Introduction to Hops

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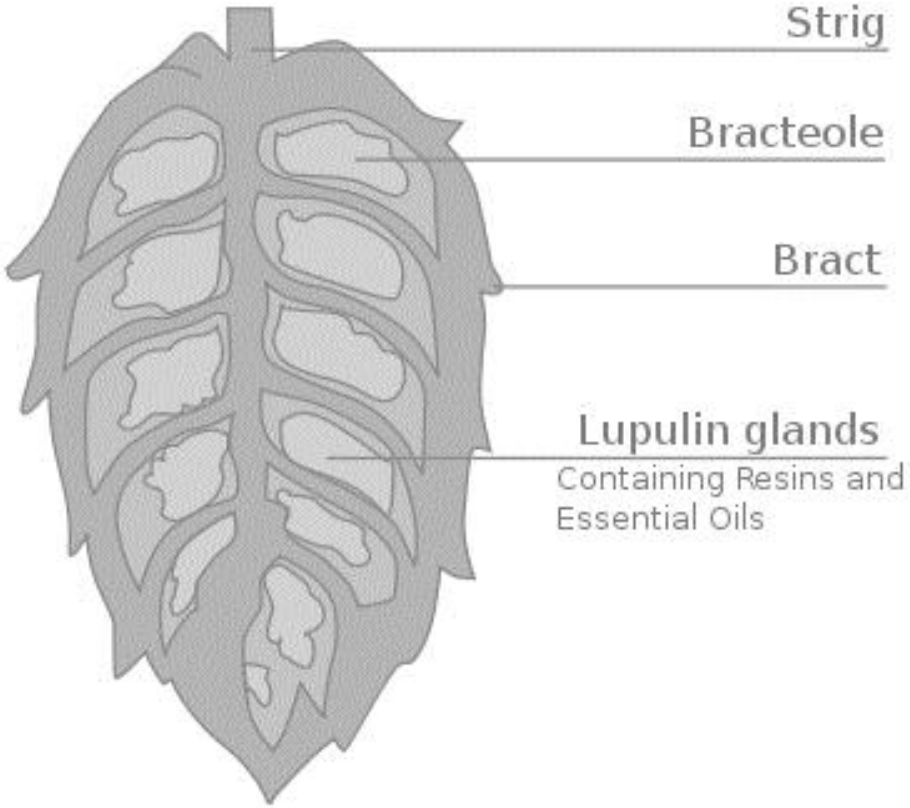
Strig
Bracteole
Bract
Lupulin glands
Containing Resins and
Essential Oils

What are Hops?

The hop (Humulus Lupulus – Humulus is a genera of the Cannabaceae family of plants which includes Cannabis) plant produces female flower clusters (called strobiles, also referred to as cones or whole-leaf hops) that are harvested and called “hops”. Hops grow on perennial vines which can grow to 20 feet in height, and typically are grown on a rope or trellis. The vines die back each year: Sections of the vine can be cut and used as rhizomes (horizontal underground stems that send out roots – examples include asparagus and ginger) to propagate the plants (and preserve the genetic structure) without pollination or the use of seeds.

Hops are primarily used in bittering, preserving, and flavoring beer. They are also used as a remedy for anxiety and sleeplessness: placing hops in your pillow helps you sleep. If you grow or use hops, be sure to not let your dog eat them – hops are toxic to dogs and cause hyperthermia (overheating, similar to heat stroke).

Hops began to be cultivated in Germany, Czechoslovakia, and other areas of Europe around 700 A.D. Prior to about 1000 A.D., beer was bittered and flavored with other flowers (heather, dandelion, and others) and herbs and various roots, some of which were toxic, depending on what was available where the beer was brewed. When it was discovered that hops were able to help in preserving beer so that it did not spoil as quickly (because of its selective antibiotic properties that discouraged growth of Gram-positive spoilage organisms like Lactobacillus, Pediococcus, and other bacteria (some of which are pathogenic to humans), but did not prevent growth of Saccharomyces yeasts), most brewers went from making gruits (beers not flavored with hops) to using hops for its preservative qualities and bitterness.

Hops, like grapes, are very sensitive to the “terroir” in which they are grown. Different light, oxygen, moisture, soil content, and temperatures will give hop varieties different qualities: The same hop variety grown in different locations may have completely different characteristics.

