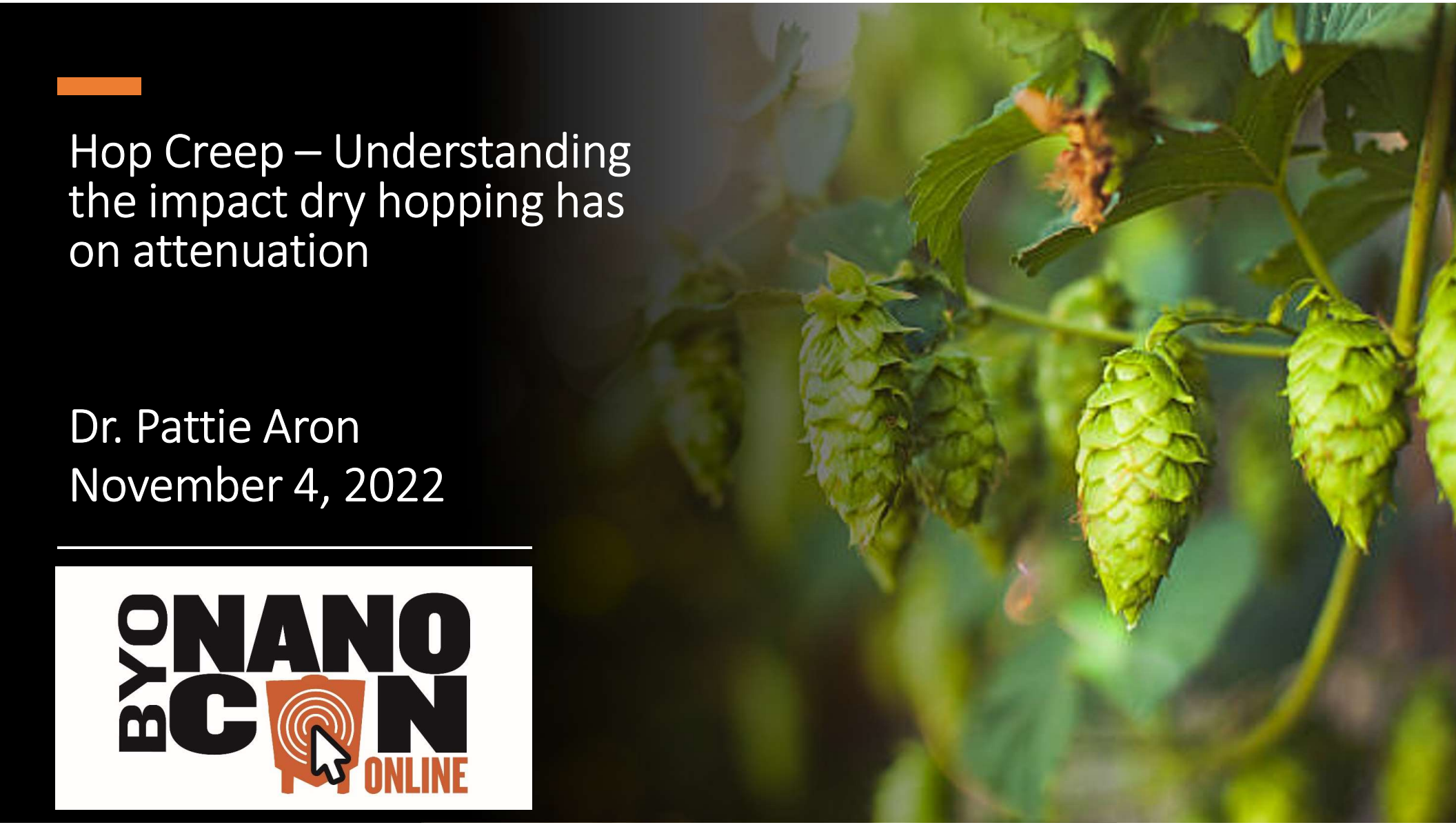
Hop Creep – Understanding the impact dry hopping has on attenuation

Dr. Pattie Aron

November 4, 2022

BYO NANO CON ONLINE



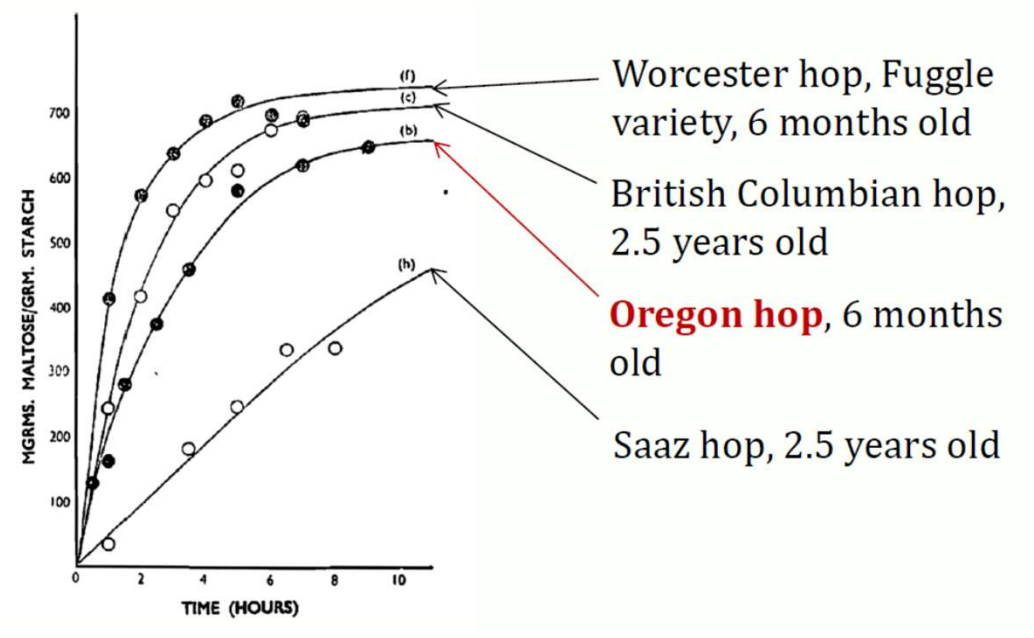
History of Hop Creep – 130 Years

1893 – Brown and Morris, The Brewers Guardian, maltase activity evidenced in dry hopped cask ales.

