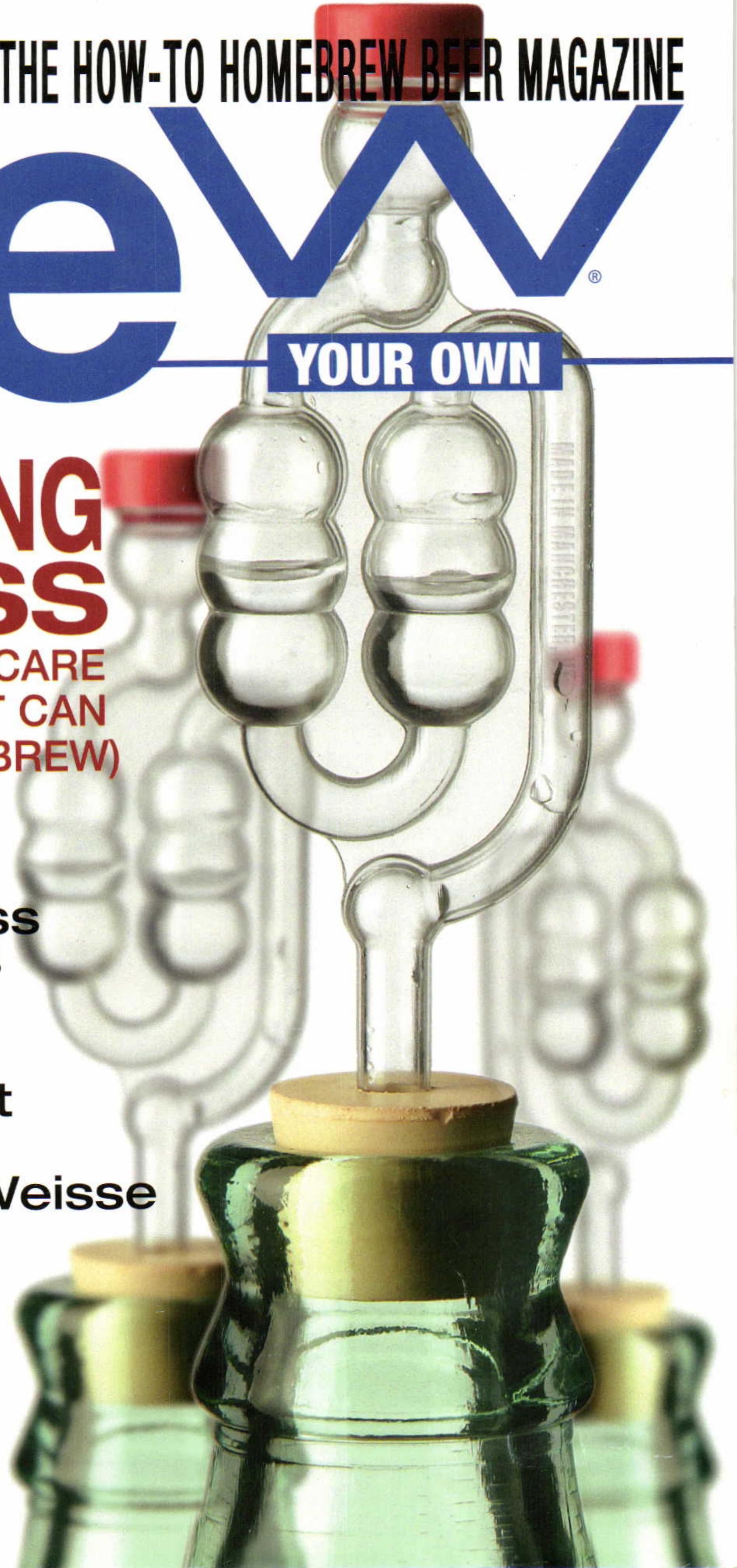
INSIDE SIERRA NEVADA'S NEW HOP TORPEDO: HOW IT WORKS & HOW TO BREW

Brew Your Own®

THE HOW-TO HOMEBREW BEER MAGAZINE

SEPTEMBER 2009, VOL.15, NO.5



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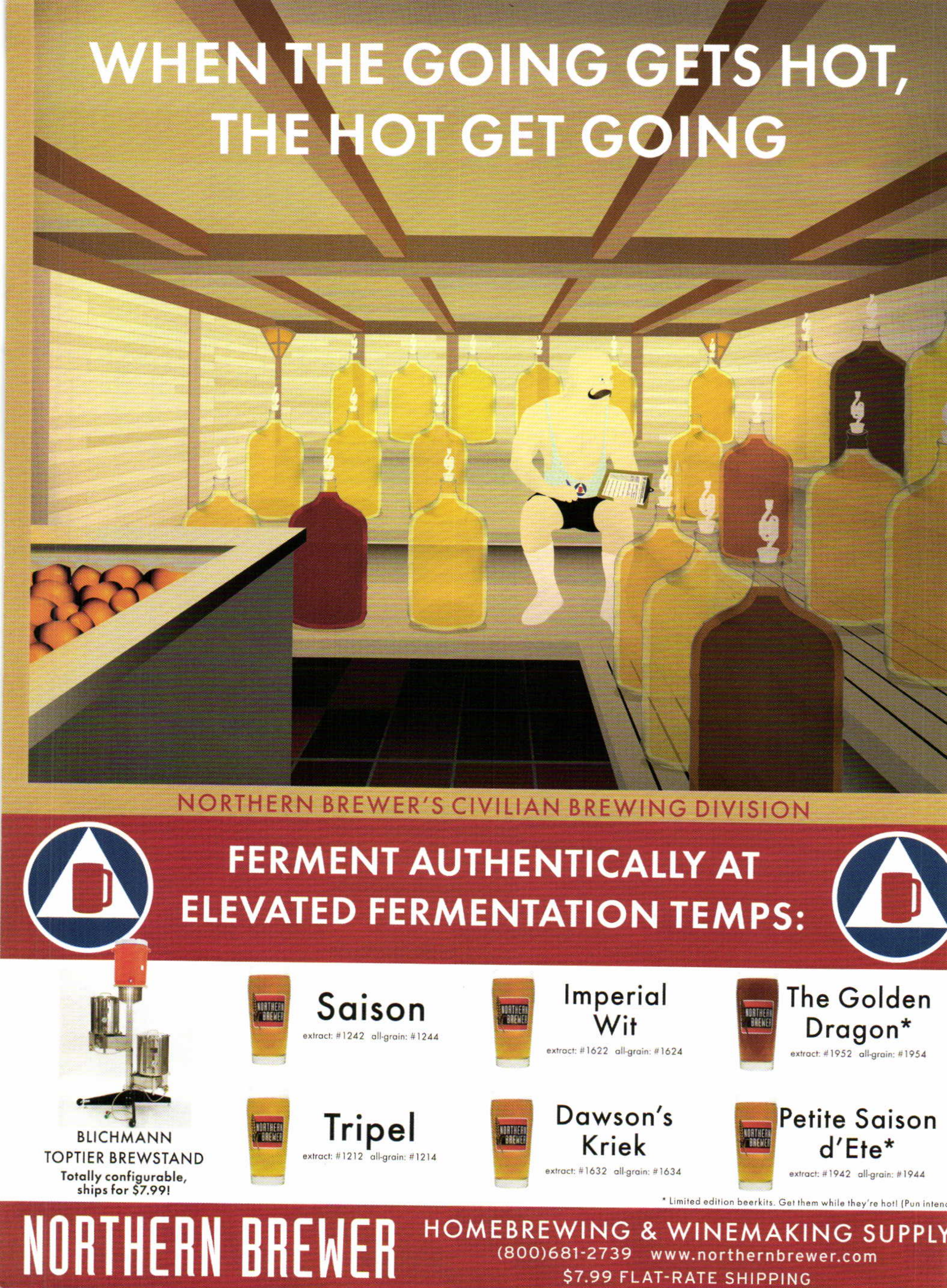

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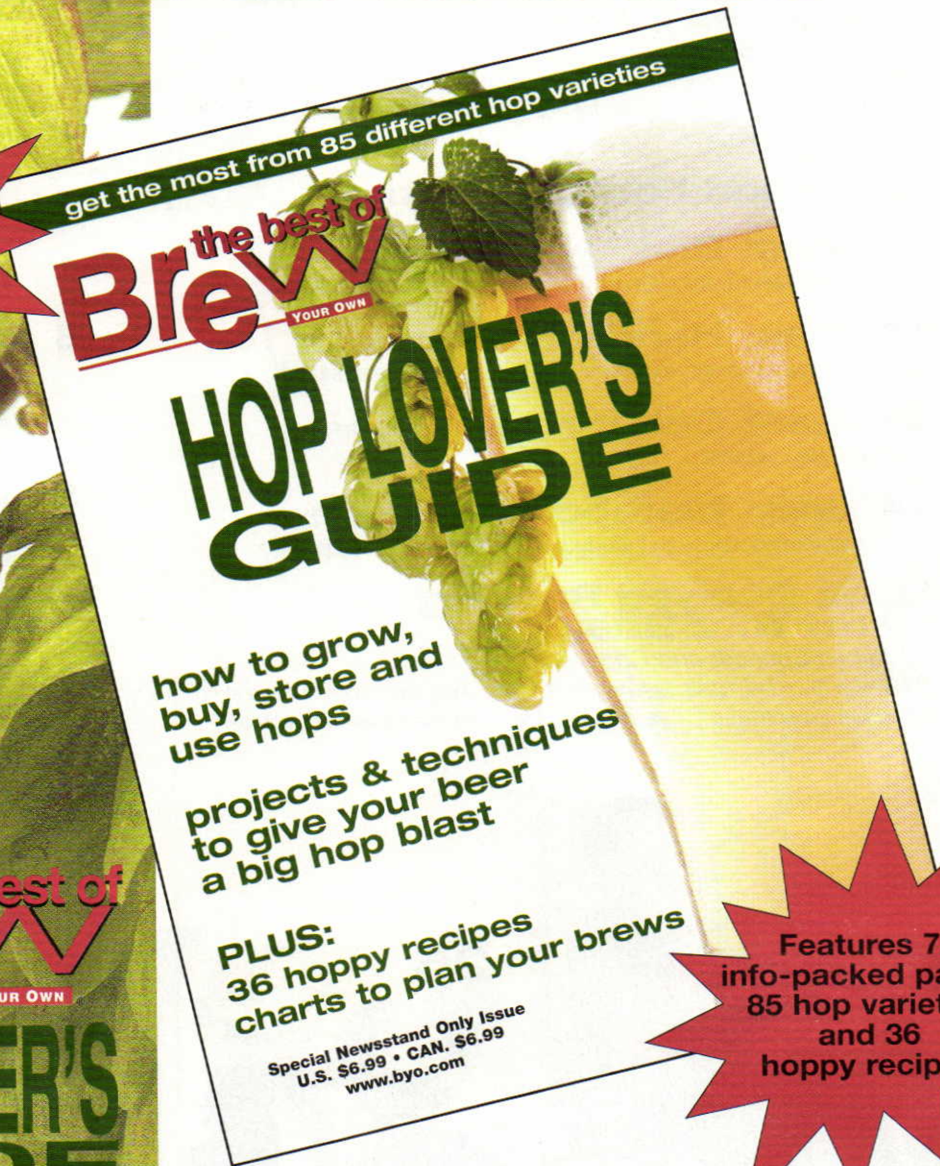

Features 72 info-packed pages, 85 hop varieties and 36 hoppy recipes

the best of Brew Your Own

HOP LOVER'S GUIDE

We've collected and updated the best hops information from the past 12 years of *BYO* and included updated charts with the specs for 85 hop varieties including new varieties and suggested substitutions for hard-to-find hops. We've also detailed different hopping methods, hop growing info, hop-related build-it projects and 36 hoppy recipes. A few of the reasons you will love this new reference...

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Brew YOUR OWN
THE HOW-TO HOMEBREW BEER MAGAZINE

SEPTEMBER 2009
Volume 15 Number 5

Features

Departments

Where to find it

Home Grown

Brewed with our own hops & barley

Estate—Brewers Harvest Ale is a handmade beer produced with 100% local hops and barley, sustainably grown on-site at our brewery in Chico. This beer reflects the flavors of our home—drawing from the richness of California's legendary Central Valley and the surrounding foothills of the Sierra Nevada Mountains. Taste the soul of one of the world's only estate-made beers and see for yourself why things taste better when they're made at home.

SIERRA NEVADA BREWING CO.

Chico, California

RECIPE INDEX

Page

BYO RECIPE STANDARDIZATION

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

Extract values for malt extract:
liquid malt extract (LME) = 1.033–1.037
dried malt extract (DME) = 1.045

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

Hops:
We calculate IBUs based on 25% hop utilization for a one hour boil of hop pellets at specific gravities less than 1.050.

Brew YOUR OWN

THE HOW-TO HOMEBREW BEER MAGAZINE

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Cover Photo: **Charles A. Parker**

Mail

Split on Summer Solstice

I'm brewing the Anderson Valley Summer Solstice from the July-August 2009 issue and was wondering if the Wyeast California Lager yeast should be treated as an ale or a lager. I know that it is obviously a lager by name, but as it seems like it is a sort of "hybrid" between the two, my question is if this beer would benefit from a diacetyl rest after primary fermentation or not?

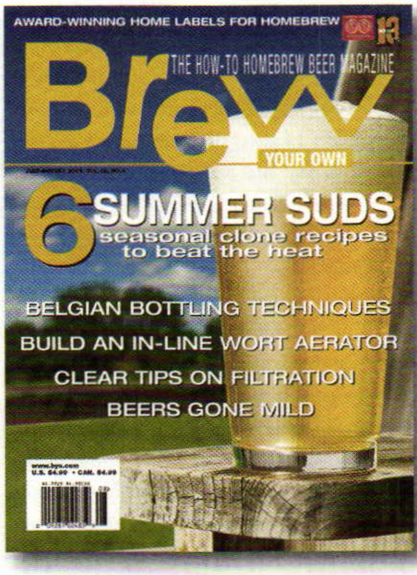
Jonathan Eseman
via email

Wyeast 2112 (California Lager) and the equivalent White Labs strain, WLP810 (San Francisco Lager), are the yeast strains most often chosen by homebrewers when making a "steam" beer — a style of beer that is a hybrid between ales and lagers. Our advice would be to treat the yeast as a lager strain when it comes to deciding on your pitching rate. Make a nice, big yeast starter — 3-4 qts. (3–4 L), for 5 gallons (19 L) of beer — and raise plenty of healthy yeast. During fermentation, the yeast is treated more like an ale strain with regards to the temperature the fermentation is carried out at, 65 °F (18 °C).

At 65 °F (18 °C), you should not have any problem with diacetyl. This is 5 °F (~3 °C) higher than many brewers perform a diacetyl rest at to begin with. On the other hand, you want your summer beer to be as clean and crisp as possible, so holding the temperature at 65 °F (18 °C) for an extra day or two after fermentation finishes wouldn't be a bad idea. Performing a diacetyl rest will never harm a beer, even if the beer doesn't need it. So why not take the worry out of your brewing and add one, if it will put your mind at rest? Good luck with your summer brew!

Rhizome

I am writing in response to your reply to Mark Banner's email regarding hops rhizome splitting (July-August 2009). Although I do not disagree with your reply, I have to ask, why not let mother nature store them for you? Having grown hops here on the coast of Maine for about 10 years and having divided my Willamette bed twice, I have found it easy to dig and divide my plants in the spring. Just treat them as normal in the fall, cutting the bines down and cleaning up the crowns, and let them winter over. In the spring, when the ground becomes workable and before the first shoots show, follow your



instructions, amend the soil and replant. I have done this with no appreciable loss in yield.

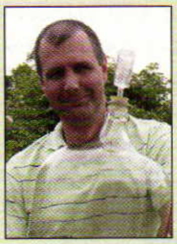
Darren McLellan
via email

You can indeed leave your hop rhizomes in the ground and dig them up in the spring. In fact, this is when commercial hop farmers dig for them. The hop is a hardy plant and digging for rhizomes can be done either in the fall or spring. If you don't have room in your fridge to store them, leaving them in the ground until spring is a great idea. On the other hand, if you live in the South, digging them up in the fall and storing them cold overwinter may improve your plant vigor and yields the next growing season.

Gluten Free Fermentation

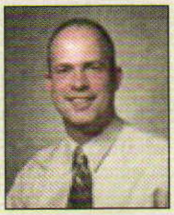
We made a batch of sorghum beer this past weekend and it seems to be very slow to start fermentation. The recipe formulation is similar to one of the recipes in the *Brew Your Own* article by Glenn BurnSilver from the March-April 2007 issue. We used White Labs California Ale yeast (no starter, but the tube did give off a good hiss when opened for pitching). Aeration was done by the "shake and roll" technique on the carboy. There's been very little foam or other visible sign of fermentation. On Monday, we re-pitched with Danstar dry yeast (re-hydrated) and used welding oxygen and a diffusion stone for aeration. We did the beer as a training/demo session for two friends of ours. We made a brown ale at the same time,

Contributors



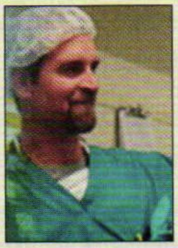
JAMES SPENCER is the host of the *Basic Brewing Radio* and *Basic Brewing Video* podcasts, which can be found at www.basicbrewing.com. James started brewing in 1996 and in 1998 he won the only homebrew contest he ever entered — the 3rd Annual Ozark Homebrew Contest.

In this issue, *Basic Brewing* teams up with *Brew Your Own* magazine and presents the first in a series of collaborative experiments. Find out if leaving your beer in primary for an extended amount of time ruins it. The article begins on page 50.



DR. CHRIS WHITE is a member of *BYO*'s review board. Chris has researched and developed a library of brewers yeast strains from around the world. Homebrewers know him as the founder of White Labs, which he started in 1995. Chris did his undergraduate work in biochemistry at the University of California, Davis. Later, he earned a Ph.D. in biochemistry from UC, San Diego.

On page 42 of this issue, Dr. White discusses what it takes to culture your own yeast at home and on page 44 he takes on the topic of yeast metabolism.



GREG DOSS is also a member of *BYO*'s review board. Greg earned a B.Sc. degree in microbiology from Oregon State University in 1996. After college he brewed professionally for five years — as an assistant brewer with Big Horse Brewing Co. (Hood River, OR) and as the head brewer of The Rock Brewing (Seattle, WA). He is currently the QC Manager and Microbiologist at Wyeast Laboratories. In his spare time, he brews beer and plays basketball.

On page 36 of this issue, Doss discusses what a homebrewer needs to know in terms of how to handle their yeast and monitor their fermentations.

and it followed the usual/expected fermentation path. We put both carboys in the same house, so that he could see how beer behaves in the carboy during fermentation.

In the sorghum beer today, there's been just a little foam on the surface of the wort. I haven't yet taken an intermediate specific gravity reading.

Is sorghum wort hard/slow to start fermenting? Do you have any tips or suggestions for this batch? Glenn BurnSilver proposed getting another pack of yeast and making up a starter, briefly re-boiling (to sanitize) the wort, cooling and trying over. That seems reasonable to me. I'm not ready to give up on this batch yet, so would appreciate any ideas or comments you might have.

Jim Jacobson
Broomfield, Colorado

Sorghum wort does ferment a little more sluggishly compared to barley or wheat worts. And, the fermentation raises less foam. If there is any foam at all on the surface of your wort, that's probably a sign that fermentation has started. One thing we would recommend is to add some yeast nutrients. Take about a ½ tsp. of complete yeast nutrient and boil it in a bit of water, then add it to the brew as soon as possible. Better yet, make a small (500 mL to 1 L) yeast starter with some sorghum syrup or honey and add the nutrients to that. Pitch when the starter is fermenting well, which should occur within 24 hours. (Again, don't expect a lot of foam.)

If the fermentation grinds to a halt with less than ⅓ of the expected attenuation, make the starter (as above) and lightly aerate the full wort when you pitch it. If the fermentation is slow, but still chugging along — or if the yeast have already chewed through more than ⅓ of the fermentable sugars — skip the aeration. We would not recommend reboiling your partially-fermented beer and starting over.

Guessing at the status of a fermentation based on how much foam is present is risky — especially with sorghum wort. Taking density readings with your hydrometer will tell you for certain if the fermentation is proceeding or not. Given that you're working with sorghum, don't sweat it if the fermentation takes a few extra days.

The effort put into making a yeast starter always pays off in terms of initiating a good, speedy fermentation and hitting your target final gravity. We strongly recommend paying attention to pitching an adequate amount of healthy yeast. Likewise, if you suspect a fermentation is having problems, taking a gravity will allow you to confirm this and take the guesswork out of what your next move should be. Good luck with your sorghum beer!

Questions, concerns, comments?

Contact us!

Brew Your Own — The How-To Homebrew Beer Magazine

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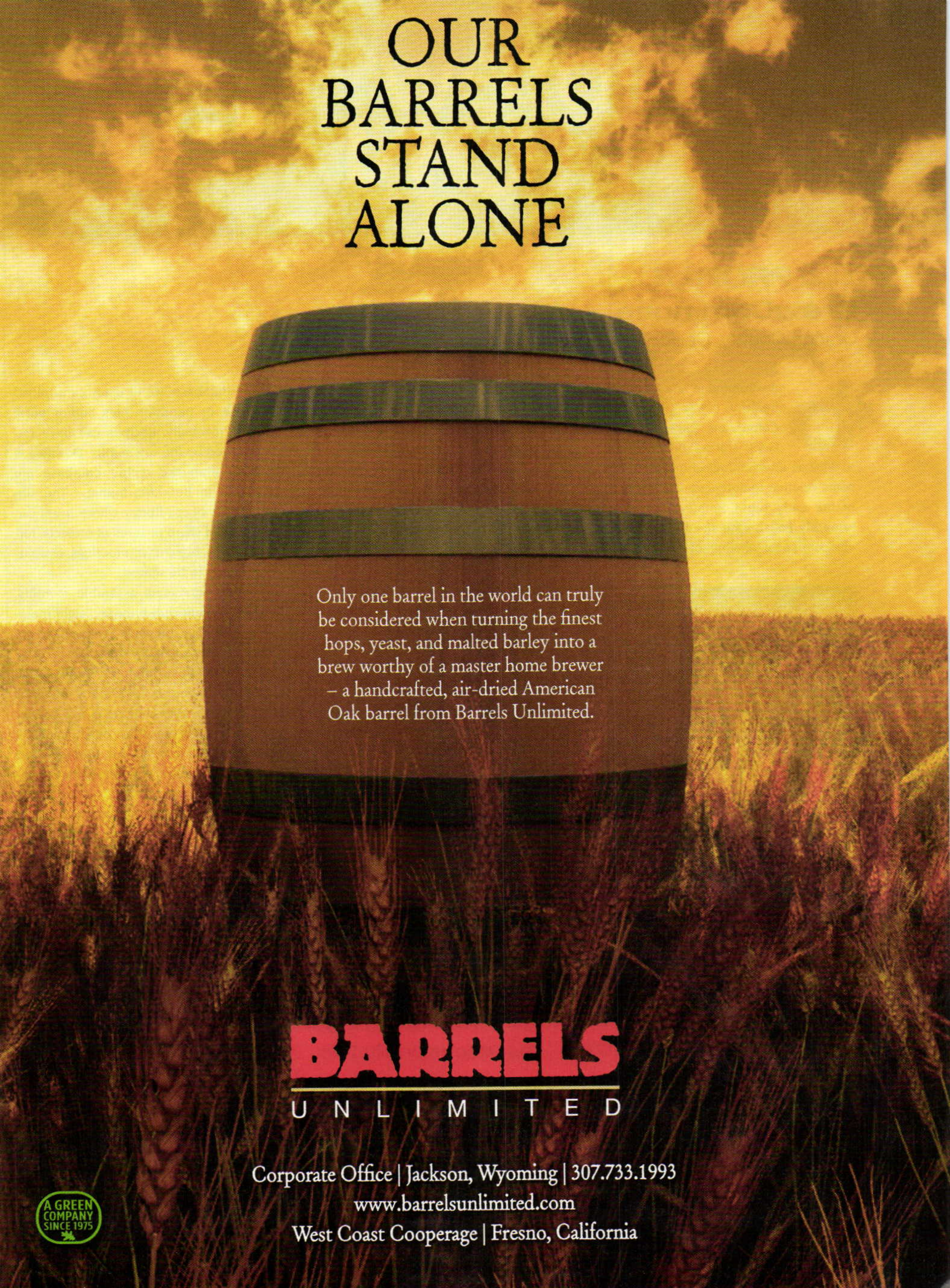
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club PROFILE

BrewCommune

Orange County, California

brewCommune is a club with a healthy web presence. Cofounders Dave, Sean, and Geoff started BrewCommune in 2002 as a technological means to overcome relative remoteness. The main goal of the early BrewCommune site was to remotely collaborate the brewing hobby via communal sharing of recipes, techniques, blogs etc. It wasn't long before registration grew and the nucleus discovered their relatively close proximity and started getting together for brewdays.

BrewCommune started as an online club and grew to include club brewdays.

