



TM

**YAKIMA  
CHIEF  
- HOPS -**



# **DRY HOPPING TECHNIQUES**

**SPENCER TIELKEMEIER, EAST DIVISION LEAD & BREWING INNOVATIONS**

**ANDY ARSENAULT, KEY ACCOUNTS DIVISION LEAD**

## **OUR MISSION**

**To connect family hop farms to the world's finest brewers**

## **OUR VISION**

**We are the global supplier of choice, focused on sustainably produced, innovative hop products. We are a responsible neighbor and asset to our communities, enriching the products, businesses and lives of everyone we encounter.**

## **OUR VALUES**

- **Passion: For people, product, planet and process**
- **Respect: Teamwork and collective responsibility**
- **Integrity: Transparency and accountability in all we do**
- **Dedication: Quality and sustainability**
- **Excellence: An emphasis on innovation and continuous improvement**

# GROWERS

We are the only 100% grower owned hop company. Our grower families have been harvesting hops in the Northwest since the 1800s and have acquired a wealth of knowledge and expertise throughout the decades to create the highest quality hops.

These grower-owners include:

- 3D Farm/BC Hop Farm
- Brulotte Farms
- B.T. Loftus Ranches
- C&C Hop Farms
- Carpenter Ranches
- Gasseling Ranches
- Perrault Farms
- Sauve & Son Farms
- Sodbuster Farms
- Van Horn Farms
- Black Star Ranches
- Coleman Agriculture
- Double R Hop Ranches
- Oasis Farms



# YAKIMA CHIEF HOPS KEY DATA



**Pounds Handled of 2019 Crop:**  
**39.8 Million LBS (19,900 MT)**

**Percentage of U.S. Crop: 38%**

**Grower Owners: 15**

**Allied Growers: 36**



# DRY HOP TECHNIQUES

# DRY-HOPPING

- Addition of hops to the cold side of the brewing process
- Dry hopping has been around for centuries
- Traditionally hops are added post-fermentation
  - Newer DH techniques have become popular



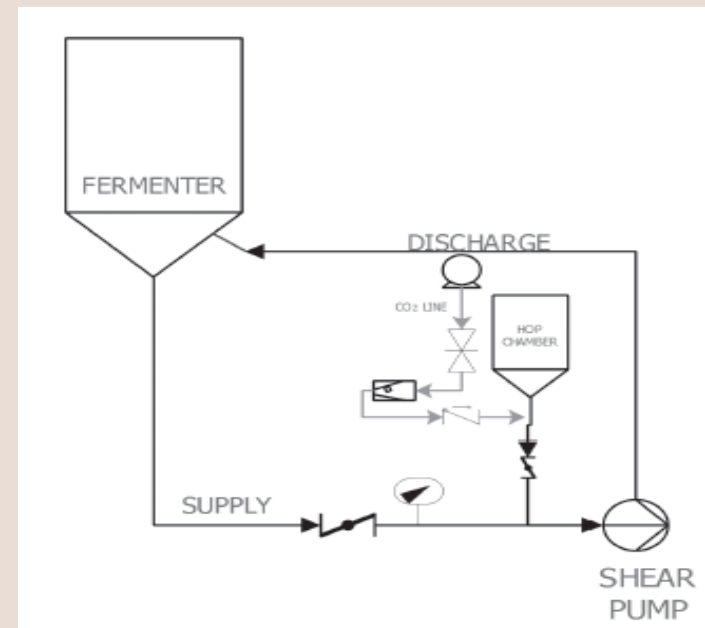
# DRY HOPPING BY HAND...

- **Easy to perform**
  - Do not perform on a tank that has built any pressure, adding hops to “carbonated” beer can cause off gassing and tank overflow
  - Can be performed slightly before terminal gravity has been reached, to neutralize any possible O<sub>2</sub> addition.
  - Additions early during fermentation can cause overflow, up and out of the fermentation tank. Some brewers add a small amount of hops, let the tank “degas” then add the rest
  - CO<sub>2</sub> can be bubbled through the bottom outlet @ 3/5psi to create positive pressure, which can aide in keeping O<sub>2</sub> out of the hop addition process.
- **Safety issues**
  - Ladder usage and safety concerns



# HOP DOSER SYSTEMS

- 3-4x volume turnover in recirculation
- Portable and safe to use
- Applications:
  - Hops
  - Spices
  - Coffee
  - Tea
  - Vanilla
  - Syrups
  - Fruits





# DRY HOPPING VIA HOP DOSER

- SAFETY
- IMPROVED HOP EXTRACTION
  - CUSTOMER BREWERY CLAIMS TO HAVE REDUCED HOP USAGE BY 17% WITH MINIMAL SENSORY IMPACT
  - RARELY USING MORE THAN 8-10 G/L
- COLD-SIDE OXYGENATION RISK REDUCED
  - CAN PURGE THE UNIT WITH CO2 TO <10PPB O2
- CAN BE USED FOR COLD SIDE ADDITIONS OF FRUIT PUREE WITHOUT THE RISK OF INTRODUCING O2
- "CHOPPER" PUMP CREATES A DIFFERENTIAL PRESSURE FOR INDUCTION FROM THE VESSEL. PELLETS ARE CHOPPED TO MAXIMIZE SURFACE AREA, FLAVOR AND AROMA
- DELICATE BALANCE OF FLOW, FLOW DISRUPTIONS CAN CAUSE ISSUES, GAS BUILD UP IN PUMP HEAD, CAVITATION, BEER CAN GET INTO THE UNIT AND CREATE IMPACTED HOPS
- COST OF MACHINE AND MAINTENANCE OF MACHINE (GASKETS AND PUMP SEALS)



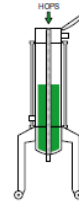
# HOP CANNONS

## Hop Dosing

### Benefits

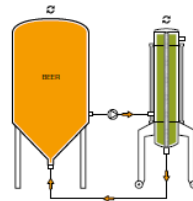
- > Optimum infusion of essential hop oils into the finished beer
- > Increase in yield and taste stability
- > Defined increase in the hop aromas in the finished beer
- > Gentle dissolving of hop pellets in cold beer
- > Reduction in contact time
- > Freely selectable hop dosing time and duration
- > No CO<sub>2</sub> losses in green beer
- > No heat added through the omission of the High Shear mixer
- > Good removal of the extracted hop solids – no filtration problems
- > Cleaning possible with external CIP system
- > Can be retrofitted at any time
- > Reliable application

### Procedure



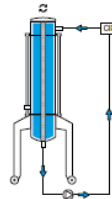
#### Filling

The HopGun is filled with hop pellets through a large access port. The HopGun circulates the contents of the tank until the required degree of extraction is reached.



