# Technical Question T4: Hops, My Answer

I based this off the feel and length of an answer from a fellow judge who got master rankings with about 400 words.

The hop plant is a bine which is native to the northern latitudes 35-55 degrees but is also grown in a similar climates of the Southern hemisphere. America, Germany and Ethiopia produce the bulk of the world’s hop arvest. The hop plant is prolific in producing a cone flower which is what we use in beer brewing as a seasoning. The hop plant is a vigorous growing bine similar to ivy and other climbing bine(vine) like plants. The cone flowers they produce are coveted for their oil content which is responsible for their aromatic, flavoring and antibacterial characteristics that have made them so wonderful for beer. When hops are considered for brewing it’s the Alpha Acid and total oil content that is strongly considered when choosing a variety. The cones are picked in late summer, kilned and packed away for use in the brewing process.

# Hops add their characteristics to beer in the form of bittering, flavor and aromatics. Traditionally these characters are added by applying hop additions at certain times in the boil and fermentation process. Bittering is applied by boiling hop Alpha Acids, converting them to iso-alpha acids which are bitter. Traditionally bitter hops are added 60-90 minutes. Flavor additions come from the same essential oils of the hops by adding hops later(in the last 40-15 minutes) of the boil so that the oils are not boiled off. Humulene and Myrcene are the primary contributors to flavor. Aroma hop additions come in a late boil addition (less than 5 minutes). Aroma hops are also added in the form of dry hopping in which alcohol extracts essential oils from hops into the beer. Dry hopping is typically where you get your grassy notes in American ales. Mash hopping is a technique where hops are added to the mash and is thought by some to produce a pleasant bitterness. First wort hopping is steeping hops while lautering and is thought by some to produce a more pleasant aroma, flavor and bitterness in beers.

# Noble hops(Tettnanger, Saaz, Hallertau, Splatz) are associated with continental Eurpoean beer styles. Especially Czech, German and Belgians. Noble hops are complex, floral and spicy although quite delicate as is prized in these classic brewing cultures. The Belgians strongly identify with Syrian Goldings and Czech beers strongly identify with Saaz hops. Germans strongly identify with Hallertau. Fuggles, Kent Goldings, Challenger are associated with English Beer styles. These hops impart a very Earthly, floral and woody character. American beer styles are associated with new world hops such as Centennial, Cascades, Columbus, Citra, Simcoe as Citrus, Pine and tropical fruit flavors/aromas are hallmarks of American beer styles. Northern Brewer is a traditional hop with rustic, minty, woody hop that has love in America and Europe but is most identified with California Common beer. Due to the American love for “new world” hops there has been a recent demand for hops from New Zealand and Australia. Such as Nelson Sauvin which add radically different flavors compared to goose berries and white wine like character. Poland uses a hop called Lublin(variety of Saaz) in their Baltic porters.

# Technical Question T4. “Hops”

#  Discuss hops, describing their characteristics, how these characteristics are extracted, and at least four distinct beer styles with which the different varieties are normally associated. Address the following topics:

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| **30%** | **Describe hop characteristics.** |
| **30%** | **Discuss how hop characteristics are extracted.** |
| **40%** | **Identify associated beer styles.** |

**The Hop Plant**

The hop plant (Humulus Lupus) is a *bine* (not a vine), native to the northern latitudes (35-55° latitude) of the northern hemisphere. They require long growing days and well-drained soil of 5.0-7.0 pH. They can grow to be up to 20 feet tall. They are quite vulnerable to various types of mold, so do well in drier climates. Alpha acids, responsible for hop bitterness, have a mildly bacteriostatic action on gram-positive bacteria, meaning that they have a preservative effect.

 Hops are picked in late summer or early fall when the cones (technically, *strobiles*) have dried sufficiently. When picked, they should have a slightly papery texture. They are dried at warm (90-100 °F) temperatures in a kiln (traditionally, a building called an *oast)*, then packed in airtight packages and kept refrigerated to prevent degradation of oils and resins. *Terroir* (growing region) has an effect on hop characteristics, due to different soil and climatic conditions.

