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Brew Your Own®

THE HOW-TO HOMEBREW BEER MAGAZINE

MARCH-APRIL 2019, VOL.25, NO.2

FINDING HOPPINESS

- 7 New Hop Varieties For Your Homebrew
- Revisiting Classic American Hops
- Craft A Better New England IPA Through Science

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THE HOW-TO HOMEBREW BEER MAGAZINE

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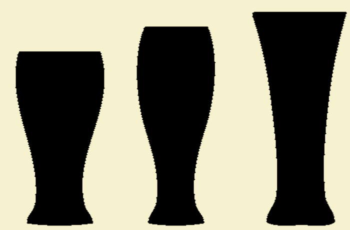
RECIPE INDEX



RECIPE STANDARDIZATION

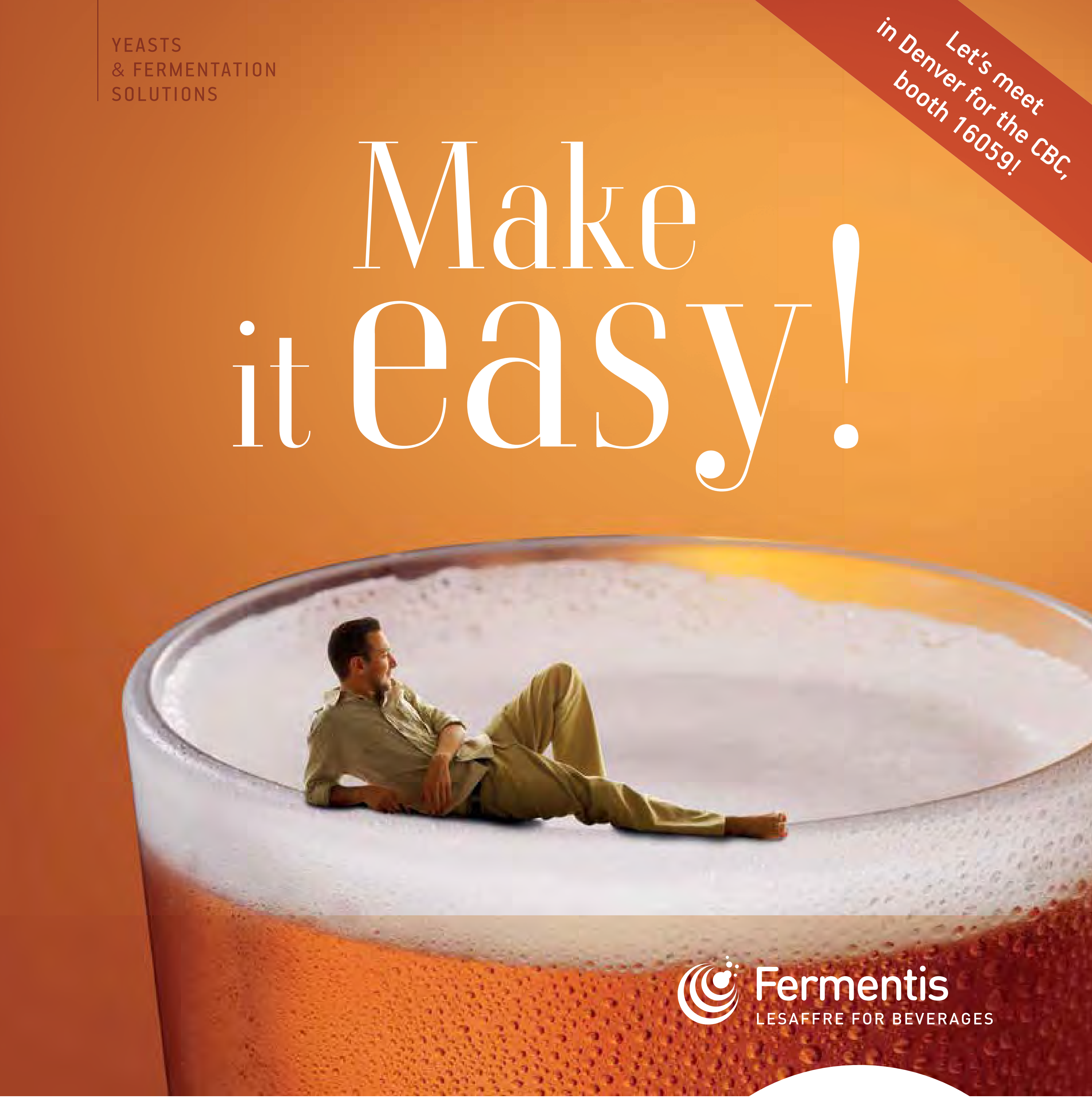
EXTRACT EFFICIENCY: 65%
(i.e. — 1 pound of 2-row malt, which has a potential extract value of 1.037 in one US gallon of water, would yield a wort of 1.024.)

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

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

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

Gallons:
We use US gallons whenever gallons are mentioned.



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Q

Pizza and beer are a beautiful pairing, but do you have another favorite food-beer pairing?

I have sampled a world of food and beers having lived on three coasts. For me it is all about the experience. We were in New Orleans one year for a photography convention and as luck would have it we found our way to an oyster bar in the French Quarter, I believe Desire. One of my favorite combos is oysters, gumbo, and Dixie. Yes, I know that's two and a beer but it really eats like one. We made our way through many dozens of oysters and Dixies that night. To this day it's one of my favorites, oysters dripping in seawater, a touch of lemon, Tabasco and chased with a Dixie. Feel free to swap in your favorite lager. Enjoy with friends. Cheers!

There's so many options and yet, so little stomach space. I believe that variety IS the spice of life so to pick a favorite is difficult. Seafood, especially oysters, paired with a fruity, peppery saison is delightful and refreshing in the summer. Or if I'm having a decadent moment, I'll reach for a rich, dark chocolate cake coupled with a tart kriek or framboise. The acidic qualities of the beer aid in cutting the richness of the dessert.

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Calibrating Your Equipment

Calibrating equipment is too often an overlooked part of our brewing process. It does not take long to calibrate some key pieces of equipment and the ramifications for having them can mean significant improvements for your beer. https://byo.com/article/calibrate-your-hydrometer-and-fermenter-techniques/

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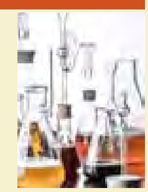
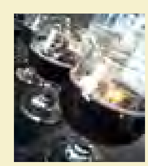


Homebrewing Experiments

Homebrewing and experimenting go together like a hand in a glove . . . homebrewers have always been experimenting. But are you sure that you are doing it properly? Learn from some seasoned veterans the methodology and results from several homebrewing experiments. https://byo.com/article/hb-experiments-layout/



Brewing Big Barleywines

Big, brash, and bold — barleywines can be one of the more challenging beer styles for homebrewers to master. Learn more about the history, best brewing practices, tips, and biggest challenges when tackling this monster of a beer. Also you will find several recipes included. https://byo.com/article/barleywine/

MEMBERS ONLY

A Guide to Brewing Honey Beers

Honey can be used in brewing to boost potency, lighten body, manipulate perceived sweetness, and lots more! Learn how to use honey in your homebrew, and try brewing three award-winning commercial clones. https://byo.com/article/honey-beers-and-clones/

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MAIL

FERMENTING BELL'S HOPSLAM CLONE

The December 2018 issue has a recipe to clone Bell's Hopslam Ale and being intrigued I brewed it last weekend using the brew-in-a-bag (BIAB) method. Everything went well and it's fermenting nicely with blow-off tube in place. My question is about the instructions, the final sentence says, "On day five of fermentation, add the dry hops addition. Bottle or keg after 3 days on dry hops." Is this suggesting to add dry hops to the primary after only 5 days? And then keg after only 8 days total? This does not follow any conventional ale recipe in my experience. Can you please clarify? Unless otherwise instructed I plan to treat this like most other ales I have brewed and leave it in primary for 2 weeks, secondary for two weeks, dry hopping the last 5-7 days before kegging.

Mike Grace • *via e-mail*

BYO *Recipe Editor Dave Green responds: "Hi Mike, Yes, that is indeed correct . . . but that doesn't mean you need to follow those instructions in the recipe to a T. There is nothing wrong with your timetable, but commercial breweries need to free up tank space, so time is of the essence for them. With that said, I've been known to keg my IPAs within about 1 week if using a higher flocculating English ale strain, which I use for my New England-style IPAs. I would push that back to 2 weeks if I were using a lower flocculating German ale strain (including the Chico strain, which this clone recipe calls for). Dry hops can go either in the fermenter or in the keg.*

"Proper pitch rates and fermentation temperatures are key as there is less room for error if you do want to turn around a beer this quickly. But if you have that under control, then 8 days with good flocculating yeast and dry hopping occurring in the primary fermenter gets a thumbs up from me. But once kegged, then it will be about a week in before I would serve. Also, Bell's recommended using the Chico strain as a substitute for their proprietary strain, but I've always used Anchor's strain (Wyeast 1272 - American Ale II) in my Bell's clones and find it to be quick flocculating and more suited for a quick turnaround like instructed here. By the way, if you notice, some brewers are now dry hopping at the same time they pitch the yeast!

"Hope that helps and that the Hopslam finishes strong!"

contributors

Jeff Gladish began homebrewing in 1990 and soon became known for his smoked beers as well as his Poblano Wit, but he also makes a pretty decent Pilsner. He brews in 10-gallon (38-L) batches about once a month and is about to keg batch number 389. Jeff holds the rank of BJCP Master Judge as well as seven-times recertified Master Automobile Technician, two achievements that he says indicate he takes tests well. He lives in Tampa, Florida with his wife of 42 years, Ellen, who although quite happy to imbibe in other spirits, does not drink beer. In spite of that she has graciously tasted and offered her opinion on every batch of homebrew since the beginning. Jeff is a lifetime American Homebrew Association member and past President of both Tampa Bay BEERS and Best Florida Beer. He is the rare homebrewer with no plans to "go pro" declaring that he has already "ruined one perfectly good hobby."

Jeff makes his *BYO* writing debut beginning on page 34, sharing tips for brewing balanced pepper beers.

Scott Janish is a beer researcher and writer at his popular homebrewing blog ScottJanish.com and Co-founder of Sapwood Cellars, a Maryland-based brewery specializing in fresh hoppy ales and barrel-aged sour beers. Scott is also the author of a self-published advanced brewing book focused on the science of brewing hop-forward beers titled, *The New IPA: Scientific Guide to Hop Aroma and Flavor,* scheduled to be released in early 2019.

Scott makes his *BYO* writing debut beginning on page 60 with an overview of some of the most critical research he discovered in the process of writing his book.

Betsy Parks was the Editor of *Brew Your Own* and *WineMaker* magazines from 2013–2017, and worked for both publications for more than 10 years. She is currently pursuing her master's degree in writing and publishing at Emerson College in Boston, Massachusetts. Prior to joining the magazines, Betsy attended the New England Culinary Institute in Montpelier, Vermont, and worked as a chef in commercial kitchens. Later in life she returned to college and received a bachelor's degree in journalism, and joined *BYO* after graduation.

In this issue, beginning on page 52, Betsy explores the newest hop varieties to become available to homebrewers.

THE v4 KETTLES

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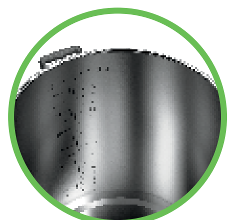

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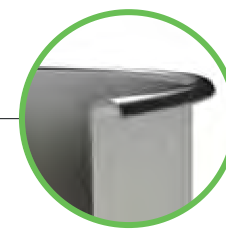

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FINDING THE GRAINS FOR DALE'S PALE ALE CLONE RECIPE

The clone recipe for Dale's Pale Ale (from the December 2017 issue of *BYO*) calls for Simpsons Premium English Caramalt (25 °L) and Simpsons dark crystal malt (80 °L). Dale says these are very important to the character of his pale ale. I cannot find a source that carries both, I did check 5 or 6 brew shops but no success, can you help?

Al Freeberg • *via e-mail*

Hi Al, You should be able to find the dark crystal malt from suppliers online. Unfortunately, the Premium English Caramalt will be the difficult one to obtain in the US. (Searching online, Chicago Brew Werks carries both, but are currently sold out.) There are international and Canadian shops that have it in stock for readers outside the US, but if you are stateside then you may need to find a substitute. Fawcett's pale crystal malt should do the trick.

CLARITY IN WATER

I read Dave Green's "Beginner's Block" article on water in the January-February 2019 issue of *BYO*. He mentions the water molecule as being "magnetic," but I think he means "polar" since it doesn't have magnetic properties. Also, under "Acids and Bases" he says a pH of 7 means 1 x 10^-7 hydronium ions per liter. Wow, that's not very many! I think it's actually 1 x 10^-7 Molar, which is a lot more!

Gary Schwartz • *via e-mail*

Story author Dave Green responds: "First, yes "polar" would probably be the best word to use in that reference, but since I started the sentence with "Polarity drives . . ." I thought using the earlier simile to a magnet would help readers get a visual in their heads en lieu of graphics . . . but using the term "magnetic nature" is not the proper phrasing. Magnetic-like nature should have been used instead. Second, wow, yeah, guess it's been a while since I've taught chemistry. That facet sailed right on by me as I was writing this piece! I need to take on a few more zeroes there when Avogadro's number is used.

"Thanks for reading, Gary, and pointing out these errors."

WRITE TO *BYO*

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

BEGINNER'S BLOCK

BY DAVE GREEN

GRAIN HUSKS EXPLAINED

Here at *Brew Your Own* magazine, we field a lot of questions that revolve around the husks of brewing grains. Grain husks serve a very specific purpose for many all-grain brewers and can be both a benefit and a drawback at times. Learning what grains have husks and those that do not, as well as when huskless grains may benefit your beer or when adding husks to a mash can be advantageous to your brewing goals.

WHAT IS THE HUSK?

There are several synonyms for a grain's husk, such as the hull or chaff. A grain's husk is its protective sheath and it is inedible to humans, so farmers have always worked to remove a grain's husk after harvest. The grain's husk is distinct from the bran layer, though some processing techniques, such as pearling, will remove both the husk and the bran of a grain. One of the easiest to understand examples is found with rice. Rice hulls are the almost plastic-like outer shell of a rice grain and are never included when you buy rice. The bran layer on the other hand is what makes brown rice, brown. Remove both the husk and the bran and you are left with white rice. The bran contains of lot of the fiber, proteins, and minerals of the grain.

Traditionally grains had their husks removed via a two-step process: Threshing (loosening the husk) followed by a winnowing (husk removal process). Once the husk is removed, the grain is now said to be "naked." Some grain's husks are rather easy to remove and simply tossing the grains around in a basket is enough to winnow the husks off. But with some grains the husk is thick and firmly attached to the outer bran layer of the grain. That is the case when dealing with barley husk, so unless specially marked, barley that we brew with will all have husks on them. Wheat on the other hand is easier to thresh and winnow, so malted and unmalted wheat we purchase for brewing will be naked. Rye malt you will find is huskless, while oats are husked unless specifically marked, like in Simpons's Golden Naked Oats®. Meanwhile, flaked and rolled grains no longer contain husks.

Adding rice hulls to a mash is a great way to create a more fluid and easier to manage grain bed.

THE DOWNSIDES OF A HUSK

The composition of husk is really more closely aligned to wood than it is to the rest of the grain. Composed of cellulose, lignin, hemicellulose, and a protein matrix, the structure of the husk allows it to be a great shield for a maturing grain seed. But from a brewing perspective, this aspect means that it provides very little in use for us chemically speaking. And during the malting process, the husk can actually turn against us. Those same compounds that provide the structure to the husk can also contribute astringency, and burnt-acrid flavors when highly roasted. For some beers and beer styles, a brewer may actually want a little bit of this characteristic, so grains such as black patent malt and black/roasted barley still have their husks included. But for smoother flavor in darker beers, brewers may want to select dehusked roasted malts. It is easy to find dehusked black malts if you know what you're looking for. Any dark roasted wheat malt or rye malt will be dehusked. For barley you can seek out Debittered Black Malt, or Weyermann's Carafa® Special line, or Briess' Blackprinz® malt. To take it a step even further, some roasted malts will even be pearled, removing both the husk and the bran layer that contains a lot of the grain's polyphenols, such as Viking's Pearled Black Malt (not to be confused with the Pearl variety of barley).

BENEFITS OF THE HUSK

All-grain brewers of all sizes and levels gain a huge advantage thanks to a benefit that husks provide. Acting as mini-spacer in a mash, husks allow liquids to flow through a grain bed. Without any husks, the grains and their associated beta- glucans, which can be extremely gummy, will create a thick porridge-like mass in the mash tun. Without the "structure" provided by the husks, the grain bed is more like a ball of dough then a grain bed. It's just not efficient and in lauter tuns the compaction can be enough to prevent any water from draining through the grains. At that point, we brewers have what is known as a stuck mash. There is simply no avenues for the liquid to move through the thick, starchy mash. The husks create those micro-sized pores that allow the liquids to sieve their way through.

If you plan on using a high percentage of huskless grains such as wheat malt, luckily for us we can easily toss in some rice hulls. These husks are by-products of rice processing and all-grains brewers should always keep some on hand. I know many Brew-In-A-Bag (BIAB) brewers are saying "we don't need rice hulls!" But even BIAB brewers benefit from a more porous mash where liquids are able to diffuse and they allow for a quicker drain of their grains.

BYO POLL RESULTS — WHAT'S IN YOUR FERMENTER?

In January, we asked followers on Facebook, Twitter, and Instagram what beer(s) they've got in a fermenter at home. We compiled everyone's responses into 13 general categories. It may not be too surprising to those of us in the Northern Hemisphere that the Stout-Porter category took top position since it was compiled in the middle of winter and they often can sit in fermenters longer than some other styles.

WHAT'S NEW

BLICHMANN ENGINEERING MODULAR POWER CONTROLLER

For brewers that are looking to get into electric brewing or to upgrade their boil control capabilities, the folks at Blichmann Engineering have crafted a controller for you. Available in a 240 V (7200 W) and 120 V (2400 W) model, this power controller is designed for boil kettles where temperature control is not needed. Utilizing linear power control allows for 0–100% optimization of the potential power of the immersion heater. This unit was designed to be plugged into the BoilCoil, but works with all manufacturers' immersion heaters and can control up to 4 additional relays if more than one heating element is used in the kettle. Find out more at *www.blichmannengineering.com*

SABRO™ HOP

Formerly known as HBC 438, the Sabro™ hop is the latest release from the Hop Breeding Company. Bred from wild hops indigenous to the American Southwest, *Humulus lupulus var. neomexicanus*. A unique brewing hop with notes of tangerine, coconut, tropical fruit, and stone fruit, but some tasters note cedar, mint, and cream in the mix as well. These are available for purchase at better homebrew shops and several online vendors. Or keep your eye out for a commercially-brewed beer with them in order to give this unique hop variety a taste. For more information on this variety, check out the "Hot New Hops" article starting on page 52 of this issue.

WHICH CAME FIRST, THE CHICKEN OR THE EGG?

A recent study published in *Nature Metabolism*, found a possible explanation of why certain cellular organisms such as *Saccharomyces cerevisiae*, produce ethanol. According to scientists at the University of Groningen in the Netherlands, the reason may actually lie in the fact that it is a way to slow energy production, sort of like an engine governor. When placed in a nutrient-rich environment, such as those found in brewer's wort, a yeast cell heads into hyper-drive metabolically speaking. When energy production exceeds a certain level, the yeast cells will switch from respiration to fermentation, effectively slowing down energy production.

This self-regulated "safety cap" on the cell's metabolic rate means that instead of taking each 6-carbon sugar ring and fully respiring the sugar down to 6 carbon dioxides, we instead get 2 ethanol and 2 carbon dioxide molecules. This is a lot less energy efficient (19 times less efficient) for the yeast cell . . . but this, biologically speaking, may actually be a good thing for the organism. What the scientists theorize is that this excess energy would stir up too much motion within the cell, effectively harming key cellular functions acting within the cell. Meanwhile, ethanol production by yeast has traditionally been viewed as a biological advantage, as ethanol is lethal to many competing organisms. So, the question then is, why did this ethanol-producing mutation occur? Was it for cellular safety reasons or was it for biological advantage? Maybe a little of both — but to read more about the study, visit: www.nature.com/articles/s42255-018-0006-7

Upcoming Events

MARCH 15 — WineMaker International Amateur Wine Competition is open to all homemade ciders, meads, and wine. Entry deadline is March 15 for the largest amateur competition of its kind in the world. Learn more at www.winemakermag.com/competition.

MARCH 22–23 — BYO Boot Camps are being held in Asheville, North Carolina. Join *BYO* for this unique learning experience, offering a range of in-depth, full-day, small-class brewing courses split over two days. Space is limited, so sign up now. Additionally, there are local craft brewery tours available. Learn more at BYOBootCamp.com.

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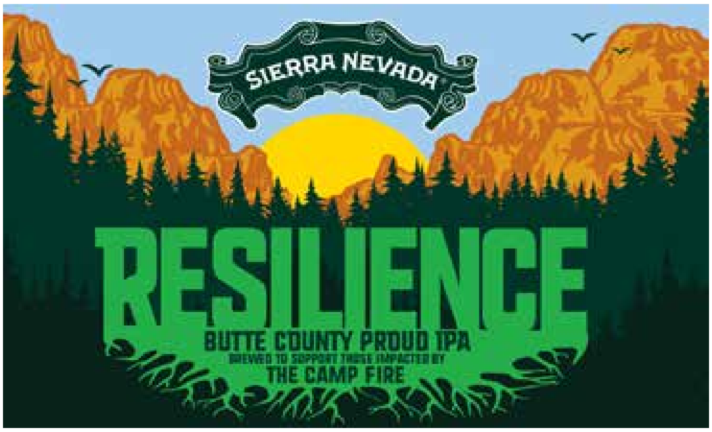
YAKIMA VALLEY HOPS

BY MICHAEL BURY

SIERRA NEVADA'S RESILIENCE IPA



Resilience. *Webster* defines it as "an ability to recover from or adjust easily to misfortune or change." The Camp Fire that spread through Butte County, California beginning on November 8, 2018, was more than just misfortune; it was the most destructive and deadliest California wildfire to date. It also took top dishonor as the world's costliest 2018 natural disaster as insurance estimates are in the realm of $10 billion.

Full containment of the fire took 17 days and during that time it scorched over 153,000 acres, destroyed 13,000 homes and another 6,000 buildings, and killed at least 85 individuals. Everyone in that region knew someone who was affected. Air pollution was horrendous with additional concerns around toxic chemicals such as VOCs, asbestos, and heavy metals being distributed, or minimally, affecting the burned areas. The smoke was carried on high winds as far as the eastern seaboard of the United States.

In the face of such a natural disaster, many of us would probably feel a sense of hopelessness. While the 5,000+ firefighters battled the blaze, the Grossman family and their brewery, Sierra Nevada, desired to extend a hand and help those who were impacted. They set up the Sierra Nevada Camp Fire Relief Fund to provide for long-term support for those affected. The Fund, which was supported through the Golden Valley Bank Community Foundation, was established with $100,000 from the brewery.

However large $100,000 might seem, it still paled in comparison to the monetary damage that Camp Fire caused. Enter Resilience Butte County Proud IPA, a fundraising beer from which 100% of sales would further supplement the relief fund. Ken Grossman was hoping for 200 breweries to lend a helping brew.

200 breweries was rapidly surpassed. As of the writing of this article, nearly 1,500 breweries have participated in the endeavor, which constitutes about 20% participation rate of US-based breweries. Several international breweries from the United Kingdom, Germany, and Guam have also participated. With the substantial number of breweries contributing 100% of sales of the beer to the Camp Fire Relief Fund, it's estimated that $15 million will be raised.

The participating brewery demographic is quite diverse as well. In the list, you'll find many of the largest craft breweries in the United States like Stone, Bell's, Deschutes, Sam Adam's, New Belgium, Brooklyn, and Dogfish Head. But you'll also find some of your local watering holes as well. In my own 25-mile area, 16 breweries participated (for a complete listing of participating breweries go to sierranevada.com/resilience-butte-county-proud-ipa).

But the raw ingredients for Resilience had to come from somewhere on someone's dime. To help with that, Sierra Nevada asked their suppliers to donate ingredients and for wholesalers and retailers to carry the beer and donate every dollar they received. Even though it was a big ask, everyone graciously followed through. Malt was donated by BSG, Canada Malting, Country Malt Group, Great Western Malting, Malteurop, Rahr, Briess, Cargill, and Admiral Maltings. And we're not talking about a couple hundred of pounds. For instance, Country Malt Group donated 70 metric tons of malt, which has been valued at more than $100,000. This allowed 220 breweries to brew their batches of Resilience. Many hop suppliers also got involved. Hops from CLS Farms, Crosby Hop Farm, Haas, Hopsteiner, and Yakima Chief Hops were donated to breweries.

In all, Resilience Butte County Proud IPA hit the market in late December and into the new year with more than 17,000 barrels produced — or 4.2 million pints — strong. Every dollar Sierra Nevada receives will go to those impacted by the Camp Fire. If you didn't get the chance to savor it, the following recipe will provide you with a chance to make it at home. And while you're brewing the beer, we strongly urge you to make a donation to the Sierra Nevada Camp Fire Relief Fund at: https://www.goldenvalley.bank/Community-Foundation.aspx

"We appreciate the tremendous amount of support and compassion shown from folks around the world. With the brave men and women risking their lives fighting this fire and the outpouring of support from communities near and far, we know we are on a path to healing and rebuilding." — The Grossman Family of Ken, Sierra, and Brian.

SIERRA NEVADA BREWING CO.'S RESILIENCE BUTTE COUNTY PROUD IPA CLONE

(5 gallons/19 L, all-grain — recipe configured to *BYO* recipe standards)
OG = 1.065 FG = 1.016
IBU = 64 SRM = 12 ABV = 6.5%

INGREDIENTS

12.5 lbs. (5.7 kg) Rahr 2-row pale malt
1.25 lbs. (0.57 kg) Crisp crystal malt (60 °L)
8 AAU Centennial hops (80 min.) (0.8 oz./23 g at 10% alpha acids)
8 AAU Centennial hops (15 min.) (0.8 oz./23 g at 10% alpha acids)
5.6 AAU Cascade hops (15 min.) (0.8 oz./23 g at 7% alpha acids)
5 AAU Centennial hops (0 min.) (0.5 oz./14 g at 10% alpha acids)
3.5 AAU Cascade hops (0 min.) (0.5 oz./14 g at 7% alpha acids)
0.5 oz. (14 g) Centennial hops (dry hop)
0.5 oz. (14 g) Cascade hops (dry hop)
Imperial Yeast A24 (Dry Hop) or similar yeast blend such as White Labs WLP644 (Saccharomyces "Bruxellensis" Trois) blended with White Labs WLP095 (Burlington Ale) strains
¾ cup corn sugar (if priming)

STEP BY STEP

Crush the malt and add to 4.3 gallons (16.3 L) strike water to achieve a stable mash temperature at 152 °F (67 °C) until enzymatic conversion is complete. Sparge slowly with 168 °F (76 °C) water, collecting wort until the pre-boil kettle volume is 6.5 gallons (24.6 L). Boil the wort for 80 minutes, adding the hops as indicated in the recipe.

After the boil is finished, cool the wort to 200 °F (82 °C) and then add the 0-minute hop stand additions. Stir the wort to create a whirlpool, then let settle for 20 minutes before chilling the wort down to yeast-pitching temperature. Now transfer to the fermenter, aerate the wort, and pitch the yeast. Ferment at 60–62 °F (16–17 °C). As the kräusen begins to fall, typically day four or five, add the dry hops to the fermenter and let the beer sit on the hops for four days. Bottle with priming sugar or keg and force carbonate the beer to 2.4 volumes CO_2.

SIERRA NEVADA BREWING CO.'S RESILIENCE BUTTE COUNTY PROUD IPA CLONE

(5 gallons/19 L, extract with grains)
OG = 1.065 FG = 1.016
IBU = 64 SRM = 12 ABV = 6.5%

INGREDIENTS

6.6 lbs. (3 kg) extra light dried malt extract
1.25 lbs. (0.57 kg) Crisp crystal malt (60 °L)
8 AAU Centennial hops (80 min.) (0.8 oz./23 g at 10% alpha acids)
8 AAU Centennial hops (15 min.) (0.8 oz./23 g at 10% alpha acids)
5.6 AAU Cascade hops (15 min.) (0.8 oz./23 g at 7% alpha acids)
5 AAU Centennial hops (0 min.) (0.5 oz./14 g at 10% alpha acids)
3.5 AAU Cascade hops (0 min.) (0.5 oz./14 g at 7% alpha acids)
0.5 oz. (14 g) Centennial hops (dry hop)
0.5 oz. (14 g) Cascade hops (dry hop)
Imperial Yeast A24 (Dry Hop) or similar yeast blend such as White Labs WLP644 (Saccharomyces "Bruxellensis" Trois) blended with White Labs WLP095 (Burlington Ale) strains
¾ cup corn sugar (if priming)

STEP BY STEP

Place the crushed malt in a muslin bag. Steep the grains in 5 gallons (23 L) of water at 160 °F (71 °C) for 20 minutes. Remove the grain bag and wash with 2 qts. (2 L) of hot water. Top off the kettle to 6.5 gallons (24.6 L) and heat up to boil. As soon as the water begins to boil, remove the brew pot from the heat and stir in the dried malt extract. Stir until all the extract is dissolved then return the wort to a boil. Boil the wort for 80 minutes adding hops at the times indicated in the recipe.

After the boil is finished, cool the wort to 200 °F (82 °C) and then add the 0-minute hop stand additions. Stir the wort to create a whirlpool, then let settle for 20 minutes before chilling the wort down to yeast-pitching temperature. Now transfer to the fermenter, aerate the wort, and pitch the yeast. Ferment at 60–62 °F (16–17 °C). As the kräusen begins to fall, typically day four or five, add the dry hops to the fermenter and let the beer sit on the hops for four days. Bottle with priming sugar or keg and force carbonate the beer to 2.4 volumes CO_2. BYO

BY DAVE GREEN

RUNNING YEAST TRIALS

Comparative fermentations

Yeast trials can mean a lot of different things, but ultimately it implies splitting a wort into at least two different fermentations. This is a great way to compare how the yeast will perform under different conditions, whether at the outset of fermentation, during active fermentation, or post-fermentation. We got recommendations for running yeast trials from two experts in the field.