#### Dry hopping

The precious oils and flavours are released and the suspension is returned through a specially developed candle in the interior of the HopGun. Course particles are retained allowing only fine, easily extractable hop particles to reach the beer.



#### Cleaning

The system can be cleaned manually or with an external CIP system. Evacuation is performed with CO<sub>2</sub> or N<sub>2</sub>, or with deaerated water.

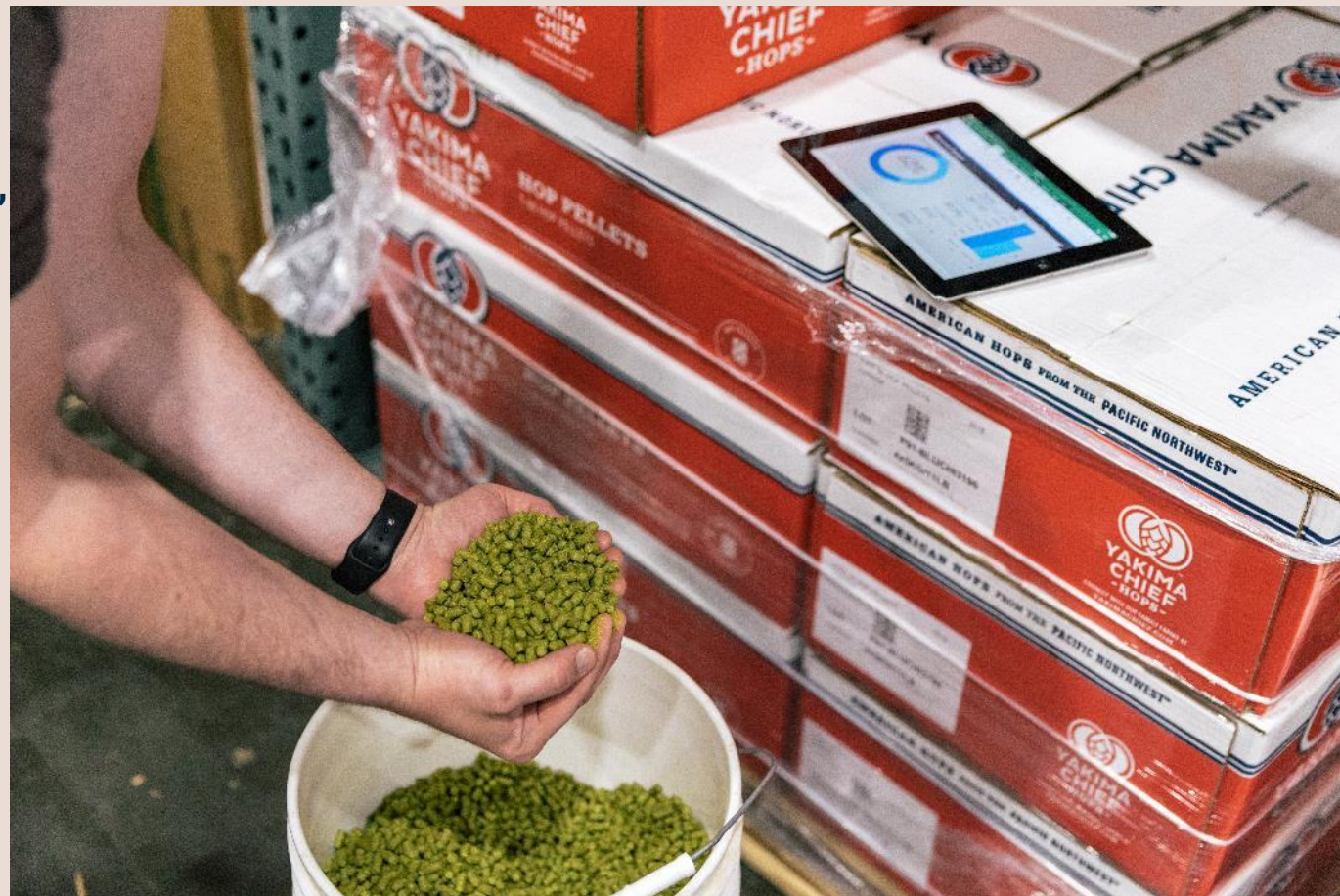


### Standard sizes (maximum hop pellets quantity)

4 kg Glass   10 kg   25 kg   50 kg   100 kg

## DRY HOPPING RATES

- Best method is unit of weight per volume of beer
- Adding more hops, can mean adding more vegetal matter, and decreasing your final beer yield
  - Cryo Hop pellets- 50% usage rate of a T-90 pellet
- 1 to 5 lbs/bbl → 0.4 to 2 kg/hl → 3.9 to 19.5 g/l
- Will vary by style:
  - Popular American beer styles:
    - Pale Ale-
    - Traditional IPA-
    - Traditional Imperial IPA-
    - Hazy IPA or “New England Style IPA-



## DRY HOPPING RATES AND AROMA EXTRACTION

- There will be a point of “diminishing returns”
  - Dry Hop rates of 2-12 g/L have been claimed to be the best spot for hop aroma extraction.
  - A point can be reached where more hops doesn’t equal more aroma impact
  - This will vary by variety and oil contents of the hops being used.
- Dry hop residence time should be 3 days or less in the fermentation tank. Longer hop exposure in the beer will not result in more aroma present.