1941 – Janicki, Kotasthane, Parker and Walker: ‘The diastatic activity of hops together with a note on maltase in hops’

Mid – 2010’s – Hazy, highly dry hopped beers increase in popularity – Hop Creep Creepin up.

2016 - Allagash Brewing—The brewery dumped its first 60-barrel test batch of Hoppy Table Beer with a target carbonation of 2.6 volumes when it reached 4.5 volumes in three weeks….



Journal of the Institute of Brewing 47, no 1 (1941); 24-26.

1893 Brown and Morris

'On Certain Functions of Hops Used in the Dry Hopping of Beers'

The addition of hops to cask beers had been widely practiced, however the distinct conditioning or 'freshening power' of the hops was not well understood.

Dry hopped beer entered into a brisk 'after fermentation'

<u>Postulated three potential causes</u>:

1. Hops Contain Fermentable Sugar,
2. Wild Yeast Consume Dextrins,
3. Hops Contain Diastatic enzymes.

Brown and Morris Findings, 1893

Under the right conditions – hops can produce up to 91% of their own weight of fermentable sugar.

Evidence that both hops and hop seeds contain diastase.

2017 - Hop Creep and the over-attenuation of dry hopped beer.

“Shellhammer, Bodah, and Allagash Brewmaster Jason Perkins told the story at CBC in 2017. When their presentation, “Unintended Over-Attenuation from Dry Hopping Beers,” was complete, the second brewer to ask a question began, “We are all slaves to the creep.”

The phenomenon has been called hop creep from that day forward, “creep” referring to an ongoing and slow reduction in final gravity. (There is not a single word to describe this reduction in German, so German brewers also call this “hop creep.”)”

Brewing with Hops: Don’t Be Creeped Out
Stan Hieronymus explains the creeping phenomenon of dry-hopped beers that seem to have minds of their own—and ways to keep them under control.
STAN HIERONYMUS Oct 19, 2020
https://beerandbrewing.com/brewing-with-hops-dont-be-creeped-out/

What creeps?

Alcohol – leading to a drier than desired beer, higher than anticipated ABV

CO_2 – increased volumes can result in gushers or exploding cans/bottles

Diacetyl – Refermentation can produce spikes

Tank Residency Time – Longer duration

Hop Creep Secondary Fermentation Traits

TABLE 1: An example of hop creep in a beer that was dry-hopped near the end of active fermentation when the apparent extract reached 3.5°P (O.G. 14.3°P)

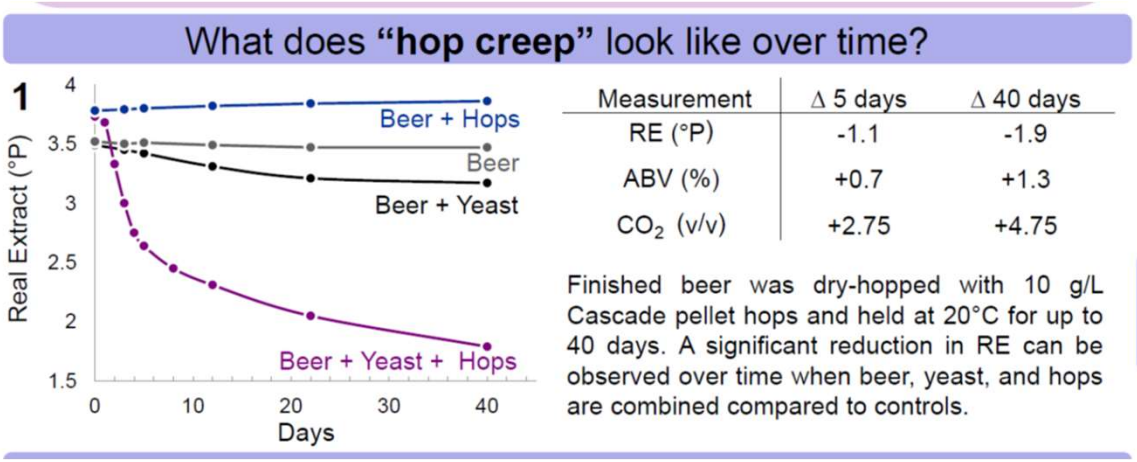
Beer property	Unit	Without dry-hopping*	9 days after dry-hopping	Absolute Difference
Real extract	%w/w (°P)	5.03	4.70	-0.27
Apparent extract	%w/w (°P)	2.75	2.25	-0.50
Real degree of fermentation (RDF)	%	67.36	70.44	+3.08
Apparent degree of fermentation (ADF)	%	81.20	85.02	+3.82
Alcohol	%v/v	6.42	6.92	+0.50
CO_2	volumes			+2.02

*beer chemistry performed on a forced fermentation of the beer without dry-hopping

Arnbjørn Stokholm and Thomas H. Shellhammer
Oregon State University, Corvallis, Oregon

How Does Hop Creep Happen?

- **Unfiltered, highly hopped beers are problematic when three conditions occur simultaneously pre-dryhopping:**
-
  - Unfermentable real extract
  - Active Yeast
  - Hops of high diastase activity used for dry hopping



Kirkpatrick and Shellhammer. Poster 35. 2017 ASBC: Investigating enzymatic power of hops.