Meanwhile, the brewing knowledge the site contained in the forum entries grew and was indexed by the major search engines allowing users to get brewing questions answered via the web. As such, the online community grew to achieve international status. In early 2004, BrewCommmune registered as a club with the AHA. In 2005, club officials were elected and the club has continued to grow at a steady pace. BrewCommune.com remains a totally independent set of forums maintained by the club membership with members all over the world. The club boasts 33 paid members (up from 29 in 2007). The web community has over 400 registered users, an active open forum area with discussions around equipment, techniques, ingredients, recipes, competitions, and other areas of general interest. BrewCommune.com also has an online recipe database where users can upload ProMash or BeerXML files and/or enter recipes manually. Recipes can have ratings added by the community. Downloads directly from the recipe database are available in BeerXML format. The site also has a photo library where users can upload and share pictures of projects, fermentations, brew-days, meetings, or whatever needs to be shared.

BrewCommuners assemble monthly, and at a recent club brewday, eight members had four brewing sessions going. Systems present included a Sabco Brew Magic, a recently completed Brutus and a pre-Brutus homegrown system. In addition, club members helped a new brewer get started with an extract batch. In all, 35 gallons (132 L) of wort were produced and several gallons of fine homebrew managed to disappear.

Visit us at www.brewcommune.com (website registration is free, membership is cheap!) We look forward to having you join our "Commune"ity!

byo.com BREW POLLS

Do you reuse your yeast?

No, but I plan to 28% Yes, occasionally 24% Yes, frequently 16%

Have you ever tried cooking with malt extract?

No, but I would like to 41% Yes, and I'll do it again 27%
Yes, but only once or twice 6%

Check out the latest poll question and vote today at byo.com

club DROOL

Bull Falls Brewers Homebrew Club

Stratford, Wisconsin

In February 1995 microbiologist Terese Barta taught a Science of Brewing Malt Beverages course in the Wausau, Wisconsin area. After the course completed, Ms. Barta along with about 15 people formed a club so that her students could continue the craft of homebrewing. That club was the genesis of the current Bull Falls Brewers Homebrew Club.

Around 2001 two of the members, Bill Flood (who served as club president for many years) and Jeff Berens, started kicking around the idea of a club "Big Brew" system — something large enough that everyone in the club could take home 5 gallons (19 L) from a single brew. In June of 2004 we held our first "Big Brew." Jeff's personal HERMS system was used in conjunction with the new equipment to brew 90 gallons (341 L) of dunkelweizen. We still have photos of that historic event on our website at http://www.bullfalls-homebrewers.org/bigbrew2004.html. Two years later we maxed the system out, brewing 150 gallons (568 L) of robust porter. About twelve club members met at 8 a.m. to join in the blessing of 400 pounds (181 kg) of grain. I think we finally had everything cleaned up and put away around 10:30pm. Carboys were already burping by this time. There was a quiet "CO_2 Symphony" in the brewhouse from 30+ airlocks as we shut the lights off around 3 a.m.

A local farmer donated an old corn hopper that Jeff thought might work as a mashtun. Bill, and fellow member Bob Beck, acquired 165 gallon (625 L) and 75 gallon (283 L) stainless kettles and had legs welded on. Jeff picked through a local scrap yard and found some stainless screen for the mashtun. With a little elbow grease and some help from a local welder the system was starting to come together.

During our first big brew, the grain was slowly added to the mashtun while other club members stirred it in with boat oars! Our super HERMS system was fired up to get the grain to mashout. This worked surprisingly well, increasing that giant mash by about 1 degree every five minutes. From there we started sparging into boil kettle one. Fortunately, when kettle one is full the HLT/boil kettle 2 is empty and we start filling it while we recirculate wort between the two. The 45 gallons (170 L) of HERMS water is used to help finish our sparge.

Our brewhouse efficiency (if I calculated it right) came in around 80%. We learned a lot from our first run with this system and have plans for improvements next time. We tend to start by seeing what we can get for free and then build around that. We've already got three different yeast strains offered which gives us great flexibility. We've also talked about doing a parti-gyle-style brew like Fullers does. Our separate boil vessels seem like an obvious fit to try it.

In August of 2006 opportunity knocked: Jeff found a 294 gallon (1,1.13 L/1113 KL) stainless steel vessel, out of some factory from the Oshkosh area, for just $100!

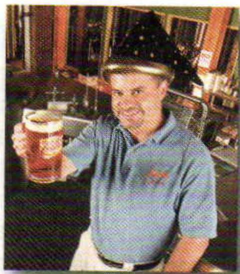
From left to right:

- 165 gallon (625 L) boil vessel
- 152 gallon (575 L) HLT/boil vessel
- 294 gallon (1,113 L) mash tun
- 45 gallon (170 L) kettle with 50 foot copper coil (super HERMS unit)
- a couple march pumps move the water/wort through PEX tubing

Near the end of sparging, two jet burners are fired up under both kettles and we get one rockin' boil! 90 minutes later we're pumping wort through counter flow chillers into carboys. Yeast is supplied by a local brewpub and one of our members gives everyone a healthy dose of oxygen from his large oxygen tank. We made 225 gallons (852 L) of beer on our first brew. We basically have a 7-barrel brewing system. The entire brew day is very long, but a heck of a lot of fun!

Club members bless the 400 pounds (181 kg) of malt for their brew. Pop over to our website (http://www.bullfalls-homebrewers.org/Big%20Brew%20Details.html) for more photos and information. Feel free to drop an email to tappr@yahoo.com if you have any questions.

what's happening at BYO.COM

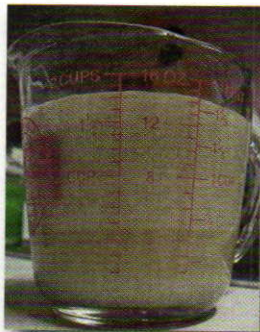


Mr. Wizard's New Blog:

Catch up with *BYO*'s Mr. Wizard, Ashton Lewis. In addition to answering your homebrew questions, Ashton is also Master Brewer at Springfield Brewing Company and Process Engineer for Paul Mueller Company in Springfield, Missouri where he helps design brewing systems for commercial breweries large and small. Follow along during his many beer-related travels.
http://www.byo.com/blogs/blogger/Ashton%20Lewis/

More fermentation fodder:

This month we examined all yeasts small and...er...small. But as the late, great Billy Mays would say, that's not all! Check out our online directory of yeast-related stories for even more information about fermentation.
http://www.byo.com/stories/list/indices/58-yeast



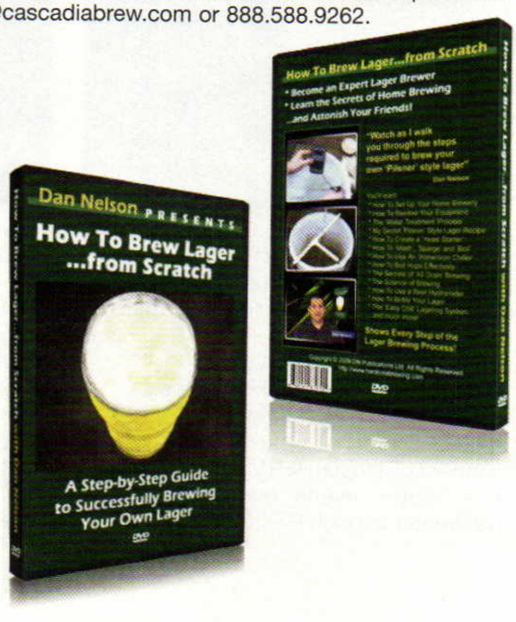
WHAT'S NEW

New Beer Kit from Coopers

Coopers Brewery announces a new addition to their International Series. Coopers English Bitter captures the style of traditional bitters pulled from the barrel in pubs across England. The can contains wort made from pale malt, crystal malt, roasted malt, wheat malt, bittering and aroma hops. The yeast included with the can is an ale strain. To obtain the targeted profile it is recommended that this brew be used with 500 gm of Coopers Light Dry Malt. The new English Bitter can be found at fine retailers everywhere. For more information contact Cascadia Importers at market@cascadiabrew.com or 888.588.9262.

New Brewing DVD

DN Publications Limited in the UK announces the release of their new DVD,"How to Brew Lager . . . from Scratch." This DVD is intended for beginner, intermediate and advanced brewers and includes nearly an hour of hands-on instructional video to take you step-by-step through making an all-grain batch of lager beer. Visit www.hardcorebrewing.com for ordering information.



replicator
by **Marc Martin**

Dear Replicator,
I have been homebrewing more than ten years now and have a been a member of two clubs in other parts of the country. Most of my friends, club members and fellow homebrewers seem to have gravitated toward the extremely hoppy pale ales the past few years. I have always been a fan of the darker, malty beers and most of my batches run from ambers to stouts.

Recently I have discovered what may be my favorite beer. Triple Rock Brewery and pub is across the bay in Berkeley and I just had their Dragon's Milk Brown Ale. It has the malt profile I like but with a great hop presence too. Even a couple of my "hop head" friends like it. I have become addicted and even fought the Oakland bridge traffic as soon as I found out it was back on tap.

Larry Soper
Palo Alto, California

Larry, your request couldn't have been more timely. Two weeks after I received your email I had the opportunity to attend the American Homebrewers Association annual convention in Oakland, California. I hopped the BART train and three stops later I was in downtown Berkeley.

During the four block walk to the brewery you quickly discover that Berkeley still has retained some of the 60s-era loose and liberal feel. Quirky shops and interesting ethnic cafes line the streets. With its old style store front and laid back décor, Triple Rock Brewery matches the theme perfectly.

The Triple Rock Brewery was the brain child of brothers John and Reid Martin (no relation to the Replicator). John is a co-founder of the California Small Brewers Association (CSBA), and has served as CSBA Treasurer since 1989 and Reid is also the owner of Big Time Brewery in Seattle, Washington.

Both brothers come from homebrew roots and began homebrewing while in college. Reid first brewed with his college roommates in the kitchen. John attended a homebrewing class through Oregon State University and brewed his first batch, a stout, at a friend's old farmhouse. The brothers thought it would be cool to combine their love of flavorful beer and classic American taverns and open their own alehouse. After convincing the city bureaucrats that a small brewery would complement the downtown area they opened the doors to Roaring Rock Brewery in March of 1986. This made them one of America's first five brewpubs and the only one still operated by the original owners.

When word of this new Roaring Rock Brewery made its way to Latrobe Brewing in Latrobe, Pennsylvania, the producers of Rolling Rock, a lawyer was soon on the phone to Reid. This snag necessitated a name change to Triple Rock, which honors the brewery's three regular house beers, Pinnacle Pale Ale, Red Rock Ale and Black Rock Porter.

I was met at the brewery by head brewer Rodger Davis who related the story of the brewery and gave details about their beers. Rodger began his brewing odyssey in 1991 by camping with some neighbors and discovering that they were homebrewers. The very next week he went to the local supply store and bought everything he needed for his first batch. Six years later, still brewing at home, he decided that he could make a career of this hobby and enrolled in the Siebel Institute. Since then he has brewed for San Francisco Brewing, Pyramid Brewing, Drakes Brewery and for this past year at Triple Rock.

We sampled the Dragon's Milk Brown while he described the profile and ingredients. This beer is designed to be in the upper parameters of an American Brown Ale. It is definitely malt forward with some slight coffee notes created by the roasted barley. The high alpha magnum hops provide an "in your face" bitterness that is balanced by the chocolate and crystal malts. Rodger ferments all of his ales on the cooler side at 65 °F (18 °C) in order to deter ester production and recommends you do the same.

Larry, you'll no longer have to fight that brutal Bay Area traffic to get your favorite beer because now you can "Brew Your Own."

For further information about the Triple Rock Brewery and their selection of other fine beers visit the Web site at www.triplerock.com, call them at 510-843-2739 or stop in at 1920 Shattuck Avenue in Berkeley and have a pint.

Triple Rock Brewery Dragon's Milk Brown Ale
(5 Gallons/ 19L. extract with grain)
OG = 1.068 FG = 1.016
IBUs = 55 SRM = 27 ABV = 6.8 %

Ingredients
6.6 lbs. (3 kg) Briess light, unhopped, malt extract
1.1 lbs. (0.49 kg) Briess dried malt extract
1.5 lb. (0.68 kg) crystal malt (75 °L)
0.25 lb. (0.11 kg) chocolate malt
0.25 lb. (0.11 kg) roast barley (450 °L)
11.2 AAU Magnum pellet hops (60 min.) (0.8 oz./23 g of 14% alpha acid)
4.3 AAU Cascade pellet hops (30 min.) (0.75 oz./ 21 g of 5.75% alpha acid)
3.25 AAU Chinook pellet hops (0 min.) (0.25 oz./7 g of 13% alpha acid)
3.2 AAU Simcoe pellet hops (0 min.) (0.25 oz./7 g of 12.8% alpha acid)
½ tsp. yeast nutrient (last 15 minutes of the boil)
½ tsp. Irish moss (last 15 minutes of the boil)
White Labs WLP001 (American Ale) or Wyeast 1056 (American Ale) yeast
0.75 cup (150 g) of corn sugar for priming (if bottling)

Step by Step
Steep the crushed grain in 1.5 gallons (5.7 L) of water at 150 °F (65.5 °C) for 30 minutes. Remove grains from the wort and rinse with 2 quarts (1.8 L) of hot water. Add the liquid and dried malt extracts and bring to a boil. While boiling, add the hops, yeast nutrient and Irish moss as per the schedule. Now add the wort to 2 gallons (7.6 L) of cold water in the sanitized fermenter and top off with cold water up to 5 gallons (19 L). Cool the wort to 75 °F (24 °C). Pitch your yeast and aerate the wort heavily. Allow the beer to cool to 65 °F (18.3 °C). Hold at that temperature until fermentation is complete. Transfer to a carboy, avoiding any splashing to prevent aerating the beer. Allow the beer to condition for one week and then bottle or keg. Allow the beer to carbonate and age for two weeks.

All-grain option:
This is a single step infusion mash using a total of 12.25 lbs. (5.6 kg) 2-row pale malt. Mix the crushed grains with 3.75 gallons (14 L) of 168 °F (75.5 °C) water to stabilize at 150 °F (65.5 °C) for 60 minutes. Sparge slowly with 175 °F (79 °C) water. Collect approximately 6 gallons (23 L) of wort runoff to boil for 60 minutes. Reduce the 60 minute hop addition to 0.7 oz. (20 g) Magnum pellet hops to allow for the higher utilization factor of a full wort boil. The remainder of this recipe and procedures are the same as the extract with grain recipe. Note: If the Simcoe variety of hops is not available in your area, substitute Cascade.

Homebrew CALENDAR

September 12
Blue Ridge Brew Off (Asheville, North Carolina)

The Mountain Ale & Lager Tasters [MALT] homebrew club annually produces this competition in Asheville. The competition serves as a qualifying event for the North American Masters Championship of Amateur Brewing (MCAB) and the Carolina (CBoY) regional honors: brewer of the year, master brewer of the year, club of the year, and mead maker of the year. An award will be given in memory of Dr. George Fix, one of MALT's esteemed members, for the highest scoring entry from a beginning homebrewer. Entries are $6 and the on-line deadine for applicants is September 6. Visit http://maltsters.org/GeneralInfo2009.htm for more info.

September 18–19
Northern California Homebrewer's Festival Dobbins, California

The annual NCHF features live music, raffles, nationally known speakers, a club-only homebrew competition and the state's only Brewer's Dinner. The event takes place at the Lake Francis resort. Festival tickets include Friday and Saturday camping. Reservations must be made in advance for the Brewer's Dinner. For more information: http://www.nchfinfo.org/index.html.

September 1–October 10
Seven Bridges Cooperative National Organic Brewing Challenge Registration

Organic homebrewers get a chance to face off head-to-head in this AHA/BJCP sanctioned competition. Contest judging will take place on October 18. Brewers can enter in either the homebrew division or craft brew division for a fee and have several styles of beer in which they may compete. Winners will receive prizes as well as a chance to have their own recipe published on the Seven Bridges recipe page. For more information: http://www.breworganic.com/Competition/index.html.

BEGINNER'S block

Your First Cider

by Betsy Parks

Shorter days and crisper nights may signal the end of summer, but they are also the classic signs for the beginning of apple season. This fall, take a break from barley and try making a batch of your own hard cider.

What it's made from

Hard cider is, of course, made from fresh apple cider, but not all fresh ciders are the same. Store-bought ciders often contain preservatives like sodium benzoate or potassium sorbate, which will prevent the yeast from fermenting the juice. Try finding a local cidery that can provide you with fresh, unadulterated cider. If you can't find a local producer that doesn't include preservatives, look for cider in the store that contains no preservatives.

As for yeasts, many cider makers use winemaking strains, such as Champagne or Premier Cuvee, however there are also specific strains available through your local homebrew supplier that will work well, such as White Labs WLP775 English Cider or Wyeast 4766 Cider™ yeast.

If you want, you can also make a cider starter with about a pint of the cider mixed with your yeast, adding cider gradually as the yeast multiplies until you have about a quart of starter. For more information about making a yeast starter, read "Making a Yeast Starter" in the July-August 2007 issue of BYO.

Technique

Recipes for hard cider vary, but the method can be approached a few ways: by directly fermenting the cider without heat and relying on wild yeasts, or by heating the cider, chilling and adding yeast. The first method requires either fresh, unpasteurized cider or cider that was irradiated by ultra violet light, which is often referred to as cold pasteurization. This process kills pathogenic bacteria such as E. coli, but does not kill the wild yeast from the apples. Making cider with wild yeast can produce unpredictable results, however. Adding cultured yeast to unfermented cider that contains wild yeasts may also produce unpredictable results. Also, if you are using unpasteurized cider, it is a good idea to heat it enough to kill any unwanted, harmful bacteria, so the heated method is a better choice for beginning cider makers. Heating does not, however, mean boiling, as this will cause pectins present in cider to gel, which will make your finished cider cloudy. Simmer the cider at about 160 °F (71 °C) and hold it there for at least fifteen minutes. After that, chill it to somewhere below 80 °F (27 °C), transfer it to a sanitized fermenter, aerate it well and pitch the yeast. After about seven to ten days, rack the cider off of the dead yeast cells into a secondary fermenter, preferably a carboy, and seal the top with an airlock and bung.

Once in the secondary, the cider will need to ferment for about two more weeks. When the cider has fermented to dryness, you can bottle it. If you want to make a sparkling style, add ¾ cup of corn sugar and a package of Champagne yeast to a 5-gallon (19-L) batch. If you plan to make the cider sparkling, however, be sure to use sparkling-wine style bottles that can be capped with crown caps as the pressure may cause regular wine or beer bottles to explode.

Web extra:

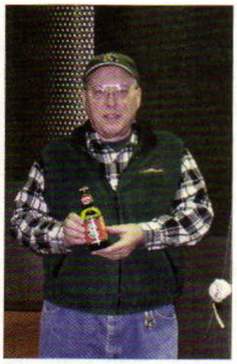
For even more details about making cider, check out BYO on the Web at **http://byo.com/component/resource/article/142**

Super Cider

Advice for making great hard cider

by Betsy Parks

In the fall, apples are everywhere, so why not take a break from beer and try making a batch of hard cider? Before you start, however, take some tips from this issue's three hard cider makers who will tell you that all apples were not created equal when it comes to fermentation.



GREG FAILING, Cidermaker, Technical Manager at Green Mountain Beverage, makers of Woodchuck Draft, Strongbow, Cider Jack and Woodpecker English Cider. Greg started his career in winemaking in the Finger Lakes area of NY in the early 1970s and worked in the labs of Gold Seal Vineyards. Over the next nine years he worked his way into the head winemaker position and then moved on to Canandaigua Wine Company in Canandaigua, New York. Joe Cerniglia later invited him to Vermont to make apple wines and create the Woodchuck line of hard ciders. He has been making the apple wines and ciders for the last 23 years.

We make both a New England and a slightly more English style cider. The Woodchuck line was designed to be very American and the amber is sweet, fruity and easy to drink. When we created the product there was no real cider category in the US market and I knew most Americans thought of cider as the stuff coming off the press in the fall. It was not until later that we came up with a cider aimed at the beer drinkers (802) and then one for the wine drinkers (Granny). The other part of our product line is Cider Jack, which is designed to be similar to the European style.

We ferment our ciders with a derivative of the Champagne yeast, but any white wine yeast that is designed to maintain the original character of the juice will work. The advantage with a full size professional operation is that we can have temperature control of the tanks and large-scale filtration. Most of our cider is cold settled after fermentation and then it is filtered through a very tight filter. This removes any solids and the residual yeast.

The easiest way to clarify cider at home is to chill the product after the fermentation so that the yeast will settle to the bottom. The product needs to be racked at least once after it settles to be sure the product is as clean as it can get. Remember that during this time the product is susceptible to infection and oxidation and one should add SO_2 to keep it safe. SO_2 can often be found in the form of tablets or powdered potassium metabisulfite. Follow the directions so you do not get too much, as it affects the taste, but you need to have enough to keep the product healthy.

The most common problem I've seen in cider making is having no temperature control on the fermentations. If they get too hot they can develop strange characters. Getting the product as clear as possible after the fermentation is also important. If the product sits on the yeast and solids for too long, it can start to pick up off characters as the yeast and solids breakdown.

When making small batches of cider at home, the biggest consideration is to have clean equipment and healthy juice. Using barrels and other items that cannot be cleaned is a good way to end up with many gallons of cider vinegar, which might not be bad if that is what you actually wanted, but won't satisfy your craving for hard cider.

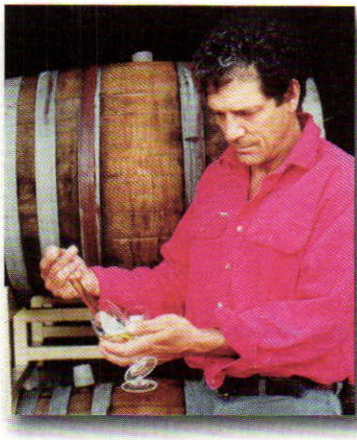
ANDREW BROWN, cider maker at Blue Mountain Cider, Milton-Freewater, Oregon. Andrew studied enology at Walla Walla Community College in Washington state and later went on to work for three years as Cellar Master for Saviah Cellars (also in Walla Walla, Washington) for two years as the Assistant Winemaker and a year as the Winemaker for Watermill Winery in Milton-Freewater, Oregon.

The varieties I feel make the best cider are the old English cider varietals, such as Foxwhelp and Braeburn, as well as some that are common to the US like New Town Pippen. The main thing to look for in a cider apple is above average glucose and fructose levels, lower pH and high acidity. Choosing apples is a balancing act between acidity and sweetness to get the mouthfeel where you want it.

I use dry Champagne or dry wine yeasts for cider because nutrient deficiencies don't affect the yeasts as much — EC 1118 is a good one. Definitely experiment as much as you can with small batches. If you don't have the time to try different yeast strains, choose a yeast that isn't temperamental.

Clarifying all depends on the style of cider you're going to make. We have experimented and used all kinds of ways to clarify our ciders, including cold stablization, bentonite and different enzymes to break down proteins and pectins. My preferred method is bentonite because I end up with the least amount of loss but get the best clarification.

Probably the most common mistake when making cider is trying to ferment with a lack of nutrition in the cider. Backyard apple trees may not yield the correct nutrients. Look to your local brew supply store for someone with knowledge about making ciders.



STEPHEN WOOD, owner and cidermaker for Farnham Hill Ciders at Poverty Lane Orchards in Lebanon, New Hampshire. Stephen grew up growing and raising apples in Lebanon since 1965. During the past ten years he has transformed the orchard from a commercial grower-packer-shipper of common apple varieties into a specialized orchard and cidery featuring both antique and cider apple varieties.

I believe that choosing apple varieties is the most fundamental part of making cider. Like wine and unlike beer, if you follow a relatively low intervention method, the fundamental thing you get is an expression of what you started with. I like to use a blend of varieties, including some bittersweets, which are high in sugar and high in tannins that bring a tannic structure to the cider that is not available from other varieties. Some examples include Dabinett, Yarlington Mill, Somerset Redstreak and Bramto. Bittersweets tend to be very low in acid, however, so to get the palate-cleansing acid I use varieties like Esopus Spitzenberg, Ash Mead's Kernel and Wickson. Finally I also use varieties that add a fruity characteristic such as Golden Russet. It is important to note that apples that make a great eating or cooking apple, or even a cider apple, may not make the best hard cider. For example, Macintosh changes entirely when it's introduced to yeast.

We use Pasteur Champagne yeast, which is readily available from manufacturers like Red Star and Lalvin. Do not use brewer's yeast — you are fermenting something very different than beer. The main objective to us is to allow the fruit to express itself. We did a lot of yeast trials for years looking for a yeast that didn't sing its own song in the cider, and the Champagne yeast works best.

If you want to make a small batch of cider, try locating a cider producer that presses the kind of apples that make good hard cider. Every year while we are pressing cider, we make a small tank of a few hundred gallons of the sort of juice that makes good hard cider, and we collect a substantial collection of customer carboys and corney kegs to fill. The fruit is the main thing — just going to an orchard and buying some cider is just not a good bet no matter how good that cider is.

Also, when you're first starting out, don't add stuff. Just because your grandfather added a quart of maple syrup doesn't mean you should too. It's like salting your food before you taste it. If after you are finished you want that flavor, go for it, but in the beginning just make cider and see how you like it first.

Soaking Whole Hops

"Help Me, Mr. Wizard"

Squeezing grain bags, going all-grain

by Ashton Lewis

Whole hop problem

I am on a quest to maximize the volume of beer I produce with each session, ultimately filling each corny keg to max capacity. As such, I am in the process of defining and marking volume levels in my various brewery vessels (kegs, carboys and boil kettle). I use a recycled commercial keg for the boil, modified with cutoff top, spigot and dip tube. When it came to determining the volume of dead space in the kettle below the dip tube, I ran into a conundrum using whole hops. How do soaking hops factor into this? Do they displace any appreciable volume of wort? My instinct from observing the floating hops is that the effect should be negligible (which would not be true if the hops submerged completely). Do pelletized hops behave any differently?