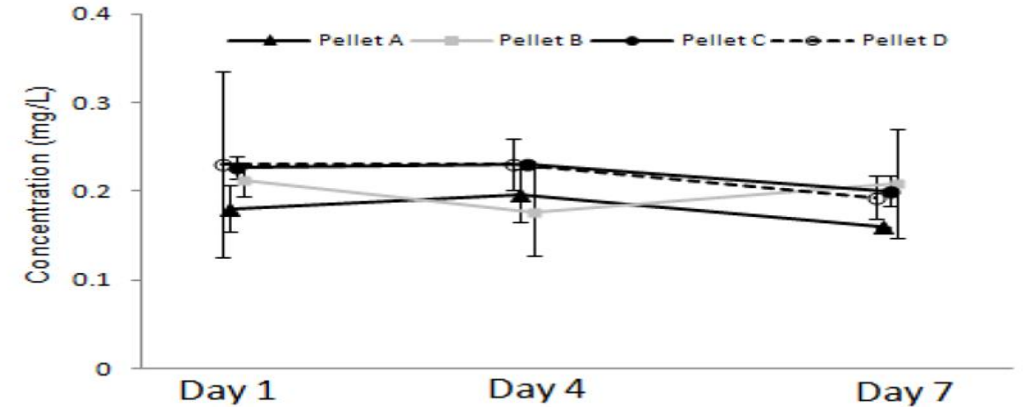


Figure 5. Average linalool concentration at Days 1, 4, and 7.

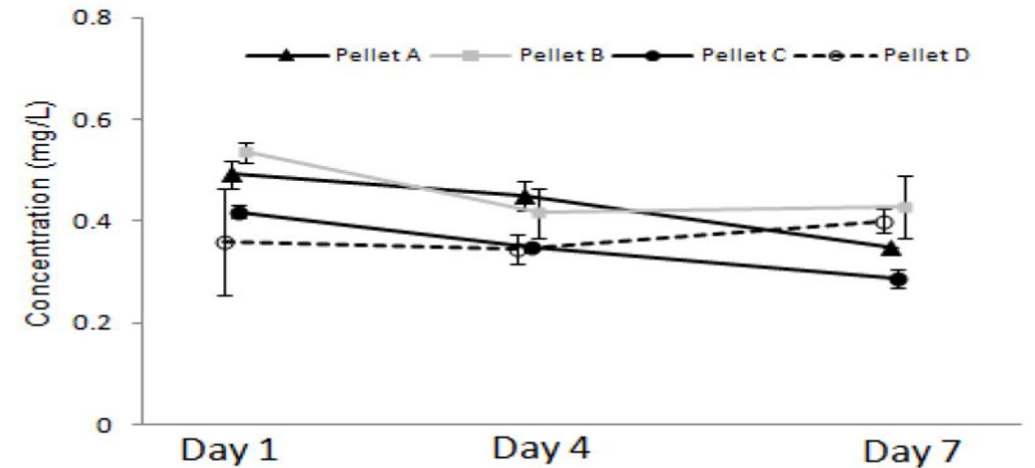


Figure 6. Average myrcene concentration at Days 1, 4, and 7.

1. Wolfe, Peter H.; Thesis: “A Study of Factors Affecting the Extraction of Flavor When Dry Hopping,” pgs 51-51.

# DRY HOPPING AND AROMA EXTRACTION – SHORT TERM DRY HOP

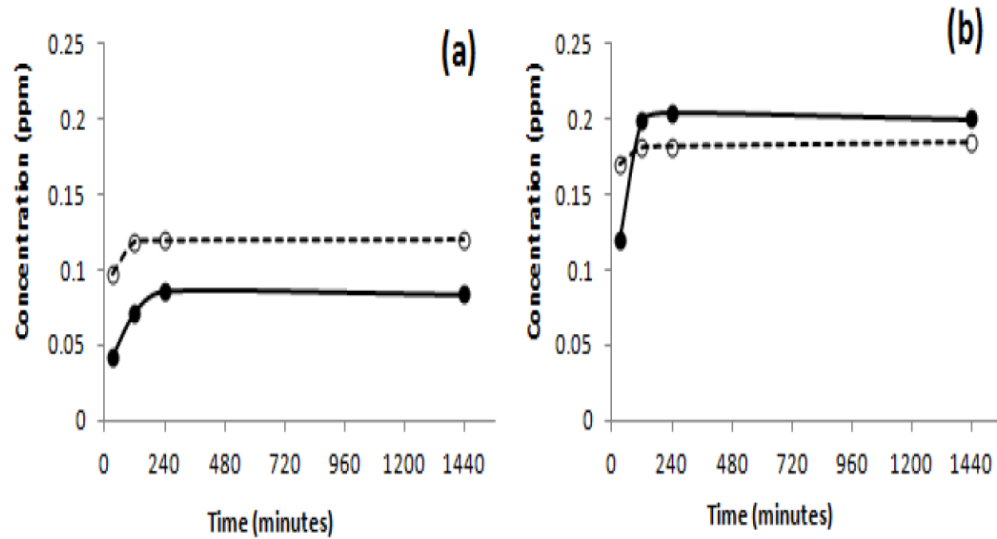


Figure 7. Myrcene (a) and humulene (b) concentrations during a 24 hour dry hop treatment with pellets (---○---) or whole cone hops (—●—).