Trials can be slow and tedious, but if you're into the process the results can be very interesting.

Kara Taylor has been with White Labs since 2009. She became interested in fermentation science while homebrewing during her days at Loyola Marymount University. She received a B.S. in biology in 2009 and began employment at White Labs in San Diego as a yeast laboratory technician. Since November 2018, she functions as the Technical Laboratory Manager. She enjoys traveling the world judging beer and educating brewers about fermentation.

When we started our tasting room, I really didn't understand how much of an influence a yeast strain could have on mouthfeel. Lagers brewed in an ale recipe still had a crisper mouthfeel. A panel of English strains showed how different creaminess can be influenced by strain.

My favorite story was when we were in Copenhagen and had provided brewers with a "wandering" pitch of yeast that travelled from brewery to brewery. Each brewery made a different style with the yeast, which was a farmhouse-style blend. We served all of the beers at a festival and it was funny because most of the beers were hard to tell apart. It was a great example of how a yeast-forward strain can dominate a beer, regardless of a style.

When running trials, there are a couple of different factors that we look at. Not only will we compare different strains but we will compare the same strain against itself . . . with the exact same conditions. This allows us to choose the most robust yeast to store in our bank. This may not be something homebrewers look at, but you may find that different generations of the same yeast can produce unique characterisitics in the final beer. We're looking primarily for attenuation and flocculation characteristics when we perform these type of tests. When we compare different strains we will compare attenuation, flocculation, mouthfeel, as well as flavor and aroma characteristics.

I would recommend if you want to do some different variables such as pitch rates, trub levels, or fermentation temperatures, make sure that you focus enough time and thought so that you're changing only one variable at a time. If you change the pitch rate between two fermenters while one fermenter has all the trub and the second fermenter has almost none, it's hard to know what made an impact. Trials can be slow and tedious, but if you're into the process the results can be very interesting.

Utilizing a control is something that is done in a scientific setting and may be difficult for homebrewers. You may think about comparing your beers to a commercial beer that is similar or a "standard" in that style. Trying to come up with your own homebrewed control when running yeast trials would not be a bad precedent to set either. I would say that doing a trial against a neutral strain such as WLP001 (California Ale) yeast is probably our most common, but we might be trying to compare yeasts that are more similar, like hazy strains that are popular these days.

We are lucky to have a brewery in-house and have the ability to do a lot of trials. For those, we usually round up a group of employees to help do some tasting notes. We will also run all of the beers through our analytical lab to help match up what we are smelling and tasting to the data. You can often perceive something as sweeter, but when you look at the data the beer actually has a lower gravity than the rest. Combining the tasting and analytical data can be very powerful when analyzing yeast strains. I highly recommend bringing friends or homebrew club members to a table for sensory analysis. Blind tastings are always fun!

Tamara Logsdon is the Quality Control Lab Coordinator and Brand Manager at Wyeast Laboratories, which provides liquid yeast for fermentations around the world. With a degree in biology and philosophy of science from the University of Puget Sound and having grown up with the family business, she has experience in just about every aspect of the company. She is currently balancing lab research and improving the presence of liquid yeast in the wine and cider industries.

Yeast trials are small-scale fermentations set up to experiment with different variables, so that any parameter of the brewing process can be adjusted, measured, manipulated, etc. Like all good science, trials give you the ability to set up a control, which is a standard for comparison between known and unknown outcomes. For example, if you were interested in adjusting your favorite saison recipe, your control should be your original recipe. It's familiar, you know what to expect when you brew it, how it should taste. You should have detailed notes on your brewing process so that the final beer is reliably consistent. Your variables could be a change in yeast strain, how the strain is expressed on different mash methods, using a harvested pitch compared to a fresh one, just to name a few. Maybe you want to troubleshoot an issue you're having such as stuck fermentation or an off-flavor in your beer. Variables are limitless! Trials will help you gain a better understanding of the intricacies of brewing and how a specific parameter can influence the final outcome of your beer.

Homebrewers mainly focus on yeast strain trials. There are several fermentation dynamics you can trial with the same strain (temperature, pitch rate, pressure, to name a few). I think there are no limits or requirements other than what you want to understand better or control with more intention. Use a simple, low-gravity, neutral recipe that will allow any nuances to be identified. If your goals are specific to a recipe you already brew, perfect the details and use that as your standard.

When I started working on sensory analysis, it was very informal. I would ask as many questions as possible and describe what I was tasting in a beer to colleagues or friends in the industry and listen to their feedback and interpretations until I understood how to identify and use sensory vernacular. Whether a sensory evaluation was being done on a sample in the lab, or I was at a local brewery, I asked questions all the time. Your sense of smell and taste are two of your most powerful tools – it truly takes practice to calibrate them! BYO

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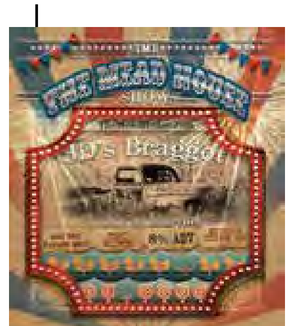

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BY ASHTON LEWIS

FEELING THE PRESSURE

Also: Tips for unitank users

Q HOW DOES ELEVATION AND ATMOSPHERIC PRESSURE AFFECT BEER CARBONATION AND DISPENSING? I SCUBA DIVE AND UNDERSTAND THE EFFECTS OF CHANGING PRESSURE. WONDERING HOW MY HOMEBREW MAY BE AFFECTED BY BIG ELEVATION CHANGES?

NATALIE KAPTEYN
SPRINGFIELD, MISSOURI

A Atmospheric pressure does affect beer carbonation and dispense, but the answer to this question is a little confusing depending on where the beer being dispensed was carbonated, and how carbonation is defined. It also depends on what is meant by the term "pressure." In an attempt to write an answer that is not overly confusing, I will break this subject into a series of bite-sized questions and answers to help prevent myself from becoming too confused! And to even further reduce confusion, I will try to reference as few units of measurement in this answer as possible; there are enough concepts involved in this topic without avoiding unit bias. Beer uses several languages; so if you live in a metric world, hang with me!

WHAT IS PRESSURE?

All things within the gaseous blanket surrounding the earth are exposed to the weight of the atmosphere. Depending on vertical position in this column of gas, items are exposed to less or more pressure. I think of this as if I am standing in a tube that extends from sea level to the boundary of the atmosphere; as I move up in this imaginary tube, the column of gas sitting upon me becomes shorter. This illustrates the concept of atmospheric pressure. Most of the world communicates pressure in relation to atmospheric pressure, and no matter where we go, 0 psi typically means "local pressure." I will return to gas pressure in a moment, but first want to cover hydrostatic pressure.

If we move this imaginary tube to the ocean, we can now travel below sea level and into the water. As we descend down into the column of water, we have the weight of the atmosphere and the weight of water upon us. This water weight is referred to as hydrostatic pressure and 33.8 ft. (10.3 m) of water column is equal to the pressure of the atmosphere at sea level. This means that when we descend 33.8 ft. (10.3 m) beneath the surface of the ocean, we have the equivalent weight of two atmospheres of pressure upon us. One atmosphere of over-pressure is another way of expressing the water pressure in this example, and it means that the water pressure is in addition to atmospheric pressure. Scuba divers are well aware of this pressure and monitor it when diving.

This is where pressure becomes a bit confusing; some of the world ignores atmospheric pressure and 0 psi in Tokyo, Japan (131 ft./40 m above sea level) may or may not mean the same thing as 0 psi in Quito, Ecuador (9,350 ft./2,850 m above sea level). A pressure gauge designed to measure over-pressure will read 0 psi in Tokyo and will also read 0 psi in Quito, but the absolute pressures at these locations are not the same, so this 0 psi nomenclature is clarified by using the term gauge pressure and designating the measurement as 0 psi_g or

Boosting the keg pressure maintains the same gas concentration, but the carbon dioxide volumes in the dispensed beer changes with elevation because of relationship between pressure and volume.

Photo courtesy of Shutterstock

Bourdon gas pressure gauges allow brewers to measure the over pressure found inside sealed vessels such as kegs or unitanks.

0 psi (gauge). Gauge pressure can be defined in mathematical terms by the following: Gauge pressure (psi_g) = Absolute pressure (psi_a) – Atmospheric pressure (psi_{atm}).

Although atmospheric pressure at sea level varies with changes in atmospheric conditions, pressure at sea level is defined as 760 mm of mercury column, or 14.7 psi_a; and as we move up in elevation the atmospheric pressure drops. This means that absolute pressure, or the total pressure exerted on something, and atmospheric pressure are equal when a pressure gauge reads 0 psi_g. Since gas solubility in liquids is affected by absolute pressure, it is less confusing to scientists and engineers to communicate pressure in absolute terms of psi_a, where $psi_a = psi_g + psi_{atm}$.

PRESSURE GAUGES

Eugène Bourdon, a French watchmaker and engineer, developed the ubiquitous, old school, gas pressure gauge and patented his invention in 1849. The so-called Bourdon tube design uses a thin, flat, hollow piece of metal formed into a C-shape. One end of the tube is open and the other end is sealed, similar to a balloon. When gas in the tube is pressurized, the tube radius increases and this movement is used to turn a gear mechanism that moves the dial indicator. Pretty clever application of gears! The nifty thing about Bourdon tube gauges is that they measure over-pressure and are unaffected by changes in atmospheric pressure. This is why gauge pressure is handy, and it's also why relying on gauge pressure to calculate things that depend on absolute pressure, like gas solubility, is problematic.

Atmospheric pressure is easily measured using a barometer. The original barometer was designed by Evangelista Torricelli in 1643 using a tall glass tube filled with mercury, then inverted over a reservoir of mercury, creating a vacuum in the tube. In this set-up, atmospheric pressure pushes upon the mercury reservoir, and the height of mercury in the sealed tube can be measured to determine the atmospheric pressure. Barometric pressure and atmospheric pressure are synonymous terms, and the barometric pressure at sea level (760 mm of mercury) is often reported using the abbreviations 760 mm Hg and 760 Torr, the latter as a reference to Torricelli.

UMMM, WHAT ABOUT BEER?

When a keg or bottle of beer is filled without over-pressure, the pressure on the beer is equal to the atmospheric pressure. When this keg or bottle is sealed and pressurized, the absolute pressure above the beer is equal to atmospheric pressure plus the gauge pressure. Carbon dioxide solubility is proportionally related to pressure and inversely related to temperature. Increase pressure (at a constant temperature) and carbonation rises; lower the temperature (at a constant pressure) and carbonation rises.

Brewers measure carbonation level using two different units of measure-

ment, and, again, this introduces a bit of confusion. The fundamental expression of carbonation references how much carbon dioxide is dissolved in beer, and the unit of measurement is grams of carbon dioxide per liter of beer. A typical carbonation level is 5 g/L, and the equilibrium conditions for this level of carbonation are 11.5 psi_g at 38 °F (3 °C). In order to make this less confusing, let's convert 11.5 psi_g to 26.2 psi_a by adding atmospheric pressure at sea level (14.7 psi). Absolute pressure decreases by ~0.5 psi for every 1,000 ft. (305 m) increase in elevation above sea level. Determining the gauge pressure required to maintain this level of carbonation is the practical question because gas pressure is measured with Bourdon tube gauges; so what is that pressure? This is simple to determine by the following calculation:

$$psi_g = 26.2\ psi_a - (14.7\ psi - [9350\ ft./1000\ ft. \times 0.5\ psi])_{atm}$$
$$psi_g = 26.2\ psi_a - (14.7\ psi - 4.7\ psi)_{atm}$$
$$psi_g = 26.2\ psi_a - 10\ psi_{atm}$$
$$psi_g = 16.2\ psi$$

A convenient way of thinking about this is that the pressure applied to a keg needs to increase 1 psi_g for every 2,000 foot gain in elevation. Easy peasy, right?

Here is the head-scratching problem with this discussion. We have maintained 5-g/L carbonation level by changing the keg pressure with the elevation gain, but the volume of this dissolved gas expands to different volumes depending on where the beer is dispensed. Using the ideal gas law, 5 grams of 0 °C carbon dioxide (0.1136 moles) occupies 2.54 L at sea level (14.7 psi_a) and 3.7 L at 9,350 ft. (10 psi_a). The volume of the expanded gas is that other measurement of carbon dioxide I referenced at the beginning of this dive down the rabbit hole of carbonation, and what this example shows is that the beer carbonation level, when expressed in volumes, increased from 2.54 to 3.7 volumes when dispensed at a tap in Quito. Boosting the keg pressure maintains the same gas concentration, but the carbon dioxide volumes in the dispensed beer changes with elevation because of relationship between pressure and volume.

TAKE HOME MESSAGES

BYO is dedicated to homebrewing, and the primary focus of most homebrewers is to brew great for local consumption. With this goal in mind, I suggest carbonating beer to a level that produces the best tasting beer around the elevation where the beer is brewed. If a Pilsner-style beer is brewed at sea level, the normal carbonation level for this style should be in the 2.5–2.6 volumes or 4.9–5.1 g/L range. If a Pilsner-style beer is brewed in Quito at 9,350 ft. above sea level, I believe the target level of carbonation should be 2.5–2.6 volumes and not 4.9–5.1 g/L of carbon dioxide.

Why? Because, the sensation of carbonation has more to do with gas expansion in the mouth and stomach, bubbles tingling on the tongue, and the appearance of foam than the actual concentration of dissolved carbon dioxide. We only notice that a beverage contains dissolved carbon dioxide when the gas comes out of solution. This is why carbonated beverages always seem to be over-carbonated when consumed on commercial aircraft where the cabin pressure is about 11 psi_a or 8,000 ft. (2,438 m) above sea level. At this reduced pressure, 5 grams of carbon dioxide expands to 3.58 L, compared to only 2.58 L at sea level!

The last question that comes to my mind when noodling my way through this interesting labyrinth is why brewers use two different methods to describe carbonation level. While the volume seems to be the user-friendliest unit when it comes to describing how carbonation affects mouthfeel and foam appearance, the volume is not the easiest unit to use for calculations. But using grams of carbon dioxide per liter of beer is great for brewing calculations, especially when determining how much priming sugar is required to achieve a given carbon dioxide concentration, because glucose yields 49% of its weight as carbon dioxide when used for priming. Need 20 grams of carbon dioxide? Use 20/0.49 or 41 grams of glucose.

And one last thought; if you are brewing beer for competitions that are held up or down the hill from where you brew, consider a carbonation target that works for the final destination. This may be akin to home field advantage for certain competitions.

Q I'VE RECENTLY COMPLETED A MAJOR HOMEBREWERY UPGRADE, INCLUDING TWO UNITANKS AND A GLYCOL CHILLER. IT SEEMS THAT MOST OF THE BOOKS AND ONLINE RESOURCES HAVE YET TO CATCH UP TO THE EQUIPMENT ADVANCEMENTS IN HOMEBREWING. ARE THERE GOOD SOURCES OF INFORMATION FOR BEST PRACTICES FOR UNITANKS AND OTHER ADVANCED EQUIPMENT?

QUESTION FROM LAZURNA
(FROM LIVE SESSION Q & A)

A The best treatise I have read about the development and use of unitank fermenters is in the textbook *Brewing Yeast and Fermentation* by Boulton and Quain. Although the subject is covered in other brewing texts intended for the commercial brewer, for example *Technology Brewing and Malting* by Wolfgang Kunze, Boulton and Quain cover many of the practical challenges of unitank fermentation, such as temperature stratification upon cooling, in great detail and discuss solutions to these very real challenges. D. R. Maule wrote an excellent historical account of fermentation design in his "A Century of Fermenter Design" published as a Centenary Review in the *Journal of the Institute of Brewing* (*J. Inst. Brew.*, March-April, 1986, Vol. 92, pp. 137-145) that covers the evolution of fermenter design from the late 1800s through the publication date. I will offer some thoughts about your question from the perspective of a small, craft brewer.

The development of the modern, single-tank, fermentation and aging system can be traced back to Dr. Leopold Nathan's cylindroconical tank designs that were patented in 1908 and 1927. Nathan was a Swiss chemist and his designs differed from conventional fermenters at the time because his fermenter design was closed, had a conical bottom, and incorporated a method to strip sulfur volatiles from beer after fermentation with gas. One of his patented designs incorporated an agitator and resembles a modern yeast propagation vessel. The primary design challenge with these vessels was the inability to easily and effectively clean the inside. Clean-in-place (CIP) developments in the early 1960s are credited to broader use of Nathan-type fermenters. Today, the cylindroconical fermenter (CCV) or unitank fermenter is the norm for breweries of all sizes. It is important to note that the term "unitank" was first used by the Rainier Brewery in 1968 to describe a new twist on the Nathan fermenter; the main differences were a 1:1 aspect ratio (shorter and squatter than the Nathan fermenter) and shallower cone. Although small-scale brewers chuckle about the concern of hydrostatic head in fermenters, tanks that have liquid columns taller than about 30 ft. (9.1 m) do present challenges, and this was one of the issues addressed with the Rainier unitank (and Asahi tank design from 1965).

The main features of these designs are that they are closed, permit for fermentation and aging in the same vessel, include sufficient cooling area to quickly chill beer to near-freezing temperatures, and allow yeast to be separated from beer. The following is a description of how many brewers use unitanks.

1. Wort is cooled and aerated between the brewhouse and the fermenter. The cooling set point is targeted to about 2 °F (1 °C) below the fermentation temperature set point. This is important because the tank is mixed as fermentation begins. If coolant is allowed to flow into the cooling jackets before fermentation causes liquid movement, temperature stratification will occur where the bottom of the tank becomes very cold. This can cause major delays in fermentation.

2. Although it is common to see foam, yeast, and beer flowing from unitank vent lines during fermentation, most commercial brewers try to avoid this from occurring because it represents loss and is just another thing to clean. Most unitanks are designed to be filled to 70–80% of the vessel's gross volume. In general, skinnier tanks with higher aspect ratios (height:diameter) require more headspace than squattier tanks because the skinnier tanks have more tank wall contact area per volume of beer, and foam stability increases with wall area. Many breweries use anti-foaming agents, like polysiloxane, to keep foaming to a minimum during fermentation, allowing brewers to maximize tank space.

3. The progress of fermentation is tracked on a regular schedule by taking a sample, degassing, and measuring specific gravity. Regular sampling provides information about how things are going, allows for sensory evaluation, and is especially important for beers that are spunded, or capped, for natural carbonation. Spunding is a great way to naturally carbonate beer and is very simple given the proper tools. If you want to use this method, it is imperative that the tank's design pressure is not exceeded and that the tank is equipped with a pressure relief valve.

4. Into hoppy IPAs? No problem! Unitanks are easy to dry hop, and the most common method is to simply add hop pellets into the fermentation from the top of the tank before fermentation ends. The main benefit to dry hopping at this stage is oxidation mitigation (OMG = oxygen mitigation is good, and it's really cool to see this uber beer geek term used so often in social media); since carbon dioxide is still being produced any oxygen entering the tank headspace will be scrubbed out, and oxygen in the hop pellets will be consumed by the yeast cells. Dry hopping after fermentation is complete requires precautions. Hopping during fermentation also allows for biotransformation of hop compounds.

5. Once everything to do with fermentation is complete, the unitank is chilled. Although some brewers cool to an intermediate temperature, most brewers crash cool the tank down to about 32 °F (0 °C). This step accomplishes a few important things. The first is that chilling the beer increases yeast flocculation and initiates yeast sedimentation as the floc sizes grow the floc density increases. Yeast can be harvested and re-used, and most breweries prefer cropping the yeast as soon as it settles into the tank cone. If you don't plan on re-using this yeast, it is still important to remove it from the tank cone because yeast autolysis may lead to off flavors, especially in larger fermenters where the yeast mass in the cone of the fermenter can become very warm from continued metabolic activity.

Deep chilling also causes chill haze to form. Provided sufficient time, these haze particles will settle. The challenge with large, commercial fermenters is that the tall tank height means that gravity clarification can take a very long time to occur. Finings, filtration, and centrifugation are the common methods used to speed beer clarification. At home, very clear beer can be produced with or without finings depending on the grist bill and yeast strain being used.

6. Unitanks are so-named because there is no other vessel used for fermentation and aging. This name is a bit of a misnomer in that many brewers use them. The majority of beer produced by craft breweries is not completely carbonated in unitanks. In fact, many brewers do not spund their fermentations and rely on in-line or in-tank carbonation in a separate tank to increase beer carbonation before packaging. As long as your unitank is designed for pressure, in-tank carbonation is very easy; simply increase the headspace pressure in accordance with a carbonation table based on the beer temperature. Given sufficient time, which is not a problem if using gravity clarification, the beer will absorb carbon dioxide from the tank headspace. BYO

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STYLE PROFILE

BY GORDON STRONG

ENGLISH BARLEYWINE

My favorite winter beer

When the weather turns cold, I start thinking about my long-term beer collection — those big beers I've been saving for the right occasion. The oldest ones tend to be the malty high-gravity beers that I enjoy in the winter like Belgian dark strong ales, doppelbocks, imperial stouts, and, of course, barleywines. And as I'm sipping those beers in front of a roaring fire, I remind myself that I ought to brew new ones to replace those I'm sampling now.

While I brew several types of barleywines, my personal favorites are the darker type of English barleywine, kind of the grandfather of all the others. They develop such depth when well-made, well-packaged, and well-kept, changing and maturing over the years like fine red wine. Sometimes I resort to hiding beer from myself so that it can mature in my personal archive. It's always a shame when the last bottle you have winds up being the best that you tasted.

The current BJCP (Beer Judge Certification Program) Style Guidelines group English barleywine in Category 17 (Strong British Ale), along with British strong ale, old ale, and wee heavy. English barleywine is listed as style 17D. As we explore the style further, you'll see that this style covers a fairly broad range of strength, color, flavor, and balance. There is even a range of spellings, with barley wine being favored in the UK and barleywine being most common in the US. Legal requirements in the US often mean that "Barleywine-Style Ale" appears on the label, lest impressionable consumers believe they are drinking a grape-based product.

They develop such depth when well-made, well-packaged, and well-kept, changing and maturing over the years like fine red wine.

ENGLISH BARLEYWINE
BY THE NUMBERS

OG:	1.080–1.120
FG:	1.018–1.030
SRM:	8–22
IBU:	35–70
ABV:	8.0–12.0%

Photo by Charles A. Parker/Images Plus

HISTORY

Strong, malty, rich beers have long been brewed in England, so it's fairly easy to think of English barleywine as being an old style. However, they are best thought of as the modern descendent of the strongest Burton ales, a style family that covered a wide gravity range. Dark, sweet, bitter, strong, and typically aged, Burton ale was a "keeping beer" that helped put Burton-on-Trent on the brewing map prior to the development of IPAs.

Bass Brewery made up to six different Burton ales, with the strongest being called their No. 1, and having a starting gravity of 1.110. They began calling this beer a barleywine in 1872. As Burton ales eventually fell from favor, barleywines, old ales, and strong ales persisted, although two world wars wreaked havoc on their gravities.

Barleywines were exclusively a dark beer until 1951 when Tennant (now Whitbread) first brewed Gold Label, a pale-colored barleywine. The famous Thomas Hardy's Ale was created by the Eldridge Pope Brewery in 1968 as a vintage-dated 1.125 OG old ale, but it possessed many of the characteristics common to barleywines. In fact, many beer writers and historians don't believe there is a difference between the two styles. The BJCP has chosen to treat old ales as a style with a noticeable age character as a differentiator.

The dark and golden varieties of English barleywine persist, and are recognized within the BJCP Style Guidelines as part of the range. The darker versions draw upon the long history of Burton ales, while the golden versions are a post-World War II creation. Both are valid interpretations of the style.

Currently, barleywines are often a limited-release winter seasonal offering. Many are vintage-dated, which encourages collecting and cellaring. Modern variations, such as J.W. Lee's Harvest Ale (first brewed in 1985), are barrel-aged in casks that contained a wide variety of spirits. However, barrel aging is not a requirement of the style. Beers that have barrel character are best entered in Category 33, Wood Beer.

The barleywines of England had an influence on the world of brewing, inspiring the American variations (Anchor Brewing Co.'s Old Foghorn, first brewed in 1975) and also Belgian versions (such as the famous 12% Bush beer from Debuisson, first brewed in 1930 or 1931). These beers in turn helped start new styles and trends in other countries with emerging craft beer markets.

SENSORY PROFILE

English barleywines are rich, malty, and strong. They can have a malt complexity often accentuated by age character. Warming, full-bodied, and hearty, they are frequently thought of as cold-weather sippers. There are balance differences between pale and dark versions (pale versions are often more bitter and drier, and can show more hop character, while darker examples have more malt complexity and can be sweeter).

As we discussed, the color can range from pale to dark, with the paler versions typically being a deep gold to dark amber color, and the darker versions being deep copper to dark brown. They are not usually black, as this would be more typical for stouts. Clarity can be brilliant, particularly if aged, although younger versions can have some haze. The beer should have a head; but longer-aged barleywines may lose this trait. Aged versions can have head-forming and -retaining proteins break down or drop out.

The aroma and flavor of barleywine are rich and malty, often complex and multi-layered, with bready, biscuity, caramelly malt flavors (more toffee-like in the paler versions) and having a considerable fruity component (often with dark or dried fruit aspects). When aged, these fruity components come out more, and darker versions will have a higher level then the paler ones. The hop aroma can vary wildly, as can the bitterness and flavor. Light to strong hops, with an English character (floral, earthy, tea, or marmalade-like), are common. Bitterness can be light to

ENGLISH BARLEYWINE

(5 gallons/19 L, all-grain)
OG = 1.100 FG = 1.029
IBU = 45 SRM = 18 ABV = 9.5%

INGREDIENTS

18 lbs. (8.2 kg) Golden Promise pale ale malt
1.5 lbs. (680 g) torrified wheat
12 oz. (340 g) English medium crystal malt (45 °L)
8 oz. (227 g) English dark crystal malt (135 °L)
2 oz. (57 g) pale chocolate malt (225 °L)
15 AAU Challenger hops (60 min.) (2 oz./57 g at 7.5% alpha acids)
Wyeast 1968 (London ESB Ale) or White Labs WLP002 (English Ale), or SafAle S-04 yeast
¾ cup corn sugar (if priming)

STEP BY STEP

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

Mash the Golden Promise and torrified wheat at 149 °F (65 °C) for 60 minutes. Start recirculating wort. Add remaining grains and raise the temperature to 168 °F (76 °C) for 15 minutes. Sparge slowly and collect 6.5 gallons (24.5 L) of wort. Boil the wort for 90 minutes, adding hops at the time indicated in the recipe.

Chill the wort to 64 °F (18 °C), pitch the yeast, and ferment at this temperature until complete. Rack the beer, prime and bottle condition, or keg and force carbonate the beer.

ENGLISH BARLEYWINE

(5 gallons/19 L, extract with grains)
OG = 1.100 FG = 1.029
IBU = 45 SRM = 18 ABV = 9.5%

INGREDIENTS

12.5 lbs. (5.7 kg) Maris Otter liquid malt extract
12 oz. (340 g) English medium crystal malt (45 °L)
8 oz. (227 g) English dark crystal malt (135 °L)
2 oz. (57 g) pale chocolate malt (225 °L)
15 AAU Challenger hops (60 min.) (2 oz./57 g at 7.5% alpha acids)
Wyeast 1968 (London ESB Ale) or White Labs WLP002 (English Ale), or SafAle S-04 yeast
¾ cup corn sugar (if priming)

STEP BY STEP

Starting with 6.5 gallons (24.5 L) of water in the brew kettle; heat the water to 158 °F (70 °C).

Steep the crystal and chocolate malts for 30 minutes. Remove and rinse. Turn off the heat. Add the malt extract and stir thoroughly to dissolve completely. You do not want to feel liquid extract at the bottom of the kettle when stirring with your spoon. Turn the heat back on and bring to a boil.

Boil the wort for 60 minutes, adding hops at the time indicated.

Chill the wort to 64 °F (18 °C), pitch the yeast, and ferment until complete. Rack the beer, prime and bottle condition, or keg and force carbonate the beer.

TIPS FOR SUCCESS:

While these step by steps provide a general guideline for brewing a quality English barleywine, there are many tweaks that brewers can make to fine-tune the beer to their liking. A longer mash will help with better attenuation rates for the yeast. Collecting more wort in the brew kettle and increasing the boil time will not only boost the brewhouse efficiency of the beer, but can also increase the color and body of the beer as well.

Aging is an aspect that is the brewer's perogative. Sample how the beer is developing with age to best guide your decisions. Setting aside a small number of bottles to age several years is a fun endeavor!

fairly strong, although fading with time. Stronger versions will have a little alcohol character, but this should never be strong or burning.

The mouthfeel is full-bodied and somewhat chewy in texture, although not as thick as a wee heavy. The alcohol should be noticeable as a warmth, not a burn. Carbonation is typically restrained. The texture can change quite a bit over time as the beer conditions, with younger versions being thicker and more viscous, and the older versions becoming a little thinner. Acidity from aging is typically undesirable, and is more typical of old ales.

The balance of the beer can vary depending on the strength, the finishing gravity, and the bitterness level. The finish can range from moderately sweet to moderately dry, and age can have an effect on this balance as the beer tends to become more dry over time. The bitterness can be just enough to balance the malt, or fairly bitter, again with age having an effect. Bitterness levels also drop over time. The alcohol level also tends to move with the sweetness, as younger versions can have more apparent alcohol as the malt sweetness will balance it, but both reduce in intensity over time.

Aging the beer can produce Sherry, vinous, or Port-like qualities, lower bitterness and mouthfeel, faded hops, and increased fruity esters. It is important for tasters to understand the age qualities of the beer and appreciate the differences over time. Well-kept beers will continue to age and change, and this is a good thing just like with good quality red wine. Darker beers will gain more dark caramel, treacle, molasses, dried fruit, and similar aromatics while paler beers will develop honey, toffee, pome fruit, and light caramel qualities.

