. Oxygen drives these haze interactions and can also induce polymerization in polyphenols to form more insoluble complexes over time. Metal ions play a role as well. Ions such as iron, copper, zinc, calcium, and potassium have an affinity for haze constituents.[9] They also increase oxidative reactions that lead to permanent haze. Hop acids are hydrophobic molecules that create a push and pull between other beer constituents. Thus, they can create colloidal systems in foam and in haze that can lead to greater stability.

Haze-forming proteins survive the kettle boil due to their size and structure that allows them to participate in both hydrophobic as well as ionic and H- bonding. Polypeptides and amino acids originate from barley/grain and undergo proteolytic and chemical modification during mashing and kettle boil. While up to 20% of total grain proteins are thought to be water soluble, some barley water-soluble proteins are believed to

Photo by Shutterstock.com

The key contributors to achieving a balanced, persistent haze are protein, polyphenols, carbohydrates, hop acids, and a supportive yeast strain.

be resistant to proteolysis and heat coagulation. A finished beer may contain about 500 mg/L proteinaceous material with polypeptides having molecular weights ranging from <5 to >100 kDa. Only 2 mg/L of protein is needed for haze formation. These 2 ppm of protein are haze active (HA). Barley hordein is HA because of its high order of proline (ranging from 7–30%), an amino acid with a high affinity for polyphenols. Asano et al. proposed mechanisms of protein and polyphenol interaction via hydrogen, hydrophobic and ionic bonding and identified the haze-forming capacity of different fractions of beer. What they discovered is that size matters: Mid molecular weight proteins (15–40 kDa) have higher haze-forming potential.[10]

Researchers Ye et al.[11] investigated 23 genotypes of barley to identify the chemical components in malt associated with haze formation. Their work revealed that besides total protein, albumin, globulin, hordein, glutamic acid, proline, and phenylalanine content all positively correlate to increased haze potential. Hydrophobic amino acids such as tryptophan, phenylalanine, tyrosine, leucine, isoleucine, and valine are also haze active.

NEIPA grain bills can range from 50–90% barley malt with the remainder substituted with high-protein adjuncts such as oat or wheat. Wheat is high in protein with a high HA protein content (16% total protein, up to 80% HA),[12] while oats typically have less total protein (~13% and only 10% HA). A comparison of oat and barley in various forms reveals that barley typically has twice the proline content of oats, while levels of other amino acids that are known to cause haze are quite consistent.[13] Despite the difference in HA proteins, oats tend to lend a hazier impact to beer. The reason for this is thought to be due to dextrins.

Dextrins are carbohydrates; polysaccharides with glucose as the structural component. Within the dextrin family are alpha-glucans (amylose and amylopectin) as well as beta-glucans (D-glucose monomers linked by beta-glycosidic bonds). When starch in barley or other grains such as oats are not fully degraded the residual dextrins contribute to haze. Often we associate problems with alpha-glucans to brewhouse optimization. While beta-glucans are typically the result of poor or low malt modification.[14]

Another form of dextrin, glycogen, can also cause haze issues. Glycogen is released from stressed yeast or poorly managed yeast. Haze from these large molecules is permanent, and instable because of relatively larger molecular weight (>40 kDa).

Dextrin hazes can result from the presence of glassy kernels (>3% inclusion), non-optimal milling that leads to lower enzyme activity, short mash temperature rests that lead to poor starch conversion, high lauter temperatures that result in late saccharification, agglutination in the kettle, and stressed yeast. Beta-glucans that survive the brewing process can be as large as 300 kDa and thus lead to post-filtration turbidity, permanent haze, and sedimentation. However, beta-glucans of a smaller size are more soluble in nature and can lead to more persistent and stable hazes. Lee et al.[15] compared the beta-glucan content of barley and oats to reveal that averaged across genotypes, total beta-glucan content of barley and oat groats is similar. However, soluble beta-glucan content of oat groats is greater than that of barley. Oat groats have a higher ratio of soluble-to-total beta-glucan content than most barley genotypes. This explains why oats — although lower in HA proteins — can lead to such lusciously abundant and persistent haze.

While higher molecular weight glucans can lead to flakes and chunks, something for brewers to beware of is pectin. In our lab at the Rahr Technical Center, we've been asked, "Can you look at this beer? We want it to be really hazy but not chunky," in reference to a snow globe type effect. While

Photo by Shutterstock.com

While yeast and hops get much of the attention, the biggest contributor to the haze in NEIPAs is the grain bill. The inclusion of undermodified malt contributes higher protein and higher glucan content, while the addition of oats favors haze formation due to relatively higher soluble beta-glucan content.

sometimes this issue can occur due to brewhouse issues or undermodified malt, another suspect that comes up time and again is pectin. Brewers beware if adding fruit or even exogenous pectin in an effort to increase haze. Pectin is an acidic polysaccharide present in fruits and is useful for setting jams and jellies. Isolated pectin has a molecular weight of 60 to 130 kDa, which is ideal for permanent haze formation. Pectin can be used in the food industry as a stabilizer, but it must exist in the right conditions — generally it requires heat in the presence of sugar at low pH (acidic conditions pH 2.8–3.6) during which the pectin network opens up and forms hydrogen bonds and hydrophobic interactions binding carbohydrate chains together into a gel-type network. Some pectins require a divalent cation such as calcium for binding at higher pH but this also occurs under high solids content. Therefore, in most beer applications pectin would not behave as a 'stabilizer' and is not going to be your stable haze friend. It will make wonderful flakes and chunks that float and fleck about.

Photo courtesy of Dr. Pattie Aron

Excessive pectin results in flakes and chunks in suspension — generally not the look brewers are going for with hazy IPAs.

HOP ACTORS

So far we've discussed grain's hazy potential but what about hops? Hops offer polyphenols as well as hop acids. While the majority of polyphenols in beer actually derive from malt, a significant portion of polyphenols do originate from hops. They have been the target of haze removal products such as polyvinylpolypyrrolidone (PVPP), because PVPP has a similar chemical structure to HA proline-rich proteins. The hop- and malt-derived phenolic compounds that survive the brewing process tend to be smaller in nature, either monomeric, dimeric, or polymeric of low molecular weight. When proteins and polyphenols complex they form a large network when the number of haze-active protein binding sites is equivalent to the number of polyphenol binding sites. This type of haze formation can occur rapidly in the kettle or slowly during fermentation and aging. The ingress of oxygen to the package as well as mineral content can affect the rate, but in general the hazes formed can be quite persistent and increase over time.

Hop acids behave similarly to phenolic monomers due to their carbon ring structure and alcohol groups — the "ols." Hop acids such as alpha and beta acids are also hydrophobic in nature. They are key players in foam formation as well as foam stabilization due to their push and pull with foam active proteins. During the boil alpha acids isomerize into iso-alpha acids, which are more water soluble, very bitter, and still hydrophobic in nature. Beta acids are generally less soluble and tend to oxidize during the brewing process.

The late- and dry-hopped nature of NEIPAs leads them to have higher alpha as well as beta acid content than their West Coast counterparts. Maye and Smith investigated the effects of hop compounds on beer turbidity to find that hop constituents can account for as much as 12% of analyzed haze in NEIPAs. The authors were surprised to find up to 14 ppm beta acids (average 5 ppm) in NEIPAs whereas West Coast IPAs and other bright beers typically have none. Alpha acids were also higher in NEIPAs, but these are relatively common in dry-hopped beers. The prevalence of these non-polar hop acids in NEIPAs vs. West Coast IPAs is thought to be due to the amount of haze present that derives from protein-polyphenol complexation. Increased alpha and beta acid content is also found in yeast-forward beers like hefeweizens. The shape of beta acids reminds me of a pregnant spider. They have a central ring with long hydrophobic legs (prenyl groups) sticking out. The shape and the stereochemistry of the molecule makes them rather "large" for their size, however the six membered ring and enolization potential (electrons can flow around the molecule) make them very effective emulsifying agents in foam and in hop extracts. Imagine a flat, long-legged molecule doing very slow cartwheels through haze-active proteins and acidic carbohydrates, maybe yeast, and you've got yourself a haze for days scenario.

Work by Huismann and coworkers corroborates this effect of hop bittering products on haze potential.[16] The authors added beta acids into beer and evaluated their haze potential over the duration of 60 days. What they found indicated that when beta acids are included as part of a hop bittering product at optimized dosing haze potential and haze stability can be maximized.

This brings up the question — can haze modifiers be dosed into beer to improve haze potential and stability. Although we don't have a lot of published data and trade secrets are rather protected at this point in time, we do know that there is a potential. If you take a rather clear beer and dose in exogenous tannins or a mixture of beta acids and hop products you can achieve a somewhat persistent haze. However we don't have enough data to say how much or to what beer matrix, these are still lessons we are learning in our race for haze for days.

SYNOPSIS

While the old-school model of haze formation and haze mitigation gives a great starting point for identifying opportunities for stable haze produc-

STAR GAZER HAZY DOUBLE IPA

(5 gallons/19 L, all-grain)
OG = 1.064 FG = 1.012
IBU = 35 SRM = 4 ABV = 7%

This hazy double IPA was formulated to showcase the minty and green apple aroma notes from German Polaris hops and the tropical and juicy aromas from BSG Hops' Zamba™ blend. The grist bill is typical for the style with a little boost from sucrose to increase wort gravity without adding non-fermentables or additional malt flavor. The hopping schedule and yeast strain are intended to set the stage for aroma retention and biotransformation while keeping hop bitterness in check.

