Hop Quality 101

• Hops & brewing review

• Hop Quality farm to bale
  Sanitation
  Pests
  Diseases
  Drying & baling
Chemistry & Brewing

• Why are Hops added to Beer?
  
  • Bitterness to balance sweetness
  • Foam stability
  • Non-bitter flavor (aroma)
  • Microbiological stabilization
# Chemical Composition of Dried Hops

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>6-12</td>
</tr>
<tr>
<td>Soft Resins</td>
<td></td>
</tr>
<tr>
<td>Alpha acids</td>
<td>2-16</td>
</tr>
<tr>
<td>Beta acids</td>
<td>1-10</td>
</tr>
<tr>
<td>Essence Oil</td>
<td>0.5-2.5</td>
</tr>
<tr>
<td>Hard Resins (Tannins &amp; polyphenols)</td>
<td>2-5</td>
</tr>
<tr>
<td>Amino acids</td>
<td>0.1</td>
</tr>
<tr>
<td>Simple Sugars</td>
<td>2</td>
</tr>
<tr>
<td>Pectin</td>
<td>2</td>
</tr>
<tr>
<td>Oils &amp; Fatty acids (unseeded hops)</td>
<td>0-2.5</td>
</tr>
<tr>
<td>Protein &amp; non-Cellulose Carbohydrate</td>
<td>15</td>
</tr>
<tr>
<td>Ash (Mineral content)</td>
<td>8-10</td>
</tr>
<tr>
<td>Cellulose</td>
<td>40-50</td>
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</tbody>
</table>
Hop Cones & Parts – Dried & Baled
Lupulin Glands

This is where most of the materials of interest to the brewer are located. α & β acids, hop oil & Xanthohumol.

Proanthocyanidins & glycosides in green tissue.
Alpha Acids

Term is plural!

3 major & several minor alpha acids. Ratio of these is variety dependent.

\[
\text{R} = \text{isopropyl} \quad \text{cohumulone} \quad 11-52\%
\]
\[
\text{R} = \text{isobutyl} \quad \text{n-humulone} \quad 40-82\%
\]
\[
\text{R} = \text{sec-butyl} \quad \text{adhumulone} \quad 5-17\%
\]
Kettle Isomerization of Alpha acids to more bitter iso-Alpha acids

Alpha acid 10 ppm

Iso-alpha acid 120 ppm
Alpha Utilization

Typically, 50% of alpha added to kettle is removed with trub & hops. Most of what remains in wort is iso-alpha.

50% of what survives wort boil (as iso-) is removed with yeast. Overall Utilization 25%
Factors Affecting Utilization

- Wort pH
- Altitude (boiling point of wort)
- Gravity (boiling pt & increased trub)
- Kettle depth & boil time
- Hopping rate (more hops = worse utilization)
- Yeast count & foam loss in fermentation
- Aseptic filtering & chill-proofing
- Many others......
Beta Acids

Beta acids completely insoluble in beer.

Beta acids do NOT isomerize – no iso-beta.

Oxidation products of beta acids formed during bale storage are bitter and found in beer.

<table>
<thead>
<tr>
<th>Beta Acid</th>
<th>R =</th>
<th>% of Beta Acids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lupulone</td>
<td>iso-butyl CH₂CH(CH₃)₂</td>
<td>15-60%</td>
</tr>
<tr>
<td>Colupulone</td>
<td>iso-propyl CH(CH₃)₂</td>
<td>35-80</td>
</tr>
<tr>
<td>Adlupulone</td>
<td>sec-butyl CH(CH₃)CH₂CH₃</td>
<td>5-12</td>
</tr>
</tbody>
</table>
Beta Oxidation to Hulupones

Hulupones increase in baled hops (oxygen!) with age.

Are bitter & measured by IBU analysis
Hop Bale Aging & Bitterness Potential

• Baled hops lose alpha with age. Alpha ox products not particularly bitter.
• Baled hops lose non-bitter beta as well and ox products ARE bitter.
• If there is about as much beta as alpha, these two processes balance out and hops lose no bitterness potential with time.
• Only aroma hops have as much beta as alpha.
Old “Cheesy” Hops
Oxidation Products of $\alpha$ & $\beta$ formed in bales, found in Beer
Hop Storage Index (HSI)

• Used on hops & pellets to determine what % of α & β acids have been lost to oxidation.
• Part of normal ASBC alpha analysis. After toluene extraction & alk. MeOH addition, UV absorbance @ 275 & 325 nm taken.
• HSI = 275 nm/325 nm absorbance
• = 0.25 for fresh hops, about 2 for hops with no alpha remaining
HSI vs. % (α & β) remaining