Biochemistry of Hop Creep

- **Dextrins + protein + minerals + ash = real extract (RE)**
  - Dextrins survive brewing process to contribute to sweetness, body and mouthfeel.
  - RE resultant from the mashing process remains steady during fermentation unless exogenous enzymes or amylolytic (starch degrading) yeast are present:
    - *Saccharomyces diastaticus*
    - *Brettanomyces*

Int. J. Life. Sci. Scienti. Res., 2(4): 339-354 (ISSN: 2455-1716) Impact Factor 2.4 JULY-2016

Review Article (Open access)

Amylolytic Yeasts: Producers of α-amylase and Pullulanase

Djekrif D. S[1*], Gillmann L[2], Bennamoun L[1], Ait-Kaki A[1], Labbani K[1], Nouadri T[1], Meraihi Z[1]

[1]Research lab in Microbiology Engineering, Faculty of Biology, Biopole Chaab Erssas, University, Constantine, Algeria

[2]SONAS-IUT laboratory, University of Angers, Angers, France

*Address for Correspondence: Djkrif-Dakhmouche Scheherazed, Lecturer, Department of Natural science and Life (Biology), University of Frères Mentouri, Constantine, Algeria

Received: 01 May 2016/Revised: 31 May 2016/Accepted: 22 June 2016

ABSTRACT- Amylases are among the most important enzymes used in various industries. They represent approximately 30% of the world enzyme production. These are of ubiquitous occurrence and hold the maximum market share of enzyme sales. These comprise hydrolases, which hydrolyze starch to diverse products as dextrins, and progressively smaller polymers composed of glucose units. They are highly demanded in various arrays such as food, pharmaceuticals, textiles, detergents, etc. However, enzymes from mold and bacterial source have dominated applications in industrial sectors while few species of yeast were studied for the amylases production. This review focuses on the amylolytic yeasts and their enzymes and we were interested at α- amylase and pullulanase, their distribution, structural-functional aspects, physical and chemical parameters, and the use of these enzymes in industrial applications.

Key-words- Amylolytic yeast, α-amylase, Pullulanase, Industrial application

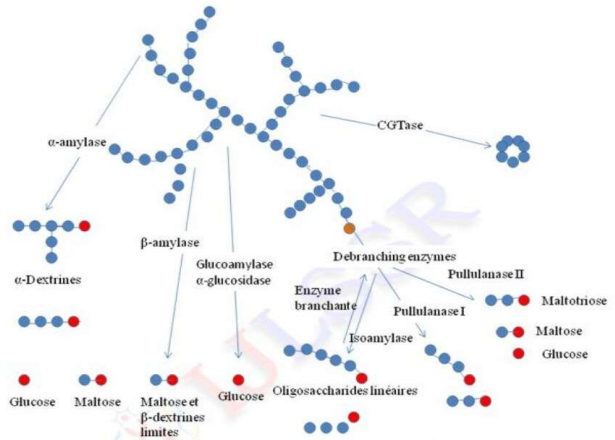


Figure 1: Modes of action of amylolytic enzymes [67]

Biochemistry of Hop Creep

- Hops possess amylolytic enzymes that break down long chain carbohydrates (dextrins) into more readily fermentable units.
  - Amyloglucosidase, α-amylase, β-amylase
  - Typically hop enzymatic activity is mitigated in kettle boil

Cascade hops have broad (low) enzyme activities

Enzyme	Hops	Malt (130 dp)
Amyloglucosidase	0.02	NA
α-amylase	0.25	198
β-amylase	0.49	13
Limit dextrinase	0.25	NA

Werrie, Sylvie Deckers & Marie-Laure Fauconnier (2021)

Figure 1. HPLC-ELSD beer sugar chromatogram after 14 days of dry-hopping.

The red line represents beer in the presence of hop, the green line represents beer in the presence of hop and yeast and the blue line represents beer in the presence of yeast.

Journal of the American Society of Brewing Chemists
The Science of Beer

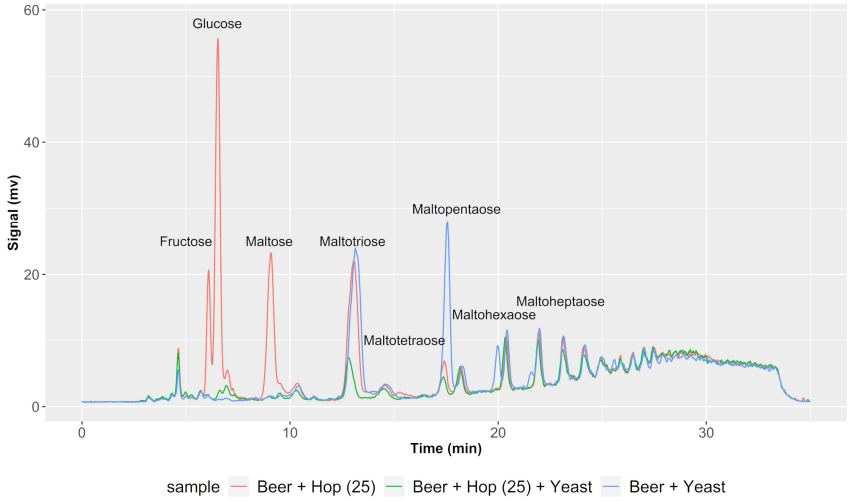
ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/ujbc20

Brief Insight into the Underestimated Role of Hop Amylases on Beer Aroma Profiles

Pierre-Yves Werrie, Sylvie Deckers & Marie-Laure Fauconnier

To cite this article: Pierre-Yves Werrie, Sylvie Deckers & Marie-Laure Fauconnier (2021): Brief Insight into the Underestimated Role of Hop Amylases on Beer Aroma Profiles, Journal of the American Society of Brewing Chemists, DOI: 10.1080/03610470.2021.1937453