INGREDIENTS

6.5 lbs. (2.95 kg) Rahr North Star Pils Malt or other North American 2-row Pilsner malt
3.25 lbs. (1.47 kg) red wheat malt
1.5 lbs. (680 g) flaked oats
6 oz. (170 g) acidulated malt
1 lb. (454 g) sucrose (add with first wort hops)
8 AAU Polaris hops (first wort hop) (0.4 oz./11.5 g at 20% alpha acids)
2 AAU Polaris hops (60 min.) (0.1 oz./2.8 g at 20% alpha acids)
5 AAU Zamba™ hops (60 min.) (0.5 oz./14 g at 10% alpha acids)
20 AAU Polaris hops (hop stand) (1 oz./28 g at 20% alpha acids)
10 AAU Zamba™ hops (hop stand) (1 oz./28 g at 10% alpha acids)
1.5 oz. (42 g) Polaris hops (dry hop at day 2)
1.5 oz. (42 g) Zamba™ hops (dry hop at day 2)
1.5 oz. (42 g) Polaris hops (dry hop at day 4)
1.5 oz. (42 g) Zamba™ hops (dry hop at day 4)
SafAle K-97 (German Ale), Omega OYL-044 (Kolsch II), or LalBrew Köln yeast
1 cup corn sugar (if priming)

STEP BY STEP

This recipe uses reverse osmosis (RO) water. Add 2 tsp. calcium chloride, ½ tsp. calcium sulfate (gypsum), and ¼ tsp. sodium chloride (non-iodized) to the mash water before mashing-in. Note that acidulated malt is included in the grist bill; mash pH following mashing-in should be about 5.4.

Mash the malts at 154 °F (68 °C) for 60 minutes. Start recirculating wort. Sparge slowly and collect 6.5 gallons (24.5 L) of wort. Add first wort hops and sugar while sparging the mash.

Heat to boiling, and boil the wort for 70 minutes, adding hops at the times indicated in the recipe. Adjust original gravity post-boil with RO water as required.

Chill the wort to 158 °F (70 °C), add the hop stand additions and give the wort a long stir to create a whirlpool, then let steep for 10 minutes. Continue cooling wort to ~68 °F (20 °C). Pitch yeast, and ferment between 60–68 °F (15.5–20 °C) until complete.

Dry hops should be added on day 2 and day 4 of fermentation. If using hop bags for dry hopping, remove bags on day 7; if not, rack into secondary fermenter or keg equipped with spunding valve. Complete fermentation and any hop creep following dry hopping should be finished by about day 21.

Prime and bottle condition, or serve from keg if naturally conditioned during aging.

STAR GAZER HAZY DOUBLE IPA

(5 gallons/19 L, partial mash)
OG = 1.064 FG = 1.012
IBU = 35 SRM = 4 ABV = 7%

INGREDIENTS

3.5 lbs. (1.6 kg) Pilsen dried malt extract
1 lb. (454 g) wheat dried malt extract
1.5 lbs. (680 g) red wheat malt
1.5 lbs. (680 g) flaked oats
2 tsp. 88% lactic acid (add with first wort hops)
1 lb. (454 g) sucrose (add with first wort hops)
8 AAU Polaris hops (first wort hop) (0.4 oz./11.5 g at 20% alpha acids)
2 AAU Polaris hops (60 min.) (0.1 oz./2.8 g at 20% alpha acids)
5 AAU Zamba™ hops (60 min.) (0.5 oz./14 g at 10% alpha acids)
20 AAU Polaris hops (hop stand) (1 oz./28 g at 20% alpha acids)
10 AAU Zamba™ hops (hop stand) (1 oz./28 g at 10% alpha acids)
1.5 oz. (42 g) Polaris hops (dry hop at day 2)
1.5 oz. (42 g) Zamba™ hops (dry hop at day 2)
1.5 oz. (42 g) Polaris hops (dry hop at day 4)
1.5 oz. (42 g) Zamba™ hops (dry hop at day 4)
SafAle K-97 (German Ale), Omega OYL-044 (Kolsch II), or LalBrew Köln yeast
1 cup corn sugar (if priming)

STEP BY STEP

This recipe uses reverse osmosis (RO) water. Add the crushed wheat malt and flaked oats to a muslin bag and mash in 1 gallon (3.8 L) of water at 154 °F (68 °C) for 60 minutes. Remove the grains and rinse with 1 gallon (3.8 L) of hot water. Bring total volume up to 6.5 gallons (24.6 L) and stir in the malt extracts. Once fully dissolved, add the first wort hops, sucrose, and lactic acid.

Heat to boiling, and boil the wort for 60 minutes, adding hops at the times indicated in the recipe. Adjust original gravity post-boil with RO water as required.

Chill the wort to 158 °F (70 °C), add the hop stand additions and give the wort a long stir to create a whirlpool, then let steep for 10 minutes. Continue cooling wort to ~68 °F (20 °C). Pitch yeast, and ferment between 60–68 °F (15.5–20 °C) until complete.

Dry hops should be added on day 2 and day 4 of fermentation. If using hop bags for dry hopping, remove bags on day 7, if not, rack into secondary fermenter or keg equipped with spunding valve. Complete fermentation and any hop creep following dry hopping should be finished by about day 21.

Prime and bottle condition, or serve from keg if naturally conditioned during aging.

tion, we still don't have a complete understanding of every input's impact. We know that in order to achieve a balanced, persistent haze we need protein, polyphenols, carbohydrates, hop acids, and a supportive yeast strain. The inclusion of undermodified malt can induce haze due to higher protein and higher glucan content. The use of oats as an adjunct favors haze formation due to relatively higher soluble beta-glucan content. The addition of alpha and beta acids due to prolonged and late dry hopping in a beer with higher than typical protein content can lead to more persistent foam and haze. Exogenous tannins can impact haze formation and duration. Pectin can take you beyond haze and into flakes or chunks. The choice of yeast strain can impact juicy flavor potential and add a component of haze, but may not be the key to haze. While we are still adding more information to our hazy juicy paradigm, more research is in order. Until then we will continue to fine-tune recipes and optimize brewing process in order to achieve the most sought after hazy haze for beer with the juiciest of flavor. BYO

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A DIY WORTH A CLOSER LOOK

Inside a state-of-the-art homebrewery

story and photos by Adam Wirth

My journey into homebrewing started like the majority of us; walking into my local homebrew supply shop and declaring, "I want to brew! What do I do?" I started small with extract brews, but quickly started to dream of brewing all-grain batches and building my own equipment to do so. I'm an engineer by trade, which fueled my build of a three-kettle HERMS (heat exchange recirculating mash system) with electric controller, all of which I built myself from scratch. All was right in the world.

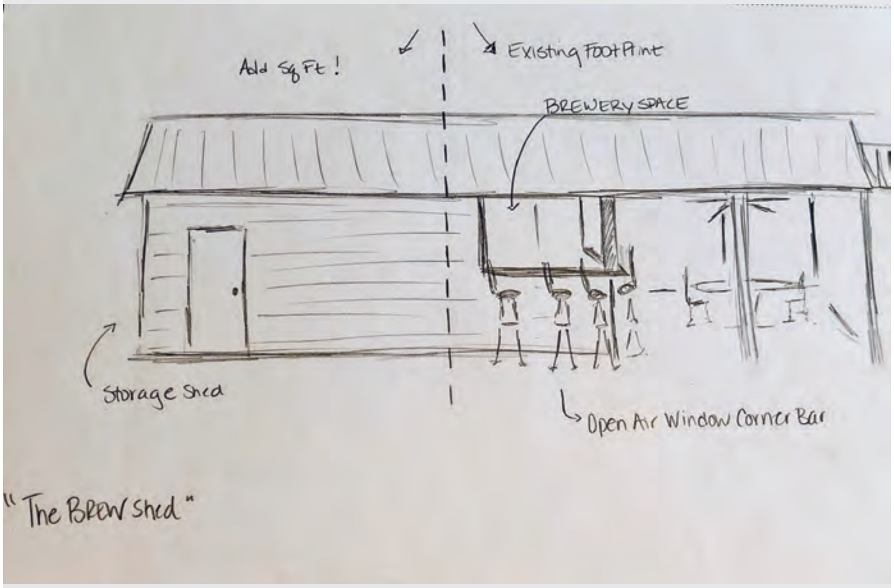
After the first several brews, it became apparent that the dream system I built had a flaw — its setting. My brew space where the system resided lacked some major essentials: Water supply, drainage ability, and ample space for brewing. I found myself lugging 5-gallon (19-L) pails of water to my garage, setting up temporary hoses draining into the yard, and moving yard equipment in and out to make space to brew. Homebrewing became exhausting! So, in the midst of a pandemic where I've been quarantined at home, I decided to use my off time to build a brewery. In late 2020 I officially moved in, and the list of add-ons for the brewery was extensive. Follow along as I highlight some of the major components that are now home to my total homebrewing experience.

Welcome to Zonut Brewing!

PLANNING/CONSTRUCTION

The idea was to take an old rotting shed that had a patio/pergola area attached and transform it into a brand new 14x24-foot (4.3x7.3-m) combo building to house a storage shed in the back and a fully insulated and temperature-controlled brewery space in the front. We were able to salvage the pergola area while tearing down the shed and ended up building the rest from scratch. This project was the quintessential "while we're at it . . ." space.

ORIGINAL SKETCHED PLANS



THREE-KETTLE HERMS SYSTEM

The heart of Zonut Brewing is the three-kettle HERMS. I wanted the control of using electric brewing, and with inspiration from several other electric brewers I settled on using three 20-gallon (76-L) kettles, modified with quick disconnect fittings to use transfer hoses. The system is built around a garage storage rack, which was the perfect size for the equipment. The 30A controller I built from scratch is mounted on a swinging TV stand, so it stays out of the way when not in use. The controller build tested my patience in wiring, but turned out great and gives me precise temperature control on the hot liquor tank (HLT) and mash kettles. A steam condenser attached to the boil kettle makes for very little steam release in the room, and requires much less power for a rolling boil. The system is finished off with lighting, black high-density polyethylene (HDPE) paneling, and of course, the brewery logo.

