In Hop Pursuit

The OSU-Indie Hops Aroma Breeding Program

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Indie Hops – We Sell Flavor

- Established 2009. “Hop Shortage.”
- INBEV/Bud pulls plug on public breeding
- $1 Million (now $1.3M)
- Increase Oregon hop acreage
- Increase Genetic Diversity
- Increase Yield/Disease Resistance
- First Oregon Merchant with “cool” Pellet Mill
- Breed new aromas & flavors

The Nectar

HOP ANATOMY

LUPULIN GLANDS

BRACTEOLES

STRIG

Most of the power from the hops is packed inside these volatile lupulin glands. The glands ball together into sticky yellow clusters which contain resins, acids, and essential oils. The resins contain the bittering compounds and the oils contain the aroma substances. The alpha acids (humulones) and beta acids (lupulones) are what give beer that bitter taste.

Key components responsible for hop flavor, hop aroma and hop bitterness in beer are the essential oils and resins found in and on the hop leaves themselves. Even the leaves of mature cones ooze a smattering of lupulin. The bracteoles and leaves of the cone also contain tannins which are also good for the plant. They can help ward off bacteria and fungi, and the polyphenols they produce help protect plants and beverages from the ravages of oxidation. If you sip a beer and your mouth puckers, it's probably because your beer is loaded with tannins, which interact with your salivary glands.

Most of the tannins in a hop cone are actually found in the strig and stem, as opposed to a very low percentage in the hop leaves. These tannins pump out the medicinal or bioactive properties of hops, also known as polyphenols. This is what vitamins, energy drinks and all manner of magical potions, powders and elixirs are made of. These would include those natural little life-sustaining gems like flavonoids, catechins, quercetin and xanthohumol. In the human body, they're supposed to roam through the immune system scavenging free radicals which can trigger fatigue, inflammation and, much worse, cancer. Hops contain one of the highest levels of polyphenols in plants (around 4-6% by weight). The polyphenols also contribute to the harshness or smoothness of the bitterness.

CLOSE UP OF LUPULIN GLANDS

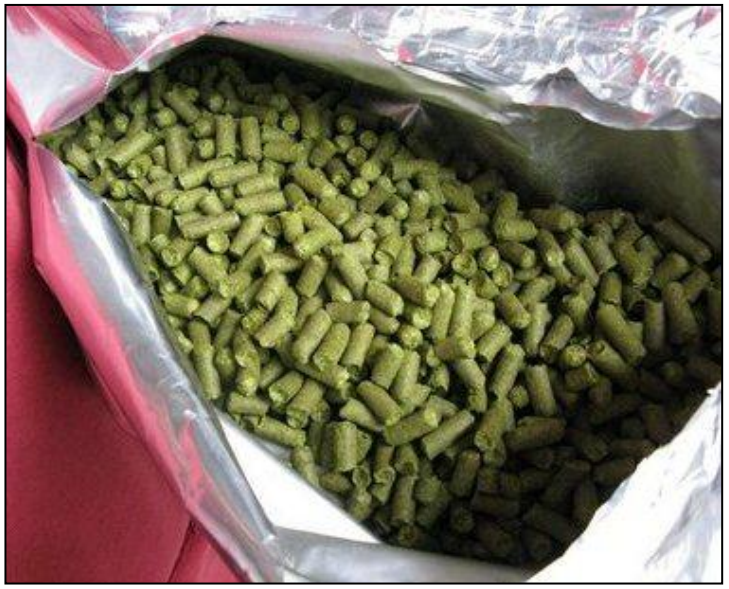
WORTHY BREWING

Indie Hops
OREGON GROWN

There Will Be Oil

Preserve the Precious Oil

- Larger avg. pellet particle size
- Longer contact time in Tank
- Cooler Temp at the Pellet Die
- Keeping it cold (28F) - storage
- Pelletize within days of harvest
- Bales to <1% O2 purged foil bags to 28F cooler w/i 1 hour



OSU-Indie Hops Breeding Program

- Complex Chemistry, Many unknowns
- What essential oils are desirable?
  - Over 400 known oil components
    Another 400 unnamed, tracking 40
- Can we target?
- Is more total oil better?
- Hop Oil Maturity – Optimum harvest time?
- Dry Hop – when and how long?
- How is Flavor influenced by malt, yeast, adjuncts, hop combos, liberated glycosides, staging, amounts, etc?

