THE SECRET TO HOP AROMA AND FLAVOR

#### BY JAMIL ZAINASHEFF

ave you recently come across a craft brew with a massive hop flavor and a smooth bitterness that you really loved? If you're like me, you wondered how the brewery created such an incredibly huge, but smooth, hop character. The secret, it turns out, is very large additions of late hops.

Late hopping is the addition of hops during the latter part of the boil. It is an excellent method for creating hop aroma and flavor in your beer. In general, any additions with less than 30 minutes left in the boil and prior to cooling the wort are considered late hop additions. Although some hop oils are lost during this shorter boil, reactions between the hop compounds and the wort create other desirable flavor-active compounds not found in hops.

Many brewers turn to dry hopping in an effort to get more hop flavor and aroma, but dry hopping results in a completely different hop character, which may be out of place in certain styles.



While dry hopping is a great technique, it is often characterized as more resiny and grassy, while boiled hops are often characterized as more floral and spicy. Ray Daniels, in *Designing Great Beers*, says, "Latehopped additions have been characterized as more floral, fragrant, and less grassy than dry-hopped additions."

#### FLAVOR AND AROMA

It seems really simple when you think about it: add more late hops and get more flavor and aroma. Most of us, when we started brewing, were told that early hop additions are for bittering only and late hop additions are for flavor and aroma only. What we were not told is that shifting the bittering load to late in the boil can still provide substantial bittering in addition to a huge hop flavor and aroma. Done right, it can produce some spectacular results. While the great brewing scientist Jean de Clerck found late hopping to be wasteful and possibly harmful to beer flavor, professional brewers today are turning more and more to late hopping to get the big hop aroma and flavor that consumers crave. Sure, it costs more, but many brewers find their customers appreciate the results.

I first learned how far some brewers were pushing late hopping while drinking a pint of AleSmith's Evil Dead Red with owner/brewer Peter Zien. This Halloween





seasonal ale has substantial malt character, smooth bitterness, luscious mouthfeel and an evil-looking, almost blood red (deep mahogany) color. Yet what really made me take notice was the amazing hop flavor and aroma from start to finish.

"Except for 3 or 4 IBUs, we add all of the hops during the last 10 minutes of the boil," Zien revealed. At that time I had never heard of, nor tasted, anything like that, and I was intrigued as much by the possibilities for this technique as I was by the beer I was enjoying.

Evil Dead Red is San Diego, Calif.-based AleSmith's most extreme example of late hopping. "The beauty of this beer is how the components of malt and hops exert themselves separately and substantially, rather than working to balance each other," Zien says. "The trick lies in a heavy load of late hopping, creating a big flavor and aroma profile with only a minimum of up-front hop bitterness. This allows the malt character to remain strong and perceptible even in the face of big hop flavors and aromas."

AleSmith's longtime brewer Tod Fitzsimmons created Evil Dead Red as a homebrewer several years ago and the beer has been a seasonal staple at AleSmith for the past seven years.

"Our main goal with late hopping at AleSmith is to impart a substantial degree of both hop flavor and aroma to the ale," Zien explains. "With the exceptions of our Wee Heavy Scotch Ale and Nautical Nut Brown Ale, all of our beers contain late hop additions in varying degrees. We late hop certain beers with late kettle additions and/or post-boil additions in a hopback. We also dry-hop some beers in the secondary."

Another brewery that has embraced late hopping is Firestone Walker Brewing Company of Paso Robles, Calif. Brewmaster Matt Brynildson says, "We practice a lot of late hopping on the majority of our beers. Our main goal with increasing our late hops is big hop aroma and flavor. All of our beers have at least some hops that are added at the beginning of boil for bitterness, as this also helps to keep foaming and boil-over down in the kettle, but these kettle charges are minimal to allow for larger late hopping charges. I brewed a flagship beer at another regional brewery where 95 percent or more of the IBUs were a result of whirlpool hopping."