BREWING INGREDIENTS AND METHODS

Barleywine is an English ale, so it's no surprise that English ingredients and brewing methods are common. The beer is made with a single infusion mash, and is often the first step in gyling multiple beers. The easiest way of thinking of that is using the first runnings of the mash for the strongest beer, and the second runnings for another. That's a simplification, because in a parti-gyle brew, the runnings are fermented separately and blended to form additional beers. Fuller's does that with their Golden Pride barleywine, producing their ESB and London Pride at the same time. However, it's important for the later beers to have some of the first runnings in them, or the beers would taste grainy and thin.

The mash temperature for barleywines is somewhat open to debate. Some like to make them like Scotch ale (or wee heavy) and mash high around 158 °F (70 °C). I think that produces too thick of a beer and makes it hard to attenuate properly. I prefer to mash around 149 °F (65 °C) to be more attenuative. The high gravity of the beer will provide all the body you need. This point is also made in Fal Allen and Dick Cantwell's *Barley Wine* style book.

British base malts with their bready, toasty, nutty, and biscuity flavors are common; pale ale malt of some kind is pretty much required. Experimenting with different varieties of malt can produce interesting flavor combinations. Not all British pale ale malt is Maris Otter, there are many other varieties with different flavors, such as Pipkin, Optic, Halcyon, Pearl, Chariot, and Golden Promise. There are differences between maltsters as well, so keep an open mind as you experiment.

Much of the flavor comes from the base malts. High amounts of crystal-type malts give good color and flavor but often at the expense of attenuation and sweetness, and these malts can lead to excessive levels of raisin-like aldehydes when aged. Darker malts might be used for color adjustment but can add unpleasant flavors and push the beer more into the stout family. British brewers often will use adjuncts such as brewing sugars, corn, and wheat in their beers. Brewing sugars can take the place of crystal-type malts in that they provide color and flavor, in a manner similar to Belgian brewers. Whatever additional ingredients are used beyond base malts, use some restraint as the base malt flavors should dominate.

Some color development can occur through a long or hard boil. Decocting the mash is not traditional at all but I've heard some homebrewers do this for color and flavor development. Extended boiling, which is traditional for this style, is a good way to boost both color and gravity. Specialty grains may be an easy fix, but there are other ways to develop flavor and color without affecting the body and finish of the beer.

English-type hops are typical, such as Northdown, Target, Golding, and Fuggle. Most IBUs come from a boil addition. Flavor and aroma hop additions can be light to moderate, but the beer should not seem IPA-like. Dry hopping is uncommon, but can add a nice touch if done with restraint. For barleywines I intend to age, I tend to over-hop them knowing that the hops will fade with time. So I try to balance the beers for when they will be served, not when they are finished with fermentation. There is no formula for this, it takes some experience and practice. Be careful about using too many low alpha acid hops since the vegetal mass in the kettle can produce off flavors.

Traditional English yeasts are common, with ones that provide fruity esters and showcasing a malty finish being typical. Some of the more highly attenuating English strains are fine as well, since there are a lot of malt sugars to ferment. I have tried most commercially-available British ale yeasts, and they all work well with this style. Fermentation temperature ranges can vary, although higher ale temperatures should be avoided to reduce fusels. I keep fermentation temperature at or below 68 °F (20 °C). The challenge is to ensure a complete, healthy fermentation. Pitching at a higher rate (double a standard strength beer, or more) and oxygenating the wort can improve results, as can adding yeast nutrients.

Water doesn't play a big role in the flavor profile of this style, but if you have a choice in adding calcium salts to your beer, I would use calcium chloride instead of calcium sulfate. Calcium chloride accentuates the malty, round, sweet flavors in beer rather than providing a sharp edge and sulfury flavor. That seems better suited to barleywine to me.

HOMEBREW EXAMPLE

I have several recipes for English barleywine, but the version on page 27 was the latest one I made. I was working on some recipes using Golden Promise malt from Scotland, and had a large part of a sack left. Since I really enjoyed the flavor of a mostly Golden Promise grain bill in Timothy Taylor's Landlord, I wondered what a big beer made with mostly Golden Promise would be like. Delicious, it turns out . . .

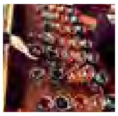
I like the flavors of Golden Promise since it has more of a malty taste and less of a biscuity note than Maris Otter. Alternatively, there is low-colored Maris Otter malt that you may want to look at as well for a bit less biscuit notes. I use some torrified wheat (stop autocorrecting this to "terrified wheat"!) to add more of a toasty flavor and to improve head retention. Small amounts of crystal malt add some caramel complexity and I add a bit of pale chocolate malt to adjust the color.

I'm using a single bittering addition of traditional English hops, targeting about 45 IBUs. The balance will be on the malty-sweet side at this level. I'm mashing at the lower end of the range to help with attenuation, and I've selected a classic English ale yeast that produces fruity flavors while favoring malty beers.

Since I'm trying to showcase the base malt, I've tried to keep this recipe simple and to balance it so that the malt is foremost. Some friends who have brewed this recipe have aged the beer on wood to give it a drier touch and to accentuate the toastiness. If going this way, I'd recommend medium or medium-plus toast French or Hungarian oak.

Barleywines are rich and strong beers, and the character can change over time. Pale and dark variations add another level of interest. It's hard to approach the style with a single target in mind since there are so many possibilities. The challenge is to understand and appreciate the broad nature of the style, and to not expect each example to have it all. I love to see how these beers develop over time and to enjoy them in season. BYO

THURSDAY, MARCH 21, 2019



INSIDER TOURS OF ASHEVILLE CRAFT BREWERIES - You'll tour – and taste – at four different craft breweries right in the city of Asheville or in the towns surrounding Asheville during this pre-Boot Camp offering. You'll have the opportunity to meet brewers and ask questions in addition to sampling beers. Includes a meal. A great way to kick off your Boot Camp experience and check out some of Asheville's booming craft beer scene.

FRIDAY, MARCH 22, 2019 ASHEVILLE BOOT CAMPS

Each Boot Camp will run from 10 a.m. to 5 p.m. and is limited to just 35 people. Your boot camp includes lunch, a lunch keynote with Brian Grossman of Sierra Nevada Brewing, plus a post-Boot Camp Asheville Craft Beer Reception with local craft breweries pouring samples.

ADVANCED HOPPING TECHNIQUES – ***Josh Weikert*** – Join *BYO* Contributing Writer Josh Weikert as he explores when and how to add hops to create awesome hop-forward beers. You'll cover timing and techniques of hop usage including mash hopping, boil hopping, whirlpool/knockout hop stand additions, and dry hopping. You'll cover hop varietal choices, hop pairing/blending, evaluating hops including hop rubbing and sensory training, water adjustments and much more to get the most out of your hops and into your glass. *Please note this workshop will also be offered on Saturday as well.*

TROUBLESHOOTING HOMEBREW FAULTS & FIXES – ***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 as *BYO*'s Mr. Wizard. You'll have the chance to experience many faults first-hand to better recognize them later.

ALL-GRAIN BREWING ESSENTIALS – ***John Palmer & 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* best-selling 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 mashing and some advanced tips as well.

ADVANCED ALL-GRAIN TECHNIQUES – ***Gordon Strong*** – Pull out the mash tun and get ready to learn advanced all-grain techniques hands-on with *Brew Your Own* 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.*

BARRELS & WOOD-AGING – ***Michael Tonsmeire*** – Learn how to choose, use, and maintain oak barrels – and oak alternatives – for your brewing. Barrels are a significant investment in money, time, and beer so understanding how to properly select and use them is essential. Learn hands-on from *Brew Your Own* Columnist and *American Sour Beers* book author Michael Tonsmeire. Michael will also cover options for barrel alternatives and how to best use the broad variety of available products such as chips, staves, and spirals including both oak and non-oak alternatives. This full-day workshop will also cover special brewing and recipe considerations to making beers to complement the flavors of woods, spirits, and wines to take your wood-aged beers to a new level.

HOMEBREW EXPERIMENTS – ***Drew Beechum, Denny Conn, and Marshall Schott*** – 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/book authors Drew Beechum and Denny Conn from Experimental Brewing and blogger/podcaster Marshall Schott from Brülosophy – 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! *Please note this workshop will also be offered on Saturday as well.*

ADVANCED RECIPE FORMULATION – ***Brad Smith*** – Create your own signature recipes and learn the keys to developing the specific grain bill, hop schedule, and ingredient proportions to meet your homebrewing goals. Brad Smith, *BYO* Contributor and BeerSmith software owner, 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 envisioned in your glass. You'll also explore ingredients, techniques, and understanding your own brewing system. *Please note this workshop will also be offered on Saturday as well.*

ADVANCED YEAST TECHNIQUES – ***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 and viability, the do's 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 unique chance to learn in a full-day seminar format about getting the most from your yeast from one of the true leaders in the beer yeast field.

TWO-DAY BOOTCAMP: COMMERCIAL BREWERY START-UP – ***Steve Parkes*** – When you register for this Boot Camp you will attend it for both Friday and Saturday unlike our other offerings to better cover more material in greater depth. Opening a commercial craft brewery is a far cry from just ramping up the amount of beer you brew. Over Friday and Saturday you'll walk through the steps, planning decisions, and keys you need to know on both the brewing and management side to successfully open a commercial craft brewery with the Lead Instructor and Owner of the American Brewers Guild Steve Parkes, who has trained hundreds of professional brewers. Learn from Steve's decades of expertise and wide range of experience to help you better achieve your goals. Over two full days you'll be guided through all the various elements you'll have to know for the next big step toward starting a craft brewery.

SATURDAY, MARCH 23, 2019 ASHEVILLE BOOT CAMPS

Each Boot Camp will run from 10 a.m. to 5 p.m. and is limited to 35 people. Your Boot Camp includes lunch, a *BYO* Columnist Q&A lunch keynote, plus a post-Boot Camp Asheville Craft Beer Reception with local craft breweries pouring samples to wrap up your full day.

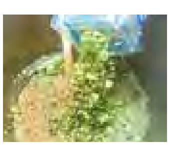
SOUR BEER TECHNIQUES – ***Michael Tonsmeire*** – Learn hands-on traditional European as well as newer American methods to produce sour and funky beers from Michael Tonsmeire, the *Brew Your Own* Columnist who literally wrote the book on the subject with *American Sour Beers*. Michael will demonstrate the unique skills needed to create your own delicious sour beers including wort production (extract and all-grain), growing alternative microbes, blending, aging on fruit, and sanitation. The focus will be on practical topics difficult to convey by words alone, so no biology or chemistry degree required. You'll leave with a clear understanding of the processes to reliably produce sour beers suited to your palate and desired time frame.

HANDS-ON HOMEBREW SCIENCE – ***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 the beer. You'll have the chance to understand how to not only 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.

ADVANCED YEAST LAB – ***Kara Taylor*** – Join White Labs' Laboratory Operations Manager Kara Taylor at White Labs' Asheville facility 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 up close and personal what you may have read in books or magazines, or listened to in seminars, and Kara is the perfect teacher to lead you personally through the world of yeast using lab equipment you can source for your own home use.

BREWING WATER ADJUSTMENTS – ***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 brew 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 this critical ingredient.

Due to many requests we are repeating four of our most popular Boot Camp topics from Friday again on Saturday to give more people the opportunity to register for the following workshops that have all sold out at prior locations.



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SUNDAY, MARCH 24, 2019

INSIDER TOURS OF ASHEVILLE CRAFT BREWERIES

You'll tour – and taste – at four different craft breweries right in the city of Asheville or in the towns surrounding Asheville during this post-Boot Camp offering. You'll have the opportunity to meet brewers ask questions in addition to sampling beers. Includes a meal. A great way to wrap-up your BYO Boot Camp experience and check out some of Asheville's booming craft beer scene.

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FULL BOOT CAMP DETAILS & REGISTRATION AT: BYOBOOTCAMP.COM

Brew Your Own — The How-To Homebrew Beer Magazine — BOOT CAMP

REGISTRATION

ASHEVILLE, NORTH CAROLINA
MARCH 22 & 23, 2019

Name ______________________________

Address ______________________________

City ____________________ State/Province __________

Zip/Postal Code ____________ Country ____________

Phone ______________________________

E-mail ______________________________

SAVE UP TO $75 BY REGISTERING FOR BOTH DAYS EARLY!

❑ EARLY DISCOUNT - REGISTER BY FEBRUARY 22 - $475 - (SAVE $75!)
BOTH FRIDAY AND SATURDAY BOOT CAMPS (choose one each day)

❑ TWO-DAY REGULAR REGISTRATION - AFTER FEBRUARY 22 - $500 - (SAVE $50!)
BOTH FRIDAY AND SATURDAY BOOT CAMPS (choose one each day)

❑ ONE-DAY REGULAR REGISTRATION - $275
EITHER FRIDAY OR SATURDAY BOOT CAMP (choose only one below)

Friday, March 22, 2019

❑ Advanced Recipe Formulation
❑ Barrels & Wood-Aging
❑ Advanced Hopping Techniques
❑ Troubleshooting Homebrew Faults & Fixes
❑ Advanced All-Grain Techniques
❑ Homebrew Experiments
❑ All-Grain Brewing Essentials
❑ Advanced Yeast Techniques

Saturday, March 23, 2019

❑ Hands-On Homebrew Science
❑ Sour Beer Techniques
❑ Brewing Water Adjustments
❑ Advanced Yeast Lab

Please note due to repeated requests we are repeating four of the most popular Boot Camp topics from Friday again on Saturday to give more opportunity to register for the following workshops.

❑ Advanced All-Grain Techniques
❑ Advanced Hopping Techniques
❑ Advanced Recipe Formulation
❑ Homebrew Experiments

❑ Turning Pro & Commercial Brewery Start-Up - TWO DAY BOOT CAMP

****PLEASE NOTE A SEPARATE REGISTRATION FORM & FEE IS REQUIRED FOR EACH BOOT CAMP ATTENDEE****

REGISTRATION FOR BOOT CAMP INCLUDES:

- 10 a.m. to 5:00 p.m. Boot Camp limited to 35 people per class
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TURN UP THE HEAT

BREWING WITH HOT PEPPERS

by Jeff Gladish

Most beer styles are about balance. This is not to say that all the flavor and aroma aspects of every beer style are in equilibrium, but that there is a balance to each style. For example, a West Coast IPA would be balanced toward the use of hops in flavor, aroma, and bittering while a traditional bock beer would lean toward bready malts throughout its profile. Pepper beers can be balanced by heat either way — with so much heat that only a few brave souls can stand to drink a pint or balanced equally with the malt, hops, and fermentation characteristics so that the pepper aroma, flavor, and heat balance the base style of beer. Some pepper beers can focus less on the heat as you swallow and more on the initial aroma of the type of pepper used. Not all pepper beers are scary hot. With such a wide range of ways they can be utilized in a recipe — not to mention the various techniques of *how* they can be used in brewing — peppers are a really interesting and fun ingredient to brew with.

A LITTLE ABOUT PEPPERS

Peppers are a New World contribution to the global culinary community, having been cultivated in Bolivia for 6,000 years then "discovered" by Columbus on his earliest trips from Europe and spread so extensively that regions on the other side of the planet are known for their use in spicy foods. They can be so mild as to only present a fruity or vegetal character or so hot that printed warnings are appropriate. Peppers can range in heat, based on the scale that Wilbur Scoville devised in 1912, from fewer than 100 Scoville Heat Units (SVU) in a bell pepper to the 10,000 range in a jalapeño and well over 100,000 in a habanero. Bhut jolokia, also known as the ghost pepper, can be over 3 million units, but that is still only a small fraction of the intensity of police pepper spray.

Heat from a pepper is actually a pain response, not a taste. Our brains warn us to stop eating something with capsaicin (the hot part of the pepper), mistaking it for poison. In a similar way, mint stimulates a nerve receptor sensitive to cool temperatures, leading us to believe it tastes cold.

The pepper's capsaicin is secreted via a special gland in the stem and forms mostly in the placental material (the white pith surrounding the seeds). There is some heat in the seeds only due to their proximity to the pith. Each part of the pepper has a different sort of heat and flavor. The seeds and pith material have a grainy, somewhat nutty taste while the flesh has the actual pepper flavor.

PEPPER BEER STYLES

One can add any kind of pepper to any style of beer. It all depends on the flavor you are after and where you want it balanced. The use of chili peppers such as ancho, guajillo, and pasilla in a strong stout, coupled with vanilla and chocolate has brought several examples of Mexican imperial stout into the market. Hunahpus, from Cigar City, has just a hint of heat to balance the other herbs, spices, and malts. Raw jalapeños can add a "green" flavor to a beer, making it suitable for a light-flavored style such as American wheat or Pilsner. Roasted peppers enhance and complement roastier beer styles such as stouts and porters along with adding a nutty contribution. Smoked chipotle peppers in a beer turn the resulting beer into a delicious accompaniment to a Mexican meal with flavors complementing the chocolate and spicy flavors of the food. Spiced beers, such as Belgian witbiers or even estery/phenolic saisons seem to work particularly well with peppers, letting the pepper flavor and aroma meld with other spices to create a confluence of something more than the original beer. Salt plays well with heat and spices as well. Think of how well salt, caramel, and pepper go together in a chocolate bar and then imagine a beer designed with that in mind. Or how about a chipotle Gose?

Craft breweries have been releasing beers with various hot pepper varieties, and in various base beer styles, to much success. On the top end of hot pepper beers from craft breweries you will find Ghost Face Killah from Twisted Pine Brewing, brewed with the addition of six different peppers including one of the hottest, the bhut jolokia. Only truly brave pepper-heads will be able to finish an entire pint, but it is so popular that it is their most requested beer, brewed every couple of months. More subtle but still showing a high Scoville ranking are beers made with the habanero pepper. Ballast Point Habanero Sculpin is a widely available example. Lower on the heat scale is Cerveza Chilebeso from Great Basin Brewing Company in Nevada, which uses jalapeños in the recipe. This year's gold medal winner at the Great American Beer Festival was White Legs Jalapeño Wheat Ale from Tribute Brewing Company in Wisconsin.

My own pepper beer that I have received recognition for is based on a strong Belgian witbier, but with the addition of roasted poblano peppers for flavor and aroma and a touch of habanero so that the drinker will recognize some heat, but not be hesitant to take another sip.

With only a few exceptions, pepper beers seem to share a fairly strong malt backbone and usually rate low on the bitterness scale. Peppers seem to blend more easily with sweet flavors than with bitterness.Pepper heat in a bitter IPA may lead to clashing flavors unless there is a firm malty backbone or some residual sweetness in the beer, but then again it all depends on what you are looking for in your homebrew.If adding peppers to a hoppy beer, it may be a good idea to choose fruit-forward hop and yeast varieties to accompany the spiciness.

TERMS TO KNOW

Ancho – A dried poblano pepper.

Capsaicin – The colorless irritant phenolic amide that makes peppers hot.

Cayenne – The species from which countless varieties of bell, jalepeño, and poblanos are derived.

Chile – 1. A country in South America 2. New Mexican and Spanish spelling of chili.

Chili (alternate British spelling – chilli) – The pod of the capsicum plant.

Chilly – Needing warmer clothing.

Chipotle – Smoked/dried jalapeño.

Pepper – The name Columbus gave to chilis, thinking he had landed in Asia.

Scoville Heat Unit – The measurement of the heat of peppers and other spicy foods, based on the concentration of capsaicinoids (among which capsaicin is the predominant component) created by Wilbur Scoville.

BREWING WITH PEPPERS

To prepare peppers to add to your

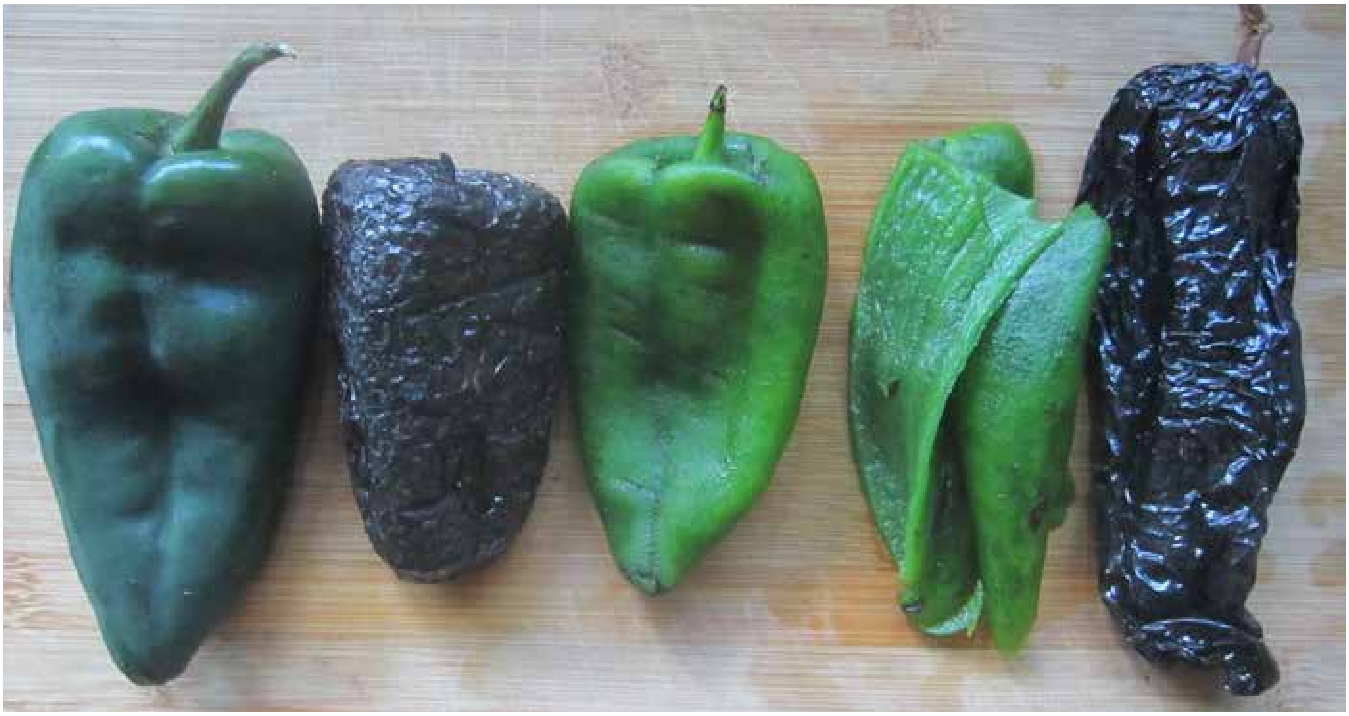


Photo by Jeff Gladish

The various stages of poblano pepper preparation — any of which may be appropriate for use in homebrew depending on the character you are after. From left to right: Raw, charred, with the char peeled off, with the stem and seeds removed, and an ancho (dried poblano pepper).

beer, the most important piece of equipment is a pair of gloves. Don't touch any part of your body until after you have removed the gloves and washed your hands. Touching your face or rubbing your eyes can be painful. An inopportune bathroom break can be a memorable if not serious mistake.

After putting on the gloves, remove the stem of the pepper and cut the flesh open. Most of the heat will be in the white, pithy section and inner ribs with some heat in the seeds as well. Most brewers remove the seeds either thinking that they are a big source of heat or more correctly, that they don't add a good flavor to the beer. Discard the seeds. Leave the white pith for more heat, or if less heat is desired then cut it out.

My first attempts at pepper beers in the mid 1990s were exactly what I wanted with respect to the aroma and flavor, but had an amazing disappearing head. The beer would pour with nice, white foam and then a few seconds later, *poof*, it would disappear (the foam, not the beer; the beer took a little longer). I found that removing the shiny outer surface of the peppers fixed this problem. In retrospect, I don't think that this is a wax sprayed on by the retailer or farmer for beauty or protection, and research has shown that less than 20% of tested peppers have trace amounts of pesticides. It could be a natural shine. Removing it by roasting was my solution and this had the added benefit of a resulting roast pepper flavor and aroma. You could also wash the shiny surface with some alcohol, such as vodka.

Peppers can be added at any point in the brewing process, even in the mash, although my experiments with this resulted in very little character, either in heat, flavor, or aroma.

Some brewers will deseed, devein, and toss the peppers in at the end of the boil to pasteurize them. Carlos Sanchez, Head Brewer at Six Rivers Brewing in Northern California, roasts and then chops the entire pepper — seeds and all — in a blender before tossing them into the kettle at the end of the boil. This assures him that no bacteria from the pods will survive into the beer. He brews a pepper beer once a month and particularly likes habaneros in an American wheat beer.

Others add them post-fermentation as more of a "dry pepper" addition. I have found that you get more bang for your buck as to flavor, aroma, and heat with these cold-side additions. As with dry hopping, this accentuates the pepper aroma. It is important in this case not to rely entirely on the alcohol in the finished beer to neutralize any potential bacteria that may be on the skin of the pepper. If adding them post-boil, it is safer to either roast the peppers or to sterilize them with some alcohol. Marc O'Brien, Head Brewer at Tribute Brewing Company washes his jalapeños in a brewing cleanser and then soaks them in sanitizer before adding them to the fermenter. I had never heard of this preparation method, but if you are concerned about infections then it shouldn't hurt anything to do it.

Still others will go a bit further and roast the peppers, rinse off the char, and add them right to the keg. When I do this I like to pasteurize the peppers in the toaster oven for a few minutes at 200 °F (93 °C), although after roasting there is little chance of any bacteria being present. I just like to be sure. Leaving the peppers in a keg of beer does not seem to be detrimental to the flavor over time. All the heat will be extracted after a week or so and once that happens the beer will not subsequently get progressively hotter as it is consumed. I have left peppers in a keg for months with

PEPPER BEER RECIPES

POBLANO WIT

(5 gallons/19 L, all-grain)
OG = 1.064 FG = 1.012
IBU = 15 SRM = 4 ABV = 6.6%

I've made this beer over a dozen times and most of the time it wins its category in competitions. It has two Best of Show trophies from the Pepper Extravaganza Competition in Florida, plus a Great American Beer Festival gold medal as the Pro-Am entry in 2013 with Cigar City Brewing Company.

INGREDIENTS

6 lbs. (2.7 kg) Weyermann Pils malt
6 lbs. (2.7 kg) Weyermann light wheat malt
1 lb. (0.45 kg) flaked oats
2 quarts (2 L) rice hulls
4 AAU Cascade hops (60 min.) (0.75 oz./21 g at 5.5% alpha acids)
1 oz. (28 g) Indian coriander (10 min.)
0.5 oz. (14 g) dried chamomile flowers (10 min.)
1 oz. (28 g) grapefruit zest (10 min.)
3 poblano peppers (about 7 oz./200 g raw, or 4 oz./113 g treated, per instructions)
½ habanero pepper
Wyeast 3944 (Belgian Witbier) or White Labs WLP400 (Belgian Wit Ale) or Mangrove Jack's M21 (Belgian Wit) yeast
¾ cup corn sugar (if priming)

STEP BY STEP

Mash the grains at 152 °F (67 °C) for 60 minutes together with 0.5 oz. (14 g) calcium chloride and the rice hulls for easier lautering. Although the rice hulls may not be necessary in some systems, it is good insurance in a fly sparge rig.

Collect the wort and boil for 60 minutes, adding the hops at the start of the boil. At ten minutes left in the boil add the coriander, citrus zest, and chamomile. Chill to 65 °F (18 °C) and pitch the yeast. Ferment until specific gravity is unchanged for three days.

When final gravity is reached it is time to prepare the peppers. Roast the peppers over an open flame until all of the outer surface is charred black. Set them aside, covered and allow them to steam until cool enough to handle. Remove the charred surface, cut off the stem and remove the placenta and seeds, then cut them into strips lengthwise and heat them in an oven for 10 minutes at 200 °F (93 °C). Once cool, add the peppers to the beer and rest for 5 to 7 days before packaging or add them directly to the keg in a hop sack or large tea strainer. Carbonate to about 2.5 volumes of CO_2.

POBLANO WIT

(5 gallons/19 L, partial mash)
OG = 1.064 FG = 1.012
IBU = 15 SRM = 4 ABV = 6.6%

INGREDIENTS

6 lbs. (2.7 kg) wheat dried malt extract
1 lb. (0.45 kg) Pilsner malt
1 lb. (0.45 kg) flaked oats
4 AAU Cascade hops (60 min.) (0.75 oz./21 g at 5.5% alpha acids)
1 oz. (28 g) Indian coriander (10 min.)
0.5 oz. (14 g) dried chamomile flowers (10 min.)
1 oz. (28 g) grapefruit zest (10 min.)
3 poblano peppers (about 7 oz./200 g raw, or 4 oz./113 g treated, per instructions)
½ habanero pepper
Wyeast 3944 (Belgian Witbier) or White Labs WLP400 (Belgian Wit Ale) or Mangrove Jack's M21 (Belgian Wit) yeast
¾ cup corn sugar (if priming)

STEP BY STEP

Place the grains in a large grain bag. Mash the grains in 3 qts (2.8 L) water at 152 °F (67 °C) for 45 minutes with 0.5 oz. (14 g) of calcium chloride. After 45 minutes, wash the grains with 1 gallon (3.8 L) of water. Top off the kettle to 6 gallons (23 L) and stir in the dried malt extract while off heat. Once all the extract is dissolved, bring the wort to a boil.

Collect the wort and boil for 60 minutes, adding the hops at the start of the boil. At ten minutes left in the boil add the coriander, citrus zest, and chamomile. Chill to 65 °F (18 °C) and pitch the yeast. Ferment until specific gravity is unchanged for three days.

Follow the remainder of the all-grain recipe instructions.

PEPPER BEER RECIPES

TRIBUTE BREWING CO.'S WHITE LEGS JALAPEÑO WHEAT CLONE

(5 gallons/19 L, all-grain)
OG = 1.052 FG = 1.010
IBU = 16 SRM = 3 ABV = 5.5%

This recipe was designed and brewed by Marc O'Brien at Tribute Brewing Co., Eagle River, Wisconsin. It won a gold medal at the 2018 Great American Beer Festival in the "Chili Beer" category. The spring seasonal is described by the brewer as "A clean, refreshing wheat ale with jalapeños added post-fermentation. Lightly carbonated to allow the pepper flavor to come through."