**Hop Chemistry**

 **1*. Lupulin.*** The active ingredient in hops, produced by glands within the strobiles of female plant. Lupulins appear as a powdery, sticky yellow resin.

 2. Soft Resins

 ***A. Humulones and Cohumulones.*** These are the source of alpha acids, which contribute bitterness to beer. In order for alpha acids to be soluble in liquid, they must be isomerized by boiling. Alpha acids constitute 3-10% of dry weight of the hop cones. Cohumulones are said to impart a harsher bitter. Alpha acid levels drop as hops age, especially if they are exposed to air or are stored at warm temperatures. Alpha acid percentage in poorly stored hops can drop by up to 60% within a year. For this reason, hops are stored cold and are packed into vacuum-sealed, oxygen barrier packages.

 ***B. Lupulones and Colupulones.*** These are the source of beta acids. Beta acids don’t isomerizes or contribute bitterness, but do contribute to hop aroma.

 ***3. Essential Oils.*** These are volatile compounds detectable as hop flavors and aromas. They are easily lost during boiling, but can be retained by adding aroma and flavor hop additions late in the boil, as well as dry hop additions late in the fermentor or cask. Dry hopping works because essential oils can be extracted by alcohol and carbon dioxide.

***A. Hydrocarbon-Based Oils:*** Monoterpenes & sequiterpenes. They represent about 75% of essential oils.

 I. Monoterpenes.

 *a)* *Humulene* has a delicate, refined flavor and oxidizes to produce spicy notes. “Noble” hops have high humulene levels.

 b) *Myrcene* is more pungent, and is higher in U.S. hops. It oxidizes to produce citrusy or piney notes.

 *II. Sequiterpenes:* Farnesene & Caryphyllene. They oxidize to compounds with “grassy” aromas.

***B. Oxygen-Bearing Oils:*** Also called essential alcohols, they represent about 25% of essential hop oils. *Linalool* has a hoppy aroma. *Geraniol* has a floral, perfumy aroma like geraniums.

**Measuring Bitterness**

 ***IBU:*** Hop bitterness is typically measured in non-scientific units of measurement called International Bitterness Units (IBU), or just BU (bitterness units). The lower threshold for detecting hop bitterness is about 10 IBU, the upper threshold for detecting hops is about 100 IBU, the degree of resolution is about 5 IBU (that is, the average person wouldn’t be able to tell the difference between otherwise identical beers where one had 20 IBU, but the other had 18 or 23 IBU, but they would be able to do so if the beer had 15 or 25 IBU).

 Beer with less than 20 IBU is considered to be lightly hopped. Beer with more than 50-60 IBU is considered to be heavily hopped.

 ***HBU:*** This is a rule of thumb measurement used by some homebrewers to calculate hop bitterness. It consists of alpha acid % x ounces of hops. For example, 2 oz. of hops at 5% Alpha Acid would count as 10 HBU. HBU is a very simplified form of figuring Hop Utilization.

 ***BU:GU Ratio:*** Since hop bitterness is balanced by alcoholic strength, malt bitterness, yeast character and other factors, a useful method of determining relative bitterness is by calculating the beer’s BU:GU ratio. This is a subjective measurement invented by Ray Daniels, which a ratio of the beer’s IBU level against the last two digits of its Original Gravity. For example, an Imperial IPA with 100 IBU, but an O.G. of 1.050 would have a BU:GU ratio of 2:1 (extremely hoppy), while a Weizenbock (20 IBU, O.G. 1.070) would have a ratio of 1:3.5 (very malty).

**Hop Utilization**

 Sometimes called Kettle Utilization Rates (KUR), hop utilization is a measure of how much hop bitterness actually gets into your beer. Hop utilization varies from 0% for hops added at the end of boiling or used for dry hopping, up to a maximum of 25-33%.

 There are several different formulas for determining hop utilization rates, devised by homebrew gurus such as Jackie Rager, Glenn Tinseth, Randy Mosher and others. All work equally well and give approximately similar values. When brewing, you should choose one formula and stick with it. One formula is given below:

 IBU extraction formula: W x A x U x 7489 / V x C

 *Where:* W = oz. hops, A% = Alpha Acid %, U = Utilization %, V = wort vol. in gallons, C = 1+ ((O.G. - 1.050) /2)) - a correction for wort gravity. 7489 is a conversion factor from mg/l to ounces per gallon.