Brynildson added, "American craft brewers practice a number of different methods of late hopping, with one very popular method being whirlpool hopping. This is a bit of a fusion between traditional late hopping and hopback methods. Adding hops late in the whirlpool results in lower isomerization of alpha acids and good uptake of hop oils and flavor components (especially with pellet hops). The fact that there is some isomerization (about 15 percent in whirlpool versus 35 percent in the kettle) of alpha acid means that not only hop aroma and hop flavor can be achieved, but also some bittering."

Having found out about the increased use of late hops at some of my favorite breweries, I began experimenting with it myself and encouraged a number of experienced homebrewers to give increased late hopping a try. Longtime homebrewer David Sousa brewed an IPA with Columbus hops, all at 15 minutes or later. "The results were as expected and more," he said. "The hop flavor was huge. Another thing I noticed was an increased mouthfeel. The beer had a really nice texture in addition to a very clean hop flavor. And it doesn't make you feel like you need to wait before you take another sip. Dry hopping, by comparison, tends to cling to the palate a bit more."

Sousa's comment on mouthfeel echoed my results and those of another highly experienced and technical homebrewer, Scott Lothamer, who made a Classic American Pilsener adding hops at 20, 10, five and one minute left in the boil. The result was a huge hop flavor, and when compared to another Classic American Pilsener of the same terminal gravity, it showed significantly more mouthfeel. This beer went on to win Best of Show at a homebrew festival the following week.

While there seem to be a lot of positive results, John Palmer, in his book *How to* 



#### **Evil Twin**

This beer ends up rich and malty, yet with a devilishly huge hop aroma and flavor. It is loosely based on AleSmith's delicious Evil Dead Red. Thanks to Peter Zien for his help with this recipe.

#### Ingredients

for 6 U.S. gallons (23 liters)

l 2.0 lb	(5.44 kg) British Pale Malt 3L
l .0 lb	0.45 kg) Crystal 40L
l .0 lb	(0.45 kg) Munich Malt 8L
0.50 lb	(0.22 kg) Victory Malt 25L
0.50 lb	(0.22 kg) Crystal 120L
0.25 lb	(0.11 kg) Pale Chocolate Malt 200L
0.5 oz	(14 g) Centennial pellet hops, 10% alpha acid (20 min.)
	(6.4 IBU)
0.5 oz	(14 g) Amarillo pellet hops, 7%
	alpha acid (20 min.) (4.5 IBU)
l.0 oz	(28 g) Centennial pellet hops,
	10% alpha acid (10 min.) (7.6
	IBU)
l.0 oz	(28 g) Amarillo pellet hops, 7%
	alpha acid (10 min.) (5.3 IBU)
l.0 oz	(28 g) Centennial pellet hops,
	10% alpha acid (0 min.) (0 IBU)
l.0 oz	(28 g) Amarillo pellet hops, 7%
	alpha acid (0 min.) (0 IBU)

**Extract with specialty grains option:** Using liquid malt extract, replace English Pale Malt with 8.75 lb (3.97 kg) pale malt extract. Replace the Munich malt with 0.75 lb (0.34 kg) Munich malt extract. Using dry malt extract, replace English Pale Malt with 7 lb (3.17 kg) pale malt extract. Replace the Munich malt with 0.50 lb (0.22 kg) Munich malt extract. **Yeast:** A clean, neutral yeast that attenuates in the mid-70-percent range is perfect. White Labs WLP001 or Wyeast 1056 American Ale are excellent choices. A good dry yeast option is Fermentis Safale US-56. Ferment at 68° F (20° C).

Target Original Gravity: 1.066 (16.21 Plato) Approximate Final Gravity: 1.016 (4.08 Plato) Brewhouse Efficiency: 70% Anticipated SRM: 17 Anticipated IBUs: 23.8 Anticipated ABV: 6.66% Wort Boil Time: 90 minutes

#### Directions

Single infusion mash at  $154^{\circ}$  F (68° C) using a ratio of 1.3 quarts water to 1 pound of grain. While you could go with a shorter boil, the 90minute boil enhances the blood-red color. It also adds a touch more melanoidin and caramel notes. Cool the wort quickly after the last hop addition to retain as much hop aroma as possible. Optionally, dry hop with more Centennial or Amarillo if you're a real hop monster. Carbonate to no more than 2 volumes and serve at 45 to 55° F (7.2 to 12.8° C).

