OMEGA YEAST

YEAST MANAGEMENT BEST PRACTICES

in Dry-Hopped Beer

Dr. Allison Lange
R+D Molecular Biologist
Omega Yeast

Vermont Craft Brewers Conference
November 11-12, 2024

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Who are we?

Omega Yeast labs
Chicago, IL / St. Louis, MO

High quality, pitch-ready liquid yeast

Handful of microbiologists, homebrewers, professional brewers and craft beer fans who made it our express purpose to make brewing easier and better for everyone

Dr. Allison Lange
R&D Molecular Biologist

HOP CREEP

Talk Overview

- Current Understanding of Hop Creep
- Variables that Impact
- Methods to Mitigate
- Assay to Predict
- Strains to Prevent Diacetyl

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Dry Hop Creep: A Little History

- 1893 Horace T. Brown - “Freshening Power of Hops”
- 1941 Janicki et al. - “Maltase in Hops”
- 2017 (~120 years later!) - “Hop Creep”
    - Shellhammer Lab, Allagash, Bell’s, Russian River…
    - Hop diastase enzymes and refermentation in dry hopped beers

Horace T. Brown

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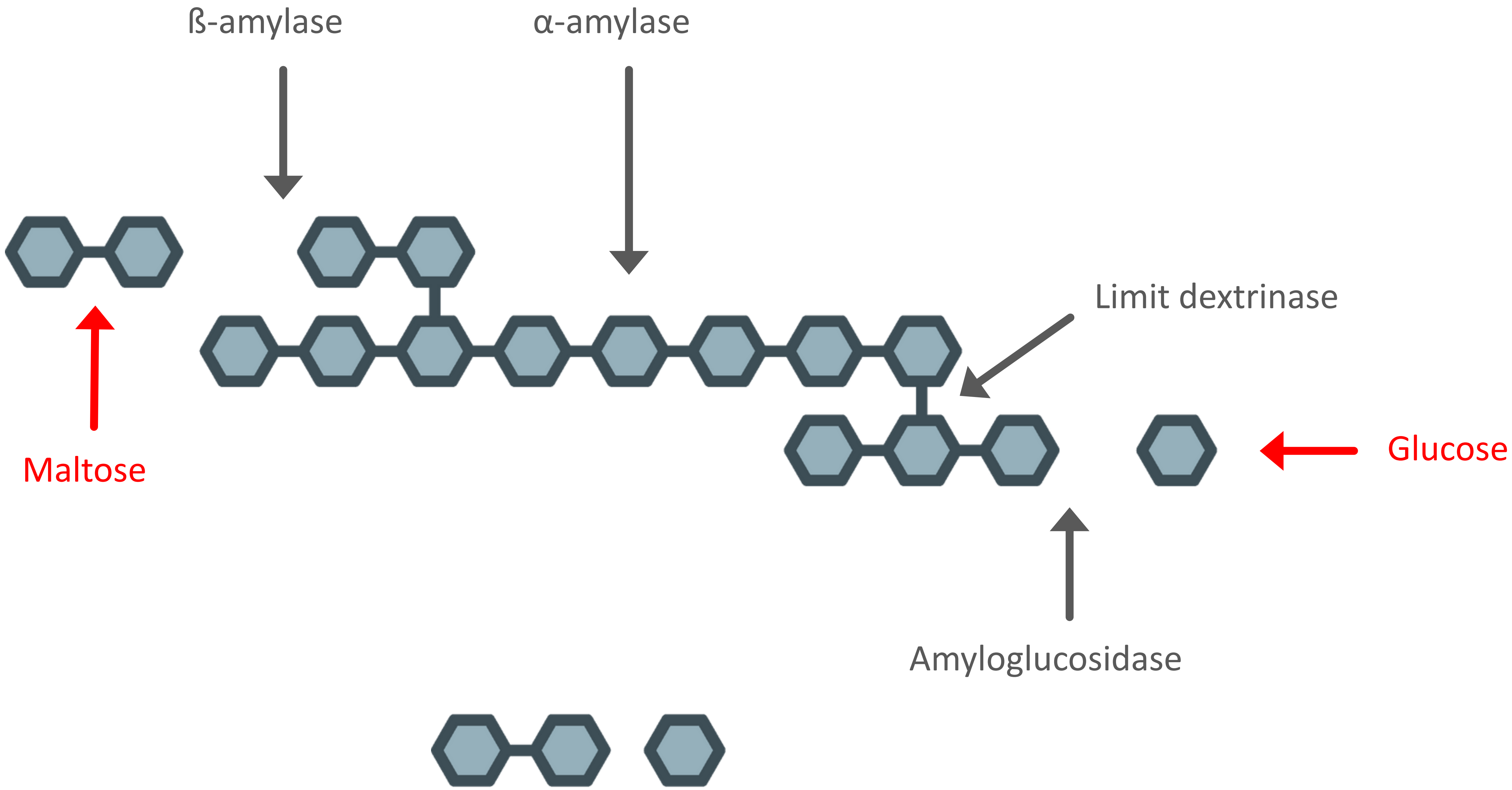
Hop Creep Produces Glucose and Maltose



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Hop Creep Causes Refermentation

Refermentation!

Maltose 

Glucose 

CO2
ABV
Diacetyl

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Where Do the Enzymes Come From?

Hops themselves or the microorganisms on hops?

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Hops are Most Likely Source of Enzymes

JOURNAL OF THE AMERICAN SOCIETY OF BREWING CHEMISTS
2022, AHEAD-OF-PRINT, 1-13
https://doi.org/10.1080/03610470.2022.2084327

Taylor & Francis
Taylor & Francis Group

Open access

A Search for Diastatic Enzymes Endogenous to *Humulus lupulus* and Produced by Microbes Associated with Pellet Hops Driving "Hop Creep" of Dry Hopped Beer

Matthew T. Cottrell

Heavy Seas Beer, Halethorpe, MD, U.S.A.

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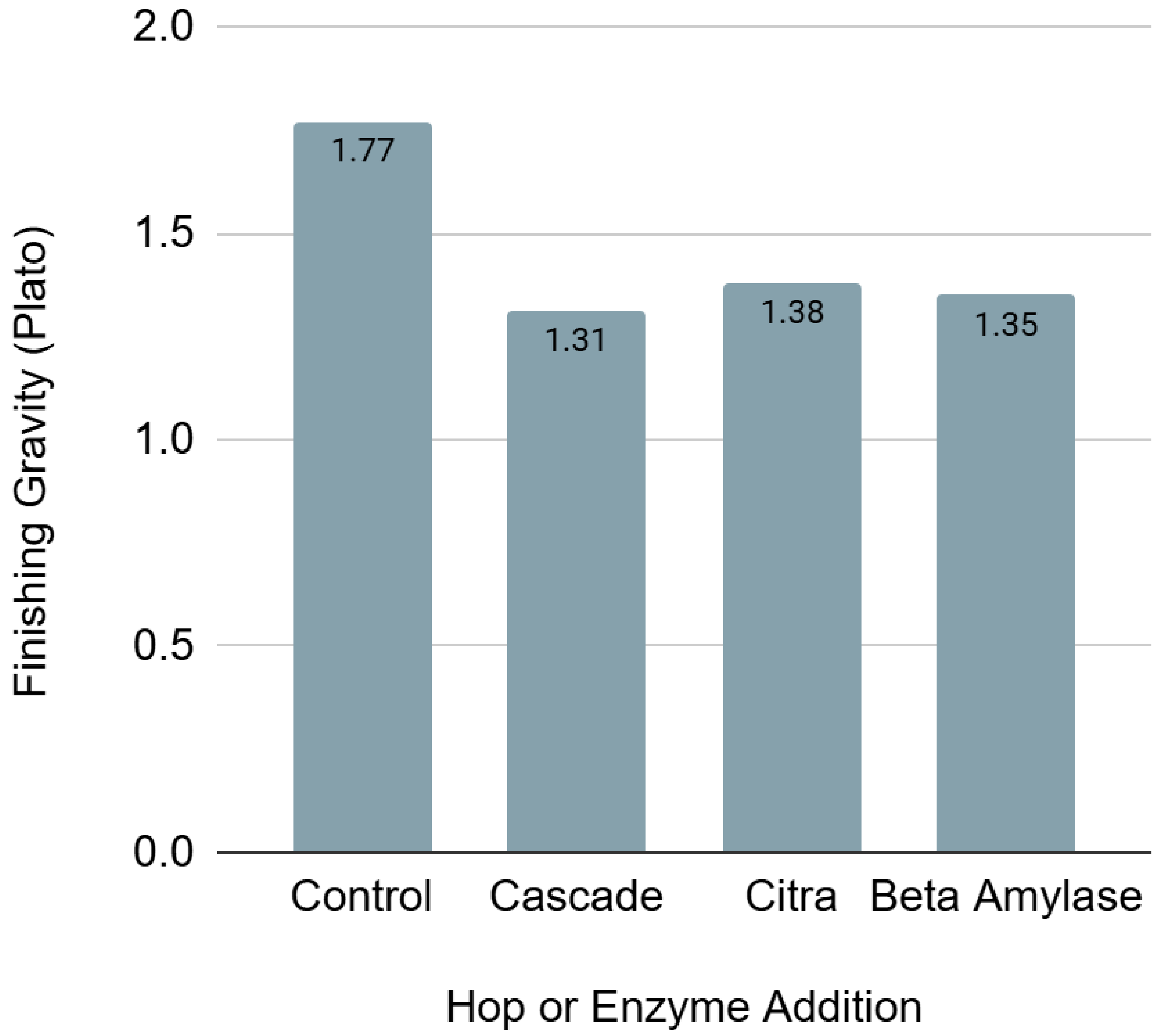
Enzyme Addition Mimics Hop Creep



- OYL-004 (West Coast I)
- 15P wort with 0.5#/BBL KO DH or enzyme addition

Hop Creep is Substrate-Limited

Agent of Creep is Probably a Beta-Amylase Enzyme

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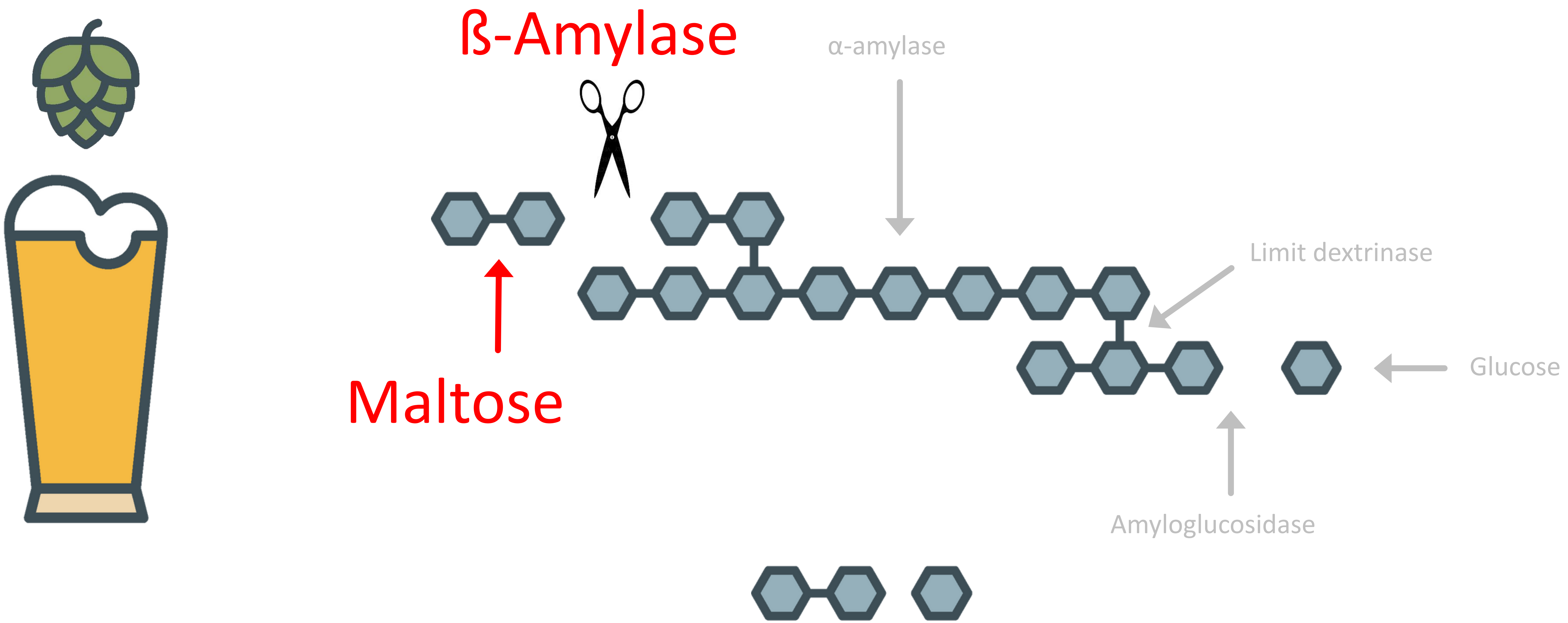
Beta Amylase is Likely Hop Creep Enzyme



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HOP CREEP

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What Variables Impact Hop Creep?