KEEZER BUILD

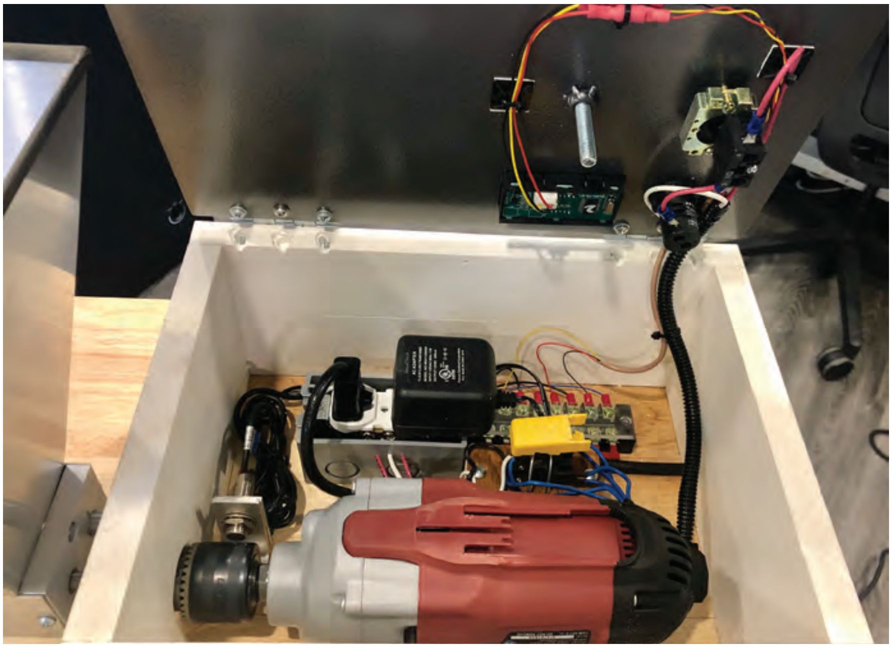
My keezer starts with a 7-cubic foot Arctic King chest freezer, which is the perfect size for four Corny kegs. I'm a big fan of nitro beers, so I wanted to have total flexibility for using both CO_2 and nitro on any tap. To do so, I constructed a parallel manifold setup that can channel both gases to each secondary regulator. I took extra care to make sure all my fittings were sealed before final installation. Since the taps are remote from the keezer, I placed a small glycol reservoir in the unused space that can keep the beer lines cool on their way to the taps. An Inkbird controller maintains optimum beer temperature.

IRON PIPE FOUR-TAP SYSTEM

The aesthetics in the brewery are meant to be industrial. I once saw iron pipe used in a craft brewery and I knew right then what I wanted to use for my taps. The system starts with 2-inch (5-cm) iron pipe from the home center. To ensure serviceability, I cut a large window in the faucet pipe and formed a piece of steel sheet to cover the opening and house the faucet shanks. With the four lines plumbed in and wrapped around a glycol cooling line, I used small button head machine screws to secure the shank panel. From there, the remaining elbows and vertical members were screwed together, and the tap system was ready to be bolted directly to the countertop. I chose Intertap flow control faucets for flexibility in using CO_2 or nitro in a single tap, and finished it off with custom cut tap handles and 3D printed dogs. (Zonut Brewing is named after our brew dog, Zoe). And "while we're at it . . ." since I had a sink just below the taps, I added a glass rinser to the drip tray.

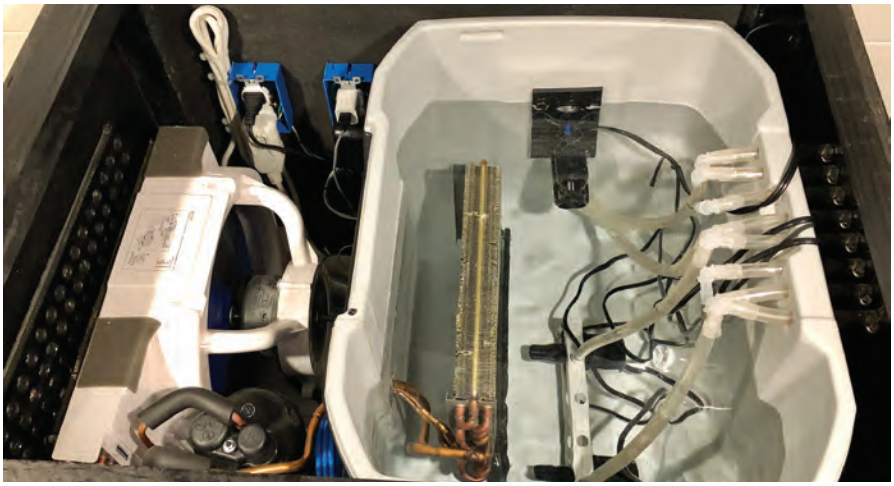
GRAIN MILL

While I have access to a local homebrew shop's grain mill, I wanted to include my own motorized grain mill in the space to have more control and freshness over the crush. I bought an inexpensive high-torque drill that I modified to fit in a case with external speed control, directly spinning the rollers. This mill mentioned an optimum RPM of 350 for grain crushing. Well, how would I know what speed I'm turning? An easy add-on was a Hall-effect sensor fixated on the drill chuck. Now I can dial in the precise RPM no matter what type of grain I'm using. There's something very exciting about listening to your grain mill spooling up right before you intend to mash. I mounted the whole system on a standard kitchen island I found at the home center, which houses a bucket perfectly for catching the grain.



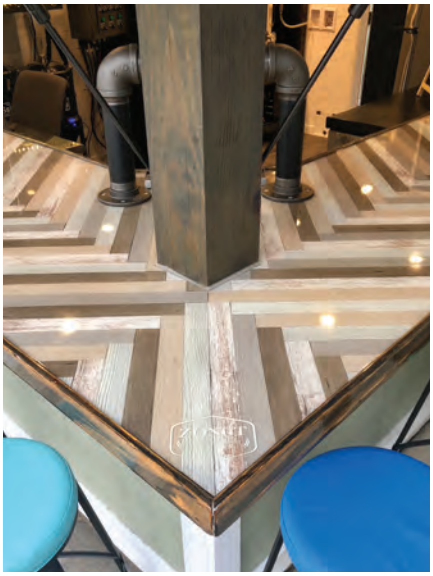
GLYCOL CHILLER

I wanted to use a glycol chiller for total control over the Ss Brewtech fermenters, however glycol units are quite expensive. Instead, using a standard 5,000 BTU wall air conditioning unit, the evaporator can be placed in a 60 qt. cooler full of glycol to do the same job as purpose-built chillers. As I wanted a professional look, and keeping with the industrial theme, I built a custom enclosure with an LED lighted plexiglass front, so the entire unit is visible. An Inkbird controller keeps the glycol as cold as desired, and as a finishing touch I added an old iPad as a screen to monitor Tilt hydrometers. This thing is a beast — I'm certain it can control many more fermenters. (I think my homebrewing friends will start to drop off their fermenters soon!)



BAR TOP AND SWINGING DOORS

From the beginning, we wanted a brewing space that connected the indoor and outdoor spaces. As such, we devised a plan to have a bar top area that could be accessed both in the brewery and out in the patio space. We wanted the bar to have a unique look and feel, so I made a plywood base that we inlayed pre-finished wood strips in a herringbone pattern, and then poured ⅜-inch of epoxy bar top resin on top. The look is dramatic and gives a real sense of depth. Resin countertops also allowed us to insert our brewery logo in between pours. We also built swing-up doors at the corner bar area that utilize gas struts and truly invite people into the space from outdoors. Entertaining is now a joy and promotes our favorite hobby with every pour.



Tapping into Maple Beers

Conquer the challenges of brewing with maple syrup

by Derek Dellinger

Some flavor pairings are so obviously complementary; it's perhaps inevitable that they become trends. The perfect maple beer has long been a dream of many a brewer, and it's clear that brewers and drinkers alike enjoy finding their maple paired with some form of dark beer, usually a big stout. Yet as self-evident as this pairing may be, it is not always the easiest to achieve. Many of the compounds responsible for maple syrup's unique, earthy flavor are quite volatile and thus easily scrubbed away during the fermentation process, leaving only faint evidence of the brewer's intent. That's hardly what you'd want under any circumstances — and especially not when an ingredient comes with as hefty a price tag as maple syrup.

Some of this conundrum may stem from the fact that the styles of beer which maple syrup would intuitively seem to pair best with — dark beers — are perhaps the most resistant to showcasing subtler nuances. Indeed, the flavors we associate with maple syrup are largely the result of Maillard reactions created through the application of heat, much as with coffee or even the roasted malts that give stouts their roast. But while a big, dark, roasty stout might allow coffee and chocolate to punch through, the character of maple is just a bit too volatile to claim the same staying power. With maple syrup, our idealized combination of flavors may just result in a paradox of practicality, and a lesson in managing expectations. Does one simply accept that the combination of flavors a drinker most desires might not hit the intensity level that they're looking for, or does one try to meet those expectations through a clever manipulation of the fermentation process?

Photo by Charles A. Parker/Images Plus

As I see it, there are several possible approaches to consider when planning out a maple brew. One can lean into expectations and simply load up a stout with as much maple syrup as possible. Or, one might change up the base style, searching for a showcase that won't drown out the maple with competing characteristics — doesn't a maple cream ale have a nice-sounding ring to it? You could, of course, simply take a less direct path toward finding your maple beer nirvana, and enhance the perception of maple flavor with something that simply tastes like it, like fenugreek or candy cap mushrooms. Or, finally, you could decide to circumvent the issue altogether, and simply prevent the maple syrup from fermenting at all by adding it into a beer that no longer contains active, viable yeast.

IN ITS RAWEST FORM

Those lucky enough to live in maple country might understandably feel the urge to go as maple-forward with their brew as possible, and in this case, why limit yourself to just one source of flavor? Brewers in the appropriate regions might consider a beer that combines not only syrup, but maple sap as well, and perhaps even bark. All varieties of maples, including black, red, and silver can be tapped for syrup, though naturally the highest concentration of sugar will be found in the sap of the sugar maple. Regardless, maple sap contains nowhere near the sweetness of its condensed syrup, and is so close to raw water that it can be used to replace your brewing water entirely.