## HAVING FOUND OUT ABOUT THE INCREASED USE OF LATE HOPS AT SOME OF MY FAVORITE BREWERIES, BEGAN EXPERIMENTING WITH IT MYSELF AND ENCOURAGED A NUMBER OF EXPERIENCED HOMEBREWERS TO GIVE INCREASED LATE HOPPING A TRY.

Brew, says, "A word of caution when adding hops at knockout or using a hopback depending on several factors, e.g. amount, variety, freshness, etc., the beer may take on a grassy taste due to tannins and other compounds which are usually neutralized by the boil (15 minutes)."

I asked Zien and Brynildson about any negative effects they might have encountered with increased late hopping. Zien said, "We haven't run into any negative effects of abundant late hopping to the AleSmith lineup. Critical factors appear to be the freshness and low cohumulone levels of the hops, softened water (especially the carbonate/bicarbonate value) and original gravities in excess of 1.055 S.G. (13.57 Plato). Perhaps a lower gravity beer would show signs of 'grassiness' or 'green leaf' aromas/flavors and astringency with severe late hopping, as the malt profile would not be able to offer any significant balancing or smoothing help."

Brynildson said, "Most of the negative effects are just yield and efficiency issues: low hop utilization, lower whirlpool wort yields and possibly some issues with plugging up the heat exchanger. However, the bottom line is that it is worth it because it makes excellent beer!"

#### WHAT ABOUT BITTERING?

Adding more late hops to increase hop flavor will also increase bitterness. You will



need to reduce the bittering hop additions to end up with the same overall IBU level. When AleSmith brews beers like Evil Dead Red, with lots of late hop additions, they get most of the bittering from the late hops. This allows for the maximum late hop charge and a huge hop flavor.

Moving hops to late in the boil not only reinforces the huge hop flavor and aroma, but some brewers suggest it also results in a much smoother, less harsh bitterness.

Greg Noonan in *New Brewing Lager Beer* writes, "Beers that are heavily hopped in the beginning of the boil exhibit a cleaner krausen fermentation head and are more stable than beers hopped later, but the hop bitterness will be coarser and less pleasant."

Several homebrewers have reported that after switching a recipe to all late hops, they experienced this effect. Sousa reports, "The bitterness seemed more rounded and less angular than a regularly bittered beer."

Shane Petersen has brewed more than 150 batches of beer, but he had never tried this technique. He brewed an all-latehopped IPA, with hop additions at 10 and five minutes only. Petersen says he was looking for more hop flavor, but also smoother bittering. He says the resulting beer "is really nice, very hoppy and flavorful with an extremely smooth bitterness. My main worry was that my IPA wouldn't be bitter enough. When I tasted the wort after chilling, I was even more worried because it didn't have any bitter zing to it, but after fermenting, it turned out that the bitterness level was just right. The hop flavor came through nicely and I'm really happy with it."

However, Brynildson warns, "There is no definitive proof that I am aware of that

there is a harsher bitterness or a different bitterness as a result of late hopping," so the smoother bitterness might be more expectation than actual perception.

#### **HOP SELECTION**

Select your late hop varieties based on their aromatic qualities. Brynildson said Firestone Walker uses a number of low alpha aroma varieties as well as mid-alpha dual purpose hops for late hopping. Examples include Styrian Golding, East Kent Golding, Cascade, Centennial, Crystal, Mount Hood and U.S. Fuggle.

Zien says AleSmith looks for aromatic hop varieties with good flavor characteristics and low co-humulone values.

"In our experience, these are the hops that isomerize without imparting harsh or astringent-like hop profiles," he explains. "This goes beyond late-hopping for flavor and aroma, and applies equally to smooth bittering early in the boil as well. The hops that have worked best for our late hopping include Cascade, Amarillo, Tomahawk, Simcoe, Chinook a newer variety, Palisades. and Tomahawk and Simcoe have relatively high alpha acid values and somewhat low cohumulone values and are best used in lesser percentages than the other hops mentioned. For our English-style ales, we use East Kent Golding and Styrian Golding. One of AleSmith's Belgian-style Ales, Lil' Devil, benefits from a run through a hop-back containing Styrian Golding whole hops on its way to the heat exchanger."

