

HOPS

“Hops have been brewers' allies since the first century, and it would be difficult to list all the beers, not to mention entire beer styles, that have been rescued from blandness by a well-defined and pleasing hop presence. The reader should be warned, however, that hop chemistry is the least developed and the least understood part of brewing science. Thus the ability to create a stable and pleasing hop presence in beer is one of the greatest challenges to a brewer's art.”

-George Fix in *Principles of Brewing Science*

1. History, or; “At The Hop”

A. The Spread of Hop Use and Cultivation

- The first documented hop garden was in the Hallertau region of Germany in 736 A.D., and hops are thought to be used in brewing before the 11th century.
- Use of hops in beer becomes popular, gradually replacing gruit and other herbs, due to its properties of beer preservation and making a cloying malt liquor more palatable. Hop cultivation and use in brewing spreads through Bohemia, Slovenia, Bavaria and the Netherlands.
- In 1516 the German Beer Purity Law, or Reinheitsgebot, is enacted and hops become a required ingredient in all beer brewed in Germany.
- The Dutch bring hop cultivation over to the colonies and plant hop gardens in Manhattan in 1612.
- Hop cultivation in the colonies thrives and New York becomes one of the top hop producers in the world by the 19th century.
- Germans settling in the Midwest establish breweries and hop gardens during the mid-19th century. During the massive Wisconsin harvest of 1867, 15,000 people were transported in to harvest the cones by hand. Every evening the hop barns hosted dances, fiddlers and all. The word “hop,” as in a social dance, comes from these lively stomps.
- Oregon and Washington begin growing hops in the late 1800's and the crops thrive. Competition from the Northwest and the spread of mildew and other diseases rendered all other U.S. Hop growing regions insignificant.
- Today, much of the cultivation of hops is geared towards the more cost efficient high yielding, high alpha varieties and those more resistant to aphids, mildew, wilt and other diseases. Hops are grown, for the most part between the 35th and 55th degrees of latitude in either the northern or southern hemisphere since they require a relatively lengthy period of daylight during the growing season. In South Africa, Zimbabwe, and certain other areas closer to the Equator than 35 degrees, lights are used to extend the lighted period. Hops also require a cold dormant period each year.

B. The English Lag Behind, or; Ale Vs. Beer

-Despite the widespread use of hops by the Dutch and other European immigrants in England starting around the 15th century, English brewers and pub-goers alike generally rejected this bitter interloper as a “wicked weed” quite unworthy of their sweet ale. Although, there were enough curious assistant brewers out there to raise some concern. As use spread, many laws sprang up as to what ingredients may be used in an ale (absolutely no hops) and in beer (hops ok). Brewers caught putting hops into their “ales” were brought to court and fined. It was also not unheard of for consumers to sue their brewers for damages if hops were found in their ale. “Beer” was legal, but very unpopular. For the next 200 years or so there was a general disdain for the use of hops in brewing and much celebration of the traditional Ale (cloyingly sweet as it

must have been) of England. Despite this disdain, brewers continued to experiment with hops and the government made increased regulations creating quality standards for their cultivation, “The ale-wives and brewers, however, were wiser than their customers, and, induced also by the fact that their hopped ale went not sour as of yore, stuck to their colours—nailed to a hop pole not doubt—and slowly but surely educated the taste of the people. It was, however, a long process.” (John Bickerdyke, *The Curiosities of Ale & Beer*).

-The English went on to cultivate some of the most celebrated hops in the world, Kent Goldings and Fuggles, and made some of the world's first “hoppy” beers.

2. *Humulus Lupulus*, The Structure of a Hop

The hop cones we use in brewing are the flowers of the hop vine. Everything of use to us in the brewing process, the hop oils and acids, are stored in the yellow **lupulin** glands at the base of each bracteole, or petal. The percentage by weight of each hop cone, after picking and drying, can be approximately broken down as follows:

Moisture	8-11%
Alpha-acids	2-18%
Beta-acids	2-10%
Essence oil	0.4-2.5%
Tannin	2-5%
Pectins	2%
Ash	8-10%
Protein	15%
Cellulose	40-50%

A. Alpha-acid, It Puts The Bitter In Your Beer

-Alpha-acids include humulone, cohumulone and adhumulone, and are expressed as a percentage of the total weight of the hop. When isomerized in the boil, these iso-acids become soluble and impart bitterness to beer.