INGREDIENTS

5.25 lbs (2.4 kg) Superior Pilsen malt
5.25 lbs. (2.4 kg) Canada Malting wheat malt
3.25 AAU Summit hops (60 min.) (0.2 oz./5.7 g at 16.6% alpha acids)
10 oz. (283 g) jalapeño pepper
Wyeast 1056 (American Ale) or White Labs WLP001 (California Ale) or SafAle US-05 yeast
¾ cup corn sugar (if priming)

STEP BY STEP

Try to keep the chloride-to-sulfate ratio at 2:1. Mash the grains at 152 °F (67 °C) for 60 minutes. Sparge and collect the wort, boil for 60 minutes, adding the hops at the beginning of the boil.

Cool and ferment at 65 °F (18 °C) until specific gravity is unchanged for three days. Prepare the raw peppers by soaking them in brewery cleaner then sanitizing, removing tops, cutting in half, and removing the pith of some jalapeño halves to control the heat as desired. Add the prepared peppers after primary fermentation is complete. When the desired flavor, aroma and heat level is reached (between three and seven days), package either in a keg to about 2.5 volumes of CO_2 or in bottles with corn sugar.

TRIBUTE BREWING CO.'S WHITE LEGS JALAPEÑO WHEAT CLONE

(5 gallons/19 L, extract only)
OG = 1.052 FG = 1.010
IBU = 16.2 SRM = 4 ABV = 5.5%

INGREDIENTS

5.75 lbs (2.6 kg) wheat dried malt extract
3.25 AAU Summit hops (60 min.) (0.2 oz./5.7 g at 16.6% alpha acids)
10 oz. (283 g) jalapeño pepper
Wyeast 1056 (American Ale) or White Labs WLP001 (California Ale) or SafAle US-05 yeast
¾ cup corn sugar (if priming)

STEP BY STEP

Starting with 5 gallons (19 L) of water that has a chloride-to-sulfate ratio at 2:1, heat to 180 °F (82 °C) then remove from heat. Stir in the dried malt extract until the extract is fully dissolved. Return wort to heat and bring up to a boil. Add the hops and boil for 60 minutes.

Cool to yeast-pitching temperature and transfer wort to fermenter. Top off fermenter to 5 gallons (19 L) and ferment at 65 °F (18 °C) until specific gravity is unchanged for three days. Prepare the raw peppers by soaking them in brewery cleaner then sanitizing, removing tops, cutting in half, and removing the pith of some jalapeño halves to control the heat as desired. Add the prepared peppers after primary fermentation is complete. When the desired flavor, aroma and heat level is reached (between three and seven days), package either in a keg to about 2.5 volumes of CO_2 or in bottles with corn sugar.

PEPPER BEER RECIPES

HOLAMOLÉ

(5 gallons/19 L, all-grain)
OG = 1.080 FG = 1.016
IBU = 77 SRM = 36 ABV = 8.4%

The grain bill is a variation on Denny Conn's proven Imperial Porter recipe. The hop schedule was chosen for a citrus and mint character, while the spices and peppers were chosen to mimic the flavor of Mexican molé sauce.

INGREDIENTS

10.5 lbs. (4.8 kg) North American pale malt
2.5 lbs. (1.1 kg) Weyermann Munich II malt (9 °L)
1.5 lbs. (0.68 kg) Crisp brown malt (65 °L)
1.25 lbs. (0.57 kg) Crisp pale chocolate malt (225 °L)
1 lb. (0.45 kg) Crisp crystal malt (120 °L)
0.5 lb. (0.23 kg) Crisp crystal malt (45 °L)
15.8 AAU El Dorado hops (60 min.) (1 oz./28 g at 15.8% alpha acids)
19.8 AAU Northern Brewer hops (10 min.) (2 oz./56 g at 9.9% alpha acids)
1 Whirlfloc tablet (20 min.)
1 small cinnamon stick (~0.1 oz./3 g)
4 oz. (113 g) Ecuadorian cocao nibs (crushed)
0.5 lb. (225 g) crushed almonds (raw or toasted)
4 ancho chilies
Wyeast 1450 (Denny's Favorite 50 Ale) or another American ale yeast
¾ cup corn sugar (if priming)

STEP BY STEP

Mash the grains together at 153 °F (67 °C) for an hour, then sparge the grains and collect wort.

Boil for 60 minutes. Add hops and Whirfloc as indicated. After the boil, chill to 65 °F (18 °C), aerate, and pitch yeast. Ferment until completion (specific gravity unchanged for three days). Between day three and day seven of fermentation, pasteurize the peppers by baking in a toaster oven for two minutes at 150 °F (66 °C). Let the peppers cool and then add all the spices, herbs, and peppers to the fermenter. Sample for spiciness level and adjust to taste. When fermentation is complete, keg or bottle condition to 2.5 volumes of CO_2.

HOLAMOLÉ

(5 gallons/19 L, partial mash)
OG = 1.080 FG = 1.016
IBU = 77 SRM = 36 ABV = 8.4%

INGREDIENTS

3.5 lbs. (1.6 kg) extra light dried malt extract
3.3 lbs. (1.5 kg) Munich liquid malt extract
1.5 lbs. (4.8 kg) North American pale malt
1.5 lbs. (0.68 kg) Crisp brown malt (65 °L)
1.25 lbs. (0.57 kg) Crisp pale chocolate malt (225 °L)
1 lb. (0.45 kg) Crisp crystal malt (120 °L)
0.5 lb. (0.23 kg) Crisp crystal malt (45 °L)
15.8 AAU El Dorado hops (60 min.) (1 oz./28 g at 15.8% alpha acids)
19.8 AAU Northern Brewer hops (10 min.) (2 oz./56 g at 9.9% alpha acids)
1 Whirlfloc tablet (20 min.)
1 small cinnamon stick (~0.1 oz./3 g)
4 oz. (113 g) Ecuadorian cocao nibs (crushed)
0.5 lb. (225 g) crushed almonds (raw or toasted)
4 ancho chilies
Wyeast 1450 (Denny's Favorite 50 Ale) or another American ale yeast
¾ cup corn sugar (if priming)

STEP BY STEP

Mash the pale malt and the brown malt in 2 gallons (7.6 L) of water at 153 °F (67 °C) for 45 minutes. Add the pale chocolate and crystal malts and hold for 15 minutes. Sparge the grains with 1.5 gallons (5.7 L) of hot water. Top off the kettle to 6 gallons then stir in the two malt extracts. Stir until completely dissolved, then bring wort to a boil.

Boil for 60 minutes. Add hops and Whirfloc as indicated. After the boil, chill to 65 °F (18 °C), aerate, and pitch yeast. Ferment until completion (specific gravity unchanged for three days). Between day three and day seven of fermentation, pasteurize the peppers by baking in a toaster oven for two minutes at 150 °F (66 °C). Let the peppers cool and then add all the spices, herbs, and peppers to the fermenter. Sample for spiciness level and adjust to taste. When fermentation is complete, keg or bottle condition to 2.5 volumes of CO_2.

Photo courtesy of Shutterstock.com

The options are nearly endless when deciding on a pepper variety to use in your homebrew. That selection should be determined based on availability, as well as how the pepper's flavor and heat will complement the base beer recipe.

no off flavors while the beer was on tap. Keep in mind that peppers contain a small amount of residual sugar, which could lead to more carbonation than intended.

My own experience with different types of chili peppers is that the flavors drastically change when roasted or smoked with the resulting peppers gaining a nutty flavor along with the smokiness. I have been told that in the American Southwest during the autumn pepper harvest season, the air is thick with the smell of roasting chilis. Roadside stands and even grocery stores will set up drum roasters outside to prepare the chilies. That's the aroma I want in my pepper beer.

Peppers can vary in heat level even within the variety. Sometimes a poblano pepper is very mild and the one next to it in the bin at the market is much hotter. This sometimes has to do with ripeness, as the riper a pepper is the hotter it is. Serranos will turn from green to red or yellow as they mature, so the red ones usually pack more heat than the fresher green ones. The opposite may hold true with Hatch chilies as the ripe red peppers have a sweeter, earthier profile.

Wayne Wambles, Head Brewer at Cigar City in Tampa, Florida, has added dried peppers after fermentation with no treatment, but in my opinion it may be safer to include a short pasteurizing step or alcohol soak before hand. On a recent trip to my local Latin supermarket I found several dried pepper varieties on the shelf, marked by heat intensity: Mild ancho and pasilla, medium guajillo, and very hot morita and arbol peppers were all available for purchase. These dried peppers, used in similar ways as fresh or roasted peppers, work quite well in beers also.

Adding the peppers after fermentation is a safe way to add heat if you have time. Add the number and type that you think will give you the result you are looking for and wait three or four days. If a sample shows the need for more heat, flavor, or aroma, add the appropriate type of peppers to accomplish that goal. If more roasty aroma is needed, add some chipotles; if it needs more heat, add some habanero or scotch bonnet. If you are looking for more fresh pepper flavor, add green chilis of the type you like.

Because the resulting heat in the above methods is difficult to measure until after the additions due to variability in the peppers, another method is to soak the peppers in ethanol and then dose the beer with that liquid extract. This can be scaled up by measuring the amount added to a pint and then calculating the amount needed for the whole batch. Soak the pepper in vodka or your other favorite clean alcohol for a few days and sample it in a pint of beer a drop at a time. For added complexity use a more flavorful alcohol such as Bourbon or Scotch, but be careful not to make a boilermaker (unless of course that's what you want). A liqueur I particularly like in cocktails, Ancho Reyes, may be fairly easy to make at home with this method. Alternatively, as a time saver it could be purchased and used to spike your homebrew.

To find out what effect a hot chili will add to a particular beer, try dosing a glass of the beer with a dash of hot sauce. Using a type of hot sauce that lists little to no vinegar in the ingredients will provide the best results. This method may not be the best for dosing an entire batch due to the loss of clarity and head retention, but it can give you an idea of how a variety of pepper will taste in a glass of your homebrew. Besides that, it's fun!

The amount and type of peppers affects the aroma, the flavor, and the heat level of the resulting beer. Using three poblano peppers in 5 gallons (19 L) will add the appropriate aroma and flavor in a lighter style of beer, but usually lacks the punch of heat. Half a habanero or a dried roasted anchochile will remedy this.

One other thing to note, soaking hot peppers in alcohol will decrease but not eliminate the heat from the peppers. A friend of mine soaked a ghost pepper in a bottle of his sweet mead for several months and thinking that all the heat had been transferred into the liquid, he ate the pepper. His recovery was not immediate.

GET CREATIVE WITH RECIPES

I once had a pepper beer while judging a homebrew competition that had a small pepper in each bottle, curiously treated to remove all the heat, leaving only the flavor of a Thai chili. It resulted in more of a novelty than a new beer. Soaking hot peppers in an acidic liquid such as lemon juice removes some of the heat, but not all. An experiment by *Epicurious* found that lemon-lime soda removed all the heat from a pepper, but it also removed a lot of the flavor as well, making a cayenne pepper taste like a bell pepper. This seems like a waste of a good pepper to me, unless of course you like hot lemon-lime soda.

It is possible to completely remove the heat by diluting and loosening the capsaicin in the blisters of the walls by rubbing it and then rinsing it off with an alcohol soak. This may give an idea of the actual flavor of the pepper without its heat.

Another sub-style of beer that has caught on in the craft beer world and among homebrewers in recent years are molé-inspired beers. Think of the long list of ingredients in a Mexican molé sauce with the chocolate, nuttiness, and umami as well as pepper and work that into your homebrew recipe. Sean Paxton, the Homebrew Chef, collaborated with Ten Barrel Brewing to make Sexy Mexy, an imperial milk stout with cinnamon, lactose, dos de leche, and then anchos added in the secondary. He points out that these chilis add a leather flavor and a bit of cherry when added and finds that heat should be considered one of the actual flavors of a beer in addition to sweet, salty, sour, bitter, and umami. He adds that the temperature of the beer at serving directly affects its heat level, noting that it will get progressively hotter as the beer warms.

It all comes back to the balance of the beer. Light beers, both in color and strength, make a good background for both heavy and mild pepper heat. These styles allow the pepper flavors to be the star while the other beer flavors lend supporting roles or, just the opposite, they can let all the flavors play together as one. More aggressive styles, such as stronger ales or those with more complex malt profiles can stand up to and complement stronger pepper flavors and heat without distracting too much from the base style.

Ultimately, you can put any variety of pepper in any style of beer at any point in the process. It all depends on what you want. Just go slowly. You can always add more later.

Appreciating the Classics

by Kaleb Schwecke

The hops that started the US craft beer revolution

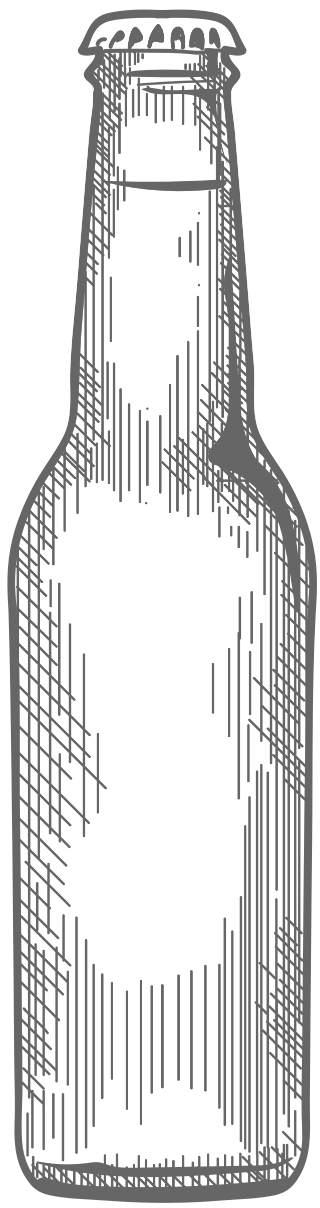
The classics are classics for a reason. Whether talking about books, music, or even beer, it is important to understand what the classics are and why they hold that special title. Classics broke the established mold, defined genres, and inspired imitators.

In the world of beer, hops were the single most important ingredient that defined and shaped the American craft beer movement. And two hop varieties that are undisputedly enshrined as classics because of this movement are Cascade and Centennial. These two hops did have their share of troubles to start, but they went on to dominate usage in both commercial brewing and homebrewing throughout the 1990s and at the turn of the century. They have also managed to survive and solidify their place as two of the top hops, while other varieties from the same era like Liberty and Willamette have almost been forgotten and replaced.

Because many popular hop varieties from the early craft beer movement have been left by the wayside, it is difficult to single out another variety that is deserving to stand side-by-side with Cascade and Centennial. Certainly Chinook, the single hop featured in Stone's Arrogant Bastard Ale, has some claim to the classics' crown and still occupies a good chunk of acreage. There is also an argument to be made for Columbus, Tomahawk®, and Zeus, (the CTZ hops) but even though those varieties made a rebound in 2018 due to their alpha market potential, total acreage is still down by about 40% from 2000 (USDA Crop Production August 2018).

2018 was a milestone year because Cascade was unseated as the top hop by acreage planted. Its number one position was usurped by one of the newer kids on the block, Citra®. "I'd say that the search for all things new is ultimately what sets craft beer drinkers and brewers apart," said Julian Healey author and founder of Hopslist.com. "Most craft beer consumers expect variety and experimentation from craft breweries. Loyalty in that regard is given to brewers who offer consistent quality and creativity amid that variety. I believe it also pushes the whole industry forward."

So, in an industry driven by consumer tastes seeking out the next new beer or hot hop, what place do the classics have?



CASCADE HOPS

"Cascade is the definitive hop for American craft brews."

— Third Edition of the Barth-Haas Hops Companion

Cascade was the result of decades of work by the USDA breeding program at Oregon State University. Back in 1956 when the first seed was selected by breeder Stan Brooks, Cascade was simply known as plant 56013.[1] Genetically, Cascade was considered a bit of a mutt, with English Fuggle for a mother and a Russian father named Serebrianka. The result was a unique floral and citrus aroma that is best described as zesty grapefruit. But even though Cascade offered a unique and now-desirable aroma, its fate was not always certain. When the first test plots were harvested in 1969 there were no buyers and no interest. After being in development for 13 years, it looked like Cascade was doomed to the slash pile. It was not until verticillium wilt destroyed the Mittelfrüh crop over in Germany that Cascade secured its first contract. Coors Brewing Co. was the first brewery to sign Cascade contracts, and many other breweries quickly followed in looking for an American-grown alternative to imported European hops.

Cascade was officially released in 1972 and by 1976 it accounted for 13 percent of hop acreage in the United States. But by 1977, popular opinion already started to turn from Cascade and the Barth Hop Report wrote, "The hope placed in them (Cascade) originally as a replacement for imported European aroma hops was not fulfilled." Cascade started getting yanked out of the ground as breweries began to back out of contracts. By 1985, Cascade was once again being called a dead variety. Yet in another fortuitous twist, 1985 was the year that Steve Dresler and Ken Grossman from Sierra Nevada Brewing came to the Yakima Valley of Washington State for hop selection. They took out a 3-year contract on Cascade and the rest is well-known history. "Cascade was the first, and for quite a while the only, hop available that exhibited what has become known as New

Cascade hops owe much of their success to Sierra Nevada, which reversed a trend of Cascade hops being pulled from fields when the brewery entered a three-year contract to buy the variety.

World character — mostly thinking about citrus fruits and pine. And Sierra Nevada played a very large role in making consumers and brewers aware of that," said Stan Hieronymus, author of *For the Love of Hops*. Behind their flagship Pale Ale, Sierra Nevada went on to become the second billion-dollar American craft brewery and they still buy more Cascade at the craft level than anyone else.

Eric Desmarais, 4th generation owner of CLS Farms in Moxee, Washington (a sub growing region of the Yakima Valley), grows Cascade and sells it directly to Sierra Nevada for their Pale Ale. He said, "All varieties tend to have a life cycle. Cascade is probably the best example of the longest life cycle and that speaks volumes to its sustainability over the long term and what it gives to brewers. I suspect that Centennial and Chinook will have a shorter lifecycle than Cascade. I think Cascade is still with us for quite a while longer, but I could see maybe some other publics (publicly owned varieties through the USDA, not a branded, trademarked, or patented hop) coming in and starting to replace Centennial and Chinook. But interestingly enough, Centennial and Chinook are both very unique varieties, each with their own unique aromas, so there won't be anything to replace them for quite some time."

Cascade's longevity can at least in part be attributed to its versatility. By today's standards it has a lower alpha acid percentage (4–7%), but Cascade still gets used in both bittering and aroma applications. Its lower bittering power is a blessing in some ways, as it allows Cascade to be used in almost any style as it does not overpower even the lightest of lagers. But its real value is in the zesty, fresh grapefruit aroma that defined a generation of beer.

CENTENNIAL HOPS "THE LITTLE LOST PUPPY"

Centennial was developed by Charles Zimmerman and S.T. Kenny at Washington State University in partnership with the USDA. Centennial owes its name to the Washington state centennial anniversary in 1989, one year before its commercial release in 1990. Centennial was conceived in 1974 and has a mishmash of genetics including Brewers Gold, Fuggle, East Kent Golding, and a smattering of Bavarian hops. Initially described as a "super Cascade," Centennial offers similar citrus characteristics, but is backed by a woodiness that made it entirely unique. Centennial's cedar and oaky elements are due to a pair of compounds (cis-rose oxide and caryophylla-3,8-dien-(13)-dien-5-beta-ol) that are prominent in Centennial and are believed to contribute to its unique aroma.[1]

Desmarais said he is the single largest grower of Centennial with about 560 acres last harvest. "Varieties like Cascade and Chinook were primarily driven by big macros. Coors was the first buyer of Cascade and that's what gave Cascade its first big opportunity. Same story with Chinook, because a lot of it was — a lot of it is — bought by Coors. But Centennial was just like a little lost puppy in all of that. It had really no advocate to it. It just got bred and released and kind of got a dinky cult following with craft brewers, but just stayed very low acreage. So Centennial's rise to prominence really is completely on the back of craft brewers, which makes it a uniquely American craft variety."

Owed most of the credit for popularizing Centennial hops is Bell's Brewery in Kalamazoo, Michigan. In 1997, before Centennial hops were widely grown, Bell's brewed their first batch of Two Hearted Ale exclusively using Centennial hops. Two Hearted has gone on to become one of the most iconic American craft beers and has been Bell's best seller for many years (for more history on Bell's Brewery and Two Hearted Ale, see the cover story from the December 2018 issue of *BYO*).

Desmarais expanded his Centennial acreage in 2007, 2012, and in 2016. He said that there is a little backup of Centennial due to recent over-supply, but Desmarais has not seen overall demand for Centennial diminish. "As a true craft variety, Centennial's demand is really tracking right along with the rest of the craft beer industry and staying strong."

Centennial's nickname "Super Cascade" is mostly due to its higher alpha acid percentage (9–13%). This allows it to be an effective bittering hop as well as offering a bigger aroma. Because of this alpha potential, Centennial can be "juiced" or turned into CO_2 alpha extract. This helps soak up any surplus crop and adds some price and risk stability for farmers.

Photo courtesy of Yakima Valley Hops

The popularity of Centennial hops can largely be credited to Bell's Brewing, which first used the variety in the single-hopped Two Hearted Ale in 1997.

PUBLIC DISPLAY OF AFFECTION

"Brewers tell us that public varieties like Cascade and Centennial are important to them," said Desmarais. "So we try to make that a decent part of the portfolio of varieties we grow. Especially recently, brewers have made a renewed commitment to the public breeding program. Financial commitments. Brewers, from the smallest to the largest, have indicated that they want public hops and they want a strong public breeding program. So now there is a lot of work being done to build that program back up." The financial commitments that Desmarais talked about come in the form of funding grants from the Brewers Association to the USDA-Agricultural Research Service. The grants will help expand the programs in both Washington and Oregon and help pay for another hop breeder.

With the additional funding also comes a new strategy. "The public space previously has really been driven by the growers, growing for one or two big customers. And where the proprietary varieties really have succeeded is by putting a bunch out there, seeing what sticks, and those that don't seem to disappear fairly quickly," said Desmarais. "So now the name of the game is getting out varieties rapid fire and giving the brewers a huge selection to choose from and letting the brewer decide what they like."

This new approach gives brewers the chance to weigh in on a variety at various early stages in its life. In November 2018, the Brewers Association, in partnership with Yakima Valley Hops, the Hop Research Council, and Draught Lab, hosted the first annual Hopsource. Hopsource was a weeklong sensory panel that allowed brewers of all sizes as well as homebrewers to do sensory analysis on experimental varieties in the public program. This new strategy of brewer-driven demand puts the future of US hop varieties directly in the hands of brewers.

But even when the next big superstar hop comes along, whether public or private, Healey does not see the classics ever leaving us. "There's still a big place for Cascade and Centennial. They've been the backbone of American ales for a really long time and will continue to be," said Healey. "When it comes to American IPA or APA, I believe the current collective palate expects certain varieties to be present. If you're making beer to connect with that palate, in that respect, hops like Cascade and Centennial are irreplaceable."

WHAT ARE AGRONOMICS AND WHY DO THEY MATTER?

Even though most varieties of hops come from a very small European gene pool, there are still big differences in disease resistance, yield per acre, and even ideal growing conditions. Agronomics simply refers to how well each variety performs in each of those categories. And in order to become a successful, staple hop, a variety does need to excel across the board to provide a consistent crop from year to year.

"The one thing about those three varieties (Cascade, Centennial, and Chinook), they are super stable from a growing perspective," said Desmarais. "We know exactly what the disease pressure is on them, we can pin them into a tight yield projection, and picking windows are well known. Those varieties have really vetted themselves out in all those ways. They have been vetted by the brewers and they have been vetted by the growers."

Alternatively, newer hop varieties sometimes don't have this advantage. "When new varieties come out, and the speed of new varieties coming out, the pace has really quickened, and so we have seen some new proprietaries that when they are expanded out on a larger scale they start failing from an agronomic perspective," said Desmarais. "Because when they are on a three-acre or five-acre field, it does not really translate well into when it is spread out over 2,000 acres across three states with three different growing climates. So with some of these proprietary varieties, we have been seeing wild yield fluctuations and in some cases complete failures."

Not only does the country where a variety is grown matter, but even as little as a 30-minute drive within a growing region can make big differences depending on the variety. Desmarais used Centennial as an example of a finicky hop and said that even within the Yakima Valley, not all the lower valley regions are suited to growing the variety. He said that Centennial is very sensitive to daylight length, which makes it very difficult to grow a quality crop outside of a few select areas in the Yakima Valley.

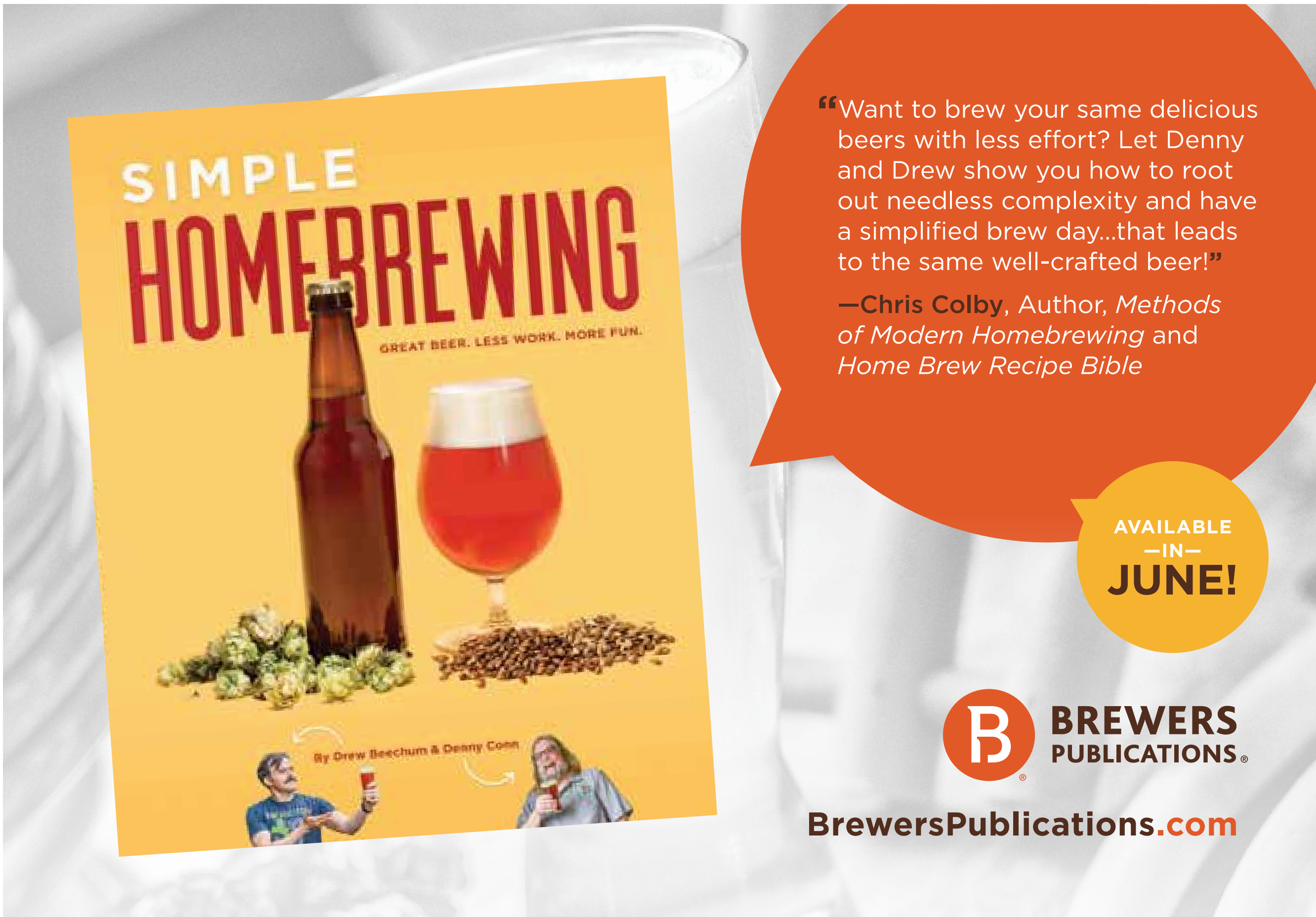
Centennial's temperamental nature has caused some problems for the variety as there can be great variances in quality and yield, depending on where it was grown. This has caused some price instability for Centennial, which has led to huge price swings depending on the harvest. This instability has created some headaches for brewers in the past, but Desmarais believes the variety will see a period of consistency over the next couple of years.

UNDISCOVERED POTENTIAL

Even today, after decades of use, experimentation, and study, hops like

Photo courtesy of Yakima Valley Hops

A field of Centennial hops growing in the Yakima Valley of Washington State.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Fresh, dried, and pelletized Cascade hops.

Cascade and Centennial still have their secrets. A hop's alpha acid is the primary value that brewers concern themselves with, but there are hundreds of compounds, oils, and flavonoids produced by the hop cone. Much of what is produced by the hop's flowers is yet undiscovered and unnamed. A typical hop data sheet will include values for, at most, 20 compounds, but even today it is still common industry practice to only include the alpha acid percentage on a label. So this still leaves large swaths of unexplored territory even in classic hops that have been in common usage for decades. "As brewing scientists are able to tell brewers more about what's inside of hops and how to access that, Cascade will remain valuable, used in blends to create aromas and flavors not associated with Cascade 20 years ago," said Hieronymus.

It is this blending of hops that holds huge potential for unlocking new aromas and flavors because they are usually greater than the sum of their parts. The main three terpene hydrocarbons found in hop cones are myrcene, humulene, and caryophyllene, but the chemical composition varies based on variety. Some other trace terpenes, such as linalool and geraniol, are present in some varieties, but not others. These terpenes can go through chemical restructuring in the presence of yeast in what is commonly referred to as biotransformation. This process can combine terpenes into entirely new aromas and flavors, but the whole process might be dependent on having a trace terpene available to act as a catalyst.

