WEST COAST IPA TECHNIQUES | SIZING YOUR BREWHOUSE | BEYOND THE PALE: SCOTTISH EXPORT

BrewYour Own

THE HOW-TO HOMEBREW BEER MAGAZINE

SEPTEMBER 2021, VOL.27, NO.5

GET THE MOST FROM YOUR YEAST

- BEST PRACTICES FOR BETTER BEER
- SELECTING THE RIGHT STRAIN
- HARVESTING & REUSING YEAST
- CREATING NEW HYBRID STRAINS

UNDERSTANDING HOP EXTRACTS

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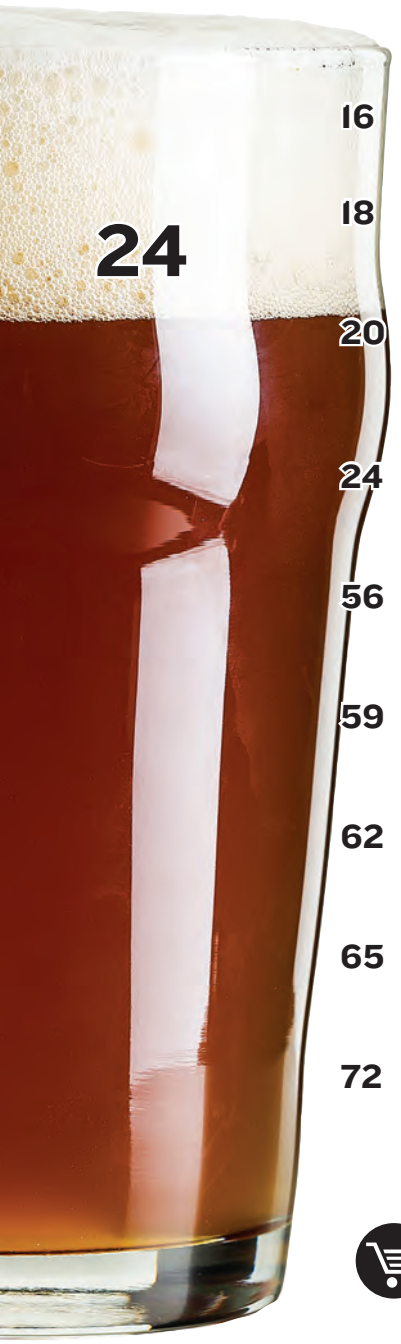

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RECIPE STANDARDIZATION

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

EXTRACT VALUES FOR MALT EXTRACT:
liquid malt extract (LME) = 1.033–1.037
dried malt extract (DME) = 1.045

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

HOPS:
We calculate IBUs based on 25% hop utilization for a one-hour boil of hop pellets at specific gravities less than 1.050. For post-boil hop stands, we calculate IBUs based on 10% hop utilization for 30-minute hop stands at specific gravities less than 1.050. Increase hop dosage 10% if using whole leaf hops.

Gallons:
We use US gallons whenever gallons are mentioned.

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Charles A. Parker/Images Plus

Q Do you have a favorite toy/tool in your brewing arsenal?

The most valuable tool in my brewing arsenal is information and knowing how to quickly access and apply it to the problem at hand. This may seem like a contrived revelation, but it's the truth. A very close second is my trusty goblet because no brewing toy brings more happiness than a full goblet of a well-brewed homebrew!

My favorite toy in the brewhouse isn't like anyone else's — on this fact, I'm certain. I have a whole garage filled with gidgets, widgets, and gadgets like my different brew rigs, fermenters, signs, and lamps. It's a giant pack of prayer incense that sits right by the door. Every brew day, I light a few sticks and offer up a brief nod to the universe to help make my brew go smoothly. Not that I'm looking for any spiritual intercession — but it's that the lighting of the incense focuses my purpose for the day and gets me into that right frame of mind to have a great brew day.

I'd have to say it's our hop doser? I know they are available in smaller scale for homebrewers with conicals. It allows you to add dry hops while there is still pressure on the tank, purging out any oxygen that might be introduced as well.

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suggested pairings at BYO.COM

Yeast Pitching Rates

As brewers, our job is similar to that of an elementary school custodian: Keep the place clean and make sure the environment is conducive for the little buggers to do what they need to do. Make sure you're starting them off on the right foot. https://byo.com/article/pitching-rates-yeast-techniques/

MEMBERS ONLY

Stein Beer

The word "steinbier" means "stone beer" in German. The name originates from a technique of boiling wort in the brew kettle by dropping super-heated stones into the kettle. Since brew kettles were made of wood and could not be direct-fired this was a way for the wort to be brought to a boil. Learn the technique of brewing your own stein beer. https://byo.com/article/steinbier-techniques/

Hazy IPA

Although the style has its detractors, it's still one of the darlings among craft beer enthusiasts. Get some pointers from Gordon Strong on brewing a juicy, hazy, and aromatically hoppy beer that will make you proud to call your own. https://byo.com/article/neipa-style-profile/

MEMBERS ONLY

Using Dry Yeast

There are many advantages to using sachets of dry yeast in your homebrewery. Terry Foster explains how this type of yeast is produced as well as the preparation and pitching rates recommended for your brews. https://byo.com/article/techniques-layout-7/

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Mangrove Jack's M12 Kveik Yeast is a single culture that uses an isolate from the Kveik family of yeasts from Norway. The culture has been carefully maintained by Sigmund Gjernes since the 1980s.

FERMENTATION RANGE:	FERMENTATION TIME:	ALCOHOL TOLERANCE:
68 - 104 °F (OPTIMAL RANGE 86 - 104 °F)	2 - 4 DAYS	12%

ATTENUATION:	FLOCCULATION:
HIGH (77 - 82%)	VERY HIGH (5/5)

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Available to retailers through BSG HandCraft:
bsghandcraft.com/mangrove-jacks

MAIL

FOLLOWING UP ON DIP HOPPING

You people at *BYO* do a great job of informing the homebrew community about processes and techniques and you have scored a homerun with your article by John Holl, "Dip Hopping," in the May-June 2021 issue. I wanted to send you an update to my previous email (included in the July-August 2021 "Mail") in which I expressed my intrigue by this technique. A new/old process that can increase aromatics and open up flavors in hops not normally tasted? You had my attention. I watched a podcast from *Chop and Brew* by Chip Walton with the same cast of characters as in your article. It didn't take long before I started a discussion with my brewing partner about the process and even a shorter timeframe before we had our first beers in production using dip hopping. We both did parallel brews of a double IPA and were both very impressed with the results. The bittering seemed softer and the hop profiles and aromatics were much more pronounced. This experiment led to the best DIPAs either of us had ever made. Not long after these beers were completed, I engaged James Claus at 3 Disciples Brewing (Santa Rosa, California) in a discussion about the process and another commercially-made dip-hopped beer is now in production. Innovation lives in the homebrewing community. Information sources like *Brew Your Own* magazine with great ideas help us to keep it this way.

Drew Jackson • *Mendocino, California*

SOURCING INGREDIENTS

I don't think I've ever been as inspired to try a new recipe as I was to brew Birra Venezia after reading "Italian Pils" in the July-August 2021 issue of *BYO*. However, I quickly discovered that both the malt (Eraclea Pilsner) and the key hops (Diamant and Aurum) are not available to U.S. homebrewers.

Michael Kavanaugh • *via email*

Editor's Note: *This was one of about a half-dozen inquiries we received asking about the availability of ingredients in this recipe. Editor Dawson Raspuzzi responds:*

"First, I'll start with an apology for the confusion and frustration this recipe caused readers who excitedly added this recipe to their brewing schedule only to find out that sourcing ingredients was more difficult than anticipated. We have found the two hop

contributors

Scott Burgess, Founder of Bierkeller Columbia in South Carolina, grew up in the Carolinas (with a brief stint in the United Kingdom), and spent nearly a decade studying and working in Bamberg, Germany and environs. Originally planning to study comparative literature through the University of South Carolina exchange program and a subsequent Fulbright grant, Burgess instead found his true love — and calling — in learning about the hundreds of small breweries and their beers. Bierkeller is the culmination of this life's work. Bierkeller brews authentic takes on a handful of Franconian favorites Burgess found over the years. Beyond all things beer, Burgess enjoys watching UNC Tar Heels basketball, F1 motorsports, and generally hanging with his son, Noah.

In his first article for *BYO* on page 32, Scott takes us back to his time in Bamberg where he fell in love with rauchbier, exploring the classic examples, and offering tips for brewing the smoked beer at home.

Jeff Mello is the Chief Yeast Wrangler of Bootleg Biology, a commercial lab in Nashville, Tennessee producing unique yeast and bacteria cultures for homebrewers and craft brewers since 2013. The yeast wrangling life chose Jeff when he set jars of wort in his backyard and discovered Bootleg's first wild yeast culture, *S. arlingtonesis*, and thus the Local Yeast Project was born. Today Bootleg Biology maintains a professional bank of several hundred yeast and bacteria cultures that are propagated for brewers and breweries of all sizes around the world.

Wrangling yeast is something homebrewers of all levels can do, as Jeff explains in his inaugural story for *BYO* on page 44.

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'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.

Beginning on page 50, Pattie takes readers through the history, benefits, and how to get the most from hop extract.

MAIL

varieties Michael mentioned are going to be the toughest ingredients in this recipe for homebrewers to find. Here is what Mike Brennan, the National Sales Manager in charge of the BSG HandCraft division said regarding Eraclea Pilsner malt and Diamant and Aurum hops (BSG is the exclusive distributor of these ingredients in the U.S.): 'Weyermann Eraclea is available to all shops who have an account with BSG. Homebrewers — ask your shop owner to order you a bag. We currently do not repack it into smaller bags since it is a base malt; a 1-pound (0.45-kg) bag is not an appreciable quantity for a brew. We do sell Diamant and Aurum hops in large format (5 kg/11 lb. boxes) and we also happen to have those two varieties in 2-kg (4.4-lb.) sizes on our spot hop purchase list. They are relatively new to us, having only landed into our system in March. Again, ask your LHBS to bring it in. If we see continued demand and we have the availability, we will repack into 1 oz. (28 g) format.'

"One idea for those who belong to a homebrew club is to go in on a larger purchase and break the bag up to more appropriate amounts. Maybe your club would be up for an Italian Pils style of the month competition?

"Those of you who suggested we offer substitutions to recipes where ingredients aren't easy to source are absolutely right. This is a practice we have tried to follow in the past and in the future we will be more careful to make sure it happens every time. Other suggestions included that we not run a recipe where ingredients are difficult to source, which is more complicated. We do try to keep ingredients called for in recipes in BYO *to ones reasonably accessible to homebrewers, however in this story the recipe wasn't only a recommendation for homebrewers, but an actual brewing log by the authors Horst Dornbusch and Thomas Kraus-Weyermann, who have been doing research and test brews of the Italian Pilsner style for some time. In other words, this recipe is what they brewed, and as such they provided the recipe. It likely isn't as useful to homebrewers who can't get some of the ingredients (yet) due to this, but fortunately there were two other Italian Pils recipes also provided by the authors with ingredients more readily available in this story. But, back to the idea of substitutions. I asked Mike Brennan about this too, and believe he offered some great ones:*

***Aurum** – German Tettnanger or German Northern Brewer. 'German Northern Brewer tends to have a bit higher concentration of hop essential oils, especially a-caryophyllene (woody/spicy) and b-caryophyllene (pepper/woody/herbal) than Tettnanger. However, Tettnanger is a parent of Aurum so the overlaps work well.'*

***Diamant** – German Saphir, Spalt, and Saaz. 'German Diamant's profile includes citrus/floral/berry notes; Saphir's citrus/berry overtones fit, as well as Spalt's citrus/herbal/berry and Saaz' citrus & spice. Saphir's total essential oil content (0.8–1.4 ml/100g) is the closest to Diamant's 1.5–2.0 range.'"* BYO

BEGINNER'S BLOCK

BY DAVE GREEN

TASTING YOUR HOMEBREW CRITICALLY

We gathered for the first time since the COVID-19 outbreak at one of our homebrew club member's newly opened brewery taproom. As we naturally broke off into small sub-groups, focusing on different aspects of beer and brewing, I chatted with one fellow club member about how he feels like he has really started to nail down his IPA recipe and process. But because he hasn't had anyone over to taste it he felt like there was no merit to this claim. He followed that by saying, "I just don't know how to taste my beer critically." So this piece is dedicated to him because in order to improve our craft, we all should be able to judge our beer's merits and faults.

GAINING EXPERIENCE

First of all, the more you taste various beers, the better you can hone your likes and dislikes. Some great ways to really broaden your palate include: Visiting local breweries for samplers, buying mixed-pack beers, attending beer festivals, and/or regularly attending homebrew club meetings for tasting events. Don't get stuck buying the same style by the same brewery! Did you really like the malt profile for that Munich helles? You should inquire what base malt was used. The hop character of a beer not agree with you? You could possibly find out that hop variety is one you should avoid or find a blending partner that could lift it. Get critical of other beers first. Don't be afraid to offer a critical assessment of the beer. But make sure it is constructive criticism. For example, a beer you taste is overly sweet and cloying. You could find out what yeast strain they used and the pitch rate, if they used yeast nutrients, was lactose or maltodextrin included, was the final gravity where they intended it? Trying to find the merits and faults in other's beers can really help guide your decisions in your own brewery.

FINDING FAULTS

I find that pinpointing faults in a beer is best done in groups. Unfortunately sometimes groups can go down the wrong wormhole too as the power of suggestion is a real thing in the groupthink mentality. So be sure that you don't necessarily listen to other opinions as gospel. If someone says they're finding oxidative notes, but you're not sensing any . . . go with your gut first. Finding qualified beer tasters to compare notes with can go a long way in training your palate.

A short list of common faults includes acetaldehyde (green apple), astringency (drying sensation on tongue), diacetyl (movie-theater butter), dimethyl sulfide/DMS (cooked cabbage/corn), metallic (just as it would seem, sensation on the tongue), oxidation (muted hop and malt character in light examples, wet cardboard in extreme), phenols (complicated, not always a fault: https://byo.com/article/the-phenolic-phamily/), and vinegary (just as it would seem). Yeast-related faults are typically noted with the presence of acetaldehyde and diacetyl or can appear as under-attenuated beer (sweet and cloying). Poor sanitation can come in the form of chlorophenols (Band-Aid/medicinal smelling and tasting phenols), unintended phenolics, or vinegary notes. Process-related faults are typically noted as astringency (or hop burn), oxidation, DMS, or metallic and chlorophenols (both in the case of not properly treating source water).

A great way to train your palate to sense some of these faults is through a beer faults sensory training course. Some homebrew clubs will organize such events and there are kits available online. But they are not cheap and best done in a group setting. Inventive brewers have come up with their own DIY faults sensory training. The Beer Judge Certification Program's (BJCP) study guide has one you can use to dose beer to recreate off-flavors.

TASTING YOUR BREW

Once you gain a level of comfort in expressing your likes and dislikes in certain beers you can simultaneously start picking up on the faults as well. This means you're well on your way to being honest and critical of your own brews. Just because your yeast didn't finish fermentation as low as you expected, that doesn't mean the beer is under-attenuated and will be sweet and cloying. A small misstep on brew day could have meant that was as far as the yeast could go. The beer's smell and taste will be your guide.

For tastings, don't serve samples too cold and give the glass a good swirl before you get your nose in there. Take a moment and breathe it in . . . don't rush this part. Take notes, then when you take a sip, give it a good swish around your mouth, almost like mouthwash. I personally find that sometimes a well-timed burp can bring some aromatic characteristics back to my nasal glands that were missed in first passing. You may find that a beer that finished at 1.020 instead of the expected 1.016 like it did last time, is indistinguishable in character. But still, try to troubleshoot why it finished four points higher.

Keeping a brewing journal and each beer's tasting notes will help you gain the experience and knowledge needed to improve. Don't be shy in asking for other's opinions. Just because some friends and/or loved-one's say, "Mmm . . . that's good" doesn't actually make it a good beer. I've made beers that were just not good, but friends would still say they liked them. I love tinkering with my process and recipes, something that keeps the hobby fun to me . . . some are winners, some are not . . . but each year I find the tide overall continues to lift.

BREWING ADVICE FOR YOUR FORMER SELF

We asked our social media followers the question: **If you could go back in time and tell the younger you who was just brewing their first batch of beer one thing about the hobby, what would it be?**

We received quite the response! Here are just a select few:

@CJCrerar: Spend the money on cold side vs. hot side and keg vs. bottling!

@TSbroject: You better really love doing dishes.

@springsyeti: Relax. Beer was made long before modern conveniences.

@rustybarrelbeer: Start putting money aside for a brewery.

@TrisBiss: Focus more on the cold side of brewing i.e. fermentation temperature control.

@SunriseBrewer: The boil kettle does not need to be spotless and sanitized.

@iansberg: Get a one-gallon setup for small batch . . .

@Dan76390872: Relax and enjoy, especially the hop high. Oh, and save your pennies cause it's addicting.

@esnw33430: Clean it again and always take the taps apart.

@bran09n: You are not going to save money brewing beer.

@GregCruickshank: Sanitation is key, but solid process is better.

@DoctorAmish: Don't overlook the water.

@Zdsmith31: Don't start drinking until the boil begins.

@GabRodz: Cover the house floor with towels.

Cmsthatsme: Correct fermentation temperatures are where it's at.

danpratt1977: SMaSH! Learn the right way.

kordis_brewhouse: Get ready to spend a lot of money and time on this!

garryfawson: Recipe formulation is all about the balance between malt and hops, not forgetting the importance of the yeast flavour profile for the specific beer you are making.

ct0166jrg: Don't wait 26 years to jump into all-grain . . . it's not that intimidating after all.

steventjjones: The formula iCK = cCK +1, where iCK is the ideal number of Corny kegs you wish to own, and cCK is the current number of Corny kegs you own.

boccacciobrew: Take a pre-fermentation gravity reading. Who knows how strong that first brew was.

carlstone679: Don't add yeast at temperatures higher than 25 °C (77 °F).

curtjudgesbeer: Sanitation is key. Take time to clean and sanitize and you will not be disappointed!

alfonso.mma: Don't try to acquire every setup you see on videos. Also don't try to make the strongest or hoppiest beer. Focus on well-balanced beer.

Andrew Moisant: Don't add raw fruit to your fermenter . . .

Jonny Randall: Listen to *Brew Strong* on the Brewing Network!

John Lehtonen: Focus on water chemistry and yeast health.

Ronnie Williams: Take your sweet time, don't get in a hurry. Take good notes and collect lots of data.

SweetWater Escola: Buy kegs, don't bottle.

Scott Chaney: Slow and easy. No batch a week. It will make the fun last longer and stretch the money out.

Jim Moler: Buy once . . . cry once!!!!

Steve Smalenberg: Wait until cleanup to start drinking.

David Vanlandingham: Brew beer like your grandma used to cook — by feel and instinct. Don't overthink the process and become a beer engineer.

Brandon Martin: Your beer will only ever be as good as the attention you pay to your yeast.

Evan Marshall: Don't forget the DME before bottling.

David Spain: Don't put hops down the disposal.

Chuck Gutensohn: Bottling is ridiculous, get a keg system.

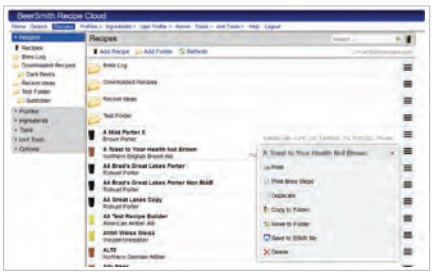
WHAT'S NEW

ANVIL OXYGEN FREE TRANSFER KIT

For use with their Crucible™ conical fermenters and stainless steel bucket fermenters, the new Oxygen Free Transfer Kit from Anvil Brewing Equipment creates a closed loop environment for the transfer of your homebrews. The transfer starts with a purged Corny keg. The beer is filled from the bottom as the CO_2 from the keg cycles to the top of the fermenter. The kit contains a 4-ft. (1.2-m) liquid hose, a 5-ft. (1.5-m) gas hose, a liquid ball-lock disconnect, 90° polypropylene elbow, gas ball-lock disconnect, and all the necessary connections to create the closed loop. Retail price is $35 and more information can be found at: https://www.anvilbrewing.com/product-p/anv-o2-free-transfer-kit.htm

LALBREW FARMHOUSE

A new yeast hybrid called LalBrew Farmhouse is the result of the research and development work of Renaissance Biosciences in Vancouver, British Columbia. Both lab and field trials have confirmed this yeast as unique, performant, and displaying a desirable saison flavor profile. The Renaissance research team used classical and non-GMO science to produce a strain that did not have the STA1 gene, responsible for the diastatic activity of traditional saison yeast strains. Care was taken to retain normal brewing sugar utilization to produce dry saisons. Additionally, the patented technology from UC-Davis ensures that the strain will not produce sulfurous off-flavors, therefore enhancing the saison yeast's aroma characteristics. https://www.lallemandbrewing.com/en/united-states/product-details/lalbrew-farmhouse



BEERSMITH WEB-BASED RECIPE EDITOR

BeerSmith has two new announcements, first is a web-based version of BeerSmith 3 along with a desktop BeerSmith 3.2 update. BeerSmith Web lets you to edit your cloud-based recipes from anywhere by simply logging into your cloud account at BeerSmith Recipes.com. This new web-based layout can be utilized on your desktop, tablet, and phone/mobile devices. This new service is a free upgrade to all Gold, Platinum, and Professional BeerSmith 3 license holders. There is a free 30-day trial available for new users along with online tutorials to help get you get started. When you purchase a Gold, Platinum, or Professional license for BeerSmith you get access to both the web-based recipe editor and the latest desktop program. Learn more at: http://beersmith.com/blog/2021/05/10/beersmith-for-the-web-preview

Upcoming Events

Brew Your Own — The How-To Homebrew Beer Magazine — Boot Camp

IN-PERSON BYO BOOT CAMP
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BYO REPLICATOR

BY DAVE CLARK

DEAR REPLICATOR, As a new brewer I find that I have had better results brewing dark beers compared with some of the lighter styles, especially lagers. I tend to like the bigger, more robust dark beers, such as imperial stouts and porters. I remember having a delicious imperial porter from Fat Head's Brewery when I was visiting friends in Cleveland, Ohio. The beer was rich, complex, and full of flavor. I'd like to take a shot at brewing one myself if you can help me out with some intel. Cheers!

