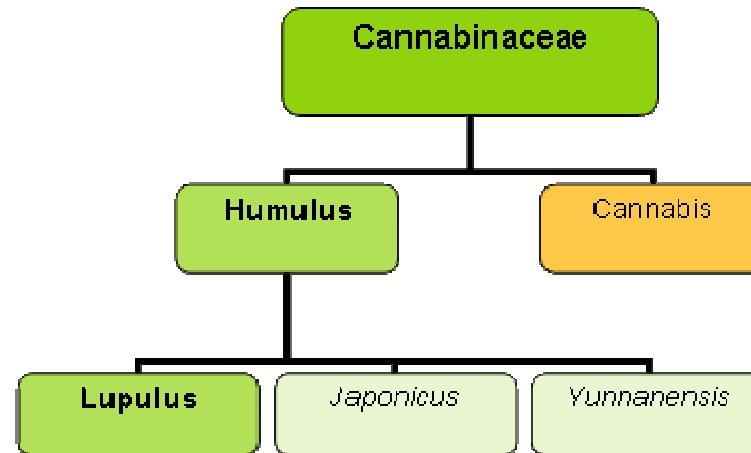

Hops

Andy Hejl

Why are Hops in Beer?

- Hops are an essential component in modern beer
 - Provide several benefits
 - Bitterness
 - Flavor/Aroma
 - Preservative qualities
 - Some drawbacks of using hops
 - Astringency
 - Light sensitivity
 - Haze
-

Hop Family Tree



- It's true – hops are closely related to cannabis

Hop Growing Regions

- Hops mainly grown in temperate climates
 - Grown throughout the world
 - Germany/Central Europe
 - US – Pacific Northwest
 - United Kingdom
 - China!
 - New Zealand
 - The location of growing is very important
 - Same variety from different region will be different
-

Hops in the Field

Hop vines growing in the field



Picture of Different Hop Cones

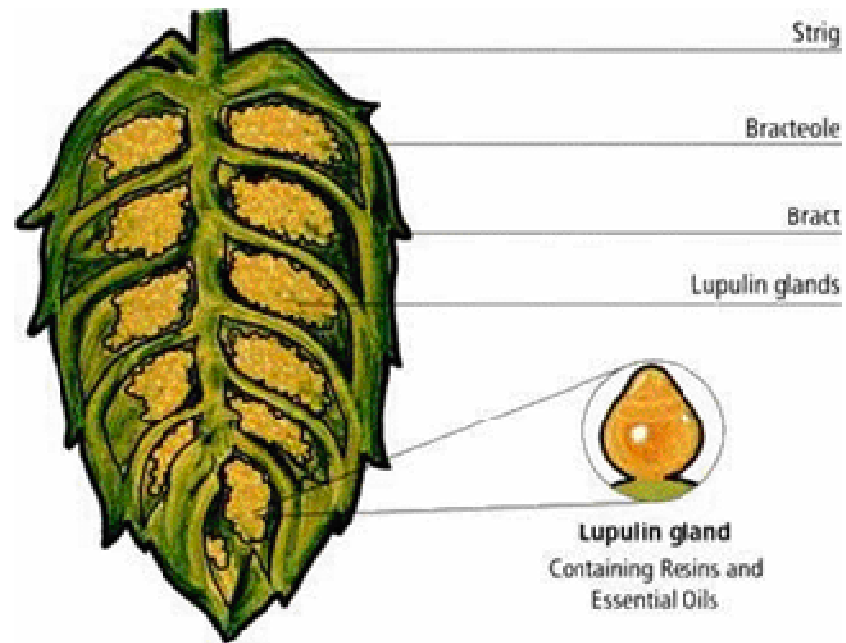


Fuggle



Nugget

Anatomy of a Hop Cone



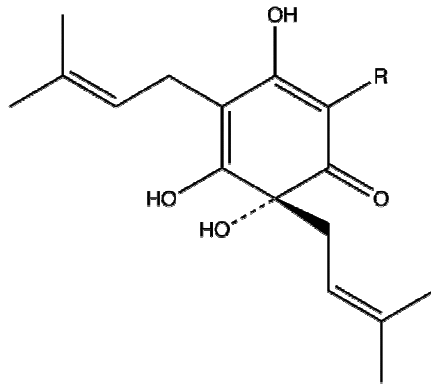
- Cones produced on female plants
- Lupulin glands are where hop essential oils are stored
- Strig – center stem
- Bracteoles – leaf portion