NEW WORLD HOPS AROUND THE WORLD

"What I'm seeing is that the international craft market is mimicking what happened in the US. So if the US is in the seventh or eighth inning of craft, many other countries are just starting in the first inning. So I suspect for quite a number of years, they will trail what happened here and use Cascade, Centennial, and Chinook," said Desmarais. He explained that maybe as demand starts to dip here in the US for these varieties, new international breweries will make up the difference in demand. "One of Cascade's greatest attributes is that it can be used in really any style of craft beer, because its aroma is a little bit more muted and more subdued than a Citra®, which is more intense and pointed." Another one of Cascade's great attributes is that it can grow and produce in many different climates around the world.

"*Terroir* has a huge impact on hops," said Healey. "Brewers in Australia have been using locally-grown Cascade for decades. I know some who refuse to use US Cascade as a substitute for the Aussie stuff when local supply runs out. It's not that either is necessarily good or bad, they're just different. That distinction is not genetic, it's purely down to where it's being grown. If brewers outside the USA want that "American" Cascade experience, they really do have to get it from the source."

Desmarais said that every single purchase order he has received from breweries outside of the US asks for Cascade. He estimated that eighty percent also ask for Centennial and sees the continued growth for international demand of US-grown Centennial and Cascade.

"New brewers in other parts of the world are just getting to know New World hops," explained Hieronymus. "In some cases, they may end up using these public varieties (particularly Cascade) grown in their own country, where *terroir* will come into play. In many cases, at least when they can get the varieties, they turn immediately to Citra®, Mosaic®, (and) Galaxy™ because they generate the bold, intense aromas and flavors that grab attention. Rather than starting with Cascade and getting to know newer varieties, as American brewers who've been in the business a while have, they learn about the new stuff first. Will they do their homework and discover the unique qualities of Cascade and Centennial? That's where my crystal ball gets too hazy (no references to a beer style intended) to see clearly." BYO

REFERENCES

[1] Hieronymus, Stan. *For the Love of Hops.* Brewers Publications, 2012.

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Hot New Hops

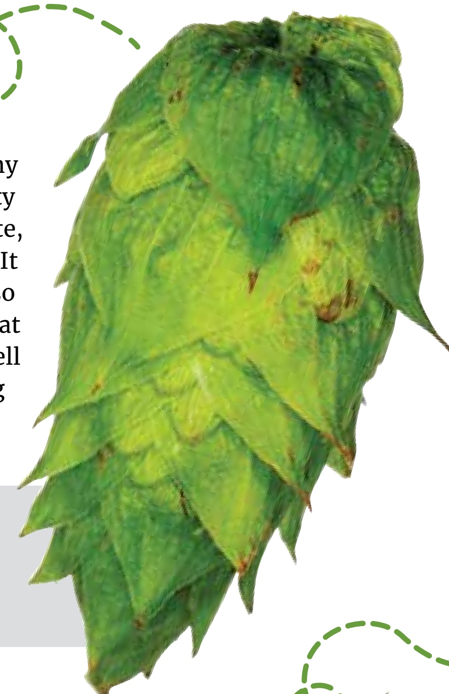
Get to know the newest hop varieties

by Betsy Parks

Tech companies love talking about "early adopters" — these are the people who are first to get the newest gadget, software, or trend and spread the word to the masses. The brewing industry isn't so different from tech — new breweries open every week and thousands of new beers roll down their bottling and canning lines as a result. And craft brewers — whether new to the market or giants in the industry — are constantly in search of cool new ingredients as drinkers demand fresh takes on beer styles, especially hops. The great thing about homebrewing is that you can brew whatever you want, with whatever you want, whenever you want. In fact, homebrewers are very often the early adopters who break trends in craft brewing. If you're one of those homebrewers who can't wait to brew with the newest ingredients, here are seven new hop varieties to try.

Photo courtesy of Yakima Chief Hops

EKUANOT® (14.5–15% ALPHA ACIDS)



This variety, formerly known as Equinox, was developed by the Hop Breeding Company (HBC) in Yakima, Washington and released in 2014 as HBC 366. The name of the variety was changed in September 2016 from Equinox to Ekuanot® due to a trademark dispute, and is becoming popular with pro brewers as a late-, whirlpool-, or dry-hop addition. It features aromas of lime, melon, berry, cedar, papaya, clove, and sage. Some brewers also say that the aromas can skew into green bell pepper territory. Michael Brown, brewer at Mirror Twin Brewing in Lexington, Kentucky brewed the American pale ale Eukanot Tell Me What To Do (see recipe on page 58) with the variety and describes the hop as being very citrus-forward with lots of lemon and lime. "I would say use it as a late-addition and whirlpool-[hop] because of the high alpha acids," Brown said.

Commercial beers brewed with Ekuanot®: Sierra Nevada Brewing Co.'s Ruthless Rye IPA (Chico, California), Sierra Nevada Brewing Co.'s Harvest Single Hop IPA (Equinox™) (Chico, California), Great Divide Brewing Co.'s Hop Disciples (Ekuanot®) (Denver, Colorado), Deschutes Brewery's Pinedrops IPA (Bend, Oregon), Mirror Twin Brewing's Eukanot Tell Me What To Do (Lexington, Kentucky).

LORAL® (10–12% ALPHA ACIDS)

Another variety developed by the hopheads at HBC, Loral® was originally known as HBC 291. The folks at HBC describe this hop as having a noble heritage that straddles the fence between Old and New World hop aromatics — sometimes even called a "super noble hop." Originally released in 2016, Loral® has a lot of big-name brewery representation thanks to its floral, citrusy, and herbal qualities that are perfect for brewing modern IPAs and pale ales, as well as hoppy lagers. Stone Brewing Co. alone has brewed multiple offerings such as Scorpion Bowl, Exalted IPA, and Vengeful Spirit using Loral®. The variety would also work well in any style that's normally brewed with a noble hop, including porters and stouts, Pilsners, bocks, dunkels, and so on.

Commercial beers brewed with Loral®: Stone Brewing Co.'s Vengeful Spirit IPA (Escondido, California), Lone Pint Brewery's Zythophile Lone Hop Loral (Magnolia, Texas), Garage Project's Loral Royale (Wellington, New Zealand), Dogfish Head's Loral (Milton, Delaware).

MEDUSA (2.5–4% ALPHA ACIDS)

This is one of the first commercially-farmed *neomexicanus* subspecies of hops released to the brewing industry (for more about *neomexicanus* hops, visit https://byo.com/article/neomexicanus-hops/). The aroma variety comes from CLS Farms in Moxee, Washington, and is sometimes called Multihead. It was released around 2014 (although not made readily available to homebrewers until more recently) and was semi-famously included in Sierra Nevada's "Harvest Wild Hop IPA" and other "wild hop" brews around that time. There are newer varieties of *neomexicanus* hops on the market these days that have greater yields for growers (see the section later in this story on Zappa™ hops), CLS, however, plans to market Medusa more exclusively toward homebrewers — so Medusa should be in good supply at most well-stocked homebrew shops. Another cool thing about Medusa hops is that they are not patented so you can source rhizomes fairly easily to grow at home. Look to Medusa for aromas of lemon, lime, apricot, and melon in any American pale ale or IPA, as well as perhaps a saison or wheat beer.

Commercial beers brewed with Medusa: Sierra Nevada Brewing Co.'s Harvest Wild Hop IPA (Chico, California), Burlington Beer Co.'s Single Hop IPA Medusa (Burlington, Vermont), Tröegs Brewing Co.'s Nitro Chocolate Stout (Hershey, Pennsylvania), Crazy Mountain Brewery's Neomexicanus Native (Denver, Colorado).

PAHTO™

(17–20% ALPHA ACIDS)

This "super high" alpha acid bittering hop is one of the newest bittering hop releases from HBC (2018) and is creating a lot of buzz on the commercial brewing side of the industry. It's currently not widely available to homebrewers, however HBC has 1,700 acres of Pahto™ currently planted, with more planned for this year, and this can only mean that homebrewers will see this variety in homebrew shops sooner rather than later. Look for it and Sabro™ in sample packs for now, and in wider release later in the year. Originally released as HBC 682, this variety is described by HBC as having a "smooth bittering profile with mild, pleasant aromatics." The name comes from the native name for Mount Adams, which is the second-highest mountain in Washington State. Pahto™ would be appropriate for a very wide variety of beer styles — anything that you would like to brew that would benefit from its clean bittering profile.

> **Commercial beers brewed with Pahto™:** Because this is such a new release, there aren't many brews released yet with the official brand name, but you may have seen some limited releases before the hop was named, such as Russian River Brewing Co.'s Hop 2 It (HBC 682) (Santa Rosa, California), Lagunitas Brewing Co.'s New Dogtown HBC 282 Pale (Petaluma, California), and Manor Hill Brewing's Experimental Hop Series - HBC 682 (Ellicott City, Maryland).

SABRO™

(12–16% ALPHA ACIDS)

This variety is one of HBC's newest aroma hop releases, and is a cross pollination of a female *neomexicanus* hop. It has been available to homebrewers for a few years at this point, and some might recognize it from its earlier nickname, "Ron Mexico." HBC describes this hop as strongly expressive, "with distinct tangerine, coconut, tropical fruit, and stone fruit aromas, with hints of cedar, mint, and cream." Sabro™ has become a bit of a darling among craft brewers since its release as HBC 438, and you can find many commercial examples around the US that are brewed with it. If hop-forward pale ales, IPAs, Pilsners, or wheat beers are your thing, this is definitely a variety you should try.

> **Commercial Beers Brewed with Sabro™:** Odell Brewing Co.'s Sabro IPA (Fort Collins, Colorado), Holy Mountain Brewing's Sabro Fresh Hop (Seattle, Washington), and Cellarmaker Brewing Co.'s Sabrosa (San Francisco, California).

STRATA®

(11-12.5% ALPHA ACIDS)

Released in 2018, Strata® is a dual-purpose hop that is the first patented variety developed by Portland, Oregon-based Indie Hops in partnership with Oregon State University. Kegerator.com might have nailed the best aroma description of this variety as "passion fruit meets pot" with notes of mango, melon, citrus, and grapefruit — perfect, clearly, for any big, bold, "dank" pale ale and IPA, but also not out of place in any American amber, brown, or stout. Strata® has become an "it" variety among craft brewers, so it might be hard to source at the moment as a homebrewer, though not impossible. With demand will come more production, however, so look for Strata® to hopefully be more available after this year's hop harvest.

> **Commercial Beers Brewed with Strata®:** Worthy Brewing's Strata IPA (Bend, Oregon), Bear Republic Brewing's Strata Rebellion (Cloverdale, California), Base Camp Brewing's Harvest Saison (Portland, Oregon), Deschutes Brewery's 2018 Chasin' Freshies IPA (Bend, Oregon), Mt. Hood Brewing's Timberline Tucker (Government Camp, Oregon), and Sierra Nevada Brewing Co.'s 2018 Hoptimum (Chico, California).

ZAPPA™

(7–9% ALPHA ACIDS)

Named for the late, great Frank Zappa, this is the newest 100% *neomexicanus* hop variety released from CLS Farms. Developed in the same way as Medusa, Zappa™ has a higher yield for growers, so as mentioned earlier it will be taking over a lot of space originally planted with Medusa. Originally only available to commercial brewers, Zappa™ is now hitting the homebrew market as well. It features aromas of passionfruit, mint, and spice. If endorsements mean anything, Zappa™ certainly got one of the biggest when Sierra Nevada bought nearly the entire crop in 2015. If it's good enough for the hopfathers in Chico, it's certainly more than worthy of your homebrewery.

> **Commercial Beers Brewed With Zappa™:** There aren't many craft brews on the market at the moment as Sierra Nevada cornered the market so early on this hop. More acreage will mean more brewers will be able to get their hands on this variety this year, however, so look for more commercial beers brewed with Zappa™ to show up in the market in 2019. In the meantime, get your hands on Sierra Nevada Brewing Co.'s Zappa Wild Stache IPA (Chico, California).

WHERE DO NEW HOPS COME FROM?

Photo courtesy of Yakima Chief Hops

It might seem like there are tons of new hop varieties on the market today, but that wasn't always the case. Only a few decades ago, before craft beer began to boom, commercial brewers worked with fewer than 100 classic varieties. Even the varieties that we nowadays consider "classics" like Centennial, Mt. Hood, and Liberty weren't released or popular among brewers until around 1990. Up until then, 80% of all the hops grown in the United States were Cluster.

Hops, like any other agricultural product, have been tinkered with for a long time. In the US alone, hop farming started in Oregon in the 1860s, and the USDA re-established a hop breeding program at Oregon State University in 1935 after Prohibition. After the game-changing popularity of Cascade hops in the late '80s and early '90s, however, the interest in developing and releasing new varieties sharply increased, and it's now common for at least a handful of new varieties to be released each year.

Developing new hops is not as easy as just planting a few rhizomes in a field and hoping for the best, however. There is a lot of science behind plant development, which takes time (and lots of money). In the US, hops are developed mostly by public breeding programs, although there are also some private breeding programs that are run by hop merchants and growers. The difference, as a consumer, in who breeds and releases hops is that those that originate from a public program can be used by any hop grower, while those developed by private programs are patented — only the hop merchants and growers who fund the programs may grow and sell them.

Most of the money to fund new public hop development in the United States comes from the Hop Research Council (hopresearchcouncil.org), which is a non-profit organization that funds and directs hop research to benefit the US hop industry. A lot of the money for this research comes from the world's largest brewing companies — AB-InBev, MillerCoors, etc. All US hop dealers belong to this organization, and the HRC decides how funding is distributed among hop researchers.

There are three methods for producing new varieties: Benefit mutation, mass selection, and chemical inducement. Ralph Olson explained these three methods very well for *BYO* in the story "Creating New Hop Varieties" (online at https://byo.com/article/creating-new-hop-varieties/.) For every new blockbuster hop that is released, however, thousands more experimental varieties never make it to the market, especially through mass selection. For example, Olson explains, Hopunion USA (now Yakima Chief Hops) crossed more than 10,000 cultivars to come up with a single commercial variety — Columbus. The process can take years before a variety is deemed acceptable.

Hops are bred to satisfy the tastes and needs of commercial brewers and growers. For example, MillerCoors might decide that they would like a new variety that has a certain aroma. Because MillerCoors is a major financial contributor to the Hop Research Council, and would buy the majority of a crop of a variety that suits their requirements, hop breeding programs will focus their efforts on developing that ideal hop. Craft breweries with buying power have this advantage as well; for example Sierra Nevada Brewing Co. loved CLS Farms' *neomexicanus* hop variety, Zappa™ so much that they bought essentially the entire 2015 crop. Surely if Sierra Nevada has a wishlist for another hop variety in the future, hop breeders will make it a priority. For growers, experimental varieties must be pest- and disease-resistant, and growing yields must be consistently viable to be cost effective. If the variety doesn't meet the requirements of both the grower and the market demand, and is too expensive to grow, an amazing aroma hop that doesn't produce enough hops is simply not going to make it to release when there are so many other potential varieties waiting in the wings.

So while homebrewers don't have the influence to dictate what new hops come on the market, the good thing about today's often-criticized, fickle, and ever-more-educated beer drinkers is that demand for new styles, and thus innovative ingredients, remains at an all-time high. Literally thousands of new hop varieties are being evaluated and examined right now — the next big hop could be ready for release!

REUBEN'S BREWS' BITS AND BOBS (2018) CLONE

(5 gallons/19 L, all-grain)
OG = 1.066 FG = 1.012
IBU = 50 SRM = 5 ABV = 7%

"For our first release of Bits and Bobs in 2018 – our seasonal rotating IPA – we used Strata®, Citra®, and Azacca® as the primary hops. The idea with this specific beer release is that every spring we have a new recipe using the malts and hops we had grown to love over the prior year. It's the perfect excuse to be continually trying new hops, working with hop farms, and working on new hop blends. For the first release, we had a nice clean malt profile to let the hops shine through and take center stage."

– Adam Robbings
Brewmaster, Reuben's Brews

INGREDIENTS

11.5 lbs. (5.2 kg) pale malt
1.7 lbs. (0.77 kg) Vienna malt
0.6 lb. (0.27 kg) Carapils® malt
1.6 AAU Simcoe® hops (60 min.)
 (0.125 oz./3.5 g at 13% alpha acids)
1.5 oz. (43 g) Azacca® hops (0 min.)
0.5 oz. (14 g) Strata® hops (0 min.)
1 oz. (28 g) Citra® hops (0 min.)
1.5 oz. (43 g) Azacca® hops (dry hop)
1.5 oz. (43 g) Strata® hops (dry hop)
1.5 oz. (43 g) Citra® hops (dry hop)
Wyeast 1056 (American Ale) or
 White Labs WLP001 (California Ale) or
 SafAle US-05 yeast
¾ cup corn sugar (if priming)

STEP BY STEP

Crush the malt and add to 4.3 gallons (16.3 L) strike water to achieve a stable mash temperature at 152 °F (67 °C). Hold at this temperature until enzymatic conversion is complete. Sparge slowly with 168 °F (76 °C) water, collecting wort until the pre-boil kettle volume is 6.5 gallons (24.6 L).

Boil the wort for 60 minutes, adding the hops as indicated. After the boil is finished, turn off the heat and add the 0-minute hop-stand additions. Stir the wort to create a whirlpool, then let settle for 10 minutes before chilling the wort down to yeast-pitching temperature. Now transfer to the fermenter, aerate the wort, and pitch the yeast. Ferment at 66–68 °F (19–20 °C).

As the kräusen begins to fall, typically day four or five, add the dry hops to the fermenter and let the beer sit on the hops for four days. Bottle with priming sugar or keg and force carbonate to 2.4 volumes CO_2.

REUBEN'S BREWS' BITS AND BOBS (2018) CLONE

(5 gallons/19 L, extract with grains)
OG = 1.066 FG = 1.012
IBU = 50 SRM = 5 ABV = 7%

INGREDIENTS

6 lbs. (2.7 kg) extra light dried malt
 extract
1 lb. (0.45 kg) Vienna dried malt extract
0.5 lb. (0.23 kg) Carapils® malt
1.6 AAU Simcoe® hops (60 min.)
 (0.125 oz./3.5 g at 13% alpha acids)
1.5 oz. (43 g) Azacca® hops (0 min.)
0.5 oz. (14 g) Strata® hops (0 min.)
1 oz. (28 g) Citra® hops (0 min.)
1.5 oz. (43 g) Azacca® hops (dry hop)
1.5 oz. (43 g) Strata® hops (dry hop)
1.5 oz. (43 g) Citra® hops (dry hop)
Wyeast 1056 (American Ale) or
 White Labs WLP001 (California Ale) or
 SafAle US-05 yeast
¾ cup corn sugar (if priming)

STEP BY STEP

Crush grains and place in a grain bag. Heat 5 gallons (19 L) of water, and add the bagged grains. When the water hits 168 °F (76 °C) , remove the grains and allow to drip back in the kettle. Remove from heat and stir in all the dried malt extract.

Boil the wort for 60 minutes, adding the hops as indicated. After the boil is finished, turn off the heat and add the 0-minute hop-stand additions. Stir the wort to create a whirlpool, then let settle for 10 minutes before chilling the wort down to yeast-pitching temperature. Now transfer to the fermenter, aerate the wort, and pitch the yeast. Ferment at 66–68 °F (19–20 °C).

As the kräusen begins to fall, typically day four or five, add the dry hops to the fermenter and let the beer sit on the hops for four days. Bottle with priming sugar or keg and force carbonate to 2.4 volumes CO_2.

MIRROR TWIN BREWING CO.'S EUKANOT TELL ME WHAT TO DO CLONE

(5 gallons/19 L, all-grain)
OG = 1.052 FG = 1.010
IBU = 50 SRM = 5 ABV = 5.5%

"When we made this beer it was summertime so we wanted something citrus and sessionable. The Ekuanot® hops are very citrus-forward with lemon and lime. We were using a pale ale base recipe for the sessionability. I chose the Ekuanot® hops because I tasted them at another local brewery in a S.M.A.S.H. (single malt and single hop) with Golden Promise. I liked that beer and wanted to experiment with the hop myself."

– Michael Brown
Assistant Brewer, Mirror Twin Brewing Co.

INGREDIENTS

11 lbs. (5 kg) 2-row pale malt
12 oz. (340 g) caramel malt (20 °L)
5 AAU Ekuanot™ hops (45 min.)
 (0.33 oz./9 g at 15% alpha acids)
10 AAU Ekuanot™ hops (15 min.)
 (0.66 oz./19 g at 15% alpha acids)
22.5 AAU Ekuanot™ hops (0 min.)
 (1.5 oz./43 g at 15% alpha acids)
8 oz. (230 g) Ekuanot™ hops (dry hop)
White Labs WLP008 (East Coast Ale) or
 Wyeast 1028 (London Ale) or
 LalBrew New England yeast
¾ cup corn sugar (if priming)

STEP BY STEP

This recipe is designed for homebrewers to achieve 5.5 gallons (21 L) of wort in their fermenter on brew day. This will help offset the loss of volume to the heavy hopping rate of this beer.

Crush the malt and add to 4 gallons (15 L) of strike water to achieve a stable mash temperature at 150 °F (65.5 °C). After 60 minutes, begin to lauter.

Boil for 60 minutes, adding the first hop addition 15 minutes after the wort comes to a boil and a second hop addition with 15 minutes left in the boil. After the boil is complete, turn off the heat and add the final hop addition. stir the wort to create a whirlpool, then let settle for 20 minutes before cooling to yeast-pitching temperature. Aerate wort and pitch yeast.

Ferment at 68 °F (20 °C). As the kräusen begins to fall, typically day 4 or 5, add the dry hops. Let the beer sit on the hops for 3–4 days, then transfer to a serving keg or bottling bucket. You may want to cold-crash the beer prior to the transfer by dropping temperature of the beer to 35 °F (2 °C) for 24 hours. Bottle with priming sugar or force carbonate the serving keg to 2.4 volumes CO_2.

MIRROR TWIN BREWING CO.'S EUKANOT TELL ME WHAT TO DO CLONE

(5 gallons/19 L, all-grain)
OG = 1.052 FG = 1.010
IBU = 50 SRM = 6 ABV = 5.5%

INGREDIENTS

6 lbs. (2.7 kg) extra light dried malt
 extract
12 oz. (340 g) caramel malt (20 °L)
5 AAU Ekuanot™ hops (45 min.)
 (0.33 oz./9 g at 15% alpha acids)
10 AAU Ekuanot™ hops (15 min.)
 (0.66 oz./19 g at 15% alpha acids)
22.5 AAU Ekuanot™ hops (0 min.)
 (1.5 oz./43 g at 15% alpha acids)
8 oz. (230 g) Ekuanot™ hops (dry hop)
White Labs WLP008 (East Coast Ale) or
 Wyeast 1028 (London Ale) or
 LalBrew New England yeast
¾ cup corn sugar (if priming)

STEP BY STEP

Place the crushed malt in a muslin bag. Steep the grains in 6 gallons (23 L) of water at 160 °F (71 °C) for 20 minutes. Remove the grain bag and wash with 2 qts. (2 L) hot water.

Remove the wort from heat and then stir in the dried malt extract. Stir until all the extract is dissolved and then return the wort to a boil. Boil for 45 minutes, adding the first hop addition when the wort comes to a boil and a second hop addition with 15 minutes left in the boil. After the boil is complete, turn off the heat and add the final hop addition. Stir the wort to create a whirlpool, then let settle for 20 minutes before cooling to yeast-pitching temperature. Transfer wort to a fermenter and top off the fermenter to 5.5 gallons (21 L). Then aerate the wort and pitch yeast.

Ferment at 68 °F (20 °C). As the kräusen begins to fall, typically day 4 or 5, add the dry hops. Let the beer sit on the hops for 3–4 days, then transfer to a serving keg or bottling bucket. You may want to cold-crash the beer prior to the transfer by dropping temperature of the beer to 35 °F (2 °C) for 24 hours. Bottle with priming sugar or force carbonate the serving keg to 2.4 volumes CO_2.

TIPS FOR SUCCESS:

Michael Brown said that Mirror Twin used second generation White Labs WLP008 (East Coast Ale) yeast because it contributes citrus qualities, however he suggests that homebrewers can substitute in their favorite yeast strain that attenuates well and provides a citrus kick without overwhelming the hops. Further, Brown said, "Our recipe was very simple . . . (which) allowed the hops to shine. We also wanted to accentuate the citrus qualities and make this a thirst-quenching beer for summer, so we zested 35 lemons and put the zest in after fermentation was complete." BYO

Photo by Charles A. Parker/Images Plus

NEW ENGLAND IPA: A SCIENTIFIC STUDY

What research tells us about hazy IPAs

by Scott Janish

I started writing *The New IPA: Scientific Guide to Hop Aroma and Flavor* by collecting every academic article I could get my hands on, not only on studies focused on brewing hoppy beer, but every paper I could find on beer in general. Although the book cites over 300 sources, I ended up reading hundreds of additional studies spanning topics such as hop oils, biotransformation, head retention, hop creep, impact of grains and proteins on haze and flavor, different hopping techniques, and the impact of water chemistry and dry-hopping on bitterness. The goal was to piece together years of research often forgotten or generally undiscovered and apply it to brewing modern New England IPAs, which are full of hop flavor, low on hot-side bitterness, and of course, hazy.

Despite numerous well-intentioned attempts from friends reading drafts of the book to litter the book with hazy commercial IPA recipes, I resisted. I want the book and the entirety of its research to inspire new ideas and get brewers to deviate from typical brewing practices and recipes to not only use the science to understand results (both good and bad), but to take advantage of the information to start testing variables like new processes, ingredients, yeast strains, and hot-side and cold-side hopping techniques.

The one recipe I thought would be fun to assemble (which you will find on page 66), however, is to combine a collection of academic study results to build a scientifically-inspired hoppy hazy beer using the data of everything from water profile, grist makeup, yeast selection, and hopping techniques to bring together years of work by those much smarter than I into one powerful and punchy hazy IPA! I'm not suggesting this is the new standard recipe for brewing hoppy beer, but it's a fun exercise to try and put all of the research into action. The book goes into greater depth into each brewing topic, but this article is a glimpse into the book's contents and some of the research of the core brewing areas and, more importantly (hopefully), enough useful information to inspire brewers to experiment and improve their hoppy beer!

WATER

The sulfate-to-chloride ratio is often the marker used when discussing water profiles for hoppy beer. While it's a good approach for formulating a recipe, the raw amounts of the minerals themselves are just as important. For example, a sulfate-to-chloride ratio of 10:30 and 100:300 are both 1:3 but would likely result in different tasting beers. Generally, I like to stay under 200 ppm of each as to not impart a minerally taste to the beer. The research indicates that beer brewed with water favoring chloride will result in a fuller beer and those favoring sulfate will result in a dryer beer that emphasizes bitterness.[1] Rather than relying solely on mineral water adjustments to achieve a full-bodied hop-saturated beer, it's important to also consider the impact the grist will have on mineral additions. For example, on average, base malt can add around 50–100 ppm of sulfates and approximately 200 ppm of chloride. The malting processes can result in a higher amount of minerals than the raw grain, potentially from the water the maltsters use.[2]

So, when making a hazy IPA where both fresh hop character is desired as well as a full mouthfeel and restrained bitterness, a 2:3 sulfate-to-chloride ratio would be a good place to start. Adjust with subsequent batches as well as with grist changes. As the percentage of flaked grains increases in a recipe, you could increase the amount of chloride to replace what you'd typically get from malted grains. At Sapwood Cellars, the craft brewery that I and Michael Tonsmeire opened in 2018, we are generally in the range of 150 ppm of chloride to 100 ppm of sulfate, which is a ratio that works well for several beer styles.

GRIST SELECTION

The grist selection for hoppy beers can impact more than just flavor. For example, certain grains can impact haze levels, play a role in hop compound retention, influence fruity thiol contributions, and affect beer stability. One study by Luis F. Castro and Carolyn F. Ross found that high protein and carbohydrate beer had significantly more intense dry hop flavor but scored lower on the sensory tests for dry hop aroma due to the binding of volatile compounds keeping them in the beer vs. headspace.[3] The more viscous base in hazy IPAs can thus increase the retention of otherwise volatile hop compounds. Furthering this concept is recent research of commercial hazy IPAs that found hazy beers, more than other hoppy styles, had much higher polyphenol concentrations and retained more volatile, green, and resinous compounds like myrcene.[4] Haze levels and hop bite-astringency are also likely connected and may be altered with the selection of proteins used in the grist. For example, higher usage rates of unmalted grains, like flaked wheat, results in less permanent haze. One lab test conducted by Sofie Depraetere, Filip Delvaux, Stefan Coghe, and Freddy Delvaux found that beer with 40% unmalted wheat had significantly less permanent haze than the beer with 100% malted barley and beers with 20% unmalted wheat.[5] I believe this phenomenon is likely due to the higher proteolytic activity in malt (breakdown of proteins during malting), the wheat proteins are degraded, leading essentially to smaller proteins more likely to remain in suspension. It's possible that the proteins staying in the beer are more likely to interact with hop polyphenols and otherwise volatile less fruity green hop compounds. So, to encourage haze-inducing proteins in beer using high-modified, protein-rich grains like malted wheat will likely lead to hazier beer than brewing with a high percentage of unmalted wheat.

Photo by Charles A. Parker/Images Plus

Grist selection, even among base malts, can influence the fruity flavors desired in hoppy beers.

In other words, using a large percent of high-protein malted grains like malted wheat or spelt combined with intense dry hopping rates could result in hazy but also more astringent beer. I speculate that using under-modified grains like Best Chit malt are great because they are a balance between unmalted and malted grains with a small amount of modification balancing the haze and astringency potential coming from malted wheat while also aiding in head retention and mouthfeel. As a bonus, in my experience, chit malt also aids in dense head formation, similar to a shaving cream-like foam.