It's important to note that the properties of your sap are set in wood, not stone, and thus may not only vary from year-to-year, but from day-by-day and tree-to-tree. Maple sap generally has a gravity around 1.005 to 1.007, but it may sometimes come in as low as 1.003. Typically, you can expect a pH between 6.5 to 7, but in some cases, it may range as widely as 3.9 to 7.9, depending on the season and conditions. Brewers may consider adding around 0.2 g calcium chloride per gallon (4 L) of sap to ensure adequate calcium is present, especially when brewing a maple stout.

If you are not tapping the sap firsthand, it's worth noting that some producers may offer reverse osmosis (RO) sap — sap that has been filtered and concentrated via reverse osmosis. While still much more liquid than syrup, RO sap can have a much higher concentration of sugars than sap straight from the tree, and this concentration can vary widely. In fact, if you live in a region known for maple syrup production, some producers will create a sap of whatever gravity you ask. It's much easier for someone with proper equipment to do this versus trying to hit the correct gravity at home. Using concentrated sap is the technique Sean Lawson uses to create Lawson's Finest Liquids' Maple Tripple Ale. This may not be an option for most readers, but if you are able to get sap with a known sugar content, this can help take away some of the unpredictability that comes with brewing with a natural foraged ingredient. Timing is worth considering too: Sap harvested later in the season may have lower concentrations of sugar and differ in taste compared to early-season sap.

Regardless of where and when you get your sap, keep in mind that nature is just as eager to get on with the fermenting as you are. Natural fermentation will take off on its own in a couple of days, so the sap should be kept cold in the interim, and frozen for longer periods if you are unable to brew with it immediately. Using fresh or properly stored sap is critical as off-flavors (fecal-like) show up pretty quickly if stored improperly.

One's first instinct when it comes to replacing all of the brewing water with pure sap may be to wonder if the flavor will become overwhelming, but generally, you'll find the opposite to be true. Because there is so little to maple sap beyond water and dilute minerals, and the sugar content is so low, little maple flavor will make it through the fermentation process. Indeed, it is the long, long boiling process that sap undergoes in order to become syrup that is responsible for most of the flavor of maple as we know it — as the water evaporates, the sugars are transformed through caramelization and Maillard reactions. However, the sap itself will add a mild mineral and ester character to the beer, which holds up well to the profile of something like a stout or porter.

For a fully mapleized stout, let's not only double down, but triple down on the maple. If you live in the Northeast of the U.S., Southeast of Canada, or one of the less popular maple sugaring regions with access to sap, you no doubt have access to bark as well. Try peeling a few ounces of bark from a tree and toasting it in the oven before adding to the boil, enhancing the toasty, earth notes in the beer.

MAPLE BREWING TECHNIQUES

Boiling is already an integral part of the syrup making process, so maple syrup certainly doesn't require any more of it. In fact, adding your syrup during the boil will only diminish your chances of saving as much of the precious, delicate flavor as possible. Whether brewing an all-in stout with sap and syrup alike, or a toned-down variation with just syrup, set the syrup aside until after fermentation has completed. While I don't always recommend racking to a secondary vessel, I find it's absolutely warranted in cases like this when you want to introduce the maple with as little turbulence as possible. Dumping a bunch of maple syrup onto a thick, hungry yeast cake is only going to stir up a vigorous secondary fermentation, and just as with adding the syrup to the boil, this risks blowing off many of the maple's volatile molecules. After transferring to a secondary, there will still be plenty of yeast left behind to ensure the maple is fermented out, but the process will be a slower, gentler integration. For similar reasons, I recommend building your beer around a slow, steady yeast variety, preferably one comfortable with fermenting steadily at lower temperatures, without pumping out a lot of esters.

Just how much maple syrup should you add? Frankly, I've found it's next to impossible to go overboard in this regard. I have brewed beers with as much as 1 part maple syrup to 4 parts

Photo by Shutterstock.com

If you live in the land of sugar maples, you may maximize the maple in your recipe by replacing your brewing water with maple sap.

beer. After taking this approach for a maple imperial stout using an entire gallon (4 L) of maple syrup in a 5-gallon (19-L) batch, I still found that the beer could have been, well, a bit more maple-y. So much of maple's essence relies upon its richness, and once fermented out completely, it's just not that overwhelming of a flavor. But the main consideration here, in the end, will likely come down to cost. Maple syrup certainly isn't cheap, and dumping a gallon (4 L) or more of the stuff into a batch is not going to be economical for most brewers. For most recipes, I would recommend at least 32 fl. oz. (950 mL) of syrup per 5-gallon (19-L) batch, though lighter beers may still shine with less than this.

Until recently, maple was sold in three grades, corresponding to its color. Led by the state of Vermont, the USDA recently changed from the letter grade system to a self-descriptive system. When brewing with maple syrup, you'll want to seek out what was formerly Grade C syrup, now known as "Very Dark and Strong Flavor." If you can't find this darkest of dark maple syrups in your area, simply search for the next shade down, or what would have previously been labeled Grade B. While the average consumer tends to stick to the lightest shades for their pancakes and waffles, you'll want the most robust of maple syrup to hold up to your beer.

Another glaring caveat that until now has been left unaddressed: What if you do want your beer to be sweet?

Beyond dosing your beer with syrup in the glass, the simplest method is to fall back on crystal malt. Or, to reach for the brewer's latest darling ingredient: Lactose sugar. These ingredients can quickly become overbearing, but depending on your goals, they're certainly able to deliver the perception of sticky sweetness that many expect from a maple beer. Used more discreetly, a moderate dose of lactose — half a pound up to a pound in a 5-gallon batch (0.23–0.45 kg/19 L) — supplies a clean, smooth mouthfeel and drags the beer just into the spectrum of sweet. This approach can be especially effective if brewing a dark beer on the less-than-imperial side, such as a porter or a more modest stout.

What if adding a perception of sweetness back into your maple-infused, thoroughly-fermented beer isn't quite enough? Perhaps you're over this whole fermentation thing, ready to embrace maple flavor wholly undisturbed and undiminished. In other words, you want to combine finished, stable beer with maple syrup, but dodge the flavor-scrubbing fermentation of that syrup.

This tactic is relatively easy to achieve for those with the ability to keg their beer, but for practicality and stability reasons, should probably be avoided by those who bottle condition. If one wishes to avoid fermenting their maple syrup, they'll have to neutralize their yeast after fermentation has completed. The easiest way to accomplish this is using two common winemaking ingredients, potassium metabisulfite (Campden tablets) and potassium sorbate. After fermentation, cold crash the beer if you're able, then transfer the liquid to a secondary vessel to free the beer from as much yeast sediment as possible. Add about 2 grams per gallon (4 L) of potassium sorbate plus two whole

Campden tablets. Let the beer sit for at least a day to ensure even dissolution within the liquid. After this, add your desired volume of maple syrup — though keep in mind you will not need nearly as much by volume as with other techniques, and a large volume of maple syrup will make your beer incredibly sweet. Allow the beer to age for an additional week or two after this. Some slight refermentation may still occur, since Campden and potassium sorbate do not actually kill yeast, but rather inhibit it from multiplying.

BASE BEER STYLE SELECTION

Though many brewers will want to go big with a maple beer, it may be wise to stick to the lighter side of dark and the smoother side of roasty. A porter or brown ale can serve to contrast the woodsy maple essence just as well as a big stout, but if one does choose to go in the stout direction, avoid leaning too hard into bitter, roasted malts. The rich, potent base of a Russian imperial stout is only going to make it all the harder for the maple to peek through. Consider blackening your beer instead with less intense malts like Carafa III® and Blackprinz®, which still impart notes of coffee, chocolate, and roast, without becoming overly acrid or overbearing.

Thus far, I've made the assumption that you'll be wanting to stick to a dark beer base, and load it up with as much maple as possible to make sure the flavor sticks around. However, I've found that maple works across a surprising variety of styles and grain bills, and you should feel little hesitation for exploring in this regard. Using a healthy percentage of oats or wheat in the grain bill can add to the perception of a full, silky mouthfeel, and a small percentage of a light smoked malt like oat-smoked wheat can help to enhance some of the earthiness of the maple. Style-wise, maple pairs quite well with nearly every shade of beer, and will shine especially well in ambers and red ales, which also offer the bonus of a touch of residual sweetness. Regardless of the style, a small percentage of crystal malt will help to balance out the dryness that the maple will impart, which many drinkers might find paradoxical. For a beer that's smooth and rich, but shies away from sweetness, Munich or Vienna malt may be the perfect thing, granting just enough fullness to the mouthfeel.

Of course, given that this gentle sugar benefits from a slow, steady fermentation at lower temperatures, why not embrace the slowest and lowest of all fermentations? A lager with a light grain bill provides little to hide behind. I suspect this combination sounds like it might clash — a notoriously delicate category of beer combined with a notoriously gratuitous breakfast topping. Fortunately, we don't have to worry about such marketing paradoxes when brewing at home. In truth, the end result of fermentation will likely leave maple syrup as the perfect, mineral-y, earthy, just-slightly-sweet partner for a light, neutral lager base. Think somewhere along the lines of a Vienna or helles lager — already perfect drinks for the transition seasons, paired with the Northeast's finest spring bounty.

With the tactics described in this article you should be able to craft a maple brew that lands anywhere from dark to light and sweet to dry. With so many variations to try, your greatest challenge may be getting your hands on enough syrup.

Photo by Shutterstock.com

A slow fermentation on the cooler side of a yeast's recommended temperature range will help prevent scrubbing all of the delicate flavors from maple syrup additions.