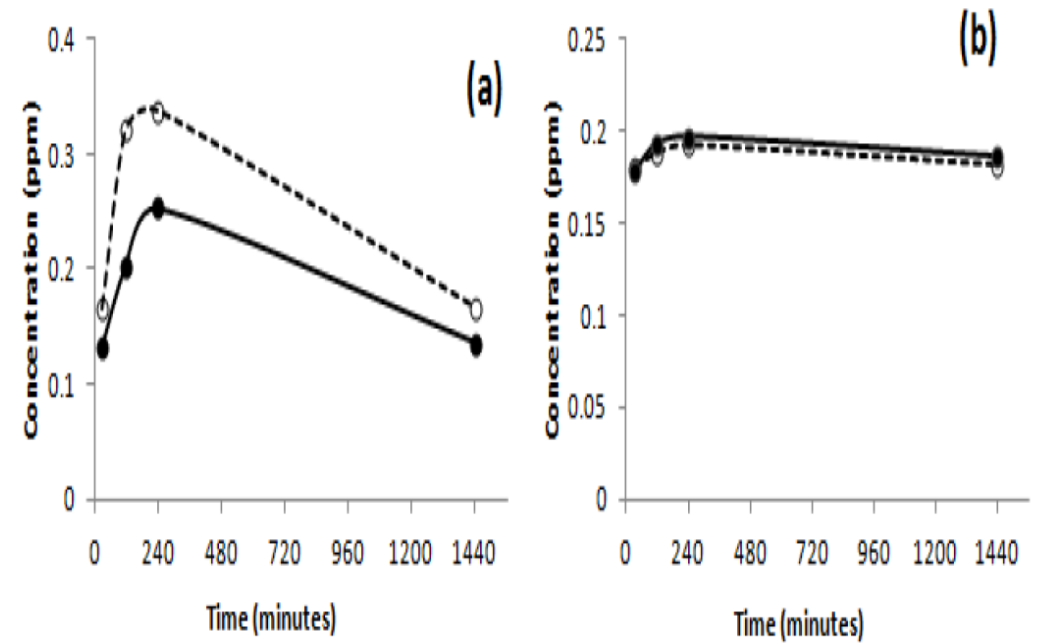


Figure 8. Linalool (a) and geraniol (b) concentrations during a 24 hour dry hop treatment with pellets (---○---) or whole cone hops (—●—).

# CONSIDERATIONS FOR AGITATION – CO2 ONLY

## Positives

- Gently agitating with CO2 has been known to shorten dry hop time
- Relatively cheap and easy to set up
- Increases extraction of desired hop aroma
- Maximize both hydrocarbon & monoterpene alcohol extraction in a shortened duration

## Negatives

- Possible over extraction of undesirable hop compounds creating hop astringency and unwanted perceived bitterness
- Possibly negative impact of CO2 interacting with yeast in suspension



# CONSIDERATIONS FOR AGITATION – RECIRCULATING W/ PUMP

## Positives

- Recirculating with a pump has been known to shorten dry hop time
- Increases extraction of desired hop aroma
- Maximize both hydrocarbon & monoterpene alcohol extraction in a shortened duration

## Negatives

- Possible over extraction of undesirable hop compounds creating hop astringency and unwanted perceived bitterness
- Increased polyphenol levels from over extraction
- Dedicated pump and related equipment for recirculating
- Pump selection is important to minimize shearing of hops and to minimize dissolved oxygen pickup.



## TANK VOLUME & GEOMETRY

- Tank volume and geometry can have a direct effect on the efficiency of dry hop extraction.
- Not all fermenters are created equal
- Scaling up your dry hop from a 20 bbl fermentor to a 100 bbl fermentor might not be as easy as just multiplying by 5.
- Trial and error to determine best dry hop approach when it comes to tank design.







# HOP CREEP

# HOP CREEP

- Colloquially known as “hop creep”, refermentation is a secondary fermentation induced by dry-hopping beer
- Hop creep has become a major issue at some breweries with the advent of high dry hop dosing rates
- At least 4 enzymes present in hops will affect refermentation after dry-hopping-  $\alpha$ -amylase,  $\beta$ -amylase, amyloglucosidase, and limit dextrinase<sup>8</sup>
- While the enzymes present in hot-side hop additions will generally be denatured during the brewing process, dry-hopping reintroduces enzymes at temperatures that will not denature the enzymes
- These enzymes start breaking down previously unfermentable portions of wort



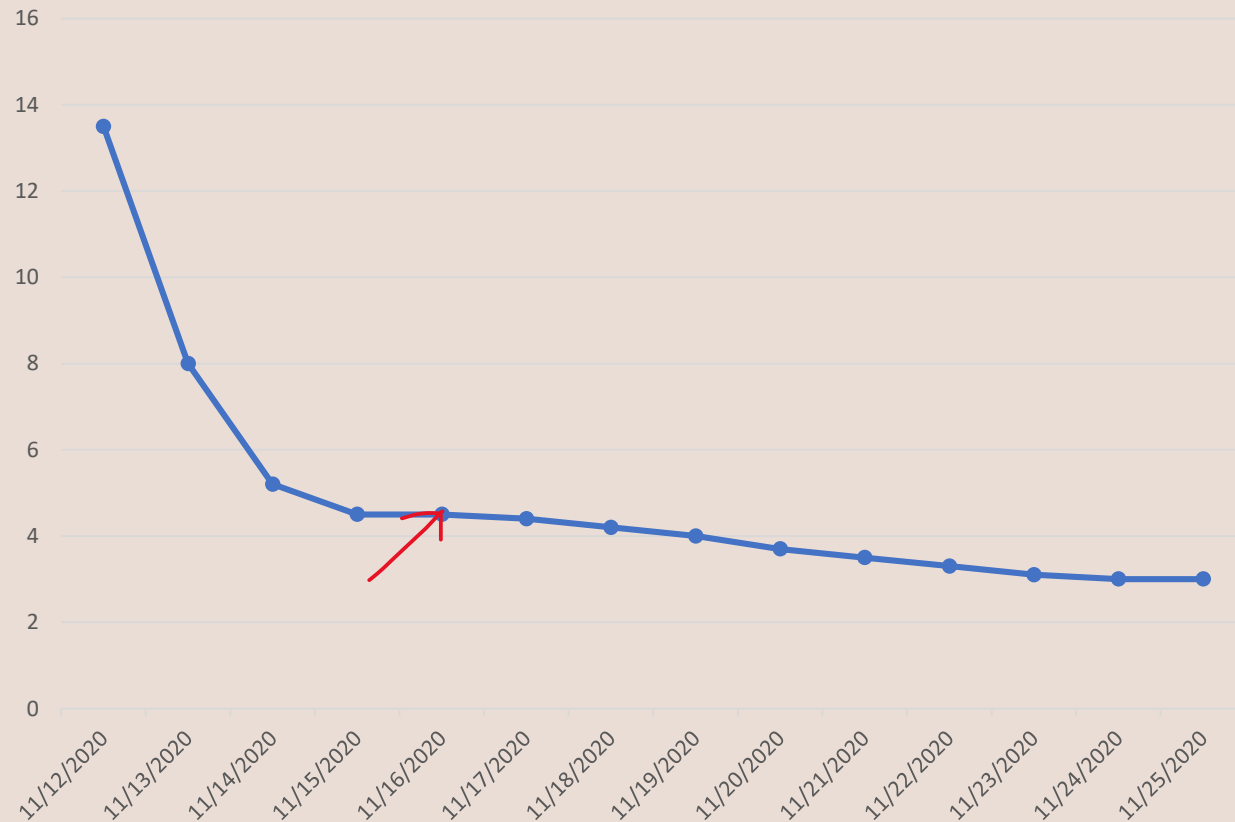
# HOP CREEP – WHEN DOES IT HAPPEN?