Interestingly, even base malt choices may influence the fruity flavor desired in hoppy beers. For example, Full Pint 2-row was tested with five other base malts and found by a sensory panel to produce a fruiter beer with flavors of watermelon rind.

Photo by Charles A. Parker/Images Plus

Hops used early in the boil for bittering can impart more flavor than some may think. Hops low in alpha-humulene and beta-caryophyllene are ideal for New England IPAs.

Further analysis showed that Full Pint has compounds that may be influencing the fruity flavors, including a volatile metabolite called alpha-ionone, a ketone associated with floral, pear, and watermelon rind flavors as well as a small number of monoterpenes, which could potentially boost a beer's overall fruity monoterpenes levels with most coming from hops.[6]

HOT-SIDE HOPPING

Traditional kettle aroma in beer is described as spicy, woody, and herbal — not attributes generally sought in fruity-forward hazy IPAs. Although early bittering additions are typically kept to a minimum to highlight hop flavor over bitterness, early bittering hop varieties choices can impart more flavor than you might anticipate. For example, when hops are boiled, newly formed oxygenated sesquiterpenes can be formed leading to more traditional kettle aroma and flavor.[7] Hop varieties high in alpha-humulene and beta-caryophyllene (like East Kent Golding, Nelson Sauvin, Northern Brewer, Golding, Pacifica, Vanguard, Progress, and Fuggle) will impart more of the spicy, woody, and herbal character in beer and might want to be avoided for bittering hops in hazy beers. On the other hand, here are some hops that are high in alpha acids but relatively low in α-humulene and β-caryophyllene: Waimea™, Loral®, Citra®, Mosaic®, Galaxy®, Bravo, Galena, and Columbus. Consider these hop varieties safe for early bittering additions when fruit flavors are the focus and spicy herbal flavors are not.

WHIRLPOOL HOPPING

Late whirlpool hopping is important for achieving hop saturated flavor because the fruity hop compounds are lost in the boil due to evaporation and trub. One paper found that linalool losses can be as high as 80% of the original concentration within just five minutes of boiling.[8] In fact, hydrocarbons from hops have been shown to peak almost immediately when added to boiling wort and then start their decline.[9] Sensory tests also show beers that are whirlpool hopped scored higher for estery-fruity and fruity-citrus flavors than beers that were only dry hopped.[10] In that study, beers were made with Simcoe® hops with additions at either 60 minutes, 20-minute whirlpool (right after the boil, no cooling was done), and dry hop only (for 48 hours).

So, incorporating late whirlpool hops is an important step to getting hop flavor but factors such as whirlpool temperatures can also play a role as late hopping at 185 °F (85 °C) retained slightly more measured linalool compared to warmer at 203 °F (95 °C) or cooler at 167 °F (75 °C). Sensory differences between the different temperatures showed that beers late-hopped at 203 °F (95 °C) scored highest for citrusy, spicy, and ester descriptors. The 185 °F (85 °C) late hop

Photo by Charles A. Parker/Images Plus

Hop variety, as well as wort temperature, play a significant factor in whirlpool hopping.

temperature scored higher for floral and herbal descriptors. The 167 °F (75 °C) hop addition scored the lowest in nearly every category except for the sylvan (woody) characteristic.[11] Lowering the temperature of the whirlpool will also lower the isomerization of alpha-acids to iso-alpha-acids, potentially allowing for larger hop additions for flavor vs. bitterness.

Another variable to consider in late-hopping is the hop variety used. Especially looking towards the oxygen fraction of a hop variety as an indicator of its predicted aroma intensity as low oxygen fraction = less intensity, high oxygen fraction = more intensity.[12] So, hops high in compounds like geraniol and linalool (part of the oxygen fraction) as well as high in total oil are likely to have a greater impact on hop flavor intensity. Examples of such varieties are Brewers Gold, Centennial, Bravo, Citra®, Ekuanot™, Olympic, Simcoe®, Mosaic®, and CTZ.

DRY-HOPPING

Optimal dry-hop duration is a common topic debated among brewers, but some research shows extraction of dry-hops is done relatively quickly. For example, Peter Wolf found that when testing for linalool and myrcene, dry-hopping for a week didn't result in additional extraction of the oils when compared to just a couple of days of dry-hopping.[13] Of course there are way more hop compounds than just linalool and myrcene, but these are often used as markers to determine hoppinesses in lab tests. You can even speed up the extraction of dry hops to just hours if the hops are agitated or recirculated as one test found full extraction of linalool in just four hours when agitated. Even when dry hopping cold, you can get quick extraction. Willi Mitter and Sandro Cocuzza found that unagitated, dry-hopping at 39.4 °F (4 °C) resulted in slightly faster extraction of linalool compared to dry-hopping at 68 °F (20 °C). Day 2 linalool concentrations in both trials were approximately 80% of day 14 concentrations.[14]

Dry-hop amounts can also play into overall hop flavor. For example, Scott Lafontaine and Thomas Shellhammer found that dry-hopping with Cascade hops beers scored the highest for citrus marks when

Studies have found extracting the positive attributes from hops during dry-hopping happens relatively quickly and dry-hopping in multiple stages may improve overall extraction.

dosed at 4 g/L, but at higher hopping rates, the citrus aroma scores were suppressed compared to the herbal and tea descriptors. The conclusion (for Cascade hops, anyway) is that dry-hopping at a rate of 4–6 g/L (approximately 4.5 oz./130 g in a 5-gallon/19-L batch) may be the best way to maintain the citrus quality of the hop and over dry-hopping may alter the perception of a hop variety.[15]

Dry-hopping in multiple stages and with fewer hops may also help to get more overall extraction from dry hops, as one paper by Ray Marriot shows that linalool extraction dropped 20% when dry-hopping in larger amounts compared to smaller.[16] For homebrewers, this would mean a drop of about 20% extraction when dry-hopping around 5 gallons (19 L) of beer at a rate of 400 grams vs. 50 grams (14 vs. 1.8 oz.) at once. Try experimenting with low dry-hop dosages (45–90 grams/1.6–3.2 oz. at a time for homebrewers), and dosing two to three different times throughout the fermentation to increase extraction rates.

Batch size can also impact dry-hopping extraction. One study (from Schnaitter et al.) determined a 5-gallon (19-L) vessel had substantially higher concentrations of hop compounds extracted from dry-hopping than the two larger industrial-scale batches with the same dry-hop rates. Sensory testing revealed that the reduced batch size resulted in higher intensities in smell and taste as well, but the hop characteristics were defined as less fruity than the larger batches and more of a raw hop and herbal character in the smaller batch.[17]

BIOTRANSFORMATION

Hops contain volatile flavors detectable in their original state, but also contain many non-volatile glycosides that can also contribute to the aroma, but first must be released through enzymatic hydrolysis (β-glucosidase).[18] One way to encourage β-glucosidase activity to unlock flavors from hops is by purchasing commercially-available enzymes with proven glycosidase activity or pitching yeast that has been tested to produce β-glucosidase during fermentation (more on this later). A study from Takoi et al. that investigated glycosidically-bound flavor potential in beers made with 42 hop varieties found when using a commercial glucosidase enzyme to release the monoterpene alcohols that Amarillo® showed the most glycosidically-bound geraniol potential.[19] The results suggest to me that if a commercial enzyme is used, or a known β-glucosidase-producing yeast, then Amarillo® would be one of the best hop choices to try and boost flavoring potential. Combining Amarillo® with β-glucosidase could potentially shift the aroma and flavor of Amarillo® more toward lime/citrus and away from floral. Of the geraniol-dominant (rose-like) hops tested, Bravo, Chinook, and Mosaic® showed the most glycosidically-bound geraniol potential, which also makes them excellent choices when a known amount of β-glucosidase is present during fermentation.[19]

Multiple studies have examined the β-glucosidase activity of hundreds of different yeast strains and the highest activity has continually found to reside in non-*Saccharomyces* yeast strains. Studies have also shown a handful of wine yeast strains that will produce the enzyme during fermentation (like QA23, 58W3, 71B-122).[20]

One method of biotransformation that has been detectable in some ale strains like Lallemand dried West Coast ale yeast is the transformation of fruity terpenoid alcohols during primary fermentation.[21] Specifically, geraniol was found to convert into citronellol (lemon-lime) and linalool was converted into terpineol (lilac) during ale fermentations. One study by Andrew King and J. Richard Dickinson found that most of these terpene alcohols were converted within the first few days and after that, the decreases occurred at much lower and steadier rates,[22] suggesting these compounds must be in the wort at the start of fermentation. Regarding dry hopping and biotransformation, late stage fermentation dry hopping did not reflect this same monoterpene alcohol biotransformation, according to a study by researchers at Sapporo Breweries.[23] In that study, the later the hops were added during dry hopping, the less chance of biotransformation of geraniol to β-citronellol. Some hops varieties have been tested to have more free geraniol than geraniol precursors (bound), which means the free geraniol is more readily available for biotransformation early during fermentation. Examples of hops high in free geraniol are Motueka™, Bravo, Cascade, Chinook, Citra®, Mosaic®, and Sorachi Ace. Conversely, hops like Comet, Hallertau Blanc, Polaris, Amarillo®, Summit, and Vic Secret™ were found to have more bound geraniol and would result in less biotransformation to β-citronellol during primary fermentation.

> **Dry-hopping in multiple stages and with fewer hops may also help to get more overall extraction from dry hops . . .**

HOP THIOLS

Hop thiols are sulfur compounds found in hops at very low concentrations but have low taste thresholds, which means these thiols (mainly 4MMP (boxtree), 3MH (grapefruit), and 3MHA (passionfruit), which is converted from 3MH), can have a flavor impact in hoppy beer even in low

NEW ENGLAND IPA RECIPE

NEW ENGLAND IPA

(5 gallons/19 L, all-grain)
OG = 1.070 FG = 1.018
IBU = 74 SRM = 4 ABV = 6.9%

INGREDIENTS

10 lbs. (4.5 kg) Great Western Full Pint malt
2.5 lbs. (1.13 kg) malted oats
2.5 lbs. (1.13 kg) Best Malz Chit malt
1.7 lbs. (0.77 kg) white wheat malt
1 oz. (28 g) Columbus hops (mash hop)
8.2 AAU Columbus hops (60 min.) (0.53 oz./15 g at 15.5% alpha acids)
27.6 AAU Amarillo® hops (1st hop stand addition) (3 oz./84 g at 9.2% alpha acids)
31 AAU Bravo hops (2nd hop stand addition) (2 oz./56 g at 15.5% alpha acids)
2 oz. (56 g) Citra® hops (1st dry hop)
2 oz. (56 g) Galaxy® hops (2nd dry hop)
1 oz. (28 g) Citra® hops (2nd dry hop)
1 tsp. Irish moss (15 min.)
0.25 g Rapidase Revelation (fermenter)
SafAle S-04 or Wyeast 1318 (London Ale III) or RVA 132 (Manchester Ale) yeast
0.5 g VIN 7 wine yeast
¾ cup corn sugar (if priming)

STEP BY STEP

Starting with reverse osmosis (RO) water, add calcium chloride and calcium sulfate to achieve 150 ppm choride and 100 ppm sulfate. Mash in the grains and mash hops to achieve a stable mash temperature at 158 °F (70 °C). Hold at this temperature for 60 minutes, then begin mash-out process. Sparge with enough water to collect 7 gallons (26.5 L) in the kettle. Bring wort to a boil for 60 minutes, adding the second hop addition as the wort comes to a boil and Irish moss with 15 minutes left in the boil.

After the boil is over, chill the wort down to 200 °F (93 °C) and stir in the first hop stand addition. After 10 minutes, check wort temperature. Add the second hop stand addition when wort temperature is 185 °F (85 °C); some additional chilling may be required if wort is still warmer than this. After another 10 minutes begin chilling the wort all the way down to yeast pitch temperature. Aerate the wort and transfer into a sanitized fermenter.

Ferment at 66–68 °F (19–20 °C). On day 1, add the Rapidase Revelation enzymes. On day 4, add the first dry-hop addition. After 3 days, rack the beer into a CO_2-purged vessel such as a keg or carboy, then chill beer to 58 °F (14 °C).

After fermentation is complete (7–10 days) soft crash the beer to 58 °F (14 °C) to encourage the yeast and first hop addition to settle out. After a day or two at 58 °F (14 °C), rack to a CO_2-purged keg with the second dry-hop addition, purging the hops and the keg at the same time. Alternatively, you can add the second dry-hop addition to the primary fermenter, but purge the headspace with 10 PSI of CO_2 while adding the hops to prevent oxygen exposure. Wait 2–3 days and package the beer as normal or serve out of the keg with the hops if they are placed in a fine mesh bag or a dry hop canister to prevent the keg from clogging while dispensing.

NEW ENGLAND IPA

(5 gallons/19 L, partial mash)
OG = 1.070 FG = 1.018
IBU = 74 SRM = 5 ABV = 6.9%

INGREDIENTS

3.3 lbs. (1.5 kg) wheat liquid malt extract
3.5 lbs. (1.6 kg) extra light dried malt extract
2.5 lbs. (1.13 kg) malted oats
2.5 lbs. (1.13 kg) Best Malz Chit malt
1 oz. (28 g) Columbus hops (mash hop)
8.2 AAU Columbus hops (60 min.) (0.53 oz./15 g at 15.5% alpha acids)
27.6 AAU Amarillo® hops (1st hop stand addition) (3 oz./84 g at 9.2% alpha acids)
31 AAU Bravo hops (2nd hop stand addition) (2 oz./56 g at 15.5% alpha acids)
2 oz. (56 g) Citra® hops (1st dry hop)
2 oz. (56 g) Galaxy® hops (2nd dry hop)
1 oz. (28 g) Citra® hops (2nd dry hop)
1 tsp. Irish moss (15 min.)
0.25 g Rapidase Revelation (fermenter)
SafAle S-04 or Wyeast 1318 (London Ale III) or RVA 132 (Manchester Ale) yeast
0.5 g VIN 7 wine yeast
¾ cup corn sugar (if priming)

STEP BY STEP

Starting with 7 gallons (25.6 L) RO water, add calcium chloride and calcium sulfate to achieve 150 ppm choride and 100 ppm sulfate. Heat 2 gallons (7.6 L) of the water to 168 °F (76 °C). Place crushed grains and mash hops in a large grain bag and submerge in the water to achieve a stable mash temperature at 158 °F (70 °C). Hold at this temperature for 60 minutes, then remove the grains and wash with 1.5 gallons (5.7 L) water. Top off to 7 gallons (26.5 L) in the kettle. Bring wort to a boil, then remove from heat and stir in all the malt extract. Once extract is fully dissolved, bring back to a boil and boil for 60 minutes total. Add the second hop addition as the wort comes to a boil and Irish moss with 15 minutes left in the boil.

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

Photo by Michael Tonsmeire

Simcoe® hops (pictured up close and cut in half here), as well as Citra®, Apollo, and Eureka, have a high percent of both free and bound thiols, making them good candidates for both late-hop and dry-hop additions.

amounts. Like with monoterpene alcohols, which can be in a free or bound state, thiols in hops are also in either free or bound states, meaning the bound thiols need to be unlocked by an enzyme (called β-lyase) to impact the flavor of the beer. Hops high in bound thiol precursors should be added during the late-hopping phase to help cleave these precursors during fermentation. On the other hand, hops that are rich in free thiols can be added as the dry-hop, where enzyme activity from yeast isn't required to release the aromatic thiols.

Citra® was determined to be one of the most versatile hops, meaning it works great both as a late-hop and a dry-hop because it contains similar amounts of both free and bound thiols. Three other varieties have a good percentage of both free and bound concentrations of 4MMP are Apollo, Eureka, and Simcoe®. Cascade, Hallertau, Hallertau Perle, Saaz, Citra®, and Calypso are great choices for late hot-side hopping (to push 3MH levels) and potentially 3MHA levels (during fermentation).[24] You can purchase commercial products that may contain the β-lyase enzyme and release bound thiols like Rapidase Revlation Aroma (I would start experimenting with a dosage rate of 0.25–0.5 grams per 5 gallons/19 L of beer).

You can also incorporate yeast strains that have been tested to contain the enzyme to release bound thiols, but again, most of the research has been focused on wine yeast. One study showed that the wine strains VIN 13 and VIN 7 released the most 3MH, VIN7 also released the most 4MMP and 3MH, suggesting it may be able to do the same with hops (tested here with grapes).[25] In my experience with wine strains in hoppy beers, a little can go a long way. I'd suggest starting with a blend of ale and wine yeast, going as low as 2–5% of the blend in wine yeast to start, in order to prevent a strong phenolic fermentation profile.

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Braggot

The Harmonious Synthesis of Malt and Honey

by Rob Friesel

Braggots are often described as a happy marriage of beer and mead — the harmonious synthesis of malt and honey. But they are more than simply beers with some honey, or meads with a little malt. Instead, they are something unique where those flavors are fully integrated with one another.

Braggots have ancient origins, as well as a diverse array of modern takes. In this article, we'll take a look at the history of braggots, what goes into them, and how to make one.

Photo by Charles A. Parker/Images Plus

Color, aroma, and flavor of honey varies widely among varietal honeys, which should be selected with the base recipe in mind.

A BRIEF HISTORY OF BRAGGOTS

Depending on how broad your definition of braggot, the earliest mention may be the *Hymn to Ninkasi*, the 3,800-year-old Sumerian song praising the goddess of beer.[1] The *Hymn* describes a beverage made with malted grain, honey (though possibly date syrup), and wine.

Fast forward to 700 BCE, when Midas, King of Phrygia (in modern Turkey), was entombed with drinking vessels that contained evidence of a similar elixir.[2] The evidence? Tartaric acid (a chemical fingerprint for wine and grape juice), calcium oxalate (indicating a barley beer), and the "long-chained, saturated carbon compounds of beeswax" (pointing to honey, and thus to mead).

The inclusion of grapes in these ancient examples raises questions about whether they were truly braggots as we know them today. Nevertheless, the most salient point remains: Brewers have been blending wort and honey to make an intoxicating beverage for thousands of years.

Braggots emerge as a distinct entity in post-Renaissance Europe, appearing in writings that date to the 14th century. They show up under numerous names including *brach*, *bracket*, *bragaut*, *bragawd*, *bragget*, and *bragot*, among others. The formulae for these braggots vary nearly as much as their names, differing from region to region and era to era. A particularly interesting observation is how 16th and 17th century brewers would use honey to fortify beers made from the second runnings, raising gravities above what would otherwise result in small or table beers.[3]

Braggots, like mead, ale, gruit, and other beverages of this era, were almost certainly not hopped. Instead they would have been bittered and flavored, much like a gruit, with spices and herbs.[4] These braggots would have had complex flavors, but would also have finished quite sweet.

As a style, braggot is said to have held on until the mid-19th century in the Lancashire region of northwest England. They largely went extinct after that until homebrewers began reviving the style in the late 20th century.[4]

Finding ourselves in the 21st century, it's worth considering what modern braggots look like. The Beer Judge Certification Program (BJCP) style guidelines give us this description: "A harmonious blend of mead and beer, with the distinctive characteristics of both. A wide range of results are possible, depending on the base style of beer, variety of honey and overall sweetness and strength." This allows for the full range of colors (from palest straw to darkest black), honey varietals, malts, hops, bitterness levels, spices, and car-

bonation levels. Regardless of this practically wide-open field, we can borrow from the BJCP's description of imperial stout for our guiding principle: "the components need to meld together to create a complex, harmonious [braggot], not a hot mess."

BRAGGOT INGREDIENTS

A braggot's essential ingredients are honey, malt, and yeast. Any hops or spices are at the discretion of the brewer and depend on their vision of the finished product.

Brewers new to braggots commonly ask what proportions of honey and malt to use. I've seen braggot recipes where the original gravity contribution from honey ranges from as little as 15% to as high as 70%. Judging from these diverse recipes, there isn't a consensus on a "floor" for either ingredient. The BJCP style guide doesn't specify explicit numbers either, but it does say that "products with a relatively low proportion of honey should be entered as an Alternative Sugar Beer." Given that braggot appears in the "Mead" section of the style guide, we can conclude that the honey contributions should be significant in terms of gravity, as well as the overall impression. To that end, 15% seems too low; in the absence of other guidance, I would suggest that at least 40% of the original gravity should come from honey.

Another common question is a bit of a chicken-and-egg scenerio: Do you select a base beer style to accommodate the honey varietal, or do you select the honey based on the beer? The short answer is that it doesn't matter, as long as the result is balanced. You can take the visionary approach, crafting the formula and selecting ingredients guided by your imagination of the end product. Alternatively, you can approach it pragmatically, starting with a honey varietal that you happen to have on hand, or a base beer that you already like. Again, what matters most is creating a harmonious synthesis of the mead and beer elements.

Honey

Each honey varietal's color, flavors, and aromas are derived from the nectar of the flowers visited by the bees that made it. According to the National Honey Board, there are over 300 unique honey varietals available in the United States alone, with colors ranging from *water white* (e.g., fireweed) to *dark amber* (e.g., buckwheat), and aromas/flavors covering the full spectrum of complexities and intensities. Given the sheer number of them, we can't go into details about the varietals here. That said, orange blossom and tupelo honey show up often as community favorites. I've developed a fondness for blackberry and raspberry honey; and raw wildflower honey is often available from local apiaries in many regions. I tend to check Ken Schramm's list in *The Compleat Meadmaker* (pp. 94–99) for a sensory profile during my own selection process.

With braggots, honey selection should be made with the malt component in mind. First, find a honey that you like, one that has interesting aromatics and flavors, and use the best honey you can get your hands on. Raw, unfiltered, unpasteurized honey is critical to success. Next, consider what malt flavors would combine well with it, thinking about complementary and contrasting flavors. Lastly, evaluate the components for balance, making sure to use enough honey so that it will stand as a peer to the malt character. A common recommendation is to use one pound (0.45 kg) of honey per gallon (4 L) of wort.

Malt

As with designing a beer, start with a large proportion of base malt, layering in the character malts to achieve the color, flavor, aroma, and mouthfeel that you're after in the finished product. Consider using a light touch when incorporating roasted malts, darker crystal malts, or anything else with an intense character (e.g., melanoidin malts or smoked malts). This is not to say that you cannot build a braggot atop a bold beer, just that you may need to lower the malt proportions to achieve the proper balance.

Malt Extract

Extract brewers have most of the same considerations; the extract-based beer still needs to be in balance with the honey, and the proportions can be modified to achieve that. The main difference is that, with both dry and liquid extracts, the malt choices are already locked into the product and so the main knob you have to turn is the overall quantity.

When making a braggot with malt extracts, try to get as much information as you can about the extract. Some manufacturers can provide a data sheet that will give you the details on the malts used to make it, specifying the types and their proportions. This will help give you an idea of the aroma/flavor profiles you'll get in the finished braggot.

Like with many extract recipes, you can also use steeping grains (e.g., crystal and roasted malts) to help modulate the color and flavor of the wort that will go into the braggot.

Hops

While braggots of yore would have added bitterness and additional flavors through herbs and spices (which we will discuss under the "Spices" heading later in this article), the inclusion of hops is a modern innovation to the style. Although not strictly required, omission of a bittering agent is likely to result in a too-sweet beverage. To that end, when formulating a braggot, you're faced with a decision about whether to apply hops primarily for bitterness, or if they should also contribute to the overall aromas and flavors.

First, consider how the bitterness balances with the acidity, tannins, sweetness, and alcohol of the finished braggot. The bitterness should offset any residual sweetness without also clashing with the acidity. You don't want it to overwhelm the mead character.

If starting the formulation from a base beer, use its hopping rate as your baseline, but you'll likely need to reduce the overall quantity to achieve the balance you're after.

If instead you're layering the beer characteristics onto the mead, consider 20–25 IBUs as a starting place, adjusting up or down depending on characteristics like gravity, residual sweetness, acidity, and the resulting flavor profile.

The specific choice of hops will depend on the braggot's beer elements. As stated earlier, if the base beer provides your braggot's foundation, stick with the hops already in that recipe. Otherwise, consider how much hop character you want to add, and what kind. Generally speaking, stick to "gentler" low-alpha hops such as Fuggle, Tettnang, or Willamette; you'll probably want to avoid the more modern high-oil, high-alpha hops. Again: The key is not to overwhelm the honey character.

Yeast

Braggots make a fine environment for many yeast strains, and there are just as many recipes out there that use wine yeast as beer yeast. When designing your braggot recipe, consider the character you're after in the finished product, and let that guide your yeast selection. Look at the strain's nutrient requirements, its temperature range, and its typical ester and phenol profile. Ask what those elements will contribute to the braggot and how they will enhance (or distract from) the rest of the impression.

If your recipe leans more to the malt, look first to ale yeasts; if it leans more toward honey, look at wine yeasts. That said, there is a lot of room for interpretation, and you shouldn't feel constrained by such a simplistic rubric.

Longtime award-winning home meadmaker Jason Phelps, who opened Ancient Fire Mead and Cider in Manchester, New Hampshire last year, says the base beer style can guide yeast selection. "Is that style typically defined to a good degree by the yeast used? If so, using a yeast made for the style will ensure the yeast character is present," he advises.

While wine yeast is common, it does have its drawbacks and Phelps suggests avoiding them because they typically have an inability to break down the more complex malt sugars, which may lead to a sweeter braggot. That said, a sweeter braggot may be exactly what you want, and if it is, a wine yeast may be beneficial. Blending ale and wine yeast strains, or using them in stages, is also a consideration that Phelps suggests, but there are yeast interaction concerns (killer factor) to be aware of.

There really are a lot of good options — I took first place in a competition with a braggot fermented with a saison yeast (find the recipe on page 78).

Spices

As we touched on earlier, braggot recipes with historical inspirations often eschew hops for bittering, instead relying on a gruit-like spice combination. Such herbs and spices would have included meadowsweet, heather, cloves, ginger, pepper, galingale, mace, and nutmeg.[4] The inclusion of such ingredients in those historical recipes was largely influenced by

Photo courtesy of Shutterstock.com

what was available to those ancient brewers; our modern pantries typically have many more options, most of which make suitable contributions. Once again though, consider the overall impression of your finished product and use moderation. You want those spices to complement the other flavors of the braggot and avoid creating clashes.

ADDING THE HONEY

One of the most important decisions when making a braggot is when to add the honey. It's possible to add it during the boil, but this is not recommended; the boiling action will drive off many of the aromatic compounds. If you feel the need to pasteurize the honey, then consider adding it immediately after turning off the heat or during the chilling. Depending on the chilling method, the honey should be above 150 °F (65.5 °C) long enough to pasteurize it. There is also another benefit to hot-side honey additions. Honey contains enzymes, so any dextrins from a high temperature mash will likely be chewed up from the honey enzymes when added late in the hot process. Furthermore, the heat should aid with combining the honey into the wort. However, as with the boil, the primary risk of adding the honey at this stage is losing aromatics to volatilization.

The most common method for integrating the honey is adding it in the fermenter. Waiting until the wort is cool eliminates the risk of losing the honey's aromatics, though mixing may be more difficult. If going this route, consider softening the honey (especially raw honey) in a hot water bath prior to this step to aid in mixing.

It's helpful to calculate the honey's volume ahead of time. Plan your kettle volume such that you leave sufficient space in the fermenter for what the honey will displace — you don't want an overflowing carboy like I had my first time! On average, 12 pounds (5.4 kg) has a volume of approximately one gallon (4 L). You can calculate your target wort volume with this equation:

$$BV - (H / 12) = WV$$

Where *BV* is the target batch volume in gallons, *H* is the quantity of honey in pounds, and *WV* is the wort volume (in gallons) you should transfer from the kettle to the fermenter.

Another common method for adding the honey is to "feed the yeast" during active fermentation. In this case, you prepare the wort and pitch yeast as usual, then after some period of active fermentation you add the honey directly to the fermenter. This effectively treats the base beer like a large yeast starter. This method can be particularly useful for high-gravity braggots, especially if you do not have the equipment to prepare a yeast starter or to oxygenate the wort.

When and how to add the honey is largely up to the brewer, but here are a few points to consider. Given that most of honey's sugars are simpler than the wort's, you may want to wait until fermentation slows down (a sign that the majority of the complex sugars have been consumed) before adding the honey to avoid stalled yeast. This should be anywhere from 5–7 days after pitching. Another useful aspect of waiting until this point is that it ensures a large and viable yeast colony.

The simplest method of combining the honey during fermentation is to open the fermenter and pour it in. If you decide not to stir, this will help minimize oxygen ingress and potential oxidation, but also means the honey will collect at the bottom with the sediment, potentially preventing the yeast from accessing all of the sugars. Stirring with a sanitized long-handled spoon or wine whip will encourage complete mixing, but may draw in more oxygen and increase the risk of oxidation prior to packaging.

A variation on this method involves adding the honey in stages. For example, add the first pound (0.45 kg) of honey 24–48 hours after pitching the yeast; then add the second pound (0.45 kg) 24–48 hours later, repeating until all of the honey has been added. The primary advantage of this method is that it increases the gravity gradually, minimizing the risk of yeast shock; however, you're also opening the fermenter more frequently, increasing the risks of contamination and oxidation from oxygen ingress.

PACKAGING

After reaching terminal gravity, it's time to rack the braggot off the sediment. If the formulation calls for bulk aging, do so at this time. Afterward, it's time to prepare this braggot for serving!

Putting aside the kegging vs. bottling question, there are a couple of decisions that we need to make at this point. First, do we want to backsweeten the braggot? Second, do we want to carbonate it, and if so, to what level and using what method and/or priming sugar? As with most other elements of a braggot, consider how these decisions will interact with one another, and how they will impact the overall impression of the final packaged product.

Backsweetening

If the braggot seems too dry or lacks honey character, consider backsweetening. Take a small sample of the braggot (using a syringe with milliliter markings) and mix in fixed amounts of honey to work out the proportions. When the flavor profile tastes right, scale up the amount needed and mix that into the finished braggot prior to packaging.

Note that if you are backsweetening, you will also need to stabilize the braggot with something like potassium sorbate or potassium metabisulfite to prevent the remaining yeast from fermenting this honey. Furthermore, stabilizing in this fashion will require you to force carbonate later if you want a sparkling braggot.