Todd Morgan
Olympia, Washington

I like the idea of marking all of your vessels so that you know the volume of what you are brewing at various steps. When you consider the fixed time required to brew a batch of beer it certainly makes sense to want to maximize your yield per batch. It also makes it much easier to hit your targeted original gravity and also to track yield if you're into crunching numbers.

Wort losses after boiling are important to brewers of all sizes and wort loss in trub can be significant, especially in very hoppy beer. In my experience, wort losses are minimized by having a good method of separating hops from wort. To directly answer your question, hops do not displace much liquid and your vessel calibration should not have much error when you begin adding hops because there are simply not much hops added to wort, even in very hoppy beers.

Where things can become difficult, however, is when it is time to separate the wort from the hops. Carrying hops forward into fermentation is typically something that is intentionally minimized. Brewers using pelletized hops usually do this by using some sort of whirlpool method. Giving the wort a good stir after the boil has stopped works reasonably well in the type of kettle you have. The idea is to get the hops to form a mass at the bottom of the kettle where they hopefully remain while the wort is removed. In high gravity beers this doesn't work so well because the hops are more buoyant due to the higher wort gravity. Couple this with the use of certain special malts and a high hopping rate and wort losses increase compared to a "normal" brew.

Reducing wort loss is one benefit of using cone hops. Since cone hops are removed with a strainer of sorts, wort loss is typically proportional to hopping rate because dry hops will absorb a given amount of wort per ounce. A hop strainer also acts as a filter for trub, and if wort gently flows through the hops retained in the strainer much of the hot break formed during boiling will be contained in the hop bed. If you are interested in doing something like this you could easily add a screen in your kettle and your wort losses will be minimized. Some brewers may be tempted to squeeze the spent hop bed to remove as much wort as possible, but this practice is not advised as it can extract stuff, like trub, that is best left behind.

Squeezing grains

My brewing crew always does extract brewing with steeped specialty grains. When we take the bag out of the water, we always squeeze the bag with tongs to get out the remaining liquid. In Jamil Zainasheff's "Irish Red" column in the March-April 2009 issue of *BYO*, however, he specifically instructs the reader to rinse the bag with warm water and warns against squeezing the bag. Why? Does squeezing the bag add undesirable elements of the grain to the water?

James Mulvenon
Burke, Virginia

I too was once a squeezer and quickly discontinued the technique because of what many brewers have learned about this practice; better beer is brewed by avoiding the squeeze. The two primary compounds that are extracted from malt during mashing and steeping are soluble carbohydrates and proteins. During exposure to hot water, some of the soluble proteins precipitate. In brewing lingo this is trub. When grains are used in a mash, most of the trub precipitated during the mash remains in the spent grain bed. Most brewers who mash recirculate the wort back into the mash until clarity is achieved. The reason this is required is that it takes some time for the mash bed to set up as a filter. Once clarity is achieved, clear wort is run to the kettle.

When specialty malts are steeped in a grain bag the grains really do not behave as a filter and trub is not filtered from the wort, as is the case when a mash tun or lauter tun is used to separate spent grains from wort. Nonetheless, some of the trub is retained in the grain bag. By squeezing the grain bag more trub and cloudy wort is moved into the wort. This is why gently rinsing the bag with hot water is suggested instead of squeezing; it also extracts more of the good stuff from the grain bag.

An argument could also be made that squeezing the grain bag may also extract more polyphenols from the specialty malts. I am not sure that this actually happens, but it is another reason not to squeeze the bag. You can also end up with some small malt particles in the wort if your mechanical method is too aggressive.

Regional techniques

One of the steps I was taught while learning to homebrew was something called a "protein strain." This involves scooping the foam from the wort as it begins to boil. I don't know if this is just a local custom or not. I've never read anything about this process, but even the brewer/owner of our local pub performs this procedure in his 10-barrel system. Is it really necessary? What would happen if I didn't do this?

Richard Gleason, Jr
Visalia, California

I am always amazed at the various techniques that brewers use and how many techniques seem to be grouped in clusters around the originator of the technique or the brewer who brought a new technique to an area. I have heard of brewers using this technique and can honestly say that I have no idea why it is used. Maybe the idea is to remove coagulated protein as it rises to the surface of the boiling kettle simply because it can be removed. Or maybe the idea is to reduce foaming during the boil or improve hop utilization.

What I can tell you is that almost all of the beer you buy at a store or bar is not brewed using this technique. Most commercial brewers bring their kettles to a boil and do very little during the boil aside from adding hops and preventing boil-overs by either controlling steam flow to the kettle or spraying water on rising tides of foam before it can escape the kettle. Trub is formed during the boiling and this trub is typically removed before fermentation begins.

The most common method used to remove trub after boiling is by the whirlpool method. Most modern breweries, whether using cone or pelletized hops, have whirlpool vessels. The method of use is very simple; wort is pumped into the whirlpool through a tangential fitting sized to produce an inlet velocity of about 10 feet/second. As the wort spins, a pressure differential is established resulting in the collection of solids in the center of the vessel. For brewers using pelletized hops, the whirlpool method also removes any hop residue.

Since I have never used the protein-strain method I cannot really tell you what will happen if you choose not to skim the protein during the boil. I can guarantee you will not end up with some sort of unexpected brewing disaster. Personally, I am one of those brewers who likes to get things started in the right direction, set the timer, then come back periodically to see how things are going.

Aside from the old saying that a watched pot never boils, which of course is not true (see you can learn something practical by reading my column!), I don't find hovering over the kettle during the boil to be all that exciting. But the corollary to the watched pot saying is that an unwatched brew kettle almost always boils over; so you see, it's a classic Catch-22. Maybe the protein strain was something developed by a clever mathematician to resolve this paradox and allow the kettle to boil while being watched and thus preventing boil-overs, since you're technically not watching, but skimming it. By the way, at Springfield Brewing Company we use a foam switch to prevent boil-overs and kettle watching, thereby killing two birds with one stone. That's three clichés in one paragraph for a new Mr. Wizard record!

Going all-grain

I have been extract brewing for two years and want to go all-grain, but I'm hung up on the grain bill. I have read in *BYO* that certain grains can only be mashed while others can be both mashed and steeped. I have found various charts similar to *BYO*'s grain and adjunct chart, but none of the charts state how the grains must be utilized. I would also like to know how to tell the difference between base malts and specialty malts, and what percentage of the grain bill needs to be a base malt. Is there a comprehensive chart or resource that I'm missing? Any help to get me over my brewing speed bumps would be great!

Jason Trever
Rancho Cucamonga, California

This question reminds me of my own questions before I did my first all-grain brew. I don't know why all-grain brewing seems so intimidating. One reason may be all the hype that all-grain brewers generate by so many technical nuances of what happens and what can go wrong when conducting a mash. Then you throw in one of the flow charts about which grains can be used as base malts and how much crystal malt, for example, can be used before you end up with the world's least drinkable beer and mashing just seems so intimidating that it's a wonder any brewer who reads all of these things ever musters enough courage to conduct a mash.

Luckily, there is no giant master chart attempting to present every combination of possibilities that a brewer may want to attempt when mashing. What you do have at your finger tips is an enormous collection of recipes assembled in books and posted online. For a brewer just getting into mashing, I suggest using proven recipes because you can focus on getting the mashing technique down before you begin improvising. This may seem boring, but brewing is like any other art that requires technique. Jimi Hendrix didn't play "Voodoo Chile" the first time he picked up a guitar and you (hopefully) won't be using some bizarre grist bill requiring a complete chart of what can and cannot be done in the mash tun.

When you start to formulate your own recipes you can learn an awful lot about your ingredients by reading their analytical specifications. In order for these to make sense you will need a basic understanding of what goes on during mashing. Again, this information is stuff you need to know once you throw away the sheet music and begin writing your own songs. Basically you need a mixture of starch, which must be gelatinized before it is broken down by enzymes, and amylase enzymes to conduct a mash. Some special malts have little to no enzymes because they are destroyed during kilning. In the category of special malts with no enzymes, some contain starch, some contain caramelized sugars and some mainly contain what amounts to either burnt starch or burnt sugar. The latter two types of grains are typically not used at rates above about 15% because anymore doesn't taste all that great and they can be used without mashing. Special malts that contain starch but no enzymes need to be used alongside a malt that does contain enzymes.

The backbone of most beers is what is generically known as pale malt. There are many different pale malts used by brewers, for example pale two-row malt, pale six-row malt, ale malt, Pilsner malt, etc. A few things these grains have in common are sufficient enzymes to convert their starch into fermentable sugars and low-to-medium toasted flavors from kilning.

Brewers wanting to enhance these base malts use special malts for color and flavor. Special malts usually make up less than about 25% of the total grist bill. Some special malts like Munich malt do contain enzymes and these can sometimes, depending on the color and enzyme level, make up the entire grist bill for a brew. German rauchmalz is a special type of

Munich malt and rauchbier from Bamberg is about 95% rauchmalz.

Brewers wanting to lighten the body, color and flavor intensity of beer often use starchy adjuncts, mainly corn or rice, to dilute the flavor of malt. As with special malts, adjuncts usually account for less than 25% of the grist bill. The reason for this is that adjuncts and most specialty malts do not contain enzymes and dilute the enzyme concentration of the mash. By the way, brewers from the UK often refer to specialty malts as adjuncts, since they supplement the main ingredient or pale malt and that, in simple terms, is what the term adjunct literally means.

Now if you really want to push the limit with using special malts and adjuncts you may need to boost the enzyme content of your mash. You can do this in large part by selecting pale malts that have a very high content of amylase enzymes. Six-row malt is the most notable example, but brewers need to remember that wheat malt is also usually very enzyme rich. You can also reach for the bottle and augment the enzymatic content of your base malt with exogenous enzymes that are usually the product of fungal fermentation. Some brewers unaffectionately use the term "industrial enzymes" to describe these products, probably because it reminds one of the stuff added to laundry detergents to remove really nasty stains. Another way to add adjuncts without worrying about enzymes is using sugar or special syrups formulated for brewing. But I don't think that is exactly what you were thinking with your question.

I do suggest two sources of information that I think will help give some direct answers to your question about usage rates. Check out www.brewingwithbriess.com and www.weyermann.de. Both of these websites have product specifications on various special malts, recommendations on usage rates and insight into what beer styles the grains may work with.

When to move

I've been fermenting for two weeks in a single, primary vessel and then bottling. This affords me the luxury of tasting and judging my efforts sooner as well as freeing my equipment so I can brew more often, plus it requires less effort than racking to a secondary. But am I short-changing myself and sacrificing the flavor of my beer? When does it become necessary to remove the beer from the yeast trub so as to avoid off-flavors due to autolysis?

Nathaniel Letcher
Iowa City, Iowa

You want a short answer so that you can focus on the basics. This is an excellent question and I will begin my stating that my answer does not have anything to do with sour beers or beers that use *Brettanomyces* because long aging with yeast and or bacteria is required for these styles. When you ferment beer I suggest getting your fermentation complete, as indicated by checks using a hydrometer, going through a diacetyl/acetaldehyde reduction step, chilling the beer to knock most of the yeast out of solution and racking into the bottling bucket or keg. Most beer styles do not benefit from extended contact with the large amount of yeast that is created during the early stages of fermentation.

Assuming that you bottle condition, you do want some viable yeast to be present in the bottle so that carbonation will occur. If you wait too long yeast viability will definitely begin to fall. The nice thing about bottle conditioning is that beer does continue to age or "ripen" in the bottle and you are not preempting anything by putting your beer in its final container before months of aging, provided that some viable yeast is in the bottle.

You can equate bottle conditioning to lagering if done right since a bottle of beer with yeast and a small amount of fermentables is not much different from a lagering tank or cask of ale. The two main differences are that lagering tanks and casks are vented and are larger than a bottle. You do not want to rack a stinky brew with immature aromas, namely sulfur notes, into a bottle because these aromas will not escape. This is not true when examining lagering tanks and casks. That difference aside, if you complete fermentation, give your beer about a week for a diacetyl/acetaldehyde reduction step and a few days in the cooler to knock the bulk of yeast to the bottom of the fermenter, your bottle conditioned brew can finish its journey and is ready to drink when your palate dictates.

Strong beers are different because they usually don't finish with the speed of beers that have an original gravity less than about 15 °Plato (1.060). Your hydrometer checks may indicate that several weeks are required for fermentation to be complete. Add another week or so to this time table and your beer may be well over a month old before bottling. For these beers it is common to add a small dosage of fresh yeast to the bottle to facilitate carbonation, because the viable yeast that remains typically have reduced vitality, and barring a dose of ED medication, may not be up for much action in the bottle.

I don't believe in nonchalant brewing. Bottling beer "whenever" translates to lack of planning. Yeast autolysis does happen; when you learn to reliably pinpoint its flavor you will know that many beers bottled when someone remembered about the batch in the lower 40 have an autolyzed note . . . and sometimes a whole bloody chorus belting out Soy Sauce Sally!

Brew Your Own Technical Editor Ashton Lewis has been answering homebrew questions as his alter ego Mr. Wizard since 1995. A selection of his Wizard columns have been collected in "The Homebrewer's Answer Book," available online at brewyourownstore.com.

Do you have a homebrewing question for Ashton? Send inquiries to *Brew Your Own*, 5515 Main Street, Manchester Center, VT 05255 or send your e-mail to wiz@byo.com. If you submit your question by e-mail, please include your full name and hometown. In every issue, the Wizard will select a few questions for publication. Unfortunately, he can't respond personally. Sorry!

Berliner Weisse

A sour summer refresher

by Jamil Zainasheff

When I was still a neophyte in the beer geek world I didn't quite understand the attraction of sour beers. Most of the sour beers I tried didn't seem balanced or pleasant to my young palate. However, I was determined to understand and appreciate every BJCP style, including the sour ones like Berliner weisse. This was back in the day when it was still reasonably easy to get your hands on Schultheiss Berliner Weisse and Berliner Kindl Weisse and I had about two liters of each. The first time I sampled them, they didn't thrill me. Their primary characteristics were lactic sourness, a thin body, and not much more. But a few weeks later, after the heat of summer kicked on, I tasted more Berliner weisse along with some barbeque. As luck would have it, Berliner weisse is an excellent match for the sweet, smoky, slightly fatty barbeque meats, and also the heat of summer. Suddenly it became clear why someone would enjoy this style. Summer is a time when drinks like lemonade are popular. Tart and refreshing is very pleasing when the days are hot and sweaty.

Most brewers avoid brewing sour beers and I guess I'm really not very surprised. After all, we are told from day one that we should do everything we can to keep bacteria out of our beer. Sour flavors are a flaw, right? Most sour beers are made with bacteria and bacteria are nasty, right? While sour beers may not be for every palate, well made sour beers are far from nasty; they can be pleasant, balanced and supremely drinkable.

Berliner weisse is a sharply sour, somewhat acidic, low-alcohol beer. It has a light body, a dry finish, and spritzy carbonation. The color ranges from white to very pale straw. It can be clear to hazy and has very little head retention. A sour character dominates both the flavor and aroma. Rounding out the character of the beer is often bready or grainy notes and sometimes fruity and floral notes. However, these are subtle background notes at best. This beer has a "clean" ale character, not a heavily estery or funky one that reminds you of a barnyard. There may be a mild *Brettanomyces* character, but it should be no more than a background note. It is a mistake for this to be anything other than clean. It should not be phenolic. It should not be acetic. It shouldn't be bitter or have any hop character either.

The grist for Berliner weisse is very simple, just a blend of continental Pilsner and wheat malts. The ratio can be anything from 40/60 in favor of wheat or Pilsner or anything in between. Many people use a 50/50 blend, but I prefer to go a little heavier toward the Pilsner malt. If you want to do well in competition, the beer must show enough of the sweet grainy character of the continental Pilsner

BERLINER WEISSE by the numbers

OG:	1.028–1.032 (7.1–8.1 °P)
FG:	1.003–1.006 (0.8–1.6 °P)
SRM:	2–3
IBU:	3–8
ABV:	2.8–3.8%

RECIPE

Berliner Weisse

Saures Biergesicht

(5 gallons/19 L, all-grain)
OG = 1.032 (8.2 °P)
FG = 1.006 (1.5 °P)
IBU = 4 SRM = 3 ABV = 3.5%

Ingredients

3.75 lb. (1.7 kg) Durst continental Pilsner malt 2 °L
2.75 lb. (1.24 kg) Great Western wheat malt 2 °L
3 AAU Hallertau hops (0.75 oz./ 21 g at 4% alpha acids) (15 min.)
White Labs WLP011 (European Ale) or Wyeast 1338 (European Ale) yeast
White Labs WLP677 (*Lactobacillus* Bacteria) or Wyeast 5335 (*Lactobacillus delbrueckii*) yeast

Step by Step

I use Durst Pilsner malt and Great Western Malting Co. wheat malt. Feel free to substitute any high quality malt of a similar flavor and color from a different supplier.

Mill the grains and dough-in targeting a mash of around 1.5 quarts of water to 1 pound of grain (a liquor-to-grist ratio of about 3:1 by weight) and a temperature of 149 °F (65 °C). Hold the mash at 149 °F (65 °C) until enzymatic conversion is complete. Infuse the mash with near boiling water while stirring or with a recirculating mash system raise the temperature to mash out at 168 °F (76 °C). Sparge slowly with 170 °F (77 °C) water, collecting wort until the pre-boil kettle volume is around 5.2 gallons (19.7 L) and the gravity is 1.031 (7.9 °P).

Once the wort is boiling, add the bittering hops. The total wort boil time is 15 minutes after adding the bittering hops. No kettle finings are needed. Chill the wort to 67 °F (19 °C) and aerate thoroughly. Pitch

1 package of the liquid yeast and liquid bacteria at the same time or give the bacteria a couple days head start if you want more of a sour profile to your beer.

Ferment around 67 °F (19 °C) until the yeast drops clear. Transfer beer to a separate vessel with minimal head space and allow sourness to develop further. This may take a month or more depending on conditions. Rack to a keg and force carbonate or rack to a bottling bucket, add priming sugar, and bottle. Make sure you use very stout bottles and lots of caution if you're going to try and naturally carbonate this beer in bottles. It can be very dangerous. Target a carbonation level of 3.5 to 4 volumes.

Saures Biergesicht

(5 gallons/19 L, extract)

OG = 1.032 (8.1 °P)
FG = 1.006 (1.5 °P)
IBU = 4 SRM = 3 ABV = 3.5%

Ingredients

- 4.6 lb. (2.08 kg) wheat liquid malt extract
- 3 AAU Hallertau hops (0.75 oz./ 21 g at 4% alpha acids) (15 min.)
- White Labs WLP011 (European Ale) or Wyeast 1338 (European Ale) yeast
- White Labs WLP677 (*Lactobacillus* Bacteria) or Wyeast 5335 (*Lactobacillus delbrueckii*) yeast

Step by Step

I use the wheat blend extract my homebrew shop carries. Almost any wheat extract will work just fine. Always choose the freshest extract that fits the beer style. If you can't get fresh liquid malt extract, it is better to use dried malt extract (DME) instead.

Mix enough water with the malt extract to make a pre-boil volume of 5.2 gallons (19.7 L) and a gravity of 1.031 (7.8 °P). Stir thoroughly to help dissolve the extract and bring to a boil.

Once the wort is boiling, add the bittering hops. The total wort boil time is 15 minutes after adding the bittering hops. No kettle finings are needed. Follow the fermentation and packaging instructions for the all-grain version.

Ferment around 67 °F (19 °C) until the yeast drops clear. Transfer beer to a separate vessel with minimal head space and allow sourness to develop further. This may take a month or more depending on conditions. Rack to a keg and force carbonate or rack to a bottling bucket, add priming sugar, and bottle. Make sure you use very stout bottles and lots of caution if you're going to try and naturally carbonate this beer in bottles. It can be very dangerous. Target a carbonation level of 3.5 to 4 volumes.

Web extra:

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for the average judge to detect. While that isn't really a requirement, most judges treat it as one. If competition interests you, approximately 60% continental Pilsner and 40% wheat is the blend that seems to work in front of many judges.

Traditionally, this beer is made via single decoction with mash hopping, but with today's highly modified malts a single infusion mash is fine. A lower mash temperature of 149 °F (65 °C) assures plenty of easily fermentable sugars.

If you're brewing with extract, you can use any wheat blend on the market. They will each have their own character. If you are particularly interested in dialing-in your blend, you can try to source wheat malt extract and continental Pilsner malt extract in the proportions you want, but it is far easier, and just about as good, to go with one of the prepared blends that your homebrew shop has for making a German style wheat beer.

There isn't a need for any other grain or malt. Some folks add things like crystal malt or dextrin type malts, but they are either inappropriate or unnecessary. Don't over think it or overdo it, keep it simple.

Use any German hop in this beer. If you want to be picky about it, noble hops are the way to go, but really not necessary. Just avoid anything with bold aroma or flavor compounds, such as citrusy American varieties. The bittering level is in the range of 3 to 8 IBU. It is really just enough background bittering to provide some subtle firmness, but not enough to make the beer seem bitter in any way. Keep in mind that there is very little malt sweetness to balance, so you need to be careful on the bittering level. A bitterness to starting gravity ratio (IBU divided by OG) around 0.1 should be plenty.

While a decoction mash and no boil may be traditional, I prefer to give my Berliner weisse a short boil to kill any unwanted organisms in the wort. That way I'm starting with a clean slate. The drawback to boiling is the formation of DMS (Dimethyl Sulfide). Lightly kilned Pilsner malt contains SMM (S-Methylmethionine). Above 140 °F (60 °C) SMM is converted to DMS, which is often described as a cooked corn or vegetable aroma. The half life of SMM is approximately 40 minutes and it takes about 100 minutes of boiling to completely reduce the SMM and boil off DMS to undetectable levels. Boiling for short periods of time, with wort made from lightly kilned Pilsner malt, can result in noticeable DMS in the beer. I have not run into this problem when doing a short boil for Berliner weisse, but some other brewers have reported problems with it. It may be that the malts I use and very rapid chilling of the entire wort below the 140 °F (60 °C) threshold is enough to keep the DMS character under control. If this is of a concern for you, there are a couple of

"Keep in mind that this style has no hop flavor and no hop aroma, so don't use anything other than early hop additions."

alternatives that you might want to explore. The first is no boil, with a standard mash. There is some conversion of SMM to DMS in the mash at higher temperatures, but it should be acceptable. Of course, at lower mash temperatures, some unwanted organisms may survive the mash temperatures and end up spoiling the wort in unpleasant ways. The other alternative that may work for you is decoction mashing, where the boiling of the mash kills organisms in that portion, but also can convert SMM to DMS.

If you do choose to boil the wort, the hop addition should be at the beginning of the boil. If you're skipping the boil, then you'll need to mash hop. Keep in mind that this style has no hop flavor and no hop aroma, so don't use anything other than early hop additions.

There are several ways to sour your Berliner weisse. Some folks like to avoid using any sort of bacteria in their breweries and instead add lactic acid to their beer. This method is quick and easy, you can control the amount of sourness in the beer, and the level of sourness won't change over time. However, I consider the results similar to microwaving a steak. It is fast and easy, but the taste and texture are just not the same as grilling.

Another technique for souring Berliner weisse is inoculating the wort or mash with a handful of grain. Most grain has a population of *Lactobacillus* and other critters all over it. Tossing a handful into the mash or wort and letting it sit for a day or two around 100 °F (38 °C) will develop into a sour, aromatic soup. When you boil the wort, it stops the action of the various bugs, leaving a fixed amount of sourness. This technique is quite a bit more variable than dosing with lactic acid, but it adds a nice variety of flavors other than sour. If you're lucky, the beer can be fantastic. If you're not lucky, at least the snails seem to enjoy it.

My preferred technique for Berliner weisse is to add a commercial *Lactobacillus delbruckii* culture, such as White Labs WLP677 *Lactobacillus* Bacteria or Wyeast 5335 *Lactobacillus delbrueckii*. This is as simple as purchasing the product from your homebrew shop and tossing it into the beer along with your neutral ale yeast. While the main flavor characteristic of this bacterium is lactic sourness, it also produces other subtle flavors and aromas which make a more intriguing beer than using lactic acid and it is a much more reliable way to add sourness than tossing in a handful of grain. For the neutral ale yeast, I like either White Labs WLP011 European Ale or Wyeast 1338 European Ale fermented around 67 °F (19 °C). Sourness will develop over time and is dependent on the amount of food the ale yeast leave for the bacteria. Don't rush it and be patient. Give it at least a month — and maybe several months — to see how the beer will develop. If you find that your beer is not souring enough for your tastes, then you might try adding the bacteria culture a few days before the ale yeast, to give them a head start.

Napoleon's troops referred to Berliner weisse as "the Champagne of the North" and you will want to carbonate yours along the same lines. The high level of carbonation in this style helps add a dryness and acidity to the beer. Target a carbonation level of 3.5 to 4 volumes. If you are going to bottle this beer, be very careful. High carbonation and glass bottles can result in severe injury or death.

> "If you find yourself interested in this style, you might want to do as the Berliners often do and drink your Berliner weisse 'mit schuss' or 'with syrup'."