 ***Factors that aid hop utilization:*** Alpha acid extraction depends on a number of factors:

 *\* Lower wort concentrations.* Higher OG wort makes it harder for isomerized alpha acids to go into solution.

 *\* Longer boil times (up to a maximum of 2 hours).* Longer boil times give alpha acids more time to isomerize and get into solution. By contrast, flavor and aroma hops don’t add as many alpha acids because they are exposed to heat for a shorter amount of time.

 *\* Sulfate additions.* Sulfate helps isomerize alpha acids.

 ***Calculating Total IBU:***To figure the total IBU extraction for a beer, you must calculate the IBU extraction for each hop addition, as described above, and sum the results.

**Primary Methods of Extracting Hop Compounds**

 ***Bittering/Kettle Hops:*** These hop additions are responsible for most of the alpha acids in beer.

 Kettle hops are boiled in wort for 60-120 minutes. Maximum bitterness utilization is 25-33%. Only humulones and cohumulones (IBU) are gained using this method; more volatile compounds are boiled away. The lovely hop aromas you get from the boiling wort represent flavor and aroma that *isn’t* going into your beer!

 For this reason, commercial brewers prefer high alpha acid varieties with relatively few essential oils as kettle hops. Higher alpha acids means fewer hops are needed, which helps to cut costs and also means that fewer polyphenols are extracted from the hops (although this is a relatively minor problem).

 Maximum IBU extraction is obtained after about 120 minutes of boiling; there is no need for longer boil times.

 ***Flavor Hops:*** Added 15-40 minutes before wort boil ends. IBU utilization is 5-15%, some volatile compounds are preserved, mostly the less volatile compounds which are only detectable in flavor.

 Flavor hops walk the line between adding IBU and adding flavor and aroma additions to the beer. Brewers often use lower alpha acid hops, with higher levels of essential oils, as flavor hops.

 ***Aroma Hops:*** Added 0-5 minutes before wort boil ends, or allowed to steep in hot wort after flameout. IBU utilization is 5% or less.

 Aroma hops impart just the most volatile essential oils to the beer, typically those found in the aroma. As with flavor hops, brewers often use lower alpha acid hops, with higher levels of essential oils, as aroma hops.

**Other Methods of Extracting Hop Compounds**

 ***Mash Hopping:*** Hops added to mash. Very little hop bitterness is extracted, but hop aroma and flavor compounds somehow survive the wort boiling process. Mash hopping is said to result in a smoother bitterness, but hop utilization is reduced by about 80%. Mash hopping is traditionally used when making Berlinerweisse.

 ***First Wort Hopping:*** Hops are added to lauter tank during mash run-off and allowed to steep before being boiled. As with Mash Hopping, hop aroma and flavor compounds somehow survive the wort boil, but hop utilization is reduced. It is said to produce a more pleasant hop flavor, aroma and bitterness. This method is sometimes used when making German and Bohemian Pilsners.

 ***Hopback Filtering:*** Hot wort is run from the kettle to the fermentation tank (or to the cooling tank or heat exchanger) through a filter or strainer filled with hops. This gives an effect very similar to aroma hopping, since the hops in the hopback only add hop aroma. A hopback also serves to partially filter the wort. Running wort through a hopback is a common English brewing technique.

 ***Dry Hopping:*** Hops are added to the secondary fermenter or to the cask. Alcohol in the beer extracts the essential oils, which increases hop aroma. This is a common American and British brewing technique, which is less commonly encountered in German and Belgian brewing.

 Practically, very few bacteria survive on hop and even fewer survive once the hops get in contact with the alcohol in the beer, so there is very little risk of infection from this technique.

 Leaving the drop hops in a beer for a long period of time (months), or using massive amounts of hops might extract polyphenols (astringency, protein haze) or impart grassy notes.