Serena Clark
Sheboygan, Wisconsin

Fat Head's Brewery of Cleveland, Ohio has created quite a reputation for its hoppy beers, such as Headhunter and Hop Juju, but the malty offerings are equally impressive. The Imperial Porter is a specialty (i.e. not part of the regular menu offering) that packs a punch in both flavor and alcohol percentage. Before diving into the beer, let's talk about Fat Head's, its key personnel, and how this award-winning brewery came to be.

The brainchild of Brewmaster/Co-Founder Matt Cole and Restaurateur Glenn Benigni, Fat Heads' story crosses state lines and is a testament to determination and dedication. Matt Cole crafted award-winning beers at notable breweries such as Baltimore, Great Lakes, and Rocky River Brewing for over a decade. Like many driven Brewmasters, Cole had the vision to open his own place and when the itch grew strong enough, he called on longtime friend Glenn Benigni to see if he wanted to get into the craft brewing business.

Benigni is Owner/Operator of Fat Head's Saloon, a wildly popular craft beer bar in the heart of Pittsburgh's South Side entertainment district. Opened in 1992, it became known for its huge sandwiches coined "Headwiches" — said to be as big as a person's head. Fat Head's Saloon was one of the early torchbearers for Pennsylvania craft beer bars. Combining Benigni's business expertise and Cole's brewing magic, the two embarked on creating a brewery that would focus on equal parts great atmosphere, hearty food, and of course, world-class beer.

In 2009, the first Fat Head's Brewery opened in North Olmsted, Ohio, a suburb of Cleveland. Success was almost instantaneous, with two-hour lines on weekdays becoming the norm. No matter how hard Cole and his right hand man, brewer Mike Zoscak worked, demand quickly outpaced production, making a separate production facility a necessity just three years later.

During this extreme growth period, noted brewer Chris Alltmont joined the team, having spent time brewing at Wallaby's, Brew Kettle, Willoughby, Crooked River, and Gordon Biersch. Alltmont completed the brewing leadership team that continues to produce award-winning beers that have captured medals at prestigious competitions such as the World Beer Cup (WBC) and Great American Beer Festival (GABF).

A second Fat Head's Brewpub opened in Canton, Ohio, and another in Portland, Oregon (no longer operating as a Fat Head's) before the team went all-in on a world-class beer hall/biergarten/production facility. A $13 million endeavor located just outside of Cleveland, the new facility produces all the Fat Head's beer sent into distribution. The massive brewpub seats 275 inside and another 75 on the extensive patio. Fat Head's Brewery plans are to produce upwards of 45,000 barrels of beer in 2021.

Fat Head's has a reputation for crafting some of America's best IPAs, but the brewery has also been highly successful with its lagers and malt-forward beers. Its flagship IPA Headhunter is a two-time WBC and GABF medalist as well as two-time grand champion of the National IPA Challenge. Hop Juju Imperial IPA is a three-time GABF winner and has also captured gold at the WBC. Goggle Fogger Hefeweizen was the gold medalist at the 2020 GABF awards. In fact, Fat Head's has medaled at the Great American Beer Festival every year since the brewery's inception!

Their Imperial Porter showcases Cole's talents for packing a punch with flavor, while creating balance and a true depth of flavor. The recipe utilizes a whopping eleven different malts, many of U.K. origin, to create its complex flavor profile. The wort is boiled 90 minutes to ensure rich flavor development of the malt, as well as to ensure any potential dimethyl sulfide (DMS) from the Pilsner malt is driven off.

A combination of Magnum, Simcoe®, and Mosaic® deliver the appropriate amount of hop bitterness and flavor to complement the rich malt flavors. Good porters benefit from a relatively hard water profile. Enhancing with calcium chloride (which will accentuate the malt character) and calcium carbonate (which will help balance the acidic dark malts) is advisable for soft water. Alternatively, holding the dark malt additions from the mash until you are ready to lauter/recirculate will help. This will reduce potential astringency from the highly-kilned dark malts in the grist.

Keeping fermentation temperature steady during primary fermentation is key when brewing a beer of this strength in order to avoid production of fusel alcohols. Letting it free rise a couple degrees after it's about ⅔ fermented will help achieve the final gravity numbers and finish the beer nicely.

When it's ready to drink, serve above refrigeration temperature, preferably 45–50 °F (7–10 °C) in a tulip or similar type glass. The Imperial Porter clone makes a great complement to a decadent chocolate fudge brownie or a medium-strength maduro cigar.

FAT HEAD'S IMPERIAL PORTER CLONE

(5 gallons/19 L, all-grain)
OG = 1.086 FG = 1.024
IBU = 50 SRM = 56 ABV = 8.6%

INGREDIENTS

5.5 lbs. (2.5 kg) Golden Promise pale ale malt
4 lbs. (1.8 kg) Pilsner malt
4 lbs. (1.8 kg) Fawcett Pearl pale ale malt
1.2 lbs. (0.54 kg) chocolate malt
1.1 lbs. (0.49 kg) Munich malt (10 °L)
9.6 oz. (0.27 kg) brown malt
8.8 oz. (0.25 kg) Carapils® malt
7.2 oz. (0.2 kg) crystal malt (120 °L)
2.9 oz. (82 g) Briess Midnight Wheat malt
2.6 oz. (73 g) debittered black malt
2.6 oz. (73 g) roasted barley
9 AAU Magnum hops (60 min.) (0.75 oz./21 g at 12% alpha acids)
6.9 AAU Simcoe® hops (30 min.) (0.5 oz./14 g at 13.8% alpha acids)
6.2 AAU Mosaic® hops (5 min.) (0.5 oz./14 g at 12.4% alpha acids)
White Labs WLP013 (London Ale), Wyeast 1028 (London Ale), or Lallemand Nottingham yeast
¾ cup corn sugar (if priming)

STEP BY STEP

Using a fairly thick mash, achieve a single infusion mash temperature of 150 °F (66 °C). Hold at this temperature for 60 minutes or until converted. It is advisable to hold the highly roasted grains (chocolate, Midnight Wheat, black malt, and roasted barley) until you are ready to recirculate to reduce astringency. Start lautering by raising the mash temperature up to 168 °F (66 °C), then hold for ten minutes. Add the roasted and crystal grains then recirculate. Vorlauf until your runnings are clear before starting to collect. Since you are doing a 90-minute boil, collect about 7 gallons (26.5 L) of wort. Add the hops as stated in the recipe.

Upon completion of the boil, chill the wort to 65 °F (18 °C), pitch a healthy count of yeast and oxygenate thoroughly. When fermentation is about ⅔ complete (at 1.040), let temperature free rise to 67 °F (19 °C). Total fermentation time should be at least two weeks so the yeast has time to clean up off-flavors. Keg and carbonate to 2.6 v/v or bottle.

FAT HEAD'S IMPERIAL PORTER CLONE

(5 gallons/19 L, partial mash)
OG = 1.086 FG = 1.024
IBU = 50 SRM = 56 ABV = 8.6%

INGREDIENTS

3.3 lbs. (1.52 kg) Muntons Maris Otter light liquid malt extract
2.4 lbs. (1.1 kg) Pilsen dried malt extract
2.16 lbs. (1.1 kg) pale ale dried malt extract
1.2 lbs. (0.54 kg) chocolate malt
1.1 lbs. (0.49 kg) Munich malt (10 °L)
9.6 oz. (0.27 kg) brown malt
8.8 oz. (0.25 kg) Carapils® malt
7.2 oz. (0.2 kg) crystal malt (120 °L)
2.9 oz. (82 g) Briess Midnight Wheat malt
2.6 oz. (73 g) debittered black malt
2.6 oz. (73 g) roasted barley
9 AAU Magnum hops (60 min.) (0.75 oz./21 g at 12% alpha acids)
6.9 AAU Simcoe® hops (30 min.) (0.5 oz./14 g at 13.8% alpha acids)
6.2 AAU Mosaic® hops (5 min.) (0.5 oz./14 g at 12.4% alpha acids)
White Labs WLP013 (London Ale), Wyeast 1028 (London Ale), or Lallemand Nottingham yeast
¾ cup corn sugar (if priming)

STEP BY STEP

Heat 3 gallons (11.4 L) of water in your mash tun and add only the Munich and brown malts (in a muslin bag) for mashing. Achieve a mash temperature of 150 °F (66 °C). Hold at this temperature for 60 minutes or until converted. With about 10 minutes to go during the initial mash, add all the roasted grains (in a separate muslin bag). These grains do not need to be mashed and adding them later may help reduce astringency from the highly kilned malts.

After mash is completed, let the liquid drain from the grain bags, remove bags, then increase temperature to near-boiling. Remove from the heat source and slowly stir in all the malt extracts. Be sure extract is fully dissolved, then return to the heat source and boil for 60 minutes adding hops as indicated in the ingredients list. (Note: a 90-minute boil is not necessary to drive off DMS since that takes place during the extract's creation process.)

Upon completion of the boil, chill the wort to 65 °F (18 °C) and top up your fermenter to a total of 5 gallons (19 L) with pre-boiled, pre-chilled water. Pitch a healthy count of yeast and oxygenate thoroughly. When fermentation is about ⅔ complete (at 1.040), let temperature free rise to 67 °F (19 °C). Total fermentation time should be at least two weeks so the yeast has time to clean up off-flavors. Keg and carbonate to 2.6 v/v or bottle.

TIPS FOR SUCCESS:

According to Brewmaster Matt Cole, the non-traditional addition of roasted barley adds a nice level of complexity to balance the chocolate flavors of the other dark malts.

He suggests Crisp and Simpson's malts as the best choices for the character malts for this beer due to their high quality and flavor profile. BYO

BY DAWSON RASPUZZI

YEAST SELECTION

What the pros consider when choosing yeast

Yeast is the most critical ingredient to determine the outcome of your beer. With such a wide variety available, choosing the right strain for each batch cannot be overlooked.

The primary characteristics for strain selection should revolve around the beer the brewer is looking to produce. If the brewer is looking for a specific flavor profile (more esters, less esters, phenolic character, neutral, etc.) they should select a yeast based on the manufacturer's information about the flavor profile. Additionally, the attenuation range should be considered for the specific profile of the beer. If the brewer is looking to produce a high-alcohol beer they need a strain that is capable of high-gravity fermentation. Lastly, the brewer should consider whether they can keep the temperature in the range best suited for each yeast. Yeast suppliers do their best to communicate these parameters through their websites and publications.

Brewers should also consider the yeast's interaction with raw materials. Fermentis has performed applied research studies on how strains interact with raw materials. So far we have communicated primarily on yeast's interaction with hops. The strains SafAle S-04, SafAle K-97, and SafAle S-33 have shown strong, complementary interactions with American hops, primarily varieties rich in thiols and their bound precursors, but also with terpenic hop varieties; either bio-converting those precursors and liberating aromatic thiols and to some extent terpenes; and/or producing flavors; thus enhancing the typical hop flavors and fruity character produced by those hops, especially in styles like New England IPA.

Homebrewing isn't limited to what is "normal" in terms of strain selection and offers a chance to play with uncommon strains (or multiple strains) for specific styles. For example, I enjoy trying multiple strains in a split batch, where everything is the same except for the yeast strain and maybe the fermentation temperatures to adjust to each specific strain. This would be the scientific method to really see the impact of the yeast and allowing the brewer to make an educated decision on which strain is better. Remember to adjust the pitch rate for whatever volume you are fermenting to make sure the profile is repeatable in a "normal" sized batch.

I wouldn't say there are common "mistakes" made by those new to brewing when it comes to yeast selection, but rather that the brewer is selecting a strain that they aren't familiar with and get unexpected results. For example, if a brewer selects a POF+ (phenolic off-flavor positive) strain, without knowing that it has the capability to produce phenols. It is not difficult to understand how this can happen, if the brewer is focused on producing a beer with high isoamyl acetate or other esters. Additionally, we have found that phenolics interfere with the perception of hops in hoppy beers, which can come as a surprise to brewers making IPAs and trialing a wide range of yeast strains. In this case, the beers made with POF+ yeast strains may look good on paper, but then once tasted will not have the same flavor perception or expression of hoppy character due to the interference of the phenolic compounds. In order to have the same "hop character" the brewer would have to increase the hop dosing in the POF+ yeast strain beer.

Understand that the information produced by suppliers are in controlled, standardized experiments and can differ when the yeast is introduced into a different wort or media. This is especially true for attenuation and flavor profile, as there are a number of adjuncts (sugars, juices, alternative grains, honey, etc.) that will impact the fermentability of the wort and also introduce precursors for flavor compounds.

Understand that the information produced by suppliers are in controlled, standardized experiments and can differ when the yeast is introduced into a different wort or media.

Kevin Lane is the Technical Sales Support Manager of the Americas for Fermentis. Since joining Fermentis in 2013 he has been involved in all aspects of the business including beer, wine, cider, and distillation. Prior to joining Fermentis he has also held positions at Briess and MillerCoors, where he ran the pilot brewery.

Fausto Yu-Shan has experience as a professional brewer trained in commercial breweries using adjuncts, decoction mashing, open fermentation, and bottle conditioning. He has also instructed in quality control and yeast propagation at breweries and Wyeast Laboratories, Inc.

The primary characteristic of a yeast should be if it is appropriate to the beer style. Other fermentation considerations include:

Alcohol Tolerance: Important to know it when brewing high-gravity beers and as a general rule.

Temperature Range: Depending on the brewing equipment setup available, the homebrewer can plan which yeast strains will perform at their best for his or her brewing conditions.

Attenuation: Will indicate the amount of sugar the yeast can consume to produce alcohol, which can be controlled by the ingredients in the recipe or mashing temperatures.

Flocculation: Will influence if the beer needs filtration or, depending on the beer style, if it needs to be cloudy. It also helps in the effortless way to harvest the yeast for subsequent batches.

Flavors and Aromas: Some yeast strains will enrich the flavor or aroma, such as wheat yeast strains enhancing the banana aroma.

Vitality: As any living organism, the more active and stronger cells are selected, which in brewing will influence the fermentation performance and therefore beer production.

Viability: Knowing the quantity of living cells will indicate the capacity to adapt to an environment, as well as how the percentage of living yeast cells will impact the fermentation process.

For the beginning homebrewer we recommend starting with a versatile yeast strain, such as Wyeast 1056 American Ale because it can ferment at a higher temperature range, so in case of a mistake it can still be resolved.

One of the biggest mistakes I see among homebrewers is having high expectations when they start the hobby trying to brew Belgian or more complicated beer styles and after discouraging results the enthusiasm fades away. Gain experience and then move on to Belgian or lager beers and experiment to know how far you can manage them. After that you can move on to *Bretts* and lactic acid bacterias to create the most appetizing flavors and aromas.

BY ASHTON LEWIS

SELECTING A FERMENTER

Also: The intricacies of shelf stability

Q I'VE BEEN BREWING FOR 30-ISH YEARS. NOT BEING AS YOUNG AS I USED TO BE, IT'S TIME TO MOVE ON FROM MY OLD RELIABLE GLASS CARBOYS FOR FERMENTATION. BUT WHAT SHOULD I GET? I'D PREFER TO STEER CLEAR OF PLASTIC BUCKETS. THERE ARE STAINLESS STEEL FERMENTERS AND THE CHEAPER PLASTIC CONICAL FERMENTERS. I'M NOT SURE WHICH ROUTE TO GO.

I LIKED MY GLASS BECAUSE I COULD TAKE A PEEK AT THE BATCH, BUT MOSTLY BECAUSE THEY ARE RELATIVELY EASY TO CLEAN. BUT, THEY ARE HEAVY AND EVEN WITH A HANDLE OR LIFT STRAPS, HARD TO CARRY. I DO MOSTLY 5-GALLON (19-L) BATCHES AND THE OCCASIONAL 2.5- TO 3-GALLON (9- TO 11-L) BATCH.

KEN STECH
PENDLETON, SOUTH CAROLINA

As long as you are not aging your beer for prolonged periods in plastic, the risk of oxidation can definitely be mitigated by racking into another vessel shortly before or after fermentation is complete.

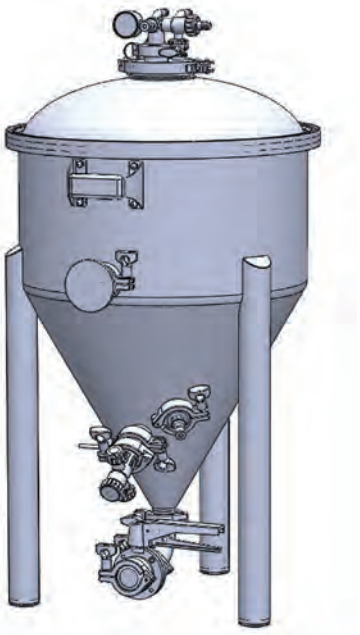

Image courtesy of Blichmann Engineering

The rise of the homebrew-sized unitank comes with an amazing array of advantages for those willing to purchase. But they are not without downsides as well, besides their price tag.

A This is a straight-up opinion question and I will give you my thoughts sans specific type or brand. And as a reminder to seasoned readers and news to newer readers, 20 years of my professional career was with a custom, stainless steel equipment company where I saw some pretty interesting brewing equipment.

My first thought on this topic is for the brewer to define what they want or need with a fermenter. When brewing at home, I like to ferment in one vessel then age and carbonate in a separate vessel. This method is well-suited for plastic. These vessels are relatively lightweight, they do not break, and make for handy fermenters. And as a bonus, clear options allow the brewer to see what's going on in the fermenter. The primary downside to plastic containers is oxygen migration.

As long as you are not aging your beer for prolonged periods in plastic, the risk of oxidation can definitely be mitigated by racking into another vessel shortly before or after fermentation is complete. Old-school brewers like us cut our teeth reading about primary and secondary fermenters. The current trend is to do everything in a single vessel, but old-school secondary vessels do have their benefits. And one of the biggies is allowing for the use of a simple primary vessel and a simple secondary vessel. At home, the handy secondary is usually a keg because beer can be aged, conditioned, clarified, and served from a single tank. Brewers with the right sort of space can open-ferment in something as simple as a bucket and rack into a keg.

But since you're not interested in buckets there are lots of alternatives in the world of plastic fermenters these days. If I were looking at this myself, I would select a fermenter with an oversized outlet valve at the bottom to allow for the removal of trub and yeast sediment, a lid on the top for easy access, and racking port for when it's time to move the beer into a secondary.

Another option these days is to do what most commercial breweries do, and that's buy a stainless steel vessel that can be used for both fermentation and all of the things that can be done in a pressurized secondary vessel. These little cuties have a long list of benefits. For starters, stainless steel is just plain cool stuff. Stainless tanks are tough, keep oxygen and light out, and can be

customized to the hilt by adding special nozzles (that's what tank-folk call the bits and bats welded to the vessel), thermal wells for thermometers, cooling jackets, insulation, and whatever else one wants to add.

With all of this comes a few downsides. For starters, a tricked out stainless fermenter is much heavier than your glass carboy. That may not be a problem if you put it on wheels or bring your wort to the tank. Another challenge is discovered when one does a cost per volume calculation, because this number keeps falling and falling as tank size increases. This fact drives brewers towards larger vessels and larger is not always better if the goal is to have fun brewing lots of different types of beer because pretty soon a brewer simply has too much of a single beer. Large or small, stainless fermenters are usually heavier than glass carboys and cannot be simply hefted into a refrigerated fermentation chamber. But these tanks can be equipped with cooling jackets and simply connected to a glycol system and controlled by picking up a thermocouple or RTD (resistance thermometer detector) to connect to a temperature controller and glycol solenoid valve to maintain the perfect temperature. But those years in the stainless world tell me this is quickly becoming expensive.

Whether you are going to plastic or stainless, consider how your new fermenter will be cleaned. Clean-in-place (CIP) equipment can be super handy, but cleaning a tank with a CIP spray ball is not always as simple as pumping cleaner through the ball, rinsing, sanitizing, and filling. While some tank nozzles, such as those on the top of a tank, are cleaned during CIP, nozzles on the side and bottom cone of tanks usually need to be cleaned by hand because they are not properly cleaned with the tank CIP cycle. Some gasket types on lids and nozzles and the doodads connected to the nozzles should also be removed, cleaned by hand, and re-assembled after cleaning.

The truth is that fancy fermenters can be a pain in the neck to clean. My preference is to minimize the number of tank nozzles to keep things as simple as possible. Speaking of nozzles, avoid pipe thread connections and industrial-type stainless steel ball valves for cold wort or beer applications because neither of these designs are hygienic (stainless is called out because material construction is only one part of hygienic design; cleanability is another).

At the risk of starting a serious chapter on fermenter design and use, I am going to ask myself a question: "What's the advice you want to give Ken?" The first has to do with getting the post-boil wort into the fermenter. Instead of bringing my fermenter to the kettle, why not take the wort to the fermenter like all commercial breweries do things. A 25-foot (7.6-m) section of beer line makes for a great transfer line, since I brew outside and ferment in my basement. Simply affix a beer nut fitting and a shut-off valves on the end. No pump required because gravity never takes a day off.

For fermenter cooling control, either position the empty fermenter into a refrigerated space before filling or rely upon the coolness of the basement and yeast strain selection to deal with what you have. The ultimate dream includes temperature controlled "closets" that are cooled with window-mount air conditioners and controlled with something like a CoolBot. Instead of using a glycol chiller, cooling jackets, controllers, and all of the stuff that comes with this sort of installation, my advice includes stainless tanks on wheels or carboys on carts that are simply rolled from fermentation into cold storage. Old-school lager cellar meets homebrewing. Oh, and this dream basement set-up includes a simple overhead crane system to help with the heavy lifting.