If you find yourself interested in this style, you might want to do as the Berliners often do and drink your Berliner weisse "mit schuss" or "with syrup." A small dollop of raspberry ("himbeer") or woodruff ("waldmeister") syrup helps counter the sourness, just like the sugar in lemonade. A number of homebrew shops carry these authentic syrups and it can be fun to have them on hand (they seem to keep very well) for those guests at your next summer barbeque.

Jamil Zainasheff is host of "Can You Brew It," a show about cloning your favorite commercial beers and "Brew Strong," both of which can be found and downloaded on the Brewing Network (www.thebrewingnetwork.com). He writes "Style Profile" for every issue of Brew Your Own.

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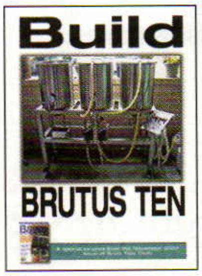

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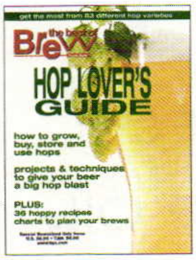

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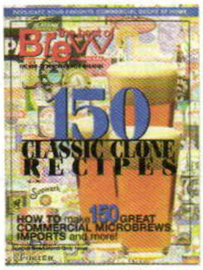

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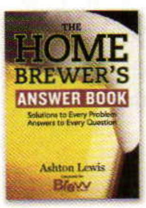

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Story by **GLENN BURNSILVER**

TORPEDOES AWAY

A NEW DEVICE FOR IMPROVING HOP OIL EXTRACTION IN DRY HOPPED BEERS.

At first glance, they appear to be leftover props from an Ed Wood science fiction B-movie: long, slender metal contraptions with rounded tops, ready to transport aliens to earth on a seek-and-destroy mission. The only problem with this scenario is that it's not an abandoned Hollywood set, but the Sierra Nevada Brewery, where these vessels are stored.

And while these mystery vessels may not be space-aged, they are certainly innovative devices for imparting hop character to beer. They are called hop torpedoes and are the latest in brewing innovation from Sierra Nevada founder Ken Grossman and brewmaster Steve Dresler. The idea for the device rose out of a growing desire, coupled with increasing consumer demand, for dry-hopped beers, including Celebration Ale and the Torpedo Extra IPA that is named after the device.

"We wanted to do something with post-fermentation hops, the dry hopping process, but stay with our historic philosophy of using only whole cone hops," Dresler explains. "Most breweries that want to do a post fermentation hopping either use pellets or extracts or oils because they are easy to use and easy on how you handle the beer. We did not want to go that route. The question was, how do you get whole hop flavor and aroma into a beer without going from one tank to another and having (to utilize) hop bags?"

For years, Dresler explains, the brewery dry hopped with giant hop bags. But even after prolonged soaks, the center of the bags typically contained dry or marginally damp hops that never really touched the beer. This poor saturation resulted in an under utilization of the volatile hop oils. Dresler knew there had to be a better system than a passive soak. The plan was to come up with a way to circulate the beer through large beds of hops.

"As we were discussing these things in meetings, Ken got together with tank fabricators and was describing things on the phone and drawing pictures on napkins," Dresler recalls. "All of a sudden we have this upright tank with proper fittings and a manway on top to hold the hops in place. We did some in-house modifications and *voilà*, there you have it. It's nothing unique or fancy. It's basically a small tank you hook up to a big tank."

HOW IT WORKS

It's what goes into the small tank that counts, hops, hops and more hops — up to 80 lbs. (36 kg) per vessel. Here's how it works: the vessel, which holds 150 gallons (570 L) of liquid, is filled with hops and then the beer from the fermentation tank is slowly pushed through it. The beer is then pumped back to the main tank. At the beginning of the circulation, the beer is at fermentation temperature (68 °F/ 20 °C), carbonated and may still have some yeast in suspension. Depending on batch size, typically between 100 and 400 barrels, the beer might pass through two torpedoes before returning to the main tank. The circulation continues — at a rate of 3 gallons per minute (11 L per minute) — for four days, during which the beer is chilled. Prior to circulation, the loop is flushed with carbon dioxide (CO_2) to minimize the amount of oxygen coming in contact with the beer.

"That's really all it is," Dresler said with a laugh. "We slowly circulate the beer through this vessel and back into the tank in the loop, and by doing so we very passively extract the volatile oils from the hops. But we do so much more effectively and efficiently than you can by having the teabag approach. We're using everything we can get out of the hops."

The torpedo is similar in many ways to a hopback (or hop jack). A hopback is a vessel that lies between the kettle and the heat exchanger. Hopbacks are packed with hops and hot wort flows through them, quickly extracting water-soluble hop oils. The wort is then chilled and fermented.

SIERRA NEVADA'S HOP TORPEDO — a device the brewery designed for dry hopping beer — holds 150 gallons (570 L) of beer and up to 80 lbs. (36 kg) of whole hops. Beer is circulated through one or more torpedoes slowly for four days, ensuring that all the desired oils are extracted from the hops. The system is flushed with carbon dioxide before use to minimize the beer's exposure to oxygen. The brewery's Torpedo Extra IPA, named for the device, is dry hopped with whole hops — a mix of Crystal, Magnum and a new hop variety called Citra.

Photos Courtesy of Sierra Nevada Brewing Company

Sierra Nevada Torpedo Extra IPA clone

(5 gallons/19 L, all-grain)
OG = 1.070 FG = 1.018
IBU = 70 SRM = 11 ABV = 7.2%

Ingredients

14 lbs. (6.4 kg) pale malt
11 oz. (0.31 kg) caramel malt (60 °L)
17 AAU Magnum hops (60 mins)
(1.2 oz./34 g of 14% alpha acids)
1.0 oz (28 g) Magnum hops (5 mins)
1.0 oz. (28 g) Crystal hops (5 mins)
0.67 oz. (19 g) Magnum hops (dry hop)
0.67 oz. (19 g) Crystal hops (dry hop)
0.67 oz. (19 g) Citra hops (dry hop)
Wyeast 1056 (American Ale), White Labs WLP001 (California Ale) or Fermentis US-05 yeast
1 cup corn sugar (for priming)

Step by Step

Mash at 152 °F (67 °C). Boil for 90 minutes, adding hops at times indicated. Ferment at 68 °F (20 °C). Dry hop for 10 days to 2 weeks or use a torpedo to add hop character.

Sierra Nevada Torpedo Extra IPA clone

(5 gallons/19 L, partial mash)
OG = 1.070 FG = 1.018
IBU = 70 SRM = 12 ABV = 7.2%

Ingredients

3 lb. 5 oz. (1.5 kg) pale malt
11 oz. (0.31 kg) caramel malt (60 °L)
4.0 lbs. (1.8 kg) light dried malt extract
2 lb. 4 oz. (1.0 kg) light liquid malt extract (late addition)
17 AAU Magnum hops (60 mins)
(1.2 oz./34 g of 14% alpha acids)
1.0 oz. (28 g) Magnum hops (5 mins)
1.0 oz. (28 g) Crystal hops (5 mins)
0.67 oz. (19 g) Magnum hops (dry hop)
0.67 oz. (19 g) Crystal hops (dry hop)
0.67 oz. (19 g) Citra hops (dry hop)
Wyeast 1056 (American Ale), White Labs WLP001 (California Ale) or Fermentis US-05 yeast
1 cup corn sugar (for priming)

Step by Step

To get the proper amount of hop bitterness, you must be able to boil 4.0 gallons (15 L) of wort. Mash grains at 152 °F (67 °C) for 45 minutes. Collect wort and add water to make 4.0 gallons (15 L). Stir in dried malt extract and bring wort to a boil. Boil for 90 minutes, adding hops at times indicated. Add boiling water if wort volume drops below 3.5 gallons (13 L). Add liquid malt extract for final 15 minutes of the boil. Ferment at 68 °F (20 °C). Dry hop for 10 days to 2 weeks or use a torpedo to add hop character.

Sierra Nevada Torpedo Extra IPA clone

(5 gallons/19 L, extract with grains)
OG = 1.070 FG = 1.018
IBU = 70 SRM = 12 ABV = 7.2%

Ingredients

1 lb. 5 oz. (0.6 kg) pale malt
11 oz. (0.31 kg) caramel malt (60 °L)
5.0 lbs. (2.3 kg) light dried malt extract
2 lb. 6 oz. (1.1 kg) light liquid malt extract (late addition)
17 AAU Magnum hops (60 mins)
(1.2 oz./34 g of 14% alpha acids)
1.0 oz (28 g) Magnum hops (5 mins)
1.0 oz. (28 g) Crystal hops (5 mins)
0.67 oz. (19 g) Magnum hops (dry hop)
0.67 oz. (19 g) Crystal hops (dry hop)
0.67 oz. (19 g) Citra hops (dry hop)
Wyeast 1056 (American Ale), White Labs WLP001 (California Ale) or Fermentis US-05 yeast
1 cup corn sugar (for priming)

Step by Step

To get the proper amount of hop bitterness, you must be able to boil 4.0 gallons (15 L) of wort. Steep grains in 3 qts. (~3 L) of water at 152 °F (67 °C) for 45 minutes. Add water to make 4.0 gallons (15 L), stir in dried malt extract and bring to a boil. Boil for 90 minutes, adding hops at time indicated. Add boiling water if wort volume drops below 3.5 gallons (13 L). Add liquid malt extract for final 15 minutes of the boil. Cool wort and transfer to fermenter. Add cold water to make 5 gallons (19 L). Pitch yeast and ferment at 68 °F (20 °C). Dry hop for 10 days to 2 weeks or use a torpedo to add hop character.

In contrast to a hopback, the torpedo is used on the cold side and extracts both water-soluble and alcohol-soluble compounds from the hops. The contact time required for the torpedo is much longer than with a hopback, and the hop oils extracted in the torpedo encounter far fewer yeast cells and do not experience a vigorous primary fermentation.

The other hop-extracting device with obvious similarities to the torpedo is the Randall. Developed by Dogfish Head, the Randall is a large canister that sits on the line between keg and tap. It is filled with hops and when a beer is drawn, it travels first through the hops, picking up some of the hop oils. Both the torpedo and the Randall filter carbonated beer through a bed of hops. The primary differences are the extended contact time with the torpedo and the fact that the beer is circulated through the device repeatedly, whereas the beer makes a single pass through the hop bed in a Randall.

TORPEDO EXTRA IPA

The result is an IPA with an intense hop aroma. The key, Dresler says, is total saturation that allows almost 100 percent utilization of hop oils, which in Torpedo Extra IPA is a combination of Crystal, Magnum and Citra.

Citra is a new hop variety that has a unique flavor profile, showing hints of gooseberry, passion fruit, lychee, grapefruit and lime. If you wish to try the clone recipe, on the facing page, you will likely have trouble finding this variety as it is new. If you can't locate a source, Amarillo may be the best substitute.

Even with 70 IBUs of bitterness, the beer does not come across as harsh, because the bitterness is backed by ample hop flavor. Although the focus of the beer is on the hops, there is just enough malt presence to make it a balanced brew.

"We can analyze the beer as we're doing it," Dresler says. "Eventually the hop oils flat line, but it's not because the beer is saturated, but that we've extracted the entire amount out of the hops."

Dresler says mastering the IPA took about two to three years, and there were a number of challenges. One was making sure the beer was well blended. This was accomplished by setting the return pipes higher in the beer.

"You're basically drawing out of the bottom, going through the hops and returning to the tank through the bottom but at a higher level," Dresler said. "We didn't want to saturate the beer with hop oils at the bottom, but by introducing the beer back higher in the tank we get a better mixing and blending as well."

Dresler also needed to fine-tune a recipe that would work well in conjunction with the vessel. The malts and boil hops were the easy part in creating this 70 IBU, 7.2% alcohol by volume (ABV) beer, he says, it was balancing the post fermentation hops that needed a lot of tweaking — something he seems to enjoy.

"I can modify the hops I'm using in the torpedo vessel to construct layers of aroma and flavor by having a quantified approach to it," he says.

"Different varieties of hops have different levels of volatile oils, so when I'm going to use the torpedo I'll rub the hops and get an idea of what hops and what percentage I want to use to end up with a really nice dry-hopped beer."

"But we've also learned that, depending on the temperature and the flow rate, you tend to extract these compounds at different times in the process," he added. "Some aromas come off very early in the circulation in the torpedo, some a little later. As we've developed this, we've learned when to hook up to the tank depending on what we want, how long we want to circulate, at what rate and at what temperature. We use all of this information to develop unique aroma profile. You can really develop some nice nuance and flavors with it."

Dresler notes that all the monitoring offers one other advantage, knowing when to cut the flow to prevent off flavors.

"We monitor everything closely," he says. "You can over circulate through the vessel and get more of a grassy, stemmy-type note. We now know when to cut that off. You take the positive attributes that give more floral notes. You're leaving some stuff behind, but it's stuff you don't want."

Dresler adds that even filtering of the Torpedo Extra IPA is reduced to prevent stripping any of the crucial hop aroma.

"We're willing to sacrifice some of that beer clarity for enhanced flavor, aroma and mouthfeel. We've left all that original hop flavor and aroma intact," he said.

"Quality of hoppiness and aroma is something we're very proud of here."

A HOMEBREWED TORPEDO?

For the homebrewer wanting to produce this beer, the biggest difficulty, naturally, would be emulating the torpedo. While certainly not against the idea of a homebrewer using something like a torpedo device, Dresler questions the need, especially when considering that homebrewers are not under a production constraint and can leave the hops on the beer for as long as one chooses. Plus, most batches tend to be relatively small.

"One of the things with homebrewing, most of the vessel sizing is relatively small," he says. "The teabag method tends to work really nicely and efficiently at this level."

Even if a homebrewer fabricated a torpedo-like device, Dresler says circulation becomes the real issue since most homebrewers rely on gravity.

"The ability to pump and circulate would be the most difficult part," he says. "But, if you can set up a pumping system in your homebrew system where you can go from a vessel into another vessel and back to another and have a canister of some type, like a filter housing, you could put hops in there and slowly pump the liquid through it. That would be kind of a way to emulate the same effect. It would be difficult at home, but if you're the gadget type of guy, it would be kind of a fun challenge to see what you can do."

One possibility for a set-up to emulate the effect of a torpedo could be assembled by almost any homebrewer who kegs his beer. If you had three Cornelius kegs, you could push beer with CO_2 pressure from one keg to another, with a keg in the middle serving as the torpedo. For this, you would hook up the full keg to the torpedo with a tube connected from the "beer out" post on the full keg to the "gas in" post on the torpedo. The torpedo would be, in turn, connected from its "beer out" post to the "beer out" post on the receiving keg. A final tube would extend from the "gas in" post on the receiving keg into a glass of water. This would serve as a gas trap, to relieve pressure on the receiving keg without letting oxygen in. The center keg — the torpedo — would contain whole hops in a dry hop bag. The torpedo and receiving keg could be flushed with CO_2 prior to pushing the beer. The full keg would, of course, be connected to your CO_2 tank and should be connected to the torpedo last, so that beer doesn't start flowing before you're ready. You may also want to let some beer build up in the torpedo before letting it start to flow into the receiving keg. This will prevent you from pushing foam from the torpedo. Beer could be pushed through the hop bed several times by simply reversing the connections once the receiving keg is full.

For the hop-headed homebrewer or inveterate gadget guy, a homebrewed torpedo could add a twist to your IPA.

Glenn BurnSilver is the Features Editor at the Fairbanks Daily News-Miner where he writes "Beer Here," a monthly beer column.

Photo by Charles A. Parker/Images Plus

all about YEAST

Brewer's yeast are living organisms that transform the wort we make into beer. Handled correctly, these yeast work quickly, consistently and produce good results. However, if they are treated poorly, the quality of your fermentations will suffer. Sluggish fermentations, poor attenuation and off flavors can all result from the improper care of your yeast. Fortunately, a little knowledge of your yeast's needs goes a long way.

Your Guide to Biology and Brewhouse Handling

We've assembled a collection of articles describing how yeast work and how they should be handled in your brewery. Chris White explains the biochemical reactions occurring in yeast that are relevant to brewing in "Yeast Metabolism." He also explains how to culture your own yeast in "Yeast Culturing." Greg Doss explains how yeast is best handled in the brew house and the ways yeast health and fermentation progress should be monitored. But first, Chris Colby reviews the basics of yeast biology and then examines how the yeast species we brew with evolved into the brewery workhorses they are today. The information here should guide you to consistent, quality fermentations.

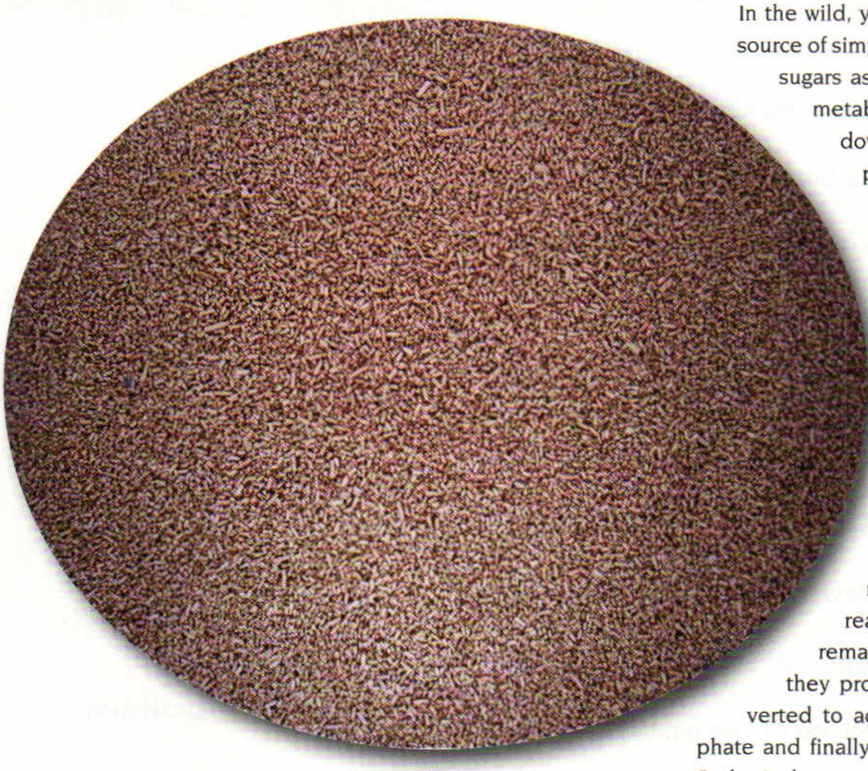
YEAST PACKAGE CONTENTS

Story by **CHRIS COLBY**

BIOLOGY of yeast

BREWER'S YEAST are living organisms. Just two species of yeast — *Saccharomyces cerevisiae* (ale yeast) and S. *pastorianus* (lager yeast) — are used in the overwhelming majority of beer fermentations.

How did brewer's yeast get so good at brewing?



In the wild, yeast live on rotting fruit, tree sap or any other source of simple sugars. Most yeast species consume simple sugars as their sole carbon source, although some can metabolize organic acids or alcohol. Yeast can break down sugars via the Krebs Cycle, when oxygen is present. In the absence of oxygen, most species can ferment sugar, producing alcohol. The preference of most yeast to use aerobic respiration, when oxygen is present, is called the Pasteur Effect.

Brewer's yeast is unusual in that, in the presence of both sugar and oxygen, it ferments sugars. This sometimes called the Crabtree Effect. It does this despite the fact that aerobic respiration yields far more energy than alcoholic fermentation. In wild strains of S. *cerevisiae*, both oxygen and alcohol are present soon after they colonize a piece of fruit. When the alcohol level reaches a certain point, the yeast do something remarkable . . . they begin to consume the alcohol they produced. Alcohol taken in by the yeast is converted to acetaldehyde, then acetate, then acetyl phosphate and finally acetyl CoA, before being fed into the Krebs Cycle. In brewery fermentations, this does not happen to any appreciable degree because oxygen is excluded from the beer (and hence the Krebs Cycle cannot function). A group in Japan did find, however, that yeast with a knocked out ADH_2 gene — which codes for the enzyme that converts alcohol to acetaldehyde — produced beer with lower levels of acetaldehyde.

Why would S. *cerevisiae* ferment sugars, only to consume a part of the ethanol they produce later? The answer is that alcohol is toxic to most other microorganisms. Brewer's yeast initially begins producing alcohol to poison the environment for other species. Once it has crowded out most of it's rivals, it takes in some of the alcohol it has made and degrades it via the Krebs Cycle.

Of the 1,500 species of yeast — and the tens of millions of bacterial species — only two are good brewing species, S. *cerevisiae* (ale yeast) and S. *pastorianus* (lager yeast). (If you include wine in the conversation, you can add S. *bayanus* to the list.) But what makes a yeast suitable for use in brewing? How did S. *cerevisiae* and S. *pastorianus* acquire the characteristics that make them good at brewing? Scientists in the last ten years have found out some of the details. S. *cerevisiae* is not just a favorite of brewers, its also a favorite of biologists. In fact, S. *cerevisiae* has been a model organism for many years. As such, it was the first eukaryote to be completely sequenced (back in 1996). Just one year later, however, scientists made an astounding discovery.

Whole Genome Duplication

What scientists found was that S. *cerevisiae* had undergone a whole genome duplication 100 million years ago (MYA). The primary evidence for this comes from looking at the modern S. *cerevisiae* genome and comparing it to the genome of related species, such as *Kluyveromyces lactis*. *Kluyveromyces* is a yeast with 8 chromosomes and its chromosomes map onto the S. *cerevisiae* genome in a 1:2 fashion. For each *Kluyveromyces* chromosome, there are two *Saccharomyces* chromosomes that have the same genes, in the same order. But, there's a twist. Many of the genes on the two *Saccharomyces* chromosomes are missing, but in a complementary manner. One way to visualize this is to think of a hypothetical chromosome with 10 genes, named (for convenience) 1 through 10, in that order. The *Kluyveromyces* chromosome would have those 10 genes, in that order. The two *Saccharomyces* chromosomes might contain the genes 1, 2, 3, 7, 8, 9 and 3, 4, 5, 6, 10, respectively (and in those orders). The two *Saccharomyces* chromosomes contain all of the genes found in the *Kluyveromyces* chromosome, just spread out over two chromosomes — with one interesting twist.

You may have noticed that there's a "3" in both of our example chromosomes. This illustrates something else researchers found. Although most of the duplicate genes had been deleted (or inactivated) in the modern *Saccharomyces* genome, about 10 percent of the genes were present in two copies. Of the two copies, one was always similar to the corresponding gene in *Kluyveromyces*. The other frequently showed that its sequence had diverged from other copy. And for brewers, the interesting aspect of this is that most of the doubly-retained genes deal with sugar metabolism. And the kicker is, the timing of the genome duplication (100 MYA) corresponds with the rise of the Angiosperms — plants that produce flowers and fleshy, sugary fruits.

Duplication of Alcohol Dehydrogenase

About 80 MYA, the ancestor to modern S. *cerevisiae* experienced a small duplication event, involving only part of a single chromosome. This created two copies of the enzyme alcohol dehydrogenase, ADH_1 and ADH_2. ADH_1 catalyses the formation of alcohol from acetaldehyde, whereas ADH_2 catalyses the reverse reaction. The presence of two different ADH enzymes, with opposing functions is, as you have probably guessed, part of the basis of how S. *cerevisiae* can consume alcohol, as described above.

The sequences of ADH_1 and ADH_2 are very similar, and ADH_1 in S. *cerevisiae* is similar to one of the ADH enzymes in *Kluyveromyces* (which has independently duplicated its ADH genes twice, yielding four genes). From this, scientists inferred that ADH_2 was the gene with "new" function and that the ancestral ADH gene functioned to produce, not consume, alcohol. They confirmed this by comparing ADH_1 (from S. *cerevisiae*) to the appropriate ADH gene in *Kluyveromyces* and inferring all the most likely ancestral sequences. They then synthesized these enzymes and tested their kinetics (how they perform, basically.) Most of the "resurrected" enzymes had some function and in most it was predominantly to produce alcohol from acetaldehyde.

The Origin of Lager Yeast

Lager yeast, S. *pastorianus*, ferments at significantly colder temperatures than ale yeast. It has long been known that S. *pastorianus* has a different set of chromosomes than S. *cerevisiae*, and two fundamentally different types of lager yeast exist. Recently, researchers found out the source of this difference. As it turns out, one type of lager yeast is a hybrid between S. *cerevisiae* and S. *bayanus*, a yeast that can ferment at much lower temperatures than S. *cerevisiae*. The other type of lager yeast is a second hybrid between S. *cerevisiae* and S. *bayanus*. In both cases, the S. *bayanus* genome is almost entirely retained, while S. *cerevisiae*-derived sequences have mostly been lost. By comparing the remaining *cerevisiae*-derived sequences in S. *pastorianus* to wild species of S. *cerevisiae* and also strains that ferment wine, sake and ales, researchers concluded that, in both cases, the *cerevisiae*-derived sequences in lager yeast came from an ale strain. However, in each case, the ale strain was different. This is not surprising since it has always been expected that S. *pastorianus* arose in a brewery.