Some studies suggest that late hopping with high cohumulone hops tends to result in a harsher bitterness. However, Brynildson says he doesn't buy into that theory. "I also believe that the cohumulone argument is independent of how you are utilizing the hops—kettle hopping or late hopping," he said. "Some of the best smelling hops in the world are high in cohumulone and I plan to continue using them."

Given that a number of brewers report a less harsh bitterness from late hopping, it might be a lesser issue than first thought. It might be more important to





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# TO USE THIS TECHNIQUE IN YOUR OWN BEERS, REPLACE ALL OR PART OF YOUR traditional bittering hop additions with additions at 20 minutes or less remaining in the boil, increasing the amount of hops to get the same ibus.

select late hops based on their flavors and aromas first, and their cohumulone fraction second.

With this technique comes the question of using whole leaf or pellet hops. Petersen

uses a false bottom in his boil kettle and was able to use whole hops for his experiment. His concern was that a large amount of pellet hops might clog his counter-flow chiller. However, using whole hops results in a very large mass





that can make it difficult to extract the wort at the end of the boil.

The majority of brewers I spoke with use pellet hops for this technique. Pellets break up quickly and expose the alpha acids for isomerization. Brynildson advises using pellets for late/whirpool hopping.

#### CALCULATING THE NUMBERS

To use this technique in your own beers, replace all or part of your traditional bittering hop additions with additions at 20 minutes or less remaining in the boil, increasing the amount of hops to get the same IBUs. Replace all of your bittering hops for an intense hop flavor. Replace a lesser amount to just enhance the hop flavor.

While isomerization is limited during a short boil, hop utilization isn't linear across the boil time. You don't need six times as much hops for a 10-minute boil as compared to a 60-minute boil. Assuming you're getting about 30 percent utilization at 60 minutes, you'll get around 17 percent at 20 minutes, 14 percent at 15 minutes and around 10 percent at 10 minutes. So you'll need to approximately double or triple your hops to get an equivalent bitterness. If you're already calculating your bitterness with software or some other tool, use the same method to make this adjustment.

It is said that most formulas for calculating bitterness are not as reliable for very late hop additions, but don't let that stop you. It is quite difficult to detect a 5 IBU difference in most moderately bittered beers and impossible in a highly bittered beer.

In beers with significant bitterness (50+ IBUs), you still might want to add a charge of high alpha hops early in the boil. If you don't, the amount of hop flavor can completely overwhelm some beers.

#### OTHER TIPS FOR LATE HOPPING

Keep in mind that the amount of time from when you add the hops until the wort is at pitching temperature affects the hop character and the bitterness.

"Getting great hop aroma takes execution, knowing your raw materials and knowing your brewhouse," Brynildson says. "If you throw hops into the whirlpool and then take two hours to cool, you will not get the effect you are looking for. We throw our late hops into the whirlpool at the last possible moment and then cool and transfer to the fermenter as quickly as possible."

Sousa suggests increasing the wort volume in the boil kettle. "You'll lose some of your wort to the large amount of hops in the kettle," he said. "Increase your batch size an extra quart per 5 gallons to compensate."

High wort pH can emphasize the hop bitterness and result in a harsh bittering perception, so hold off on "Burtonizing" your water or other similar mineral additions.

Zien sums it up best: "As far as any recommendations for the homebrewers interested in late hopping, I would say explore your own boundaries and don't be limited by the hop amounts listed on most recipes. Experiment with the levels of late kettle, post-boil [during chilling, in a whirlpool or a hopback], and dryhop additions that your brewing system, as well as your palate, can handle. Use the malt bill to create the right profile that will showcase the type of hop character that you're looking for in any particular beer style. Also, make sure to use the freshest ingredients and make a habit of tasting and smelling your grains and hops. Great tasting grains and pleasant aromatic hops are likely to come off the same way in your finished beer."

Jamil Zainasheff is a former Ninkasi award winner at the National Homebrew Competition. A member of the Quality Ale and Fermentation Fraternity, he lives in Elk Grove, Calif.

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