- Hop Creep is a secondary fermentation that is induced by dry hopping a beer because gravity readings will “creep” lower over time

Date	Gravity Reading, P
11/12/2020	13.5
11/13/2020	8.0
11/14/2020	5.2
11/15/2020	4.5
11/16/2020	4.5
11/17/2020	4.4
11/18/2020	4.2
11/19/2020	4.0
11/20/2020	3.7
11/21/2020	3.5
11/22/2020	3.3
11/23/2020	3.1
11/24/2020	3.0
11/25/2020	3.0

← DH

Hop Creep During Dry Hopping



# MITIGATING HOP CREEP

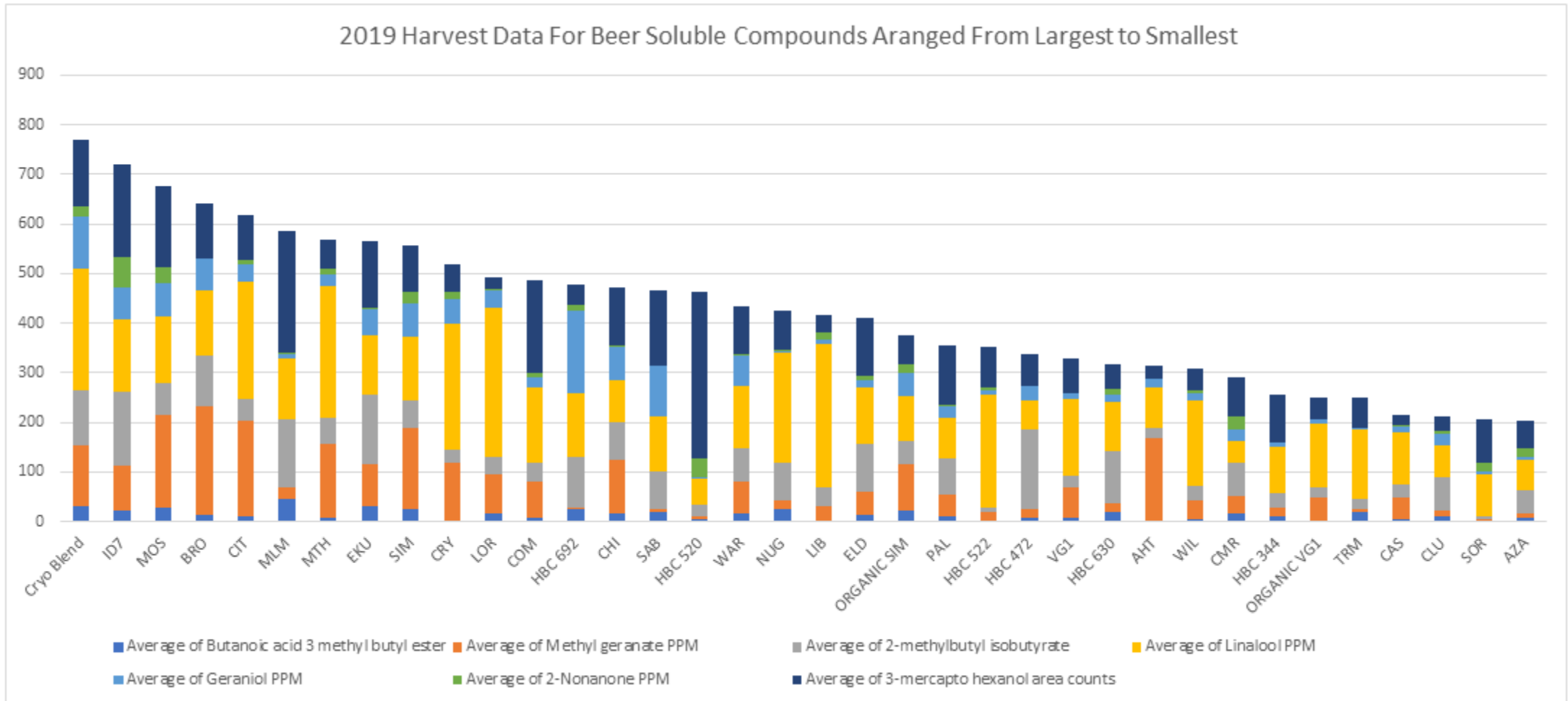
- **Wort composition considerations**
- **Increase Dry Hop Temperature**
- **Filter or Pasteurize Finished Beer**
- **Reduce Dry Hop Levels**
- **Cold Store Beer**
- **Dry Hop Earlier**