 ***Hop Fractions:*** Hop oils and alpha acids can be chemically extracted from hops and separated into individual compounds. A variety of hop oils are available, as are extracts of alpha acids. These are rarely available to homebrewers, but are sometimes used by large commercial brewers to standardize their products or to achieve a particular aroma or flavor profile. Hop fractions are also used to keep beer from becoming lightstruck, since the sulfur-bearing precursors to the lightstruck phenomenon are removed during the extraction process.

**Important Hop Varieties**

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| Hop Variety | Origin | Characteristics | Styles |
| Hallertauer Mittlefrüh, Tettnang, Spalt | German | “German Noble hops” with low bitterness, but complex, “elegant” spicy, floral notes. Used for flavor/aroma only. Often low IBU. | Munich Helles, Dortmunder Export, German Pils, Bock |
| Saaz | Czech | “Noble” hop with mild floral notes. Used for flavor/aroma only. | Bohemian Pils |
| Goldings, Kent Goldings, Fuggles | U.K. | Earthy, floral, spicy, woody notes. Medium IBU. Used for bitter, flavor & aroma. | Eng. Pale Ale, IPA & Barleywine |
| Cascade, Centennial, Columbus, Chinook, etc. | U.S. Pacific NW | Nicknamed “C” hops. Citrusy, grapefruity, piney. Medium to high IBU. Developed quite recently (early 1970s). Includes recent proprietary varieties (e.g., Amarillo, Citra, Warrior). So called “dual use” hops - can be used bitter & flavor/aroma. | American Pale Ale, IPA & Barleywine |
| Bittering Hops (e.g., Perle, Bullion, Galena, etc.) | All | High-alpha acid hops with lower levels of essential oils and/or “rougher” flavors & aromas. Mostly used for bittering. | All, esp. IPA, Barleywine |

**Other Hop Varieties**

 While these hop varieties aren’t particularly important in themselves, they provide distinctive character to certain styles of beer described in the BJCP Guidelines:

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| --- | --- | --- | --- |
| Hop Variety | Origin | Characteristics | Styles |
| Cluster | U.S. | An old (19th century) American variety with a somewhat “rough” aroma and flavor. Mostly used for bittering. | Classic American Pilsner |
| Lublin | Poland | Polish-grow Saaz hops. Used for flavor & aroma. | Baltic Porter |
| Northern Brewer | Europe, America | Rustic, minty, woody. Used for bitter, flavor & aroma | California Common |
| Styrian Goldings | Belgian | Spicy. Used for bitter, flavor & aroma. | Witbier, Belgian Pale Ale |
| Strisselspalt | France | Similar to some German noble hops. | Saisons, Bière de Garde. |

**Noble Hops**

 The term “noble hop” is used to describe certain traditional varieties of German or Czech aroma/flavor hops.

 *\* Generally accepted noble varieties:* Hallertauer Mittelfrüh, Spalt(er), Saaz (AKA Zâtec) and Tettnang(er),

 *\* Terroir counts!* Noble varieties are only considered “noble” if they are grown in the area for which the hop variety is named. (i.e., noble Hallertauer can only come from the Hallertau valley in Germany). A U.S.-grown noble hop isn’t noble!

 - *Hallertauer Mittelfrüh:* Grown in the Hallertau (AKA Holledau) region in central Bavaria in Germany.

 - *Spalt:* Grown in the the Spalter region south of Nuremberg, Germany.

 - *Saaz:* Grown in Bohemia in the Czech Republic.

 - *Tettnang:* Grown around the town of Tettnang in southern Baden-Württemberg in Germany.

 \* Chemically described as:

 - 1:1 alpha : beta acid ratio.

 - 2-5% alpha acid.

 - low cohumulone & myrcene content.

 - high humulene content.

 - >3:1 humulene : caryophyllene ratio.

 *\* Prone to oxidation* = poor storage stability.

 \* Consistent bittering potential even when aged.

 *\* Debatably noble:* Certain hops have similar chemical profiles to the accepted noble varieties. For this reason, some brewers, scholars and beer writers argue that they should be considered “noble” as well. Debatably noble varieties include East Kent Goldings, Fuggles, Hersbrucker and Styrian Goldings, as well as modern descendents of the noble varieties grown in the traditional regions (e.g., Hallertauer Gold, Spalt Select).