Hops lose their aromatic and flavor characteristics over time, particularly if exposed to oxygen and/or heat. Hops can be stored in the freezer in sealed containers (preferably with the air replaced with an inert gas like argon, or with nitrogen) for a year or more.

Hops for Beer

Hops are used in several parts of the brewing process for different reasons including preservative qualities, bittering, and adding flavor and aroma.

Typically, hops are allowed to mature on the vine, and then harvested and dried before they are sold to brewers. Hops are typically provided as “whole hop” or “whole leaf” cones or compressed “plugs, or chopped up and provided as small pellets. Both whole and pellet hops have their advantages and disadvantages (and each has relatively radical proponents). Whole hops may provide a more natural flavor and aroma, and are often easier to handle (such as when removing from the boiled wort), but may also

provide less surface area contact with the wort, resulting in potentially less extraction. Pellet hops provide more surface area for contact and so provide good availability to the alpha acids and essential oils, but also may provide extraction of the vegetal components inside the chopped “leaves”, and since the pellet hops break up into very small particles during the boil, filtering out the hops may be more difficult. Hops can also be used from extracts (like HopShots) and tinctures, providing the essential oils and resins without the vegetable matter.

Hops provide two main resin components that are used in beer: Alpha Acids and Beta Acids. Essential Oils are also an important component for flavor and aroma.

Alpha acids are insoluble compounds that can be extracted from the hops by boiling: The high temperature of the boil isomerizes (changes the structural arrangement of molecules in the humulone into isohumulones without modifying the molecular formula) the alpha acids, making them soluble in the hot water. The alpha acids provide the bitterness and flavoring for the beer, and also provide the antiseptic properties to preserve the beer from spoiling. Lower levels of cohumulones produce a cleaner and crisper bittering; higher levels produce harsh and unpleasant bitterness and cause poor head retention. When purchasing hops, the “Alpha Acid Percent” (AA% - the percentage of the humulone by dry weight) is typically listed, and ranges from about 3% to 20%. The higher the percentage, the more bitterness will be provided in the beer, and the more lupulin the hop has. Boiling hops for 60 minutes or more will extract the maximum levels of alpha acid from the hops, but with an upper limit of about 30% extraction. To get the flavor components from the hops, additional hops are added with 15 to 30 minutes left in the boil. The isohumulone component of the alpha acid reacts with vitamin B_2 (Riboflavin) when beer is exposed to light at the blue end of the spectrum (particularly ultraviolet), causing the beer to acquire musky “lightstruck” or “skunky” flavors and aromas. Brown bottles provide the best protection, whereas green and clear bottles provide almost no protection from this problem. Note that some hop extracts (such as that used by Miller) do not have isohumulones, and do not get lightstruck, even in clear bottles. The bitterness of the beer is measured in International Bitterness Units (IBUs), and can range from 10 or less (light lagers) to over 100 (Imperial India Pale Ales). Note that Scottish beers historically have relatively low IBU levels partly due to the high cost of importing hops through the taxing structures in England – Scottish beers are much more malt accented. The human threshold for differentiating IBU levels is about 5 to 10 IBUs, and the levels above 100 IBUs may not be distinguishable. Some Belgian beers (particularly Lambics) have traditionally been brewed with “aged” (up to 3 years old) hops which retain the preservative qualities of the hops, but have minimal flavor impact.

Essential oils provide flavor and aroma characteristics to the beer: Myrcene provides lavender and floral aromas, Humulene provides spicy phenolic notes like coriander, Caryophyllene provides rosemary herbal notes and black pepper phenolics, and Farnesene gives floral notes like gardenia. Beta acids also include lupulones which add a more harsh taste. The flavor characteristics are extracted (but not isomerized) with a 15-30 minute boil, whereas the aroma characteristics (which are very volatile, and

dissipate quickly) are usually added with 10 minutes or less of the boil, or may be added after the boil or fermentation has completed ("dry hopping", or "wet hopping" if the hops are fresh and have not been dried). The beta acids also oxidize easily and produce cabbage and cooked corn off-flavors.

Essential Oils (and sometimes, beta acids) provide many recognizable flavors and aromas for hops in beer, including floral, lemon, grapefruit, orange, tangerine, piney, resiny, black pepper, coriander, spicy, cinnamon, gooseberry, passionfruit, tropical fruit, woody, strawberry, herbal, and earthy. Hops with low alpha acids and low levels of lupulone beta acids, but with higher levels of humulene oil are called "noble hops". There have traditionally been four "official" noble hops: Hallertau Mittelfruh (and sometimes the more hardy Hallertau Hersbrucker) from Bavaria, Saaz from Czech Republic, Spalt from Germany, and Tettnanger (also from Germany). Other hop varieties may have noble hop characteristics (Liberty is a hardier cross of Mittelfruh, Ultra is a cross of Hallertau and Saaz, etc.).