# **DRY HOP VARIETAL SELECTION**

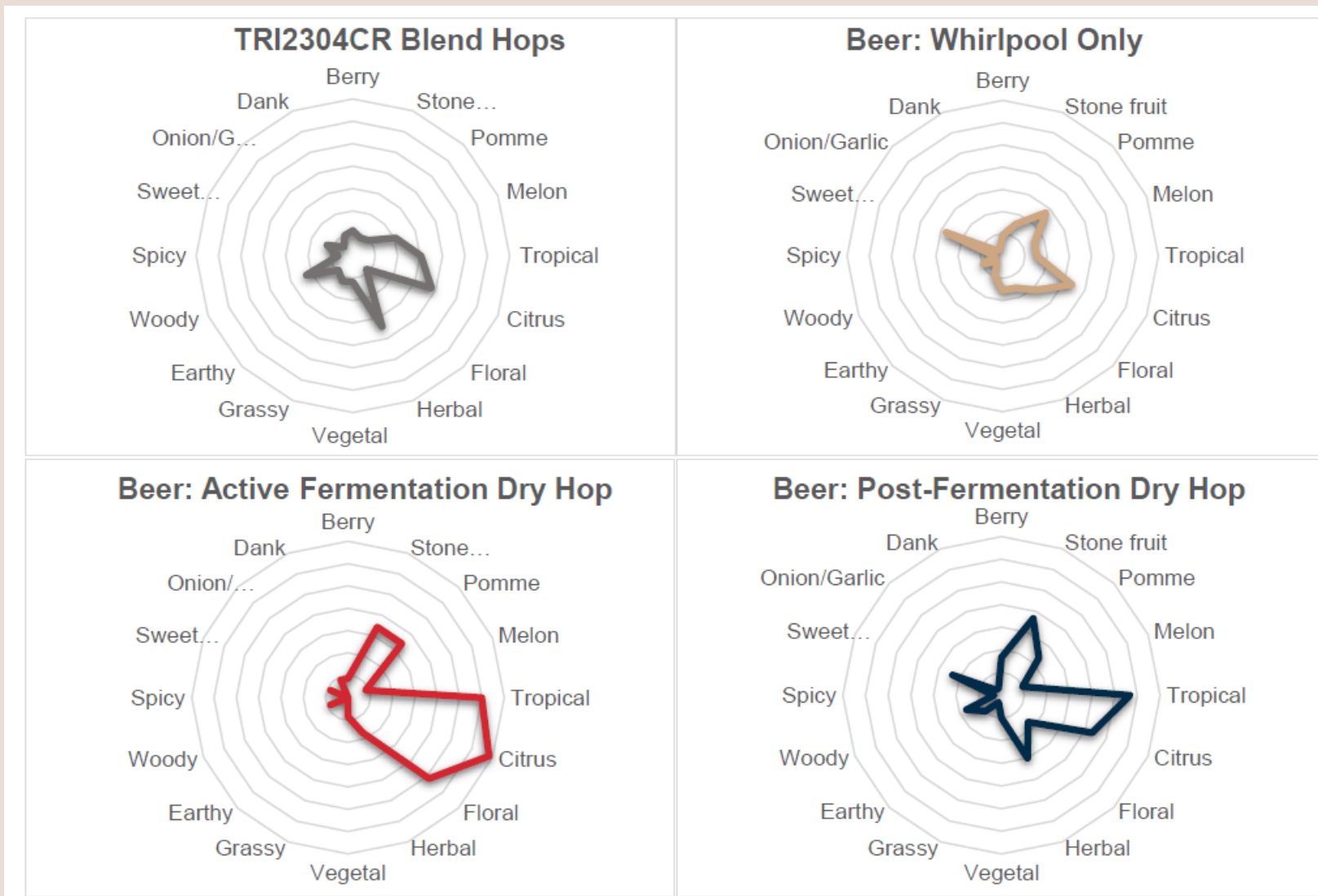
# “SURVIVABLES”