# **Question T4 “Hops” Sample Answer.**

Discuss:

 1. Hop (Humulus Lupus) is a bine, native to N. latitudes of the N. hemisphere. First used in brewing in Germany in 1079, introduced to England in the 16th century. Replaced gruit (herb mixtures) as choice beer bittering agent. Alpha acids have mildly bacteriostatic action on gram-positive bacteria. Picked when slightly “papery,” dried at ~100 °F, packed in airtight packages to prevent degradation of oils and resins. Terroir (where grown) has an effect on hop characteristics.

 2. Active ingredient: Lupulins, fr. glands within the strobiles (cones) of female plant.

 3. Soft Resins

 A. Humulones = Alpha Acids: Alpha acids isomerized during wort boil, making them soluble in liquid. Contribute bitterness. AA = 3-10% of dry wgt. Co-humulones said to give a harsher bitter. AA lvl. drops as hops age, esp. if improperly stored.

 B. Lupulones = Beta Acids. Don’t isomerize, but contribute to bitter aroma.

 4. Essential oils - volatile compounds give hop flavors/aromas. Easily lost during boil, retained by adding aroma, flavor and dry hop addit. Partially retained, through poorly understood means, via first wort hopping, mash hopping.

 A. Hydrocarbon-based oils: ~75% of essential oils.

 1. Monoterpenes: Humulene = delicate, refined flavor/aroma, oxidize to prod. spicy notes. High in noble hops. Myrcene = more pungent, higher in U.S. hops. Oxidize to prod. citrus or piney notes.

 2. Sequiterpenes: Farnesene & Caryphyllene. Oxidize to compounds w. “grassy” aromas.

 B. Oxygen-bearing oils: ~25% of essential oils. Essential alcohols. Linalool = hoppy aroma, Geraniol = floral, perfumy aroma.

IBU extraction formula: W \* A \* U \* 7489 / V x C

 Where: W = oz. hops, A% = Alpha Acid %, U = Utilization %, V = wort vol. in gallons, C = 1+ ((O.G. - 1.050) /2)) - a correction for wort gravity. 7489 is conversion factor from mg/l to oz./gal.

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| Hop Extraction Methods | Hop Characteristics |
| Kettle/Boil Hops - boiled 60-120 min. Max. bitterness utilization ~25-33%. | Bitter, Antibacterial/Preservative |
| Flavor hops - Boiled 15 - 40-min. Utilization = 5-15%. | Flavor |
| Aroma Hops - Boil 0 - 15 min., Steep after flame out. Utilization =< 5%. | Aroma |
| Mash Hopping - hops added to mash. Aroma & flavor preserved thru boil. Smoother bitter. Utilization red. by 80% | Bitter, Aroma, Flavor |
| 1st Wort Hopping - added to lauter tank during mash run-off. Said to contribute more pleasant flavor. | Bitter, Flavor, Aroma |
| Hopback - Run hot wort through filter/strainer filled w. hops. Only adds aroma. | Aroma |
| Dry Hopping - Added to the secondary fermenter. Oils extracted by alcohol in beer.  | Aroma |

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| Hop Variety | Country | Characteristics | Assoc. Style |
| Hallertauer Mittelfrüh, Tettnang, Spalter | Germany | “Noble” hops w.Low bitter, high spicy, floral, complex aromas | Ger. Pils, Bock |
| Saaz | Czech Republic | “Noble” hop w. floral, mild flavor/aroma | Bohemian Pils |
| Kent Goldings, Fuggles | England | Good for bitter, flavor & aroma. Earthy, floral, spicy, woody | Eng. Pale Ale, Eng. IPA, Eng. Barleywine. |
| Cascade, Centennial, Columbus, Chinook | U.S. Pacific Northwest | Citrusy, grapefruity, piney. American “C” hops. Inc. recent proprietary var: Amarillo, Warrior, etc. | Am. Pale Ale, Am. IPA, Am. Barleywine |
| Northern Brewer | Europe, America | Rustic, minty, woody. Used for bitter,flavor & aroma | California Common |
| Styrian Goldings | Belgium | Spicy | Witbier, Belgian Pale Ale |