Another old hop addition technique (originating with German Pilsener) that is again gaining popularity is First Wort Hopping. When sparging and lautering (draining) the wort from the grain after mashing, the hops are added as the wort comes from the mash tun. The relatively high temperature, along with the higher pH of the wort before the boil, isomerizes some of the alpha acids for slightly better extraction, but also extracts flavor and aroma compounds that are stable enough to survive through the boil, during which flavors and aromas from hops added during the boil would evaporate.

Hop Varieties

There are many native hop varieties, and many more that have been created by crossing existing hop varieties to increase disease resistance and hardiness, increase alpha acid production, and tune varieties for various other desirable characteristics. Hops are grown all over the world, but particularly in USA (Washington and Oregon produce much of the US crop), Germany, Czech Republic, England, China, Poland, France, and New Zealand. Here is a list of many of the currently available hop varieties with a typical range of Alpha Acid (which changes from harvest to harvest) and taste/aroma notes. Note that hop varieties have historically been divided into "bittering" and "flavor/aroma" hops because the older bittering hops has poor beta acid characteristics and although they provided a higher level of alpha acid for bittering, their flavor profile was not pleasant (usually described as raw, vegetal, coarse). Newer varieties of higher alpha acid hops are almost all "crossover" hops – they have been bred to have pleasant and distinct flavor and aroma characteristics, and can be used for flavor and aroma as well as for bittering. Beers listed are examples that profile the hop variety specified.

Ahtanum (4-6.5%) – citrus, grapefruit, floral, resiny, earthy
Amarillo (8-11%) – citrus:orange, floral, tropical, spicy (Rogue Yellow Snow IPA)
Apollo (15-19%) – strong grapefruit
Bramling Cross England (5-7%) – fruity, black currant, lemon, strong spice
Bravo (14-17%) – pleasant fruity and floral aroma

Brewers Gold Germany (5-9%) – usually for bittering, fruity, spicy, black currant
Brewers Gold UK (7-11%) – resiny, spicy, hints of black currant
Brewers Gold US (8-10%) – mostly for bittering, black current, fruity, spicy
Bullion UK (6.5-9%) – best for bittering (a bit rough for aroma/flavor), resiny, earthy
Cascade (4.5-7%) – medium intensity floral, citrus:grapefruit (Sierra Nevada Pale Ale)
Centennial (9.5-11.5%) – "Super Cascade", medium intensity floral, citrus
Challenger UK (6.5-8.5%) – fruity, scented, spicy overtones
Chinook (12-14%) – slight spicy, very piney, grapefruit
Citra (11-13%) – big citrus:grapefruit and tropical (melon, lime, gooseberry, passion fruit, lychee) (Sierra Nevada Torpedo)
Cluster (5.5-8.5%) – black currant, strong floral, spicy
Columbus (Tomahawk/Zeus) (14.5-16.5%) – Citrusy, woody, sharp, herbal
Crystal (3.5-5.5%) – mild, cinnamon, black pepper, nutmeg, floral
Delta (5.5-7%) – mild and pleasant, slight spicy, hint of citrus
First Gold UK (6.5-8.5%) – cinnamon, rich citrus orange peel, dried apricot
Fuggle UK (4-5.5%) – earthy, wood, fruity
Fuggle US (4.0.5.5%) – mild, woody, fruity
Galaxy Australia (13.5-14.9%) – citrus, passionfruit
Galena (11.5-13.5%) – citrus, balanced
Glacier (5.5%) – earthy, floral, slight citrus
Golding UK (4-5.5%) – smooth and sweet flavor, floral, delicate, slight spicy
Golding US (4-6%) – mild, floral
Green Bullet New Zealand (11-14%) -
Hallertau Mittelfruh Germany (3.5-5.5%) – subtle floral and spice, citrus tones
Hallertau New Zealand (6.5-9%) – woodsy, citrusy:lime, clean
Hallertau US (3.5-5.5%) – mild and pleasant, slight floral and spicy
Herald UK (11-13%) –
Hersbrucker Germany (3-5.5%) – floral, slight fruity
Horizon (11-13%) – floral, spicy
Liberty (3-5%) – mild, slight spicy, cinnamon, resiny, slightly sweet
Lublin Poland (3-5%) – slight woody, spicy
Magnum Germany (10-12.5%) -
Magnum US (12-14%) – mostly for bittering, low aroma, spice, citrus, floral, fruity
Millennium (14.5-16.5%) – bittering, mild herbal
Mt. Hood (4-7%) – floral, spice, forest, clean
Mt. Rainier (6%) – light black licorice, hint of citrus, floral, noble aromas
Motueka New Zealand (6.5-7.5%) – lemon, lime, background tropical fruit
Nelson Sauvin New Zealand (12-14%) – white wine fruity, gooseberry, passionfruit
Newport (13.5-17%) – bittering, mild
Northdown (7.5-9.5%) – very resiny
Northern Brewer UK (8-10%) – woody, earthy, fruity
Northern Brewer US (8-10%) – evergreen, wood, mint, medium intensity (Anchor Steam)
Nugget (11.5-14%) – mild herbal, floral, resiny, slight spicy
Opal (5-8%) – balanced, fruity, hoppy, floral, citrus, herbal
Pacific Gem New Zealand (13-16%) – woody, strawberry, blackberries, floral oak
Pacific Jade New Zealand (12-14%) – fresh citrus, black pepper