To link to this article: https://doi.org/10.1080/03610470.2021.1937453



Hop Creep Factors

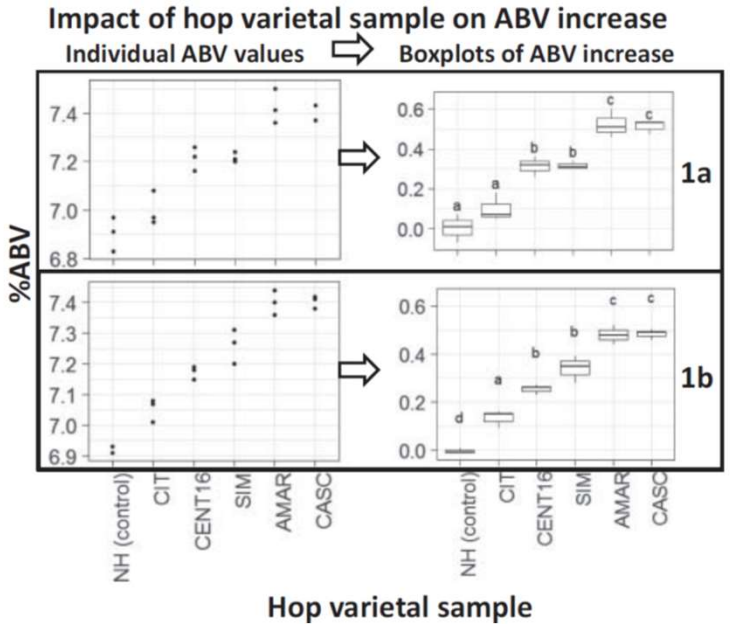
- Varietal variance in enzymatic activity
- Harvest Maturity
- Agricultural practice
- Post harvest processing
  - Kiln temperature
- Dry hopped high RE beers tend to creep more
- Hop load
- Dry hop timing
- Dry hop Temperature

VARIETAL IMPACT

Werrie, Sylvie Deckers & Marie-Laure Fauconnier (2021)

Table 2. Mean amylase activity of Strisselspalt used for the dry-hopping ($n = 3$) and genetically close related variety* from similar protocol work.[16]

Hop variety	α-Amylase (U/g)	β-Amylase (U/g)
Strisselspalt whole hop	0.13 ± 0.01	0.25 ± 0.03
Saazer*	0.12	0.21
Hersbrucker*	0.10	0.19
Hallertau*	0.08	0.17



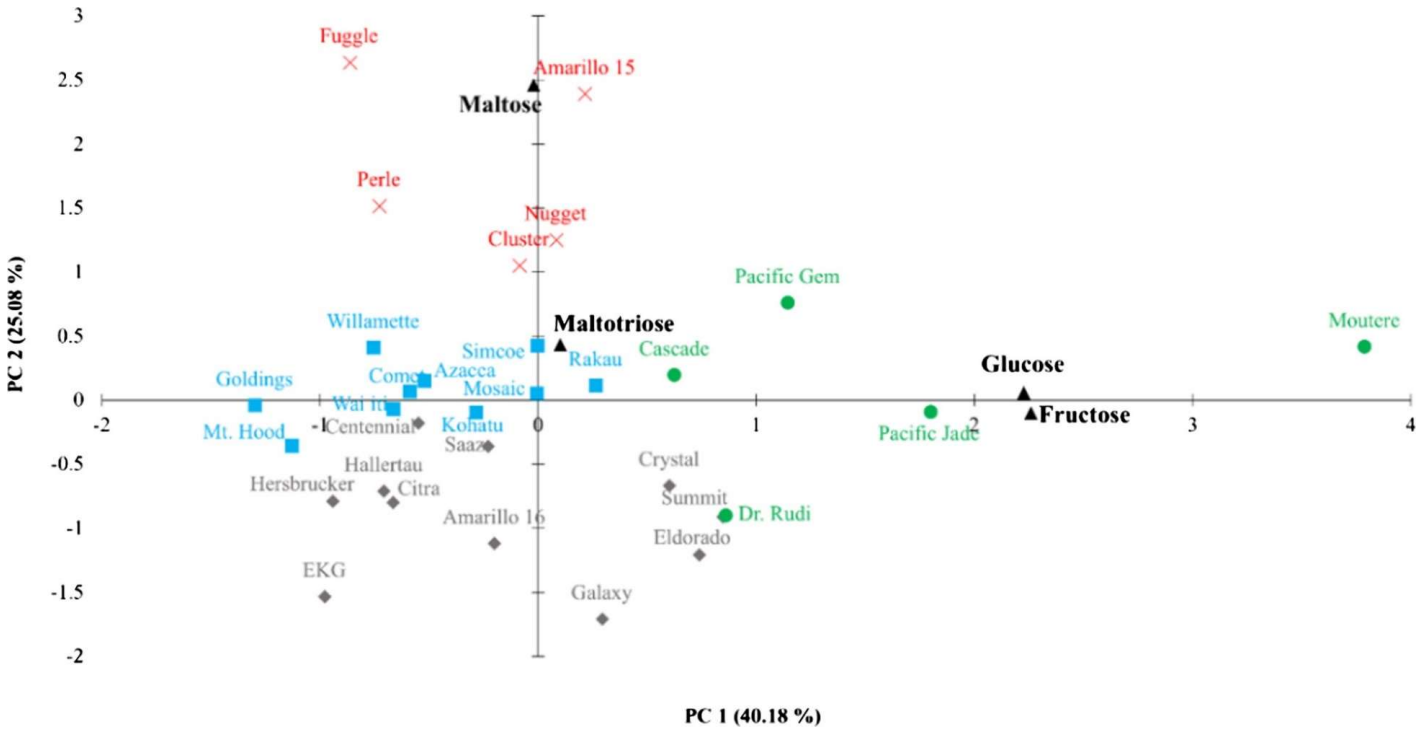


Figure 4. Principle component analysis (PC 1: maltose vs. PC 3: maltotriose) of percentage change in simple carbohydrate concentration as a result of dry-hopping beer for one day. Cultivars are grouped by agglomerative hierarchical clustering.