OUT OF YOUR CONTROL

1. HOP VARIETY/LOT
2. HOP PRODUCT TYPES
3. KILNING/PROCESSING
4. AGRICULTURAL IMPACTS

IN YOUR CONTROL

1. YEAST CHOICE
2. WORT FERMENTABILITY
3. DRY HOP DOSE RATE
4. DRY HOP TIMING
5. HOP VARIETY CHOICE

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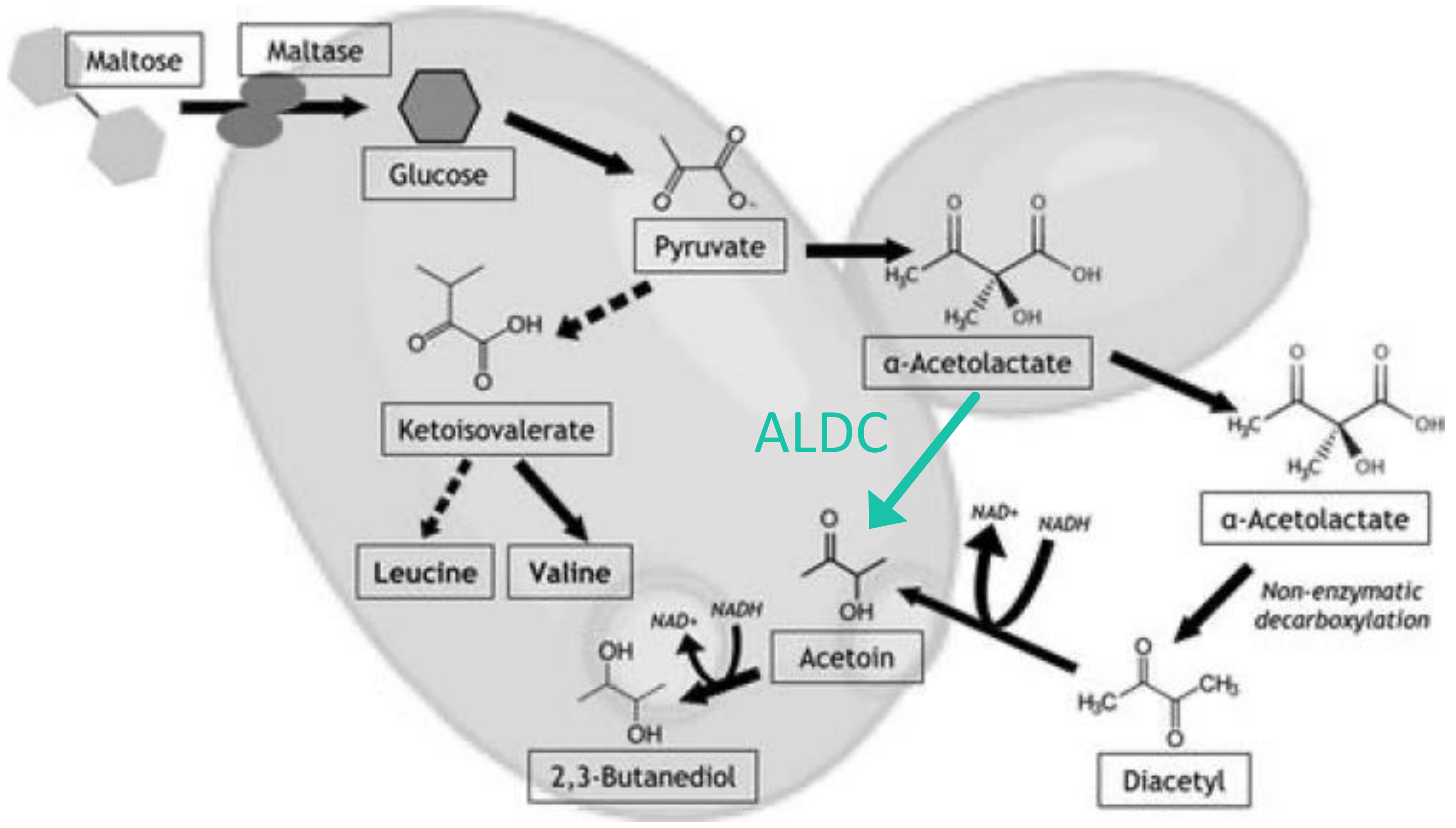
Yeast Strain Choice - Diacetyl

- Certain yeast are prone to diacetyl
  - Lager
  - Chico
  - English strains
- Not correlated to flocculation
- Yeast engineered to prevent diacetyl formation
  - ALDC = alpha-acetolactate decarboxylase



James Bruner, UC Davis/Creature Comforts

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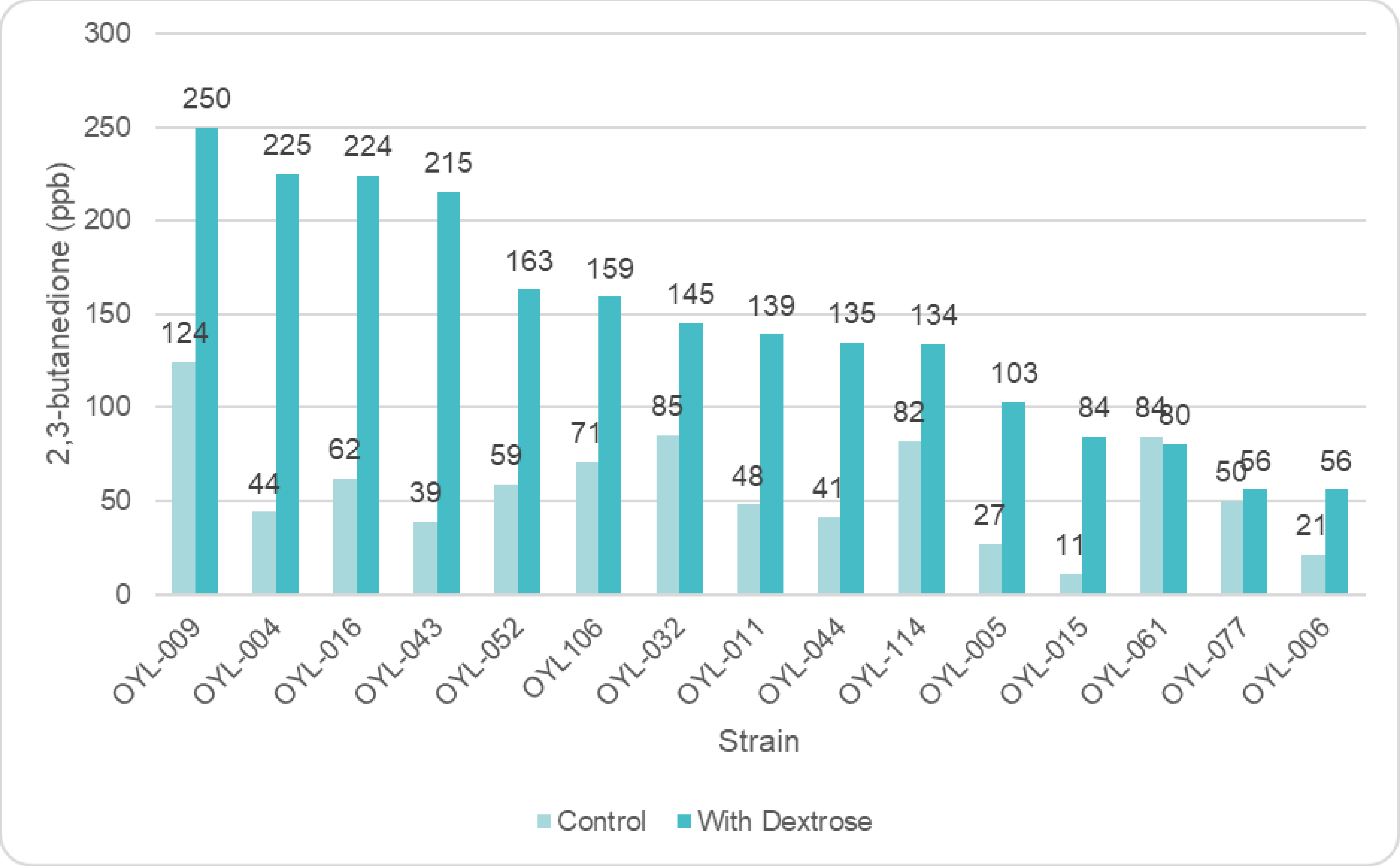
Yeast Strain Choice - Diacetyl



Forced Diacetyl Assay:

- 15P wort
- 1P dextrose added day 7
- Early crash day 9
- Harvest for GC, Plato, pH

Sensory Threshold

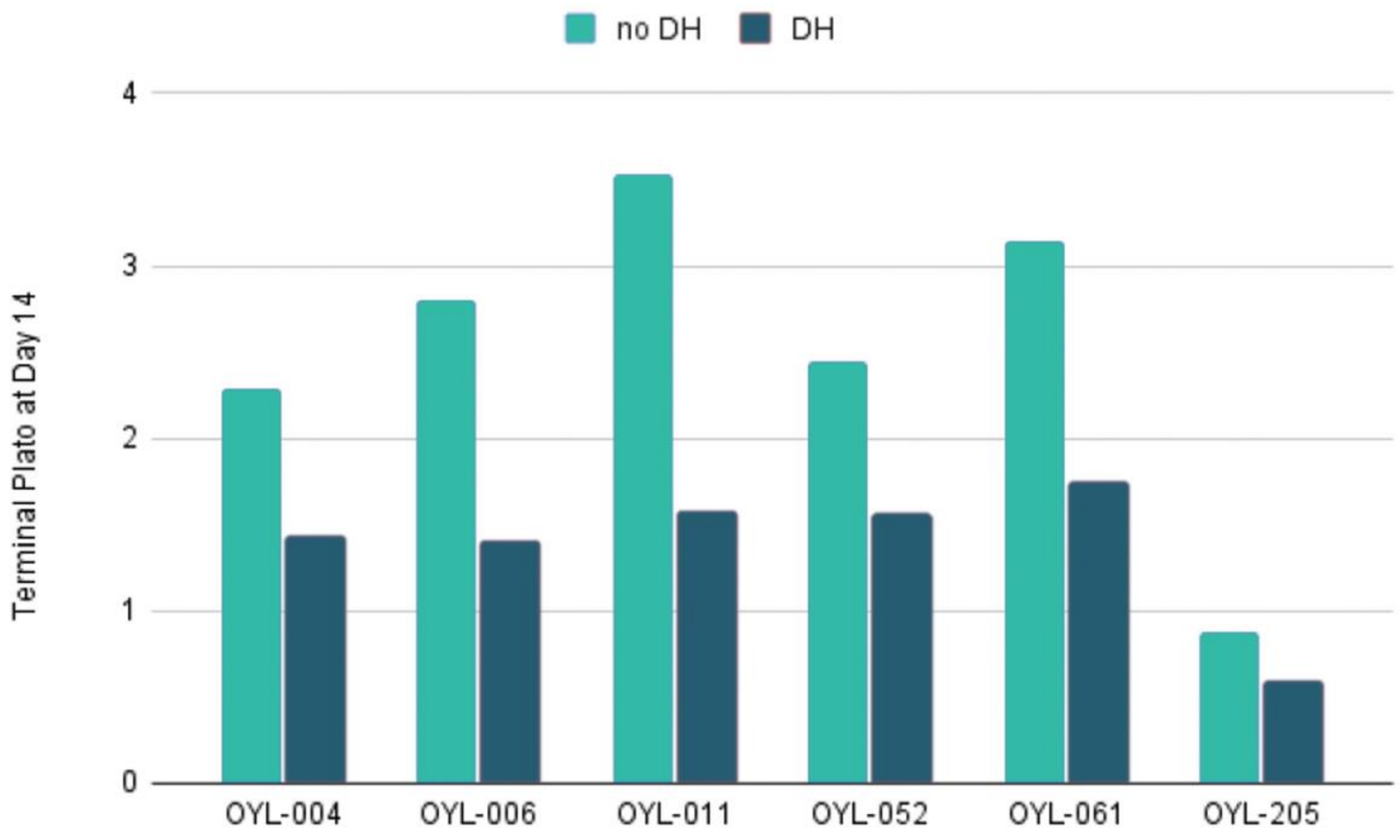
High Potential for Diacetyl Production:

- Lagers, Chico, English strains

Yeast Strain Choice - Attenuation

- Attenuation = How much the glucose, sucrose, fructose, maltose, and maltotriose is fermented
  - Chico - High 85%
  - British Ale V - Low 75%

- Larger degree of hop creep with:
  - Lower attenuating yeast
  - Less fermentable wort (mashing high)