-Alpha-acid content in harvested hops decreases with prolonged storage. So, the alpha-acid stability of a certain variety may be of great importance to a brewer choosing the appropriate hop. Alpha-acid stability is expressed as the percentage of alpha-acids remaining in baled leaf hops after six months of storage at ambient temperature. Cold-storage, pelletizing, and vacuum packing greatly extend alpha stability.

B. A Beta Of A Mystery

-Beta-acids are much less soluble in water than the alphas, so their exact bittering effects, if any, on the finished beer are unclear. They have been observed to contribute greater bitterness to beer once they have been oxidized, hence the ability to extract bitterness from old, oxidized hops despite the disintegration of alpha-acids.

C. Essence Oil

-Hop oils include myrcene, farnesene, humulene, caryophyllene, geraniol and linalool. These oils impart aroma and flavor to beer and are responsible for the aroma of the hops. They are soluble in water and very volatile.

-Myrcene: greater flavor intensity, frequently described as “pungent.” The aroma of Myrcene is not considered desirable, so a bit of aging may improve the aroma of hops, even as it diminishes the bittering character of the hops. High levels are found in Kent Goldings.

-Humulene: imparts a delicate and refined flavor that is often described as “elegant”. High levels are found in the European Noble hops Saaz, Hallertauer Mittelfruh, Tettnanger, Spalt, and Hersbrucker. Highly unstable.

-Linalool and Geraniol: impart a distinct floral character as exemplified in U.S. Cascade.

D. Tannins

-Tannins help with wort clarification. Some impair the astringency and body of beer, and some are believed to have antioxidative properties in beer.

3. Brewing With Hops

RELAX, DON'T WORRY, HAVE A HOMEBREW: “The most important thing to remember about hops is that they are flowers. If you will recognize this fact, then all the complexities of the hop and its involvement in the brewing process will be understood much more easily” (Charlie Papazian, *The Complete Joy of Homebrewing*).

A. Hops are used in beer for the following reasons:

- Bitterness
- Flavor
- Aroma
- Preservative/Antimicrobial
- Head formation/retention
- Clarification of wort

B. Bitterness

-The bitter attributes imparted to beer by hops are from the stubborn soft resin, alpha-acid. In order to extract the bitterness (i.e. create iso-alpha-acids) from these acids, the hops must be vigorously boiled for at least 60 minutes.

-Generally, hops with higher alpha acid percentages are used for this step due to cost efficiency, but any kind of hop may be used.

-These hops are often added at the beginning of the boil and usually include the bulk, if not all, of the total hops added. Approximately half of the alpha-acids added will be isomerized and retained in the wort. And, about half of these will settle out with the yeast after fermentation.

-Depending on the use, there are a few different ways to quantify the bitterness that a given beer ends up with.

-When understanding and adjusting recipes, homebrewers often use the Alpha Acid Unit (AAU), also known as the Homebrew Bittering Unit (HBU).

HBU= % alpha acid of hops x ounces of hops. This equation can be useful to calculate the *potential* bitterness of a recipe and to adjust recipes based on the variety and alpha acid % you want to use.

-The International Bittering Unit (IBU) is the measurement used by commercial breweries and is the more precise method of calculating *actual* hop bitterness in a finished beer, with

1 IBU=1mg iso-alpha acid per 1 liter of beer. The equation to determine IBU is:

$$IBU=7489 \times (W \times A \times U)/V$$

7489 = conversion from mg/l to oz/gal

W = weight of hops used in oz.

A = percent alpha acid content as a decimal

U = percent utilization factor as a decimal

V = volume of the final wort in gallons

The tricky part is determining what your hop utilization is. Factors that effect hop utilization are length of the boil, wort gravity, vigor of the boil, wort pH, age/condition of hops, hop form, hopping rate, boiling temperature, shape of kettle, filtration losses, etc. Shorter boiling times, higher wort gravity, increasing the hopping rate, fermenting with a more flocculent yeast and using hop bags will generally lower hop utilization. Using pellets instead of whole flowers, using fresher hops, and increasing wort pH will increase utilization. In general, the utilization achieved will be in the range of 20-35% under ideal conditions, with a vigorous 1 ½ hour boil and the hops boiling freely in the wort. Extractions for homebrewers are generally estimated at 20%. The only way to calculate the actual IBUs in a finished beer is through lab testing.