30 hop cultivars tested:

High: Amarillo (2015 crop), Cluster, Fuggle, Nugget, Perle

Moderate: Azacca, Cascade, Comet, Dr. Rudi, Golding, Kohatu, Mosaic, Mt. Hood, Moutere, Pacific Gem, Pacific Jade, Rakau, Simcoe, Wai-ti, Willamette

Low: Amarillo (2016 crop), Centennial, Citra, Crystal, East Kent Golding, El Dorado, Galaxy, Hersbrucker, Saazer, Summit

*one lot of Amarillo included is high in enzymatic power and one is low

Kirkpatrick and Shellhammer – investigating enzymatic poser of hops,P35, 2017 ASBC

HOP CREEP and KILN TEMPERATURE

- Lindsey N. Rubottom, Scott R. Lafontaine, Dean G. Hauser, Cliff Pereira, Thomas H. Shellhammer. (2021) Hop Kilning Temperature Sensitivity of Dextrin-Reducing Enzymes in Hops. *Journal of the American Society of Brewing Chemists* 0:0, pages 1-13.

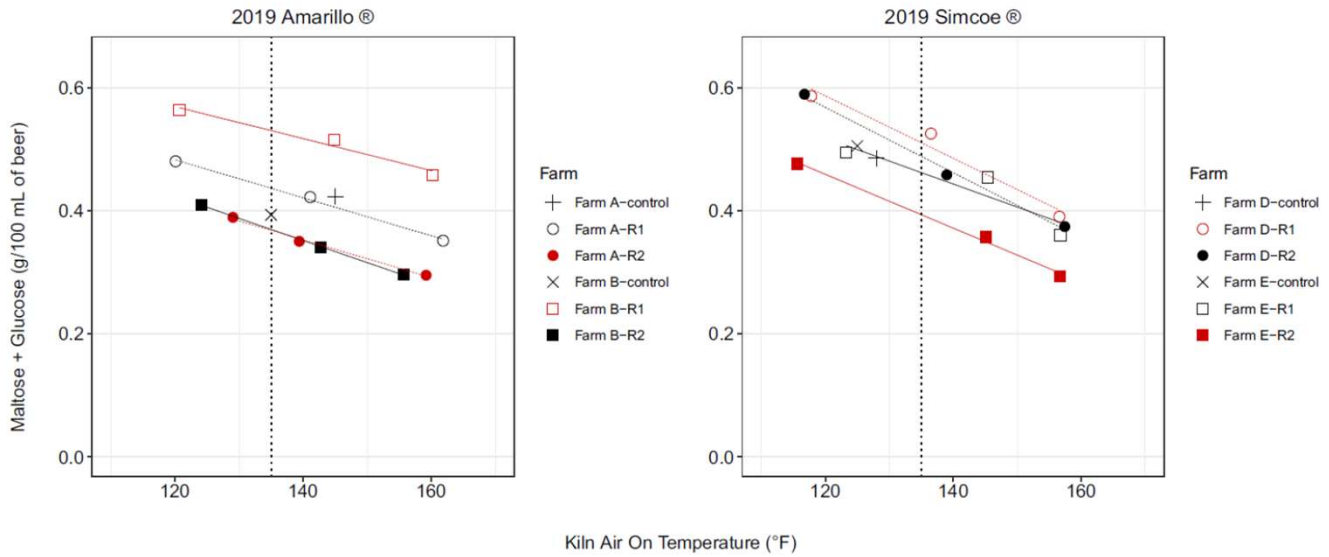


Figure 2. The effect of temperature on the dextrin-reducing capabilities of hops for two major aroma varieties: Amarillo® (left) and Simcoe® (right) for the 2019 harvest year. Enzyme activity was expressed as grams of maltose and glucose produced in a 48 h period when dry-hopping (10 g/L) a standard beer at 86 °F (30 °C), in the presence of a strong antimicrobial agent. The vertical dotted line pertains to estimates of kilning at 135 °F (57 °C). Symbols/lines in red represent the samples/treatments used in pilot scale brewing evaluations.

HOP CREEP and FLAVOR

- Pierre-Yves Werrie, Sylvie Deckers, Marie-Laure Fauconnier. (2021) Brief Insight into the Underestimated Role of Hop Amylases on Beer Aroma Profiles. *Journal of the American Society of Brewing Chemists* 0:0, pages 1-9.