MAPLE IMPERIAL STOUT

(5 gallons/19 L, all-grain)
OG = 1.076* FG = 1.021
IBUs = ~35 SRM = 45 ABV = 9.6%

** Prior to maple syrup addition*

INGREDIENTS

10.5 lbs. (4.8 kg) 2-row pale malt
2 lbs. (0.9 kg) Munich malt
1 lb. (0.45 kg) flaked oats
1 lb. (0.45 kg) Carafa® III malt
0.5 lb. (0.23 kg) crystal malt (20 °L)
4 oz. (113 g) chocolate wheat malt
8.5 AAU Northern Brewer hops (60 min.) (1 oz./28 g at 8.5% alpha acids)
8.5 AAU Northern Brewer hops (5 min.) (1 oz./28 g at 8.5% alpha acids)
32 fl. oz. (950 mL) very dark maple syrup (secondary)
Wyeast 1318 (London Ale III), White Labs WLP066 (London Fog), or LalBrew Verdant IPA yeast
¾ cup corn sugar (if priming)

STEP BY STEP

Brewers with access to maple sap may replace all brewing water with sap for this recipe. Those without access to sap can add 0.5 lb. (0.23 kg) corn sugar as substitute. The gravity of maple sap for this recipe is assumed to be ~1.005, though this will vary — take a gravity reading of the sap before brewing to adjust accordingly.

Mash grains in sap at 154 °F (68 °C) for 60 minutes. Sparge as normal and boil for 60 minutes adding hops according to ingredients list. Cool the wort to fermentation temperature and aerate the wort if using a liquid strain.

Ferment at 69–72 °F (21–22 °C). When primary fermentation is complete, rack beer to secondary vessel, then add 32 fl. oz. (950 mL or 2.8 lbs./1.3 kg) very dark (previously called Grade C) maple syrup. Allow two to three weeks for additional fermentation before packaging as normal.

MAPLE IMPERIAL STOUT

(5 gallons/19 L, extract with grains)
OG = 1.076* FG = 1.021
IBUs = ~35 SRM = 45 ABV = 9.6%

** Prior to maple syrup addition*

INGREDIENTS

6 lbs. (2.7 kg) extra light dried malt extract
1 lb. (0.45 kg) Munich dried malt extract
0.5 lb. (0.23 kg) Carapils® malt
1 lb. (0.45 kg) Carafa® III malt
0.5 lb. (0.23 kg) crystal malt (20 °L)
4 oz. (113 g) chocolate wheat malt
8.5 AAU Northern Brewer hops (60 min.) (1 oz./28 g at 8.5% alpha acids)
8.5 AAU Northern Brewer hops (5 min.) (1 oz./28 g at 8.5% alpha acids)
32 fl. oz. (950 mL) very dark maple syrup (secondary)
Wyeast 1318 (London Ale III), White Labs WLP066 (London Fog), or LalBrew Verdant IPA yeast
¾ cup corn sugar (if priming)

STEP BY STEP

If available, replace all brewing water with sap. If not, add 0.5 lb. (0.23 kg) corn sugar as a substitute.

Place all the crushed grains in a large muslin bag. Begin heating 4 gallons (15 L) of water and submerge the grains in the water. When the water reaches 170 °F (77 °C) remove the grain bag and allow it to drip back into the kettle. Turn off heat and add the malt extract. Stir until all the extract is dissolved then bring wort to a boil. Add the first hop addition at the start of the boil and second addition with five minutes left in the boil. Cool the wort to fermentation temperature, top up to 5 gallons (19 L) and aerate the wort if using a liquid strain.

Ferment at 69–72 °F (21–22 °C). When primary fermentation is complete, rack beer to secondary vessel, then add 32 fl. oz. (950 mL or 2.8 lbs./1.3 kg) very dark (previously called Grade C) maple syrup. Allow two to three weeks for additional fermentation before packaging as normal.

MAPLE AMBER LAGER

(5 gallons/19 L, all-grain)
OG = 1.044* FG = 1.008
IBU = 23 SRM = 17 ABV = 5.8%

** Prior to maple syrup addition*

INGREDIENTS

6 lbs. (2.7 kg) Pilsner malt
1.5 lbs. (0.68 kg) Munich malt
0.5 lb. (0.23 kg) melanoidin malt
4 oz. (113 g) crystal malt (60 °L)
4 oz. (113 g) chocolate wheat malt
4 AAU Tettnanger hops (60 min.) (1 oz./28 g at 4% alpha acids)
4 AAU Tettnanger hops (10 min.) (1 oz./28 g at 4% alpha acids)
4 AAU Tettnanger hops (5 min.) (1 oz./28 g at 4% alpha acids)
24 fl. oz. (700 mL) very dark maple syrup (secondary)
Wyeast 2124 (Bohemian Lager), White Labs WLP830 (German Lager), or SafLager W-34/70 yeast
¾ cup corn sugar (if priming)

STEP BY STEP

Mash grains at 152 °F (67 °C) for 60 minutes. Sparge as normal and boil for 60 minutes adding hops according to ingredients list. Cool the wort to fermentation temperature and aerate the wort if using a liquid strain.

Ferment at lager temperatures, 50–54 °F (10–12 °C). When fermentation is complete, rack to a secondary vessel and add 24 fl. oz. (700 mL or 2.1 lbs./1 kg) maple syrup. After beer has completed secondary fermentation of maple syrup, lager for additional three weeks before packaging.

EXTRACT WITH GRAINS RECIPE:

To brew this recipe using extract with grains, replace the Pilsner, Munich, and melanoidin malts from the all-grain recipe with 3 lbs. (1.4 kg) Pilsen dried malt extract, 1 lb. (0.45 kg) Munich dried malt extract, and 4 oz. (113 g) Carapils® malt.

Place all the crushed grains in a large muslin bag and add to 4 gallons (15 L) of water. Turn on the heat and when the water reaches 170 °F (77 °C) remove the grains and allow them to drip back into the kettle. Turn off heat and add the malt extract. Stir until all the extract is dissolved then bring wort to a boil. Boil 60 minutes, adding hops as indicated. Cool the wort to fermentation temperature, top up to 5 gallons (19 L) and aerate the wort if using a liquid strain.

Follow the remainder of the instructions in the all-grain recipe.

BY DREW BEECHUM & DENNY CONN

FLAVORING BEER

Get the most from additions

Despite Denny's repeated pleas for homebrewers to make beer-flavored beer, a lot of them like to add flavorings to their beers. In a fit of hypocrisy, it turns out even Denny isn't immune to the call of flavored beer. A couple of his best-known recipes are for a Wee Shroomy (wee heavy flavored with chanterelle mushrooms) and a Bourbon Vanilla Imperial Porter. And let's not forget the infamous Clam Chowder Saison collaboration with Drew. Even John Palmer got involved in that one, adding in potato flakes!

But if you're going to make a flavored beer, there are a few things to consider. To us, one of the most important considerations is to let the flavorings complement the beer. Some don't agree with this and we'll go into this more in the next section but even something as radical as the Clam Chowder Saison was in the end recognizable as a saison, not a clam chowder!

Next, you need to think about when to add the flavorings. Generally, flavorings are added either to the kettle, the fermenter (usually in a secondary), or at packaging. Which one you choose depends on what flavors you're adding and how you want them to be perceived.

The first, and to us most important consideration, is to let the flavorings complement the beer, not define it.

SELECTING FLAVORS

Flavoring a beer can go in one of two directions . . . you can use flavoring to define the beer, or to complement the underlying beer flavor. Denny prefers the second approach. While chanterelle mushrooms in a beer may sound like they'd take over, in reality their apricot flavor and aroma are a perfect complement to a malty wee heavy.

The other method seems very prevalent these days. Brewers want their hazy IPA to taste/look like orange juice. We've even seen sweet versions of sour beers! Whichever way you decide to go, sit down and think it through carefully. Try to taste the beer in your mind, not just the ingredients. Think of the integration of flavors. Do the flavors work together? Are they a natural like peanut butter and jelly or more like peanut butter and squid ink?

Why do we care? We've seen a lot of beers with, as Drew puts it, "one flavor too many." Too many flavors fighting for your palate's attention makes for a confusing and unfocused experience. For the love of Gambrinus, think beer with a focus!

KETTLE

Kettle flavorings are generally added during the last five minutes of the boil or a hot whirlpool. That helps to preserve their flavor and aroma. The big question with this method is how much to add. Since you can't taste the effect, it's always best to err on the side of caution and go a little lighter than you think it should be. If you're using strongly flavored spices, extra caution is needed — the line between "interesting lavender" and "all I taste is grandma's soap" is vanishingly thin! That guessing factor is also why this is our least favorite method, but sometimes there's no way around it.

So, what goes in the kettle? Spices are a prime choice. Spices like cinnamon or peppercorns are a great choice for the kettle. Resinous spices like rosemary work better with heat extraction, so they should be added to the list. Fruit zest, like orange, lemon, or lime, often go into the kettle. But those depend on what kind of fruit character you want in the finished beer. Putting them in the kettle will give you a more integrated but muted flavor and aroma than adding them to the fermenter.

FERMENTER

For a more forward/intense flavor or aroma, adding flavorings to a secondary fermenter is the way to go. We seldom use secondary fermenters, but

Photo by Jason Rich

Spices are just one way to add flavor to beer, but the process to extract their flavor can differ.

adding flavorings is one place it's warranted. Yeah, you could put them in the primary, but then they can sink to the bottom and get covered in trub, which will limit the effectiveness. Not to mention that adding anything with sugar will likely kick up a new fermentation, so it's good to give yourself some fermenter space. The renewed fermentation will also scavenge oxygen that may have been picked up when you transfer to secondary, allaying that fear somewhat.

Secondary is a great place to add fruit (or veggies if you want to go that route!). The flavor and aroma will be brighter and you won't run the risk of setting the pectin in the fruit like you could if added to the boil. We're making beer, not beer jelly!

Before adding the fruit, cut it up and vacuum seal it. Put it in the freezer for a while. That will break down cell walls and allow the juice to be released more readily. If you can't vacuum seal, put it in a Ziploc bag and squeeze as much air out as possible before sealing the bag and freezing the fruit. (You can push your Ziploc bag into a pot of water and use the water pressure to force the air out of the open bag top.)

Now, the big question . . . how do you sanitize the secondary additions? Obviously, sanitizing isn't an issue if you put things in the kettle. But in the fermenter, it could be an issue. One way is to use some StarSan in a spray bottle and spray them down prior to freezing.