Questions without definitive answers are fun because they allow one to explore ideas and construct new solutions. The best advice I can offer is to ask yourself what you want to do with your brewing tools, then go out and buy, build, or re-purpose equipment to meet your brewing needs. The opposite approach is to buy something that someone else designed for things that you may not need to do. I mentioned working for a custom stainless company for a reason; stainless steel process equipment is really cool stuff, but it can become very expensive in a flash. It also can require much in the way of support equipment that can turn the homebrewing hobby into a brewery engineering hobby.

Q TALK TO US ABOUT METHODS USED TO STABILIZE BEERS, CIDERS, SELTZERS, AND SUCH THAT MAY HAVE FERMENTABLES IN THE PACKAGE.

BRIAN ANDREWS
LAS VEGAS, NEVADA

A Wow, this is quite the rabbit hole of a question. Let's start out with why a fermented beverage, be it beer, wine, seltzer, cider, or some other tasty tipple, may be packaged with fermentable sugars. The most common reason for homebrewers to have fermentable sugars in the package is for bottle conditioning. The idea, of course with bottle conditioning, is to add enough fermentables to achieve the carbonation goals of whatever is being carbonated in the package. Add too little or too much priming sugar and the carbonation is going to be off. This is why it's so important to package completely fermented beer and to know the volume of beer being primed. But that's not what this question is about. You want to know how to end up with fermentable sugars in the glass without having to worry about over-carbonated or exploding beverages.

RABBIT HOLE #1; EXPLODING PACKAGES

Most homebrewers hear stories about bottle bombs when first getting into homebrewing, and some of us have first-hand experience with these problematic packages. Aluminum cans started to really become popular with craft brewers about a decade ago and with this new craft beer package, the occasional story of an exploding can was heard. At about the same time an increasing number of craft brewers began brewing

beers with lots of fermentables in the finished beer. Heavily fruited beers, enormous imperial stouts flavored with all sorts of interesting ingredients, pastry IPAs, and smoothie sours began popping up in the market. Beers with lots of unfermentables, especially lactose and maltodextrin, also became increasingly popular, but these carbohydrates shouldn't result in refermentation in the package. At first, these beers were primarily draft beers served in limited volumes because brewers were pushing the envelope of style. Beer lovers wanted these potables in packages more portable than growlers, so breweries began canning and bottling these beers. That was when exploding packages really burst onto the scene.

Although some brewers took the odd approach of expecting customers to handle these packages with the deft skills of a beer-bomb expert, many breweries hit the pause button. A few of the cheekier breweries came up with clever packaging warning of impending explosions and others criticized consumers for not being more careful with these delicate products. The cautious crowd were developing processes and quality control (QC) practices to address this very real problem and other brewers simply decided to steer clear of the problem entirely by not producing these products. Breweries are businesses and it has become very difficult not to brew what so many beer consumers want; as demand grows, so does the number of breweries brewing these types of beers.

The rabbit hole of exploding packages presents two useful takeaway ideas for homebrewers wanting to minimize the risk of unwanted secondary fermentation. The first is not much fun, but is pragmatic; don't bottle or can beer with excess fermentable sugars. For bottle-conditioning homebrewers, this is not a huge limitation because lots of fermentables in the package doesn't work with this method. The other takeaway idea is to produce these beers, package into kegs, force carbonate, store the beer as cold as possible without freezing, which is not a problem for some of these beers chocked full of soluble solids (sugar) that decrease the freezing point to ~25 °F (~-4 °C), and keep a hawk-eyed watch for signs of fermentation. Draft beer carbonation can always be reduced by venting a keg, and an uptick in carbonation level with these sweet brews is a good signal that it's time to have some friends over to clear out the keg for another brew.

RABBIT HOLE #2; PEEKING OVER THE FENCE

Although flash and tunnel pasteurization systems are not new to U.S. craft breweries, many breweries that own these incredibly useful tools keep quiet about the topic because of the biases that accompany pasteurized beer. I have one thought about these biases . . . whatever. As more breweries started to wrestle with the exploding package dilemma, the number of craft breweries with pasteurizers began to grow.

The silver bullet to dealing with fermentables in the package is a tunnel pasteurizer that runs the entire package (beer, bottle, and cap, or beer, can, and lid) through the pasteurization process. Most commercially pasteurized beers are exposed to between about 10 and 100 pasteurization units (PUs), where 1 PU is equal to 60 seconds at 60 °C (140 °F) or 0.6 seconds at 67 °C (152.5 °F). The major flavor downsides to pasteurization, especially in beers with high levels of dissolved oxygen (above about 100 ppb), are accelerated oxidation and the development of cooked aromas during the process. Once pasteurization is complete, the risk of microbiological growth in the package drops as the PU level increases and the accelerated aging during the heating process stops. Brewers determine PU targets based upon several variables including baseline micro levels, beer properties, and expected shelf life. Another set of real problems with this silver bullet are capital expense, energy use, and space requirements.

A more compact and less costly pasteurization system is an in-line flash pasteurizer, also called high-temperature short-time or HTST pasteurization. HTST systems are the norm for milk pasteurization. The major difference between milk and beer pasteurization, however, is that the goal of milk pasteurization is to kill pathogenic microbes and the goal of beer pasteurization is to kill spoilage microbes. That's why it is totally normal for refrigerated milk to sour when stored for too long, while still being safe to drink. The challenge with using HTST systems for beer is preventing re-contamination with spoilage bacteria during filling. For this reason, tunnel pasteurizers remain the gold standard for beer.

What on earth does any of this have to do with homebrewing? Not much! But that does not stop homebrewers from peeking over the fence and wondering what craft brewers are doing, just like some craft brewers did when they peeked over the fence into larger craft- and macro-brewing operations. However, homebrewers can batch pasteurize their beer. Although not common nor practical for commercial brewers to use, bottles or cans of beer can be submerged in hot water. The thermal cycle is similar to a tunnel pasteurizer, just with a different setup. I will leave the design specifics for another day, but a simple system could be configured from a brew kettle, a cooler or two, and a water pump; load the bottles into the cooler(s), gravity drain water back to the kettle, and use the pump to deliver hot water to the cooler(s). A key requirement for this method is a counter-pressure filler. It is also best to have as little yeast in the package as possible because the heat treatment will definitely lead to cell autolysis.

One closing thought about pasteurization. It works.

RABBIT HOLE #3; UTILIZING CHEMISTRY

The modern person is accustomed to magic pills that solve all sorts of problems. Wouldn't it be great if there was a magic pill that could be added to backsweetened beverages to prevent fermentation in the package? Yeah, yeah, that's a thing. Maybe. Although potassium metabisulfite (KMS) and potassium sorbate both do a great job of slowing microbial activity in packaged beverages, neither completely prevent re-fermentation. And not all microorganisms are equally affected. Sorbate is generally more effective at inhibiting yeast than bacteria, whereas sulfites are more effective at inhibiting, and even killing, certain bacteria and wild yeast.

Because both of these compounds are weak acids, their ionic states are pH dependent and their potency as antimicrobial preservatives changes with pH. What this means in practice is that the pH of the beverage being stabilized must be factored into the determination of dosage rates. Sulfite usage has another layer of complexity because sulfites can react

with beverage compounds and become bound. Bound SO_2 has no preservative effect and the only way to know how much free SO_2 is present is to run an analysis after KMS additions. (As an aside, you can dive much deeper down this rabbit hole by visiting *BYO*'s sister publication at Winemakermag.com as sulfite levels are a big topic of discussion for winemakers). Sorbate is easier to deal with because the target levels are simply a function of pH and target organism.

Digging any further into this topic quickly becomes similar to water chemistry. The takeaways about the use of sulfite and/or sorbate to inhibit changes in backsweetened beverages are that both of these preservatives have their uses, neither are absolute, dosing rate depends on cell density in the package, and a fairly complete understanding accompanied by some wet chemistry is required to get it right. In other words, read more about this advanced topic because there is no one-size-fits-all solution.

WHAT'S THE POINT?

This entire discussion leaves one wondering how to go about backsweetening at home. My tendency leans towards a combination of efficacy and simplicity. A good start to any of these methods is yeast removal; gravity sedimentation, with or without finings, and/or filtration are the common options. Also select flocculent yeast strains that are easier to leave behind when racking.

Beverage pH was not discussed earlier in the context of secondary fermentation, but suffice to say, bottle conditioning becomes trickier as pH drops. I would take advantage of this and push my beverage pH down as low as possible without goofing up the flavor profile. No reason to make things easier for the microbes we want to stop. To finish things off, I would stick to draft-only products, keep these gems chilly-chill, be vigilant with the QC through regular "sampling."

MUSING FROM THE FIELD . . . (AN ASIDE)

Every so often I see or hear something at a brewing meeting that really gets my gears turning. Unfortunately, the last brewing meeting I attended was over 14 months ago. The lack of in-person interaction with the brewing world has resulted in more time conversing and observing in that strange world of social media. Brewing groups have been good neighborhoods to cruise when boredom sets in.

It's been really exciting to see posts from so many homebrewers who identify as "noobs" or folks who are dusting off their equipment after their last brews some years ago. Lots of great conversations out there in the virtual world. And some information that can lead those seeking information astray. The unintentional misinformation shone a light on just how amazing it is to work at a magazine for brewers with a technical review board comprised of accomplished homebrewers, commercial brewers, brewing scientists, and engineers, among other experts who are committed to helping other brewers make great beer. Here's to the whole *BYO* team!

BY GORDON STRONG

SCOTTISH EXPORT

The pale ale of Scotland

The shilling ales were unaged beer that were known by their shilling designations when bottled, or as mild ale when on draft.

SCOTTISH EXPORT
BY THE NUMBERS

OG:	1.040–1.060
FG:	1.010–1.016
SRM:	12–20
IBU:	15–30
ABV:	3.9–6.0%

Photo by Charles A. Parker/Images Plus

Our understanding of Scottish ales seems to be skewed. There is a definite Scottish national beer character, but many people seem to over-exaggerate its qualities. Unless you live in Scotland, you may not be getting the freshest examples, so you might think that age effects are part of the style profile. There are strong Scotch ales that are only distantly related to Scottish ales, yet often get lumped together when discussing styles. And then there is the whole peat-smoked malt misconception — don't get me started about that one. Combine all of these factors, and you have some pretty shaky ground upon which to base your knowledge about these beers.

Scottish ales are often referred to by their old shilling names, based on their old currency standard. Scottish export is an 80/- (pronounced, "eighty shilling") beer, a designation that is often still used. The shilling names should be considered historical and not related to modern pricing. The only real use of these names today is to differentiate products from the same brewery by strength.

Scottish export is style 14C in the Beer Judge Certification Program (BJCP) Style Guidelines, along with its brethren, Scottish light (or 60/-) and Scottish heavy (or 70/-). Together, these constitute the Scottish Ale style category (Category 14). The flavor profiles of these three styles are similar, but as with English bitters, they are differentiated by alcohol strength. The smallest of the three, Scottish light, is also a bit darker than the others.

HISTORY

Scotland is a country in the northern British Isles with a long, proud, and often violent history. Originally inhabited by the Picts, it successfully resisted the advance of the Roman Empire nearly two thousand years ago. With Gaelic and Viking influence, it struggled against English encroachment for centuries (the events of the movie *Braveheart* take place during this time period). Scotland and England formed Great Britain in 1707 through the Acts of Union and Scotland is currently part of the United Kingdom, although with some degree of autonomy.

So Scots are Scottish, not English, but both are British. The people of Scotland and England have a different background and origin, so it is best not to combine stories about them too closely despite residing on the same island. However, the political union of the two countries did lead to similarities in brewing methods and styles until at least in the late 1800s when brewing was deregulated through the Free Mash Tun Act of 1880. This led to more freedom in choosing ingredients and methods for brewing, while setting taxation based on gravity of the wort.

Geographically, Scotland is divided into the sparsely-populated, mountainous Highlands, and the flatter, more industrial Lowlands. If you draw a 45 degree diagonal through Scotland from Southwest to Northeast, the Highlands are generally the Northwestern half of the country. Historically, much of the brewing industry was located in the Lowlands, with Edinburgh and Alloa being major brewing centers that had major export business. They produced a wide range of beer styles, including IPAs, stouts, strong ales, and shilling ales.

The shilling ales were unaged beers that were known by their shil-

ling designations when bottled, or as mild ale when on draft. This is the old style use of mild that is different from today's understanding of English dark mild and was to distinguish it from stock or aged products. With increased taxation and other limits imposed by World War I, gravities dropped and products became increasingly hard to distinguish from each other in the market. The shilling ales disappeared but the names were later reused when the modern version of the styles took shape after World War II.

In current form, the Scottish light fills a similar role as dark mild in the English market, although at the lower end of the gravity range. Scottish heavy is similar to an ordinary bitter, while Scottish export is similar to a best bitter or strong bitter. The beers all have a Scottish character to them, which I will explore in the next section as I discuss their sensory profiles. Scottish ales are unrelated to strong Scotch ale (also known as wee heavy), which descended from the strong historical Edinburgh ales, a style more closely related to the Burton ales of England than anything else — another factor influencing the understanding of its flavor profile.

SENSORY PROFILE

There are four main points I'd like to make before we discuss the specifics of this style. First, a Scottish ale is not a baby Scotch ale. Do not expect the same richness, sweetness, body, and depth, especially the strength of caramel flavors. Second, Scottish export is more like a best bitter than you probably expect, particularly in terms of bitterness. Third, imports often show some oxidation, which can exaggerate caramel flavors and mute bitterness. And finally, Scottish beers in general are darker, have more body, have more residual sweetness, and are less hoppy than their English cousins.

A Scottish export can have a fairly wide alcohol range, from 3.9 to 6.0% ABV, but many Scottish examples are in the 4.0 to 4.2% range. Many craft examples produced outside Scotland tend to have higher alcohol content, a phenomenon also seen particularly in U.S. craft versions of other Irish and

SCOTTISH EXPORT

(5 gallons/19 L, all-grain)
OG = 1.042 FG = 1.011
IBU = 22 SRM = 16
ABV = 4.1%

INGREDIENTS

7.75 lbs. (3.5 kg) Golden Promise pale ale malt
8 oz. (227 g) torrified wheat
8 oz. (227 g) dark crystal malt (60–80 °L)
3 oz. (85 g) roasted barley
5 AAU British Golding hops (60 min.) (1 oz./28 g at 5% alpha acids)
0.5 oz. (14 g) British Golding hops (10 min.)
Wyeast 1728 (Scottish Ale), White Labs WLP028 (Edinburgh Scottish Ale), or SafAle S-04 English Ale yeast
⅔ cup corn sugar (for 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 to the mash.

This recipe uses an infusion mash. Use enough water to have a moderately thick mash (1.5 qts./lb. or 3.1 L/kg). Mash in the pale malt and torrified wheat at 158 °F (70 °C) and hold at this temperature for 60 minutes. Add the crystal malt and roasted barley to the mash then stir them in. Begin recirculating the wort and raise the mash temperature to 169 °F (76 °C) either by infusing with boiling water or via recirculating mash system. Recirculate for 15 minutes total. Sparge slowly and collect 6.5 gallons (24.5 L) of wort in the kettle.

Boil the wort for 90 minutes, adding hops at the times indicated in the recipe. After the boil is complete, chill the wort to 59 °F (15 °C), pitch a healthy amount of yeast, aerate well if using a liquid yeast strain, and ferment at this temperature until fermentation is complete. Condition for about one week.

Rack the beer, prime, and bottle condition, or keg and force carbonate to 2.3 volumes of CO_2.

SCOTTISH EXPORT

(5 gallons/19 L, extract with grains)
OG = 1.042 FG = 1.011
IBU = 22 SRM = 16
ABV = 4.1%

INGREDIENTS

5.4 lbs. (2.5 kg) pale liquid malt extract
8 oz. (227 g) dark crystal malt (60–80 °L)
3 oz. (85 g) roasted barley
5 AAU British Golding hops (60 min.) (1 oz./28 g at 5% alpha acids)
0.5 oz. (14 g) British Golding hops (10 min.)
Wyeast 1728 (Scottish Ale), White Labs WLP028 (Edinburgh Scottish Ale), or SafAle S-04 English Ale yeast
⅔ cup corn sugar (for priming)

STEP BY STEP

Starting with 6.5 gallons (24.5 L) of brewing water in the kettle; heat to 158 °F (70 °C). Turn off the heat. Add the crystal malt and roasted barley in a mesh bag and steep for 30 minutes. Remove and rinse grains gently by dunking the grains back into the water.

Do not turn on the heat yet. Add the malt extract and stir thoroughly to dissolve completely. Once fully dissolved, turn the heat back on and bring wort to a boil. Boil for a total of 60 minutes, adding hops at the times indicated.

After the boil is complete, chill the wort to 59 °F (15 °C), pitch the yeast, aerate well if using a liquid yeast strain, and ferment at this temperature until complete. Condition the beer for about one week.

Rack the beer, prime and bottle condition, or keg and force carbonate to 2.3 volumes of CO_2.

English styles. The beer is often copper-colored and clear, with an average-sized, off-white head.

The beer is malty, mostly with a caramel and toast flavor, but a range of nutty, toasted bread, and caramelized sugar flavors are possible. A very light roasty or burnt dryness is usually present in the finish, which can be misperceived by some as smoky. This flavor isn't smoke; it's a very light level of dark roasted malt or grain.

A light fruitiness is often present, as is a light hop flavor and aroma. These characteristics often fade when the examples are not very fresh, but do enhance the overall impression. The fruitiness is usually apple or pear, and the hops quality is English (floral, earthy, orange, spicy).

The malt and hop qualities are apparent in both the flavor and aroma and the beer itself has moderate to moderately-low bitterness. Examples in Scotland seem to have more apparent bitterness than many non-Scottish craft examples. The balance ranges from somewhat malty to nearly even malt and bitterness. The fermentation character is fairly clean and neutral other than the light fruitiness from esters already mentioned.

The body found in Scottish ales tend to be medium, a fuller mouthfeel than the equivalent English beers of the same strength. Carbonation is restrained, moderate to moderately-low. There may be a slightly dextrinous, chewy quality on the palate, but this impression doesn't last into the finish. The light roast quality helps dry the finish, and leads to a lightly malty aftertaste.

BREWING INGREDIENTS AND METHODS

I've seen several people try to explain "the" way Scottish ales are made. Good luck; there is a lot of variation between breweries. So, even if some writers offer evidence, check to see if they are using data from only one or two breweries — you can usually find counter-examples quite easily. And that's fine, as long as you understand the essentials and the points of variation.

At the simplest level, Scottish ales contain mostly pale ale malt, and usually a small percentage of something dark. They may contain a wide range of other ingredients, but this seems very brewery-dependent. The pale malt is usually something British, but not typically the biscuity heirloom Maris Otter variety. Golden Promise, an heirloom Scottish variety, is sometimes used, but most often it is a generic 2-row pale ale malt. Malt varieties change over time as growers and maltsters look for better yield and disease resistance. When I started brewing, you could find varieties like Pipkin, Halcyon, and Optic, but these have largely been supplanted. Pale ale malt is typically 85–92% of the grist.

The "something dark" is black malt, roasted barley, or sometimes chocolate malt, typically between 1 and 3% of the grist. It is primarily for color, but does add a little roasty dryness to the finish. It should not be a dominant flavor. Crystal malts, sugars, and caramel coloring can also affect the color of the finished product. Peat-smoked malt is used in Scotland by distillers, not brewers, so is not found in traditional recipes.

Many examples use crystal malts for some caramel and toffee flavors, but the percentage is often quite low. I've seen it used between 2 and 10% of the grist, often in the 3–5% range. Medium to dark crystals are most commonly used, I would suspect between 40 and 90 °Lovibond. Other, lesser-used recipe ingredients include invert sugar (darker colored), maize, and wheat (flaked or torrified). So, adjuncts are clearly fair game in the mix, although remember that pale ale malt does make up the bulk of the recipe so these additional ingredients are generally less than 10% of the recipe. Some historical recipes are simply pale malt, corn, sugar, and caramel coloring.

> **"I've seen several people try to explain 'the' way Scottish ales are made. Good luck; there is a lot of variation between breweries."**

Scottish brewers tend to use single infusion mashes, often with multiple sparges. Commercial brewers often parti-gyle their beers, producing multiple beers from the same mash. But homebrewers can safely produce beers with a single infusion, often with a higher mash temperature (say, around 152–158 °F or 67–70 °C) to produce a more dextrinous mash.

While I've used long boils and kettle caramelization to enhance the malty flavors and colors, these are not traditional methods. Traquair House talks about using a long (three-hour) boil, but this is not a common method used in other breweries. I like the flavors from kettle caramelization in a Scotch ale, but I don't think it adds much to a Scottish ale. Besides, it sometimes produces buttery flavors mistaken for diacetyl.

The hopping level for Scottish export can vary quite a bit, with bitterness in the 22 to 35 range, with many closing in on 30. In a beer with a little over 4% alcohol, this may seem like a lot. It is, but also remember that Scottish ales tend to be less attenuated so have some residual sweetness to balance that bitterness. 30 IBUs won't seem the same in a Scottish export as they do in a best bitter. English varieties are most commonly used, Golding and Fuggle often for late hopping, and any variety for bittering. I think many U.S. brewers shoot for a lower bitterness level or increase the maltiness and caramel flavors to affect the balance.

Scottish ale yeast is cool-fermenting, albeit not cold like lagers. It's more like the alt and Kölsch temperatures, around 59 °F or 15 °C. Scottish ale yeast strains are available from multiple suppliers. They are fairly clean, work well at cooler temperatures, clear well, and tend to leave some

residual sweetness. If you select a different strain, these are the desirable characteristics to seek. Scottish brewing water is fairly soft, so I would avoid minerally profiles.

Scottish ales are styles where homebrewers love to experiment and build flavor profiles often with non-traditional methods and ingredients. I think that's a lot of fun and helps when you can't get the right ingredients, but don't be fooled into thinking that just because you hit your desired flavor profile that Scottish brewers must also be using these methods and ingredients.

HOMEBREW EXAMPLE

I have selected a lower-strength version of this style, very much typical for Scotland, at 4.1% ABV. The bitterness level is 22 IBUs, which is also average, although many American palates may prefer cutting that back to 15 IBUs — I leave that to the brewer as an option.