C. Aroma and Flavor

-Due to the volatile nature of the flavor and especially the aroma compounds in hops, in order to add these elements the “aroma hops” must be added late in the boil. Hops boiled for 10-30 minutes will impart the wort with flavor compounds without adding much bitterness. Since aromatic oils in hops are more unstable, the hops intended to provide aroma should be added in the last few minutes of the boil. Generally, “aroma” hops have a low percentage of alpha-acids and are prized for their flavor and aroma properties.

-Dry hopping is the addition of hops to the beer during or after fermentation. This process imbues the finished beer with a fresh hop aroma. It is advisable to wait to add the hops until the last week or so prior to bottling. This allows the beer to build up enough alcohol and acidity to minimize the chances of contamination from the fresh hops.

D. Additional Benefits From Hops

-Part of the reason for the initial widespread popularity of hops was its ability to prolong the souring of beer through its natural antimicrobial properties. In Lambics, hops are aged for at least 3 years to allow most of their alpha acids to breakdown. The resulting hop qualities are still antimicrobial, but without the bitterness.

-Hops also aid in the process of kettle coagulation to create a clearer wort. Some of the oils and tannins released from the lupulin glands in the boil will attach to larger proteins and form clumps to be removed in the hot break.

-Hops have also been seen to contribute to head stabilization.

E. First Wort Hopping

-First wort hopping consists of adding some or all of the hop additions to the first runnings from lautering and keeping them in the wort throughout the boil. The higher pH is supposed to “extract some of the finer qualities of the hop flavor” while the extended boiling time removes any harsh and undesirable elements. This method, originally used in Germany as a way to extract more bitterness, is thought to provide “a favorable bittering and flavor compound profile” as well as contributions to aroma. Homebrewers are said to be reviving this old method.

-The assertion that both hop aroma and flavor can be retained throughout the boil with this method contradicts all of my research...

Off-Flavors

A. Light-struck Or Skunky

-Riboflavin (vitamin B2) in beer reacts with light and absorbs energy, which it can transfer to iso-alpha-acid molecules in the beer. The “excited” iso-alpha-acid molecules can decompose into several products, including 3-methyl-2-butene-1-thiol (MBT), a very powerful flavor chemical, with a smell similar to that of a skunk. This can be prevented by using brown or amber

bottles instead of clear or green glass and keeping them out of direct sun or visible light. There are also certain hop extracts made with only dihydro-iso-alpha-acids, beta acids and oils to prevent the formation of MBT when exposed to light.

B. Old Hops

-The oxidation that occurs to the alpha acids over time transforms its compounds into ones that give off a distinctly “cheesy” aroma. This aroma has also been described as Parmesan cheese and sweaty socks. Proper storage of hops at a constant cold temperature and with limited exposure to light or oxygen will prolong the life of the alpha acids. Pellets and extracts will have a longer life than plugs and whole flower hops due to having less surface area exposed to oxygen. Depending on the variety, processing and storage, hops will generally be good for 2 years.

5. Hop Processing

Hops are available as whole flowers, plugs, pellets or extracts.

-Pellets have become the most common form of hop used in commercial brewing. Many of the advantages and disadvantages for each form are debatable, but some facts are clear. During pelletization all of the lupulin glands are broken apart. This leads to increased utilization (about 10-15% higher than whole hops), but may compromise some of the more volatile essential oils. Pellets are also easier to store due to their smaller volume and are less prone to oxidation.

-Various hop extracts are also available. These vary from concentrated oils and acids from the lupulin glands to already isomerized alpha-acids to essential oils for aroma.

6. Hop Varieties

Hops are categorized by their alpha-acid range into Aroma hops, Bittering hops and Dual-Purpose hops as well as by region. Aroma hops generally have a low alpha-acid content and are prized for the flavor and aroma properties they lend to beer. They can be used to bitter as well, but greater quantities will be needed and the price is generally higher for these varieties. Bittering hops generally have high alpha acid contents and can be in the sub-categories of “mid-range alpha,” “high alpha” or “super alpha”. Many of these can be considered as dual-purpose hops depending on the brewers intentions. Hops with a high alpha-acid content are often considered to have less desirable flavor and aroma characteristics, but really that's for you to decide for yourself!

The region in which a given hop is cultivated has a huge impact on the resulting flavor profile. The same variety grown from one region or country to the next may impart very different properties to the finished beer.