Denny, of course, has other thoughts on the matter. For 20 years he's been making a yearly batch of Wee Shroomy — a wee heavy with chanterelle mushrooms added to the secondary, based on Randy Mosher's recipe called Nirvana. Over the years he's tried a number of techniques for processing the mushrooms. Soaking them in vodka or putting them in a bowl of StarSan were unsuitable. The vodka added alcoholic heat to the beer, which was objectionable. Soaking in sanitizer left the mushrooms too wet and diluted the flavor. Finally one year, he took a deep breath and made a leap of faith and did neither of those. He simply brushed the dirt off of the wild foraged chanterelles, chopped them up, and vacuum sealed and froze them. He counted on the fact that the beer not only had alcohol to protect it, but also low pH post-fermentation. Lo and behold, it's worked fine for the last 10 years.

Now, we know that the thought of putting unsanitized wild mushrooms into your beer is gonna freak people out. We get it. But sometimes you just have to say "let's see what happens" and give it a try. Spoilage yeast and bacteria really don't do too well in beer. Even when inoculating beer with lactic acid bacteria and/or *Brett*, they often won't funkify as easily as many believe.

PACKAGING

Packaging is probably the best time to add flavorings if possible. Not only do you get the most intense flavor and aroma that way, but also you have the advantage of adding them to suit your own taste. No guessing at how much to use, no long online discussions where people tell you a million different methods (or that you shouldn't do it at all). Just note that if the flavoring contains sugar and you are bottling, the additional sugar should be calculated in with your priming sugar.

Liquid flavorings work best at this stage; additives like coffee, vanilla, or liquor are easy to dose at packaging. But even if your flavoring doesn't start off as a liquid, you can make it into one. Read on for more about this.

TINCTURES AND TISANES

Where kettle and fermentation additions carry a level of risk and indeterminate impact, the use of tinctures and tisanes (herbal/spice teas) can allow you to consistently dial in your flavor. You can buy high-quality flavor extracts, but where's the fun in that? But seriously, some flavors — looking at you strawberry — are best sourced from reputable extract makers.

The process for making a tincture is about as straightforward as can be, but the easy way does require time and pre-planning. Drew's usual rule of thumb is start with 4 oz. (113 mL) of a clean neutral spirit (say 80-proof vodka), roughly crush an ounce (28 g) of your desired flavoring and mix into the spirit. Allow to steep for at least one week in a sealable vessel like a mason jar. Give it a shake at least once or twice a day to encourage the process and remind yourself that you are a valuable part of the tincture creation process.

Need a tincture faster and are a nerdy cook? Grab your favorite sous vide immersion circulator and heat a water bath to 130–135 °F (54–57 °C). Place your vodka and spice mixture into small mason jars and dunk them in the bath and cook for 4–6 hours. The heat help drives the extraction and in a relatively short time you get an intense extract. (Also, homemade sous vide vanilla extract is a pretty snazzy and easy DIY gift.)

Play around with your boozy bits for different characters as well. Rum and Bourbon, in particular, make some really interesting tinctures. For instance, imagine making a mole-inspired tincture using tequila or rum as the base with chocolate, vanilla, coriander, cinnamon, and dried chilies? (Drew did this once for a riff on the "oh no, the world is ending in 2012!" kerfuffle.)

Don't forget the tisanes! Alcoholic extracts pull most of the essential oils from the target substance, but it can miss other flavors. Cinnamon is a good example. Make a tincture

"The process for making a tincture is about as straightforward as can be, but the easy way does require time and pre-planning."

and then make a tisane — bring 6 oz. (177 mL) of water to a boil and add a few roughly cracked cinnamon sticks. Let cool and filter. Taste the two side by side and you'll notice an immense difference. The tincture pushes cinnamon heat and burn – that nose searing, taste bud tingling of cinnamaldehyde. The tisane is softer and earthier with more woody notes. Putting the two together actually presents the whole flavor we expect from cinnamon/cassia.

TITRATION OR SIMPLY FIGURING OUT HOW MUCH TO USE

Figuring out how much flavoring to put into a beer post-fermentation is a straightforward process and even kinda fun! Pour yourself four 4 oz. (113 mL) samples of the finished beer. Add a different, measured amount of flavoring to each glass and taste (having a pipette to measure can be especially helpful for these trials). When you decide which you like best, simply scale that amount up to the batch size.

A sample trial might look like this:

Glass 1: 4 oz. (113 mL) of beer, 1 mL of flavoring
Glass 2: 4 oz. (113 mL) of beer, 2 mL of flavoring
Glass 3: 4 oz. (113 mL) of beer, 4 mL of flavoring
Glass 4: 4 oz. (113 mL) of beer, 6 mL of flavoring

Upon tasting, you decide that Glass 2 is the taste you want. So now, you know you need 0.5 mL of flavoring per ounce (113 mL) of beer left. If you had 5 gallons (19 L) remaining (640 oz./19,000 mL), you'd need 320 mL (10.8 fl. oz.) of flavoring to achieve the same flavor as the trial.

You should totally engage your mad scientist side by doing this process. It'll make you want to shout out "IGOR, bring me the graduated cylinders and pipettes!"

Keep in mind that a lot of flavorings will fade over time. Vanilla is a good example. Denny likes to start with vanilla a little stronger than he thinks it should be because the flavor and aroma will diminish after packaging. Just don't go crazy or you may have to wait quite a while to drink the beer.

Before leaving, we want to stress again that in this day and age of Werther's Original Double Butterscotch Marshmallow IPAs, think carefully about the flavors you're using. Make them make sense and not just "because I can." Drew often thinks about pairings found in food and replicates those patterns — with the flavors and not the actual Werther's candy. Our rule is "Recreate the experience, not necessarily the ingredients." If you want to make a s'mores beer, think about what's in marshmallows rather than using the marshmallows themselves.

Flavoring your beer can provide a unique experience totally tailored to your tastes. Just be sure to think the process through carefully and you'll end up with a beer that will be totally yours!

BY JOHN PALMER

COLD-SIDE CONSIDERATIONS

It's lurking out there . . . oxidation

This whole column can be summed up in the following statement: Oxygen is vital to the yeast but detrimental to the beer. Oxygen is utilized by the yeast to synthesize key nutrients that it needs to physically grow and reproduce. These nutrients can be essential lipids and sterols. Yeast ferment, which means they do not respire oxygen like we do. But yeast will utilize any oxygen in the wort to biochemically synthesize these nutrients, even if the oxygen is chemically bonded to other wort components — such that after fermentation the oxygen content of the beer is effectively zero. Or is it? There is a lot of debate on the detriments of hot-side aeration (i.e., oxidation of hot wort prior to fermentation) with some studies and many opinions that indicate that low dissolved oxygen brewing (popularly known as LODO brewing) can improve your beer's malt aroma and flavor as well as flavor stability. By how much is difficult to quantify.

But our focus today is on total package oxygen (TPO), oxygen that is introduced to the beer after fermentation, most often during packaging. As Dr. Charles Bamforth states in his career retrospective, "Investigations over many years reinforced that flavor stability is a problem that should be addressed commercially 'in reverse order,' with the focus on beer in the trade first and then tracking back. Thus, I am at pains to emphasize absolutely that the two most important considerations should be the minimization of oxygen in the final package and the maintenance of beer at the lowest possible temperature (short of freezing) throughout storage and distribution. Only once this is assured is it worth paying attention to upstream." [1]

BEER OXIDATION 101

So, what are the mechanisms of oxidation and staling? Oxidation is a chemical reaction resulting in the loss of electrons to a substance. Actually, you can't talk about oxidation without also acknowledging the other side of the coin, and that is reduction. In oxidation-reduction reactions (or redox reactions), one substance loses electrons (is oxidized) and the other substance gains the electrons (is reduced). Historically the terms were defined because oxygen was the primary reagent, and iron (for example) would be oxidized from Fe to Fe^{+2}, and the oxygen would be reduced. However, actual oxygen is not required — it can be any substance that gains electrons — and this is often the case in brewing. The important thing to understand is that "oxidation-caused staling" doesn't always mean oxygen. More on the chemistry of beer staling later.

FLAVOR STABILITY 1: TEMPERATURE

To put it simply: Beer is best consumed fresh. There are a couple of styles where the oxidation products tend to be more pleasant than the fermentation products, but to me those clearly represent large opportunities for improvement in the fermentation of the style. In general, the first signs of oxidation and poor flavor stability are the loss of fresh hop and malt aromas. From there, the effects vary. Different beer styles stale differently. Different storage temperatures stale differently. For example, in Pilsner beers the effects that follow aging at 77 °F (25 °C) tend to be predominately a caramel character, while at 86–99 °F (30–37 °C), the flavor change is more of the cardboard (E)-2-nonenal.[2] In hoppy ales, low temperature storage (37 °F/3°C for 2 weeks) resulted in a hop character transition from tropical fruit, dank, and citrus character to more of a tea/herbal and spicy aroma.[3] High

The important thing to understand is that "oxidation-caused staling" doesn't always mean oxygen.

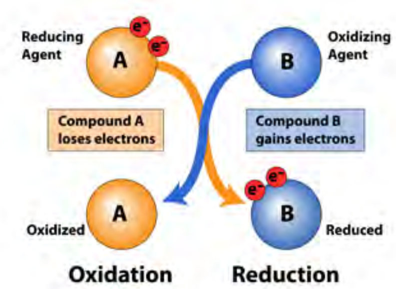


Photo courtesy of Shutterstock.com

Understanding what oxidation-reduction reactions are and how they play a role in beer staling can help solve for ways to reduce them.

temperature storage (86 °F/30°C for 2 weeks) of the same beer demonstrated a general loss of hoppy aroma and an increase of malt-derived aroma. These are just a couple of examples of the effect of storage temperature. Temperature is the one factor that everyone agrees is significant in the staling process. In fact, several studies demonstrated the applicability of the Arrhenius equation, which suggests that the reaction rate for most chemical reactions increases by a factor of 2–3x for every 18 °F/10°C increase in temperature. Beer that is stored at 32–39 °F (0–4°C) was flavor stable for several months, compared to beer stored at room temperature, which exhibited detectable stale flavors after only a few weeks.