I love Golden Promise malt, and it makes a very good base malt for all beers Scottish. It has a lightly bready and toasty flavor without being excessively biscuity. Torrified wheat at around 5% of the grist adds some body as well as a flavor like toasted whole wheat bread. I know this can be hard to find, so you could also use flaked wheat or flaked oats as a substitute. A little flavor is OK, but it's mostly about the body.

Some dark crystal malt (also around 5%) for color and a little bit of caramel and fruit flavors, but not so much as to dominate. A crystal in the 60 to 80 °Lovibond range is fine for this purpose, preferably something British. Finally, adjusting the color using roasted barley, which also gives it a little dryness in the finish. The beer should not taste roasty or porter-like. Black malts could also be used. Note the technique of adding these color grains during the recirculation.

I'm mashing the beer on the high side to encourage dextrin formation and body, so this is mostly about mouthfeel. It also tends to make the beer a little less fermentable, which is also an important part of the flavor profile of Scottish beer.

Fresh Scottish ales often have a moderate, supportive hop flavor, and I like how the floral Golding hops work in this mix. The same hops are used for bitterness as a convenience, but anything British would work.

I have always used Wyeast 1728 (Scottish Ale) in my Scottish recipes, and am happy with it. Fermenting it cool is traditional, and the yeast does work well at this temperature. The recipe lists some possible substitutes, but stick with yeast that are clean and can handle lower temperature fermentations.

This recipe can easily be scaled down to make a Scottish heavy, say at 3.5% ABV, or scaled up to a stronger but still export strength 5.2% beer. Pick the alcohol level you want, and let your recipe software do the work for you to scale it. It's warm out now, so I prefer to have a few more sessionable options on tap. 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.

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.

We look forward to seeing you in person in Denver!
Three-Day and Two-Day Registration Options Available.
Full Event Details Available at:

BYOBootCamp.com

Photo by Charles A. Parker/Images Plus

UP IN SMOKE

BAMBERG'S HISTORIC RAUCHBIER

by Scott Burgess

In 1993 I moved to Bamberg, Germany to drink rauchbier.

Okay . . . the official reason for my move was to study comparative literature as part of my Master's degree program at the University of South Carolina. U of SC has had an exchange with the University of Bamberg since 1975, and in the spring of 1993 I had been chosen to participate for a year starting that fall.

I ended up staying for ten years.

But my extended stay was not to complete my official studies. My true calling turned out not to be the hallowed halls of the university. Rather it was the green double-doors and the smooth, hand-sanded tables of the Schlenkerla tavern — just an alleyway or three away from my dorm room — that beckoned me to study what would become my "one true love" in the beer world. Eventually, I would abandon my graduate studies and my career in academia completely and take up brewing rauchbier professionally.

Bamberg, Germany is the birthplace of rauchbier, which still thrives in and around the city. Pictured here is Bamberg's Old Town Hall built over the Regnitz River.

"Half of Bamberg doesn't even like rauchbier," one of my students in the English conversation class I taught at the University of Bamberg told me early on in my stay. And she was no newcomer to the town or the beer. A "born Bamberger," as they say, she grew up literally in the halls of the famous tavern. Both her grandfather and her father were members of the super-select, locals-only *Stammtisch* (regulars' table), and she often sought them out there while walking about town after school on a regular weekday evening or on the weekends. After a lifetime of living in the city, she had never developed a taste for the stuff.

She wasn't alone. Rauchbier — or smoke beer — is a polarizing style in the beer world, perhaps the most polarizing. Its initial punch of smoke can baffle both the taste buds and the brain. Something seems not to register initially when you taste smoke in your drink. In short, it's a shock. Generally, you either love it or hate it. But even if you belong to the former group, you may not have gotten there immediately. I didn't.

When I arrived in town to begin my studies — just after making my way via bus to the riverfront youth hostel to drop off my backpack — I hopped the bus back into town and went straight to the tavern. This was a Tuesday. How do I recall such a detail? Because the tavern was closed. Tuesday was *Ruhetag* (roughly, "rest day") at Schlenkerla back then. And so it was that I would then make my way to drink what I call the second-best beer in the universe, Spezial Rauchbier.

A SHORT HISTORY OF RAUCHBIER

At least in Bamberg, the oldest rauchbier belongs to Brauerei Spezial, which dates to 1533. Schlenkerla lists 1678 as its founding. But the "style" likely goes back much longer. Some claim all beers used to be rauchbiers to some degree, since before modern techniques, beer was brewed (and malt was dried) using open fires. This is up for debate. What's not up for debate is that Bamberg has clung to these (and other) traditions rather stubbornly, and that rauchbier is a bit of an anachronism, no matter how you slice/brew it. Beechwood is traditional for smoking malt for rauchbier. It imparts a gentle smokiness from its clean-burning wood. There are other woods used for smoking malts — such as oak or cherry — that impart a different character. But beech is what's used for classic Bamberg rauchbier. (And despite there being various variations on smoke beer, classic rauchbier is what we are focusing on here.)

The smoke character is not meant to overwhelm or even consistently dominate the flavor of rauchbier. I say that the best beer in the universe is a smoked beer. The worst beer in the universe is also a smoked beer. I once got a tension headache from trying to choke down a full bottle from a brewery (that shall remain unnamed here) that apparently believed the more

smoke the better. Smoke beer is not meant to be a "stunt beer."

Historically it's been a beer of daily sustenance. And the locals sustain themselves in quantity. Bamberg has (or at least has historically had) one of the highest per capita beer consumption numbers in the world, and half the town makes up those numbers by drinking rauchbier.

The two most famous rauchbier breweries in the world are within its medieval center, and there were more rauchbier breweries in Bamberg in the past. Up until as recently as a century ago, there were some 110+ breweries operating within the small city center of approximately 70,000 people. Some continued to dabble in the style for decades; some dropped it altogether; and some have now revived it as its popularity among locals and visitors continues to grow. In addition to Spezial and Schlenkerla among in-town breweries, Greifenklau and Kaiserdom (and the Weyermann pilot brewery) make a rauchbier. Outside of Bamberg, a few dozen others produce at least one classic rauchbier. Rittmayer in Hallerndorf; Hummel in Merkendorf; Posthornla from Hönig in Tiefenellern, as well as versions from Knoblach in Schammelsdorf; Göller from Zeil am Main; Fischer in Greuth; and Kundmüller/Weiherer in Viereth-Trunstadt are some of the more famous and popular examples. Any fear that the style might not survive — and survive in its true authentic "*aecht*" forms — are not at all well-founded.

THE BEER(S)

Spezial Rauchbier is milder than its more famous relative, Schlenkerla. Many of my friends who would not drink Schlenkerla would drink Spezial. I felt that this was maybe due to the location in which it is served: the Spezial Keller, with its famous 7-spires view — a panoramic perspective across the pitched roofs of the entirety of the city of Bamberg and beyond. (Also known as "the best place on earth.")

But it's also due to the beer. Spezial's smoke is much milder than that of Schlenkerla. Like Schlenkerla, Spezial has its own in-house maltings. Local barley is malted using the smoke from a beechwood fire (Bamberg is surrounded as much by barley fields as it is by beechwood forests.) The grain that has been dampened to start germination is dried out, not in a kiln, but by the beechwood fire — specifically, by the smoke, traditionally at a cool 120 °F (49 °C). How the two most famous smoke beer breweries achieve their desired degree of smokiness is both an open secret and a proprietary process. You can watch videos of beechwood logs being chucked into a furnace at both breweries, but you cannot obtain the resulting malt commercially. The Weyermann Malting Co. also has its own process. They, too, keep the details of their kilning more or less protected. But all three produce a very different product. Weyermann malt is widely available commercially throughout the world. Other maltsters produce a smoked malt, but Weyermann's is the classic commercial version.

Spezial Rauchbier Lager exhibits a gentle smokiness. Almost treacle-toffee sweet, with a bit more rustic, grainy character. Their regular rauchbier is the mainstay at both the Keller and the tavern. It's the one I drank that first day, and it was pure heaven. So good that I almost forgot about Schlenkerla. In fact, as I drank one and then another . . . and then another, I thought that there's no way that anything could possibly be better.

That's the thing about rauchbier. Once you get a taste for the stuff, it's hard to stop. Rare is the beer or beer style that tastes better the more you drink of it. With a big IPA or a fruity sour or a (pastry or regular) stout, the first sip is usually the best. But after two or three pints, the flavors can become overwhelming or even fatiguing, in my experience. Not so with rauchbier, at least not rauchbier done right, as it's done almost everywhere in Bamberg and environs. Yes, there's an initial punch of (sometimes powerful) smoke. But if you stick with it — and the locals say you need to drink at least three half liters in order to clear that hurdle — the "base" beer begins to emerge. In the case of Spezial Lager, the base is a smooth, super-drinkable amber lager of moderate strength. It's almost like what U.S. brewers or drinkers would call a Vienna lager. Spezial also brews a Märzen. Some of these beers taste like what some drinkers (misguidedly) associate with a Märzen: A deeper maltiness bordering on caramel and perhaps a hint of roastiness. In German terms, Märzen is simply a strength designation. In the case of Spezial, it's a slightly stronger version of their lager. But it's not always (or even at all) caramelly and/or sweet. What it always is, though, is absolutely delicious.

In the case of Schlenkerla, the Märzen strength is their (liquid) bread and butter. Aecht Schlenkerla Märzen is the most famous example of the style in the world. And with good reason. It's the best beer in the universe. Okay, okay. Beer is not a competition. Everything has its place, etc. etc. But, in this drinker/brewer/author's opinion, it's still the best beer in the universe. After passing the famous, much closer-by tavern to return to Spezial for the better part of my first week

The Schlenkerla tavern serves their rauchbier in a half-liter Willi Becher glass served exclusively from traditional pitch-lined wooden barrels.

The famed entrance to Schlenkerla tavern in Bamberg, Germany.

in Bamberg, I finally made it through that warmly glowing portal beneath the traditional half-timbered façade just down the alley from home. And I never turned back. At first, the intensity was too much for me. It was a totally different experience from Spezial. Schlenkerla Rauchbier is, in almost every way, much more intense. Its smoke is stronger, more lingering. Its ABV is a bit higher. Its color is darker. Its slight roastiness and dry finish are deeper, and its drinkability even greater.

One of the biggest misconceptions about rauchbier is that it's not very drinkable. "I like it, but I could only have one," is the refrain I've heard a hundred times. Nothing could be further from the truth. Once you clear the aforementioned hurdle — and during that first visit after becoming a devotee of Spezial, it took me a while to clear it — you simply can't seem to stop. Well, I couldn't. Haven't. Won't.

With Schlenkerla Rauchbier, the emergence of the burnt toffee character reveals itself more slowly, more subtly perhaps. The dry, almost ashen finish invites you back for another sip. The smoke begins to take a backseat. The soft carbonation – Schlenkerla still serves their Märzen exclusively from traditional pitch-lined wooden barrels at the tavern – allows the beer to slide down scarily easily. How many times have I stared into my *Seidla* (half-liter glass; at Schlenkerla an unbranded Willi Becher, specifically) marveling at the stuff. Surely it couldn't be that good.

Surely it is. Every. Single. Sip. Every single time.

Starting with these two most famous examples in the most famous settings for the style is almost certainly your best bet for any introduction to rauchbier. (If you can't make it to the taverns, you can usually find bottles of both at specialty shops pretty much across the globe. But be forewarned: As the beer ages, it can take on a meaty, umami-like character that isn't found in the freshest stuff at the source.)

But the journey is just beginning. The style has become more and more popular with local breweries around Bamberg over the years (as well as with U.S. and other craft breweries worldwide). When it comes to breweries around Bamberg, there are many. When I lived there, within an hour's radius by car, there were more than 375. (Within an hour's radius by bike, an even better way to explore, there were around 150.) Of these, a handful make rauchbier. All are worth seeking out. Rittmeyer's, just south of Bamberg, is best consumed at the beautiful Kreuzberg Keller. It has a wonderful, mild smokiness and almost a crisp, even bright finish from the yeast. Wagner's version is a classic example. Hönig, as with their other delicious beers, brews a rustic version that seems to slide down even more easily than most of the rest somehow.

BREWING YOUR OWN RAUCHBIER

As mentioned, classic rauchbier is always made using beechwood smoked barley malt. You can smoke your own (if you have beechwood), but your best bet for concocting a version is to obtain some fresh beechwood barley smoked malt ("Rauchmalz") from Weyermann. Not to knock local homebrew shops, but the Rauchmalz I have found in bins at mine has been far less fresh than desired. This could be due to it being less than popular and thus sitting out for longer than most malts. Regardless the reason, if Rauchmalz is exposed to the elements for any considerable amount of time, its smokiness will almost always degrade and you will not get a very good result. So, buy bags and buy fresh if possible. Also: No cherrywood or peat-smoked malt (the latter of which should never really be used in brewing beer). We are talking classic here.

How much Rauchmalz should you use? Go big. Or at least bigger. Some fear that anything over 25% or so will

be overwhelming. I find anything under 50% to be nearly undetectable when attempting to capture the character of classic rauchbier.

Hops are traditionally of the noble German variety for both bittering and aroma. A touch of earthy spiciness is a nice way to balance the mild phenols of classic rauchbier. So, a Tettnang or a Spalt is usually a good choice. Again, don't be shy with your hops. Rauchbier can be hoppy. Schlenkerla Märzen comes in at 30 IBUs. Spezial and other popular versions are somewhere in the mid- to upper-20s. It's all about balance here, and the smoke can require a healthy dose of hops to balance its (initial) intensity.

Yeast among classic brewers is almost always the Weihenstephan strain, 34/70. A clean feel and finish are desired so the star of the show can shine. As with smoked meat, "slow and low" is a good approach to fermentation. Pitch your yeast at low temperatures and let them free-rise during primary. After primary, drop the temperatures to the low 30s (around 0 °C) and lager low and long. The smoked malt lends an antioxidative aspect to the beer, so the longer the better.

Clarifying can be done using your usual methods. I've used gelatin, lenticular filtration, and plain old long, cold lagering to good effect. Rauchbier varies in color from gold to fiery orange to red to deep brown or even black. Rauchmalz from Weyermann, however, isn't going to get you to those darker hues on its own. For color, use the old German trick of adding a bit of roasted malt during recirculation to get your desired hue. Adding a touch to the mash as well will of course impart a hint of roastiness, but too much is not appropriate. So go easy there.

For a lager strength, you can shoot for a specific gravity (SG) in the range of 1.047 to 1.053. For a Märzen strength, a bit higher. For a bock strength, 1.058 to the high 1.060s.

And with that, let's take a look at a clone recipe for the rauchbier we brew at Bierkeller in Columbia, South Carolina.

BIERKELLER RAUCHBIER CLONE

(5 gallons/19 L, all-grain)
SG = 1.055 FG = 1.013
IBU = 28 SRM = 20 ABV = 5.4%

Knowing we at Bierkeller (Columbia, South Carolina) would never be able to replicate either Schlenkerla or Spezial without access to their brewery-smoked malts, we went for something in between with our Rauchbier recipe. We feel it captures some of the depth of smokiness and dryness (and color) of Schlenkerla's famed rauchbier as well as some of the rusticity and sweetness of the beer brewed at Spezial (especially their Märzen).

INGREDIENTS

10 lbs. (4.5 kg) Weyermann Beechwood Smoked Barley malt
1 lb. (0.45 kg) Munich II malt (10 °L)
6 oz. (170 g) Carafa® Special III (dehusked)
6 AAU German Tettnang hops (60 min.) (1.2 oz./34 g at 5% alpha acids)
2.5 AAU German Tettnang hops (15 min.) (0.5 oz./14 g at 5% alpha acids)
White Labs WLP830 (German Lager), Wyeast 2124 (Bohemian Lager), or SafLager W-34/70 yeast
¾ cup corn sugar (if priming)

STEP BY STEP

This is a two-step infusion mash with a 30-minute rest at 144 °F (62 °C) and a 20-minute rest at 154 °F (68 °C). Mash-in at a ratio of 1.5 qts./lb. (3 L/kg) strike water to grains, withholding three ounces (85 g) of the Carafa® until you begin recirculation (vorlauf). At the end of the second saccharification rest, either raise the mash temperature to mash out at 168 °F (76 °C) or begin the vorlauf process. Sparge with enough water to collect 6.5 gallons (24.6 L) of wort in the kettle.

Boil for 75 minutes adding the first hop addition after 15 minutes and the second with 15 minutes left in the boil.

Once the boil is complete, chill the wort and aerate well if using a liquid yeast strain. Pitch a healthy amount of yeast (we suggest making a yeast starter if using a liquid yeast or two dry yeast sachets) at 48 °F (9 °C), allowing it to rise to 52 °F (11 °C) during the first week of fermentation, then to 58 °F (14 °C) during the second week.

When fermentation is complete, lager/secondary at around 30 °F (-1 °C) for a minimum of nine weeks once terminal gravity is achieved. Carbonate to 2.4 volumes. BYO

Photo courtesy of Scott Burgess

The Bierkeller Rauchbier (pictured here) pours a copper hue and features a flavor somewhere between Schlenkerla and Spezial's famous examples of the style.

GET THE MOST FROM YOUR YEAST

BEST PRACTICES FOR BEST RESULTS

by Aaron Hyde

Photo by Charles A. Parker/Images Plus

What we know about yeast and how we manage fermentation has changed dramatically since the early days of brewing, and even in recent decades. Advances in microbiology have gotten us closer to the fungus among us than ever before. Now more than ever, new liquid and dry yeast strains are coming to market faster with reliable cell counts and packaging of liquid yeast continues to evolve.

These advancements are in support of the brewer's true best friend; a single-celled microorganism that makes this beautiful hobby of homebrewing possible and the flavor profile of our beer up to us. Let us dig in deeper and look at how we can get great fermentations from our yeast every time.

BY-PRODUCTS AND A BIT OF BASIC YEAST BIOLOGY

In simple terms we usually think of yeast as consuming sugar and producing ethanol and carbon dioxide (CO_2). These are the two major by-products of fermentation. More specifically, yeast absorbs sugar, and enzymatically breaks these sugars down through fermentation into energy, while simultaneously producing myriad biochemical intermediates used to build cell mass. As important as ethanol and CO_2 production are to brewers, yeast also produces a wide variety of esters, higher alcohols, aldehydes, sulfur-containing compounds, and phenols. These other compounds are ultimately very influential to how your beer is going to taste. For example, Belgian ales, German wheat beers, English bitters, and Bohemian Pilsners all require very different yeast strains to drive the defining character and flavor of each.

There are many different varieties of yeast, and these varieties are often associated with specific styles. Sometimes we want to enhance phenols and esters based on the beer style, and sometimes we try to keep these in check, or make a clean beer. There are yeast strains capable of providing high phenols, others that are perfectly clean fermenters, and others that fall somewhere in between.

There are many other characteristics we look for in yeast, such as how vigorous it ferments, how quickly it ferments, what sort of alcohol tolerance it has, ideal fermentation temperature, propensity to leave behind diacetyl, what sort of attenuation it has, and flocculation. Understanding these properties can be important to understand the yeast's limits. To manage flavor though, start by following the manufacturer's instructions and use the appropriate yeast to the style you're brewing, and those statistics can be inconsequential as long as the flavor attributes it creates match what you're looking for.

Ultimately the best flavors will come from treating your yeast right. The goal is keeping the yeast in the environment in which they thrive to get the best from them. Think of them as living creatures with needs, and you will find that the better you treat them the more they will love you (and your beer) back. Proper treatment creates the expected flavor profile and the right balance of yeast flavor against the other major flavor contributors like malt and hops for the style you're trying to brew. It's as important as any other ingredient whether it's to create a clean profile that can showcase hops or create phenols with clove-like flavors as expected in a German weissbier. Brewing a beer that meets your expectations can be achieved by:

1. Selecting the right yeast.
2. Fermenting within the recommended temperature range.
3. Keeping the yeast healthy and fed properly.
4. Making sure the yeast quantity used is correct.

It may sound like a lot, but it's quite achievable for anyone brewing beer. Let's look closer at these four topics, and in combination, they will give us the best practices for getting the most out of our yeast.

CHOOSE THE RIGHT YEAST

It can be fun to experiment with yeast, but nothing can send your beer in the wrong direction when you're trying to brew a specific style like an odd choice of yeast. You might be tempted, maybe you have a sachet or vial tucked away in the back of your fridge for a Belgian ale, but are brewing up an American pale ale. "What could go wrong?" you think. Don't treat yeast like a Swiss army knife. A Belgian ale strain will quickly overwhelm the hop character of a pale ale.

Yeast is typically categorized into ale and lager yeast, with some unique strains like Kölsch, kveik, and California lager pushing the boundaries of these traditional categorizations. Ales are usually top fermenting, at warmer (think room) temperature, 66–72 °F (19–22 °C). Lager yeast are bottom fermenting, at cooler (think cellar) temperature, 48–54 °F (8–12 °C). If you want to brew a hazy IPA, don't expect any yeast to work, though many are quite capable. Brewing a Czech Pilsner? Forget about going near an ale yeast for anything authentic.

When it comes to selecting a yeast the hard work has been done for you. Yeast companies do a good job cataloging and marketing their yeast by beer style. The name may not speak specifically to the style, but it may speak to the region the style is associated with. London Ale yeast strains, as you might suspect, are great in bitters and other English styles. Then

Photo by Michael Dawson

Pitching an adequate amount of healthy yeast is a key factor in a healthy fermentation. When using liquid yeast this may mean making a yeast starter to build up the cell count.

again, London Ale yeast is very popular to ferment New England IPA, so not everything can be learned from a name. Reading the recommendations and characteristics of each strain provided by the manufacturer will prove beneficial. With a general understanding of beer style characteristics, and how yeast influences their flavor, you will soon be able to understand what differentiates a "clean" strain from a "phenolic" strain.

This sort of yeast diversity keeps beer interesting and, when factoring in different malts, hops, adjuncts, beer gravities, and water profiles, allows for a nearly unlimited number of flavor combinations.