Tastes Great, Less Phenols

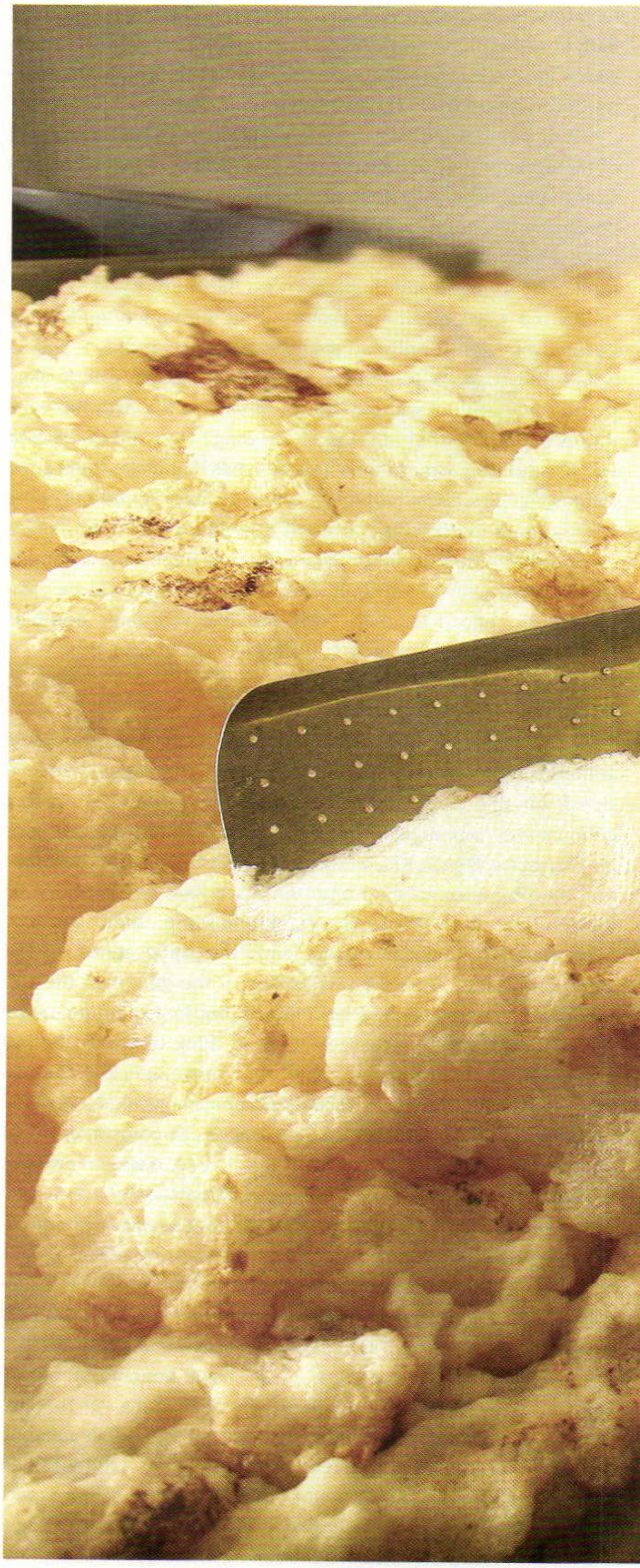
One final step in brewer's yeast evolution has been very important, but is incredibly simple to explain. Most wild species of yeast produce off flavors and aromas, with 4-vinyl-guiacol (a phenolic compound) being the most prevalent. In brewer's yeast, this gene (named POF) has apparently been deleted.

So next time you brew, think of all the duplications, deletions and divergences that your yeast's ancestors had to go through to bring you your tasty fermented grain beverage — and raise a glass to the scientists who are working on finding out the whole story.

Chris Colby is Editor of Brew Your Own. *See his blog at www.byo.com/blogs/blogger/Chris Colby/ for further discussion of some of the key papers in this field and some additional references.*

Story by **GREG DOSS**

yeast HANDLING



There are many variables involved in the brewing process, one of which being the ingredients used. Malt, hops and water are fairly static and will deliver consistent and desired results through manipulating the parameters of dosage, temperature and time. Yeast, however, is dynamic and poses additional constraints with process control and consistency. At times, yeast can appear unpredictable and make fermentations seem like a mystery.

Every brewer strives for a successful fermentation with each brew session. Successful fermentations can be defined as having a rapid onset of fermentation, rapid and complete reduction of fermentable carbohydrates, optimal production of desirable fermentation byproducts while minimizing the production of unwanted byproducts, and the rapid flocculation and sedimentation of yeast. When successful fermentation does not take place, the cause can usually be determined through an examination of the factors controlling the fermentation. This article will explore the typical parameters involved with controlling fermentation including yeast

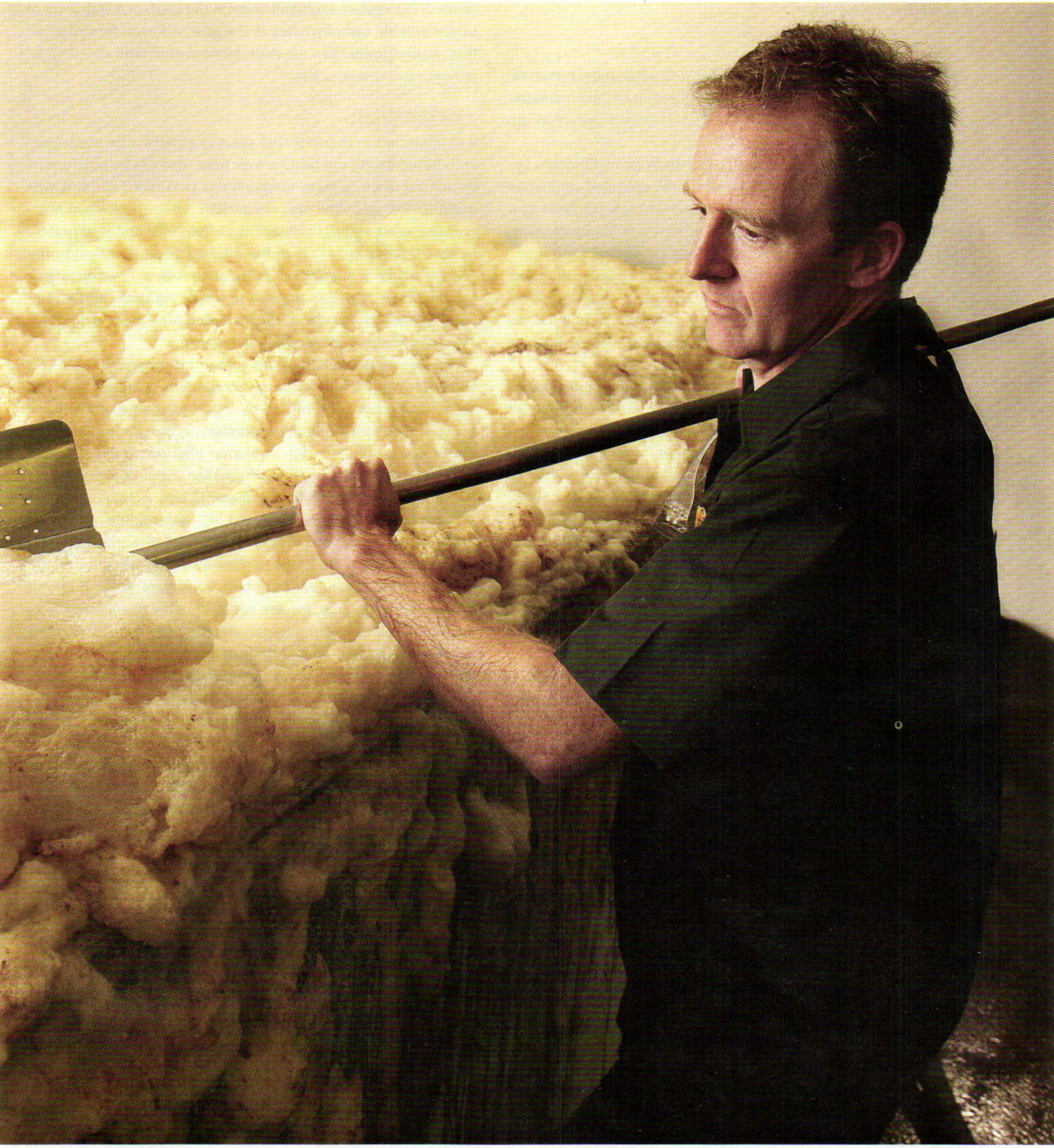


Photo Courtesy of Sierra Nevada Brewing Company health, pitch rates, aeration, temperature and nutrition. The following information will hopefully take some of the mystery out of managing fermentation.

Tools and Tests

Most brewers have the necessary tools to solve most fermentation problems. Proactively using a hydrometer and thermometer as well as performing some quick tests can take the guesswork out of the fermentation.

It is important to use and calibrate your hydrometer frequently. It should read 1.000 in water at the specified calibration temperature. It is one of the most important tools you have as it provides insight on exactly how the fermentation is progressing. Do not rely on bubbles in the airlock or a set fermentation time.

Frequent calibration of your thermometers is also important. This can be done by measuring the temperature of ice water and boiling water (make sure to adjust for altitude). Identify critical temperature points to monitor including mash, wort, pitching yeast and fermentation temperature.

When fermentations do not reach the expected terminal gravity, the problem is either in the amount of fermentable extract available or the performance of the fermentation. A forced fermentation test is an easy and fast method for determining what the terminal gravity should be. This is especially helpful when experimenting with a new recipe or brewing high gravity beers. The test involves adding a large inoculum of yeast to a small volume of wort and agitating it warm for 24–36 hours. Once CO_2 evolution ceases and the yeast settles, take a density reading. This reading will indicate the lowest potential terminal gravity of your main fermentation. I perform this test with every beer I brew.

Forced Ferment Test Protocol

Decant 1 cup (250 mL) of wort into a container (for example, a Mason Jar) with 50% head space. Add 15 mL (1 tablespoon) yeast slurry or 3 g (1 teaspoon) of dried yeast. [Note, if using slurry, the liquid added may result in a lower terminal gravity by 0.2–0.4 °Plato (0.001–0.002 SG).] Cover loosely with foil or lid. Incubate at 75 °F (24 °C) for 24–36 hours. Agitate frequently by swirling or shaking, or use a stir plate on low speed. Allow the yeast to settle and measure wort density with your hydrometer.

A forced fermentation test finishing with a high gravity indicates that there is a lack of fermentable sugar. This is either a result of incomplete saccharification in the mash or a high level of unfermentable carbohydrates in the grist. A forced fermentation that finishes lower than the main fermentation indicates a problem with the fermentation.

Yeast Health

It is important to consider that yeast is a perishable ingredient, and culture health can decline over time. This can be accelerated by any exposure to warm temperatures (>45 °F/7.2 °C). It is well worth having an online supplier include an ice pack when shipping any yeast order. High viability (% live cells) and vitality (how healthy the live cells are) of the pitching yeast is critical to the success of the fermentation. Inoculating with a poor quality or compromised culture may result in longer lag times and incomplete attenuation, as well as the increased production of undesirable byproducts, such as sulfur and diacetyl.

Assessing the health of the culture can pose difficulties for homebrewers. Brewers at home can perform a simple, yet still useful, viability/vitality testing by introducing small amounts of wort and monitoring culture metabolism. Wyeast packaging allows the brewer to monitor CO_2 evolution after introducing a small amount of wort. A quick rate of package expansion or swelling (4–8 hours) is a good indicator of good yeast viability. This test can also be emulated in a sanitized PET water bottle. Add yeast and a small amount (50 mL) of sterile wort to a plastic bottle. Crush the center of the bottle to allow for expansion and cap. (Be gentle as creases can tear the plastic.) Incubate at 70 °F (21 °C) and monitor expansion. Be sure not to allow too much pressure to build as it can have detrimental affects on the culture. This is a technique modified from Michigan homebrewer Jeff Renner's method of monitoring carbonation after bottling.

It is important to know that some strains are slower to start than others and to allow for additional time when using a new strain. If CO_2 production is slow (>8 hr.) consider making a 2-qt. (2-L) starter with the culture and checking fermentation progress with density readings. Density should reach terminal in 18–24 hours (fermenting at 70 °F/21 °C). Knowledge of yeast health prior to inoculation allows the brewer to pitch yeast with confidence.

Pitch Rates For Different Fermentation Conditions

STYLE	GRAVITY	PITCHING TEMPERATURE (°F/°C)	FERMENTATION TEMPERATURE (°F/°C)	PITCH RATE (Million Cells/mL)
Ale	<1.060 (15 °P)	>65/18	>65/18	6.00
Ale	<1.061-1.076 (15-19 °P)	>65/18	>65/18	12.00
Ale	>1.076 (19 °P)	>65/18	>65/18	>18.00
Lager	<1.060 (15 °P)	>65/18	<60/16	6.00
Lager	<1.061-1.076 (15-19 °P)	>65/18	<60/16	12.00
Lager	>1.076 (19 °P)	>65/18	<60/16	>18.00
Lager	<1.060 (15 °P)	<60/16	<60/16	12.00
Lager	<1.061-1.076 (15-19 °P)	<60/16	<60/16	18.00
Lager	>1.076 (19 °P)	<60/16	<60/16	>24.00

Pitch Rates

Another key to ensuring a successful fermentation is inoculating your wort with an appropriate quantity of yeast. Pitch rate is defined by the number of cells per milliliter of wort in the fermenter. Different beers and fermentation conditions require different amounts of yeast to reach attenuation. Inadequate pitch rates can lead to long lag times, stalling fermentations and incomplete attenuation. Pitch rates need to be increased as density increases or fermentation temperature decreases.

Pitching 1 million cells per mL per degree Plato is a standard rule of thumb used in commercial breweries. For example, a 14 °Plato wort is pitched with 14 million cells per mL. This generally applies to yeast being harvested and re-pitched from alcoholic fermentations. Yeast coming from a laboratory is in optimal condition and can be pitched at a lower rate. When using laboratory-grown yeast culture in standard ale fermentations (< 15 °P at 70 °F/21 °C), pitch rates of 6 million cells per mL are recommended. The chart on page 38 shows pitch rates required for laboratory grown cultures under different fermentation conditions.

Calculating pitch rates starts with knowing the cell density and the volume of the slurry you are working with. The cell density of laboratory-grown cultures should be available from your yeast supplier. At Wyeast, our Activators are packaged with 95 mL of yeast (+35 mL nutrient) at a cell concentration of 1.2 billion cells per mL. Once you have the volume and cell density of the slurry, you will need the volume of wort to be fermented.

The equation for calculating pitch rates is :

$$P = (C_S \times V_S)/(V_W \times 3785)$$

where

P = pitch rate (cells/mL)

C_S = cell density of slurry (cells/mL)

V_S = volume of slurry (mL)

V_W = volume of wort (gallon)

3785 = a conversion factor from gallons to milliliters

Higher pitch rates can be achieved either by simply inoculating with additional packages of yeast or by expanding the culture in a "starter" prior to inoculation. Expanding the culture involves growing the yeast in small amounts of aerated wort (10 °P/1.040 SG at 70 °F/21 °C) in one or more steps prior to brewing. Each propagation step will allow the culture to double a certain number of times. Because of the extremely high pitch rates used in starter cultures, the volume of wort is the limiting factor with growth. One Activator pitched into a 1-qt. (1-L) starter will result in 0.5 doubling of the culture while the same Activator into a 2-qt. (2-L) starter will result 1 full doubling. Starter volumes of less than 1 qt. (1 L) result in little growth and are not recommended. The starter should be complete in 12–24 hours depending on the volume of wort used.

The use of a stir plate will increase the number of doublings by 25–50%. This is mainly due to releasing growth inhibiting levels of CO_2 through agitation. Calculators are available online to assist in tailoring the optimal propagation scheme for the specific beer being brewed.

http://www.wyeastlab.com/hb_pitchrate.cfm
http://www.mrmalty.com/calc/calc.html

Pitch rates also have a major affect on the production of fermentation byproducts. Increasing pitch rates will decrease higher alcohol and ester production. Manipulating the pitch rates can deliver the desired character for a specific beer. This is especially evident when fermenting with a German wheat yeast. The use of high pitch rates can eliminate the delicate ester character desired in Bavarian wheat beers. It is recommended to not exceed 10 million cells per mL with these fermentations. Alternatively, it may be beneficial to pitch a lager fermentation at a high rate (24 million cells per mL) to produce beer with a clean malty profile.

Temperature

Pitching and fermentation temperature have a large impact on fermentation. Yeast is sensitive to changes in temperature and rapid shifts in temperature encountered at pitching can shock the culture and create inconsistencies in fermentation. It is important to pitch the yeast slurry within 10 °F (5.5 °C) of the wort temperature. Following the onset of fermentation, temperature will control the rate of metabolism and subsequently the levels of fermentation byproducts. Higher temperatures increase fermentation rate and yeast growth and lead to increases in higher alcohols and esters. Likewise a reduction in temperature will reduce fermentation byproducts. Lager strains are tolerant to fermenting in cold conditions (46–60 °F) whereas ale strains are limited to warmer conditions (58–75 °F). Some ales strains including Belgian, German wheat, and a few English strains are highly sensitive to low temperature conditions and will fail to attenuate if temperatures drop below 65 °F (18 °C). Sulfur production (rotten eggs) is often an indication of low temperature stress on the culture. It is important to monitor temperature and take necessary action to keep fermentation temperature in the desired range.

Aeration

Inadequate wort aeration could be the most common cause of stalled and failed fermentations. Yeast requires oxygen for the synthesis of membrane sterols. When oxygen is available, sterols will be synthesized until reaching a maximum level in the cell membranes, around 1% by dry weight. Every time a mother cell buds, the sterol content of the membrane is reduced. Cells will cease to bud when sterol content is reduced to 0.1%. If aeration levels are insufficient, less growth will occur resulting in a possible stuck fermentation. Optimally, 10–15 ppm dissolved oxygen (DO) is recommended to insure adequate sterol synthesis. The chart on this page shows the maximum DO reached with each method as well as the time it takes to achieve it.

Method	DO MAX ppm	Time
Siphon Spray	4 ppm	0 sec.
Splashing & Shaking	8 ppm	40 sec.
Aquarium Pump w/ stone*	8 ppm	5 min.
Pure Oxygen w/ stone**	26 ppm	60 sec. (12 ppm)

*2 m pore
**2 m pore, 3.5 LPN oxygen flow rate, 68 °F (20 °C)

Nutrient Levels

Yeast requires certain levels of nitrogen, vitamins and minerals to maintain healthy fermentation. Generally zinc is the only nutrient that may not be present in an adequate level in standard, all-malt, wort. Zinc is an essential cofactor in many important metabolic enzymes and can be supplemented with the use of yeast nutrient. Some brewing conditions — including brewing high gravity wort and brewing wort with high levels of adjuncts — can bind up or dilute nutrients leaving the yeast without necessary levels. Once again the addition of yeast nutrient can help this.

With the proper tools and knowledge, homebrewers can repeatedly conduct orderly fermentations that will reach their expected terminal gravity in a reasonable amount of time and deliver the flavor and aroma profiles the brewer is seeking.

Greg Doss is the Quality Control Manager and Microbiologist at Wyeast Laboratories in Hood River, Oregon.

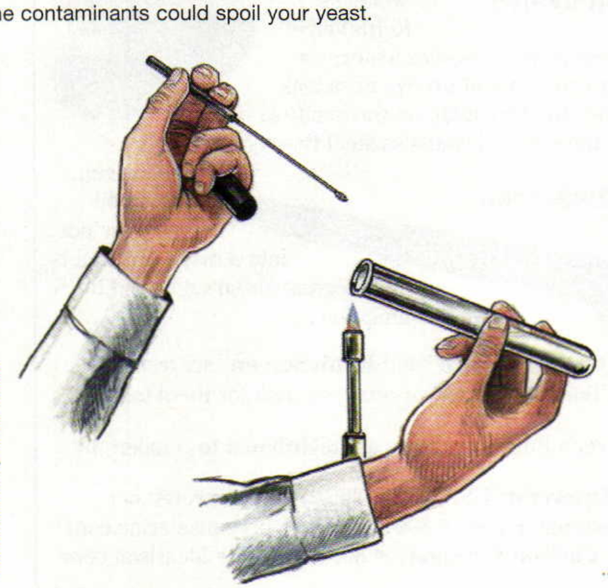
Story by **CHRIS WHITE**

CULTURING YEAST

Culturing yeast at home takes more work than buying commercial yeast, but may be worth it if you are planning on preserving yeast cultured from a bottle of beer or a strain that isn't offered year-round.

TOP: To streak a plate, you lightly rub the inoculated loop across the agar surface in a zig-zagging — almost Zorro-like — fashion. This will leave a trail of bacterial cells across the plate. These will grow into visible colonies in a few days. For best results, simply crack the lid slightly and insert the inoculation loop. Work quickly and get the lid back on as soon as possible.

BOTTOM: Whenever you open your slant, flame the tip of the test tube. Reflame before closing the cap. Never enter the slant with a loop that is not sterile. Working quickly will minimize the amount of time that airborne contaminants could spoil your yeast.



Illustrations by Don Martin

Necessary Materials

Slants and plates are commonly used in all yeast and bacteria culturing. A slant is your "mother" culture, which should remain pure due to its infrequent usage. A blank slant is made by pouring a hot, liquid agar solution into a test tube and letting it cool at an angle, creating a sloping surface within the tube. A plate is a petri dish in which molten agar has been poured and cooled. Agar is a gelatin-like material that is liquefied at temperatures over 107 °F (42 °C) and forms a gel under 99 °F (37 °C). Yeast will grow on this Jello-like surface, and provide a means of medium-term storage.

Once inoculated with yeast, the mother culture should be used to create a "working" culture. A plate serves as your working culture — which in turn provides the yeast for the starter culture that you pitch into a batch of beer. The plate actually serves two functions. It's a working store of your yeast culture, and it offers you a look at the purity of your yeast.

To prolong the life of your plates and slants, store them in the fridge. A plate will last several months, stored wrapped in parafilm with the agar side up. Slants are the best possible medium-term storage. They should be re-cultured every 4 to 6 months before they start to mutate and die. Healthy yeast should be a creamy white color. If the colonies on your slants or plates start changing color, this is most likely because they are dying.

You can buy sterile, individually-packaged test tubes and petri dishes — and all the other materials mentioned in this article — from most scientific supply houses. Some even offer pre-poured slants and plates.

Inoculation loops can be disposable or metal. They are used for transferring bacteria from an agar surface to either another agar surface or liquid media. Disposable loops are packaged sterile, and are easy to work with. Metal inoculation loops need to be sanitized by flaming prior to any transfer. In a lab, the flame would come from a bunsen burner. At home, an alcohol burner — or even a butane lighter — will suffice. When culturing, your work area should be clean and wiped down with sanitizing solution.

Streaking a Plate

Streaking an agar plate is a quick and easy way to isolate yeast, check for purity and re-culture yeast from aging plates or slants. First you should flame your loop (unless using a sterile-packed loop) and get it red-hot. Next, immerse the loop in 70% ethanol or touch it to an unoccupied agar surface to cool it. Open the slant and pass the test tube opening through flame before dipping your inoculation loop into it. Dip the loop into a sample of yeast and simply touch a colony. This will transfer plenty of bacteria to the loop, even if you don't see any material clinging to the metal. Re-flame the opening before closing the slant. Open the petri dish just enough so you can insert the loop. Touch the loop lightly to the agar surface on the plate and move it back and forth so you make a long, zig-zagging streak on the agar surface. This will inoculate the plate, although all you will be able to see is a very slight indention in the media. Replace the cover on the petri dish as soon as you finish. The microscopic bacteria transferred to the plate will grow into isolated colonies that are easily visible to the naked eye.

Grow the plate for two to three days at room temperature (70 °F/21 °C), agar side up (in other words, so the bacterial colonies are hanging upside down from the agar surface). Dense yeast will grow in the initial contact point, getting more diluted towards the end of the streaks. If isolated colonies are not obtained, a new plate can be re-streaked.

To add the 10-mL wort starter to the Erlenmeyer flask, flame the opening of the test tube while removing the foil cap from the flask. Flame the opening of flask and dump in contents the of 10-mL vial, quickly replacing the foil cap.

Making a Starter Culture for Brewing

Yeast has a creamy white color. This is typical of a healthy sample. If you have colonies that are other colors, or have a different morphology, these are likely contaminants.

Each dot on a plate is a colony or group of colonies of yeast, any of which can be selected to make a starter culture. A starter culture is the yeast that you'll pitch into a batch of beer.