Flavor Roulette?

We know what we like, mostly.

Discriminating palates can disagree

But how do we isolate and amplify?

Can we breed for particular oils?

Are there shortcuts?

Is sensory evaluation an “exact” science?

Chasing Oil

* 80-90% total essential oils captured by:
  caryophyllene - pepper, earthy, citrus (Goldings)
  myrcene - peaches, mango, orange (Amarillo)
  humulene - woody, herbal (H.M.)
  farnesene - magnolia, citrus, lavender (H.M.)

- Used in perfumes (pungent)
- Found in basil, clove, pepper, cannabis, pears, apple, orange, grapefruit, lime
- The other 10%? Winners excel at the margins. Eg linalool, a-terpineol, Citronellal, Geraniol, etc.

A Little Dab Will Do Ya?

Essential Oil		Flavor Compound
Alpha Terpineol	-	Lavender, Pineapple, Raspberry, Lemon, Lilac, Pine
Linalool	-	Orange, Floral, “fruit loops”
Methyl Heptanoate	-	Grape
Citronellal	-	Lemon
B-Pinene	-	Wood, Pine
A-Pinene	-	Pine
Citral	-	Lemon
Geraniol	-	Floral, Rose, Geranium
Citronellol	-	Citrusy, Fruity

OSU/IH tracks about 40 oils

No Shortcuts

Female Hop

Hop Maiden

Male Hop

1. Controlled Cross breeding. E.g., Tiny brush method.
2. Open Pollination. Multiple Daddies?
3. Get seeds. Lots of them.

Patience You Must Have…

- Year 1 - Crosses, greenhouse selections (10-14k seeds yr)
- Year 2 - Establish field nursery (200)
- Year 3 - Field notes, "baby year"
- Years 4-6 - Yield, chemical evaluations, sensory, hop teas, pilot brews (maybe 5 gamers?)
- Years 7+ - Advanced testing on farms, expand acreage, pilot brews
- It usually takes 9 or more years to develop a new hop cultivar…*young padawan*

Breeding Program Agronomic Criteria

- Yield (> 8 bales/ac or 1600 lbs/ac)
- Disease resistance
  - Downy, powdery mildews
  - Public varieties getting tired?
- Pest resistance
  - Two-spotted spider mite, hop aphid
- Time to maturity
  - Avoid fall rains in Willamette Valley
- Suitable to Oregon Terroir

Selecting Aroma, Naturally

Rubbing and sniffing.

Sam Adam's Jim Koch juicing up.

Brewer Collaboration: It takes a village

Test “Tea” Beers

Jim Solberg, Hop Alchemist

- Generic base ale with 5% alcohol
- An experimental hop is added to the French press and soaks for 1 hour
- Sample the beer. Evaluate.
- Narrowing down the field (10,000 seeds to 5 plants per crop year)

Case Study: X331

2009: OSU gardener offers open-pollinated seeds from backyard.

- Perle is the Mother
- Father is unknown (rogue Oregon hop stud?)
- N. American Wild Type?
- Race to fertilize fierce around Corvallis

The Chosen One – x331

- 2012: OSU Ferm Science brewbots spot X331 at OSU research farm. “The One.”
- 2012 (Fall): IH sensory analysis. Near whiplash on dry rub. Harkens back to days of youth roaming valley intoxicated by “Indian Tobacco” and low hanging free fruit.
- Fast tracked to Farm Trials.

X331: A Shooting Star?

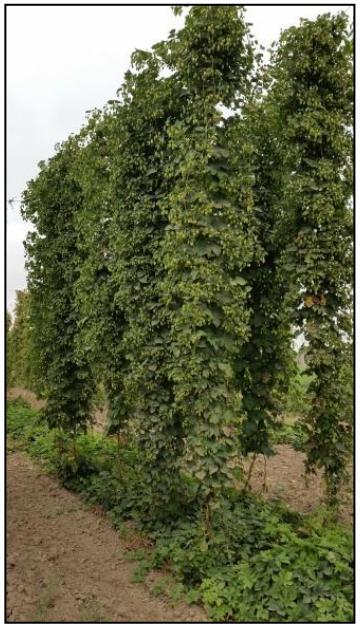
- 2013: After choosing best X-331 plant, propagate clones and plant at Goschie and Coleman farms.

