OPTIMIZING HOP QUALITY
1. Plant population and community ecology.
2. Winemaking, production and quality systems.
3. Hops, laboratory analysis for Alpha Analytics and YCH grower-owners.
4. Hop quality initiatives
   • Grower feedback
   • Process improvement (harvest, kilning, pelleting, storage)
1. Quality Factors
   • Varietal Purity
   • Growing Practices
   • Approaches to handling variability

2. Growing for Oil vs Alpha
   • Bitterness vs. Aroma
   • Alpha and Oil development
   • Determining Harvest Timing
   • Analytical vs. Sensory
   • Early vs. Late Harvest

3. Post Harvest Hop Quality
   • Moisture and Kilning
   • Hop Storage Index (HSI)
   • Hop quality and storability

4. Pellet Production & Storage
I. Quality Factors

• Regional/Abiotic – latitude, climate, soil structure
• Root Stock Age, Health and Purity
• Cultural Practices
  – Burn back, training, vines/acre, cover cropping
• Harvest Timing
• Harvest Handling
  – Pickers, kilns, farm storage, processors, merchant storage.
• Post-Harvest Processing
  – Raw hop packing, pelleting, storage, transport.
Considerable alpha and oil variability in Cascade

What are the sources?
Varietal Purity

- Clonal propagation from a single parent for multiple generations
- Accumulates disease over time
- Susceptible to competition from off-types (other varieties)
- Presence of males
Outliers can be brought to grower attention to identify potential cause.

Visual assessment of consistency and outliers.
Other factors: Yard age, virus free, males, pest pressure
Cultural Practices

- Cover Crops
- Moonscapes

Other factors: Salmon Safe, Global GAP, Organic, IPM, Fertility...
Cascade

Simcoe® YCR 14 cv.

~6.5% alpha range

~2.5% Alpha

~2.5% Alpha

~6.5% alpha range
What’s a Supplier to Do?

A. Collaboratively develop Best Farming practices to improve crop consistency

B. Embrace Variation and work with growers and brewers to make the most of it.

C. Blend lots for consistency of the varietal
Do you embrace the variability or try to homogenize the crop?
II. Growing for Alpha vs Oil
(Bittering) (Aroma)

Bittering Hops
• Hops boiled for a long time to stabilize bitterness.
• Typically, most aroma character is lost when hops are used for bittering.
• Brewers have many choices for adding bitterness.
• Super-alpha varieties: CTZ, Apollo, Bravo, Warrior, etc.
• Advanced products: CO$_2$ extract, Isomerized extracts, etc.

Aroma Hops
• Boiled for short time or not at all.
• Delicate aroma compounds are retained, some bitterness is produced at high hopping rates.
• Majority of hops in craft breweries are used for aroma.
• Highlights uniqueness of hop, making the beer unique!
Growing for Alpha vs Oil (Centennial)
Growing for Alpha vs Oil (Cascade)
Growing for Alpha vs Oil (Citra®)
Determining Harvest Timing

Harvest too Early
- Low Alpha
- Low Oil
- Reduced yield *next year*

Harvest too Late
- Poor aroma (onion, garlic)
- Oxidation (cheese, storability)
- Disease & Pests
Determining Harvest Timing

Dry Matter – Easy to test at home
• “Classic” method
• Hop cones dry naturally as they mature
• Mature cones have ~22-23% dry matter (77-78% moisture)

Alpha vs Oil development – requires lab equipment
• Harvest when target alpha is reached
  ✓ What if target is never reached?
• Harvest when oil stops increasing
  ✓ What if oil doesn’t stop increasing?

Know your crop, use your senses
• Onion / Garlic
• Pests
• Browning cones
  • Grassy / Vegetal / Green aroma
  • Dankness!

III. Factors that affect post-harvest hop quality

• Light
  – Never good, but especially bad if the cones and glands are broken, easy to control

• Heat
  – Accelerates chemical breakdown (oil and alpha)
  – Hops at 75° degrade 4x faster than frozen

• Oxygen
  – Loss of bitterness
  – Cheesy aroma

• Moisture
Hops should be dried to 8.5-10.5% moisture.

Ideally, pick cones and begin drying within hours of cutting bines.