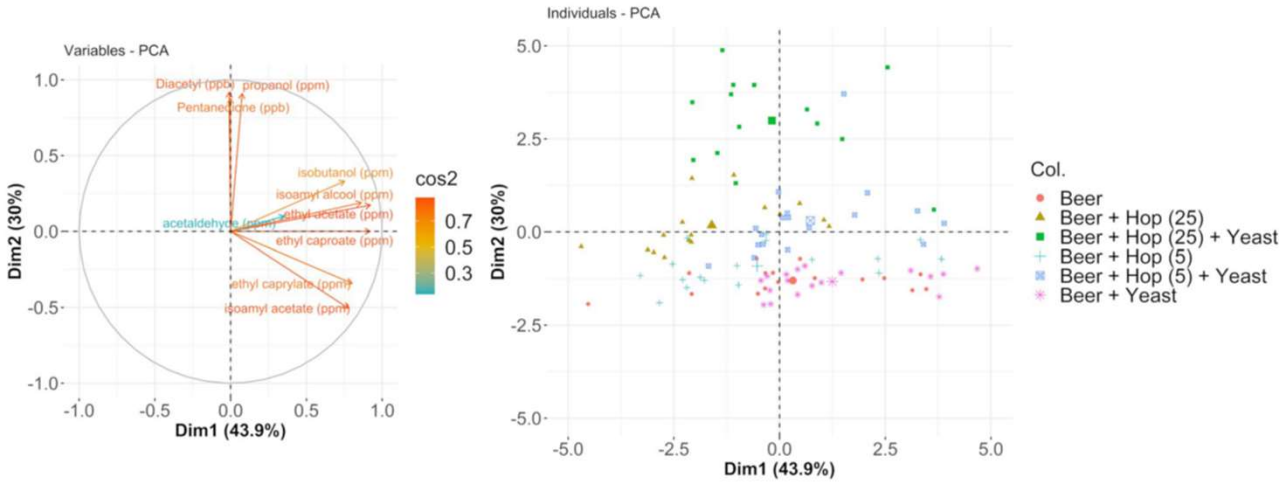


Figure 5. First two dimensions of correlation matrix principal component analysis (PCA) of yeast aroma products where (a) plot of variable contribution to component represents by arrows length. (b) plot of individuals colored by treatment were dot size represent the quality of representation for a given observation. (Color figure available online.)

The metabolism of carbohydrates by yeast in a nitrogen deprived environment led to vicinal diketone formation (both diacetyl and pentanedione) above their threshold value, after three days of dry hopping.

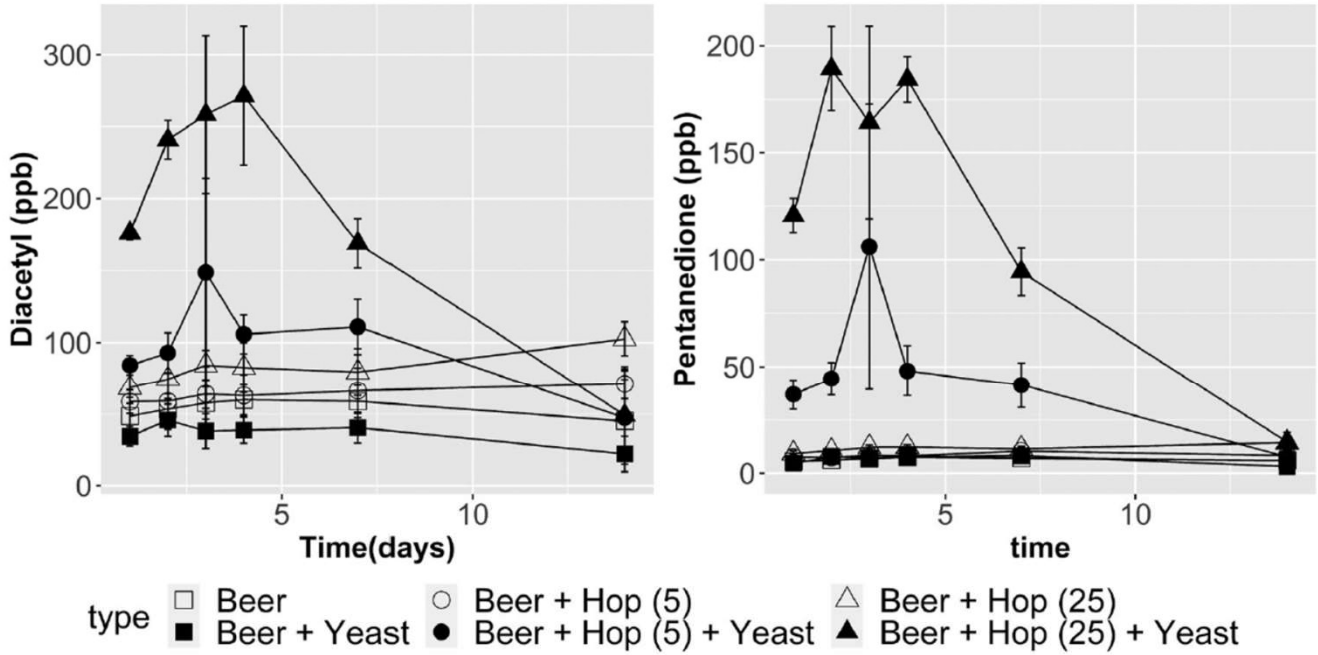
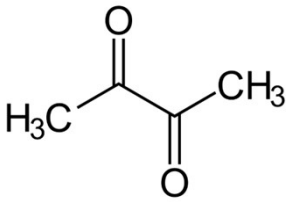


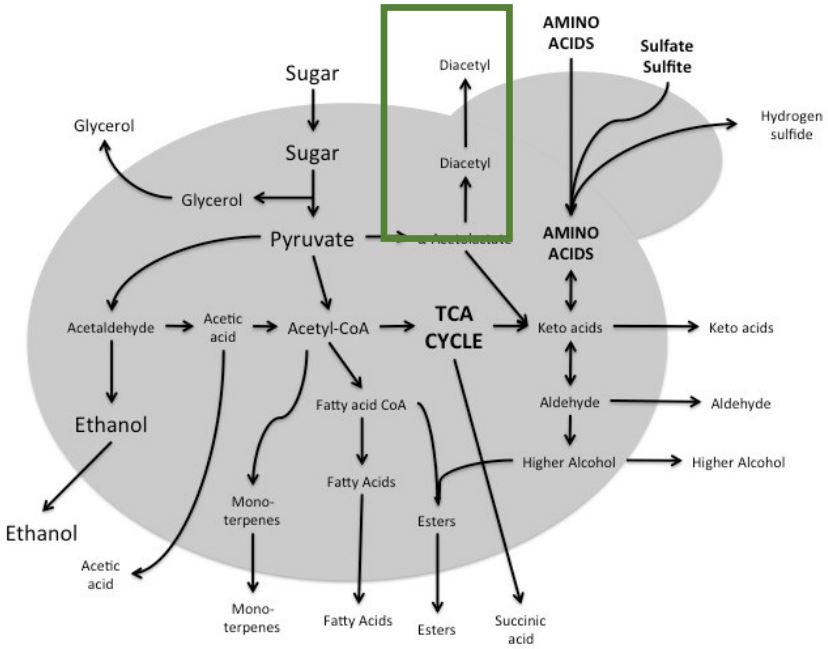
Figure 4. Vicinal diketone (diacetyl on the left and pentanedione on the right) production during dry-hopping. Beer alone (□), Beer with yeast (■), Beer with 5 g/L hop (○), Beer with 5 g/L hop and yeast (●), Beer with 25 g/L hop (△), Beer with 25 g/L hop and yeast (▲).