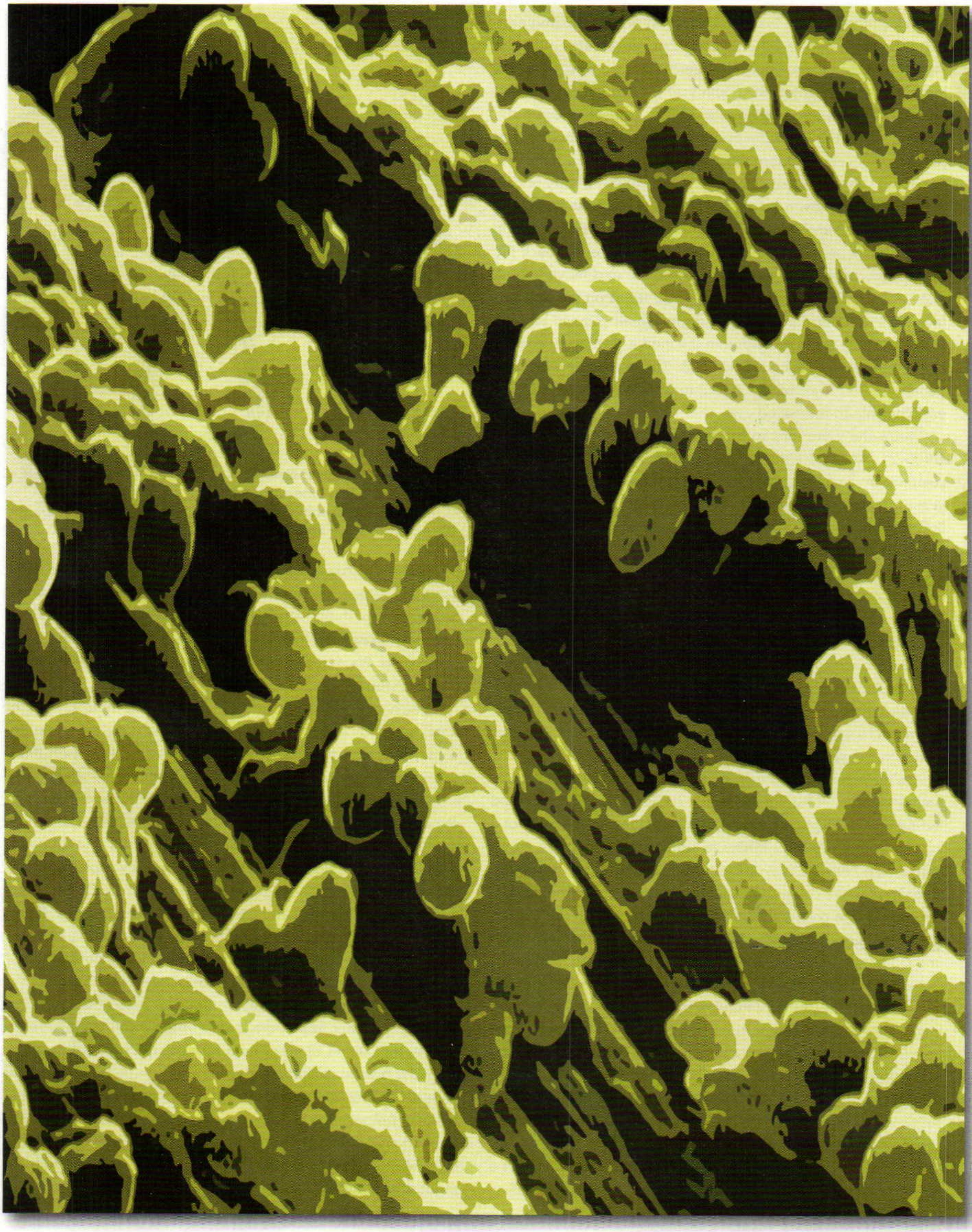
To make a starter culture, first make a sterile wort starter by boiling dried malt extract and water, adding it to a test tube and letting it cool. Then pick either a single colony from a plate or a loopful from a slant. It's better to select single colonies, grown from single cells, as they are the purest form of yeast identifiable. To pick the colony, all you need to do is touch the agar on one side of the colony then swipe the loop through the colony; you do not need to gouge a hole in the surface of the agar to get enough bacteria. A light swipe over the surface is all it takes.

Once you have the yeast on a sterile loop, transfer it to the 10-mL wort starter, being careful to open containers for the minimal time required. Flame the opening of the test tube. Then insert the loop into the test tube and shake the tip of the loop in the liquid to transfer the yeast. Re-flame the opening and cap the tube tightly. Shake starter to aerate and to mix yeast into suspension. Then loosen the cap enough to allow oxygen to get in the tube. Leave upright in a warm place (70–80 °F/21–27 °C). Your 10-mL wort starter is now inoculated and will grow over a period of 24 to 48 hours. It won't look like a normal fermentation, because very little action will be seen at the top. A white sediment will appear on the bottom, assuring you that growth has occurred. You should use this starter after approximately two days. It will keep if refrigerated, after growth has occurred, up to seven days. Warm it to room temperature before proceeding to the next step.

When you are ready to grow your starter, boil 400 mL of water with four tablespoons of dried malt extract and some dry yeast nutrient. Add mixture to your sanitized Erlenmeyer flask, or other glass container, and cap with aluminum foil. (If you use a one-liter Erlenmeyer flask and a large microwave oven, you can boil the wort directly in the flask.) Cool the wort and then add the 10-mL starter to it. Flame the tip of the test tube and flask before dumping out the yeast and quickly replace the foil cap on your 400 mL starter. Aerate the wort with sterile air or oxygen. If you have a stir plate, stir the yeast while it grows. If not, simply swirl the container a couple times a day. This culture can then be stepped up to a pitchable starter for 5 gallons (19 L) or more of beer. From this point on in your yeast propagation, it is best not to expand the culture volume by more than 10 times per step. In other words, the largest volume you could step up to from the 400 mL starter would be 4,000 mL (1.05 gallons).

Your biggest challenge in yeast propagation is to keep your cultures free of contamination. Working quickly and recapping tubes or propagation vessels as soon as possible will help. If you are serious about trying this, it would be worthwhile to take a microbiology class from your local university as all of these techniques are standard for handling any microorganism.

Story by **CHRIS WHITE**



YEAST METABOLISM

Yeast converts wort into beer. In the process, it breaks down sugars into carbon dioxide and ethanol. Also, numerous side reactions result in the production of flavor and aroma molecules.

yeast is added to wort by brewers. Now what? The yeast begin to feed on sugar and grow in numbers. The chemical reactions within an organism that sustain life are called metabolism. As brewers, the aspects of yeast metabolism that interest us most are the breakdown of sugar, which releases energy, and the chemical pathways leading to compounds that exit the cell and yield flavors or aromas.

Yeast pick up sugar, nutrients and other substances from the wort. Some of these compounds, such as sodium (Na^+) and potassium (K^+) ions, diffuse freely across the membrane into the cell. Others, including glucose, fructose and maltose, are brought into the cell through specialized pores. Some compounds — such as amino acids and calcium (Ca^{2+}) ions, when they are at a low extracellular concentrations — require the cell to expend some energy to bring them inside.

Sugar is taken up in a defined order: glucose, fructose, sucrose, maltose and then maltotriose. The degree of maltotriose uptake can determine differences in attenuation.

Before being brought into the cell, sucrose is split into its component glucose and fructose residues by the enzyme sucrose invertase. Yeast excrete this enzyme into the medium they are growing in. The uptake of maltose is aided by the enzyme maltose permease. Maltose is then broken down into its component glucose subunits by the enzyme maltase. In the presence of glucose, expression of the permease genes for maltose and maltotriose are repressed.

Oxygen is quickly taken up by yeast, usually within 30 minutes after pitching. In nature, yeast uses the oxygen to consume sugar. This is called aerobic growth. It is the pathway through which living organisms extract the greatest amount of energy from sugar. But yeast are adaptive, because they often encounter environments where oxygen is limited. Many organisms can survive in oxygen free environments and still get energy out of sugar. We call this anaerobic growth. Louis Pasteur coined the term "anaerobic fermentation" in the 1860s, to describe the ability of yeast to grow when oxygen deprived. When yeast anaerobically ferment, they produce ethanol.

Even if oxygen is present in the fermentation process, yeast will still produce ethanol. This is called the Crabtree Effect (and also the Reverse Pasteur Effect). The Crabtree Effect occurs when there are high

Figure 1
Fermentation

glucose
↓
glucose-6-phosphate
↓
fructose-6-phosphate
↓
glyceraldehyde-3-phosphate
+ dihydroxyacetone phosphate
(which gets isomerized to glyceraldehyde-3-phosphate)
↓
1,3-bisphosphoglycerate (x2)
↓
3-phosphoglycerate (x2)
↓
2-phosphoglycerate (x2)
↓
phosphoenolpyruvate (x2)
↓
pyruvate (x2)
↓
acetaldehyde (x2)
↓
ethanol (x2)

glucose concentrations. All beer wort will contain higher than 1% sugar, so fermentations will result in alcohol creation even when oxygen is present. The problem with oxygen exposure is not loss of ethanol, but off flavors that result from metabolic pathways being turned on by oxygen. For example, beer fermentations that see steady exposure to oxygen will result in higher concentrations of acetaldehyde, due to oxidation of ethanol into acetaldehyde.

In beer fermentation, the major end product of sugar metabolism is ethanol. The overall reaction from sugar to ethanol is:

Fermentation (Net Equation):

glucose + 2 ADP + 2 phosphate ⟶ 2 ethanol + 2 CO_2 + 2 ATP

ADP (adenosine diphosphate) and ATP (adenosine triphosphate) are molecules involved in the storage and transfer of energy within a cell. It takes energy to add a phosphate group to ADP, making ATP. When ATP is broken down into ADP plus phosphate, this energy is released.

There are many individual steps in this overall equation, as shown in Figure 1, and in fact the equation can be split into two parts: 1.) the pathway starting with glucose and ending with pyruvate, and 2.) the multiple pathways leading from pyruvate, which include ethanol formation. The first pathway, in which glucose is broken down into two pyruvates, is given by the following net equation. These steps in glucose breakdown are often referred to as glycolysis or as the Embden-Meyerhof Pathway.

Glycolysis (Net Equation):
glucose + 2 ADP + 2 NAD+ + 2 phosphate ⟶ 2 pyruvate + 2 ATP + 2 NADH + 2 H+

Glycolysis occurs in the free medium of the cell, the cytosol. Enzymes floating in the cytosol catalyze each step.

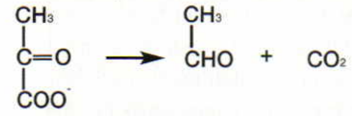
Pyruvate has many uses in the cell. For example, it is used in the production of certain amino acids. However, most pyruvate takes one of two main pathways — it can go to the mitochondria and get completely broken down to carbon dioxide (CO_2) and water. (In other words, it can participate in aerobic respiration.) Or, it can stay in the cytosol and be converted to ethanol. (In other words, it can take part in alcoholic fermentation.)

Which pathway do brewers prefer? Since we are not making water, brewers want yeast to make ethanol. Yeast gets only 8% of the energy from each molecule of glucose if they produce ethanol instead of completely breaking glucose down via aerobic respiration. This means that a yeast culture will grow into more daughter cells if it grows aerobically (with oxygen) compared to anaerobically (no oxygen). This is the reason some homebrewers will add oxygen or use a stir plate with yeast starters, the oxygen will encourage more yeast growth. But the yeast growth is still not the same as a laboratory situation due to the sugar-induced Crabtree Effect.

From the equation for glycolysis, it can be seen that the compound NAD^+ is required to produce pyruvate. NAD (nicotinamide adenine dinucleotide) is a molecule that is involved in oxidation and reduction reactions in metabolism. It exists in two forms. NAD^+ is an oxidizing agent. (In other words, it accepts electrons.) NAD^+ reacts with 2 electrons and a hydrogen ion to form NADH, a reducing agent. (In other words, it will donate electrons to other molecules.) The cell has a limited quantity of NAD^+, so it needs to regenerate NAD^+. It can do that in the Krebs Cycle, but if the cells are devoid of oxygen, this cannot happen. This leads to the buildup of pyruvate, no energy creation, and no more NAD^+ (the cells run out of it!). So the yeast need to "get NAD back" when oxygen is limiting.

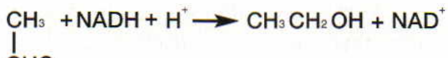
The two-step reaction of pyruvate to ethanol generates the required NAD^+.

Final Steps of Fermentation:



pyruvate — acetaldehyde

enzyme:
pyruvate decarboxylase



acetaldehyde — ethanol

enzyme:
alcohol dehydrogenase (ADH)

So the yeast is happy, or at least they can limp along. The ethanol diffuses outside of the cell, perhaps as a defense mechanism for yeast since ethanol is toxic to many other organisms, including most non-*Saccharomyces* species of yeast.

Not all of the glucose flows through pyruvate into ethanol. A small amount of glucose enters the pentose phosphate pathway, also called the hexose monophosphate shunt. This pathway produces a small amount of NADPH (a molecule similar to NADH), but is primarily a source of precursor molecules for nucleotide synthesis.

Like glucose, fructose has multiple pathways it can follow when it enters the cell. Most importantly, there are two short pathways in which it gets converted to glyceraldehyde-3-phosphate, one of the intermediates in glycolysis.

There are many side branches to sugar metabolism, and many of these add to beer's flavor. The most important of these are esters, fusel alcohols, sulfur containing compounds, carbonyl compounds such as aldehydes and ketones (including diacetyl) and phenolic compounds.

In yeast metabolism, some of the pyruvic acid gets converted to acetyl-CoA. Sugar going to this alternate pathway leads to organic acids, fatty acids, lipids, and esters.

Esters

Esters are volatile molecules and are responsible for fruity aromas and flavors such as apple, banana and guava. There are approximately 50 esters present in beer (Meilgaard, 1975). Ester profiles are a good way to differentiate beers, especially ales. Ester production will vary by yeast strain, in addition to fermentation conditions. Examples of esters are ethyl acetate (solvent), ethyl caproate (apple), and isoamyl acetate (banana).

Esters are the result of a combination of an acid and an alcohol. For example, ethanol combines with Acetyl-CoA to form ethyl acetate. Esters take some time to form; first, yeast need to create the alcohols. Esters have more of a flavor impact than acids and alcohol independently (Bamforth, 2001). The enzymes that catalyse ester formation are the alcohol acetyl transferases, AATase I and II. This enzyme combines an alcohol with an activated acid. An example of an activated acid, and most abundant, is Acetyl-CoA. When oxygen is added before fermentation, this calls for production of sterols for new cells, which draws away Acetyl-CoA from ester production (Bamforth, 2001). Therefore higher aeration levels result in lower ester levels. Another explanation for the oxygen effect is that oxygen might directly repress the expression of the AAT encoding genes (Fugii, 1997).

Fusel Alcohols

Approximately 40 fusel alcohols are found in beer (Meilgaard, 1975). They taste similar to ethanol, and can add "hot," or warming, flavors to beer. Examples are n-propanol, isoamyl alcohol and isobutanol. Many of them have quantities at or above flavor threshold, so they are important yeast-derived flavor components of beer. Amyl alcohols, such as isoamyl alcohol, are found in the highest quantity. In wine, isoamyl alcohol can account for more than 50% of all fusel alcohols (Zoecklein, Fugelsang, Gump and Nury, 1999). Fusel alcohols are generally thought to be responsible for the headaches some people get when consuming alcoholic beverages, so producers are mindful to keep their levels in check.

Fusel alcohols are produced either from pyruvate and Acetyl-CoA during amino acid synthesis, or from the uptake of amino acids (nitrogen). They begin to be formed during the lag phase of fermentation. When fusel alcohols are formed, the final step involves the reoxidation of NADH to NAD^+. Some scientists believe that fusel alcohol production occurs because of the cell's necessity to regenerate NAD^+ for glycolysis (Kruger, 1998).

Yeast strains will vary in fusel alcohol production, with ale strains generally producing higher fusel alcohol concentrations than lager strains. This is mostly attributed to the fermentation temperture — ale is fermented at higher temperature and fusel alcohols increase with temperature. Fermentation conditions also have an effect on fusel alcohol. For example, if beer wort has too little nitrogen, or an excess, both can result in higher alcohols. In fact, most of the factors that promote cell growth — including temperature, aeration and nitrogen — will also result in higher levels of fusel alcohols.

Sulfur Compounds

Lager brewing produces more sulfur compounds than ale brewing. This perhaps involves the lower temperature of lager brewing (Bamforth, Beer flavour: sulphur substances, 2001). Some wine strains also produce sulfur. Sulfur compounds are usually so volatile that they are not still present by the time you drink the finished product. Some lager beers do retain sulfur aroma and flavor.

Typical sulfur compounds in beer are dimethyl sulfide (DMS), sulfur dioxide, hydrogen sulfide, and mercaptans. Some of the sulfur in beer comes from malt, some from yeast.

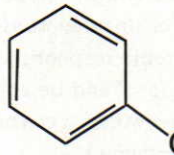
Yeast have the ability to reduce dimethyl sulfphoxide (DMSO) to DMS. DMSO is present in wort. Yeast also produce sulfur dioxide (SO_2), which not only flavors the beer but gives it anti-oxidant properties. Lager yeast strains appear to produce more sulfur dioxide than ale yeast strains.

Hydrogen sulfide gives the familiar rotten egg smell. Sulfur dioxide easily reduces to hydrogen sulfide, but luckily most of it is carried out of the beer by carbon dioxide (CO_2) released from yeast. It therefore is key to have acitve, healthy yeast in the fermentation.

Phenolic Compounds

Phenolic compounds can originate from raw ingredients, and from fermentation. They are hydroxylated aromatic rings (Figure 2). They are used in antiseptics, they have a plastic, band-aid flavor, and are less volatile than fusel alcohols. That means they will stay in the product throughout aging, so once they are made, you will probably taste them.

Figure 2.
Phenol



In beer, the phenolic flavors such as band-aid really stands out, ruining most

NEW YEAST STRAINS ON THE MARKET

WHITE LABS

WLP515 Antwerp Ale
Good for Belgian type pales ales and amber ales, or with blends to combine with other Belgian type yeast strains.
Attenuation: 73–80%
Flocculation: Medium
Optimum Fermentation Temperature: 67–70 °F (19–21 °C)
Alcohol Tolerance: Medium

WLP885 Zurich Lager
Swiss style lager yeast.
Attenuation: 70–80%.
Flocculation: Medium
Optimum Fermentation Temperature: 50–55 °F (10–13 °C)
Alcohol Tolerance: Very High

WLP037 Yorkshire Square Ale Yeast
A good choice for English pale ales, English brown ales, and mild ales.
Attenuation: 68–72%
Flocculation: High
Optimum Fermentation Temperature: 65–70 °F (18–21 °C)
Alcohol Tolerance: Medium-High

WLP006 Bedford British
Good for most English style ales including bitter, pale ale, porter and brown ale.
Attenuation: 72–80%
Flocculation: High
Optimum fermentation temperature: 65–70 °F (18–21 °C)
Alcohol Tolerance: Medium

WLP072 French Ale
Good yeast strain for Biere de Garde, blond, amber, brown ales and specialty beers.
Attenuation: 68–75%
Flocculation: Medium High
Optimum Fermentation Temperature: 63–73 °F (17–23 °C)

WLP545 Belgian Strong Ale Yeast
Well suited for Belgian dark strongs, Abbey Ales and Christmas beers.
Attenuation: 78–85%
Flocculation: Medium
Optimal Fermentation Temperature: 66–72 °F (19–22 °C)
Alcohol Tolerance: High

WYEAST LABORATORIES, INC.

2247-PC European Lager
Exhibits a clean and dry flavor profile often used in aggressively hopped Pilsners. Produces mild aromatics, slight sulfur notes and a distinctive crisp finish.
Apparent Attenuation: 73–77%
Flocculation: Low
Temp range: 46–56 °F (8–13 °C)
Alcohol tolerance: approximately 10% ABV

2478-PC Hella-Bock
Produces rich, full-bodied and malty beers. Attenuates well while still leaving plenty of malt character and body. Benefits from temperature rise for diacetyl rest at the end of primary fermentation.
Apparent Attenuation: 70–74%
Flocculation: Medium
Temperature range: 48–56 °F (9–13 °C)
Alcohol tolerance: approximately 12% ABV

2782-PC Staro-Prague Lager
Creates medium to full body beers with moderate fruit and bready malt flavors. Balance is slightly toward malt sweetness and benefits from additional hop bitterness.
Apparent Attenuation: 70-74%
Flocculation: Medium
Temperature range: 50-58 °F (10-14 °C)
Alcohol tolerance: approximately 11% ABV

beer, but important for the flavor profile of particular beer styles like Bavarian hefeweizen and Belgian lambic.

The major phenolic compound produced by most yeast is 4-vinyl guaiacol (4 VG). It is produced from the de-carboxylation of ferulic acid. Ferulic acid comes from the malt and hops used, and can be increased by adding a mash rest at 109–113 °F (43–45 °C). The gene called POF (phenolic off flavor) codes for the ferulic acid decarboxylating gene.

Yeast strains used by brewers have a natural mutation in the POF gene preventing them from producing 4 VG. In fact, if normal beer has a phenolic character, it is a good indication that the beer has been contaminated with wild yeast. In rare circumstances, phenolic character can also be derived from mutations in brewers yeast.

Yeast strains used to make Bavarian hefeweizen are good examples of wild yeast that have been purfied and cultured to produce a beer, with an intact POF gene and a resulting phenolic flavor.

Brettanomyces is another genus of yeast that is most well-known for contaminating beer and wine. It produces flavor compounds that are described as barnyard-like and horse blanket. *Brettanomyces* also produces 4 VG, so its presence in beer is easily detected, and even desired in some beer styles such as Belgian lambic beer.

Vicinal Diketones (VDKs)

Diacetyl (2,3 butanedione) is a vicinal diketone (VDK) that taints beer with a butterscotch flavor and mouth-coating feel that most beer drinkers do not like. Diacetyl is formed from alpha-acetolactate. Alpha-acetolactate is an intermediate between pyruvate and 2,3 dihydroxyisovalerate in the pathway that leads to the formation of the amino acid valine. Some alpha-acetolactate gets excreted from the cell and, if an oxidizing agent is present, gets decarboxylated into diacetyl. Diacetyl is later reabsorbed by the yeast and converted to acetoin, a flavorless molecule.

Chris White (PhD, Biochemistry, U. C. San Diego) is President of White Labs.

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Story by **CHRIS COLBY & JAMES SPENCER**

DOES **DELAYED RACKING** HARM YOUR **BEER?**

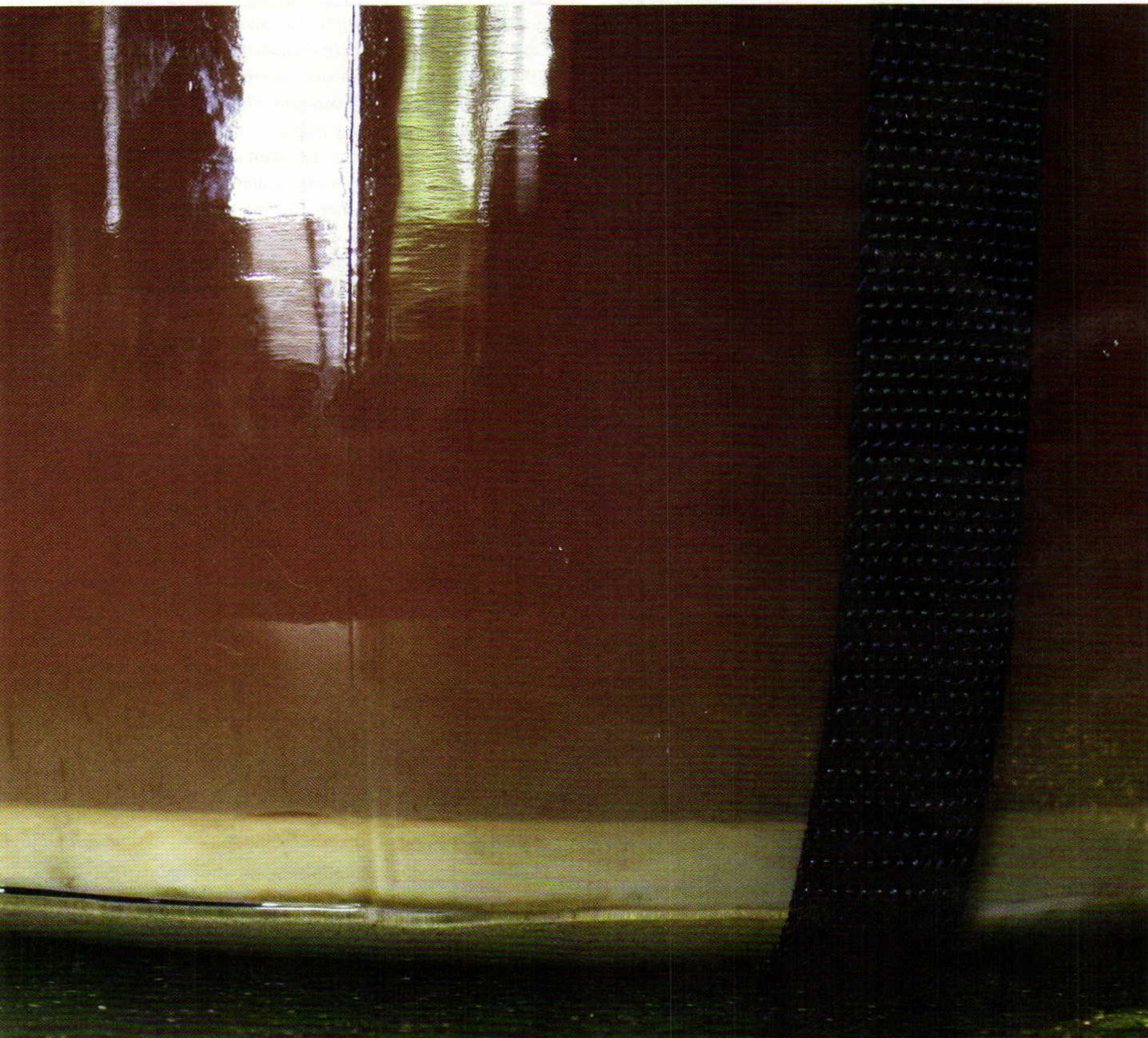
The First in a Series of Collaborative Experiments

New homebrewers are bombarded with the "always" and "never" rules. "Always be sure to let your beer finish fermenting before bottling" and "never add too much priming sugar" are two examples. While those are easily proven to be true, as anyone who has had exploding bottles can attest, there are other rules that have been handed down from one generation of homebrewer to the next that are not so quickly validated. As homebrewers become more advanced, many begin to wonder which elements of common homebrewing wisdom are true and which are simply reflections of the way things have always been done.