  Pilot brewing at Worthy and other breweries. Wins “best of show” at Basecamp Brewing Protohop Brewfest in Portland.

- 2014: First “baby” harvest from farm trials in 2014. Pilot brewing activity spurs excitement.

X-331: Ramping Up

- 2015: Too good to wait. Indie Hops decides to propagate and plant commercial trial acreage. About 9 acres.
- First commercial harvest in 2016. Nearly 2k Lbs/acre. Farmers excited. A fast mover! Not bad for summer planting.



X-331: A Go-To, Stand Alone?

- Worthy Lookout freshhop beer.

"*Passion Fruit meets Pot.*"

"Showhorse meets workhorse."

Multi-layered. Passion fruit, grapefruit, mango with a whiff of weed.

All-purpose.

X-331: The Bones of a Champ?

A Peek at the Chemistry

12-16% Alpha (tad higher than Cascade and Perle)

Total Essential Oils

- 3 mls/100gms
  (higher Centennial / 2.7 mls/100 gms)
- Alpha terpineol – tropical fruit
  - 3-10x more than Cascade & Perle
- Citronellal (fruity)
  - 3x > Cascade
  - 5x > Perle

X-331: The Bones of a Champ?

- Citronellol (citrusy, fruity)
  - 4x > Cascade
  - 3x > Perle
- Linalool (floral & Orange)
  2x More Cascade & Perle
- Trans caryophylene (woody)
  - 5x greater than Cascade
  - 3x greater Perle
- Alpha humulene (Piney)
  - 2x greater Cascade & Perle

Proud Hop Daddies

3 years ahead of schedule

Milking the Mother

Already Fertilizing the Next Generation

A Hop Star is Born?

Hop Star X1 pilot brew tapped Monday at Worthy Brewing.

In Summary, We are Oregon Proud of this:

- We use traditional breeding techniques, primarily controlled crosses between male and female plants. No GMO or Gene Splicing techniques.
- 10,000- 14,000 seeds collected each season. Narrows to just a few hundred by the following spring due to the disease gauntlet in greenhouses over the first winter.
- Roughly 200 genotypes harvested each year in the experimental field, based on vigor, DR, etc.
- These 200 evaluated for brewing characteristics, first through dry rub, then dry hopping in a “neutral” base beer, then via small scale (1/3 barrel) pilot brews.
- Perhaps 5 of the 200 remain and are planted out in farm plots of 30 hills/plants.
- Larger scale pilot brewing takes place using the farm plot hops. Maybe, if we’re lucky…just maybe we’ll have one hop from each farm plot that ends up proving worthy of commercial launch.

Making Oregon Hop Green Again

	2010	2016	Percent Change
Total Oregon Hop Yield in lbs	8,278,000	11,8000,000	**42.55%**
Oregon Hop Acreage in Production	4,622	7,669	**65.92**%

*10.6% increase in total yield from 2015-2016
*16% increase in Total Oregon hop acreage

OSU-IH Program Benefits Program Status 2015

- Evaluation of more than 1500 hop genotypes over multiple years
- Crosses involving 38 females and 20 males (+5 OP)
- Establishment of 14 advanced selections among six replicated nurseries on two commercial hop farms
- Establishment of commercial experimental blocks on two farms for one advanced selection
- Selection of a promising ornamental genotype that is being evaluated by industry
- Mentored 5 interns
- Mentored/Mentoring 2 graduate students
- Provided experience for at least 10 undergraduate research assistants
- Published 18 peer-reviewed and miscellaneous publications

Future Challenges

- Impact of Climate Change
  - Reduced snowpack, earlier melting
  - Increased avg. nighttime temps (aroma likes cooler nights)
  - Lower reservoirs, impact on irrigation supply
  - Yakima 2015 – drought + lower yields
  - Warmer winters impact on dormant rhizomes.
  - Affect vigor? Susceptibility to disease?
  - What hops are early spring risers?
    - May be better warm weather survivors
- Draught tolerant hops? OSU IH researching