Werrie, Sylvie Deckers & Marie-Laure Fauconnier (2021)

Diacetyl (2,3 –butanedione) – VDK

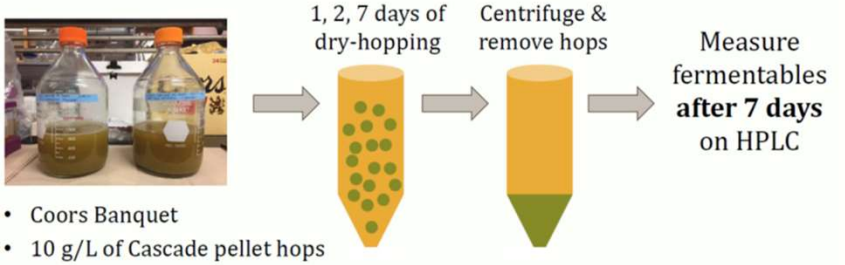
- Aroma: Artificial Butter
- Threshold: 0.15 mg/L
- Natural in early fermentation
  - Intermediate produced in the biosynthesis of amino acid Valine by yeast…
  - Undergoes oxidative decarboxylation to diketone – Chemical Reaction (requires oxygen)
  - Reduced inside the yeast cell to acetoin and butanediol.





EFFECT OF DRY HOP TIME AND TEMPERATURE

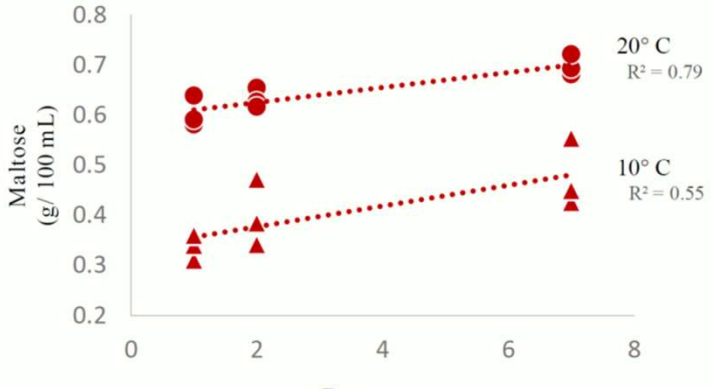
Dry-hopping time/temp: hop removal at 1, 2, and 7 days



- Coors Banquet
- 10 g/L of Cascade pellet hops
- 0.02% sodium azide (antimicrobial)
- **Incubate at 10 & 20° C**