Debating these customs over a pint or two is a popular pastime among homebrewers. Wherever we gather, whether at club meetings or online, debates on brewing practices rage. Discussing the pros and cons of various practices is fun, but with-

colLABorative

BREW YOUR OWN and **BASIC BREWING RADIO** present the results of the first in our series of collaborative experiments, testing elements of common homebrewing wisdom. In this installment, we tested the question, "Does leaving your beer on the yeast for a couple weeks ruin it?" Check out our methods and results — and consider participating in our next experiment.



Photos by James Spencer

NAME	LOCATION	YEAST	BEER STYLE	OG	1ST FG	2ND FG	COMMENTS
Sean Terrill	Lafayette, IN	Bell's White (cultured)	Wit/Am Wheat Hybrid	1.047	1.009	1.009	Flavor differences very slight.
Kevin Elsken	Upper Saint Clair, PA	WLP 802 + Windsor Ale	Light American Pilsener/Ale	1.038	1.008	1.008	No flavor differences, yeast sample slightly darker.
R.J. Parker	Mountain View, HI	Cooper's Ale	Special Bitter	1.040	1.010	1.010	Sample on yeast additional 40 days. Only subtle differences.
John Chubick	Bloomington, IL	Safale US-05	American Pale Ale	1.042	1.010	1.010	Transferred beer very slightly fruitier.
Ron Evans	Verdigris, OK	WY 1968	Oatmeal Stout	1.050	1.015	1.014	Transferred beer "cleaner."
Jacques Bertens	The Netherlands	WY 1335	IPA	1.055	1.011	1.009	Transferred beer slightly preferred by tasters - "cleaner."
Jeremy Poon	Adelaide, Australia	Safale 04	Ale	1.044	1.014	1.014	Transferred beer slightly "sharper . . .cleaner."
Hugh Brown	New Westminster, BC	WY 3944	Belgian Wit	1.048	1.009	1.008	Coriander added to one batch - both "quite good."
Adam Ross	Davenport, IA	Danstar Nottingham	North English Brown	1.049	1.010	1.008	Transferred beer "cleaner" - preferred batch on yeast longer.
Jerry Marowsky	Oak Creek, WI	Muntons Active	APA	1.047	1.016	1.015	Beer bottled earlier tasted "green" - preferred yeast aged beer.
Brian T. Glenn	Cleveland Heights, OH	WLP 002	Scottish Ale	1.060	1.016	1.016	Beer on yeast longer "drier", other batch "smoother."
George Helfers	St. Louis, MO	St. Louis Brewery Ale	Blonde Ale	1.057	1.015	1.015	Beer on yeast "bready, grainy aroma."

out evidence one way or another, talk alone — even when backed by anecdotal evidence — will not settle these ongoing debates. In an effort to test the soundness of some of these brewing rules, *Brew Your Own* teamed up with *Basic Brewing Radio*, a podcast on homebrewing (found at www.basicbrewing.com), to plan a series of experiments. We want our experiments to be collaborative, easy to execute and capable of yielding a clear result.

By encouraging collaboration among many homebrewers, we have the possibility of seeing an experimental result replicated many times over. If multiple homebrewers perform an experiment and most get comparable results, this will allow us to place more confidence in the results of the experiment.

To encourage as many homebrewers to participate as possible, our experiments will be simple to execute, require little advanced equipment and be able to be performed in a relatively short amount of time, so that results can be reported quickly. In this series of experiments, we will try to walk the line between designing experiments that are simple enough to encourage participation, but still controlled enough to yield worthwhile results.

Finally, we want to pick experimental questions for which we can get clear results. One key aspect of this involves what data is collected. Obviously, the most important aspects of beer are its flavor and aroma. However, experiments that involve judging the merits of one beer versus the other have the potential to get mired in subjective judgements. We wanted our experiments to include, where possible, actual measurements. These could include such things as original gravity (OG), final gravity (FG), time or pH. Where tasting data would be a part of the experiment, we wanted to make sure the instructions to the tasting panels would be clear. An experiment in which you ask a narrow question, such as "can you taste a difference between these two beers" is better than one in which you ask a nebulous question such as "how do these two beers compare?"

James Spencer, producer of the podcast, polled his Twitter followers (@basicbrewing) and received a wide range of suggestions. In the end, Chris and James chose the question, "Does leaving your beer on the primary yeast for a couple of extra weeks ruin it?"

A decade ago, the rule of the day was that beer must be racked off the primary yeast as soon as possible to avoid the off flavors associated with autolysis – the process of yeast degradation and decomposition. It was said that more than a week on the primary yeast was risking horrible meat-like or rubber-like off flavors and aromas. Racking to secondary was seen as necessary as soon as active fermentation completed.

But, is this true? What would happen if the beer was left on the primary yeast for an additional couple of weeks?

What We Did

To address our experimental question, we came up with three possible experimental designs and allowed each participant to choose the experiment of their choice. We also let participants choose their own beer styles and yeast.

One Carboy Experiment For the easiest version of the experiment, the participant only needed to brew one batch of beer. The brewer would ferment the beer as usual, making sure to take an OG reading. Once it finished, he or she would rack half of the beer to his or her bottling bucket or keg, then return the airlock to the carboy and let the remaining half sit for two weeks on the yeast. After the two weeks, the brewer would package the second half of the beer. After a couple weeks of conditioning, the brewer would take the FG of each beer and also taste them side by side.

Two Carboy Experiment Ideally, in an experiment, the only difference between different trials should be the experimental variable. In our case, this would be the contact time with the yeast. But, if you look at the design of the first experiment, this isn't exactly the case. Half of the batch gets packaged before the other, giving it more time to condition. With a little extra effort, we can control for this variable.

For the two-carboy version of the experiment, the brewers would again brew their beer as usual, but have a second sanitized carboy ready as the beer ferments. Once fermentation ceases, they would rack half the beer to the second carboy and let them both sit for two weeks. Then they would package them both at the same time.

Three Carboy Experiment When most homebrewers leave their beer in primary, they don't open the carboy, as happens in the first two experiments when we rack out half the contents. So we also had an experimental option that took that into consideration. In this option, the brewer would make the wort and split it evenly between two carboys. He or she would then pitch the same amount of yeast to each carboy and let them both ferment. When the fermentations cease, the brewer would rack one of the carboys to secondary and leave the other on the yeast. This more closely mimics the differences the beer would experience in real-life situations.

The data we asked the participants to collect were the original gravity (OG) of the beer and the final gravities (FG) of the two trials. We also asked them to taste the beer and see if they could tell a difference. Secondarily, we asked them to describe any differences. We also encouraged them to report any observations they found interesting. These could have included things such as differences in beer color, foam retention or any other beer characteristic. We felt that, if leaving your beer in primary for two weeks was as bad as some people imply, we should be able to get a clear cut result. If leaving the beer on the yeast led to significant off aromas or flavors, all the tasters would have to do is distinguish between bad beer (with pronounced meaty, brothy or rubber-like characteristics) and good beer (which lacks those notes).

Results

For his entry into the experiment, James brewed a very simple wheat beer, made with six pounds of dried wheat malt extract, 1.25 ounces of UK Fuggles pellet hops (boiled for 60 minutes) and fermented with Safale US-05 dried yeast.

At the two-week point in fermentation, James bottled four bottles off the primary fermenter, using Muntons Carb Tabs to prime. Also at that time, he racked half of the beer into a secondary carboy, leaving the rest on the primary yeast. Two weeks later, James bottled four bottles each from the primary and secondary fermenters, priming in the same method as before. Twenty-five days later, Steve Wilkes joined Chris and James to crack open the brews and test the results. (You can hear their discussion on the May 28th episode of Basic Brewing Radio).

A batch of pale ale sits on its yeast. If it doesn't get racked for a week or so, should it be dumped? Our results say no.

The beers were presented in a blind fashion to Steve and Chris. All three tasters thought the differences between the three beers were extremely insignificant.

Chris said that all three samples were "very similar" with a "clean" flavor. According to Chris, the beer bottled at two weeks had the least amount of body. The beer left on the primary yeast for four weeks had a very slight "meaty" or "broth-like" character, while the beer that had been racked to secondary was crisper, or — as he put it — the "zippiest."

While Steve thought the beer left on the primary yeast was the most different, it was the beer that he preferred. He described it as "most fruity."

James thought the beer bottled at two weeks had a sharper and cleaner character. While he thought the beer racked to secondary had a more fruity quality, James felt it was "cleaner" than the beer left on the primary yeast for the full time period – a beer he described as very slightly "nuttier."

The differences in aroma, color, carbonation and mouthfeel were negligible.

Missing in the discussion altogether were off-putting, obvious flaws in the beer. While James and Chris used the adjectives "meaty" and "nutty," they both felt that they had to search intently to find those characteristics, and may not have noticed them otherwise. There wasn't any of the "rubbery" character most often said to be a characteristic of autolyzed yeast.

Similarly, racking to secondary doesn't seem to have had a significant effect on the final gravity of the wheat beer. At the time of racking, the beer measured 1.014 specific gravity. Two weeks later, the beer that was left on the primary stood at 1.012, while the racked beer weighed in at 1.011 — a difference of 0.001 between the two approaches.

Twelve homebrewers from four countries responded to the call to repeat the experiment on their own and submit the results via an online form. Their results are summarized in the sidebar on page 52. Remarkably, each of the twelve used different ale yeast strains. Also remarkable was the fact that none of the participants reported that his beer had been ruined by off flavors typical of that caused by autolysis.

The most extreme example was from R.J. Parker of Mountain View, Hawaii. R.J. had transferred a gallon of fermenting beer from his primary bucket to avoid blowoff. He had let the gallon ferment and sit on its primary yeast for 40 days more than the beer that had been in the bucket.

R.J. reports that the beer left on the yeast was "very clear and slightly mellower." He also says, "it's a bit more fruity, but differences are very slight. The difference between the two batches is quite subtle."

The twelve experiment participants were split on whether the process yielded significant flavor differences. Six said there was either no or slight flavor difference, while five reported definite flavor differences. One was disqualified because coriander was added to one sample and not the other. However, in his submission, Hugh Brown of New Westminster, British Columbia, commented that both samples were quite good.

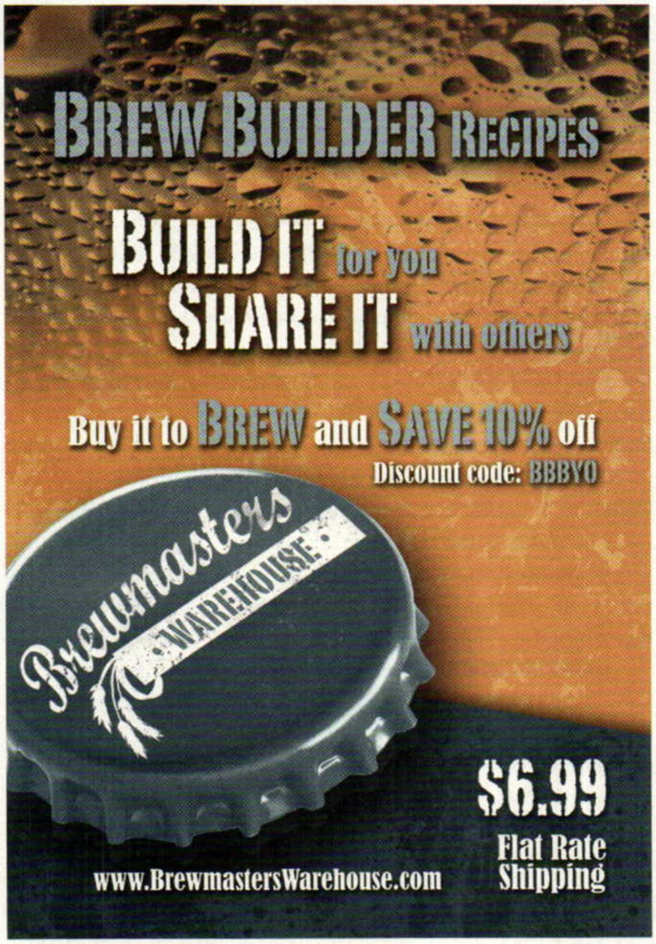
Of those that described a flavor difference, five reported that the racked beer tasted "cleaner" or "smoother." Adam Ross of Davenport, Iowa said his transferred sample tasted "cleaner," but he preferred the North English Brown that had spent more time on the yeast.

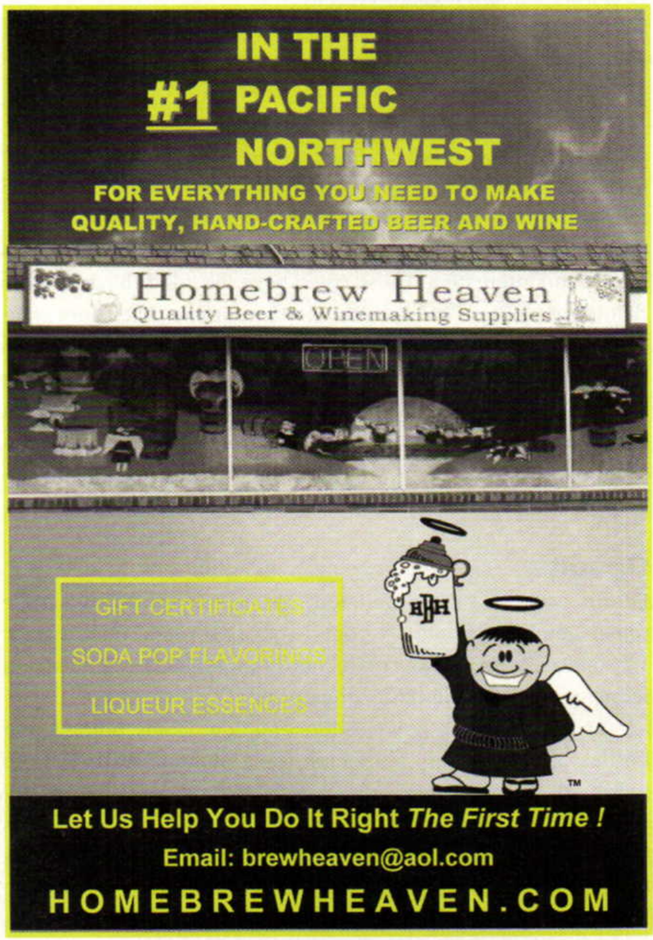
"My final verdict is that I preferred the beer that remained on the yeast," said Adam, "which is a little disappointing as I've been racking every beer I have made for almost two years now."

Jerry Marowsky of Oak Creek, Wisconsin also preferred the half of his American Pale Ale that had spent more time on the primary yeast, but he thought it tasted "cleaner."

"I believe letting the beer sit on the yeast for a slightly extended time helps the beer mellow and cuts down on cellaring time," said Jerry.

George Helfers of St. Louis, Missouri brewed a Blonde Ale. "The batch left on the yeast had definite flavor and aroma differences," George said. "I detected a bready, grainy aroma, a more pronounced hop bitterness, and overall it just was not as 'smooth' as the first batch. I do believe that the conditioning of the first





batch may have contributed to many of the differences. Therefore, I can't say for certain if remaining on the yeast affected the beer in a profoundly noticeable way."

Those expressing a preference for one sample or the other were divided equally: three on each side of the fence.

As you can see by the sidebar chart, leaving the beer in the fermenter apparently didn't make a significant difference in the gravity of the beer over the additional two weeks.

Six of the participating brewers noted differences in the carbonation or head retention of the beers. Four said the racked beers had better carbonation, while two leaned toward the beers that remained on the yeast. However, it should be noted that some of these beers had more time in the bottle or keg to condition and develop better carbonation levels.

Only one brewer reported a significant difference in the color of the samples, saying that the beer that remained on the yeast was slightly darker. Again, none of the participating brewers reported off flavors that spoiled the samples left on the primary yeast for an additional two weeks.

Conclusions

The results of this experiment are clear — leaving your beer on the primary yeast for a moderate amount of time (two to four weeks) does not ruin it. In our experiment, the flavor difference between the trial beers was very subtle and no brewer reported that the beer left on the yeast was marred by excessive off flavors. Leaving the beer on the yeast does, however, change the character slightly. Interestingly, participants were split over whether this improved or detracted from the beer. It is important to note that all of the beers in the study were ales. It is possible that lager beers — which are fermented with different yeast strains and at colder temperatures — might respond differently. In addition, off flavors or aromas may result from a longer exposure to yeast.

There are elements of our experimental design that could be criticized. For example, James performed a variant of the two-carboy experiment and disturbed the beer sitting on the yeast twice. Also, there was a variety of experimental approaches among the participants. However, we feel the consistency of the results, across ale strains and experimental approaches, shows that our result is strongly supported. Unless our experimental design somehow suppressed the development of brothy or rubber-like off characters — something we strongly doubt — we think brewers can be confident that moderately long contact with yeast will not spoil a batch of homebrewed ale. It does, however, cause a slight difference in the beer's taste.

Our next experiment will ask the question "How does pitching rate affect beer character?" Visit the *Basic Brewing* website or Chris's blog on byo.com for a description of the experiment. We invite all interested brewers to join us in tackling this topic.

James Spencer is the host of Basic Brewing Radio *and* Basic Brewing Video. *Chris Colby is Editor of* Brew Your Own.

Techniques

Feed the Yeast

Choosing and using yeast nutrients

by Jon Stika

Proper nutrition of brewing yeast is critical for yeast to grow unimpeded and ferment our wort without limitation to produce all the flavors and byproducts we desire in our beer. Adding supplemental yeast nutrient to every batch of wort is cheap insurance against a stuck, incomplete or otherwise substandard fermentation. For some styles of beer, supplemental yeast nutrients may be critical to a successful fermentation if nutrients in the wort are lacking due to a higher proportion of non-malt adjuncts in the recipe. Variations in the mineral content of potable water across the country and the fact that some brewers must use reverse osmosis or distilled water for brewing may also necessitate the addition of yeast nutrients to each batch of wort. Knowing how to choose and use yeast nutrients can help you make consistently superior beer by assuring your yeast are well fed every time.

What yeast needs

To grow, reproduce and ferment our beer, yeast require a source of energy (sugar), water, oxygen (sterol production for healthy membranes), phosphorus (for DNA replication and energy transfer), sulfur (to build amino acids), amino acids (or nitrogen with which to build amino acids that are used to manufacture protein and enzymes), fatty acids (a building block of cell membranes), potassium, magnesium, manganese, copper, iron, zinc, nickel, molybdenum, cobalt, boron, biotin (vitamin B7), nicotinic acid (Niacin or vitamin B3), and pantothenic acid (vitamin B5). The B vitamins are necessary for most enzymatic reactions that build protein, fatty acids, carbohydrates and DNA. The other mineral elements are involved mostly in enzymatic reactions.

Some or all of these essentials in the life of yeast are present in barley malt and/or the water used in brewing. However, not all of what yeast need are always present in adequate amounts for them to reach their full potential of growth, reproduction and metabolism necessary to make great beer. If you are brewing an all-malt beer using tap water, you may not need much, if any, additional yeast nutrient depending on the chemistry of your tap water. If you are brewing a beer with 25% or more non-malt adjuncts and/or using distilled or reverse osmosis water, your wort may be lacking some of the essential constituents for brewing fungi to perform their work successfully.

Most of the time, wort will be adequately nutritious to the yeast. If it is deficient, however, it is most likely a lack of nitrogen, phosphorus, zinc and biotin. Yeast needs nitrogen and phosphorus in significant quantities that may not be in adequate supply in wort, particularly for beers at each end of the original gravity spectrum. Both lighter and heavy styles of beer may rely on non-malt adjuncts; the former to keep the color light and the latter to boost alcohol or manage color and/or flavor. Either way, refined sugars or other non-malt adjuncts do not contain many of the things yeast need, but this is not typical. Zinc and biotin are two things that tend to be deficient in both barley malt and brewing water. Therefore, some supplementation of nitrogen, phosphorus, zinc and biotin is helpful in most situations to achieve top yeast performance.

Nutrient rundown

Yeast nutrients basically come in four types: diammonium phosphate, yeast hulls, yeast nutrient or energizer, such as Wyeast's Brewer's Choice Nutrient Blend and most recently, special dried yeast product called Servomyces from White Labs. If a brewer has any concerns, a dose of Servomyces, or some other complete yeast nutrient, is all that's needed.

Diammonium phosphate, or DAP, (a commonly used plant fertilizer) supplies nitrogen and phosphorus to yeast, but nothing else. Therefore, DAP is useful as a basic yeast nutrient to supply nitrogen and phosphorus, but will not help rectify a deficiency of any other essential mineral or compound. DAP can be added to the wort during the boil, or added to the boil of a yeast starter wort. A half teaspoon of DAP is generally recommended for addition to a 5-gallon (19-L) batch of wort. Barely a pinch is all that should be added to starter wort of a gallon (3.8L) or less in size if it is needed.

Yeast hulls are the dried bodies of yeast themselves. If the yeast was grown in a medium that supplied all of the essentials for their growth, then some proportionate amount of those essentials will be retained in the yeast after they are dried and killed. Yeast hulls have a limited content of nitrogen and phosphorus and therefore may need to be supplemented with DAP in a very light or high adjunct beer recipe. As a general rule, a teaspoon of yeast hulls is recommended in a 5-gallon (19-L) batch of wort, less for a smaller volume of starter wort.

Yeast hulls are often combined with DAP and other ingredients and sold as yeast "nutrient," "energizer" or "fermentation aid." If you want to be sure that a yeast nutrient contains zinc, biotin or other particular compounds, check the information on the supplier's website or catalog for a detailed description of the product. A teaspoon of yeast "nutrient" or "energizer" should be sufficient for a 5-gallon (19-L) batch of wort, with proportionately less used in a smaller volume of starter wort.

Servomyces is a unique yeast nutrient product comprised of dried and killed yeast that were grown under special conditions in a nutrient medium fortified with zinc and magnesium. With an ample supply of essential elements and compounds contained in the cell walls of the dried and killed Servomyces, the cargo of goods for the yeast that will ferment wort is more bio-available and less likely to become chelated (tied to large organic molecules) in the wort. Therefore, Servomyces not only provides a proper mix of essential compounds for yeast nutrition, but provides them in a form that is easily assimilated by the active yeast we pitch into the wort to conduct fermentation. Servomyces was developed for the commercial brewing industry, but is now available in small capsules for use by homebrewers. One capsule is sufficient to treat a 5-gallon (19-L) batch of wort with proportionately less used in a smaller volume of starter wort. It is recommended that Servomyces be added to wort during the last ten minutes of the boil.

There are also other alternatives to commercially available yeast nutrient preparations that you may already have around the house. Since zinc and biotin are the most commonly deficient yeast nutrients in typical wort, I took a look at the zinc supplement and B-complex vitamins I have been taking each day for my own health and well-being. The label on the zinc supplement showed that each tablet contains 15 mg of zinc as zinc gluconate. One quarter of a tablet of this supplement would provide approximately 0.2 ppm in a 5-gallon (19-L) batch of wort; close to the recommended amount suggested for proper yeast nutrition. I also checked the label on my B-complex sup-

Symbol	Name	Desired Range or Value	Units
K	Potassium	78-156	ppm
Mg	Magnesium	49-97	ppm
Mn	Manganese	110-220	ppm
Ca*	Calcium	1	ppm
Cu	Copper	0.1	ppm
Fe	Iron	0.1-0.2	ppm
Zn	Zinc	0.1-0.15	ppm
Ni	Nickel	0.6-5.0	ppm
Mo	Molybdenum	0.1	ppm
Co	Colbalt	6	ppm
B	Boron	4	ppm

*Ca is not considered a requirement for yeast growth and wort fermentation, but for flocculation of yeast after fermentation has subsided.

plement and found that it contains vitamins B3, B5 and B7; all the B vitamins recommended for proper yeast nutrition. As with the zinc supplement, a quarter of a B-complex tablet should be sufficient in a 5-gallon (19-L) batch of wort. Each of these nutritional supplements could easily be ground into powder and added to the boiling wort to supply zinc and B-vitamins to the chosen yeast.

Other alternative sources of yeast nutrient might be: brewing yeast that is past the recommended viability date, yeast used for baking or brewers yeast sold as a human nutritional supplement. Any of these products are a form of yeast that includes the good things that actively growing yeast would need in one form or another. If added to the boil, the yeast would be killed so as not to compete with the desired strain of yeast pitched for fermentation. Any of these products with the addition of some zinc, B-vitamin complex and DAP (in the amounts recommended previously) would result in a fairly good homemade yeast nutrient blend. Remember, a little goes a long way.

Trace elements

Many trace elements that yeast need are typically present in barley malt and/or tap water used for brewing. Most of these trace elements are used by yeast for enzymatic reactions or metabolism. The table on page 57 shows the desired range or value for essential trace elements in wort to meet the nutritional requirements of yeast. Other than potassium, magnesium and manganese, most elements are needed in very small amounts and are available in tap water or from metal utensils or containers used in the brewing process.

If you have a detailed analysis of your private water supply, you can check it against the table to see if any essential yeast minerals are lacking. Municipal water suppliers will usually be happy to provide you with a copy of the finished water analysis.