As an aside, it only makes sense to backsweeten a braggot if you must enhance the mead character. Given that many beer styles minimize residual sweetness, adding honey at this stage is likely to diminish the beer impressions in the finished product. If backsweetening seems necessary, do so judiciously.

Carbonation Level

Unlike most beer styles, braggots do not have a recommended carbonation level; how carbonated you'd like your braggot is up to the brewer.

Historically-inspired braggots will have little to no carbonation. While an uncarbonated braggot may be historically appropriate, they will likely be more successful at cask carbonation levels. In these cases, target somewhere between 1 and 1.5 volumes of CO_2.

More modern examples benefit from moderate or higher levels of carbonation, in part because flat beer is seldom appetizing. A carbonation level between 2 and 2.5 volumes of CO_2 will likely work well.

Carbonation Method

Having decided on a carbonation level, basically any carbonation method is acceptable.

First, if you backsweetened and stabilized the braggot, you must force carbonate if you want a carbonated product. To that end, you need to keg it, hook it up to CO_2, and either serve it on draft or use a bottle filler.

If you want to bottle condition, then you have the usual choices of priming sugars. As with beer, you can carbonate with corn or table sugar, as these are reliable priming agents that impart no significant flavor. Another popular priming agent is honey. Note that honey may help to boost the honey impression in the finished product, though not by much. Also, expect the honey to take 1–2 weeks longer than simpler sugars to finish bottle conditioning. In either case, you can use one of the many priming calculators available online or in your brewing software.

SUMMARY

Like many mead styles, braggots allow plenty of room for interpretation. Bringing together honey and malt and then matching them as complements presents some interesting challenges for brewers but, when well-executed, results in a delightfully complex beverage. From the still and gruit-spiced "ancient" braggots to sparkling and hop-bittered modern interpretations, balancing the elements is key. But with expressive honey and a steady brewing hand, you'll be savoring yours.

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BRAGGOT RECIPE

DIPLOMATIC MISSION BRAGGOT

(5 gallons/19 L, all-grain)
OG = 1.061 FG = 1.003
IBU = 23 SRM = 12 ABV = 7.6%

INGREDIENTS

3.5 lbs. (1.6 kg) rye malt
2 lbs. (0.91 kg) 2-row pale malt
8 oz. (227 g) caramel malt (120 °L)
5 lbs. (2.3 kg) raw blackberry honey
3.5 AAU Columbus hops (60 min.) (0.25 oz./7 g at 14% alpha acids)
3.5 AAU Columbus hops (30 min.) (0.25 oz./7 g at 14% alpha acids)
2.5 tsp. yeast nutrient (15 min.)
Wyeast 3711 (French Saison) or Imperial Yeast B64 (Napoleon) or White Labs WLP590 (French Saison Ale) or Lallemand Belle Saison
4.1 oz. (116 g) honey (if priming)

STEP BY STEP

Mash the grains at 152 °F (67 °C) for 60 minutes. Once conversion is complete, recirculate for 15 minutes. Batch sparge with 168 °F (76 °C) water, collecting 6 gallons (23 L) of wort.

Boil the wort for 60 minutes, adding hops at the times indicated in the recipe. Add the yeast nutrient to the boil with 15 minutes remaining. A kettle fining can be added near the end of the boil, but this is optional.

While the wort is boiling, prepare a hot water bath and put the container of honey into it. This should help to soften the honey and make it easier to mix with the wort later.

Chill the wort to 64 °F (18 °C) and then mix in all of the honey. Aerate the wort with oxygen, pitch the yeast, and ferment until complete. Allow temperature to free-rise into the mid-70s °F (low-20s °C). When fermentation is complete, rack and package the braggot, or rack and clarify the braggot if desired with finings before packaging (prime and bottle condition, or keg and force carbonate).

DIPLOMATIC MISSION BRAGGOT

(5 gallons/19 L, extract with grains)
OG = 1.062 FG = 1.004
IBU = 23 SRM = 12 ABV = 7.6%

INGREDIENTS

8 oz. (227 g) caramel malt (120 °L)
3.3 lbs. (1.5 kg) Briess rye liquid malt extract
5 lbs. (2.3 kg) raw blackberry honey
3.5 AAU Columbus hops (60 min.) (0.25 oz./7 g at 14% alpha acids)
3.5 AAU Columbus hops (30 min.) (0.25 oz./7 g at 14% alpha acids)
2.5 tsp. yeast nutrient (15 min.)
Wyeast 3711 (French Saison) or Imperial Yeast B64 (Napoleon) or White Labs WLP590 (French Saison Ale) or Lallemand Belle Saison
4.1 oz. (116 g) honey (if priming)

STEP BY STEP

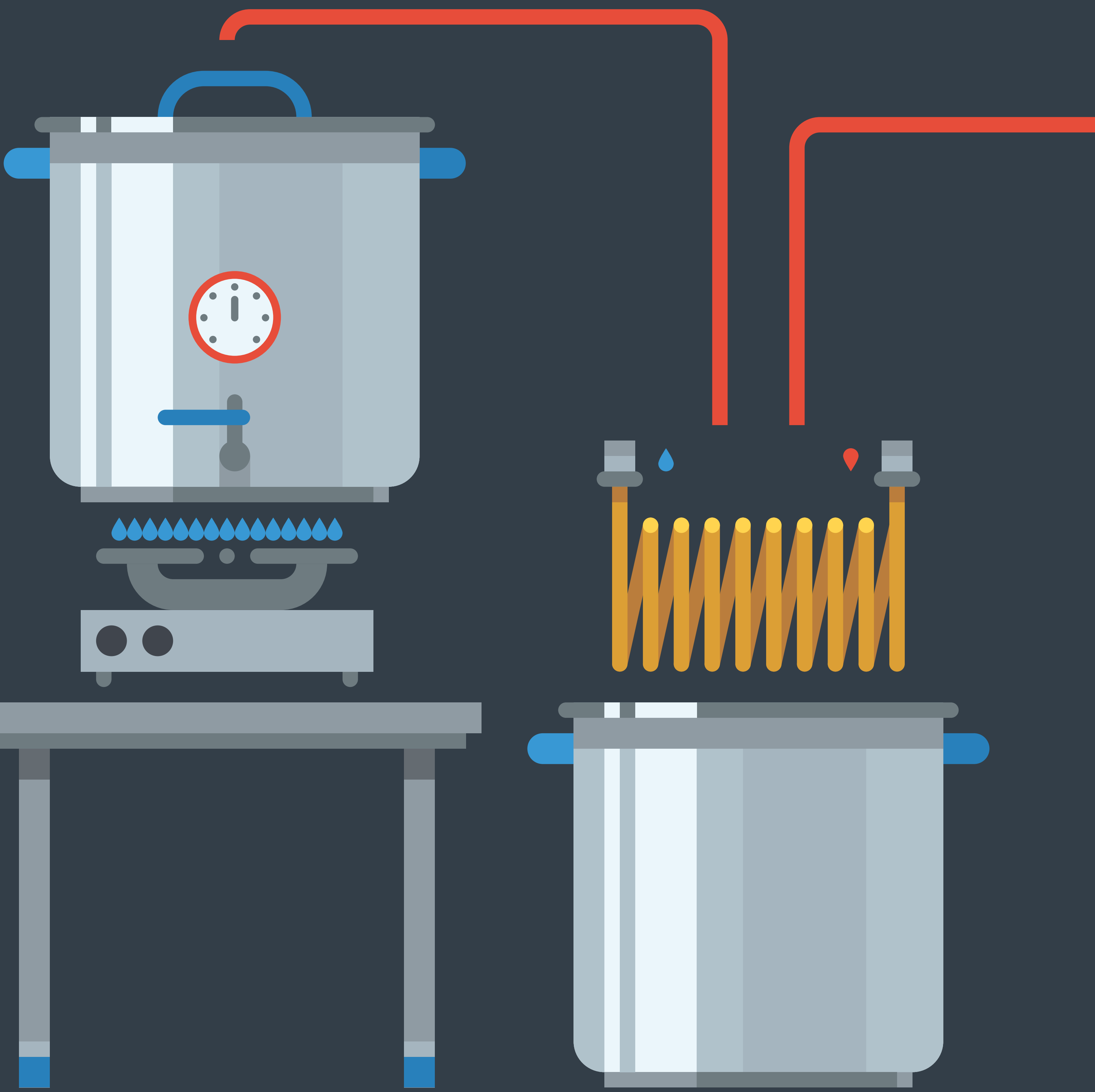
Put the crushed caramel malt into a nylon mesh bag, and put the bag into the kettle with 3.1 gallons (11.7 L) of water. Remove the bag after the water reaches 170 °F (77 °C), allowing at least 30 minutes of steeping. Continue to heat the water until it reaches a boil. Turn off the heat and stir in the liquid malt extract. When completely dissolved, turn the heat back on and return the wort to a boil.

Boil the wort for 60 minutes, adding hops at the times indicated in the recipe. Add the yeast nutrient to the boil with 15 minutes remaining. A kettle fining can be added near the end of the boil, but this is optional.

While the wort is boiling, prepare a hot water bath and put the container of honey into it. This should help to soften the honey and make it easier to mix with the wort later.

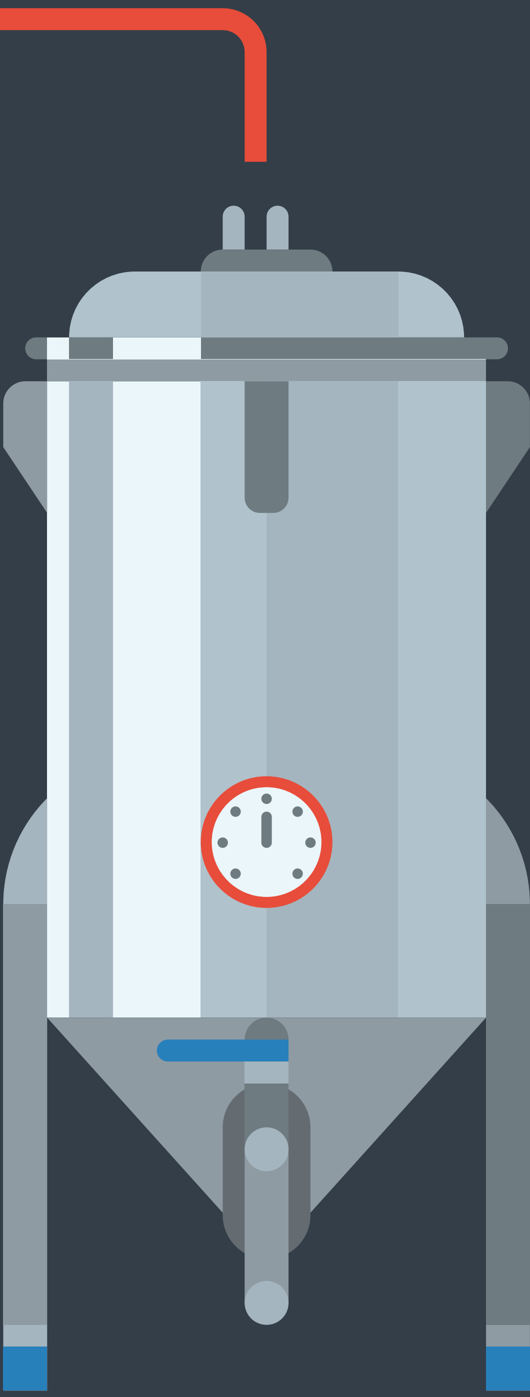
Chill the wort to 64 °F (18 °C) and then mix in the honey. Aerate the wort with oxygen, pitch the yeast, and ferment until complete. Allow temperature to free-rise into the mid-70s °F (low-20s °C). When fermentation is complete, rack and package the braggot, or rack and clarify the braggot if desired with finings before packaging (prime and bottle condition, or keg and force carbonate). BYO

Photo courtesy of Shutterstock.com



CALIBRATE YOUR HOMEBREW SYSTEM

Gain efficiencies by understanding your system



Being able to produce a consistent beer and hit all of your targets should be the ultimate goal for any brewer. It demonstrates precision and skill as a brewer. The only way to accomplish this goal is to know your brewing system and all of its variables. Over the years I have brewed on many systems — both amateur and professional — and gotten to understand how to easily calibrate any brewing system. Once everything is calibrated and you can predict exactly how it will perform, you can utilize this information during recipe formulation to create a more precise recipe that you can be reasonably sure will hit your targets.

by Jason Simmons

Homebrewers these days have systems all across the board ranging from a pot and 6-gallon (23-L) bucket (or less) to all stainless steel, professional-style systems. For homebrewing, I run a simple setup with basic equipment to brew 6-gallon (23-L) post-boil batches. I will be using a few examples of my homebrew system to help elaborate a few key points. While I enjoy brewing with fancy state-of-the-art equipment, I also love brewing with minimum equipment and relying more on the knowledge of procedures. It is not your equipment that makes the beer, rather the knowledge on how to use it properly and efficiently.

The advice that is given in this article can be used on any equipment and for brewing any size batch. What we are doing is finding factors and then applying those numbers to make the system, as a whole, run efficiently so that we can repeat the results. It may take a batch or two to fully calibrate your system, and definitely will require some back and forth adjustments on paper to dial everything in, but it is worth the time and effort to take the steps, document the findings, review the data, and finally adjust your recipes. Before any daily brewing activity, be sure that your brewing tools for taking measurements are in good working order and are calibrated.

COLD LIQUOR TANK (CLT)

It is a great practice to record all of your water usages in each stage of brewing beer. You will find out how much brewing liquor (water used as an ingredient in the production of beer) you will need and to store it for later use or transport. Some homebrewers just opt to use the water from their sink, however, you still need to measure how much water you need for mashing and for sparging to reach your final pre-boil volume. This will tell you how much total brewing liquor you will need. The amount of water needed to brew a batch of beer will vary depending on the recipe and the target end volume. Knowing your dough-in grist-to-water ratio or dough-in volume, water absorption by the grains, and sparge water volume to reach your target pre-boil will give you an overall estimate on the total water needed to produce a batch. This is helpful for when doing water treatments in your batches, or quickly trying to heat up the minimum amount of water needed for a task, which will cut down on heating time as well as fuel costs. While having enough water is usually the first concern of a brew day, it is often the last thing that I tackle when writing a recipe. I like to work through my recipe so that I can see what the other specifications are that will help guide me to a final volume number. These specifications will be discussed throughout this article. For my homebrew system, I have three 5-gallon (19-L) containers to hold up to 15 gallons (57 L) of brewing liquor to produce my 6-gallon (23-L) post-boil/9-gallon (32-L) pre-boil batches using a vigorous 90-minute boil. If 10 lbs. (4.5 kg) of grain is used I can expect to use 11 gallons of water using this formula:

10 lbs. X 0.2 grain water retention =
2 gallons water loss.

3.325 gallons (at 1.33 quarts per lb.)
dough-in volume – 2 = 1.325 gallons
first running.

9 gallons pre boil – 1.325 gallons =
7.675 gallons sparge water needed.

7.675 + 3.325 = 11 total gallons of
brewing liquor needed.

MASH TUN

1. Volume

Knowing the maximum weight of grain that can fit safely into your mash tun will allow you to calculate and know your maximum possibilities, especially when using 100% base malt to achieve maximum extract. Most of the time you won't fill the mash tun to the top, but depending on recipe or equipment size this factor is good to know. You can determine the volume needed in a mash tun using one of the following equations (the metric vs. imperial equations are slightly different and I credit that to how many decimal places you include in your math. I personally prefer including up to at least the thousandth decimal place.)

A: Mash-in volume (L) = kg malt X
(L:kg grist ratio + 0.7)

B: Mash-in volume (gallons) =
(gallon:grist ratio X lbs. of grain) +
(lbs. of grain X 0.084)

So, if using 10 lbs. (4.536 kg) grain at a water-to-grist ratio of 1.33 qt./lb. (0.3325 gallon per lb. or 2.762 L per kg) then you get 3.325 gal. or 12.528 L dough-in water volume.

A: 15.703 L mash-in volume space
(4.146 gal.) = 4.536 kg X (2.762 L + 0.7)

B: 4.165 gal. mash-in volume space
(15.772 L) = (0.3325 gal. X 10 lbs.) +
(10 lbs. X 0.084)

You can also reverse the equation to find out the maximum pounds of grain that can fit into a mash tun.

C: Mash-in volume (L) /
[(L per kg of grain) + 0.7] =
Total kg of grain needed

D: Mash-in volume (gal.) /
[(gal. per lb. of grain) + 0.084] =
Total lbs. of grain needed

When using a 15.5-gallon (58.69 L) keggle mash tun, we should target 15.0 gallons (56.8 L) as our maximum mash-in volume to give room for stirring and sparge water bed. Using the same water-to-grist ratio of 5.32 gal./lb. (2.762 L per kg) we can determine the maximum weight of grain that can fit into a mash tun.

C: 56.804 L mash-in volume /
(2.762 L:kg + 0.7] =
6.407 kg of grain (36.172 lbs.)

D: 15.0 gal. of mash-in volume /
(0.3325 gal.:lb. + 0.084) =
36.01 lbs. of grain (16.336 kg)

2. Water Usage

A. Total usage

I always measure and record how much water I dough-in with, how

Photo by Charles A. Parker/Images Plus

When measuring dough-in and sparge water, pre-boil wort volume, and wasted water, you can figure out the total amount of brewing liquor for a batch.

much sparge water I use, pre-boil wort volume, and after lautering the volume that drains out of the mash tun or wasted wort. With these numbers, you can figure out the total amount of brewing liquor (not to include brewery function water for cleaning and such) of the batch. Now you can adjust your CLT containers to match your water volume needs. For my system to produce 6 gallons (23 L) of 1.050 SG post-boil wort I can expect to use roughly 11 gallons (41.6 L) of water. This comes out to be about 1.83 gallons (6.93 L) of water needed to produce one gallon (3.8 L) of wort. Of course, the grist bill weight and the boil-off volume will need to be taken into consideration.

B. Water-to-grist dough-in ratio

Some brewers prefer a thicker mash while others prefer a thinner mash, however, the volume is usually within a particular range. Most homebrew texts suggest an average of 1.33 quarts of water per pound of grain to dough-in. I personally prefer a thicker mash and find that I average around 1.125 qts./lb. We record the hot liquor tank (HLT) before and after volumes of dough-in and sparge volumes to measure those usages. By subtracting the pre-boil volume and the wasted wort volumes from the total water used you will find the water-to-grist dough-in ratio.

Another factor to consider is how much water is retained by the grain, which is roughly 0.2 gallons per pound (1.7 L per kg). Once you know your water volumes for each section you can properly predict your water usage for each recipe or set a standard number to use.

C. Mash, sparge, or kettle salt additions

Depending on the chemistry of the water being used, a brewer might choose to use brewing salts such as calcium chloride, calcium sulfate (gypsum), calcium carbonate (chalk), or pickling lime, to name a few, to help regulate their mash pH of 5.2–5.4. When dealing with brewing salts we adjust for parts per million, or ppm, which is expressed in mg/L. By knowing the dough-in and sparge volumes you can properly adjust any salt additions to reach your target ppm within the mash as well as any kettle additions. To do this you will need a scale that measures in grams to a minimum of the tenth decimal place. Depending on your water source and your target mineral profile your results will vary, but I have found that my average salt weights do not exceed 5 grams of a particular salt. When you turn on the scale be sure to zero the scale by pressing the "tare" button along with the measuring container. This will give you a true net weight.

3. Mash Efficiency

A. Determining the mash efficiency

The main factor for your mash tun is the mash efficiency, which I record for each brew before the boil has started. Points per gallon, or ppg, is the maximum specific gravity given from one pound of malt in one gallon of water. Lists of average malt and grain ppg's can be found on the internet and are usually pretty accurate despite yearly crop fluctuations. In malt analysis available from the supplier, the number is given as a fine and coarse grind extract weight percentage (so 78% extract would mean that 1 lb. of malt yields 0.78 lb. of extract). The extract percentage of sucrose has a ppg of 46. So if Maris Otter has a given extract of 82.5% then 0.825 X 46 = 37.95 ppg. Take each malt and multiply the ppg by the pounds used for each variety of fermentables. Each malt will give you a "gravity unit" or GU, and when added together it gives a "total gravity unit" or TGU. Both of these will be at 100% efficiency. Next, take all the added GUs to make a total gravity, which is at 100% efficiency, then divide by the measured pre-boil volume to get your maximum original specific gravity (OG). Next, divide your pre-boil gravity by the maximum total gravity to get your mash tun efficiency percentage.

In regards to recipe writing, when adding any simple sugar kettle additions such as honey, table sugar, maple syrup, molasses, and Belgian candi sugar; while they provide gravity to the post-boil wort they were not involved with the mashing process so do not include them in your calculations.

Here's an example of the above:

15 lbs. American 2-row malt (36 PPG):
36 X 15 = 540 GU
1 lb. honey malt (34 PPG):
34 X 1 = 34 GU
Total = 574 GU

Say we have a pre-boil GU of 50.0 (1.050 SG), then 50/63.7 = 0.7849, or 78.49% mash efficiency.

B. Post-boil target volume and gravity

Knowing the actual variables and the

mash efficiency you can now apply the numbers to pinpoint a gravity at any given pre- or post-boil volume and then adjust your recipe accordingly to hit your targets.

[TGU at 100% X Mash Efficiency as a decimal] = TGU

TGU / Post-Boil Volume = OG represented as a GU.

Example:
[574 X 0.7849] = 450.53 batch TGU / 6 gallons post-boil volume = 75.08 post-boil (1.075 SG) target OG.

KETTLE

1. Safe Maximum Kettle Volume
Maximum kettle volume for wort production is different from that of the HLT maximum volume, even if using the same kettle. When producing wort you need to account for room to safely have a vigorous boil without causing a boil over. Most commercial kettles allow for about 40% headspace, which falls in line with my 15.5-gallon (58.7-L) keggle setup. Forty percent of a 15.5-gallon (58.7-L) keggle is 6.2 gallons (23.5 L) for head space, leaving 9.3 gallons (35.2 L) of room to safely fill wort.

2. Boil-off Rate
The boil-off rate will depend on a long list of variables, some of which will change with each brew, but it is primarily a function of how much heat is put into the system and how long the wort is boiled. Some of the other major factors include: Elevation, weather, kettle geometry, type of heat source and its output, wort gravity to a small degree, and boil time.

I always boil my wort for 90 minutes as I feel it produces a better quality wort. I use a Bayou Classic Brew Burner with 60,000 average BTU (British Thermal Unit) output. To reach my targeted 6-gallon (23-L) post-boil volume utilizing a vigorous 90-minute boil requires me to start with a 9-gallon (32-L) pre-boil volume giving a 33% reduction in wort. With these kettle numbers, I can apply them to my recipe formulations to hit proper volume and gravity targets.

3. Volume Calibration with No Sight Glass
I have no calibrated sight glass for any of my homebrew equipment. When collecting my dough-in water, sparge water, and pre-boil volume I use homebrew buckets with volume markings to take my measurements. With a post-boil volume and gravity, we can take the actual TGU and divide by the original gravity in GU. This will give you the exact post-boil volume.

Example: (Post-boil gravity of 1.072)
450.53 TGU / 72 GU =
6.257 gallons post-boil (hot).


Photo by Charles A. Parker/Images Plus

Make sure to calculate headspace for the boil when determining your maximum kettle volume.

4. Volume Loss
A. Trub loss
It is wise to measure your trub loss for recipe adjustments to reach your wort-in-fermenter target volume. This can easily be done dumping the trub into a calibrated bucket. On a homebrew scale, this may be a small amount but still worth recording.

B. Thermal shrinkage
When knocking out or heat exchanging the wort from 212–190 °F (100–88 °C) to pitching temperature of 50–68 °F (1–20 °C) you can expect a 4% reduction in volume from thermal shrinkage. For my 6-gallon (23-L) post-boil target, I can expect a loss of 1 quart (1 L) due to shrinkage.

C. Transfer loss
Depending on your equipment and size of your batches, transfer loss from the kettle to the fermenter during the knockout will vary, however, the volume should be very low.

FERMENTER

1. Headspace
I base my recipes on how much volume of wort I can fit into my fermenter, while leaving a respectable amount of headspace room for the kräusen to form and not clog up the airlock or pressure relief valve (PRV). Depending on yeast strain and fermenter geometry, the headspace required could range from 20–50% of the total volume of the fermenter space. Taking notes and kräusen measurements on your fermenter will help guide you to max out the volume in your fermentation vessel.

2. Maximum Volume the Fermentation Vessel Can Hold
For the most part, you already know the maximum liquid, or water, the vessel can hold. A 5- or 6-gallon (19- or 23-L) bucket holds just that, and conical fermenters are sized for batches. This means that, for the most part, a 1-barrel conical fermenter can ferment 1 barrel worth of wort and allow for kräusen headspace. This means the true volume is typically 25–33% larger than the batch size. It is up to you to find out what you can

Photo by Charles A. Parker/Images Plus

One of the largest reasons for fermenter losses is due to the compacted yeast slurry on the bottom of the fermenter. Yeast slurries are about 25% yeast solids, and the remainder is beer loss.

squeeze out of your fermenter, and base your target post-boil kettle volume along with the loss variables to hit your target in fermenter volume.

3. Fermenter Losses

Whether you use a conical fermenter with adjustable racking arm or a simple bucket, you will experience some beer loss when transferring to the pre-packing vessel such as a brite tank or a bottling bucket. During fermentation the yeast cells will multiply, consuming sugars and taking up liquid. Once fermentation is complete in conjunction with cold crashing the temperature, the yeast will flocculate and drop out of suspension. This will create a compacted yeast slurry on the bottom of the fermenter. Yeast slurries are usually 25% yeast solids and the remaining volume is mostly beer that can not be easily separated from the yeast solids. Some other factors to consider include cold break and dry hopping. You can expect to have greater volume losses as your hopping rate increases. Each recipe, yeast strain, pitching rate, dry hop amount, and system dead spots all add up to your total fermentation losses. Use these variables to find your constant average loss so that you are able to better hit your final packaged target volume.

I use a 7-gallon (26.5-L) (gross volume) Nalgene bottle for my fermenter. With a 6-gallon (23-L) hot post-boil volume, 1-quart (1-L) thermal shrinkage loss, and 1–2 quart/L trub loss, I can expect to get 5.25–5.5 gallons (20–21 L) of wort into my fermenter, with 1.5 gallons (6 L) worth of headspace.

Depending on the gravity, the kräusen may slightly overflow but I am ok with that if it does. This is the maximum that I can produce without getting into high gravity and water dilution brewing practices. Because of this, I start the base of my recipes off of 6 gallons (23 L) hot post-boil volume to hit all my other targets. This one factor really is the pivot point for writing a beer recipe.

PACKAGING OPTIONS AND CONTAINER SIZE

There are several packaging options to choose from with the two biggest topics being carbonation methods and the serving vessel. Force carbonating a keg is fairly straightforward, and bottling can be done with a carbonated beer in a keg using a beer gun, or by using a bottling bucket with priming sugar. When kegging, most brewers force carbonate, while others may choose to keg condition using priming sugar. For most homebrewers that keg their beer, a 5-gallon (19-L) Cornelius keg (Corny keg), or 5.16 gallon (19.4-L) Sanke keg will act as the serving vessel or brite beer tank when bottling. It doesn't matter if you force-carbonate the beer or prime with sugar to reach the desired carbon dioxide saturation level; the end target volume will always stay the same. In this case, the keg volume is the constant variable in which you are aiming to reach with as little loss as possible in each stage.

I am fond of using a wide range of sugar types for bottle conditioning. To do this I need a precise scale to measure out sugar weights to achieve the target CO_2 saturation level. Kegs are standard volumes but when using a bottling bucket it is best to have a bucket that is calibrated and marked. The finer the markings are the more accurate the math is to find a sugar weight that will reach your target CO_2 saturation volume.

For me, I try to max out my fermenter so that I can get as much beer transferred over into the bottling bucket. Here I will record the volume as exact as I can get and quickly do the math to figure out how much sugar of that type I need to weigh out to reach my desired CO_2 saturation volumes. Once I am done bottling I will calculate the packaged volume of beer then run an analysis of the entire batch worth of volumes and losses to better calibrate recipes to match my brewing system that now has actual factor numbers that we can work with and adjust.

CONCLUSION

After reviewing the long list of variables, you can begin to dial in your system to hit all targets. Many of these numbers are constant and can be calculated. These include all equipment vessel sizes, thermal shrinkage, ingredient specs, and system losses. Other numbers are more swinging estimates such as boil-off rates, varied post-boil volumes after target time is reached, or actual batch mash efficiencies. I have been able to hit my targets on any sized system, or at least come respectfully close to hitting them, even if it is the first time brewing on that system. What equipment you have to work with will dictate how you write your recipes so you can maximize your packaged beer volume per batch to hit all of your targets. With the knowledge outlined in this article, you should be able to dial in your brewing equipment and accurately predict, write, and produce a repetitive quality product. BYO

BY JOSH WEIKERT

CLEARING IT OUT

Clarity, fining, and recipe decisions

There are any number of debates to be had over the importance and role of clarity in modern craft and homebrewed beer. This isn't going to be a piece about whether the haze-crazed are right or wrong about haze in particular styles of beer. Instead, let's start from the proposition that oftentimes brewers are seeking to create generally clear beer. This "Techniques" column will focus on fining options and methods, and a discussion on different approaches to recipe design that take clarity and its effects into consideration.

THE LOGIC OF FINING

Strictly speaking, you don't *need* to fine your beer. However, there are several reasons to consider fining as a brewing practice that will generally improve the quality of your finished beer. Let's deal with the easy one first: Appearance.

Fining improves clarity, and clarity makes for pretty beer. Aesthetics may or may not matter to you, but they might make a big difference to those to whom you serve your beer. So even if a jewel-toned, crystal-clear beer is in no way more desirable to you than a murky beer, you may consider fining it anyway if you plan to present the beer. Perceptions aren't all about what's actually there. The power of the mind to distort, augment, alter, and revise our actual perceptions based on what we see and expect is a powerful consideration. If you see a good-looking beer, you're going to anticipate good flavors, which can actually result in a change in your perceptions. A good-looking beer can still taste bad, and an ugly beer can still blow your mind, but to do so it's working against your expectations. Why not help them along? Yes, it's just aesthetics — but that sentiment undermines the value and power of aesthetics in the context of organoleptic evaluation.