Different Forms for Hop Additions

- Whole hops
 - Hop plugs – whole hops compressed into discs
 - Hop pellets
 - T90 pellets – most common form
 - T45 pellets – removes some plant matter
 - Hop extracts
 - Common with very hoppy beers
 - Reduces loss in the kettle
 - Isomerized extracts – don't need to be boiled
-

Hop Resins – Alpha Acids

- Responsible for most of bitterness hops provide to beer
- Provided in a weight% of total hop, 2-20%
- Several different types of alpha acids



Humulone

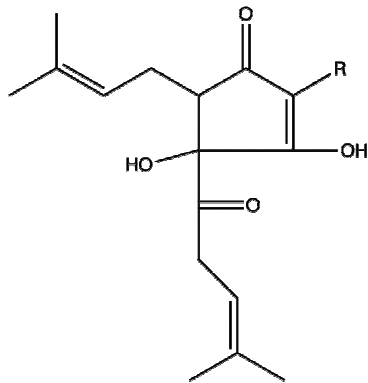
Cohumulone

Adhumulone

- Humulone is the most prevalent form
 - Cohumulone is said to be more harsh bitterness
-

Hop Resins – Isomerized Alpha Acids

- Alpha acids on their own are not extremely bitter
- In boiling wort the alpha acids form iso-alpha acids



Isohumulone

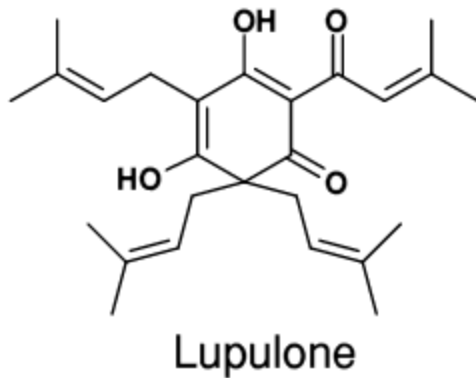
Isocohumulone

Isoadhumulone

- Iso-alpha acids are more soluble than alpha acids
-

Hop Resins – Beta Acids

- Beta acids are found in similar (or lower) levels than alpha acids



Lupulone

Colupulone

Adlupulone

- Bitterness from beta acids is due to oxidation
 - Oxidized beta acids less important as iso-alpha acids
-

Hop Oils - Hydrocarbons

- Hop oils are what give hops their characteristic aroma and flavor
 - Hydrocarbon oils make up ~75% of total oils
 - Humulene – more elegant, herbal, spicy
 - Myrcene – more pungent, citrus, pine
 - Farnesene – more common in noble hops
 - Caryophyllene
 - Essential oils are volatile and can be lost in boil
-

Hop Oils – Oxygen Containing

- Oxygen bearing oils are ~25% of total
- Two main types
 - Linalool – pleasant hoppy smell
 - Geraniol – floral (rose oil)
- Very herbal, floral hops have high quantities of these



Hop Addition Methods

- Somewhat simplified since all hops contribute to bitterness, flavor and aroma
 - Bittering – 60-90 minutes from end of boil
 - Flavor – 10-40 minutes
 - Aroma (Finishing) – 0-10 minutes
 - Dry Hopping
 - First Wort Hopping
 - Mash Hopping
-

Utilization and Hop Bitterness

- Not every bit of alpha acid in the hops is utilized (~30%)
 - Utilization is the percentage of alpha acids that make it
 - Many factors hurt utilization
 - Lower boiling time
 - Increasing wort gravity
 - Using whole hops instead of pellets
 - Using hop bags
 - Higher hopping levels
 - Alpha acids absorbed on yeast
-