Pacifica New Zealand – orange marmalade citrus, some floral
Palisade (5.5-9.5%) – floral, fruity, earthy
Perle Germany (7-9.5%) – delicate, spicy, slight floral, slight fruity
Perle US (7-9.5%) – slight spicy with floral overtones
Phoenix UK (8-13%) – crisp and pleasant
Pilot UK (9-12%) –
Pioneer UK (8-10%) – pleasant lemon and citrus
Polnischer Lublin Poland (3-4.5%) – mild aroma
Pride of Ringwood Australia (7-10%) –bittering, rough, intensely woody, earthy, herbal
Progress UK (5-7.5%) – slight sweetness, moderately strong
Riwaka New Zealand (4.5-6.5%) – strong citrus:grapefruit
Saaz Czech (3-4.5%) – cinnamon, black pepper, earthy (Pilsner Urquell)
Saaz US (3-4.5%) – very mild, spicy, earthy
Santiam (5-7%) – floral, herbal, slight spicy
Saphir (Germany) (2-4.5%) – flowery, fruity
Satus (Germany?) (12.5-14%) –
Select Germany (4-6%) –
Simcoe (12-14%) – intense piney
Sorachi Ace Japan (13-16%) – lemon, slight dill
Southern Cross New Zealand (11-14%) – lemon peel, pine needles, clean spiciness
Spalt Germany (4-5%) – woody, mild, floral, fruity, spicy
Sterling (6-9%) – herbal and spicy, hint of floral and citrus
Strisselspalt France (3-5%) – floral, lemony
Styrian Golding Slovenia (4.5-6%) – actually is Fuggle (not Golding), delicate, spicy
Summit (16-18%) – strong citrus (orange/tangerine/grapefruit), spicy, earthy, onion, garlic (Widmer Drifter Pale Ale)
Super Galena (13-16%) –
Target UK (9.5-12.5%) – floral, pleasant, intense (Wylam Ale)
Tettnang Germany (3-6%) – mild and pleasant, balanced
Tettnang US (4-5%) – pleasant and slightly spicy
Tillicum (12-14.5%) –
Tradition Germany (5-7%) – grassy, floral, herbal
Ultra (2-3.5%) – peppery, spicy, similar to Saaz Czech
Vanguard (5-6%) – similar to Hallertau Mittelfruh
Warrior (15-18%) – very mild (Left Hand Warrior IPA, Dogfish Head IPA)
Whitbred Golding Variety (WGV) England (5.5-7.5%) – sweet fruity note, pleasant
Willamette (4-6%) – slight spicy, fruity, floral, mild and pleasant, similar to Fuggle UK

Resources

www.HopUnion.com
www.USAHops.org
http://www.ars.usda.gov/pandp/docs.htm?docid=14772
http://www.yakimachief.com/hopvarieties/hopvar.html
http://www.freshops.com/
http://en.wikipedia.org/wiki/Hops
http://www.hopsfromengland.com/Varieties.htm