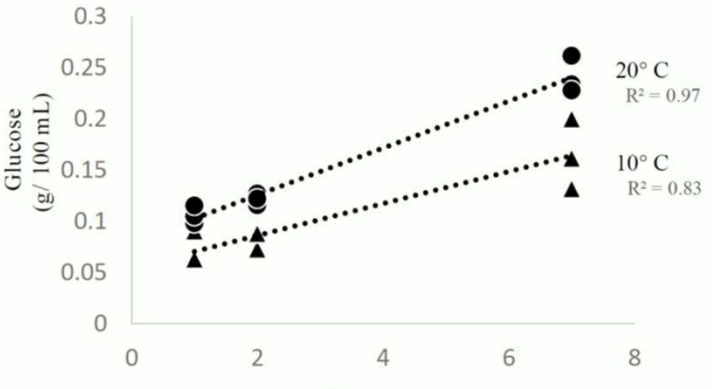
Oregon State University

Contact time & temperature effect: Maltose concentration



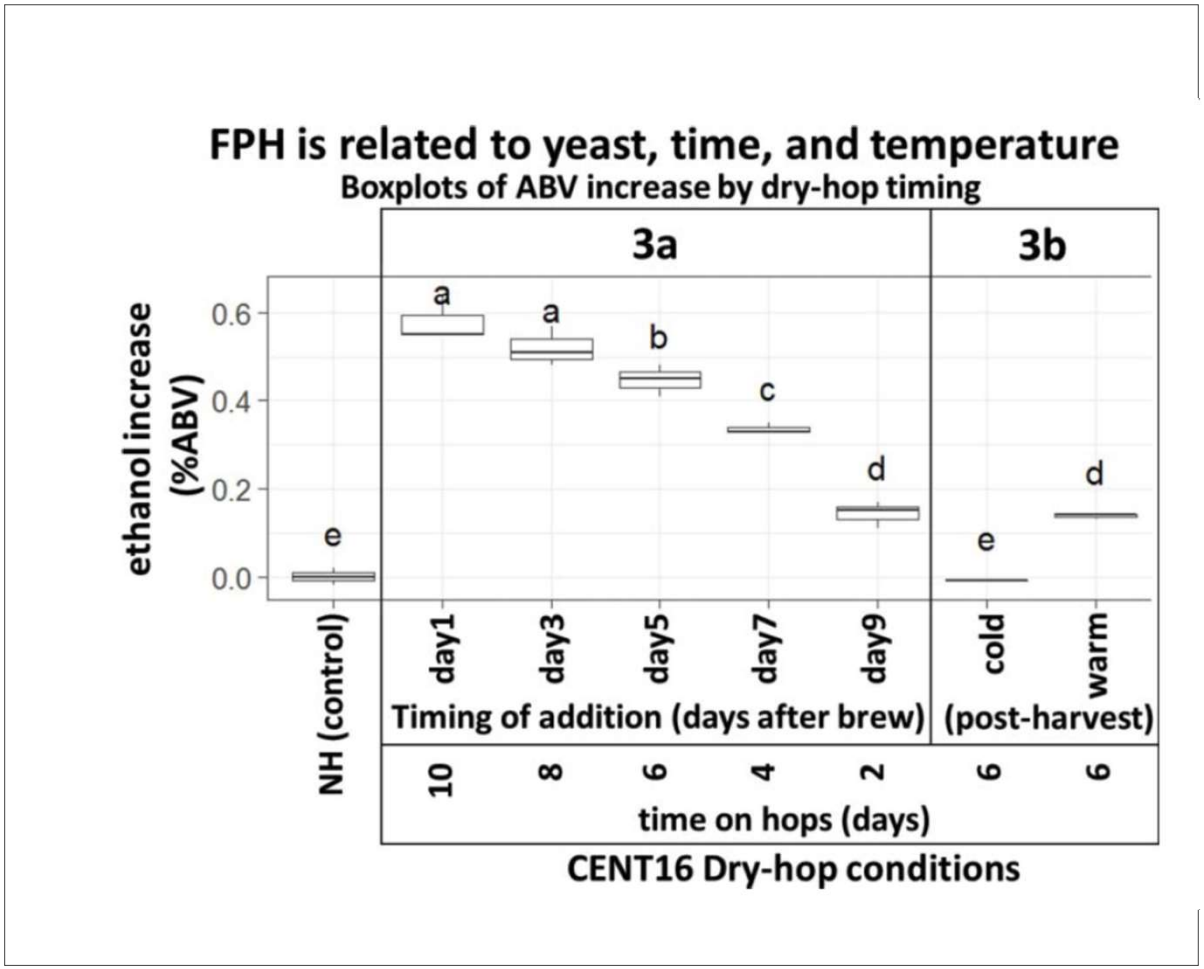
Oregon State University

Contact time & temperature effect: Glucose concentration



Oregon State University

Kirkpatrick and Shellhammer, P35 2017, ASBC



Commercial Example at Bell's Brewery.

Early addition (day 1) ABV% shift of 0.6%

Late addition (day 9) = ABV% Shift of 0.15%

Jake recommends dry hopping early to get the full effect of biotransformation, and consistent timing to predict dry hopping effect.

- Jacob A. Kirkendall, Carter A. Mitchell & Lucas R. Chadwick (2018) The
- Freshening Power of Centennial Hops, Journal of the American Society of Brewing Chemists, 76:3,178-184

Dry Hopping Practice Effect on Hop Creep

Stone and Wood: determined that 86°F (30°C) is the optimal temperature for enzyme activity and that the optimal pH range is 4.0–4.5. They also learned that 1 PU (pasteurization unit) is sufficient to denature hop enzymes and yeast.

Vinnie Cilurzo of Russian River: dry hopped an all-Simcoe beer called Row 2, Hill 56 with Cryo hops and compared it to use of pellets. Beer dry hopped with Cryo cleared diacetyl precursors in seven to nine days, while those dry hopped with pellets took 10 to 15 days.

Brewing with Hops: Don't Be Creeped Out
STAN HIERONYMUS Oct 19, 2020
https://beerandbrewing.com/brewing-with-hops-dont-be-creeped-out/

Tips to Mitigate Hop Creep

- Keep the grain bill simple, pull levers at mash in to limit total RE.
- Mash at a lower temperature, to reduce fermentable sugars.
- Use T-90 pellets during active fermentations, then Cryo hops toward the end (1–2° Plato from anticipated terminal gravity).
  - Replace 2 ounces (57 g) of pellets with 1 ounce (28 g) of Cryo.
  - A recipe that calls for 6 ounces (170 g) of dry hops would then include 2 ounces (57 g) of pellets and 2 ounces (57 g) of Cryo.
- Wait for VDK/diacetyl sensory before crashing beer.
  - If this takes more than five or six days, monitoe yeast health.
- Get beer off the trub within one to two days of crash cooling.
- Dry hop later than sooner.

Dry Hopping Practice Effect on Hop Creep

Arnbjørn Stokholm and Thomas H. Shellhammer
Oregon State University, Corvallis, Oregon

TABLE 2: How Dry-Hopping Practice is Tied to Hop Creep: Factors that promote/reduce hop creep

Factor	Promote Hop Creep	Reduce Hop Creep
Hop Form	Whole Cone, T90	CO_2 extracts, Cryo pellets, T45
Dry-Hop Duration	Long duration	Short duration
Dry-Hop Temperature	Warm (50-65+°F)	Cold (<50°F)
Dry-Hop Hop Load	High hop load (>2lb/bbl)	Low hop load (<2lb/bbl)
Fermenter Yeast Load	High yeast load	Low yeast load
Package Yeast Presence	Yeast present	Yeast absent
Filtration	No filtration	Filtration
Pasteurization	No pasteurization	Pasteurization

Summary

- Dry Hop Creep is not new >130 Years of documented data
- Hops possess diastatic enzymes that can break down malt sugars: Leaf and Seeds.
- The presence of active yeast accelerates hop creep: early vs. late dry hopping
- The more RE, the greater the potential for hop creep to occur
- Dry hopping temperature affects hop creep potential.
- Hop variety and form (pellet (T45, T90 vs. cryo) affect hop creep potential.
- Hop creep can be anticipated

THANK YOU!

drpattiearon@gmail.com