FLAVOR STABILITY 2: TOTAL PACKAGE OXYGEN (TPO)

It is generally agreed that after temperature, the next biggest effect on flavor stability is the oxygen that is introduced on the cold side, typically during packaging. The goal for commercially packaged beer is to be less than 50 parts per billion (ppb) TPO, as this is the generally accepted benchmark for maximizing shelf life.[4] The question is, how can we minimize oxygen in the headspace when we bottle, can, or keg our beer? It's not easy. Standing water will have an equilibrium concentration of 8–10 ppm at room temperature near sea level. That concentration decreases with warmer temperatures and higher elevations. Boiling the water for several minutes can drive it down to about 1 ppm. Keep in mind that 1 ppm is 1,000 ppb or 20x more than our goal of 50 ppb.

The next step is to understand the limitations of the materials we are dealing with. Plastics are generally permeable to gases, the amount may be small, but it is there, and 50 ppb is a low hurdle to overcome. This is the primary reason that plastic bottles for beer remain commercially absent. In addition, oxygen will absorb onto plastic surfaces and be released after filling due to the gas equilibrium change. One estimate for a 500 mL plastic bottle is that 352 ppb of oxygen will be available. The rate of desorption is temperature dependent, but 90+% will take place within one week and maybe 40–65% within one day.[5] There are additional polymeric coatings that can be applied to the container to reduce diffusion and/or absorption, but these coatings interfere with recycling of the plastic.

The better option is glass bottles obviously. The only means of oxygen ingress or CO_2 loss in a glass bottle is through the bottle cap liner. Historically these PVC-based bottle cap liners have been a significant problem for oxygen. One study from 1990 indicates that diffusion through the bottle cap could allow as much as 4 ppm of oxygen per day![6] Fortunately, there are oxygen scavenging bottle cap liners now, as well as better materials, that may address this problem. (Hopefully they are being used!)

The best practices for filling containers is an inert-gas purge and capping, or sealing, on foam . . . let's start with the purge. The idea behind the purge is to eliminate or replace the air in a bottle, can, or keg with an inert gas such as nitrogen or carbon dioxide, such that when the container is filled, there is no oxygen in the container that can mix with the beer as it is filled. In a perfect world, the gas flow would be very laminar, there would be no turbulence, and the air (and oxygen) would be displaced from the container without any mixing of the gases. In the real world, there is some turbulence, and some mixing, but the available oxygen is greatly reduced. This is why Corny kegs are recommended to be purged with CO_2 prior to filling. Purging of bottles can be done as well, such as with a counter-pressure bottle filler or the Blichmann BeerGun™, but generally if you have a kegging system you aren't bottling often — unless it's for competition, in which case I highly recommend that you do purge your bottles. Lastly, there is the well-known recommendation to "cap on foam." What this means is that as the bottle fills, you allow just enough turbulence in the beer to generate enough foam to fill the bottle neck, and indeed, emerge from the bottle, as you withdraw the fill tube. This foam is predominately filled with CO_2, and by capping on foam you eliminate any oxygen in the package. However, there is a bit more to this than meets the eye. The emergence and wiping away of foam from the top of the bottle before capping is important! Why? Because small bubbles want to become large bubbles due to partial pressure equilibria and physics. The small bubbles at the top of the neck quickly absorb oxygen from the air to try to come to equilibrium with the atmosphere. In other words, you want to cap on small bubbles of foam, after eliminating the big bubbles of foam that emerge from the just-filled bottle. You will have a much better chance of entirely eliminating oxygen from the bottle if you do.

BEER OXIDATION 201

It is important to understand that oxygen gas, O_2, is not especially reactive when dissolved into wort; it doesn't immediately react to form staling flavor compounds. Instead, the oxygen must be converted (i.e., react with other substances) into reactive oxygen species or ROS, which are much more reactive and able to initiate staling reactions. Ground-state molecular oxygen (O_2) can react with transition metal ions — primarily iron, copper, and manganese — to form superoxide anion (O_2^-) and from there can react with water to produce further reactive species such as perhydroxyl radical (OOH•), peroxide anion (O_2^{-2}), and finally to hydrogen peroxide (H_2O_2). These species can react further with the metal ions according to mechanisms such as the Fenton and Haber-Weiss equations (not shown) to produce the hydroxyl radical (OH•, not hydroxide, OH^-) and superoxide anions (O_2^-). The reactivity strength of these ROS increases as follows: Superoxide ion, perhydroxyl radical, hydroxyl radical.[2, 7] (By the way, "radical" means that the atomic structure contains an unpaired valence electron, which is a bit of a loose cannon, as it were.)

These ROS tend to react with ethanol, which is the most abundant organic compound in beer, to produce the 1-hydroxyethyl radical and acetaldehyde. Most of the acetaldehyde in beer is produced by the yeast as they process glucose into pyruvate and pyruvate into acetaldehyde and finally to ethanol, for energy. Ideally, these aldehydes should all be reduced by the yeast by the end of fermentation, but oxidation can bring some back. However, ethanol is the least reactive of the alcohols in beer — reactivity increases here with molecular weight. This means that the fusel or higher alcohols may be almost as likely to become oxidized, even though the concentration is orders of magnitude less. Thus, acetaldehyde is not the only manifestation of oxidation and staling. Aldehydes are very significant organic compounds. They typically have strong aromas, such as vanillin, which is a phenolic aldehyde and the primary component of natural vanilla extract. There are three main types of aldehydes that are associated with stale beer, and these are: Fatty acid oxidation aldehydes (hexanal — green vegetative, and the classic wet cardboard aroma of (E)-2-nonenal), Strecker degradation aldehydes (formed from amino acids, such as methional — having a cooked potato flavor), and Maillard reaction aldehydes (such as furfural — having a caramel and bitter almond flavor).[2] These are the types of aromas and flavors most often associated with stale beer. However, these sorts of flavors are often the last to appear, when the beer has turned the corner from poor to bad. The first signs of oxidation or flavor degradation is often the loss of fresh malt and hop aroma. So far, scientists have not determined whether this loss is due to breakdown of aroma compounds or if the mechanism is more of a masking issue by formation of aldehydes, or if it's a mix. It's probably a mix, which would explain the mixed results. For example, recent work by Barnette and Shellhammer indicates that hop aroma loss is not due to breakdown of hop monoterpenes.[3]

THE BOTTOM LINE

There are a lot of studies that describe oxidation of aldehydes and the creation of compounds during malting, milling, and mashing that are associated with stale flavor, but the majority of these products are eliminated during the boil or reduced by the yeast during fermentation. This shifts the focus to the cold side and our efforts to minimize TPO by purging the bottles, cans, or kegs with inert gas and capping on foam. But keep in mind that the best thing you can do to preserve your beer's flavor is to store it cold. Oxidation and staling are chemical reactions that are controlled by temperature. BYO

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BY DERRICK MARLOW

KEG LEVEL SENSOR

A new way to measure beer volume

About two years ago, I decided it's time to get back into homebrewing. Let's clarify that one of the primary motivators for me to stop brewing about 10 years ago was all the time that I had to set aside for washing and sanitizing bottles. This time was going to be different. After convincing my wife to move the kitchen table outside to make room for a kegerator, I knew I had the green light.

Kegging batches was going great, but I was really starting to get tired of that soul-crushing feeling of a keg blowing when I had no idea I had already drank that much. In line with most of my other first-world problems, I decided to do absolutely nothing about it. Fast forward to March 2020: Pandemic, quarantine . . . golf courses are closed, so can't go out and shoot double bogey on every hole. Breweries are closed, so I can't sit around and complain about my golf game to strangers. And finally I'm stuck inside forced to drink whatever hooch I brew in my backyard.

With all the extra time on my hands, I decided that I would pick up a new hobby . . . electronics. With a background in industrial automation in the water industry, I knew there had to be another way to monitor the keg level than using flow sensors or scales. Not that I'm opposed to those measurement methodologies, I just thought to myself, "Why can't I just have a sensor as part of the keg lid"?

I decided to pull the trigger on a time-of-flight sensor to measure the distance from the lid to the surface of the beer. I knew that this distance could be easily converted to a unit of volume. While I was at it, I realized that if this sensor is going to be part of the lid, why not monitor temperature and CO_2 pressure while I'm at it? At that point, I knew I had to build a sensor that could measure everything from inside of the keg. Sacrificing an old Corny keg lid and designing a 3-D printed enclosure, I built an integrated keg lid level, temperature, and pressure sensor. For about $65 (USD), you can build one of these for yourself!

This sensor has been useful and a lot of fun. It's great to have an idea of how much is left in the keg to plan future brew days and schedule the current brew fermenting. I also decided to take it a step further and develop a mobile app. Using the mobile app, if the in-laws come by to watch the cat while my wife and I are out of town, I'll know if they didn't try any homebrew . . . which is basically a requirement when they come over. This could come in handy for homebrewers who are parents of teenagers as well.

Moving forward, and with awesome support from the homebrewing community, I have been developing this model for support with Android and iOS, open-source hardware like Arduino and Raspberry Pi, and other brewing community platforms.

It's great to have an idea of how much is left in the keg to plan future brew days and schedule the current brew fermenting.

Photos by Derrick Marlow

Tools and Materials

- Drill press with drill bits for stainless steel
- Soldering iron
- 3-D printer
- 3-D printed sensor enclosure (https://www.thingiverse.com/thing:4670817)
- VL53L0X Time-of-Flight breakout board (25 mm x 12.2 mm board)
- HSCMAND150PA4A3 pressure and temperature sensor
- Male 4-pin GX16 aviation connector
- Corny keg lid
- Food-grade epoxy (recommend ZDSticky)
- 22 AWG stranded wire, multiple colors recommended (red, black, blue, white)

STEP BY STEP

1. DRILL AND INSTALL CONNECTOR

Drill a ⅝-in. (16-mm) hole in the Corny keg using a drill bit for stainless steel. Make sure to follow best drilling practices with RPM, lubrication, and bit type. This hole should be centered between the lid handle mounting brackets and approximately halfway between the PRV (pressure release valve) and the lip of the lid (1A).