Dry hopped samples attenuated 88-90%

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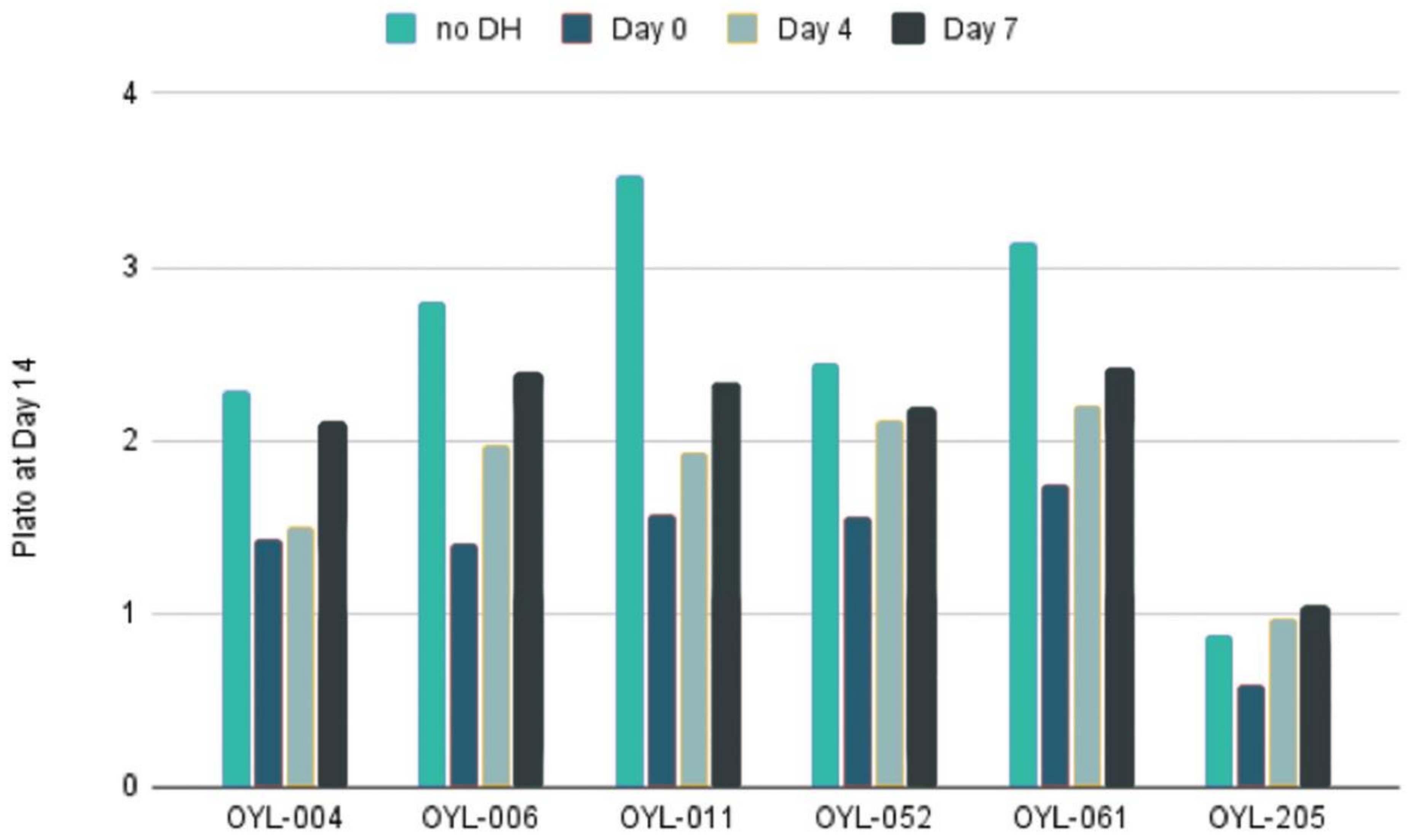
Dry Hop Timing

- Early Dry Hop (Day 0) allows hop creep to coincide with fermentation
- Late Dry Hop (Day 7) results in incomplete hop creep and slower diacetyl clearance



- Flasks were all dry-hopped at 2 lb/BBL
- Terminal plato was measured at day 14

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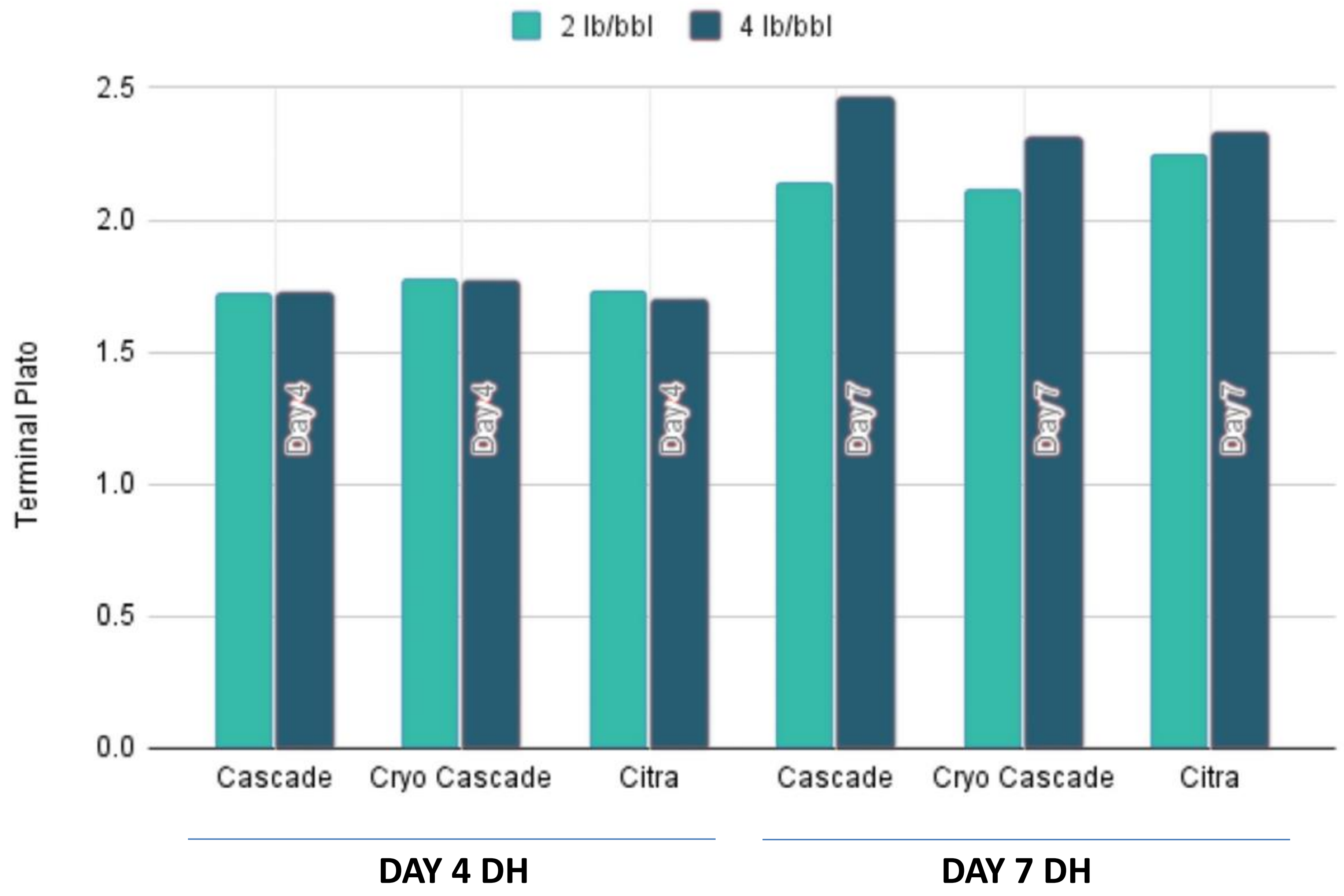
Dry Hop Rate (and Timing, Again)

Larger dry hopping rates at the end of fermentation can delay hop creep even further

Consistent between varieties



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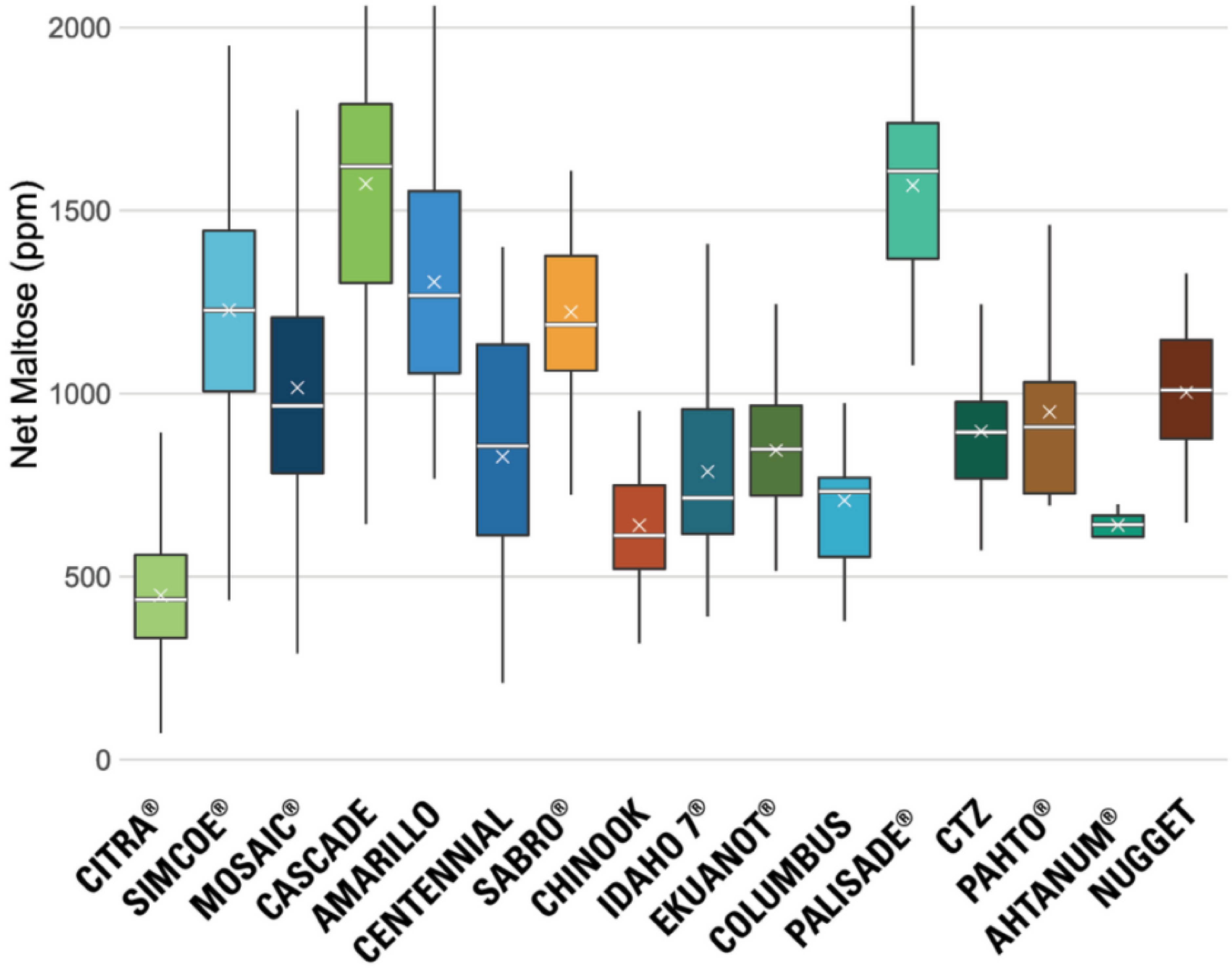
Hop Variety

Variety
- Ex. Citra low, Cascade high
- Potential for hop creep

Hop Products
- Extracts < Cryo < T90

Processing/Handling
- Kilning
- Storage

Agricultural Influences
- Terroir
- Crop Year



Rob King, Yakima Chief

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Hop Creep Resource:

Recipe and Dry-Hopping Practices

- Target attenuation/terminal Plato
- Dry hop addition rate
- Timing of the dry hop
- Temperature at dry hop
- Circulation vs static dry hop
- Dry hop contact time
- Pre or post yeast removal

BA BREWERS ASSOCIATION

Hop Creep – Technical Brief

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

EXECUTIVE SUMMARY

There is evidence that hops have amylolytic enzymes in or on them that biochemically modify beer during dry-hopping, leading to degradation of long-chain, unfermentable dextrins into fermentable sugars. This increase in fermentable sugars can, in the presence of yeast, give rise to a slow secondary fermentation, which is referred to as 'hop creep.' Hop creep requires three conditions for it to appear: (1) some amount of unfermentable real extract in the wort or beer prior to dry-hopping; (2) live yeast in suspension; and (3) the addition of hops to fermenting or fermented beer. The main consequences of hop creep result in beer being out of specification in terms of alcohol, diacetyl and CO_2 (Table 1). It is particularly concerning when it occurs post-packaging because of the consumer safety risk related to package over-pressurization. Methods for controlling hop creep, to either accentuate or reduce it, involve manipulating wort composition, yeast strain selection and suspended cell concentration during dry-hopping, and dry-hop form, timing, contact time and temperature.