# DRY HOP TIMING

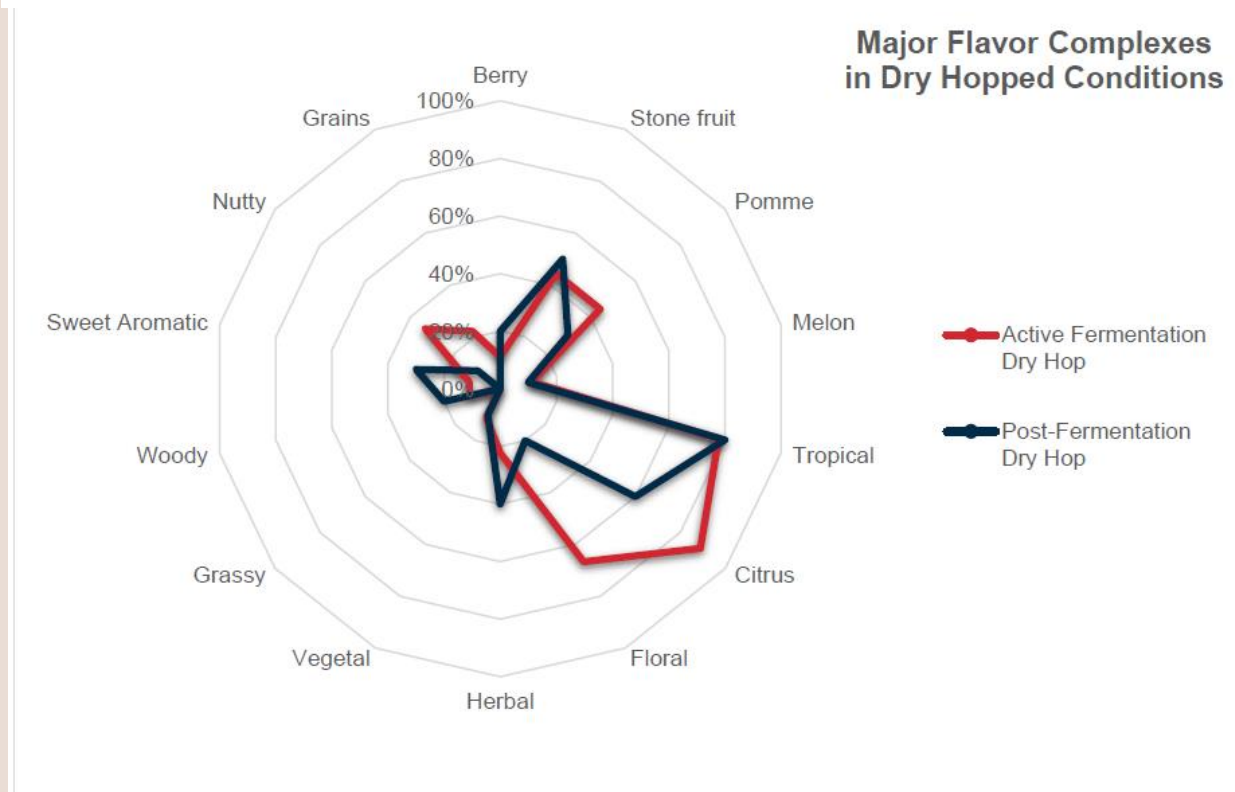
## ADDITION TIMING EFFECTS

- RETENTION OF OIL COMPONENTS
- BIOTRANSFORMATION
- ENHANCE/ DIMINISH CERTAIN FLAVORS



# DRY HOP TIMING

Dry Hop Method	Pre-DH Linalool (ppb)	Final Beer Linalool (ppb)	Pre-DH Geraniol (ppb)	Final Beer Geraniol (ppb)	Pre-DH Methyl Geranate (ppb)	Final Beer Methyl Geranate (ppb)	Wort 3MH (area count)	Final Beer 3MH (area count)
WP Only	252.6*	205.1	341.1*	145.6	113.7*	107.4	2.8e7	9.1e5
AFDH	349.1*	346.6	534.2*	232.6	121.3*	113.3	2.5e7	6.9e6
PFDH	288.0	526.1	219.1.2	589.6	113.8	121.7	N/A**	2.0e7





# DRY HOP TIMING

## WHIRLPOOL

1. Lemon
2. Apple
3. Grapefruit
4. Rose
5. Sweet Cream



## MID-FERM DRY HOP

1. Grapefruit
2. Orange
3. Peach
4. Mango
5. Apple

## POST-FERM DRY HOP

1. Peach
2. Banana
3. Mango
4. Orange
5. Passionfruit



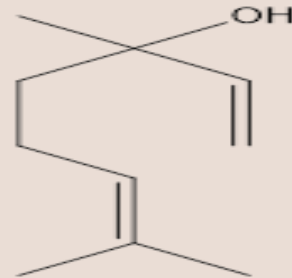
# BIOTRANSFORMATION

## BREWER'S DEFINITION

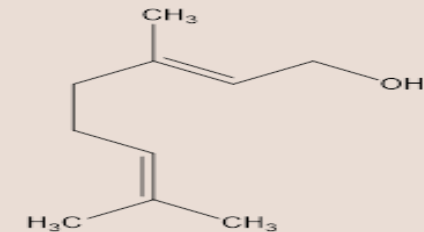
- "...the interaction of a hop compound and a *Saccharomyces* spp., which leads to a new aromatic compound through an enzymatic reaction (hydrolysis)"<sup>10</sup>

## GOALS

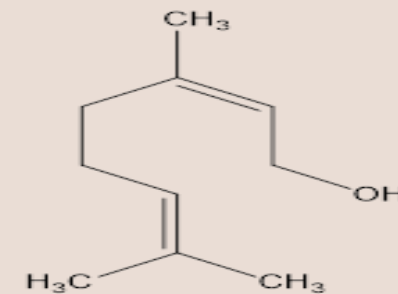
- **CONVERSION OF CERTAIN COMPOUNDS**
  - 3MH, GERANIOL, ETC.
- **ENHANCEMENT OF SYNERGIES**
  - EX. LEMON/LIME FLAVOR OF LINALOOL+  $\beta$ -CITRONELLOL+ GERANIOL



LINALOOL



GERANIOL

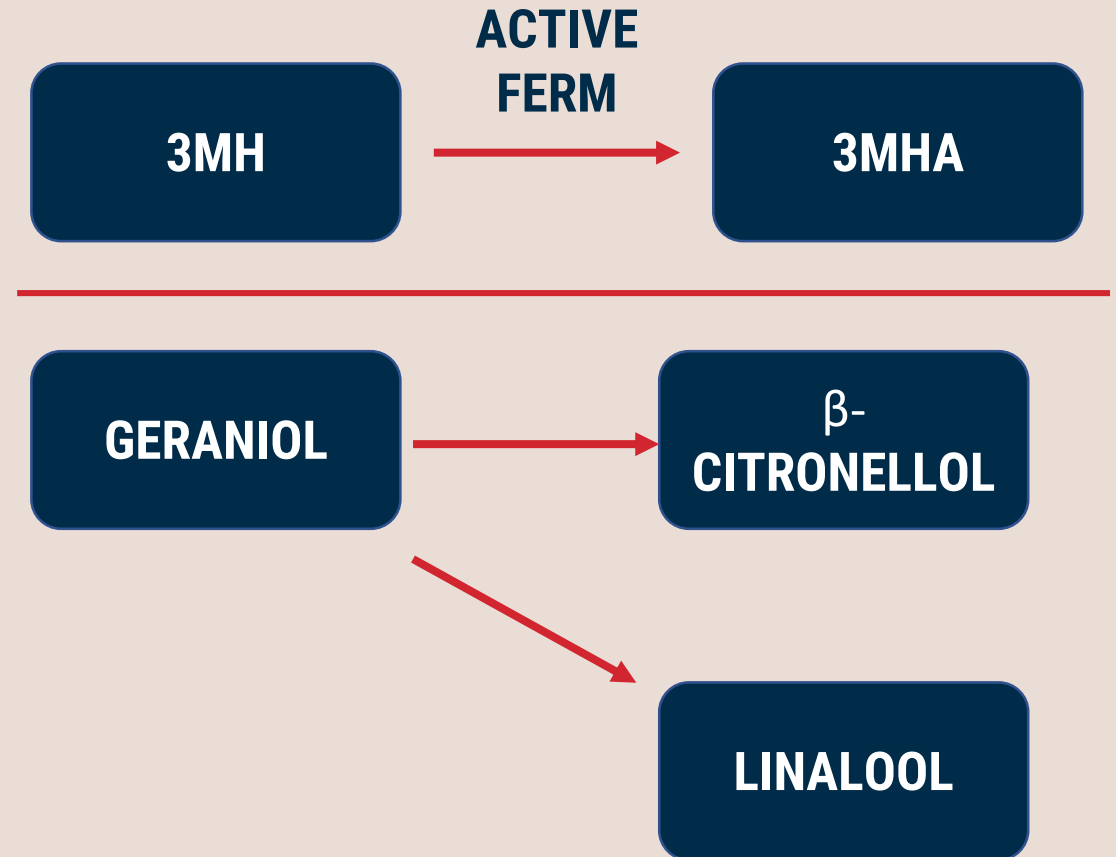


NEROL

# BIOTRANSFORMATION

## CONSIDERATIONS

- “DIFFERENT,” NOT ALWAYS “BETTER THAN”
- VARIETAL SELECTION
  - HIGH LEVELS OF MONOTERPENE ALCOHOLS, THIOLS, ESTERS
- YEAST HANDLING
  - CAN CREATE CHALLENGES
- SAFETY
  - BEWARE OF DH GUSHERS