- Under-dried hops oxidize, turn brown, smell musty (rotten lettuce).
- Also dilute alpha and oil with residual water.
- Over-dried hops shatter, lose aroma.
Hops should be dried to 8.5-10.5% moisture

Pitfalls when drying
• Outer bracts dry quickly.
• Inner strig retains moisture longer.
• Hops feel dry, but moisture remains inside.
• Moisture equalizes in bag, causing hops to feel soggy.
Simple method for drying samples of hops

- Standard household food dehydrator.
- Insert thermometer in top vents.
- Target 135°F (57°C)
- Maximum airflow.
- 3-4 hours on our dehydrator...

Drying and measuring moisture:
http://msue.anr.msu.edu/news/drying_hops_on_a_small_scale
http://www.uvm.edu/extension/agriculture/engineering/?Page=hopscalc.html
Processing and Kilning Practices

24 – 36 hours harvest to bale

1. No birds, no sticks, no poop!
2. Gentle handling at all stages is critical.
3. Kilning
   • Target 125 - 140°F
   • Can start with higher temps, decreasing as hops dry
   • Maximize airflow to carry away moisture
   • Measure moisture to achieve 8.5-10.5%
   • Adjust bed depth to minimize stratification
4. Cooling
   • Gently move to cooling floor or circulate cool air
   • Allows moisture to equalize
5. Baling
   • Protects hops from shatter
   • Reduces oxygen contact in storage
Metrics of hop quality

- Dankness
- Onion / Garlic / Cheese
- Alpha, Oil
- Hop Storage Index (HSI)

Alpha Acid potential lost in 6 months, at 68°, in bales

*Please don’t store bales at room temperature!!!*
Hop Storage Index (HSI)

- Hop compounds absorb specific wavelengths of light.
- Oxidation compounds absorb light near 275 nm, Alpha Acids absorb near 325 nm*.

\[
\frac{\text{Oxidation Compounds}}{\text{Alpha Acids}} = \frac{\text{Absorbance@275}}{\text{Absorbance@325}}
\]

- As hops age, alpha decreases, oxidation products increase, and HSI goes up.
- HSI is an indicator of hop degradation, but DOES NOT enable calculation of future alpha loss (e.g. “after 6 months...”)

* Note that this is an oversimplification
Degradation of Tomahawk® baled hops

% Alpha Acid (lines)

HSI (bars)

0.000
0.100
0.200
0.300
0.400
0.500
0.600
0.700
0.800

0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0

0.249
0.285
0.369
0.297
0.410
0.518
0.000
0.100
0.200
0.300
0.400
0.500
0.600
0.700
0.800

0
2
6

Months After Harvest
Alpha loss is greater with high harvest HSI

HSI < 0.230

Days in Storage (baled hops)
Alpha loss is greater with high harvest HSI
High harvest HSI loses more alpha per day
HSI generally does not increase through the “normal” harvest window
Two exceptions in our data
IV. Pelleting and Storage

Pelleting significantly slows degradation
• Pellet HSI = Harvest -> Pelleting
• Does not accurately predict Alpha Acid breakdown once pelleted.

Best practices
• Consistent, fine, grind.
• Die cooling (liquid N).
• Inert gas packaging (N and/or CO₂).

Why?
• Grind size = pellet consistency (manufacturing) and extraction efficiency (brewing).
• Milling ruptures lupulin glands, exposing resins and oils to oxygen.
• Heat and oxygen can cause rapid degradation.
Pelleting slows the aging process

Recognizing Pellet Quality

Observations
• Glassy = too hard
• Off color = burnt
Observations

- Inconsistent coarse grind
- Off color bits
- Density too low = oxygen
Observations
• Nice dull surface
• Consistent color
• Firm
High Quality Pellets

1. Dull, but smooth surface.
   - NOT glossy (density, temp, feed rate issue)
   - No gaps, cracks, large pores.
2. Consistent color.
   - Hops naturally vary in color, pale or dark OK if consistent.
   - No individual dark pellets (inconsistent feed).
3. Intermediate density.
   - Crushable between fingers.
   - Too hard = poor dispersion in fermenter.
   - Too soft = oxidation, dust in bag.
4. Hard vs. Soft Pack
   - Resinous hops tend to form solid bricks when vacuum (hard) packed.
   - Brewers generally prefer soft pack.
✓ Alpha is generally stable within the harvest window
✓ Oil generally increases throughout harvest window
✓ Brewers generally shopping for aroma hops
✓ Trend would suggest harvesting as late as possible to maximize oil / aroma.
✓ *Post-harvest processing and pelleting critical to preserving alpha, oil, and aroma, can negatively impact HSI*
Thank you!

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