WORT FERMENTABILITY AND BIOCHEMISTRY

The mashing process combines malted barley and warm water to create wort, which is made up of fermentable sugars (principally, maltose), unfermentable dextrins, proteins, minerals and ash. Taken together, these components are termed 'total extract.' Yeast use the fermentable sugars during fermentation to produce alcohol, CO_2, more yeast, and various other secondary metabolites, some of which contribute to fermentation-derived beer flavor. The wort components consumed by yeast are referred to as the 'fermentable extract.' In beer, the longer-chain dextrins are not fermented, and once fermentation is complete these dextrins carry through into the final beer. This fraction of the extract along with the untouched protein, minerals and ash is referred to as 'real extract.' The amount and type of unfermentable dextrins remaining in the final beer depends on the enzymic properties of the mash grist and the mashing temperature/time profile. The malt-derived enzymes are inactivated during wort boiling, and after the boil, the wort is enzymatically inactive until the yeast is added after cooling and aeration. Some brewers choose to add hops near the end of fermentation or after fermentation is complete to accentuate hop-derived flavors and aromas, in a process known as dry-hopping.

HOW HOP CREEP IS TIED TO DRY-HOPPING

During dry-hopping, enzymes associated with the hops are carried into the beer and begin breaking down unfermentable dextrins left behind from mashing into fermentable sugars. The action of these enzymes appears to be more active when hop material is suspended in beer, but a portion of these enzymes may migrate into beer and remain active even after the hops have been removed from the fermenter/dry-hopping vessel. Any amount of yeast remaining in finished beer can metabolize the sugars liberated by amylolytic enzymes, producing alcohol and CO_2. When this occurs within the brewery cellar, a brewer will notice a slow decline in the apparent gravity of the dry-hopped beer beyond the anticipated terminal gravity. This slow reduction in the final gravity is referred to by brewers as hop creep.

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

ISSUES CAUSED BY HOP CREEP

Fermenter hop creep leads to extended cellaring time, as the refermentation caused by the spike in fermentable extract can take a long or indeterminate time to finish. Extended cellar time can tie up fermentation or dry-hopping tank space, thereby delaying production of

Continued >

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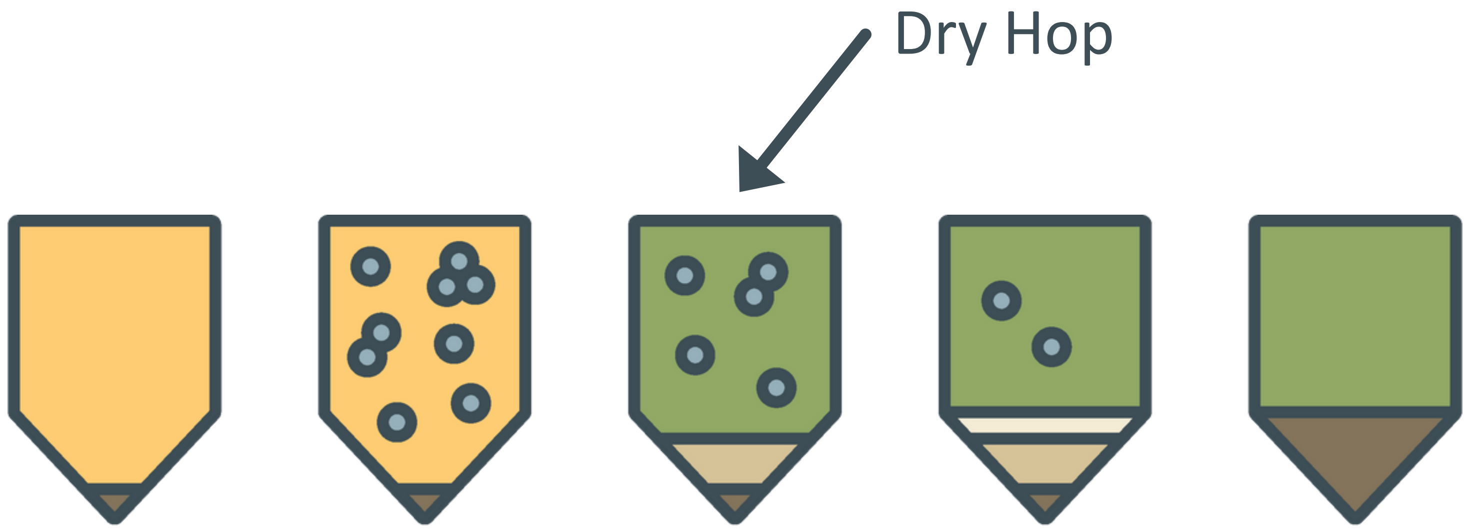
Methods to Mitigate Hop Creep

1) Ride it out

- Time dry hop for when yeast is still active (pre-diacetyl rest)

Ride it Out:
Mid-Late Dry Hop



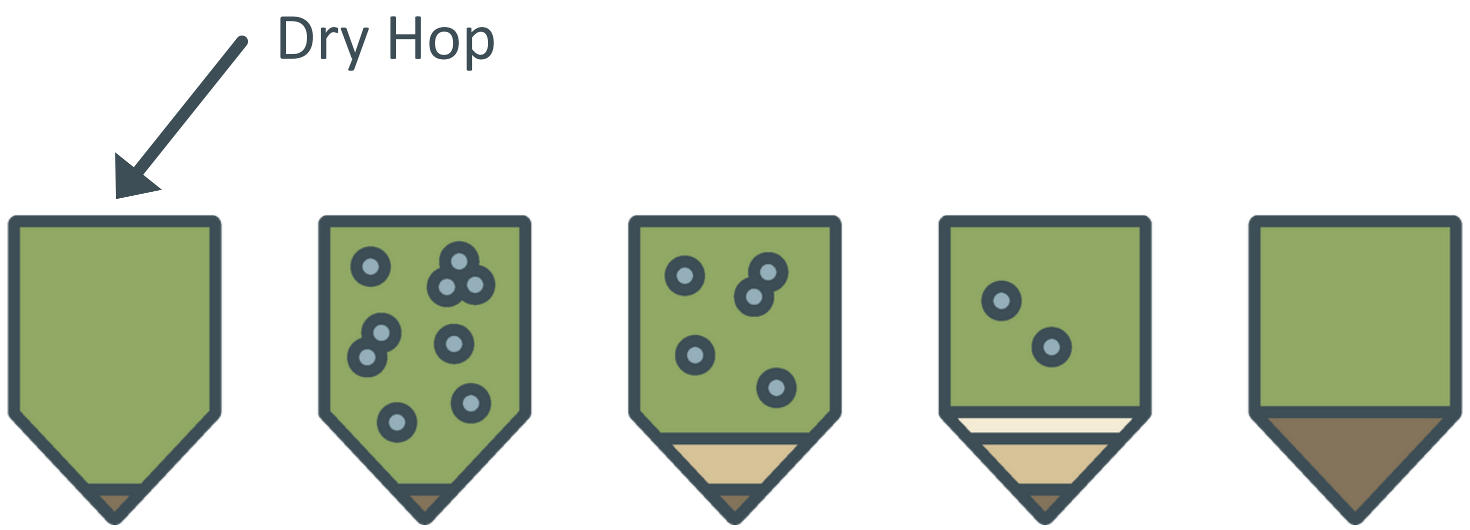
Try and harvest yeast, but still have some fermentation activity

Methods to Mitigate Hop Creep

2) Limit Potential

- Use hops with high diastase activity in the whirlpool and low diastase activity for the dry hop
- Target more conversion in the mash
- An early charge of dry hop can minimize creep potential of later additions

Limit Potential:
Early Dry Hop Charge



Hop enzymes are active during fermentation

Methods to Mitigate Hop Creep

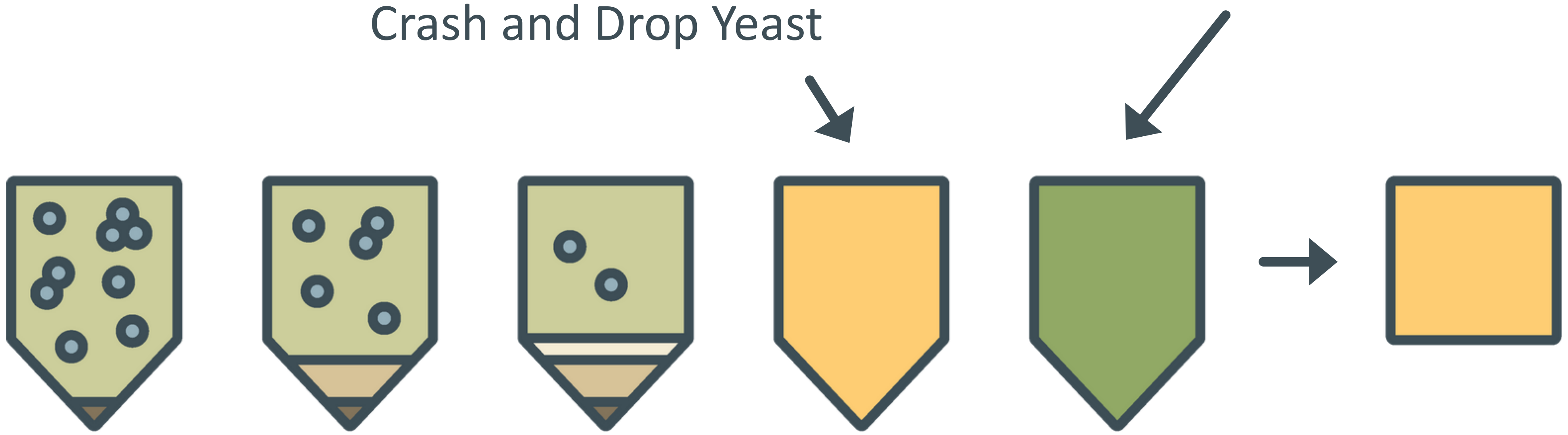
3) Prevent it with a cold, short dry hop

- Risky if enzymes have a chance to convert later in warm storage

Finished/Cleared VDK
Crash and Drop Yeast

Dry Hop Cold 24-48 hours

Prevent:
Cold, Short Dry Hop



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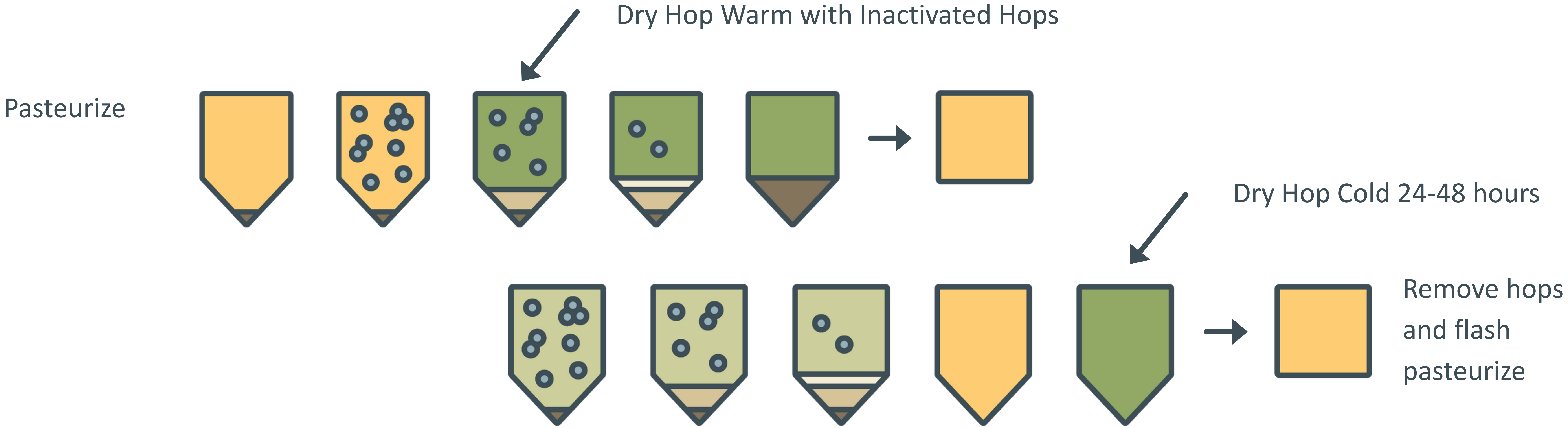
Methods to Mitigate Hop Creep

4) Pasteurize/Inactivate hop enzymes

- Direct inactivation of hops (sous-vide)
- Very low PU pasteurization of finished beer



Methods to Mitigate Hop Creep

1) Ride it out
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2) Limit Potential
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3) Prevent it with a cold, short dry hop
   - Risky if enzymes have a chance to convert later in warm storage
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Forced Hop Creep Assay:

Predict Terminal Gravity

Adapted from ASBC Wort 5. Yeast Fermentable Extract

- Measure apparent extract of pre-dry hop fermentation
- Collect pre-dry hop sample into sterilized flask with stir bar
- Add hops at total dry hop rate
- Place flask on stir plate in a warm room or incubator set to 30°F
- After 48 hours, sample the apparent extract and determine the level of hop creep

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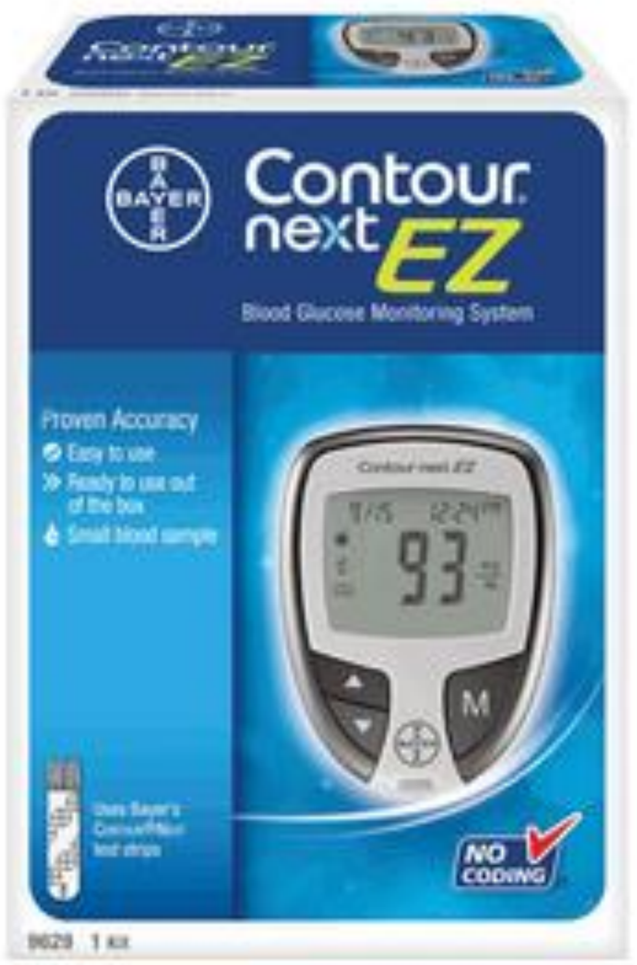
Lab Hop Creep Assay:

Measuring Diastase Activity in Hops

Adapted from ASBC Malt 6. Diastatic Power

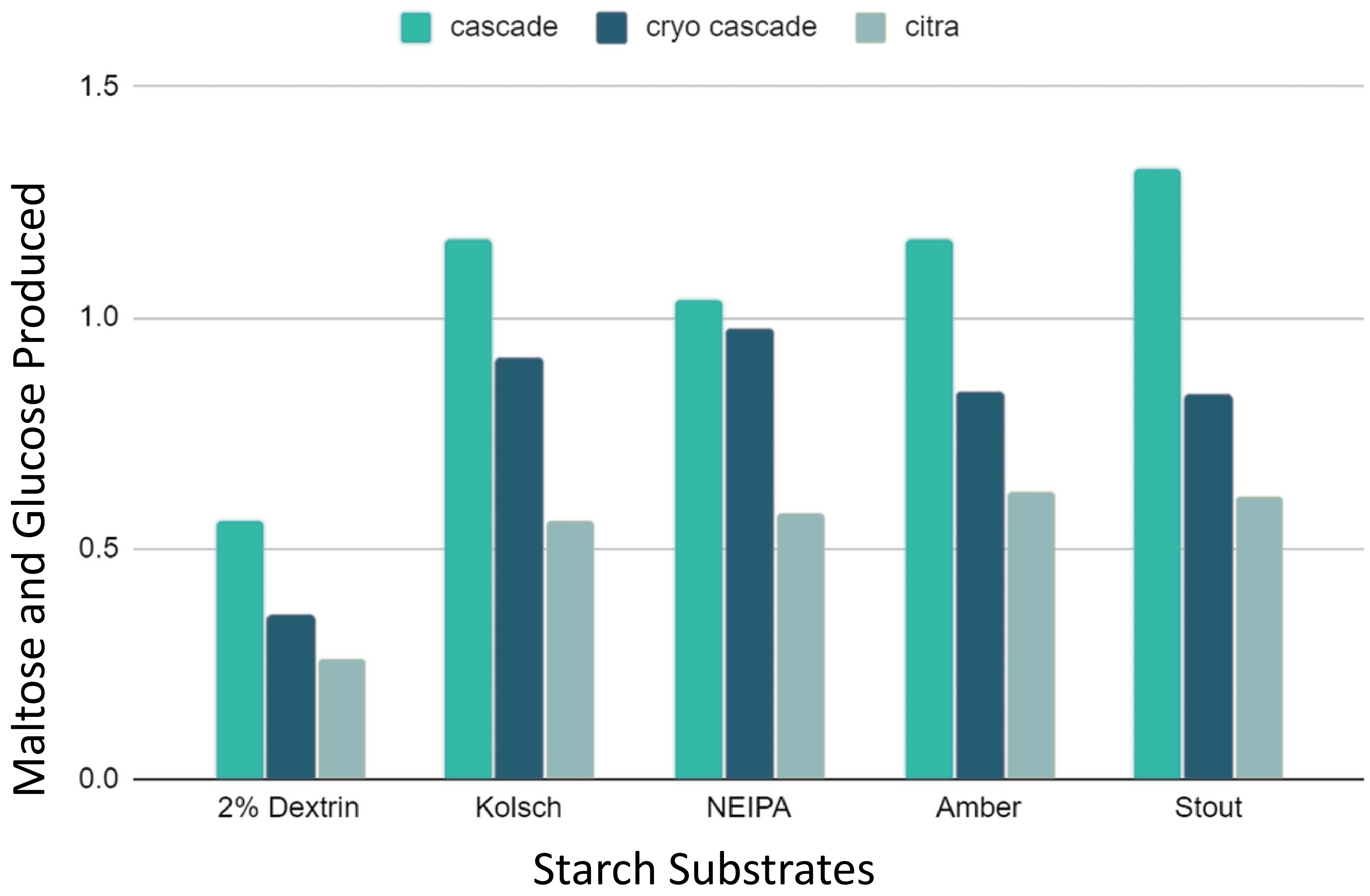
- Starch substrate or commercial beer sample incubated for 48 hours with 10 g/L of hops (2.5#/bbl)
- Measure maltose and glucose
  - HPLC: direct measurement of total maltose and glucose
  - UV/vis spectrophotometer: convert the maltose to glucose with maltase enzyme and measure total glucose with Glucose Oxidase Assay
  - A blood glucose meter: convert the maltose to glucose with maltase enzyme and measure directly with glucose meter!



Lab Hop Creep Assay:

Measuring Hop Creep Potential with a Blood Glucose Meter

- Find a suitable starch substrate
  - commercial dextrin OR *finished beer*
- Add hops at 8 g/L dose rate (2 lb/BBL)
- Prevent additional fermentation by adding sodium azide (0.02%)
- Incubate at 30C for 2 days
- Measure glucose production with Blood Glucose meter
- Add Maltase (Megazyme enzyme in maleate buffer), 24 hrs at 30C
- Measure converted maltose with glucose meter
- Sum glucose and maltose produced as “hop creep potential”



Helps you decide where to use certain hop varietals, hop products, or hop batches

Lab QC Assay:

Measuring Glucose/Maltose In Packaged Beer

- Are hop enzymes still active?
- Is there a risk for continued fermentation in package?

Mega Omega
Weldworks Brewing Co and Omega Yeast Collaboration

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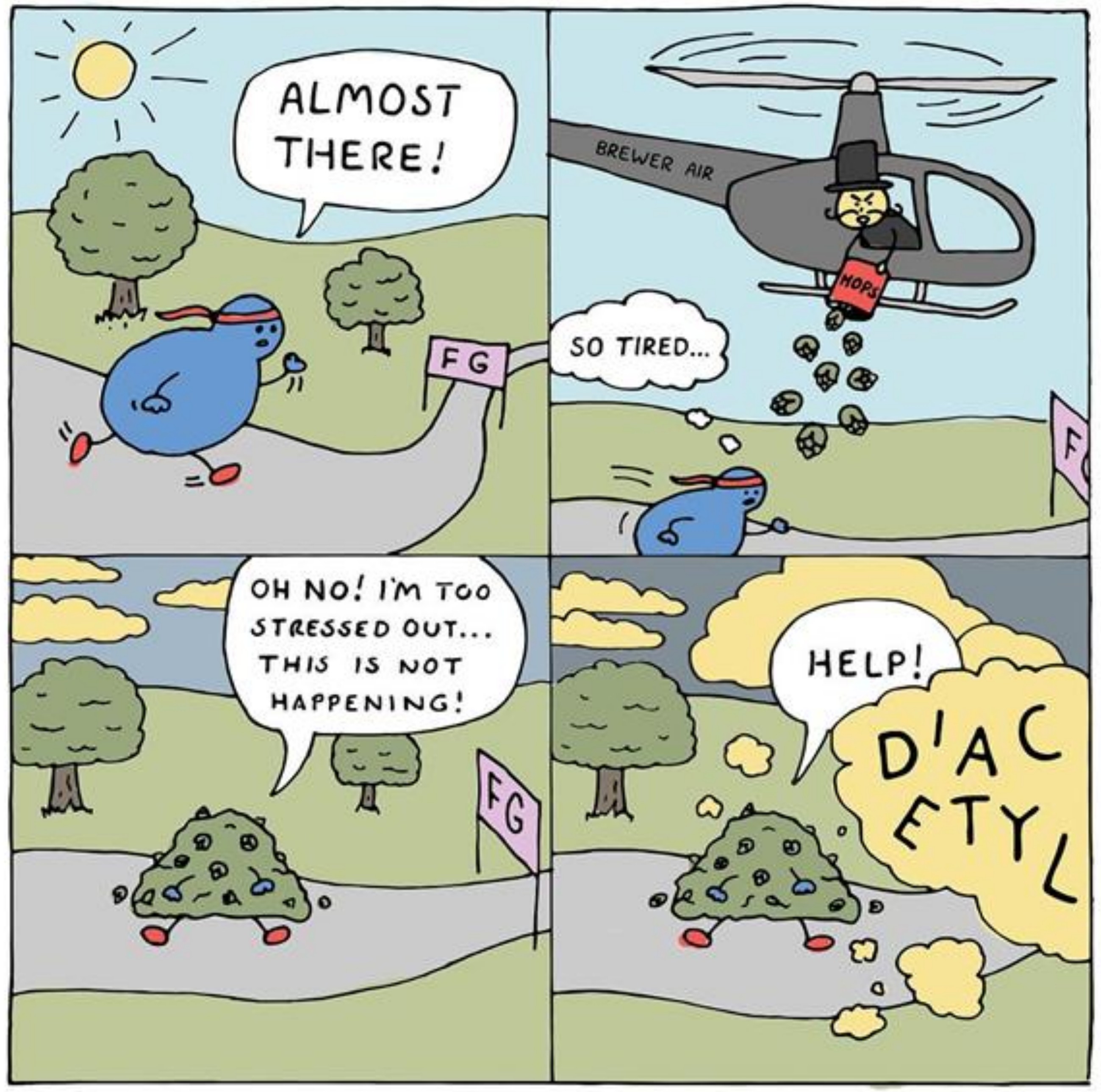
Diacetyl Production with Dry Hop