Water

If you are concerned that your brewing water may be short of a particular essential element such as; phosphorus, potassium, magnesium, manganese, or zinc, check your local health food store for a nutritional supplement containing that particular element. Review the product label for the amount of the element present in each tablet. The amount of element available is usually expressed in milligrams (mg) per serving. Divide the amount of available element in mg by the number of liters in your brewing batch size and you will have the mg/L or parts per million (ppm) increase of that element in your wort. For example; if your brewing water is low in Magnesium and you have a nutritional supplement that contains 400 mg of Magnesium per tablet added to a 5-gallon (19-L) batch of wort, that tablet would increase the Magnesium concentration by 21 ppm (400 mg/19 L = 21 mg/L or 21 ppm). Be aware that a "serving" may be more than one tablet or capsule.

Jon Stika writes "Techniques" for each issue of Brew Your Own.

Press Your Own

Build a cider or perry press

Story and photos by Paul Brannan

A small cider press can cost hundreds of dollars. It is not difficult, however, to build your own press using inexpensive materials. The design of the press is flexible, to take into account the variation in the materials you can find. To get an idea of the trade-offs you can make, it is useful to look at what the press has to do.

POMACE

After you gather and wash your apples, the first step is to crush or mill them into a kind of pulp, known as pomace. Some juice will be released in the crushing process — and the rest must be extracted by pressing.

The pomace must be held in a container when being pressed, and traditionally this was done by wrapping it in a cloth square to make a "cheese." Each cheese is assembled in the cheese former, a simple frame (as shown in photo 1). A number of such cheeses are stacked vertically in the press. Underneath, a tray (shown in photo 2) collects the juice and directs it to a container. Above the cheese levels is a flat plate which applies pressure. It is possible to place slatted wooden separators between each cheese during pressing to provide flow channels for the juice, but this is not essential. Around the tray, cheeses and top plate is a strong frame, and between this frame and the top plate is a device which exerts the pressure — such as a screw jack or hydraulic jack. (The inset photo on this page shows the cider press extracting juice.)

Once the maximum amount of juice is extracted, the pressure is released and the pressed pomace discarded. The apple juice can then be made into cider — or in the case of juice made from eating apples, drunk directly.

THE PARTS OF THE PRESS

The juice tray

This is a good place to start your design, as the dimensions of the juice tray determine nearly all of the other component dimensions. The base of the tray must be fairly strong, and have a surface that will not contaminate the apple juice or be damaged by its acidity. An offcut of laminate countertop is a cheap solution. A standard kitchen countertop is 25–26 inches (64–66 cm) deep, and the ones based on MDF/particle board with a thickness of around 1 ¼ inches (~3.2 cm) will be fine. The tray can be square or slightly rectangular, although it shouldn't be too wide as this increases the deformation of the horizontal frame beams when the press is used.

Next, glue and screw a softwood lip on each of the four sides (as shown in photo 3); 4 inch x ¾ inch lumber is about right for this. Bore a hole in one of these sides to take a length of plastic water pipe; the hole must be level with, or fractionally lower than, the bottom of the tray. A pipe with an internal diameter of around 1 inch (2.5 cm) makes cleaning easier. Seal and varnish the softwood lipping using polyurethane varnish.

There needs to be some kind of locating arrangement on the underside of the juice tray to prevent it from slipping sideways in the press frame. This could either be a tongue that fits between the lower frame members, or slats which fit on either side of the frame (as shown in photo 4).

The "cheese" former and cloths

Traditionally, a cloth

PARTS LIST

FRAME:

Lower horizontal beams:
3 ft 4 in x 2 in x 4 in (2)
Upper horizontal beams:
3 ft x 2 in x 6 in (2)
Uprights: 4 ft x 2 in x 4 in (2)
Supports: 20 in x 2 in x 4 in (2)
Carriage bolts:
5/16 in or 3/8 in x 7 in (8)
Hex nuts: 5/16 in or 3/8 in (8)
Flat washers 5/16 in or 3/8 in (16)
Hex lag screws:
5/16 in or 3/8 in x 5 in (8)

JUICE TRAY:

Laminated countertop:
25 in x 25 in x 1-¼ in (1)
Tray sides: 25 in x 4 in x ¾ in (2)
25-¾ in x 4 in x ¾ in (2)
Bottom slats: 20 in x 4 in x ¾ in (2)
Flat head wood screws:
No.8 1-¾ in (40)
Juice outlet pipe: 1 in diameter plastic water pipe, length variable

CHEESE FORMER:

Sides: 21 in x 4 in x ¾ in (2)
21-¾ in x 4 in x ¾ in (2)
Flat head wood screws: No.8 2 in (8)
Support slats: 32 in x 4 in x ¾ in (2)

Waterproof PVA glue
Polyurethane varnish

made from natural fibers was used for wrapping the cheeses of pomace. A better solution now is either plain nylon sheer curtain fabric or maybe shade cloth. Allowing for the cheese to be completely wrapped with some overlap, each cheese cloth would ideally have a minimum dimension of twice the interior size of the cheese former, plus a couple of extra feet.

To make a cheese, you place the cloth centrally over a rectangular (or square) frame — as shown in photo 1 — to give the cheese its form. As the cheeses must be a bit narrower than the juice tray, and allowing for the fact that they tend to spread slightly under pressure, it's a good idea to make the interior dimensions of the cheese former about four or five inches smaller than those of the tray, say 20–21 inches (51–53 cm).

For the first cheese, the former is placed directly on the tray. For the later cheeses, you will need a couple of wooden slats to support the former on top of the cheese underneath, to stop it sliding down. The dimensions of these slats are not critical, provided that they are longer than the width of the cheese former. Again, these slats should be coated with polyurethane varnish. Once the cheese has been folded, slide the slats out and place them on top of the cheese ready for the next layer. (Photo 9 shows the cheese former and slat, resting in the tray.)

1. Every "cheese" is assembled in the cheese former, a simple wood frame.

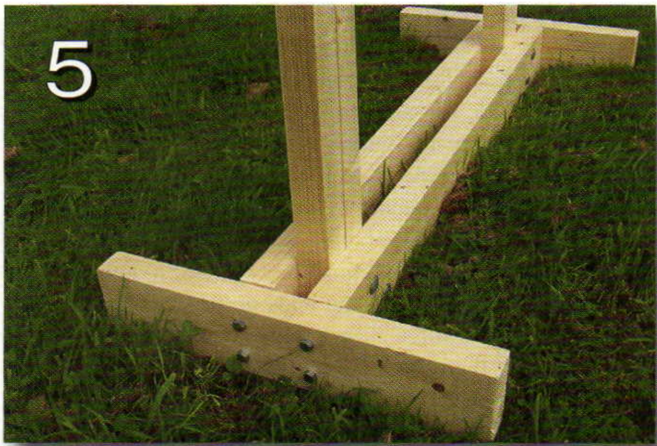
2. At the bottom of the cheese former is a tray that will collect the juice.

3. The next step is attaching a softwood lip on each of the four sides with glue and screws.

4. The base of the frame needs to have a locating arrangement, such as slats, that fit on either side.

The Press Frame

The rectangular press frame is built from planed softwood lumber, roughly 2" x 4" (5.1 x 10 cm) in section, although it might be better to increase the upper cross beams to 2" x 6" (5.1 x 15 cm) to resist bending forces. (Photos 5, 6 and 7 show the important details of the frame. The parts list on the page 59 gives the parts you would need to build the press as shown.) There is no real benefit to building a stronger frame than this with a view to increasing the pressure of the press, unless you also reinforce the juice tray and top plate. In any case, the extra pressure isn't going



5. The press frame is built from planed softwood lumber.

6. It would be best to use 2" x 6" (5.1 x 15 cm) wood for the upper cross beams to resist bending forces.

7. The width of the frame needs to be slightly larger than the juice tray.

to make a big difference to the volume of juice extracted. The top and bottom horizontal beams are double, both to resist bending forces and to provide a more stable base for the juice tray.

The width of the frame needs to be very slightly larger than the juice tray. The height depends on the number of cheeses and the minimum height of the jack which applies the pressure. The frame members are attached to each other using carriage bolts with washers under the nuts. Mark the wood with a pencil where the drill holes will go. Double check your measurements carefully before drilling the holes.

For stability, short cross beams are attached to the ends of the lower frame members using hex lag screws. When using the press, it is easier to place it on a table or workbench to have a convenient working height, and also so that the apple juice can be poured directly into a container. The length of the juice outlet pipe depends on the size and shape of the table supporting the press, and where you can position the collecting container.

Other Components

Once the stack of cheeses is in place, you need to add a top plate to spread the load of the jack across them. This can be a pine board or an offcut of a table top, with about the same dimensions as the juice tray. This should be varnished on both sides. Make sure that there are no sharp edges or corners on any part of the press which could damage the cheese cloths. (The fully-assembled press is shown in photo 8.)

The easiest way to apply pressure to the cheese stack is with a car jack; a hydraulic bottle jack is probably the simplest type to use. As the head of these jacks is usually quite narrow, there needs to be a hardwood board — or better still, a steel plate — between the two upper cross beams of the press frame against which to push.

Whatever type of jack you use, it will usually have limited travel, so as the cheeses are compressed, you will need to add wooden blocks to fill the gap between the top plate and the jack. At first, this is fairly easy; later on, the cheeses tend to spring back as the pressure is released, making it difficult — if impossible — to add further blocks. A variety of block thicknesses could help.

MILLING THE FRUIT

If you don't have a fruit mill, there are other ways to crush or pulp the apples. You could put them in a strong plastic tub and crush them using a length of 4" x 4" lumber fitted with a cross piece to act as a handle. Alternatively, you can buy simple rotating blades that attach to an electric drill. For safety — and to reduce mess — these are used in a pail with a lid; the shaft of the blade passes

8. Once you have assembled all the parts, the fully assembled press should look like this.

through a hole in the lid. For large volumes, though, you may want to buy or build a fruit mill.

OPERATING THE CIDER PRESS

Assemble the press and clean the parts which will come in contact with the apple juice — tray, cheese former, top plate. You can crush the apples in advance and keep the pulp in sealed containers for a day or two, if necessary. Position a collecting container under the juice tray outlet pipe. If this is going to be the fermenting vessel, it's best to sanitize it first using sodium metabisulfite. Six-gallon (23-L) fermenting barrels work well.

Make the first cheese of apple pulp by filling a cloth laid over the former frame. Fold over the ends of the cloth to close the cheese. Next, remove the cheese former, lay the slats on top of the first cheese. Then, place the cheese former on top of the slats and prepare the next cheese. Repeat until you have a stack of five or six cheeses. Remember that you can add slats between cheeses, to serve as juice channels, as you go.

Place the top plate on the cheese stack, and position the hydraulic jack between the top plate and the press frame. Add extra pieces of lumber as spacers if necessary.

Start applying pressure to the cheese stack with the jack. Once the jack reaches the end of its travel, release the pressure and add more spacing lumber before pressing again. Continue until the amount of juice produced tails off. After the press is used, it should be cleaned before being put away.

MAKING CIDER

Making cider from apple juice (or perry from pear juice) is not that different from making other fermented beverages. However, cider and perry is often made to be sparkling, so you will need either bottles that will hold pressure (such as Champagne or beer bottles) or a pressure barrel for a secondary fermentation.

INGREDIENTS

You can ferment apple or pear juice from the press to make cider or perry around 5–6% ABV. Or, you can add sugar to apple juice to make apple wine, at 8–11.5%, depending on how much sugar you add. For a traditional New England style cider, add a couple pounds (~1 kg) of raisins and a couple pounds (~1 kg) of brown sugar per every 5 gallons (19 L) of juice. Apple ciders can be spiced with cloves or apple pie spice. (Soak the spices in vodka and add the extract to taste.) A small amount of grape tannin — half a teaspoon or less per 5 gallons (19 L) — can also be added.

PROCESS

Sanitize your fermentation vessel. Pour in the apple juice and other ingredients, if applicable. Add ½ teaspoon of sodium metabisulfite (dissolved in a small amount of water) per 6.0 gallons (23 L) of juice. Let the juice sit for 24 hours, then add wine yeast. (Champagne yeast works well.) Seal your fermenter, leave to ferment for four weeks then rack the cider into a second fermenting barrel. Seal the new vessel with a sanitized airlock and leave it to complete the fermentation. When the fermentation has completely stopped, put the cider into bottles or a pressure barrel. Add 1 ½ tablespoons of sugar per gallon of cider for the secondary fermentation, which will add sparkle to the cider. Do not add more than this quantity of sugar as excess pressure may cause bottles to explode. Leave for several weeks before tasting, as the flavor mellows noticeably with time. If you want your cider to be clear, add ¼ teaspoon of pectic enzyme per 5 gallons (19 L) before fermentation and fine with Bentonite or Sparkalloid (per manufacturers instructions).

9. The fully assembled former with the collection tray should look like this.

This is Paul Brannan's first article for Brew Your Own *magazine.*

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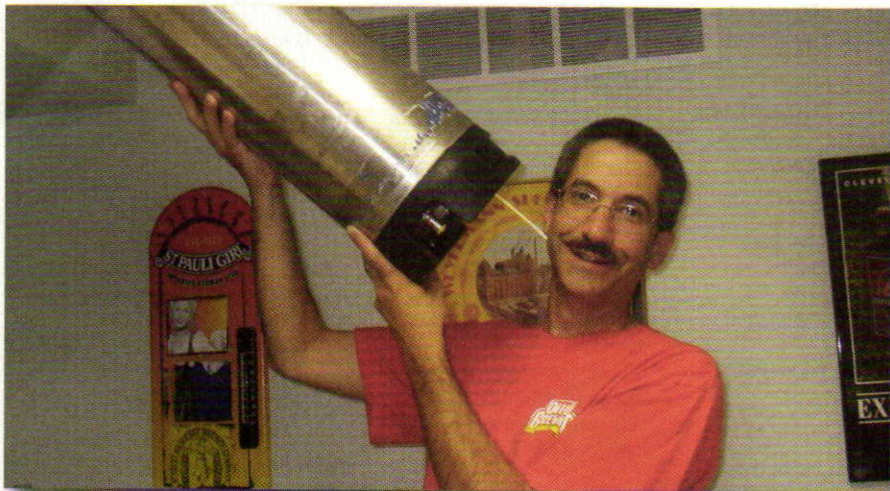
Bottomless Keg

How one brew made a lasting impression

Greg Tomei • Tallmadge, Ohio



Greg Tomei's keg went more than the distance. His weizen lasted nearly four months — including well-attended holiday parties!

Most everyone has probably heard of a bottomless cup of coffee or maybe the bottomless ocean. But I have never before experienced the bottomless keg. Here's my story.

It all started on a normal day of brewing in early November. I was brewing up a quick extract and specialty grain batch of German Dunkelweizen. With the Thanksgiving holiday coming up, I wanted to have a relatively easy-drinking beer available to the "non-craftbrew" beer-drinking crowd.

We usually have Thanksgiving dinner at our house with anywhere from a dozen to two-dozen guests. Of those, there are probably ten beer drinkers. In addition, my father's family has an extended family reunion every year on the Sunday after Thanksgiving with at least two-dozen beer drinkers, all expecting to sample the fruits of my labor.

By my calculations, my beer would be ready by Thanksgiving, giving me plenty of time to get my heavier beers brewed for the Christmas holidays and the cold northeast Ohio winter weather.

The beer was kegged in mid-November and force-carbonated one day later. My initial tapping confirmed that this quick-drinking ale would be perfect and I anticipated that it would last until the middle of December.

At this point, a power greater than any here on earth must have taken over.

Based on my family's planned get-togethers during the Thanksgiving weekend, a beer that I thought was going to last a few weeks was still hanging around well into the new year. It survived Thanksgiving dinner at my house with about five beer drinkers, including my Miller Lite-drinking brother-in-law, who happily sucked it down by what seemed to be the bucketful.

It also survived the family reunion that I mentioned. I always plan to bring a keg of homebrew for this event and this year was no different. Most everyone appreciates the quality of a well-made homebrew. Even if they don't normally drink handcrafted microbrews, they can appreciate the work involved and what it takes to create a batch.

Well, also in attendance at the party was the same brother-in-law from Thanksgiving who saw fit to serve himself and his entire family my beer in 24-oz. plastic cups. After having enjoyed my beer for Thanksgiving, he brought these cups specifically for my beer. Worse yet was the fact that these cups had a Miller Lite logo emblazoned on the side! I swear I saw him at least a half-dozen times filling his cups, two at a time, and sometimes even three. Did I mention that he was doing this for his entire family: son, daughter and son-in-law?

Ok, time to do the math. That would be more than three gallons of my precious brew, or 60-percent of my total output. Surely this beer isn't going to last much longer, and it certainly wouldn't be around for the Christmas season. The relative lightness of the keg after the party compared to when I brought it confirmed my expectations.

But this beer kept right on giving. After returning the keg back to my beer fridge, with each glassful that I poured, I fully expected it to blow. My wife even asked me if there was something wrong with the beer. For a while, I thought maybe there was.

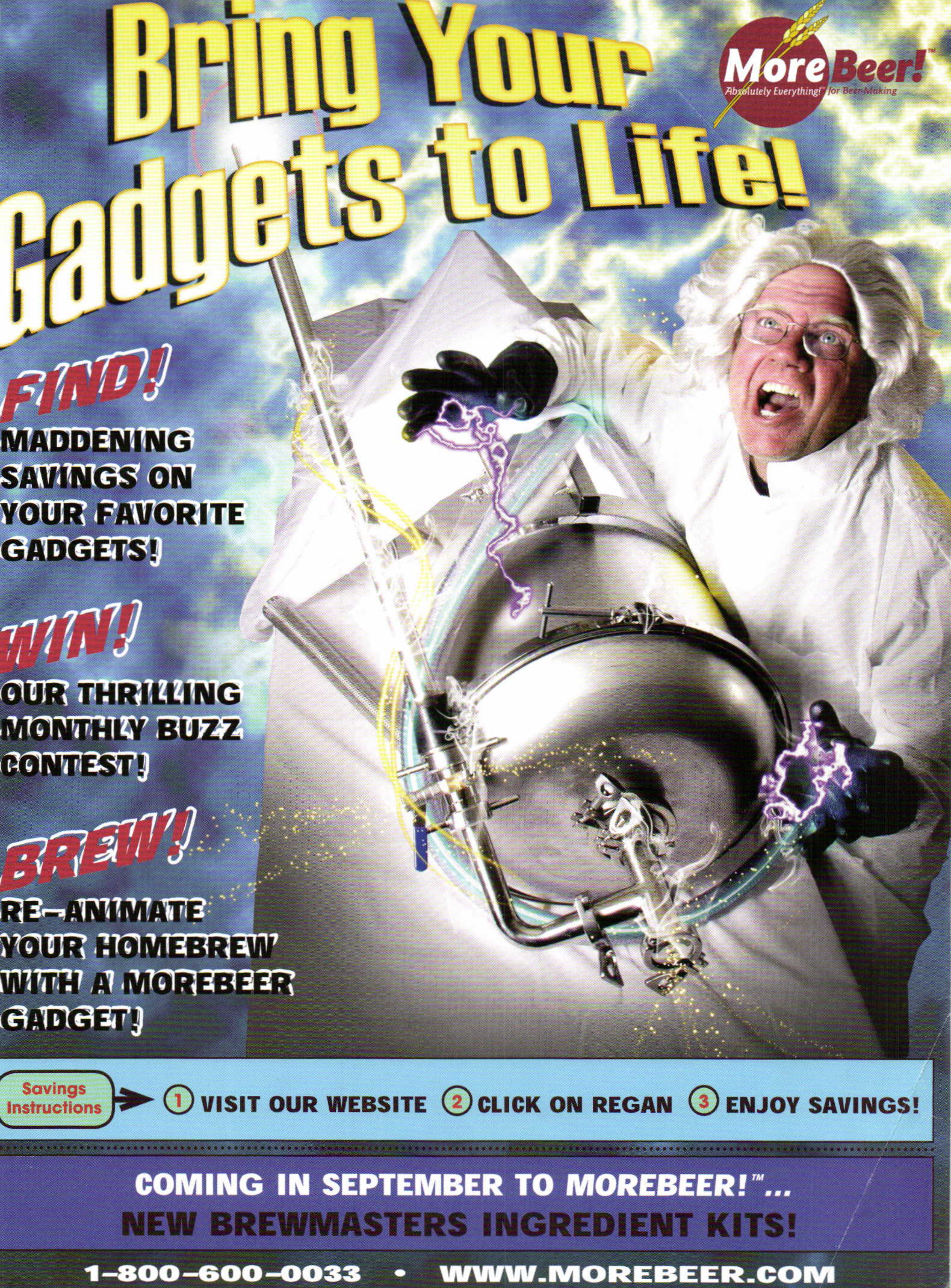
I started thinking that maybe my taste buds had deteriorated to the point where I couldn't tell the difference between this beer and Miller Lite. But that was not the case. In fact, throughout this time, the flavor miraculously kept improving. Weizens are normally best when consumed fairly fresh, but at four months, the beer actually was getting better.

But alas, like all good things, this too eventually came to an end. One day I eventually heard that familiar "pfffftttt" sound coming from the picnic tap. The keg finally blew on March 6, almost four months to the day from when I brewed it.

Ironically, it occurred during another brew session — how appropriate.

Unlike my usual thoughts of "No, it can't be, this beer died much too young," this time, I had somewhat different feelings. I felt a sense of accomplishment — a sense of awe and a great sense of hope. Perhaps it's similar to when someone dies at a very old age. You feel sad, but you know that they lived a long and fruitful life.

Someday, I hope to experience that same feeling again. And I hope that other brewers can also experience the joy of the bottomless keg.



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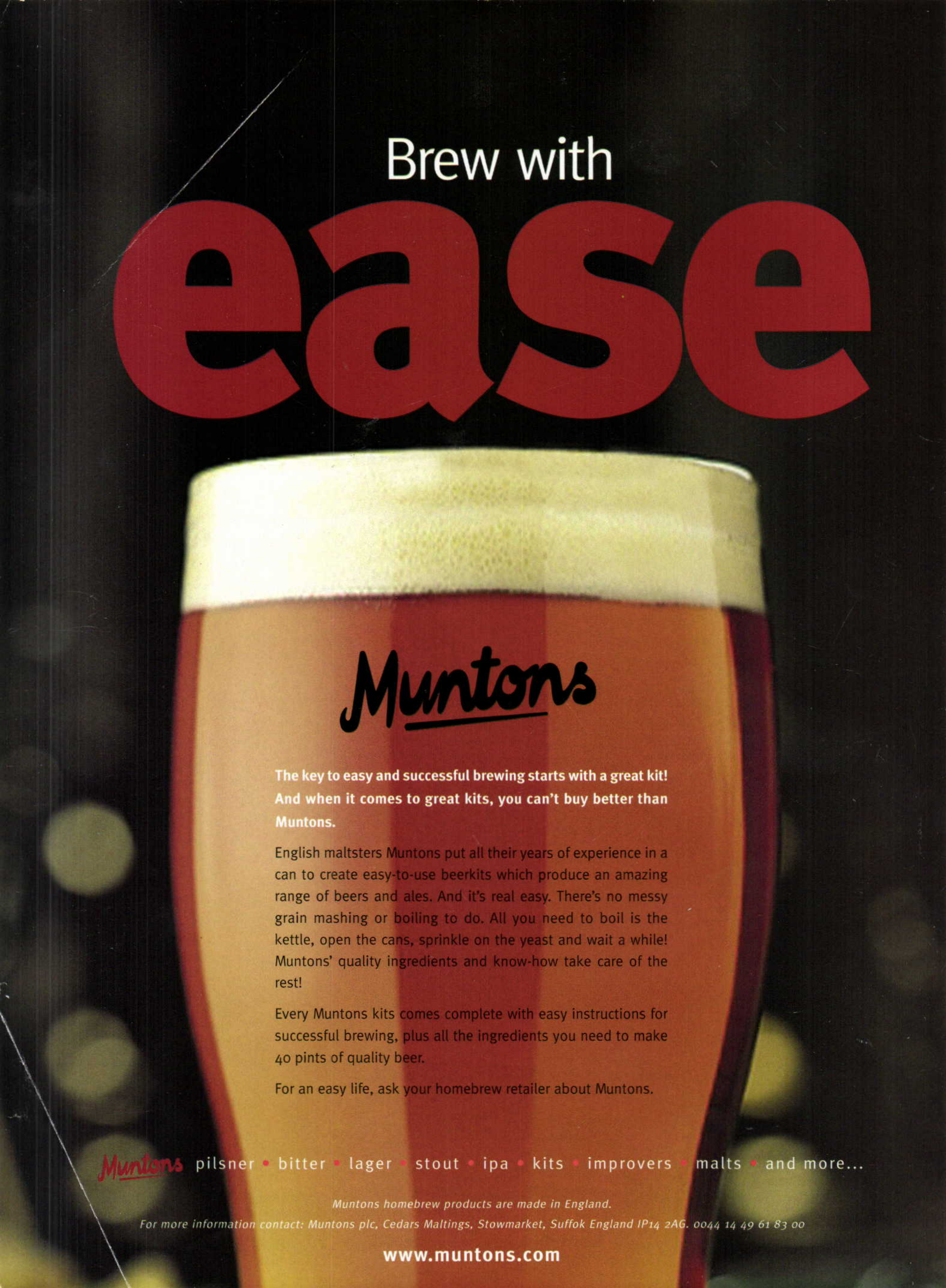
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