So how does one go about picking the right yeast once you've decided on a beer style to brew? First, find out what's available to you online or at your local homebrew store and use the yeast lab's website for more information. As mentioned before, there are a wide variety of statistics available, but if you're brewing the beer "to style" using something like the Beer Judge Certification Program (BJCP) guidelines, the yeasts that are recommended to you for the style you are brewing should all be good candidates. This means you can let flavor dictate your decision. Using Chart 1, below, let's look at an American stout as an example and compare just a few yeasts that are recommended by their yeast lab for the style.

American stout can be very roasty, somewhat bitter, and hoppy. With that in mind, we know we want something that can really focus on the malt and hops. Most of these yeasts mention being clean or neutral, which will allow these roasted and hoppy flavors to come through. What would you choose for the style? It really comes down to personal preference to hit your taste preferences.

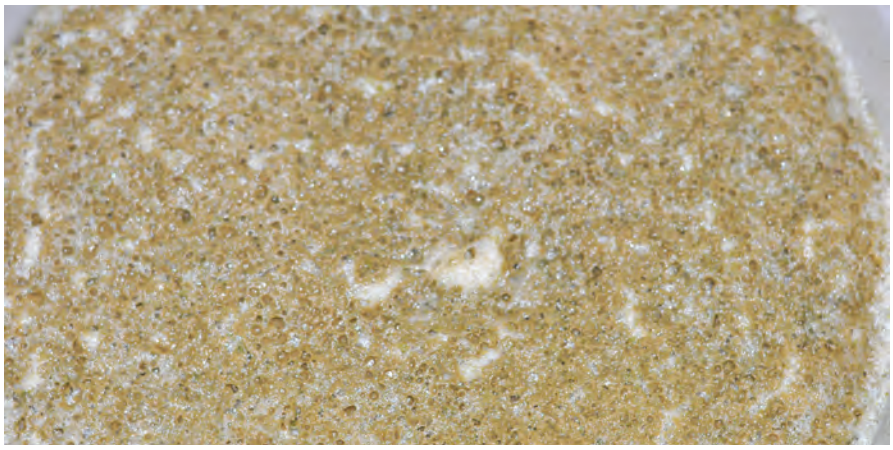


Photo by Jason Phelps

Fermenting in a yeast's ideal temperature range will help keep it from stalling or developing off-flavors.

CONTROL YOUR FERMENTATION

Controlling the rate of fermentation through temperature control is probably the most challenging factor for many homebrewers. Homebrewers put off focusing on this mostly because it can be expensive and take up a lot of space. To really have control you will likely need some sort of cooling (refrigeration), heating directly attached to the fermenter or indirectly creating ambient heat in your fermentation space, plus a thermostat to control these devices. It can get even more expensive if you invest in a professional unit like a glycol chiller paired with a fermenter that can be connected.

One thing that can be hard to quantify is the effect of temperature fluctuation on yeast. It has been proven that this can stress the yeast and create variability in the yeast produced during fermentation.[1] Is this always a bad thing? Maybe not. But temperature stability and control offer expected results, without it you can get what can sometimes be described as odd, complex, or fuzzy flavors.

So, what should you do? First and foremost, always ferment in the recommended range for the yeast. If you can do that you have won half the battle. The other half of that battle is to be able to keep the temperature stable. Some cooling systems also offer some sort of heating options. A dual thermostat can have a single temperature you can set it to, and a place to plug in both a heater (say a heating pad) and cooling device (this might be the fridge your fermenter lives in). This sort of control ultimately goes further in controlling flavor development than nearly any other part of the brewing process. Of course, low-budget options are also available. If you have a temperature-stable space in your home, fermenting there is the easiest option.

There are a few other things around temperature that will ultimately lead to a better beer. Be sure not to pitch too warm. Some yeast like it warm and will kick off fermentation quickly and create a bunch of phenols and esters you don't want. On top of this, fermentation is exothermic — it creates heat. This alone can send the yeast out of its ideal temperature range. If you don't have a way to control fermentation based on a thermostat that measures the temperature

Chart 1: Comparing American Stout Yeast Options

American Stout Yeast Options	
Strain	**Characteristics as provided**
California Ale (offered as White Labs WLP001, Fermentis SafAle US-05, Wyeast 1056, and Lallemand BRY-97)	Famous for its clean flavors, accentuates hop aromas and flavors.
Imperial Yeast A10 (Darkness Ale)	A unique character that matches perfectly with roasted and caramel malts.
Wyeast 1272 (American Ale II)	A soft, clean profile with hints of nut and a slightly tart finish.

of the beer, you may want to check it and see if you can cool it down a few degrees further once fermentation starts. A water bath or wet towel or t-shirt draped over the fermenter can help provide this. If fermentation temperatures get too cold it can slow the yeast down or pause fermentation, but a bit of additional heat will typically get them kicked off again.

MAKE SURE THE YEAST HAVE NUTRITION

Just like we need to eat a well-balanced diet to stay healthy, so do yeast. If yeasts do not have a proper nutrient balance from wort, beer flavor can be negatively affected.

Luckily, barley and other malted grains are also filled with fatty and amino acids that yeast love and is quite nutritious. Compounds like nitrogen and phosphates are required for yeast to be able to build strong cell walls, absorb sugar, and reproduce. Brewers wort really is a pretty solid yeast nutrient when all-malt beers are being brewed. The one micronutrient that is often lacking in wort is zinc, and this is one reason why nutrient blends are commonly used. Nutrient blends are also very helpful when brewing with adjuncts or higher gravity worts because the amino balance can be less than ideal, resulting in sluggish fermentations that may not completely finish.

Many homebrewers skip adding nutrients, however there are a few reasons skipping a pretty simple step toward better beer isn't a great idea. For one, things like zinc are not readily available and can really help fermentation. Two, higher gravity, stronger beers, take much longer to ferment, requiring the yeast to reproduce for a much longer time. This requires much more nutrition to complete fermentation. Another reason is that healthy yeast can complete fermentation faster, which means less time in the fermenter, less generations of yeast that can mutate or grow weak, and less time worrying about temperature control. Also, if you are brewing with a lot of unmalted adjuncts such as corn, rice, or just plain sugar, yeast nutrition may be lacking

WHEAT BEER TWO WAYS – AMERICAN WHEAT BEER & GERMAN WEISSBIER

(6 gallons/23 L, all-grain)
OG = 1.051 FG = 1.011–1.1014
IBU = 15 SRM = 4 ABV = 5.3%

You'll be brewing one batch but need two fermenters as you'll be pitching two different yeasts. The American wheat will use an American ale yeast like SafAle US-05, where the weissbier will require a German wheat strain like Mangrove Jack's M20.

INGREDIENTS

5.5 lbs. (2.5 kg) Pilsner malt
7 lbs. (3.2 kg) light wheat malt
4 oz. (113 grams) rice hulls (optional, but recommended)
3.5 AAU Perle hops (30 min.) (0.5 oz./14 g at 7% alpha acids)
1 oz. (28 g) Cascade hops (0 min.)
1 tsp. yeast nutrient (5 min.)
Clean American ale strain like SafAle US-05 yeast
Banana/clove weiss strain like Mangrove Jack's M20 yeast
6 oz. corn sugar (3 oz. per fermenter, if priming)

STEP BY STEP

Mill the grains and dough-in, targeting a mash of around 1.5 quarts of water per pound of grain (3.1 L/kg) and a temperature of 153 °F (68 °C). Hold the mash at 153 °F (68 °C) for 60 minutes. Sparge based on your system, but with enough water to yield a volume of 6 gallons (23 L) of post-boil wort, following a 30-minute boil.

Bring to a boil and add the hops and yeast nutrient as indicated. After the boil, add the Cascade hops and give the wort a long stir. Let settle for 10 minutes then chill the wort to 70 °F (21 °C) and transfer the wort evenly distributed between two sanitized 5-gallon (19-L) fermenters.

Pitch a full package of yeast into each fermenter and ferment both at 70 °F (21 °C) until activity has ceased. The fermenters may finish at different gravities. If bottling, dissolve priming sugar in ¾ cup water and add evenly to both fermenters just prior to bottling for natural carbonation. If force carbonating in a keg, target 2.5 volumes CO_2.

EXTRACT OPTION

The recipe can be brewed with just extract quite easily, completely skipping the mash. Replace the Pilsner and wheat malts with 7 lbs. (3.2 kg) of Bavarian wheat dried malt extract (DME). Add 3.5 lbs. (1.6 kg) of DME to a kettle filled with 3 gallons (11.5 L) of warm water. Bring to a boil adding hops and nutrient as per the schedule. Just before the end of the boil stir in an additional 3.5 lbs. (1.6 kg) of DME along with the Cascade hops. Stir to create a whirlpool and let settle for 10 minutes. Cool, and evenly divide wort into two separate 5-gallon (19-L) fermenters. Top up fermenters with water so both contain 3 gallons (11.5 L) wort. Continue to ferment and carbonate based on the all-grain instructions.

NOTES:

You'll notice the German weissbier style has little to no hop character, with almost all of the flavors being driven by the yeast esters and phenols, combined with some wheat malt character. You may get little to no hop aroma, which will be obstructed by the yeast.

With the American wheat style, you'll notice more hop aroma, more distinctive grain-derived wheat flavors, possibly even a bit bready, and a much cleaner finish with few phenols and esters.

You can run similar tests and change other variables. Using one strain of yeast, pitch into two fermenters and ferment one at the high end of its fermentation range, and one at the low end. These types of experiments will improve your understanding of how yeast and fermentation environment variables affect beer flavors.

from just your grain bill and nutrition should be considered.

There are many good yeast nutrient blends out there, and most include similar ingredients. Something like diammonium phosphate is a common yeast nutrient either on its own or in a blend. It is a good source of nitrogen for yeast, which helps yeast metabolize and multiply. Most blends contain zinc and other trace minerals. Without something like zinc, yeast can end up working much slower, as it helps with synthesis and absorption of sugars.

In general the nutrition provided by yeast nutrients available to the homebrewer are to help the yeast build healthier bodies (cell walls), help them absorb sugar, process that sugar, and reproduce. If any of these is compromised the fermentation process can fall apart. Sometimes that just looks like a sluggish fermentation, other times it means a completely stuck fermentation. Should you ever need to restart or need help finishing a fermentation, pitching both new yeast and nutrients will be more effective than pitching yeast alone.

YEAST NEED OXYGEN (INITIALLY)

Another major consideration in keeping yeast healthy is oxygenation. Multiplying yeast need oxygen to synthesize sterols and unsaturated fatty acid because these compounds are part of cell membranes. Yeast initially need to grow and reproduce before fermentation actually occurs. Without oxygen there may be a long lag time in the start of your fermentation. This lag can affect the flavor by creating excessive esters (might be good in some styles), and can also contribute to whether fermentation completes or not. If you don't have the means to add pure oxygen when using liquid yeast, brewers can add oxygen to wort through aeration, which is simply an atmospheric air addition as opposed to pure oxygen from a bottle.

Note that dried yeasts are propagated such that the cells are rich in membrane building blocks and glycogen. For this reason, dried yeasts do not require oxygen from wort and no

aeration step is required. Some brewers feel unsure about skipping this step and it's no problem to pitch dried yeast into aerated wort.

Air is 21% oxygen, and an aeration system consisting of an inline air filter, tubing, gas diffusion stone, and pump can be effective for getting oxygen into beer. The cooler the wort the easier it is to get oxygen to dissolve in the solution.

Other methods include simply agitating or shaking your fermenter. Splashing cooled wort while you transfer into your fermenter works as well. Anything you can do to provide the yeast a bit more oxygen during this very critical first stage of fermentation (the "lag phase") will only help you get the flavor profile and fast fermentation you're after.

THE IMPORTANCE OF PITCH RATE

We may not use the metric system in the U.S. as our primary unit of measurement, but one of the best ways to think about pitching dry yeast is by making sure you pitch between 0.5 and 1 gram per liter. For liquid yeast different manufacturers have different cell counts (cells/mL), which are listed on the package or are available from the company. For harvested yeast, 10 mL of a thick slurry per liter works well (so a 5-gallon/19-L batch would require about 190 mL of thick slurry from a previous batch). These guidelines can be doubled for lagers and high-gravity ales (over 1.065), and slightly less for low-gravity ales (under 1.040). It's always a good idea to follow the supplier's instructions when choosing how much yeast to pitch. Under-pitching, and to a lesser extent over-pitching, can affect the flavor of your beer by putting a strain on the yeast.

Now put some of what we've talked about to work with my Wheat Beer Two Ways recipe example on page 42 that you can split into two fermenters to really learn more about yeast strains. BYO

Reference:

[1] White, Chris, and Zainasheff, Jamil. *Yeast: The Practical Guide to Beer Fermentation.* Brewers Publications, 2010.

yeast wrangling

it's a part of who we are as homebrewers

story and photos by Jeff Mello

You become a yeast wrangler the first time you homebrew. It's not really a choice you make. The yeast wrangling life chooses you.

We all have different reasons why we got into homebrewing: Whether it was to theoretically save a few bucks, have a hobby that your friends and family can also enjoy, or explore your love of beer in a hands-on way.

Regardless of how we got here, we've all managed to become talented Jacks and Jills of-all-trades in pursuit of the best tasting homebrew. All it takes is a touch of engineering, a dash of chemistry, a dab of microbiology, and then mixed together with a heaping dose of creativity.

As the Chief Yeast Wrangler of Bootleg Biology, people are often surprised when I tell them I don't have a formal background in the sciences. There are few things more empowering than being self-taught and pursuing your passion using your innate skills, a morsel of knowledge, and a whole lot of ambition.

Bootleg's goal since day one has been to show people that they already have the skills and tools required to become yeast wranglers in their home. Propagate your own yeast? Yep. Source yeast from the wild? No problem. Isolate a pure culture and use it to ferment award-winning homebrew? Easy peasy.


ETF/BD
OPEN DLE
Karter
GG-17
1000ml
800
600
400

Unfortunately, the poor yeast cell is often the unsung hero of fermentation. Microbes are my life so I am clearly biased, but I believe yeast is the most important ingredient in any alcoholic fermentation and it doesn't get the attention it truly deserves. Often we're so focused on our experimental hop profiles or building the perfect malt bill that the yeast is then thrown in as an afterthought (this also happens with our winemaking and distilling comrades).

At Bootleg Biology, our goal is to push the limits of the beer world through yeast and bacteria cultures. Ferment a lager-like beer at 95 °F (35 °C) in two days. We got it. Quick sour a beer using *Pediococcus*? It'll blow your mind.

Once you've realized that you're already a yeast wrangler and put to use some of the skills I cover, you'll be making some of the best homebrew of your life!

HARVESTING YEAST & BACTERIA FROM A PREVIOUS BATCH

What you'll need: Sanitizer, alcohol, airlock, sterile water (store-bought or boiled at home), clean Mason jar or flask, open flame, and gloves.

When to harvest

You've already made 5 gallons (19 L) of fantastic tasting homebrew fermented with a lab-grown homebrew pack. So why try to even harvest yeast? Shouldn't you just leave dealing with yeast to the pros so you can stick to making the beer?

The good news is you've likely already doubled the number of yeast cells you started with. They're right there under your beautiful beer ready to be put to use again. Reusing yeast not only saves you money but uses less resources and is an essential skill for any brewer.

If you already have dreams of opening your own brewery, reusing yeast for multiple generations is one of the simplest tools you have for saving money. Professional brewers will often repitch their yeast between 5 and 15 generations. So it isn't just that first batch in which you can harvest your yeast, but many times. There's no perfect rule for knowing when to dump your yeast. The two biggest reasons are loss of viability or contamination. With a good process in place both should be minor concerns.

A few rules of thumb when it comes to harvesting yeast from homebrew:

- Only repitch yeast with at least 80% viability (see sidebar about doing a cell count on page 47). If you're unable to count viable yeast cells, that's OK! Most slurry will be healthy enough to reuse if harvested within a week or two after the beer hits terminal gravity except for styles listed in the next point.
- Avoid harvesting yeast from high-gravity beers (1.070 and higher), beers with low pH (3.5 and lower) or poor nutrient ferments (high percentage of adjuncts, or non-malt ferments). If you want to brew these beers, harvest two containers of yeast from an average-strength beer to create a yeast tree. One branch will continue and be used for typical beers and the unhealthy branch can die out by being used to ferment your high-gravity or sour beers.

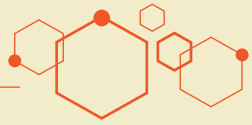
How to harvest yeast

Contamination is always a concern when homebrewing and even more so when you plan to harvest yeast. This is not the time to play fast and loose with sanitation! Luckily, you're a homebrewer and so you already know how to be sanitary.

If you already have experience with a closed fermentation system you'll have the greatest chance of avoiding contamination. Using CO_2 to push beer and purge containers of oxygen also has a side benefit of preventing microbes floating in the air from getting into your harvested yeast.

1. Crash your beer for at least one or two days at refrigerator temperatures when fermentation is complete to allow the yeast to flocculate and fall to the bottom of your beer.
2. Prepare a sterile or sanitized clear glass container for storing yeast (make sure it has double the capacity of your yeast slurry volume). Mason jars or flasks are made of borosilicate glass so can handle heat sterilization in an oven or pressure cooker or simply by being filled with boiling water. Place a lid on the sterile container un-

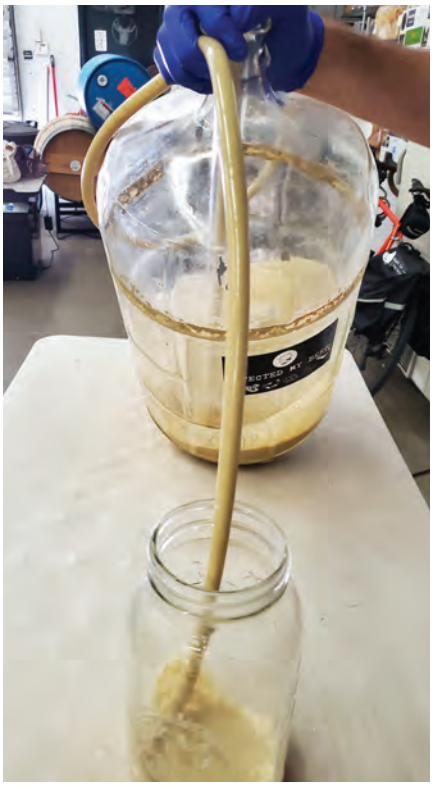
Harvesting Bacteria



Can bacteria be harvested from a quick/kettle sour? Yes! Kettle sours are basically the same as a giant starter. As with harvesting yeast, good sanitation is important to prevent contamination. When souring with a pure, lab-grown culture, contamination will be obvious if there are significant amounts of CO_2 activity or there is a large gravity drop (souring bacteria will drop wort gravity 1 or 2 points at most).

Timing is everything. Rack 500 mL of soured wort into a sanitized container about 18 to 24 hours into the souring process or before the pH drops below 3.6. Lactic acid, while being a food source for *Lactobacillus,* is also toxic over time and significantly decreases its viability. Keep harvested bacteria stored in a refrigerator for up to two to four weeks. 500 mL is more than needed to sour a 5-gallon (19-L) batch and helps account for any viability loss from the initial souring process. If the pH dropped quicker than expected, you can always harvest a larger volume of soured wort or add a gram of calcium carbonate (chalk) per liter to raise the wort pH.

There is no need to freak out if no slurry is visually present. Bacteria are so small they typically are not apparent in harvested wort other than creating a generally cloudy appearance.



After racking the beer, give a good shake to the fermenter and transfer the trub to a sanitized container to harvest yeast from a previous batch.

til you're ready to use.

3. If you have a glass or clear carboy, inspect the bottom to see the height of your yeast slurry. Rack your beer out of your carboy, if possible use CO_2 to create positive pressure inside of the carboy. Ensure you leave enough beer to keep the yeast covered. (If you'd rather not harvest your yeast, you can simply rack fresh wort if your next batch is ready to start fermenting on top of your yeast slurry and still get good results.)

4. Cover the opening to your carboy once it's purged with CO_2. Now it's time to get shaking! As safely as possible, agitate your carboy so the yeast is no longer clumping together or at the bottom. The beer and yeast mixture should become a thick liquid but not the consistency of peanut putter. If your beer was a light color, the yeast slurry should now be a tan/creamy color.

5. You should be aiming for 2 to 4 quarts/liters of beer/yeast slurry per 5 gallons (19 L). Set up your yeast storage container next to a gas flame, candle, or oil lamp. Using a freshly sanitized racking arm, move the slurry from the carboy to your container. If it gets stuck, don't stress! Shake up your carboy again to break up any thick clumps (especially a problem with English yeast strains). You can add sterile water to increase the amount of liquid. If you continue to have problems, sanitize the neck and opening of your carboy and directly pour it into your yeast storage container while agitating.

Storage and washing

You did it! No more dumping those beautiful yeast cells down the drain or using them to feed your compost bin. You're a modern Prometheus stealing fire from the gods.

It's time to inspect and care for this amazing yeast gift.

1. Refrigerate your clear yeast storage vessel for at least one day. Wait to proceed until you see obvious layers of different colors forming before proceeding to the next step.

2. You should now see an obvious layer stratification. Roughly the bottom layer is heavy denatured proteins and other heavy organic matter, the top layer is typically lighter organic matter like hops and residual beer, the middle layer should have a pronounced tan/creamy color.

3. Sanitize the lid and neck of your storage container. Underneath a flame, open the lid and pour enough sterile water to roughly double your slurry volume. Again refrigerate your container to allow the solids to separate. If your yeast storage vessel doesn't have any headspace, prepare a container with the sterile water that's twice the size and pour the yeast storage vessel contents aseptically into the larger container.

4. After another day you should see even starker contrast of layers and colors. Prepare another sterile container. Near a flame, carefully pour the top liquid layer into a container and dispose. The top layer should now be your happy yeast culture. Carefully pour this thick layer of yeast into your new sterilized container being careful to not agitate the very bottom layer so that it won't get into the new container.