Nickerson update to original (1970) HSI correlation:

\[ \% (\alpha + \beta) \text{ lost } = \log(\text{HSI}/0.25) \times 110 \]

Originally, \( \times 100 \)
Hop Oxidation and Quality of Bitterness

- Even though VERY oxidized hops may give comparable IBU levels as fresh hops, there are large qualitative differences.
- The bitterness of beer with largely non-iso-alpha bitterness (from old hops) will be harsher and more lingering than beer with the same IBU’s of iso-alpha.
- Foam will be very much inferior in beer made with old hops.
How Hops are used require different levels of sanitation

Kettle hopping

- Hops boiled for 20-60 minutes: Kills just about everything.
- Non-water soluble materials removed with the precipitated protein & hops.
- Fermentation is also a purification process.

Dry-hopping – hops added just at the end.

- No chance to kill micro-organisms with a boil.
- Any impurities and toxins are exposed to the beer just before bottling.
- Sanitation needs are much greater.
Farm Practices

• Your harvesting Facilities are a FOOD PLANT
• Birds & rodents to be excluded from harvest facilities even during down times.
• Clean equipment at the end of harvest as well as beginning.
• Motor oil, fuel, and anti-freeze should never touch surfaces (floors) that will touch hops.
Leaf & Stem and Seed

• Non-hop material and leaf & stem to be minimized.

• Brewers don’t like seeded hops. Rouge all males in the field and in nearby locations in the wild.
Male Hops

No cones – cones are female organs

Pollen sacks instead

Used for breeding
Hop Pests – Spider Mites

Problem in HOT weather – usually late season.

Life cycle accelerated with temperature

Reduces yield & perhaps quality
Mite Damage

Brown cones and accelerated maturity

If only cause of brown color – perhaps not a great problem
Mites will reduce yields
Aphids

Hop Aphid overwinters in plum & other fruit trees. Return to hops in spring. (13° C)

Reduces yield & quality – vector for diseases
Aphid mass on Leaf
Aphid Damage –
Dried cone
Aphids secrete
honey-dew on
interior surface.

Mold grows on
this creating
“sooty-mold”
Sooty Mold in Undried Cone
Powdery Mildew

Fluffy, white fungus that over winters in the root crown.

Attacks leaves & cones as the season progresses
Powdery Mildew
Reduces Yield & Quality

Infected cones often suitable for kettle hopping, but not for dry-hopping
Powdery M. in Cones

Early infection:
White mass on deformed cone

Late infection:
Cones normal in field, turn brown as they dry.
Downy Mildew
Primary infection from over-winter in root.
Secondary infection on leaves & cones
Downy Mildew
Secondary infection
underside of leaf
during cool, wet weather.
Downy Mildew more problematic for kettle & especially dry-hopping
Avoid Disease Prone Hops

• If you grow a small amount of a hop that is VERY susceptible to Downy and/or Powdery Mildew, it will act as a source of infection for all hops within a mile or more.

• This will increase cost of production (more spray) and decrease yields for more disease resistant hops nearby.

• Solution: Don’t grow these hops!
Disease Prone Hops to AVOID!

• #1 Columbus (CTZ) very prone to both Downy and Powdery. Spreads both like crazy.
• Palisade – very prone to Downy – dies in Oregon.
• Cluster and Galena also prone to Downy.
• If a hop is NOT grown in Oregon, I would NOT grow it in Wisconsin! If folks in Yakima say a hop is resistant to Downy – this has no meaning. Yakima is in the desert – NO DM!
Wind damage largely cosmetic, accelerates maturity. In extreme cases may be cause for concern.
Harvest Date

• The majority (but not all) craft brewers seem to prefer a later-harvested hop. Maybe 5-7 days past were a hop would traditionally be harvested.
• Later harvest results in a bit more alpha and oil content. Aroma of hop is more aggressive and pungent – less refined.
• Bitterness of beer made with such hops may tend to have a harsher, more lingering bitterness.
• A minority of brewers prefer a traditional harvest date.
Over-dried Hops

Hops dried below 8% moisture lose some or all aroma and will age much quicker. Cones shatter when baled.
Over-Dried Hops

- High Oxidation
- Bad storage
- Loss of aroma
- Very poor for dry-hopping
- Want moisture between 8 and 10%. The closer to 10%, the better.