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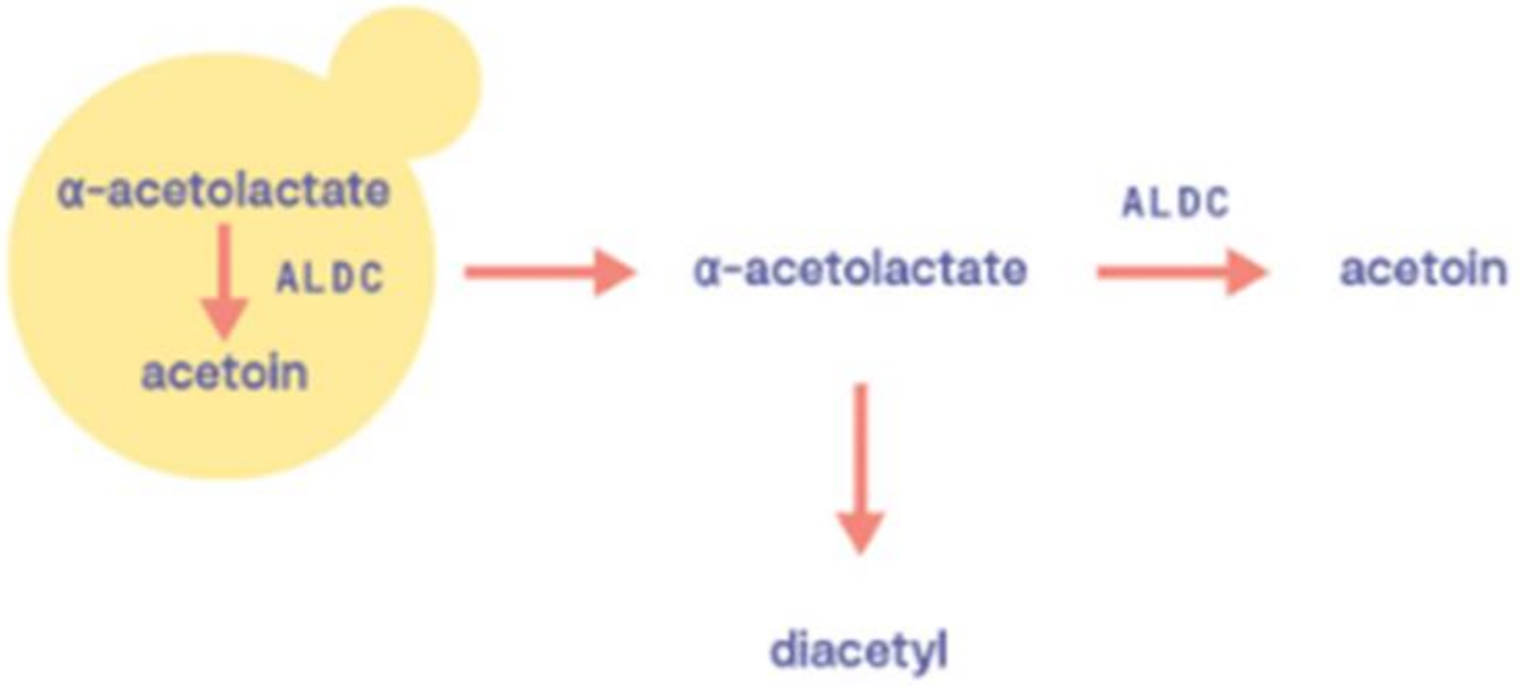
ALDC-Expressing Yeast



ALDC in cell converts α-acetolactate directly to acetoin; without ALDC α-acetolactate is excreted and becomes diacetyl OR with exogenous ALDC, it becomes acetoin in the beer.

Circumvents the production of diacetyl

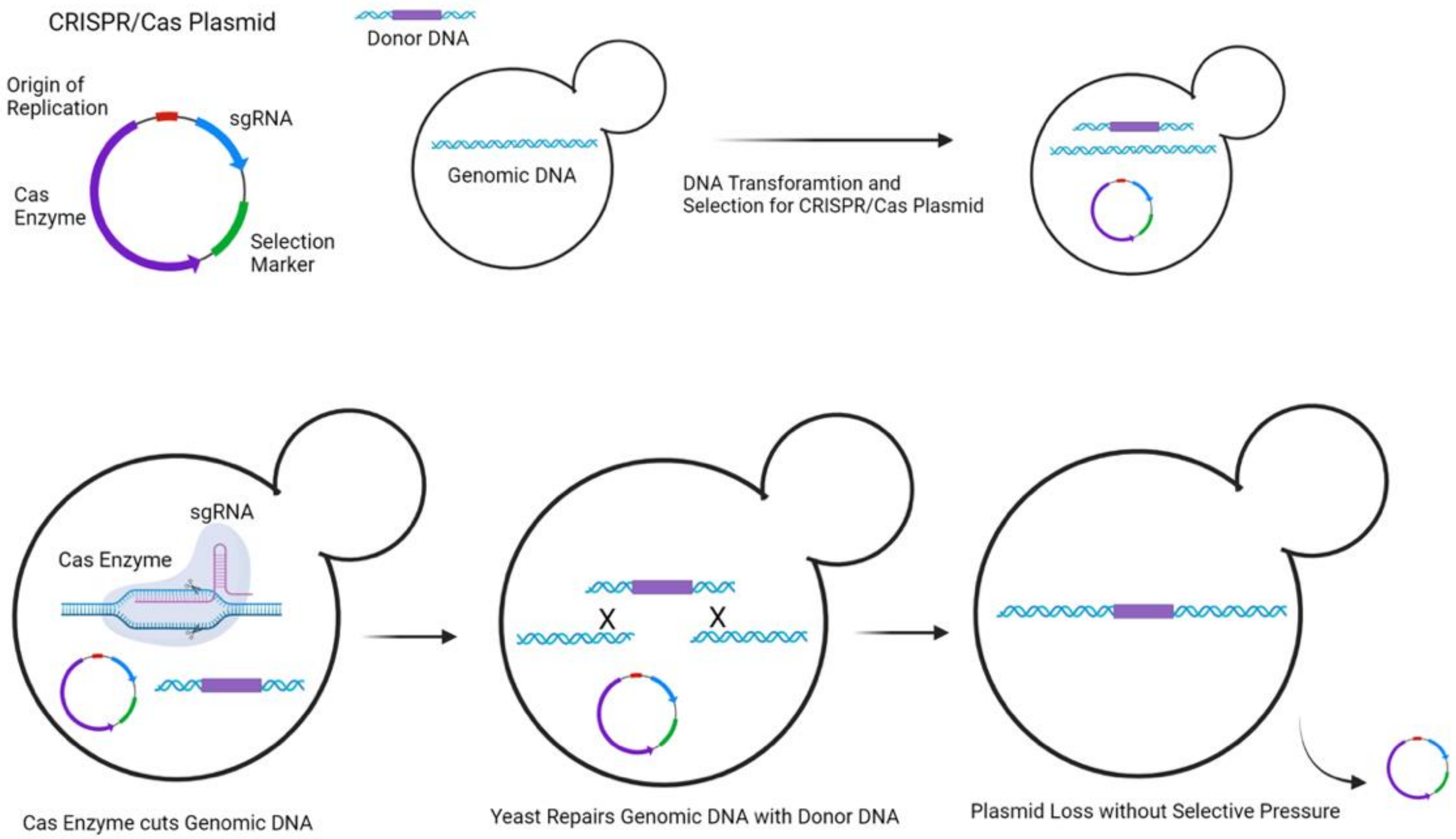
ALDC does not reduce diacetyl levels, but instead prevents the formation of diacetyl

Not a band aid for poor yeast management

Applications:

- Strains with elevated diacetyl production
- Lagers for faster turnaround
- Dry-hopped beers

Making Diacetyl Knock Out (DKO) Strains



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INTRODUCING

Diacetyl Knock Out (DKO™)

A series of familiar yeast strains engineered to knock out the formation of diacetyl before it starts. Each strain expresses the ALDC enzyme, allowing you to streamline efficiency and quality without the diacetyl hang-up.

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DKO Yeast

BENEFITS

- ALDC enzyme expressed by yeast
- Avoid diacetyl hang ups with hop creep
- Boost quality and turn tanks quickly
- Diacetyl so low, it's undetectable

OYL-430 West Coast I +	DKO LUMINA
OYL-431 British V +	DKO
OYL-432 Extra Special +	DKO
OYL-433 Bayern Lager +	DKO
OYL-434 Point Loma +	DKO LUMINA
OYL-435 Kolsch II +	DKO
OYL-436 DIPA +	DKO
OYL-437 German Lager I +	DKO

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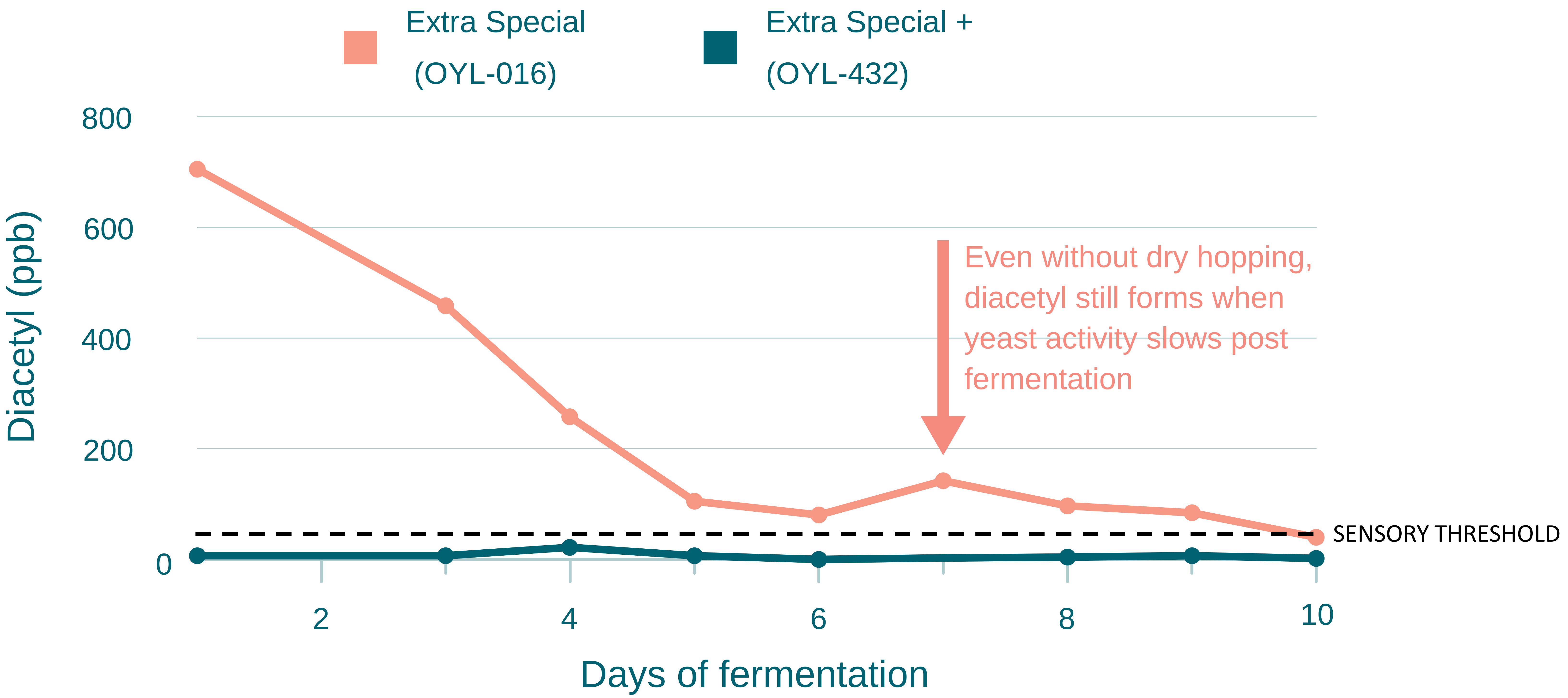
DKO Strains

Undetectable Diacetyl Levels Throughout Fermentation



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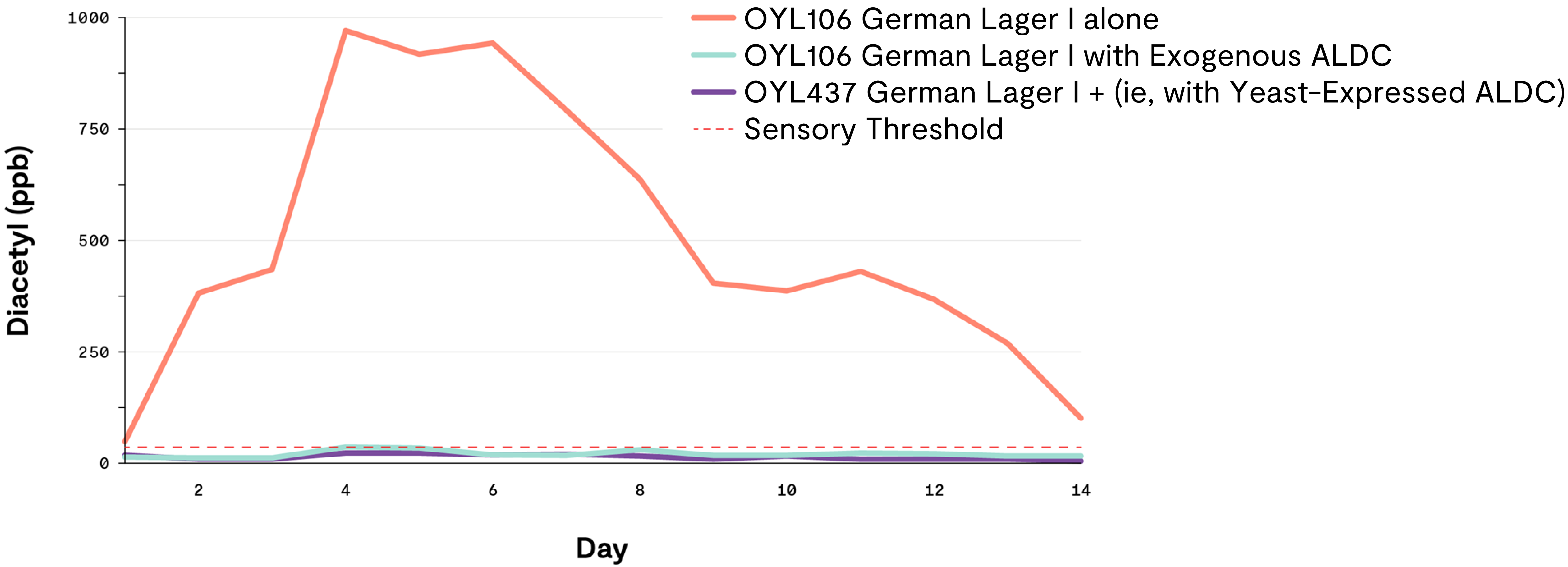
DKO Strains