Install the male 4-pin GX16 aviation connector to the keg lid with the connector facing towards the outside of the keg. Install through the lid AND the cover of the 3-D printed sensor enclosure (1B).

2. SOLDER SENSORS

Solder wires (preferably different colors for each pin) to the legs of the pressure/temperature sensor based on pinout drawing (2A).

Through-hole solder wires to the VL53L0X breakout board. Match the same wire colors as noted in the picture (2A). Fortunately, the breakout board's wiring schematic should be labeled for you. Make sure the wire is coming into the breakout board on the OPPOSITE side of the sensor itself. Trim any additional exposed wire, it should not extrude past the cavity in the bottom of the sensor enclosure. When finished, the sensors with wires should look like the picture (2B).

3. SOLDER CONNECTOR

Strip all the wires in step 2 and twist each color's stranded wire with the other sensor's wire of that color. Solder each twisted set to the single connector terminal based on the pinout (3A).

Once finished, it should look like the picture (3B found on page 66).

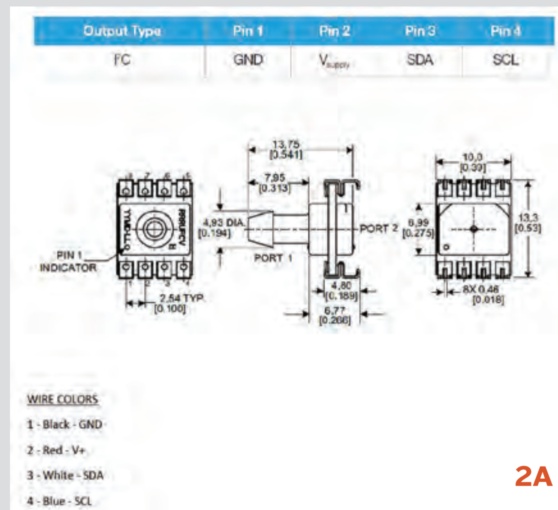
4. GLUE SENSORS

The sensor enclosure is designed with a cavity designated for the pressure/temperature sensor and a separate cavity for the VL53L0X Time-of-Flight board. If you can't figure out which one is for which sensor, it's probably time to set down that beer and call it for the day. You'll need your wits about you for this next step.

This next part is the most critical part of the sensor assembly, so take your time here. You will need to install and glue each of the sensors into their respective cavities. For the VL53L0X, this glue must seal AROUND the face of the sensor where the board meets the enclosure. For the pressure/temperature sensor, the glue must seal where the base of the sensor nipple meets the enclosure. I recommend Loctite with the SF 7452 accelerator. Applying the bead of Loctite on the enclosure, then spraying the sensor's mating surface with the accelerator creates a fast-acting (10–15 seconds) seal. This seal is critical prior to potting the sensors in epoxy. Don't be afraid to be liberal with the glue

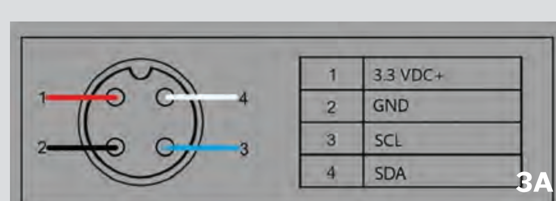

1A


1B



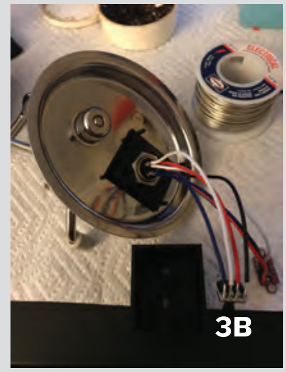
2A


2B



3A

where the sensors meet the enclosure. Don't ask me how I know, but if they aren't sealed, epoxy will leak everywhere in step 5. Just be sure to test the seals after the sensors are glued to ensure they are waterproof.


3B


4

5. EPOXY STAGE ONE

Once the glue has dried, coil the wires into the sensor enclosure and do a "test fit" to make sure the enclosure will sit flush with the lid.

Mix your food-grade epoxy based on the instructions on the epoxy bottles. Once sufficiently mixed, pour the epoxy into the sensor enclosure, making sure to hold the enclosure upright and level while pouring. Pour until the level is high enough for the "legs" of the enclosure lid to make contact with the epoxy when the lid is flush with the enclosure (5A).

Holding the enclosure (full of liquid epoxy) level, place the lid into the enclosure until the lid is flush with the enclosure body. Place the lids SENSOR SIDE DOWN on the edge of a surface allowing the nipple to extrude over the edge (5B). Add weight above the connector to keep the lid from tipping over. I've found sockets are a nice tool for this.


5A


5B

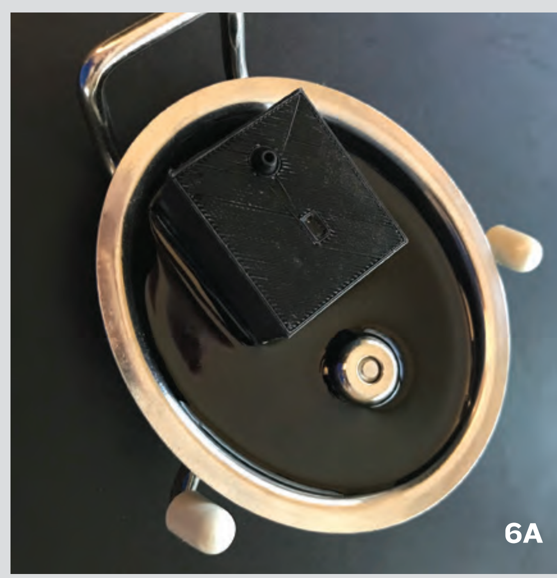
6. EPOXY STAGE TWO

After the stage 1 epoxy has fully cured (follow directions of epoxy bottles), place the lid SENSOR SIDE UP on a level surface. You may need to use something under the lid handle to make sure the underside of the lid is level. Apply a bead of glue along the outside of the sensor enclosure where it meets the lid. As mentioned in step 4, this must be sealed, or epoxy may leak in this step.

Once the glue has dried, mix your epoxy based on the instructions on the epoxy bottles. Once sufficiently mixed, pour the epoxy into the underside of the sensor lid. Pour slowly and allow the epoxy to fill evenly around the sensor enclosure and PRV. Fill until the mating surface of the sensor enclosure and lid is covered, but DON'T pour past the PRV (6A).

Once the epoxy has cured, you have successfully built your own Time-of-Flight keg level sensor!

The Flite sensor is designed to work with the Flite display or headless controller and supports integration into other brewing community platforms. For more details check out the support documentation using the QR code (6B) or visit: https://www.flitesense.com/support BYO


6A

6B

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LAST CALL

BY DREW JACKSON

A FRIENDSHIP MUSHROOMS

Brewing brothers from different mothers

When a homebrewer meets someone who shares their passion, friendships are born and the collaborative process starts to take root.

Photo by Fernando López Angulo

Fernando's finished candy cap mushroom beer, made with mushrooms from the author.

The brewing world is full of energetic people who invest a lot of time, money, and energy into making craft beer. When a homebrewer meets someone who shares their passion, friendships are born and the collaborative process starts to take root. Over the years, many fellow brewers have added to my skill set by sharing their time, knowledge, and experience, but never did I anticipate that I would meet and develop a relationship with a brewer who lives close to 6,000 miles away and speaks a different language. Welcome to the land of the internet; the place where the world gets smaller and our reach is unlimited.

Three years ago I moved to Mendocino, a small coastal community in Northern California. The beauty of the redwood forests and coastal fog were telling me I needed to brew beer that represented the magic of this special place. While attending a local meeting of the Foggy Coast Brewers I had the chance to taste an incredible barleywine with candy cap mushrooms (think maple syrup) made by Jeff Neumeier. I had no idea what candy caps were but it didn't take long before I managed to acquire some through a local forager. This led to many months of experimentation; making beers and tinctures to attempt to harness the incredible aromatics of this hard-to-find mushroom. I got help from Jeff with a recipe, talked with and shared beer with people at a local homebrew club, and asked for advice on the "Homebrewers Roundtable" group on Facebook. One person who was interested was James Claus, the Head Brewer at 3 Disciples Brewing in Santa Rosa, California. After many conversations and beer tastings, these meetings led to collaboration to produce seven barrels of a beer they called Cap That Glass, a Scottish wee heavy with candy cap mushrooms. Just when I thought it couldn't possibly get any better, along comes Fernando López Angulo, a brewer from Madrid, Spain.

Fernando was interested in my project and he had a million questions. It wasn't long before we were texting daily and using Google Translate to discuss the beer-making process. Soon, I was sharing information about my family and he was doing the same with me. He sent me pictures of his wife and I did the same for him; we even confessed our love for our dogs. We talked about beer, family, and the threat of a worldwide pandemic. Soon, mushrooms were in the mail, making their way from California to Spain so Fernando could complete his recipe.

When I discovered Fernando was a talented composer of music, he was kind enough to allow me to use his music for an art project I was involved in. When my daughter was married in October, Fernando and his wife, Marissa, made a congratulatory video to send their best wishes, and when Fernando's mother-in-law passed away from COVID-19, I tried my best to be there for him.

During this pandemic I have doubled down on my brewing and learning. I have the interest and Lord knows, I now have the time. What I didn't know when all this craziness started was how powerful this passion could be and what it could lead to. I had no idea that through my dedication to the making of great beer I could not only grow my knowledge of brewing but could also make a really good friend along the way. During this crazy time, be open to new relationships. Follow your passions, ask questions, listen to answers, and grow. Maybe you too can discover a brewing brother from a different mother. BYO

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