5. Keep the washed slurry refrigerated until you're ready to use. If storing your yeast in a hard container with a tight lid, occasionally loosen the lid to burp it and release CO_2 pressure. Even at cold temperatures yeast can be active enough to produce CO_2. Too much CO_2 can be toxic to yeast or burst a glass container.

How much yeast is enough?

Without performing an accurate yeast cell count using a hemocytometer or expensive laboratory equipment we're going to do some educated guess work. But that's OK! There's a "game

counting yeast cells

What is a hemocytometer and do I really need one? A hemocytometer, used with a microscope, is a helpful tool for visually counting the number of living and dead yeast cells in a slurry to determine accurate pitch rates. A defined amount of dyed slurry is placed on the glass slide's counting chamber (the microscopic grid marks; dead cells turn blue and living cells stay clear). Most brewer's yeast can be counted on a hemocytometer with a basic light microscope that has at least a 10x lens. Because yeast slurry is so thick, it typically needs to be diluted at least once or twice to produce an accurate count. Detailed instructions on counting cells with a hemocytometer are easy to find online.

Do you need to count viable cells to safely repitch slurry? Nope! Many craft brewers harvest and repitch based on their personal experience with individual yeast strains. Repitching based on the weight or volume of harvest slurry is often accurate enough to have a successful fermentation.

Keeping everything sterile with a flame and alcohol is critical when harvesting yeast.

of horse shoes" element to any yeast pitch cell count methodology. Let's just get close enough to an ideal pitch rate to have a healthy fermentation.

In general, we'd expect about 1 quart/liter of dense yeast slurry (no liquid) to be harvested from a 5-gallon (19-L) batch. Each yeast strain has a different cell diameter and grows to a unique cell density, so you'll naturally see variation depending on which culture you're using.

The simplest way to proceed is to assume that you harvested enough healthy yeast cells from your 5-gallon (19-L) batch of beer to make two more equally excellent batches of homebrew. Inspect your yeast storage vessel's volume markers to determine your total volume of slurry and divide in two to decide how much to pitch in a future batch.

A little bit of additional yeast knowledge will help take your harvested yeast repitching to another level. At Bootleg Biology we've discovered that you can estimate cell density based on its origin or species:

- ***Brettanomyces***: Highest
- **Pure wild yeast, saison, some Belgian cultures:** High
- **English & German ale yeast:** Normal
- **Lager yeast:** Low

This is a rough approximation of cell densities, but you can use this as a rule of thumb for repitching your yeast slurry. For lagers, pitch the whole slurry because these cultures have a low cell density and high cell count requirements. For saisons, ease back on the amount of slurry you're pitching especially because underpitching often leads to more expressive yeast character. *Brettanomyces* primary fermentations work best with lager pitch rates, so pitch all your harvested slurry. Even though *Brett* has the highest cell density of these cultures, it's a very slow fermenter so pitching more than half of the harvested slurry will help ensure a healthy fermentation.

HARVESTING FROM BOTTLES, CANS, AND OTHER CONTAINERS

You've mastered harvesting yeast from a batch of homebrew. That's a useful skill that will serve you well as you continue to improve as a brewer and push your creativity to the limit.

What if using commercially available yeast and bacteria isn't enough to push your brewing to the next level? Perhaps you know a brewery is using a house yeast strain no one else has and it just might be the secret ingredient to nailing a killer clone or winning Best in Show.

Bootleg Biology houses the Local Yeast Project, which is our internal passion project to source wild yeast from every postal code in America. Brewers often approach us and say they brewed a batch of beer using a yeast they captured from the wild that they want to contribute to the Project. But through time or neglect the only source of that yeast lives on in an old bottle of homebrew.

What then, do we give up on that culture? No! We're yeast wranglers. There are few problems our yeast skills can't solve. Let's get to work.

Before we spend our time trying to recover a yeast or bacteria from a bottle, let's make sure we're not wasting our time. Not all packaged, fermented beverages are good candidates for harvesting. Just as when we discussed earlier what types of beers are not ideal to harvest from (high gravity, sour, low nutrient/high adjunct) these are also the types of beers that prove to be the most difficult to harvest from.

Before digging into each packaged beverage try to find out if the beer has been pasteurized or filtered (sometimes the label may indicate this, or the brewery's literature on their website may give you clues). Those packaging techniques are becoming more common for craft breweries due to the increase in high final gravity beers that struggle with shelf stability. Save yourself some time and avoid these.

When Bootleg Biology was starting up, some of the first bottles we attempted to harvest unique yeast strains from were Belgian lambics because they rarely disappoint. It's not unheard of to find viable cultures in bottles that are decades old.

Keep in mind that these beers are very acidic and so are inhospitable to everything but the hardiest cultures. We most often find *Brettanomyces* and *Pediococcus* in lambic bottles, but sadly most *Saccharomyes* and *Lactobacillus* cultures don't survive the long period of time in a harsh environment. American sour brewers sometimes add Champagne yeast to their bottles at packaging to better help naturally carbonate, which may show up in any harvested dregs.

Freshly packaged beers are often a good source of viable cultures. There was a period of time when the only way to clone Heady Topper was to physically acquire a can so that you could harvest the "Conan" dregs. It's

worth mentioning that some brewers will use a different yeast to bottle condition than they do for primary fermentation (either to protect their proprietary strain or because they are looking for a more flocculent and alcohol-tolerant yeast than is used in primary). So keep in mind that the yeast you harvest may not always be the yeast you are after.

Beers marketed as "keller" often have an abundant amount of live yeast still in the beer. Yeast wranglers are able to source previously unavailable yeast strains simply by pocketing a few ounces of real ale or keller lager when no one is looking.

The saddest beer in the world is a dusty bottle sitting at room temperature for years on a bottle shop shelf. Be realistic about expectations when working with these types of beers. Save yourself some anguish and avoid attempting to harvest brewer's yeast or lager cultures from a container that is more than a year old.

What you'll need: Alcohol, airlock, clean Mason jar or flask, open flame, gloves, low-gravity starter wort, stir plate, and stir bar.

1. Store the bottle (or can, though it's much easier to harvest yeast from bottles due to their transparency and convenience of sanitizing the neck opening) upright in a refrigerator before attempting to explore its contents. It's best for any viable cells to flocculate to the bottom before harvesting and to reduce the chance of gushing when opening the bottle.
2. Near a flame, spray the bottle's cap and neck as well as your bottle opener with alcohol. Gently open bottle, spray with alcohol, flame, then pour most of the beer into a glass (enjoy!) but leave enough liquid to cover the bottle dregs. Even in brown bottles you should still be able to see thick, clumpy matter at the bottom.
3. Gently agitate the bottle to mix up any yeast slurry that has congealed to the bottom of the bottle. Spray and flame the opening of the bottle again, then pour the dregs into a sterile or sanitized container.
4. If you're excited to start experimenting with your dregs, skip the container part and pour the dregs directly into a low-gravity starter (~1.020) and put on a stir plate. There may be very low viability in the bottle dregs so it may take days on a starter to see any activity. Once the starter appears tan/cream colored, or you see signs of fermentation, you've harvested viable yeast! You'll know if it wasn't a success if the starter never changes color, CO_2 isn't produced, or the gravity doesn't drop. If that happens, it's time to try again!

At this point you'll have to use your knowledge about the original beer to determine what microbes you've harvested and whether they're a pure or mixed culture.

To brew with your dregs simply make a standard starter between 500 mL to 1 L in volume using the cell density guidelines mentioned previously.

If you'd like to learn more about making agar plates and isolating yeast to create a pure culture, which is beyond the scope of this article, check out the DIYeast section of Bootleg Biology's website: https://bootlegbiology.com/diy

CONCLUSION

You did it! I knew you could. You've got the right tools to harvest, store, and repitch yeast and bacteria cultures, which will take your brewing to a new level.

Don't forget that you can use these skills with any kind of fermented food or beverage that contains "live cultures." Want to sour a beer with kimchi? Do it! Want to ferment a beer with sourdough "hooch?" I like what you're thinking! BYO

Using sanitary practices, pour the majority of a beer into a glass and then swirl and pour the dregs into a sterile container in order to capture the yeast from a bottle. It will then need to be built up.

Photo by Charles A. Parker/Images Plus

Hop Extracts

The secret to improved yields and cleaner hop character

by Dr. Pattie Aron

At the end of the zombie apocalypse fear not, we will still have hops!

I sometimes joke that if all life on planet Earth ceased and aliens came down to investigate our lifeless planet they might wonder what all this green, bitter, sticky resin is doing in drums. What could we possibly have used it for? There is a dearth of literature on hop extracts, on optimal extraction parameters, and even less on their application in beer. Although many brewers have never dabbled in extracts, some predominant craft brewers have been using them since the mid-1990s, and macro brewers have been using them since the 1950s. More recently they have popped up for the homebrew scene in 3- and 10-mL "hop shots," literally a syringe prefilled with hop extract ready to be heated and shot right into your homebrew kettle.

HISTORY OF HOP EXTRACTS

As early as 1880 the value of hop resins as preservative agents was well known. In fact, the preservative value (P.V.) of hops was measured by hop resin content. The hop resins are comprised of alpha and beta acids and their oxidized derivatives. Both alpha and beta acids have preservative qualities, but the isomerized alpha acids are predominantly responsible for beer bitterness. Until the 1970s hops were bailed and sold as dried whole cones, which were subject to oxidation and could lose up to 30% of their alpha acid content in a year, and 50% in two years.

It is believed that the original extraction applications using solvents aimed at diminishing alpha acid losses, in effect preserving the preservative value and thus bittering content of the hops. In the 1950s solvent-based extractions were conducted on hops. These extractions were done using hexane, methanol, methylene chloride, ethanol, and other chemicals. The extracts produced were of lower purity and quality than today's commercially available extracts. The favored solvent in the 1950s was methylene chloride (with extraction still ongoing in Poland and former Czechoslovakia until the early 1990s), and then hexane was favored up until the 1990s. Hexane is the least polar of the solvents — thus it became favored to eliminate some of the more polar compounds that were thought to interfere with purity of the resin.

In 1957 Miller Brewing Company developed a process to produce light-stable hops (35% reduced hop acids, known as Rho) from solvent extracts. Miller High Life, Champagne of beers, debuted a light stable product in flint bottles in 1961. The hop product was made using a hexane extract that had undergone further processing to make it light-stable, and thus was born a beer in a clear bottle that did not skunk. Miller's hexane plant was operational until about 1982 and a larger commercial scale extract facility using hexane was in operation in the U.S. in 1991. Today there exists only one operational ethanol hop extract plant owned by Hopsteiner in Germany. At 90% purity, ethanol extracts about 30% of the hop material, which includes more vegetative matter due to its ability to solvate polar molecules. Also ethanolic extracts do not efficiently extract hop oils, and the oils that are extracted volatilize once the ethanol is evaporated. Thus the major issue with solvent-based extracts was the loss of hop varietal character due to the evaporation of the solvent off the extract and thus the evaporation of any solubilized hop oil volatiles. A secondary issue was certainly the safety concerns with the use of highly evaporative and combustible solvents. Nevertheless, solvent-based hop extracts could contain up to 50% alpha acids, significant beta acids, as well as hop oils. The extracts could be canned or put in drums that do not require refrigeration and in comparison to cone hops they offered supreme alpha acid shelf stability. The added cost of the extraction can be compensated for increased utilization, reduced storage and shipping costs, and reduced loss of alpha acids due to aging.

In the 1950s Japanese and Soviet scientists started investigating the use of liquid carbon dioxide (CO_2) for the production of hop extracts. The extracts produced were of poor quality, thought mainly due to the presence of iron and other salts or minerals in the poor quality steel of the extraction vessels. In 1975 Laws et al. of the Brewing Research Foundation (BRF) introduced liquid CO_2 hop extracts, later commercialized by Carlton and United Breweries. In 1978 Muller, Vitathum, and Huber developed a supercritical CO_2 hop extraction process. A liquid CO_2 extraction facility was commissioned in Australia in 1980 and subsequently plants were constructed in Germany (Supercritical), the U.K., and the U.S. Miller Brewing Company built their pilot CO_2 extraction plant in the 1980s and today there are several facilities in the U.S. and abroad that operate under various conditions from liquid to supercritical pressures.

WHY CO_2?

Carbon dioxide is a natural product of fermentation. It is also readily available, inexpensive, nontoxic, nonflammable, and chemically inert under most conditions. CO_2 liquefies under reasonable pressures and once liquefied can be passed through various media, through which it behaves as an organic solvent (Hyatt. *J. Org. Chem.* 1984, 49, 5097-5101). Carbon dioxide exists as a liquid below 88 °F (31 °C) and 73 atm. Above 88 °F (31 °C), CO_2 cannot exist as a liquid, it exists then as a supercritical fluid that behaves as a gas, but when highly compressed the fluid is more dense than liquid CO_2. In the supercritical phase CO_2 behaves as a solvent with a higher diffusivity, lower viscosity, and lower surface tension than liquid CO_2. In general, the supercritical phase is thought to be a better solvent than liquid CO_2. Liquefied and supercritical CO_2 behave similarly in terms of their ability to act as a covalent solvent. It behaves as a good solvent for hop resins (supercritical) and for aromatics (liquid). However, at higher pressures supercritical CO_2 extractions can negatively impact oil content. The reason for this is that at higher pressure the CO_2 gas contains water vapor as well as oils that leave the separator upon condensation.

A comparison of the essential oil content and composition indicates that liquid and supercritical CO_2 extracts of the same hops can lead to 50% reduction of oil content in supercritical extracts. The majority of this is composed of hydrocarbons that would generally either volatilize or oxidize in the kettle during boil. However, due to this it is suggested that liquid extracts display more varietal character and are preferable for flavor and aroma applications in beer.

During extraction, extract vessels are filled with pelletized hops. (The hops used must be pelletized because liquid CO_2 cannot penetrate intact lupulin glands, which contain the resins and oils. During pelletization hops are ground into a powder then pressed through a die which ruptures the lupulin glands to expose the resin and oils.) Liquid or supercritical CO_2 is then pumped through a heat exchanger to achieve desired extraction temperature, then run through the vessel at specified flow rates to ex-

Photo by Jake Parrish / Yakima Valley Hops

Hop extracts have been used by commercial brewers since the 1950s, and began to catch on with craft brewers in the 1990s. Only in recent years have they become more readily available to homebrewers in smaller sizes perfect for 5-gallon (19-L) batches.

tract hop resins and hop oils out of the pellets. Once the pressure is reduced, the CO_2 evaporates off of the extract in the heat exchanger, the extract is collected, and the CO_2 is recycled. Suggested extraction pressures and temperatures are displayed in Table 1 on this page.

Liquid extracts tend to be yellow to gold in color and higher in oil content due to the softer extraction, while supercritical extracts range from light to dark green due to the presence of chorophyll extracted under harder conditions. During supercritical extraction up to 50% of the volatile hydrocarbon fraction can be lost depending on the temperature, pressure, and flow rate of the CO_2.

During extraction the most non-polar compounds (the oils and the beta acids) elute first, then the alpha acids, then any subsequent more polar compounds. The maximum solubility of hop acids occurs at 45–46 °F (7–8 °C) due to the presence of moisture in the hop cones. Liquid plants thus operate between 41–50 °F (5–10 °C), up to 68 °F (20 °C) to minimize the uptake of moisture in the extracts. Research conducted by BRF indicates that 350 kilos of liquid CO_2 is required to extract 1 kilo of alpha acids. Supercritical plants require less CO_2 due to the higher extraction efficiency of the supercritical liquid phase and thus shorter run times are required to achieve similar extraction of alpha acids. However supercritical extracts contain more non-desirable components such as waxes and chlorophyll and are thus not as suitable for advanced processing into light-stable or pre-isomerized alpha acid products. The alpha acid content of CO_2 extracts is varietal dependent (30–50% alpha), with low alpha, aromatic varieties yielding lower alpha, so the extraction of lower alpha varieties may not make economic sense.

Table 1: Hop Extract Temperatures and Pressures by Method

	Temperature	Pressure
Liquid CO_2	41–50 °F (5–10 °C), up to 68 °F (20 °C)	60–70 BAR (870–1015 PSI)
Soft Supercritical	122–140 °F (50–60 °C), up to 176 °F (80 °C)	150–172 BAR (2200–2500 PSI)
Hard Supercritical	122–140 °F (50–60 °C), up to 176 °F (80 °C)	172–350* BAR (3000–5000 PSI) **This high of pressure is not necessary for the efficient extraction of hops*

Suggested extraction temperatures and pressures for creating hop extract.

USE AND BENEFITS OF CO_2 EXTRACTS

Due to the viscosity of traditional hop extracts, they must be heated and poured out or metered out of the storage vessel, or in many craft brewing applications, the entire can punctured and suspended into the kettle. Extracts are typically used for the bittering charge, but as Alec Mull (Vice President of Brewing Operations at Founders Brewing) suggests they can be used throughout the boil. Founders has been using extracts for close to 10 years, but on the hot side only, as to this date trials done on the cold side haven't proven effective. T90s (pellets that have 90% of whole hop material in them) and other concentrated pellets such as T45, T30 (45% and 30% of original hop material) are still used on the cold side for dry hopping. On the hot side, in addition to hop pellets, Founders uses hop extracts for various charges at 60, 30, 20, 15, and 10 minutes to end of boil. In their "irresponsibly" hopped (those with more than 2 lbs. per barrel on the hot side, or about 1 oz. per gallon/7 g per L) beers they have trialed whirlpool strike charges. Alec suggests if you are looking for a place to start, consider replacing your 60-minute bittering charge at 100% alpha substitution to the alpha in your traditional pellet charge.

Recipe development should be done using grams of alpha as a metric, not oils. The major advantage of using hop extract over pellets is yield of wort and in a very hoppy beer its use can yield as much as 8% more beer due to reduced beer and wort loss. The sweet spot at Founders is 0.4 lbs. (180 g) pellets per barrel (pre-whirlpool charge); above this rate, increased wort/beer yields merit the added cost of extracts. In their double IPA Alec says that extract use improves wort yield by 1.2–1.7 gallons per pound (10–14 L per kg) of substituted pellet.

The second advantage is that the vegetal aroma that sometimes gets in the way of the hop expression is diminished and the resultant beer is more distinct, brighter, and cleaner. Alec believes that in addition to the financial benefits, the quality benefits result in the production of better beer.

Vinnie Cilurzo agrees. He says that the use of hop extracts reduces the vegetative quality in his beer and the resultant beer has "cleaner" hop character. At Russian River Brewing, Vinnie has been using extracts since 1998. At the time the strongly held belief among craft brewers was that extracts were just for big beer. Nevertheless, a hop sales rep was able to convince him to test out extracts. The gain in yield of beer and the cleaner hop character allowed the infamous Pliny the Elder beer to "stay true to itself." Vinnie suggests using Warrior hop extract for the bittering charge as its alpha acid content (15–16%) lends it to a more economical and potentially consistent extract.

At Russian River they heat the entire can of extract up in hot water, swirl it with hot wort and pour it into the kettle as he prefers not to place the can in the kettle. Vinnie says they always use entire cans, never partial cans. At Founders, they poke holes in the metal can using a commercial can opener, or a pointed hammer, to remove the can lid and place the can inside a metal basket which is then dropped into a hop dosing vessel containing hot wort. Or in case of their automated brewing system, the cans are placed in a hop-dosing vessel where wort is pumped through to add the hop extract. Alec suggests Chinook or Bravo as easy/safe starters for bittering charge replacement, as varietal character seems maintained.

Extract cans and jugs come in various sizes ranging from 150 g to 200 kg drums or totes. It is measured in "grams of alpha" or GMA for short. An example of recipe conversion of Chinook pellets at 13% alpha acids (AA) to extract:

Lbs. of hops in charge x 454 (g in a lb.) x (AA%) = required GMA

10 lbs. pellets x 454 g x 0.13 (%AA) = 590 GMA

There are a number of suppliers of hop extracts sold in small hop shots for homebrewers. For instance, Yakima Valley Hops advertises one on their website made up of 60% Columbus or CTZ hops and 40% blended aroma varieties. Typical alpha acid concentration of the hop shots is 50–65%. Their recommended dosing is:

Volume of extract (mL) = AAU (g) x density of hop extract (g/mL)

Photo by Charles A. Parker/Images Plus

Numerous suppliers package hop extract specifically for homebrewers in plastic syringes, often with 3–10 mL each, sized specifically for 5-gallon (19-L) batches. Depending on the supplier, extracts of various hop varieties are available and the choices continue to increase as extract gains popularity.

Or 1 mL yields around 10 bittering units (BUs) in 5 gallons (19 L) of 1.050 wort added 60 minutes before the end of the boil.

When used as a hop bittering charge replacement on the hot side there are many benefits to using extracts over pellets. The economical bang for your buck in increased yields from reduction of solids, reduction of trub formation, reduction of foam. And on a larger scale the reduced cost in shipping and storage makes extract usage a no brainer. And as we've heard from some well-respected craft brewers, the use of hop extracts can also produce cleaner, brighter beer while maintaining hop varietal impact. The CO_2 extraction process also reduces and or eliminates the agrochemical (pesticide) and nitrate content of hops.

Extracts can also be stored at ambient temperature. In my former life as hop queen at MillerCoors we once sampled a drum that had been in storage in Golden, Colorado for over a decade, at ambient temperature. It had a small layer of oxidation on the top of the drum and the rest was still true to its packaged alpha content. I am positive that at the end of the world as we know it, those drums of gooey green extract will persist.

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BY DREW BEECHUM & DENNY CONN

BREWING A WEST COAST IPA

The anti-haze IPA

What has come to be known as West Coast IPA evolved from what we both think of as the original American IPA, made by Ballantine's.

Photo by Charles A. Parker/Images Plus

Lore has it that IPA originated in England as a stronger, hoppier version of the pale ales that were around in those days. The intention was that it would be more likely to survive the long, hot trip to India that way. There is a legend that a ship laden with it sunk just off the English coast at the beginning of one of those trips, and as the barrels floated back to shore the locals grabbed them and loved the new type of beer. True story? Who knows . . . not even Denny is old enough to have been there! But he definitely appreciates that something happened to introduce IPA to beer drinkers! (Gentle reminder, readers — if history gives you a really great "clean" story, it's highly unlikely to be true.)