Yeast-Expressed ALDC vs Exogenous ALDC Enzyme



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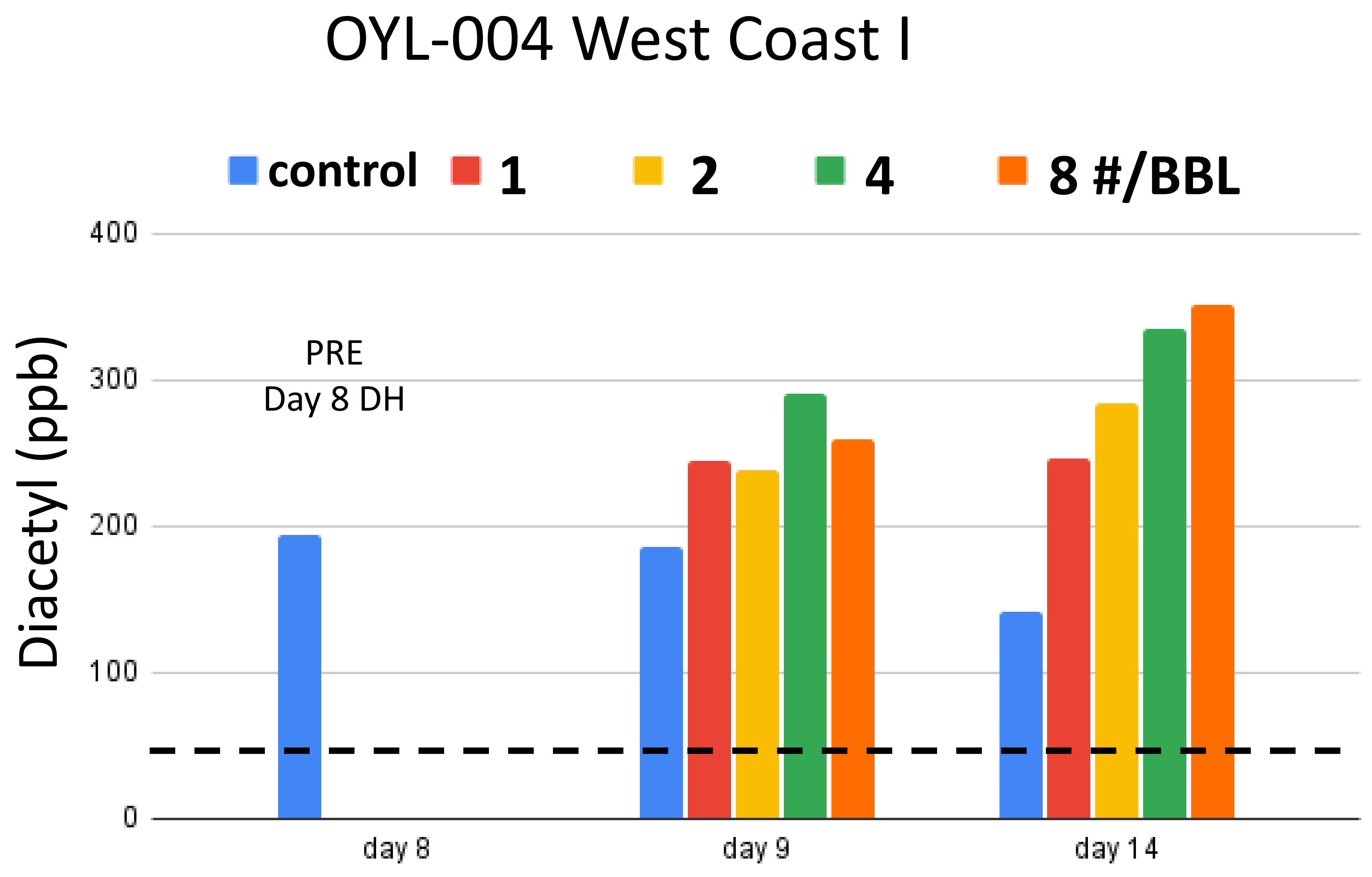
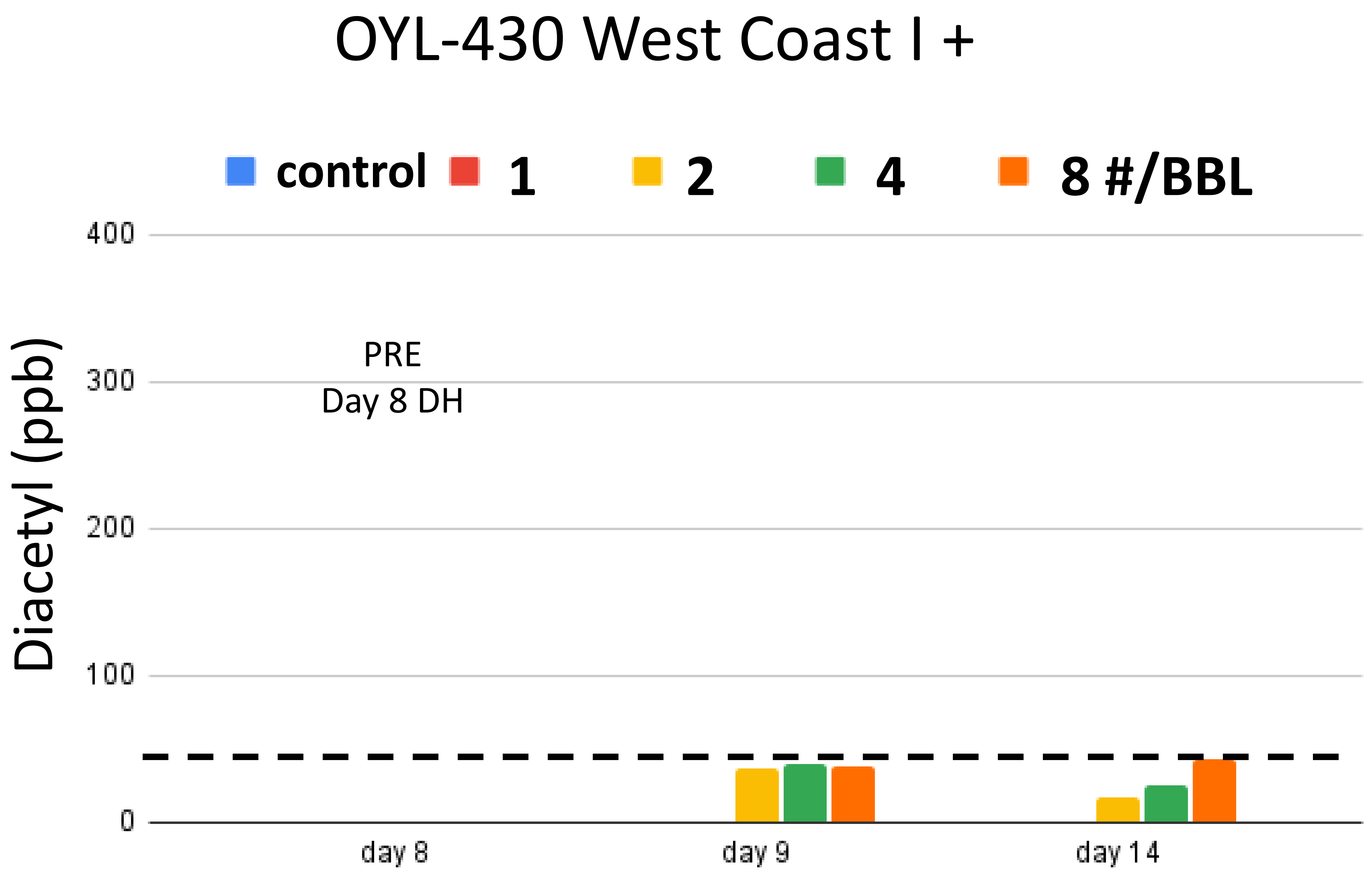
DKO Strains with Dry Hop

Undetectable Diacetyl Regardless of Hop Amounts





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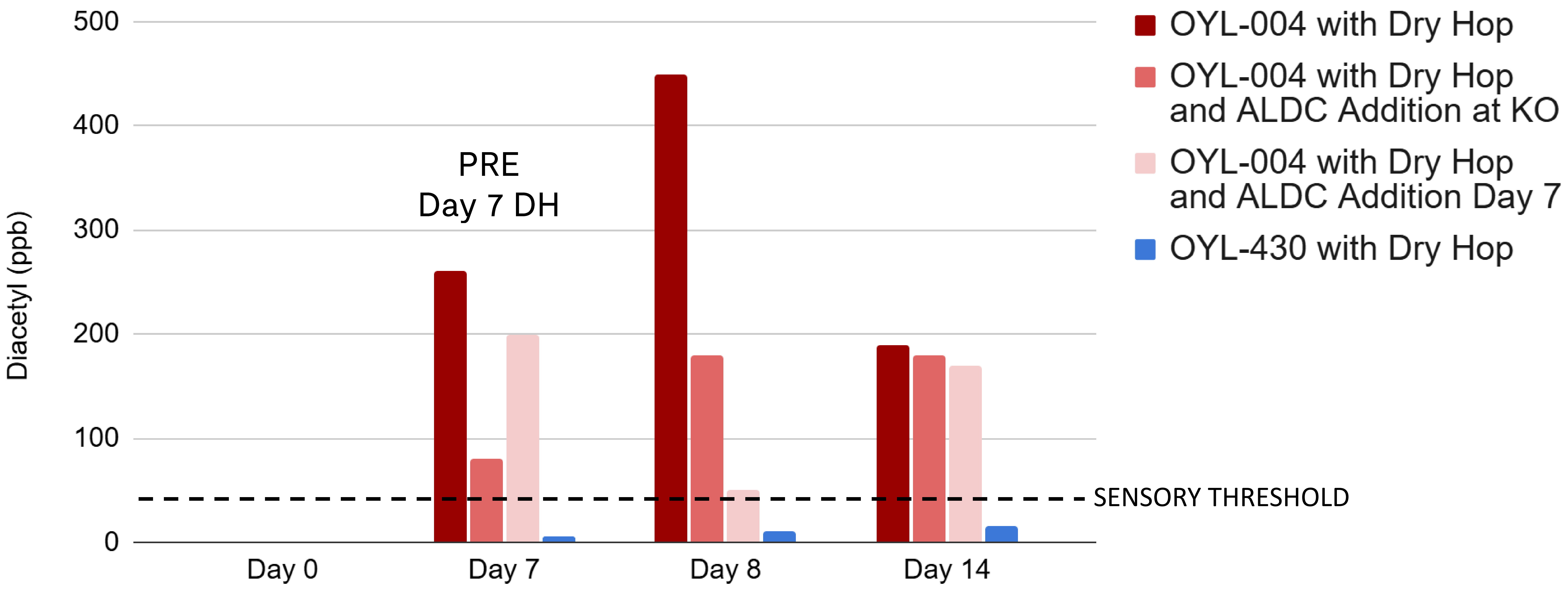
DKO Strains with Dry Hop

Yeast-Expressed ALDC vs Exogenous ALDC Enzyme Added at KO or with Dry Hop



HOP CREEP

Conclusions

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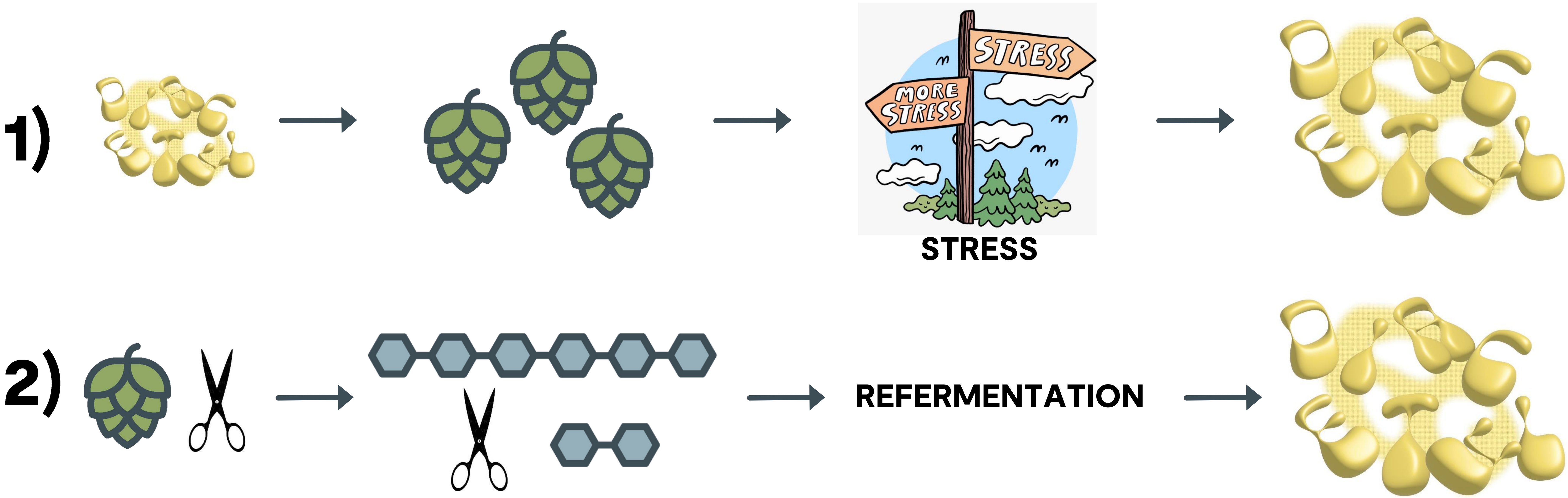
High Dry Hop Levels Lead to High Diacetyl Levels