Another reason to fine your beer is that the kinds of things that generally cause turbidity — yeast, proteins, and polyphenols — also increase the risk of off-flavor development. The presence of both biological and non-biological causes of haze can contribute to a variety of effects, including accelerated staling and production of off-flavors and precursors (think acetaldehyde, autolyzed yeast, dimethyl sulfide, diacetyl, etc). Stability can be a challenge for homebrewers. Fining allows us to take some of the causes of instability down a notch, if not off the table completely. While some methods of promoting stability are beyond most homebrewers' capabilities (pasteurization), others (fining and CO_2 flushing) are not, and should be leveraged as much as possible to keep your beer tasting like the beer you made for as long as possible!

Finally, fining is a way to promote consistency in your beers. Contributors to haze or turbidity may vary significantly with each batch, even within the same recipe. A certain grain may have higher protein content, a batch of hops may contribute more or less polyphenol content, a yeast pitch might be more or less flocculant than another; and when such things happen your output will vary. Fining helps narrow the variability across several dimensions, leaving a more-replicable beer in your fridge. Think of it in the same context as pre-heating your mash tun with boiling water — you don't want warm air in summer or cool air in winter to make you miss your target mash temps, right? The same logic applies here.

Fining allows us to take some of the causes of instability down a notch . . .

Photo by Charles A. Parker/Images Plus

Fining is typically done at two points in the brewing process, in the brew kettle and in the fermenter, prior to packaging. While fining beer is an optional process, it's one that brewers should always keep in mind when approaching a recipe.

BEGIN AS YOU MEAN TO GO ON

I'm fond of the saying, "begin as you mean to go on." The logic goes that good habits should be established at the outset. It's the first day of class in a middle school music classroom. A student enters and immediately hits some keys on the piano despite a "do not touch" sign. The teacher decides to let it slide since, after all, it's "just the first day." That teacher has just established a norm that rules in the classroom are unevenly enforced. Instead, s/he should correct the student, first day or not. Begin as you mean to go on.

In that same vein, fining (or at least the process of producing clear/clearer beer) starts during beer conceptualization, and continues through packaging. If clear beer is your goal, you should take every chance you can get to gain ground on your beer's clarity.

First, shop around for grain with a lower overall protein content. This will require that you learn to read a malt analysis (a quick primer on total protein, soluble proteins, and FAN levels will have you "malt analysis literate" in no time!). Not every malt purchased by homebrewers necessarily comes with access to a malt analysis, but it certainly isn't uncommon these days. A recent review of malt analyses conducted by yours truly found these numbers can vary significantly from maltster to maltster and from batch to batch. Short version: Always check the malt analysis sheet.

We can also think about our hops. Hops themselves can be a source of haze, thanks either to their own polyphenol contributions. Combining polyphenols with existing proteins can create a colloidal haze, particularly after dry hopping. In choosing hops, set yourself up to add as little plant material as possible and you'll add fewer polyphenols. Choose high-alpha acid bittering hops to reduce the amount of polyphenols added while maintaining the bittering level desired. Hop extracts are another route brewers can look at.

Next, take a look at your yeast strain. For clearer beer, select a yeast with high flocculation levels. More British strains fall into this category than any other, and many will drop brilliantly clear of yeast in very short order with almost no additional fining on your part. Be advised, though, that high levels of flocculation are often associated with flavors or outcomes that we will need to account for or actively avoid: These include diacetyl, higher levels of esters, and lower levels of attenuation. Less time in suspension means the yeast could struggle to complete their work. Increased temperature at the end of the active fermentation and rousing of the trub/yeast bed are ways to limit those affects.

Even water chemistry can get into the clarity game. Calcium — already necessary to promote healthy fermentation and flavor stability — also tends to encourage clarity in beer. Fifty parts-per-million are recommended, and if that level is not achieved you run the risk of creating calcium oxalate, a crystalline substance that will deflect light and create turbidity. If you're struggling with clarity and you haven't checked a water report recently, it can't hurt to take a look at your calcium levels.

TRUST THE PROCESS

Steps can be taken to promote clarity during the hot side of the brewing process. If you're concerned about high protein content of a mash you might consider a protein rest in your mashing schedule. This is an added step whereby you initially raise your mash to about 125 °F (52 °C) for about twenty minutes, prior to raising to saccharification temperatures. At that temperature, enzymes are created which cut down larger proteins into smaller chunks, theoretically reducing protein haze later in the process. However, it should be noted that this can have adverse flavor effects, making the beer taste watery or dilute (John Palmer, *How to Brew*), while potentially doing little to improve clarity. Having said that, many brewing practices are aggregate in nature. It's certainly possible that the protein rest alone may not improve clarity, but in combination with other steps it may accomplish significant improvement.

Once that wort is out of the mash tun (or if you're simply brewing an extract beer), you also have mid-boil options to improve clarity — kettle fining. This is accomplished by adding a product like Whirlfloc or Irish moss or Super Moss HB to the boil. These seaweed derivatives promote precipitation and coagulation of proteins, reducing their overall levels in your wort. Added towards the end of the boil (5–15 minutes remaining), they can promote clarity before the wort reaches the fermenter.

Next, consider your cleaning and sanitation regimen. It's safe to assume that you're cleaning and sanitizing well for a variety of reasons that have nothing to do with promoting clarity. But contaminated beers often show signs of turbidity and using old, suspect fermenters should be avoided.

Temperature management at the conclusion of fermentation is the next process to examine. After steadily increasing temperatures to promote full attenuation and yeast cleanup duties — for such things like diacetyl — adding a cold-crash step can promote further coagulation and clarification. Dropping the beer to 30–40 °F (-1–4 °C) will cause proteins, polyphenols, and yeast alike to drop out of suspension, resulting in clearer beer.

We can now consider some cold-side fining additions. Two common options are gelatin and isinglass, with a slight advantage to isinglass. Both are animal-derived products — so these are off-limits for those who want vegan beer — that promote the precipitation of proteins and polyphenols in beer. They provide a "polish" to beers with a residual haze. Isinglass, however, also promotes flocculation of yeast. One reason that gelatin is a more common choice among homebrewers, though, is that it's fairly easy to use. Isinglass, by comparison, can be a bit more labor-intensive. Another cold-side fining option is silic acid. This is the ingredient in such products as Kerry's Biofine Clear (which is animal-product-free), which has become extremely popular with craft brewers and is available to homebrewers.

For those that want to take it the extra step, homebrewers can now also filter their beer clear. Keep in mind, though, that in doing so you're eliminating the option of bottle conditioning, since one of the things you'll be filtering out is the yeast!

Last, but certainly not least (and this is among the only clarifying steps taken by many brewers), is time. Over time, nearly all sources of turbidity — proteins, tannins/polyphenols, yeast, chill haze, basically anything except microbial contamination — will drop out of your beer, leaving behind a crystal-clear product. Lagering (cold storage, for weeks or months at a time) is a legitimate approach to achieve clarity. This last option raises a concern that is hardly unique to "time and gravity," though: Flavor impacts. On that front, it's often a good idea to revisit the recipe (one more time).

BACK TO THE RECIPE

We began at the recipe, and we end with the recipe. Any time we take something out of the beer, we're probably taking flavor with it. As a result, fining requires that we adjust our recipes to account for the downstream changes we will make to the beer. We can best consider these adjustments by thinking about each flavor perception in turn, and adjusting our recipes accordingly.

For reasons I've never entirely understood, many get caught up in discussions of mouthfeel when considering clarity. Although I've never noted any particular mouthfeel difference in my own fined beers, I recognize that (hewing to the principle regarding perceptions) it's something we should account for. The good news is that while protein loss can certainly create thinner, more dilute-feeling beer, we can compensate with the addition of unfermentable sugars. Increasing the weight of crystal malts in the recipe or adding maltodextrin powder or lactose (if you also want some sweetness) will increase body in the beer. The same can be said of increasing carbonation for a fuller mouthfeel, if you find your beers are feeling a bit too thin.

For those experiencing head formation or retention issues, fining could be the source of the problem. Consider recipe additions of flaked grains (flaked barley is my preferred addition) to increase your overall level of head-forming proteins without (hopefully) adding excessive amounts of haze-forming proteins. This is a battle that can be tough to win, though, since fining agents draw no particular distinction between the two. One approach that may be helpful is to focus on using fining agents that specifically target polyphenol haze. You may promote sufficient clarity while leaving sufficient head-forming proteins behind.

Nowhere, though, does clarity bump into flavor more than in the contributions from hops. If using an especially flocculant yeast and/or filtering, increase your total bittering and flavor targets. Hop oils and isomerized acids cling to yeast (especially non-isomerized oils derived from dry hops, which haven't yet "bonded" to molecules in the beer), and the more yeast we remove, the less flavor and bitterness will carry through to the finished beer. Clear beer comes at a cost, for hops.

YOUR BEER IS FINE(D)

Once again, it is not a requirement that you fine your beer. To the extent that you do, though, you'll be happier with the results when you match and adjust your ingredients, recipes, and process to the final product you hope to produce. BYO

BY COLIN KAMINSKI

THE NEW STARTER

A novel method for ensuring yeast vitality

After spending 15 years as a pro brewer I am back doing small-batch trials. One of the most annoying transitions has been yeast quality. A professional brewery has access to very fresh yeast on demand. A brewery can have a full pitch of yeast overnighted from the lab the day of release but more often there are many fermentations in varying stages of completion a brewer can choose from. In the homebrewing environment cell count, yeast viability, and vitality are something that requires much more attention if your goal is to maintain quality and consistency. Good measures of quality and consistency are having consistent attenuations, consistent ester qualities, and consistent fermentation times. I propose a novel method adapted from Coors of England to achieve these goals that has been shown by homebrewers to also be effective on a smaller scale.

Cell count is simply the number of yeast cells available for fermentative purposes. In practice, obtaining a cell count is not very difficult or time-consuming but there is a big hurdle in acquiring equipment and setting a procedure in place to get consistent and reliable results.

The equipment needed is a 1,000x microscope, a hemocytometer, and some glassware. A camera is cheaper to produce than a good eyepiece so the cheapest microscopes now are hooked up to a computer and a usable one can be purchased for under $150 (USD). A nice stereo eyepiece model can approach $1,000 or more. Stereo is very nice if you are going to be using it for hours at a time. A hemocytometer is a special microscope slide (see page 92) that holds a very precise volume of liquid and has a grid in order to facilitate the counting of cells. Hemocytometers can be found from $15 to $100. Useful glassware is a 10 mL pipette, a two-liter flask, and a 100 mL flask. A stir plate will also be required if you plan on using this technique.

Collecting a sample to count is not a trivial task. In a homebrew size, it involves putting the pitch into a flask and stirring it to make sure it is homogenous. Use a micropipette to remove 1 mL of yeast and put it in a small flask. Then 99 mL of distilled water is added to dilute the sample to a countable number. It is important the number of cells to count is between 100 to 300 cells per μL to make counting easy and consistent and you may need a different dilution rate than the 99/1 described above. Once this is complete a small amount is removed with an eyedropper or micropipette and placed into the input port on the hemocytometer that has been fitted with a cover slip.

The hemocytometer will have some markings on it that allow you to know how to do the math. (It is really easy to be off by a factor of 10 so make sure to keep track of all the zeros.) A commonly used hemocytometer is marked: 0.1 mm and 0.0025 mm^2. The 0.1 mm tells you how high the cover slip sits off the grid. The 0.0025 mm^2 tells you the size of the smallest square. A large square is typically 20x20 small squares or 1 mm^2. The area over a large square is given by area x depth = volume or in the case of this hemocytometer: 1 mm^2 x 0.1 = 1 μL. Then the number of cells counted x dilution (100 in our example) x pitch size in mL x 1000 μL per mL = the total cell count. Again, make sure to keep track of all the zeros.

Some important cell counting tips: Only count every other small square in a checkerboard pattern and multiply by two. Count all cells that touch the top

Vitality is a measure of the yeast's ability to create a vigorous and rapid fermentation.

Photo courtesy of MoreBeer!

A 2-L flask sealed with a sterile filter in the bung allows gases to flow both ways from a flask without compromising the sterile nature of the closed envrionment.

or left lines but none of the cells touching the right or bottom lines as an example.

Once you have the equipment to count cells, yeast viability is an easy to measure parameter of how many live vs. dead cells are in a pitch of yeast. The yeast slurry is mixed and then a sample is removed and precisely diluted. The diluted sample is placed on a hemocytometer and the cells are counted. To perform a viability check a small amount of methylene blue or methylene violet (methylene violet is preferred as it makes it easier to differentiate weak cells from healthy cells) is added to the sample and the count is performed again. Any cells that turn blue are considered dead and the ratio of live to dead cells is your viability. If the measured vitality is over 90% you can use the pitch with a correction factor to get your desired pitch rate. If it is under 90% it is recommended to discard the pitch.

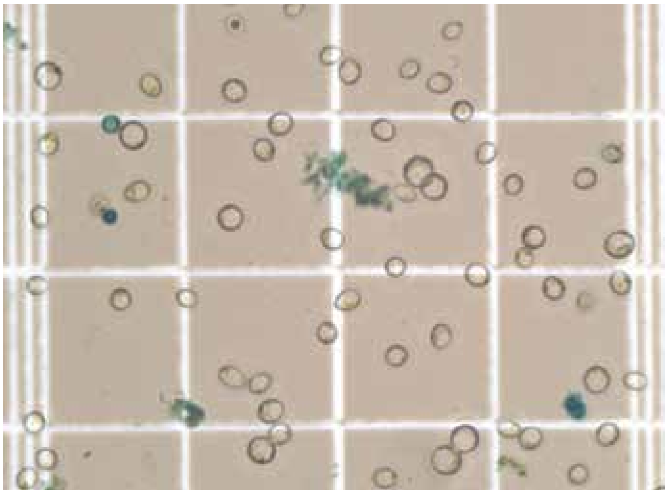


Image of a 0.2 mm² in a hemocytometer with yeast at 400x (small division visible are 0.5 mm²). Image courtesy of White Labs.

Your pitching rate for an ale (1,000,000 cells/mL/°P) will be: (pitch rate x OG in Plato x volume of wort in mL)/(yeast count x viability).

Vitality or more precisely "predictive fermentation test" on the other hand is very difficult to measure but extremely important to understand. Vitality is a measure of the yeast's ability to create a vigorous and rapid fermentation. Many methods have been proposed but a simple test that not only tells us the average vitality of the pitch and also the deviation from ideal has been elusive. An accepted method would be to use fluorescence spectroscopy to compare the relative concentrations of NAD^+/NADH but this equipment is beyond the budget of most breweries much less homebrewers. Another method used is to take a yeast sample and measure the specific rate of oxygen uptake. This is basically preformed with a dissolved oxygen (DO) meter set up to chart the O_2 levels of the sample. This correlates very accurately with yeast sterol reserves. Getting yeast sterol reserves is very important to consistent fermentation performance and many of the things we do are designed to do just that.

Beer is one of the only food products that is serially pitched. Most other food products use a mother. In a brewer's world, yeast is required to come from a resting state, uptake oxygen during a respiration phase, reproduce, then enter a fermentation stage where glycolysis turns sugars to alcohol and CO_2. When its work is completed we expect the yeast to flocculate to the bottom without leaving too many of the intermediate chemicals we call off-flavors.

Advanced homebrewers usually have a starter process that looks something like this: Take a pitch of liquid yeast purchased from a store, add it to 1 L of sterile wort and ferment it out. If it has flocculated, pour off the barm beer (the decanted portion of a starter) and pitch the yeast into 5 gallons (19 L) of aerated wort. This is a good strategy and results in decent beers but it works best if the purchased yeast is fresh and the oxygen level can be carefully controlled. Most homebrewers prefer oxygen to sterile air but it is my opinion that it is much safer to use sterile air. I have been making this argument for 20 years. So far, the foaming logistics of air have outweighed the dangers of over oxygenating to most homebrewers.

It is very difficult to over oxygenate with sterile air although it's effectively limited to beers with starting gravities under 1.080. At 1.080 and 68 °F (20 °C) the solubility limit is 7 mg/L with air and 32 mg/L with pure O_2, 7 mg/L is not sufficient enough to maintain yeast health through several reproduction cycles. For worts 1.060 and under it is much more common for large breweries to use sterile air. I have seen sterile air systems in use at Sierra Nevada and Anheuser-Busch although both also have oxygenation abilities for higher gravity products.

In 2004 I was given a scholarship from the Master Brewers Association to help me learn about yeast performance. I purchased several books that would have been unavailable on a brewer's salary. In exchange, 9 months later I was asked to give a talk about what I had learned. These books (one referenced at the end) influenced my thinking about yeast and I highly recommend for advanced homebrewers.

One of the things I read about during that time was a method piloted at Coors England by David Quain. I found the method fascinating and, while my budget never allowed me to set up the equipment to work with the 3 gallons (11 L) of yeast that I needed to pitch, I had lectured about it to many homebrewers over the years. I am very excited about the reported results. Homebrewers have reported shorter lag times, quicker fermentations, and both lower and more consistent final gravities.

Here is the outline of the method I adapted from Quain: Make a starter as normal to get your yeast cell count to the correct level using your preferred method. On brew day, while you are heating your strike water, make up a liter of 1.040 wort in a flask (about 115 grams of DME and 1 L of distilled water boiled for 15 minutes). Seal with a sterile filter that allows air to flow both ways. Cool. Pour the barm beer off your starter and add the fresh wort. Spin this pitch on the stirplate with a sterile filter until your brew day is ready for the yeast pitch. The spinning will keep adding oxygen to the wort. Ideally this should be 4 to 6 hours. DO NOT oxygenate the wort from the brew and pitch as normal. This is the magic part of the process.

What we are hoping to do is to keep the yeast in its aerobic fermentation (more precisely respiro-fermentation) phase until it has maxed its sterol reserves. It is good we elucidate this often-misunderstood point about yeast.

Saccharomyces has three general pathways of metabolism and, like herding cats, not all cells will be on the same page so we have to talk about what the majority of cells are doing at a given stage. Yeast prefers to ferment. If there is enough food, more than 0.4% glucose as an example, yeast will ferment to alcohol even in the presence of oxygen. This is called the Crabtree Effect.

If there is no oxygen present we call this anaerobic fermentation and this is the primary task we are asking our yeast to do. This is the most important part of fermentation, however, its fascinating details are beyond the scope of this discussion. Below 0.4% glucose and without other easily assimilable sugars present yeast will, in the presence of oxygen, respire. Respiration makes by far more energy for the yeast cell but, this pathway is not important to brewers because by the time the glucose level is this low, no oxygen remains for the yeast to utilize.

Yeast has a third metabolic pathway that is very important to this discussion. Since yeast does not respire in a normal fermentation what is happening? Yeast will consume all available oxygen whether it is respiring or not. This pathway is called respiro-fermentation. It does not have the energy advantages of respiration but it does have some anabolic advantages. (Anabolism is the synthesis of needed molecules.) Some of the most important things yeast can synthesize only in the presence of oxygen are the lipids needed for the cell wall membrane.

This is the reason we oxygenate the wort. Unless we supply a source of lipids in the wort, yeast will be required to make sterols in order to keep the yeast walls healthy. Once these walls get weak the yeast can become less alcohol-tolerant, die, and/or create off-flavors. One of the things we did in our yeast count was look for leaky walls with the staining. Storage time will naturally deplete sterol reserves.

Now that we have supplied the starter with 4 to 6 hours of oxygen there is no need to oxygenate the wort. For a larger pitch, bubbling sterile air or pure O_2 while mixing is required. This maxes the vitality of the yeast without oxidizing the trub or adding excess O_2 to the wort at all.

In Quain's studies he was able to get much more consistent fermentations. This is exactly what homebrewing needs. A package of yeast can be months old before it is used and its vitality and viability should be very much in question. Homebrewers using this method have reported to me lower and more consistent final gravities as well as less fermentation derived off-flavors. BYO

Further Reading:

Boulton, Christopher, and David Quain. *Brewing Yeast and Fermentation, 1st Edition*. Wiley, 2001.

Aquilla, Tracy."The Biochemistry of Yeast." *Brewing Techniques,* (Volume 5, Number 2).

"SMART" FERMENTATION

A chamber with a CO_2 harvesting system

BY GIACOMO ROSILHO DE SOUZA

I started brewing one year ago and enjoy doing small 3.25-gal. (12-L) batches, as it allows more experimentation. Moreover, a 3.25-gal. (12-L) bucket is small enough to fit into my fridge for the cold-crashing phase at the end of fermentation. Nonetheless, after a few batches my flat mates were understandably not too comfortable keeping my "beer stuff" in the fridge for a whole week. My fermenter is indeed pretty small, but it still occupies a large portion of the fridge. Hence, I had to find another way to cold crash. I took up the handcrafting/technological challenge of building my own remotely monitored and controlled fridge with an autonomous system for controlling the temperature.

My fermenting chamber consists of a 3.1-in. (8-cm) thick box in polystyrene made waterproof by an inner acrylic Plexiglas® coating. Inside the box the fermentation bucket is plunged in a water bath, with water and beer volumes approximately equal. The box's size has to be adapted to the fermenter, which in my case fits in a 13.4-in. (34-cm) cube. Adding the 3.1-in. (8-cm) of polystyrene on each side gives the final cubic box a 20-in. (50-cm) long exterior.

The temperature sensor is placed in a test tube and insulated with silicon sealant. The purpose of the test tube is to protect the sensor from moisture, and is extremely simple to clean. The cooling system consists of a small pump that forces the water to flow through a Peltier water chilling system, both the pump and the Peltier system are powered by a 12 V supply. I used a computer power supply unit (PSU).

In order to automate the temperature regulation, the thermometer is connected to an Arduino board controlling a relay, which when the beer is too warm, turns on the PSU and hence the cooling system. I avoided using a PID controller, not wanting to deal with tuning coefficients. So I wrote a very simple code for the automatization of the cooling process. First, I performed some preliminary tests turning on and off the cooling system manually and looking at the temperature evolution. As it turned out that the system is very stable and predictable, I came up with an intuitive algorithm that appears to be nonetheless efficient. In order to keep an eye on my beer's temperature from anywhere, I connected the Arduino to a WiFi module and eventually to an app on my smartphone. This I developed myself using Blynk, a freeware platform for developing apps in this framework. Interactive modules in the app allow me to track the temperature evolution, to set target temperatures and to turn on or off the cooling system. In order to have a backup, the temperature data can be sent to any email address.

Finally, I put in place a CO_2 harvesting system and chose the common two-jar system. During cold crash after fermentation, when there is a pressure decrease inside the fermenter, the two-jar system sucks back CO_2 instead of oxygen, avoiding oxidation.

Tools and Materials

- 3.1-in. (8-cm) thick polystyrene panels
- Polystyrene cutting device
- Polystyrene-safe glue
- 1.6-in (4-mm) thick Plexiglas® panels
- Silicone sealant
- Waterproof DS18B20 digital temperature sensor
- ¾-in. silicone hose
- Small aquarium water pump
- Peltier water cooler
- Cheap/old computer power supply unit
- Arduino Uno
- ESP8266 WiFi board
- Relay
- 2 small jars for CO_2 harvesting system
- Test tube

I took up the handcrafting/technological challenge of building my own remotely monitored and controlled fridge with an autonomous system for controlling the temperature.

Photos by Giacomo Rosilho de Souza

STEP BY STEP

1. BUILDING THE BOX

The goal is to build a polystyrene box large enough to contain your fermenting carboy or bucket plus a similar volume of surrounding water. I used polystyrene panels, which I've cut with a polystyrene cutting machine and then glued together with a polystyrene-safe glue.

The interior face of the box is coated with thick Plexiglas® panels, made waterproof with silicon applied to the joints. For aesthetic reasons — the fridge is in my flat share's living room — I covered the box's exterior faces with thin wood panels.

2. DRILL AND PASS ALONG THE HOSES AND SENSOR CABLE

On one face of the box you need to make four holes. Two of these holes are used for the water hoses, one for the blow-off tube, and one for the beer temperature sensor. I decided to drill an additional fifth hole for the water temperature sensor, but it's not really necessary.

Insert the beer temperature sensor in a test tube and insulate the tube with silicon. Then, drill a hole in your fermenting bucket's lid of the exact same diameter as the test tube.

3. INSTALLING THE WATER PUMP AND THE PELTIER MODULE

Connect a water hose to the pump and the other to the Peltier module, employ an additional hose to connect the pump to the Peltier module. Be careful to make the connections as short and insulated as possible — a bit shorter than mine should be optimal.

As you can see in the picture, I didn't fix the pump, but I purposely just left it hanging to the tubes in order to diminish vibrations. In fact, the fridge's most noisy parts are by far the Peltier module's cooling fans.

4. CONNECTING THE CABLES AND POWER SUPPLY

A computer power supply unit (PSU) is used to power the whole fridge. The PSU is extremely practical as it has a 5 V standby supply, which is sufficient to power the Arduino Uno unit even when turned off. The water pump and the Peltier module are connected to the 12 V pins of the PSU, which provide current only when the PSU is on. In order to turn it on, you short together the PowerOn pin and a ground pin, which I achieve with a relay controlled by the Arduino. Finally, connect the temperature sensor and the WiFI module to the Arduino.

5. PROGRAMMING THE ARDUINO AND SMARTPHONE APP

The algorithm I developed to control the system is rather simple. Let's think in the following of a target temperature of 64.5 °F (18 °C). Then, if the beer temperature is above 65 °F (18.25 °C) the Arduino turns on the cooling system and keeps it on until the beer reaches 64.5 °F (18 °C), when it's turned off. At this point, the water — which is the actual substance being cooled down — will be colder than 64.5 °F (18 °C), so after some adjustment time, beer and water will reach a thermal equilibrium of 64 °F (17.75 °C) approximately. Clearly enough, this rudimentary setting — which is sufficiently sophisticated for my small home production — may be ineffective on other builds, and a PID controller might guarantee better performances.

I developed the smartphone app with the very intuitive Blynk framework. The app displays temperature plots, allows me to set the target temperature, and to control the system manually at my whim. All temperature data is stored on the Blynk server and can be exported.

6. CO_2 HARVESTER SYSTEM

The harvesting system goes between the blow-off tube and the airlock, it is composed of two jars. The blow-off tube connects to the cap of the first jar and the airlock is plugged into the cap of the second jar. An additional hose is used to link the two reservoirs, passing through the two caps and reaching the bottom of the jars. Before fermentation starts the first jar is filled with sanitizer, then the CO_2 produced by yeast will force the sanitizer to go into the second jar, passing through the linking hose. After fermentation ends the first jar is filled with CO_2, which will be sucked back into the fermenter during the cold crashing phase due to the pressure decrease. BYO

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BY PEIRCE SULLIVAN

LET'S GET TROPICAL

An obsession with the Florida-weisse

About two years ago I was lucky enough to try Miami Madness, a beer by J. Wakefield Brewing located in Miami, Florida. Described as a, "Sour ale with mango, guava, and passion fruit added," I was blown away. To this day, I still cannot get over the depth of tropical fruit flavors and smells.

Given I'm a well-seasoned homebrewer with 10 beers under my belt on my highly sophisticated homebrew system (dripping with sarcasm here), I knew I had to tackle this beast. I dug in deep with a passion (fruit?).

... my significant other and house guests love being bombarded by bagged, frozen bricks of fruit when they're going for an ice tray!

Photo courtesy of Peirce Sullivan

BREWING PROCESS

I decided on a 50:50 split of Pilsner and wheat malts as this ratio is the most traditional to a true Berliner weisse. I typically shoot for about a 1.050 starting gravity with a normal mash routine.

Without boiling, I then cooled the wort to about 100 °F (38 °C). I learned from a fellow brewer that adding 1 mL of lactic acid per gallon (3.8 L) of wort at this point will help protect it. From here, I added my preferred form of *Lactobacillus* culture. I use 16–24 oz. (470–710 mL) of Goodbelly® Probiotic juice and it works pretty well. Finally, I flushed the headspace of the brew kettle with CO_2 and wrapped the brew kettle with plastic wrap to make it as airtight as possible. Placing the airtight brew kettle in a keg bucket with water, I set a heater to 100 °F (38 °C). This temperature may vary depending on the strain of *Lacto* you use, but this temperature has worked for me. I let this acidify for 48 hours, before bringing it to a boil. Obviously, the longer you let the wort sit pre-boil, the lower the pH of the wort will be. Honestly, I have yet to test any time frame longer or shorter than the 48 hours, but I have been very pleased with the results. I boil the wort for an hour with a bit of hops.

After cooling, I pitched 2 packets of US-05 due to the low pH and ferment as usual. Where's the fruit you ask? Well it's shoved precariously into my freezer until secondary — my significant other and house guests love being bombarded by bagged, frozen bricks of fruit when they're going for an ice tray!

FRUIT ADDITION

Fear of contamination from wild yeast or unwanted bacteria is a hazard with adding anything in secondary. For me, a liberal application of booze is the answer. Any fruit that I introduce into secondary has been spritzed, drizzled, mixed with, or otherwise infused with vodka or tequila. I have not had any infection problems to date. When racking to secondary (keg), I use the same process for an IPA that is getting dry hops. A second round of fermentation will ensue, so be sure to account for this.

I typically aim for 3+ lbs. of fruit per gallon of beer (0.36 kg/L), aged on fruit for one month, give or take a week or two. To date, I've brewed 5 of these Florida weisse beers and experimented with about a dozen different fruits. Ranging from the recognizable kiwi (I say don't waste your time) to the more elusive and incomparable lulo (it's kinda like an orange I guess?). You can reference my list at: www.byo.com/article/lets-get-tropical.

FINAL PRODUCT

What fruit you choose certainly adds its own level of acidity and flavor — but in all instances my friends, family, and more discerning fellow homebrew club folk have raved about the finished product. It comes out tart and refreshing, without being overly sweet or sour. While I don't think commercial breweries need yet to worry about the competition — I am happy to say that I've scratched my Florida weisse itch. BYO