Love it or hate it, India pale ale is arguably the most popular craft beer style around. Most bars have it on multiple taps. It's the largest category in beer competitions. That popularity has led to a diverse range of IPAs as people try to carve out a niche for themselves.

Now, there are hazy IPAs, white IPAs, red IPAs, black IPAs, zero IBU IPAs, double IPAs, triple IPAs, quadruple IPAs (Drew just covered those on the podcast). Variations to make your head spin and your tastebuds quiver. Every week a new hop leads to new names, new takes, new cans. But we're not gonna talk about any of those — this time. Nope, we're staying true to our roots — give us the bitterness of the West Coast IPA

What has come to be known as West Coast IPA evolved from what we both think of as the original American IPA, made by Ballantine's. Their India Pale Ale was dark, burnished, and wood-aged for 5-12 months (time varied by how many pennies ownership was trying to save). The yeast Ballantine's used has outlasted their IPA and its lineage is what many of us today turn to when we brew our American pale ales and IPAs. You know which one it is because it was the yeast many of the early craft brewers used. Ballantine's may have been one of the key (and longest standing) versions in America, but the model for American IPA really got set with Bert Grant's IPA and Anchor's Liberty Ale, using what was for the time (1983) an insane amount of new-fangled Cascade hops. Along the way many other breweries, like Bridgeport, Harpoon, Steelhead and many more added their stamps to the style.

But changes have happened with American IPA over time and what some people picture in their minds when you say that term has become . . . well, muddled. When we hear "West Coast IPA", we think: Clear, crisp beers with enough malt to support the hop load, a bracing bitterness, and loaded with hop flavor and aroma. No trendy techniques like all the hops at the end of the boil or fruit and vanilla additions. West Coast IPA is a very straightforward beer, using processes that have come through to us for generations.

And in our horrifically biased opinions, the best part is that they're making a comeback after their presence was significantly reduced during the haze craze. Hazy IPAs aren't going away, but it's at least sharing the stage these days. Currently when you head into a brewery taproom or bar, you might actually face a 50/50 chance of getting a West Coast IPA when you ask for an IPA. So today we're gonna give you our tips for brewing this classic style of beer.

GRAIN BILL

Keep the grist simple — pale malt and crystal should be the majority of your grist. The classic West Coast IPA grist is 90% 2-row pale and 10% crystal malts. You can toss in some Munich if you like, but don't go overboard. Shoot for an

original gravity (OG) in the low 1.060s to mid 1.070s and a final gravity (FG) in the 1.010–1.016 range.

Don't be afraid of crystal, just use it properly. 10% crystal 60L is common for a lot of West Coast IPA grain bills, but you can use 20 or 40L to lighten it up a bit. Go for 5–10% depending on your taste. Denny changes the type of crystal depending on the season. In colder months, he'll go to 60L. For light, crisp summer IPA, he chooses 10L or 20L crystal. And note, this is where the story of the classic West Coast starts — over time, the grain bills have simplified with brewers eschewing any and all crystal in an attempt to clear all the room for the hops. A direction Denny definitely does not endorse. It can lead to a very one dimensional, dare we say "boring" beer. As an alternative to standard American crystal malt, consider Munich, Caramunich®, Cararuby®, Victory® or Special Roast. But in total specialty malts should not exceed 10% of your grist.

Don't be tempted to do the classic homebrewer things … add wheat for "head retention" or dextrin malt for body. The polyphenols in the hops will bind the proteins from the grain and you'll get plenty of foam. You don't need to add more body than what the crystal will give you. Remember, you're trying to turn the world onto hops in this older-school American IPA — not malt.

HOPS USAGE

Use at least a 1:1 bittering units:gravity units (BU:GU) ratio. So make your IBUs equal to or exceeding your original gravity (for example, you should target 60 IBUs or more on a 1.060 beer). Denny likes bittering hops that slap you in the face with a bracing bitterness, so Chinook is often his choice. Drew leans more to Warrior®, which isn't quite as aggressive.

Use layered additions. At the very least use a 60-minute addition and back it up with a 5-minute addition. You can also go with 20, 10, 3, 0, whirlpool … whatever. Yes, a number of modern IPAs skip any kettle additions, but in both of our experiences it's rare to get that 100% rock-solid bitter base without at least a touch of kettle-derived IBUs.

Use more than one variety to give the beer some depth, but don't think you need a dozen varieties. Be sensible and think about the interplay between the varieties. The point is to create complex hop profiles that aren't muddled. Be careful combining big American "C's" and their citrus and pine with big doses of the New World tropical, fruity hops to avoid a conflict — that's not to say you can't, but be mindful. Pull the palate in too many directions and you'll get a jumbled experience — hops don't lend themselves to a "Wall of Sound" approach.

Even if you whirlpool, don't overlook dry hopping. Denny has stopped using whirlpool hops in favor of dry hopping. His typical IPA hop schedule is 60, 5, and dry hops. Drew on the other hand still likes to throw hops into a 170-ish°F (~77 °C) whirlpool for 20 minutes along with later additions of dry hops, but you find what works for you!

When dry hopping, don't get caught up in thinking more is better, either in terms of time or amount. Recent research has shown that there's a limit of about 8 grams/L (~1 oz./gallon) of dry hops before you start getting diminishing returns. At that level, the hop oils are approaching saturation and you won't get much more. If you're going for a very citrusy aroma, the oils for that reach saturation at even lower levels and more than that gives you herbal/tea aromas rather than fruit. (https://patspints.com/2019/01/16/the-surprising-science-of-dry-hopping-lessons-from-tom-shellhammer/)

The other bit of common wisdom that we grew up with was to dry hop at ale temperatures for 1–2 weeks. Over time, that advice has been changing and now the science is backing it up. Dry hopping for shorter, colder periods appears to infuse more fruit and less vegetal aromas with less loss of hop oils and isomerized alpha acids (at least in terms of linalool). Denny has dry hopped hundreds of batches using a variety of techniques, and nothing has ever worked as well as 48 hours at 35 °F (2 °C) (https://bsgcraftbrewing.com/reevaluating-dry-hop-techniques). Vinnie Cilurzo of Russian River Brewing Co. in Windsor, California, and a knower of IPAs, has switched to shorter dry hopping as well, but keeps them warmer — he prefers the character at warmer temperatures.

As more science gets worked around the outrageous amount of dry hops we actually use today, expect some very complicated techniques to arise. As we try and balance the extraction rates of multiple compounds of various classes of oils. When dry hopping, consider hops that have been processed to reduce the vegetal matter in them, like Cryo® hops or Lupomax™. You'll get more bang from them and with less bract they suck up less of your precious beer.

One last tip that we're seeing more and more brewers take up — dry hops, particularly large doses as favored today, raise the final beer's pH, making the beer less acidic. Brewers like Julian Shrago of Beachwood Brewing in Long Beach, California purposely acidify their beer going into whirlpool to reach a target pH of 5.1. Julian does this to combat the pH rise that to his perceptions makes the beer taste "flat and flabby."

WATER PROFILE

Your water should have a pretty good sulfate load. We're not huge fans of chloride:sulfate ratios, so we'll just recommend that you want in the neighborhood of 200 ppm of sulfate. If we were into ratios, we'd tell you to keep the chloride to half of that or less.

Sometimes in brewing IPA, you need to get more sulfate into your beer when your calcium level is already pretty high. Too much calcium (roughly in excess of 200 ppm) can lead to premature flocculation of the yeast. So if your Ca^{+2} is already up there but you need more sulfate, don't overlook magnesium sulfate, also know as Epsom salts. You certainly don't want too much Mg^{+2} either, but 25–50 ppm will be fine. (Too much magnesium imparts a very strong mineral character and may have other distressing digestive effects.)

If you need to adjust pH, don't try to do it all with gypsum or calcium chloride. Get your mineral addition sussed first and take a look at where your pH stands after that. Then if you need to lower pH, use lactic or phosphoric acid to do it. There's no easy number to give because it's all going to depend on your local water and your grist. As an example, Drew has fairly bicarbonate water and needs a little over one mL of lactic acid per gallon (3.8 L) brewing water to pull his pH down with a simple bill of pale malt and crystal 60L. Denny

on the other hand uses well water and doesn't require any pH change. The malts are just dark enough to pull the pH down where he wants it (5.2–5.4).

YEAST SELECTION

Use a clean yeast. Let the flavor profile come from the malt and hops, not the yeast. Denny's preferences for liquid yeast run to Wyeast 1450, 1217, and 1056. For dry yeast Lallemand BRY-97 is his go-to. He finds the ubiquitous SafAle US-05 too fruity for his tastes, but this is about your beer. SafAle US-05, S-04, and Lallemand Nottingham are all in the ballpark for the yeast you want for West Coast IPA. Just remember, this is West Coast IPA, not English. Keep the esters produced by the yeast to almost unnoticeable amounts.

FERMENTATION CONSIDERATIONS

The "keep it clean" plan for West Coast IPA means fermenting at lower temperatures. Denny prefers starting at 63–65 °F (17–18 °C). After about 5 days or so, he jumps up to the 70–72 °F (21–22 °C) range until final gravity is reached. By waiting to increase the temperature you avoid the fruity notes you can get from higher temperature fermentation. Then he crashes to 35–40 °F (2–4 °C) to drop the yeast before dry hopping for 48 hours at that temperature.

KEY PROCESSES

Mash in the low 150s °F (~65–66 °C). It may vary depending on your grist and your goals, but you want to mash for a fair amount of fermentability, but not so much that you lose the malt balance against the hops. Yes, hops should be featured, but you want malt there to back them up.

If you really want a bright and shiny IPA, you rarely need to do anything more than cold + time, but if you're in a hurry, gelatin is a good and inexpensive means of getting your clarity. Denny refuses to take the effort to use gelatin and gets good results with Whirlfloc/Irish moss in the kettle and solid time to allow cold conditioning after fermentation.

You can see that there's more than one way to make West Coast IPA, so just keep your goals in mind. You want a clear, refreshing beer with a bracing bitterness and loads of hop flavor and aroma. No thick, low bitterness beers that taste like orange juice. If that's what you want, then you'll have to ask Gordon Strong :). But if West Coast IPA is what you're looking for, try some of our tips. And embrace the clarity!

DENNY'S GENERIC WEST COAST IPA

(5 gallons/19 L, all-grain)
OG = 1.069 FG = 1.012
IBU = 72 SRM = 12 ABV = 7.5%

INGREDIENTS

13 lbs. (5.9 kg) North American 2-row pale malt
1.5 lbs. (0.68 kg) crystal malt (60 °L)
16.5 AAU Chinook hops (60 min.) (1.25 oz./35 g at 13.2% alpha acids)
6.8 AAU Cascade hops (5 min.) (1 oz./28 g at 6.8% alpha acids)
12 AAU Centennial hops (0 min.) (1 oz./28 g at 12% alpha acids)
2 oz. (57 g) Cascade Cryo® hops (dry hop)
Wyeast 1056 (American Ale), White Labs WLP001 (California Ale), Imperial Yeast A07 (Flagship), or Lallemand BRY-97 yeast
¾ cup corn sugar (if priming)

STEP BY STEP

Using a fairly thick mash, achieve a single infusion mash temperature of 153 °F (67 °C). Hold at this temperature for 60 minutes. Start lautering by raising mash temperature up to 168 °F (66 °C), then hold for ten minutes. Sparge with enough water to collect about 6.5 gallons (24.6 L) of wort and boil for 60 minutes. Add the hops as stated in the recipe.

Upon completion of the boil, chill the wort to 63 °F (17 °C), pitch a healthy count of yeast and oxygenate thoroughly (if using a liquid strain). As fermentation slows, you may allow the temperature to rise up to 68 °F (20 °C) to ensure completion. Total fermentation time should be about one week so the yeast has time to clean up its off-flavors. Drop temperature to 45 °F (7 °C) and add dry hop. Wait two days then keg and carbonate to 2.6 v/v or bottle.

DENNY'S GENERIC WEST COAST IPA

(5 gallons/19 L, extract with grains)
OG = 1.069 FG = 1.012
IBU = 72 SRM = 12 ABV = 7.5%

INGREDIENTS

7 lbs. (3.2 kg) golden dried malt extract
1.5 lbs. (0.68 kg) crystal malt (60 °L)
16.5 AAU Chinook hops (60 min.) (1.25 oz./35 g at 13.2% alpha acids)
6.8 AAU Cascade hops (5 min.) (1 oz./28 g at 6.8% alpha acids)
12 AAU Centennial hops (0 min.) (1 oz./28 g at 12% alpha acids)
2 oz. (57 g) Cascade Cryo® hops (dry hop)
Wyeast 1056 (American Ale), White Labs WLP001 (California Ale), Imperial Yeast A07 (Flagship), or Lallemand BRY-97 yeast
¾ cup corn sugar (if priming)

STEP BY STEP

Heat 3 gallons (11.4 L) of water in your kettle and add the crushed crystal malt in a muslin bag. Submerge the grains in the water and steep until the temperature reaches about 160 °F (71 °C) Remove the grains, you can gently squeeze the grains to get most of the liquid out. Off heat add the dried malt extract and add water to have 6.5 gallons (24.6 L) wort. Bring wort to a boil. Follow all-grain recipe for remaining boil, fermentation, and packaging instructions.

NOTES FROM DENNY:

You can substitute a different "character" malt for the crystal, like Munich or Victory®. You can use all pale malt. You can use Magnum or Warrior® hops for bittering. For a more traditional West Coast IPA, avoid tropical fruit hops. For a more modern take, go crazy with hops like Citra® or Mosaic®. This is a style you can customize to your liking as long as it's crisp and bitter. BYO

BY BRITTNEY CHRISTIANSON

YEAST HYBRIDS

Recreating our favorite strains . . . with a twist

Let's take a second to picture this: You've decided to brew a lager this week. After all the time and effort of purchasing ingredients and spending a full day brewing, it's now fermenting and all you're getting is sulfur coming out of the airlock. Yuck – definitely not what you were hoping for! Alternatively maybe you want to try a brut IPA and you want it dry, so you're thinking of using a saison yeast, but the last thing you want is all that phenolic flavor overpowering the hop character. Or on the flip side, you want to produce a saison, but you're concerned about using a yeast strain with diastatic capabilities. (*Saccharomyces cerevisiae var. diastaticus* is a common saison strain that secretes glucoamylase enzyme that breaks down dextrins and is seen as a contaminant in most instances.) If only your favorite lager strain didn't produce H_2S, or your saison strain didn't produce phenolics, or didn't have diastatic capabilities! This may sound like a brewer's sci-fi dream, but it's surprisingly not! All three of these strains exist today. The interesting thing is all these strains are not classified as genetically modified organisms (GMOs) (there is no splicing or dicing of genetic material) and they are not packed blends of two different strains. These are true genetic hybrids. All created through hybridization — breeding techniques that can develop novel strains with selectable traits. An option to solve some pesky brewing concerns. But what are hybrid yeast strains and how are they developed?

In the simplest of terms, hybridization (in the context of yeast) is a technique where you combine the genetic material of two different yeast strains to produce a genetically different offspring, a hybrid. This is not new technology, but it is newer to the brewing industry. In the past, hybrids were most commonly seen in the wine industry. This has to do with the differences between brewing and wine strains. Wine yeast strains are typically diploid cells. Now if you can stretch your memory all the way back to high school biology, you may remember that diploid cells have two sets of chromosomes. When cells go through sexual reproduction, the diploid cell will split its paired set and create haploid cells. A haploid cell only has one set of chromosomes. Two haploid cells will create a new diploid cell (which will come back to the full two sets of chromosomes and will be a 50/50 mix of genetic material from each haploid cell). This is an easier process for scientists when creating hybrid yeast strains.

Brewing strains on the other hand are a bit difficult to work with. Why? Well, first they're not diploids. Brewer's yeast is polyploid, meaning there are more than just two sets of chromosomes in each cell and second, they're poor at sporulating. This is due to brewers historically, and probably unknowingly, getting rid of strains that sporulate. Since brewers rely on consistency, if a yeast wasn't working as planned (potentially hybridized) they would switch strains to a fresh propagation and would throw out that yeast. Also, yeast cells sporulate when they are stressed out. Brewing yeast strains have been spoiled in nutritious wort for years. Thus, over generations and generations of these factors, brewing yeasts have pretty much lost the capability to sporulate altogether. But this doesn't mean that it's impossible to create a hybrid yeast strain that is good at fermenting in brewing environments. It's just more complex, and scientists have found that brewing

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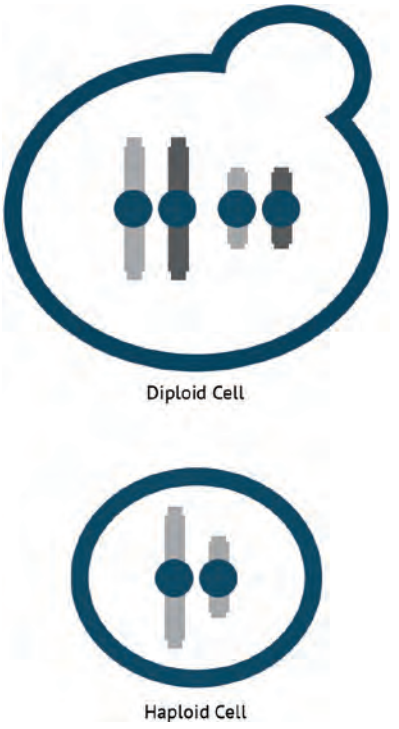


Harking back to high school biology class, diploid cells contain two sets of chromosomes while haploid cells only contain one.

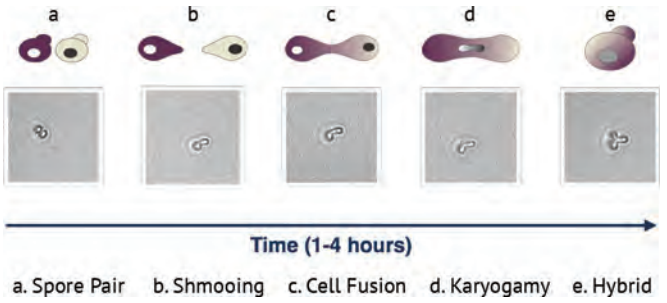
Images courtesy of Renaissance Biosciences

strains that are closer genetically to wine or Champagne strains (e.g. saison strains) tend to be easier to work with.

There are two common methods to produce hybrids. One method is **adaptive evolution**; this is where scientists place yeast cells into an environment that they will eventually adapt to. However, this can take between 100–200 generations (as it uses evolution for survival of cells), which is a slow and time-consuming process. The other method used to create these hybrid strains is called selective breeding. **Selective breeding** is the process of selecting parent strains to breed together, to then produce offspring that contain specifically selected and more desirable characteristics.

Typically, when yeast cells want to create more yeast cells, they will go through asexual reproduction. This is what brewers are most used to — one yeast cell yielding clones or genetically identical offspring (i.e. mother yeast cell budding a daughter yeast cell). For the selective breeding technique to work, the cells must undergo sexual reproduction. This is when two cells mate, or in other words, when the genetic material between the two parent cells mix and produce more genetic diversity in their offspring. For a cell to undergo sexual reproduction, instead of asexual reproduction, the cells need to be under a stressed environment to induce sporulation. According to Jessica Swanson, the Lead Development Scientist and Beverage Unit Manager at Renaissance Biosciences, low nitrogen and poor sugar source media is used to stress the cells out. Swanson explained that the reason these "cells produce spores is to survive stressful conditions. When these spores find themselves in a more favorable environment, they will produce cells (germinate), which may then undergo sexual reproduction to create a new generation of hybrid cells that are more genetically diverse allowing them to potentially be better suited in their new environment."

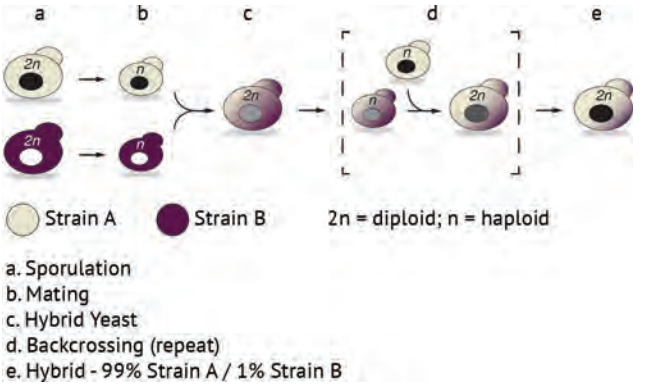
When the two distinct spore isolates are put together, they will eventually mate. The mating process will take around 1–4 hours to complete. The spores (haploid cells) will release mating factors (pheromones) to induce the hybridization events. The cells will start growing in the direction of the other cells, which is referred to as "shmooing" — one of my favorite scientific phrases! This elongation of cells will allow them to join or fuse together, and eventually the genetic material of the two spores will mix to create a new diploid cell; a.k.a. the new hybrid cell.



Creating hybrid brewer's yeast requires sexual reproduction of cells, the process of which is seen here. But pushing brewer's yeast to reproduce sexually is not an easy task.

So now we have a new hybrid diploid cell, let's call it an equal 50/50 mix of genetic material from each parent. What if you only wanted a specific trait from one of the strains, but wanted the rest of the genetic material to be that of the other selected strain? Let's break it down in a basic example. Say you have Strain A (a good brewing strain, with strong attenuating abilities) and you have strain B (a wild strain with aromatics that you wish Strain A had, but not a good fermenter). If these went through sexual reproduction and produced a simple hybrid (50/50 mix of each), you now have 50% Strain A's genetic material and 50% Strain B's genetic material. But this isn't what you're looking for as the 50% of Strain B may cause this hybrid to be a poor fermenter. Preferably, the ideal strain would be >99% Strain A (brewing strain), but still have that 1% technical yeast trait (in this example, the sensory profile) from Strain B. To accomplish this, the process of **backcrossing** needs to occur.