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Advice for Managing Hop Creep

Remember that reaction is substrate-limited

Facilitate early ß-Amylase cleavage of long-chain sugars

1) Target ß-Amylase conversion in mash
   Lower mash temp

2) Early DH
   Get attenuation drop and diacetyl production out of the way so you can safely add your 4#/BBL DH later

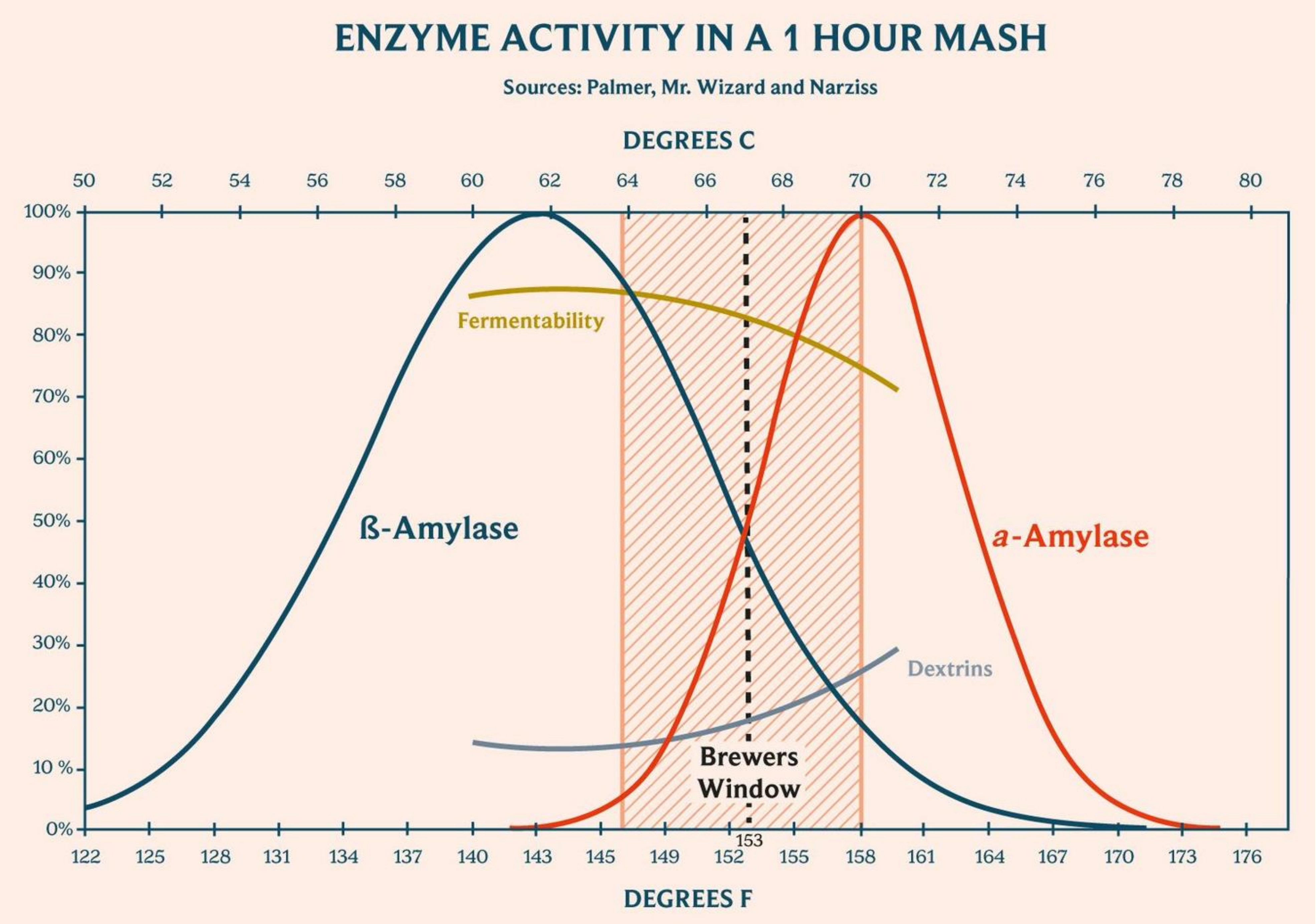
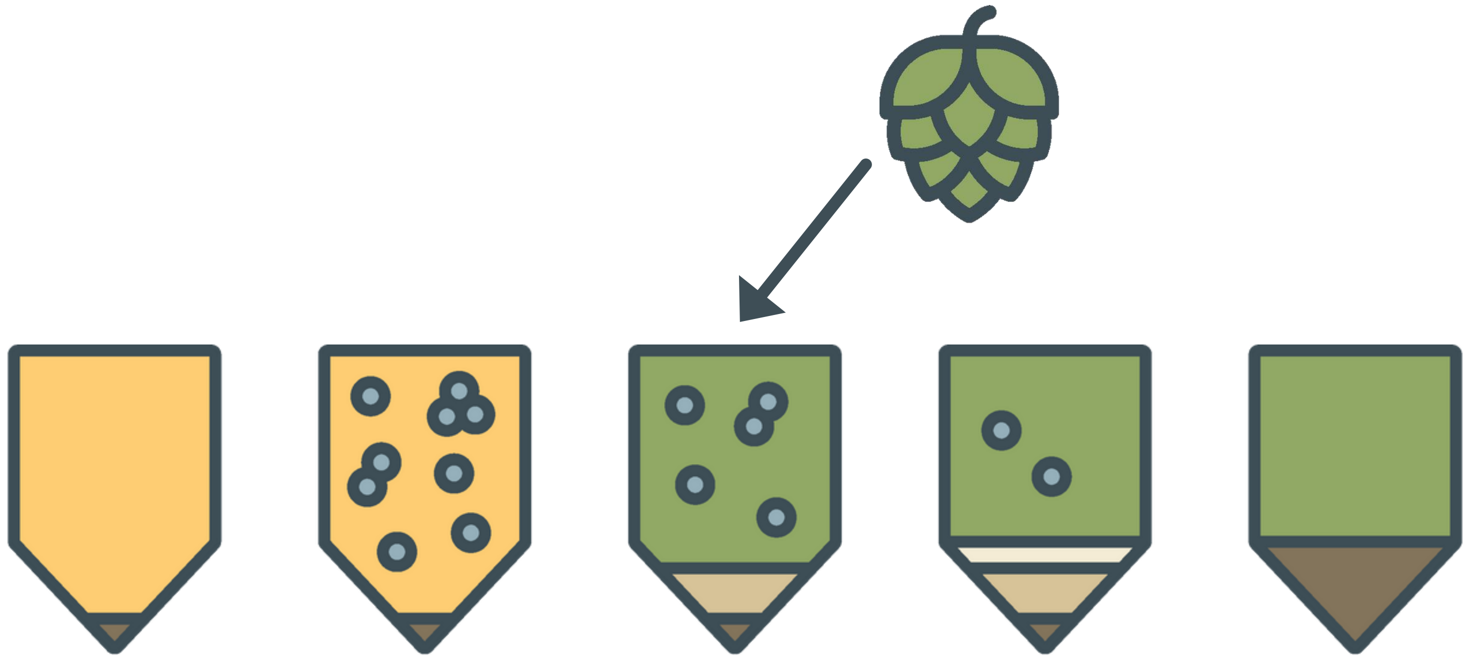


Image source: crispmalt.com

Planning for Hop Creep in Recipe Design

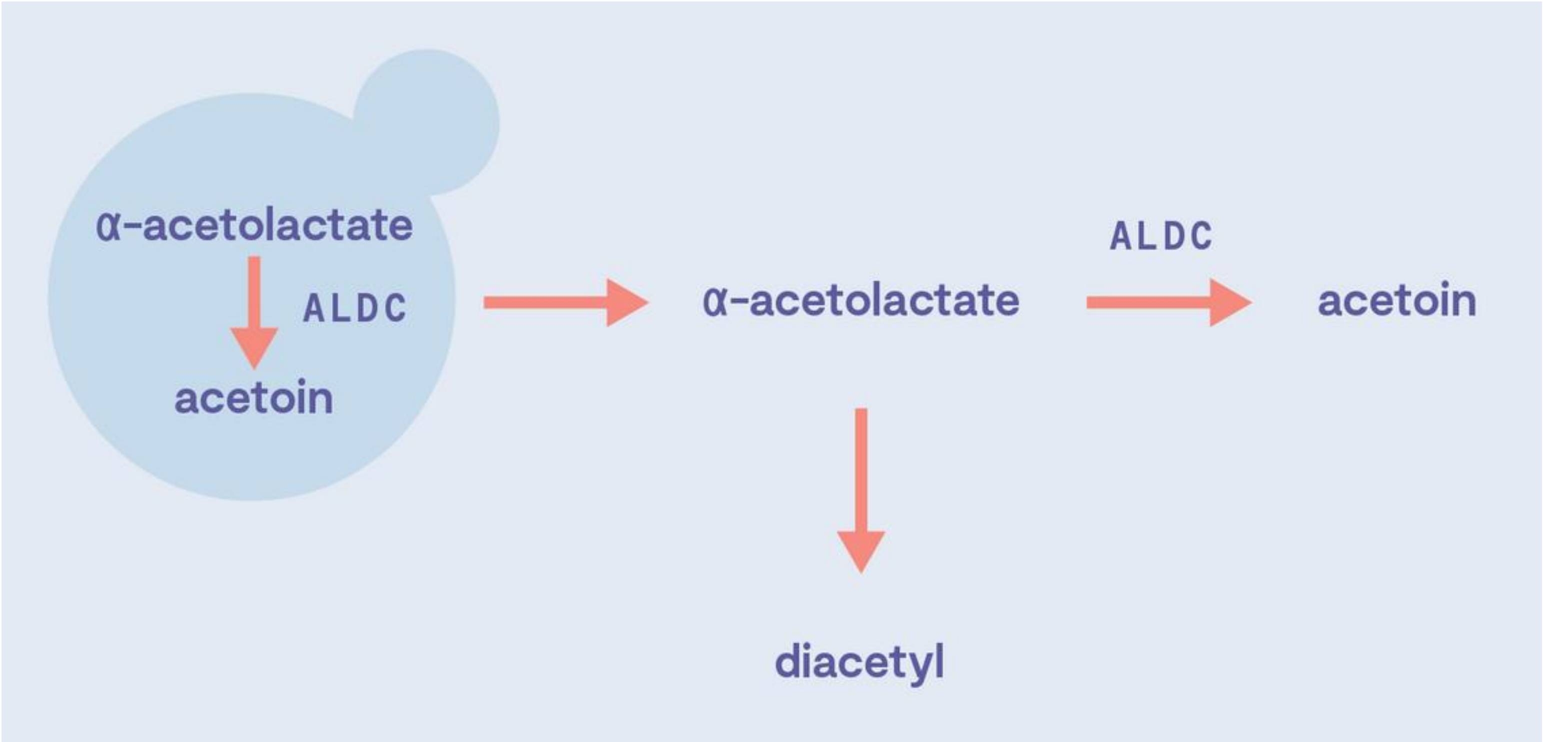
West Coast IPA

Use your Hop Creep
Mid to Late Fermentation DH and Ride it out
Target a drier finish



Hazy IPA

Try ALDC-Expressing Yeast
Try Cold, Short DH (perhaps with Flash Pasteurization)
Maintain desired full body



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Takeaways

- Hop creep happens and it is manageable!
- Think about changing your yeast strain and/or DH approach if you continue to see stubborn diacetyl or trailing fermentations
- Try ALDC-Expressing DKO Yeast!

Dry Hop Timing	Hop Creep	Haze	Repitching
Early (<25% Attenuation)	Fast	Reducing	Top Cropping
Mid (2-5°P to Terminal)	Fast	Promoting	Top Cropping
Late (At or Post Terminal)	Slow	Promoting	Bottom Cropping

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THANKS!

Dr. Allison Lange
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