# DH BEST PRACTICES

## CONTACT TIME

- **LESS IS MORE**

## TEMPERATURE

- **WARMER= FASTER EXTRACTION**
- **COLDER= POTENTIAL FOR DOWNSTREAM CREEP ISSUES**

## AGITATION

- **PROVIDE GENTLE AGITATION FOR MAXIMUM CONTACT**



# DH BEST PRACTICES

## VARIETAL SELECTION

- **FOCUS ON COMPONENT RETENTION**
- **HIGH MONOTERPENES FOR EARLY DH**
- **BLEND FOR DIVERSE FLAVORS**
- **DON'T FOCUS ON SESQUITERPENES**
  - **“IF IT ENDS IN -ENE, IT WILL NOT MAKE THE SCENE”**
    - **-PATRICK JENSEN, YAKIMA CHIEF TECHNICAL MANAGER**

## EFFICIENCY

- **CONSIDER CRYO HOPS®**



# KNOW THE ENEMY: O<sub>2</sub>

## OXYGEN'S EFFECTS ON AROMA

- **HIGHER DISSOLVED OXYGEN AT TIME OF PACKAGING HAS NEGATIVE EFFECTS ON PERCEPTION OF HOPPY AROMATIC CHARACTERISTICS**
- “Sensory descriptor frequency suggests that as a sample aged, there was a noticeable decrease in hoppy, fruity, and citrus character, and consequently, a greater expression of malty, dried fruit, and cardboard characters”

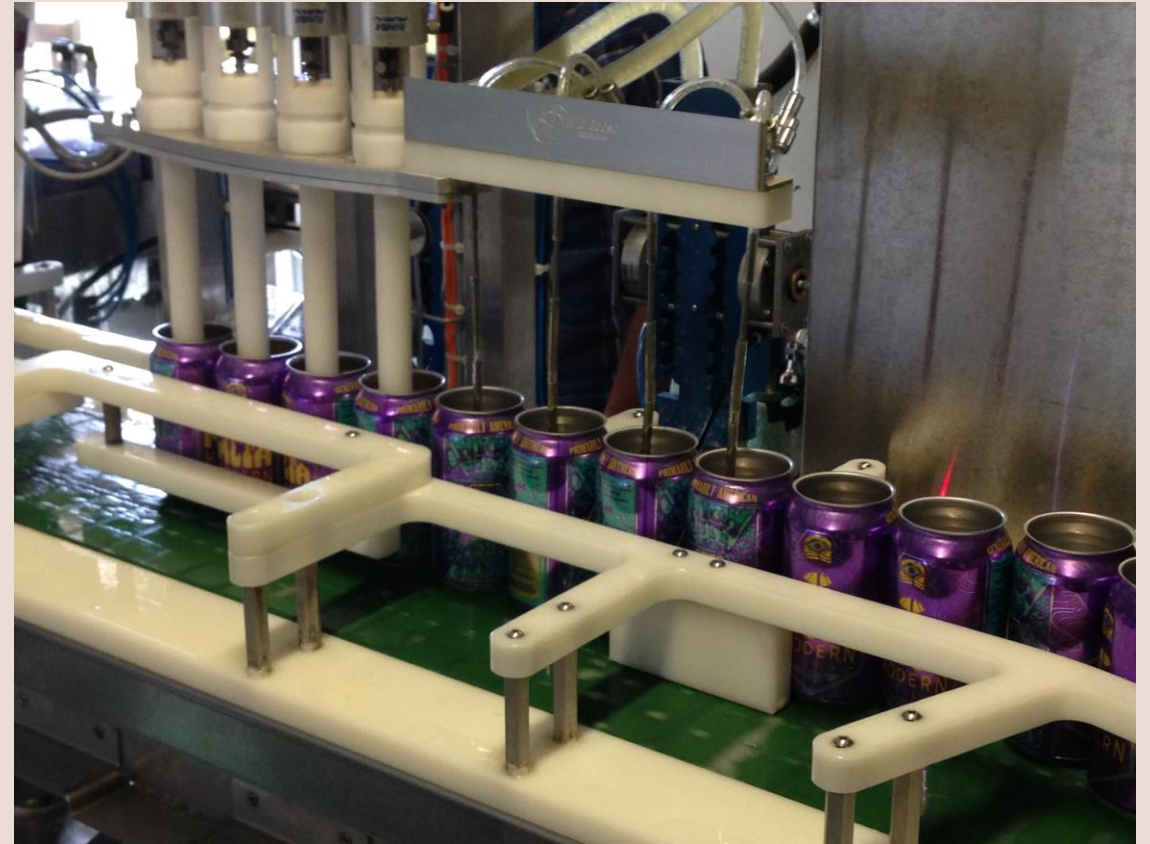
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# KNOW THE ENEMY: O<sub>2</sub>

## MITIGATING OXYGEN'S EFFECTS

- **DURING DRY HOP**
  - **LIMIT TIME OF EXPOSURE**
  - **CO2 BLANKET**
- **AGITATION**
  - **BE MINDFUL OF PUMP SEALS AND O2 POCKETS**
  - **CONSIDER "BUBBLING"**
- **PACKAGING CONSIDERATIONS**
  - **MONITOR DO BEFORE AND AFTER PACKAGING**
- **POST-PACKAGE**
  - **NO SUBSTITUTE FOR COLD STORAGE**



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**THANK YOU!**

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