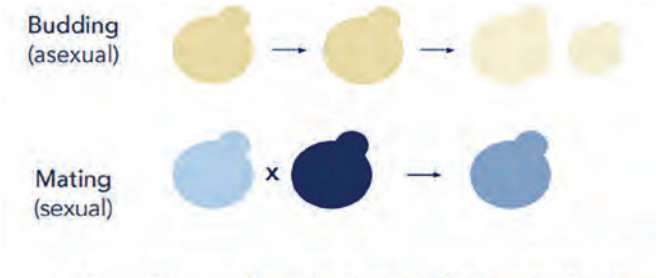
Backcrossing requires multiple rounds of breeding the first hybrid strain back with one of the original parent strains until the hybrid has all the desired traits. In the case of this simple hybrid example, the 50% Strain A/50% Strain B hybrid will be backcrossed with the original brewing strain (Strain A) over and over again. The first hybrid was 50/50, but after a second round the new hybrid would be 75%/25%, the third would be 87.5%/12.5% and so on. This process is done until the daughter strain has all the desirable brewing traits along with the one specific trait (in this example: sensory profile) of Strain B. Once it reached that >99%/<1% ratio, it's officially a fully functioning, true genetic hybrid strain that is ready to be brewed with!



After the first round of sexual reproduction, the new yeast strain would be considered a hybrid, but may not perform in the way brewers want. It often takes roughly eight rounds of backcrossing events to reach the goal.

There are countless possibilities out there when you start looking at the potential of yeast hybridization. According to Jessica Swanson, a wide variety of selectable traits can be targeted when developing hybrids. Some examples are "increasing or decreasing attenuation, flocculation, fermentation kinetics, specific flavors and aromas, stress tolerance, temperature profile, and enzyme activity to just name a few." But the end goal doesn't always have to be so specific and only about explicit traits. Lance Shaner, Co-Owner of Omega Yeast, provided another perspective of hybridization

> **Backcrossing requires multiple rounds of breeding the first hybrid strain back with one of the original parent strains until the hybrid has all the desired traits.**



Harnessing sexual reproduction to exploit genetic diversity

techniques, "You can go after targeted traits. But sometimes, instead of always having an end goal in mind, you can go through an exploratory process with no bias involved." Maybe one of those initial 50/50 hybrids or other percent of genetic mix could turn out to do something unique and great?! The possibilities are endless.

The brewing and homebrew communities are continually pushing boundaries and bringing new, innovative ideas forward. Hybrid yeast strains not only solve potential brewing problems (as listed in the introduction) but can open new doors for some fun experimentation. That's always been the beauty of brewing — sometimes it's about trying to recreate a specific beer and sometimes it's about trying something new to see how it goes. Or in the words of Lance, "Let's just see what happens!"

If you are interested in learning more about the strains listed in the introduction of this article, find them here:

1. Renaissance Yeast – offers a full portfolio of hydrogen sulfide preventing wine and cider yeast
2. Omega Yeast – Gulo Ale (Irish ale x French saison) and Saisonstein (Belgian saison x French saison)
3. Lallemand Brewing – Farmhouse Hybrid Saison-Style Yeast

A special thank you to Jessica Swanson and Renaissance Bio-sciences for providing amazing amounts of research and information on the topic of hybridization techniques, along with supplying the graphics for this article. BYO

BY JOHN BLICHMANN

BREWHOUSE CONSIDERATIONS

Digging into the details

What may seem like a straightforward decision, selecting a brewhouse, is probably the most difficult decision of starting a brewery. This is second only to, "Should I start a brewery?" My company, Blichmann Engineering, has helped hundreds of brewers answer this same question over the years and it is a pleasure to share our collective experiences with you. At the end of the day, selecting a brewhouse forces you to do the research into all aspects of your brewery planning and that means a smoother start to your new business.

Speaking of business: You are no longer a homebrewer, so you've got to change your mindset. Your first focus should be to make your business profitable. As a brewer you've likely got favorite styles you love to brew. And while it is important to have variety on tap, don't lose sight of brewing what your customers want to buy. Make sure to have those styles readily available. I've seen several brewers stubbornly turn a blind eye to consumer trends and preferences and lose business because of it. I'm not saying you need to fill your tap list with trendy styles, but keeping a lighter beer and a trendy style or two on your list will be a wise decision for your bottom line.

So how big of a system do you need? That is ultimately driven by your business plan. If you don't have a business plan, you'd better get one in the works pronto. Your bank is going to expect one and it is the best way to learn in advance if you have a solid plan to make a profitable brewery. Business plans are living documents that encompass your market study, the niche you intend to serve, growth plans, financing, competition, and personal financial goals. I can't stress enough how important cash flow is to a small business, especially in the start-up phase. The business plan can help you early in the planning phase know how much cash you'll generate, how much you need to borrow, and that ultimately defines the affordability and profitability of your brewhouse.

After the business plan is mostly solidified sizing your brewhouse system is simple math. In fact, I'll provide a link to my company's online calculator later in this article. Let's get started going through the key factors in your business plan that affects your brewhouse size.

One of the first decisions is whether you intend to operate as a taproom only, wholesale distribution only, or a combination. Wholesale-only breweries in the nano-size, 5-BBL and below, are fairly uncommon since you've got to sell a lot of beer to make enough profit to justify the investment. But some folks just want to keep things simple, forego the hassles of retail staffing and just want to brew; have their beers on tap somewhere and put a little money in their pocket. Nothing wrong with that, but do go in with eyes wide open.

Taprooms are much more the nano norm as you're selling all the beer at retail prices — but with that comes a lot of cost of retail space and staffing. As a perspective, you'll get about 200–220 pints per BBL net yield. Typical retail price for a pint is $5–$7 = $1,000–$1,500 per BBL. Typical wholesale price for that same BBL is about $500. All that said, most taprooms also sell a small portion of their kegs to outside accounts, not so much for additional profit, but for advertising to draw in new clientele.

Another absolutely vital part of the

After the business plan is mostly solidified sizing your brewhouse system is simple math.

Selecting the size and design of your brewhouse has huge implications for the type of brewery you are looking to implement.

business plan is the market study. This doesn't need to be a difficult task. If you've got other breweries in your community, what size systems do they have? How often do they brew each week? How much beer do they sell each week? How seasonal is their business? What are their best-selling styles? Other things can simply be observed. Do they offer guest taps? How often do their style offerings change? Do they have a kitchen or schedule food trucks? Do they make hard seltzer? Offer wine or liquor? If you do have a lot of local competition, what are you going to do differently to draw in customers? And this can be more than just beer related. If you don't have another brewery in your area, find a community similar in size and demographic to yours, and go visit there. Brewers are more likely to give specifics if you're not in the same locale.

Another factor that isn't talked about enough is what your personal goals are. Not everyone wants to be the next Bell's Brewery. Some want to supplement their day-job income and sell beer to local restaurants. Some just want to replace their current income doing something they are passionate about. These are perfectly valid reasons to start a brewery but they will affect the brewhouse you choose.

> **Another factor that isn't talked about enough is what your personal goals are.**

Finding your niche is also important and this, too, affects the brewhouse that'll work best in your business. Will you brew lots of styles and always offer something new for your customers every few days? That will shift you to a smaller system and more frequent brewing. Looking for a few flagship beers and also planning to distribute some of your production? That'll drive you to a bigger system. Will you brew and decorate to a specific theme? German lagers, sours, U.K. beers, Belgians, heavy metal, Sinatra? Those also affect your brewhouse and cellar tank sizing.

Some final words of wisdom to help you size your system is reminding you that there is a whole lot more to owning a brewery/taproom than brewing and cellaring. I call that the business of running the business. Alcohol and Tobacco Tax and Trade Bureau (TTB) reporting, finances/banking, purchasing and bills, IT and point-of-sale systems, equipment maintenance, managing and hiring staff, web traffic and other advertisements, growth planning, working the taproom, tours and customer events, etc. Unless you plan to hire a brewer out of the gate, only plan to brew three days a week maximum. That'll leave the other three days for the rest. And a day to rest . . . maybe.

Now that you've got the bulk of your plans together, we at Blichmann Engineering have built an online calculator to help you size your system (link after this paragraph) and it will give you recommendations for the types and quantities of cellaring tanks you'll need. There may be others out there to explore that I am unaware of, so if you do find another please use them and compare. Be sure to consider at least one bright tank for clarification and carbonation. Most nanobrewers keg their beer, but many serve from bright tanks, or do so only for their flagship beers to cut down on keg washing and filling. https://www.blichmannengineering.com/tankplanner/index/index

I recommend running a number of scenarios, particularly growth scenarios, so you ensure you've got enough room in your facility for cellaring expansion. Also note that the cellaring equipment is almost always the bottleneck in a brewery. While it is certainly not recommended for nano-sized systems, you can always run your brewhouse 24/7 to turn out a lot of batches per week, but your fermenters are already working 24/7. So you will need to keep that in mind at this point.

Once you've sized your system you'll need to select the power source. 7-BBL on down, electric is a great choice. Quiet, efficient, and the ventilation needs are fairly low . . . one of the biggest issues we run into with electric systems are their power requirements. They consume a lot of power, (roughly 4 KW–12 KW+) and you've got to make 100% sure your building can provide that. Most electric utility companies will consult with you about power that is currently available and also what can be run to the building if it isn't currently available. Don't trust your realtor or building owner at face value . . . or a residential electrician. In all cases, be sure to get power needs written into any purchase or lease contract. The other common choice, where adequate electric power is not available, or just too expensive, is natural gas. Be sure to choose an industrial-type burner with an enclosed burner box. Open-flame type burners generate a lot of heat in the brewery and can be difficult or impossible to get permitted for operation. Again, discuss your needs with the utility company and they can let you know if the building can support this.

Now that you have an idea about the size of your system and power source, there are a couple types of brewhouses out there these days. The traditional "skidded" systems include the boil kettle, mash tun, and hot liquor tank all pre-mounted to a stainless steel frame. All the interconnect plumbing is hard-piped to each tank, chiller, pumps, and so on. A platform is provided for access to the top of the vessels. The benefits of this type of system are that all tanks are plumbed and ready to go. Operation doesn't involve moving hoses between tanks and pumps. And they have that cool "pro" look to them. The main drawback is the high price and the inflexibility to modify the plumbing if you want to use a different process. They also have a learning curve to know which valve does what.

The other common type of system is individual tanks that are either floor-mounted or on a stand and interconnected with hoses. Since they are relatively short vessels,

no platform is needed. The benefits are a significantly lower price tag, flexibility in operation and layout, and they are much easier to move into your facility as individual pieces. The learning curve for a homebrewer is easy since they are plumbed and operated in a familiar way. The only real drawback is manipulating hoses during the brew day. But some manufacturers offer a hose valve manifold to somewhat mimic the hard-piped systems, yet maintain the flexibility of a hose-connected system.

Most manufacturers offer systems with insulation jackets. Some offer single wall, non-insulated vessels as well. While insulated mash tuns, as well as heat-exchange recirculating mash systems (HERMS) and recirculating infusion mash systems (RIMS) are the norm in homebrewing, they are largely unnecessary for any system over 2-BBL. The large size of the vessels retain heat much better and temperature drop over an hour is no more than 1–2 °F (0.5–1 °C). Insulation does help keep the brewhouse a little cooler but that is normally not a major issue. And it is nice to have the sidewalls cooler for burn prevention. But that does add cost to your system. In either case, step mashing and RIMS/HERMS systems are unnecessary as they are carryovers from small homebrewing systems. Today's malts don't benefit from step mashing, so save that time and money to invest elsewhere in your business.

Lastly, don't forget about the other equipment that is vital to select upfront. They are also highly dependent on your system size. A glycol chiller or temperature-controlled fermentation room is key to successful fermentations. Work with a reputable company with good local support that sells a product with a reputation of reliability. Going cheap here can be the most expensive mistake you'll ever make. Again, plan for growth. If you're planning to keg the bulk of your beers, a keg washer is a definite time saver. It also provides a consistent high-quality cleaning and sanitizing. Water is a key ingredient, so be sure you've factored in water treatment, storage, and potentially a reverse osmosis (RO) system if your local water is difficult to treat. If you plan to crush your own malts, a quality grain mill is a must. While you can buy most malts pre-crushed, the advantage of having your own mill is consistency of crush, as the crush will vary somewhat between malt suppliers. If you're only milling specialty malts you can get by with a high-end homebrew mill, but there are a couple mills on the market that are tailored for nanobrewers and are much more economical than large commercial mills.

Wrapping it all up, selecting the right system for your needs really is heavily based on your business plan. And the key factors there are being honest with yourself about how often you can realistically brew each week, carefully assessing your market potential, factoring in affordability with the cash you expect to generate each month, and determining what you hope to achieve by owning a brewery. Get these right upfront and you're setting yourself up for success! BYO

BY GREG PATERSON

KEGERATOR TOWER COOLING

An alternative chilling system

I'm proud to say that as of 2021, I've been brewing for twenty years. I spent the first decade of those years producing kits and bottling in flip tops. I read about all-grain brewing processes for longer than I'd care to admit prior to moving away from extract kits. Once I attended my first homebrew club meeting I made the jump to all-grain. Tired of washing bottles and bottling, I promptly made the jump to kegging and haven't looked back. Bottling is still my least favorite brewing-related activity. I installed my first kegerator in 2014 (pictured on right), as an under-counter install. Keeping the tower cool was a challenge, since this kegerator didn't have anything in place to do so. Relying only on convection led to many a foamy first beer dispense. I put my engineer brain to work to ponder several options.

Several were recently published in the November 2020 *BYO* "Advanced Brewing" column; two options mentioned are having a forced air fan, and a glycerol (glycol) recirculating pump. I'm here to tell you there's another option that is easy to build, inexpensive, and solid state. I built a copper pipe heat sink that keeps my beer lines and tap faucets chilled. The copper wire and pipes conduct heat away from the tower and taps to the fridge's chilling system. From there the heat is transferred to the refrigerant system. I've been through three iterations to get to what I'm presenting here. Each has improved on the last in terms of cooling capability and results.

Copper has a high heat transfer coefficient, and we'll be using that physical property to our advantage. See the following table for the thermal conductivity of other materials. Given the ubiquity of copper in plumbing and wiring, it's an ideal choice for this project. Over the many years my heat sinks have been in operation, I have yet to observe any corrosion of the copper despite the moisture often present on the fridge surfaces. I credit the low temperatures slowing the oxidation reaction.

Material	Thermal Conductivity (W/m*K)
Stainless Steel 304	14.4
Steel	59
Aluminum	236
Copper	401
Silver	428

There are a few things to keep in mind when starting a project like this. First, you want the mass of the cold side (attached to the fridge evaporator) to be larger than that of the warm side (up the tower). This will help ensure the net movement of heat away from your faucets. The second is to allow room for all of your tap lines. In this project I only have two 5-mm ID (3⁄16-in.) vinyl lines, so the inner diameter of a 1-in. trade-size copper pipe allows them to fit nicely. Note that they don't fit with the compression fittings on, so plan accordingly.

Tools and Materials

- Kegerator with tower-mounted faucets
- 5 ft. (1.5 m) ½-in. copper pipe
- 6 in. (40 cm) 1-in. copper pipe
- (5) ½-in. copper elbows
- (1) ½-in. copper tee
- (1) 1-in. to ½-in. branched tee
- Zip ties
- Zip tie mounts
- 12 in. (30 cm) 14-gauge copper wire

The system I came up with is a copper pipe heat sink that keeps my beer lines and tap faucets chilled.

Photos by Greg Paterson

1. MAKE SPACE

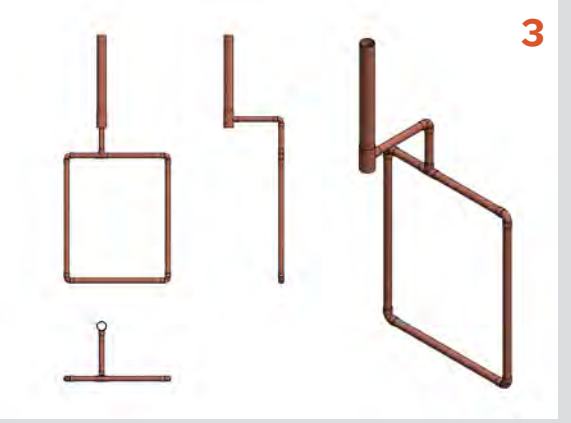
My kegerator came with a forced air fan, which I didn't find worked well and added extra noise. It also had a storage rack that I removed. You should also decide whether you want to store your CO_2 inside or outside your refrigerated space. I prefer to keep it externally for a few reasons. It allows for more space for kegs and bottles. Additionally, the CO_2-tight seals and threaded fittings of the tank and regulator won't be subject to low temperatures.

2. MEASURE AND DESIGN

Noting that my evaporator is off center, I designed the copper rectangle accordingly, and slightly undersized compared to the footprint of the evaporator. The top of the rectangle tees up, elbows to the tower opening, and connects to the branched tee adapter where my beer lines plumb into the kegerator's tower.

3. CUT AND BUILD THE EVAPORATOR SIDE

The copper apparatus can be pre-assembled and fixed in place using adhesive zip tie mounts. Additional metal connection between the evaporator and the copper piping could improve the heat transfer as well; you don't want to sub-cool the copper or have condensation freeze like it can on the fridge components. I didn't solder the joints when assembling as the zip ties hold it in place securely. This also allows me to add more copper to the cold side in the future if I see fit. With the components in hand, you'll also need a copper pipe cutter and wire cutters for trimming the zip ties. I started from the evaporator side and dry fit my elbows and tees to get my pipe lengths. Cut, dry fit, measure, and repeat. I stopped at the reducing tee, as the riser is the last thing to install. Here is a rendering of my design, adjust yours as needed for your kegerator.



4. MEASURE, CUT, AND INSTALL THE RISER

Once I had the reducing tee in place I fed my 1-inch pipe up through the tower to determine its length. Remember for all these pipes that they insert into the fittings to various degrees, so always account for that. The 1-inch copper stops short of the faucet shank barbs. The riser pipe is dropped in from above and sockets into the reducing tee. See the adjacent image of the copper heat sink installed on evaporator.

5. INSTALL BEER LINES AND SHANKS

Once in place I added some tower insulation and ran my beer lines. Of the three kegerators I've owned, I've never found one with adequate insulation, so I usually add a bit extra to the sides and on top of the shanks. Plumbing pipe insulation works well for this, and comes in several different diameters, allowing a snug fit.

6. COMPLETING THE CIRCUIT

The last step is to add some copper wire that wraps around both shank barbs with the excess (again more mass on the colder side) stuffed into the open pipe end. This last bit helps to keep the faucets cold.

If you live somewhere with lots of humidity, you may see condensation on your faucets on warm days, but that just means your beer is cold. Since the faucet is still exposed to room temperature air, it will still be warmer than the beer, so you can expect a bit more foam in your first pint.

There you have it. Tap those kegs and have a brew! BYO

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BY NICK TIER AND DAN LEPPOLD

SPACE BEER

To the edge of our world and back

Space is awesome. No, not physical space, like your yard or loft . . . outer space. It's a fascinating environment that humans have been studying for hundreds of years and we still haven't unlocked one billionth of a percent of its secrets. Like, for example, how would the conditions in space impact brewer's yeast and its ability to make beer? Now I've got your attention.

I'm a history teacher, while my friend Dan Leppold teaches science, and we like combining science and brewing. Last fall, Dan and his students were given the opportunity to send experiments into space as part of a group called Edge of Space Missions, based out of Fort Collins, Colorado. They were allotted a 2.71-lb. (1.23-kg) payload weight that would ride a hydrogen balloon into space. Yes, you can take a balloon into space.

Our students engineered the payload box to survive the trip and dreamed up experiments to go in the box for the March 2020 mission. Naturally, being a brewer, I asked Dan if there was room in his payload to send some yeast into space. I was curious if the conditions in space would affect the yeast and, let's face it, I could say that I brewed a "Space Beer" (which needs to be said with a sci-fi twang to it). After some convincing, he finally agreed.

The harsh conditions in space would cause a liquid yeast package to expand and burst, so I chose Lallemand Nottingham yeast because it is vacuum packed and has almost no liquid in the pack. We put an 11-gram sachet in the payload and kept another from the same production lot here on Earth as a control.

The payload box, with the yeast sample safely stowed inside, travelled to an altitude of over 85,000 feet (16 miles/25.7 km) — above almost all of our atmosphere. It was subjected to intense radiation, very cold temperatures exceeding -40 °F (-40 °C), and almost-complete vacuum conditions. The camera onboard captured some stunning images of the Earth's curvature, atmosphere, and the blackness of space. The highest speed registered by the balloon was 100 mph (160 km/hr) in the upper atmosphere where there is no air to slow it down. The balloon terminated and fell to earth, landing over 40 miles (64 km) from the launch site into a very friendly farmer's field.

When we got the payload back, the brewing began. I wanted to brew something that would allow any differences in fermentation to be obvious, so I chose a very light English golden ale with Challenger and Galaxy hops because, well, Space Beer! I brewed a 10-gallon (38-L) batch, split it between two fermenters and pitched the yeast directly into the wort without rehydrating. After 12 hours, both space yeast and control were bubbling away. After 5 days, they both hit a final gravity of 1.009.

About two weeks later, my homebrew club, Bruclear, organized a "socially distant," semi-blind tasting of the beers. Tasters were poured a sample of each without knowing which was which and asked to identify any differences. Shockingly, 93% of tasters (13/14) agreed there was a difference between the beers. The consensus was the Space Beer had some elements of a stressed fermentation and was harsher than the control. Personally, I was amazed. I did not expect there to be a difference, let alone one this stark.

What happened? We can't be 100% sure, but our hypothesis is that either temperature, pressure, radiation, or a combination of all three affected the yeast, probably causing enough to die off to create a stressed fermentation. The microbiologists in the club think pressure and gamma radiation are the most likely, but we'll have to conduct more experiments to be sure. I guess we'll have to send more yeast into space! Cheers! BYO

The payload box, with the yeast sample safely stowed inside, travelled to an altitude of over 85,000 feet (16 miles/25.7 km) . . .

Photo courtesy of Dan Leppold

This photo was taken from the hydrogen balloon that carried the brewer's yeast right to the edge of space and back.

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