Measuring Bitterness

- International Bittering Unit (IBU)
 - 1 mg alpha acid / 1 L beer (parts per million)
 - Measured experimentally in the lab
 - Brewing software can calculate

 - Homebrew bittering unit (HBU)
 - $\text{HBU} = \% \text{ Alpha Acid} \times \text{oz. hops}$

 - Very rough rule of thumb
 - $\text{HBU} \times 5 = \text{IBU}$
 - Only for bittering hops (60 min)
-

Balance – OG vs IBU

- The bitterness balances the residual sweetness in a beer
- Ray Daniels developed BU:GU ratio
 - BU – IBUs
 - GU – gravity units, $1.050 = 50$
- BU:GU ratio of $\sim 0.8:1$ is balanced
 - Bitter beers greater than 1.0:1
 - Malty beers less than 0.6:1
- Higher gravity beers start to require more IBUs
- Depends on many other factors (water, etc.)

Hop Varieties – English

- Used primarily in British ales
 - Bitters, pale ales, brown ales, milds
 - **East Kent Golding**
 - 4-5.5% AA
 - **Fuggles**
 - 4-5.5% AA
 - Both are traditional British hops
 - Earthy, fragrant, pleasant
-

Hop Varieties – Noble

- Central European origin
 - Used near exclusively in German brewing
 - **Tettnanger** – 3.5-5.5% AA
 - **Hallertauer** – 3.5-5.5% AA
 - **Spalt** – 4-5% AA
 - **Hersbrucker** – 3-5.5% AA

 - Light mild, spicy, floral aromas
 - Noble hops have lower levels of myrcene than other oils
 - Low cohumulone hops for smooth bitterness
-

Hop Varieties – US

- Used in most American ales, IPAs
 - Floral, citrus, pine aromas and flavors
 - **Cascade** – 4.5-7% AA
 - The classic hop for American pale ales
 - **Centennial** – 9.5-11% AA
 - **Amarillo** – 8-11% AA
 - **Chinook** – 12-14% AA
 - More intense, pungent character
 - Some of these are “dual-purpose” hops
 - Can be used for both bittering and flavor/aroma
-

Hop Varieties – High Alpha

- High alpha acid are important for big brewers
 - High alpha acid hops used primarily for bittering
 - Many of these are now low cohumulone
 - **Columbus** – 14-16% AA
 - **Magnum** – 12-14% AA
 - Clean bitterness, little aroma
 - **Horizon** – 11-13% AA
 - **Simcoe** – 12-14% AA
 - Very characteristic aroma, pine, catty, onion
-

Hop Varieties – Other

- **Saaz** – 3-4.5% AA
 - Also considered a noble hop
 - Mild, spicy character
 - Traditional in Bohemian Pilsner
 - **Styrian Goldings** – 4.5-6% AA
 - Delicate, slightly spicy
 - Many Belgian beers use this
 - **Northern Brewer** – 8-10% AA
 - Unique woody, minty, rustic character
 - A must for California Common (Steam Beer)
-

Non-Hop Spicing in Beers

- Other materials can be added to balance the sweetness in beer beside hops
 - Gruit – mixture of herbs
 - Was extremely popular before widespread hop use
 - Sweet gale (bog myrtle), mugwort, yarrow, horehound
 - Not as effective a preservative as hops
 - Many different recipes used
 - Heather flowers
 - Spruce tips
-

Hops Ingredients Question

- *Discuss hop, describing their characteristics, how these characteristics are extracted, and the beer styles with which the different varieties are normally associated.*
 - What are uses of hops?
 - Bittering, flavor/aroma, preservative
 - Characteristics
 - Alpha acids, cohumulone, isomerization, oils
 - How are they extracted?
 - Boil (bitterness, flavor, aroma), dry hopping
 - Varieties and Beer styles
 - Noble, UK, US, Saaz, ...
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