

ASBC Annual Meeting

June 4–7 ■ Fort Myers, Florida

See what SCIENCE can brew for you

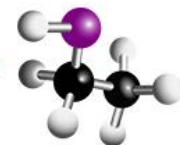
Dry Hopping and Stirring Pellets Increases Vicinal Diketones and Lowers Apparent Extract

Andrea Baillo, PhD

Melvin Brewing

Overview

- Background
- Experiment
- Results
- Conclusions
- Discussion



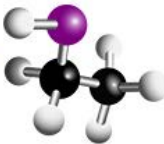
Dry Hopping Methods

At Fermentation Temp (68-70°F)

- At end of fermentation harvest/drop yeast, and cap FV
- Drop pellets in top of FV manway one day after capping
- Rouse with CO₂ from bottom of FV 48 hours post-DH
- Crash 7-10 days post-DH (brand dependent)

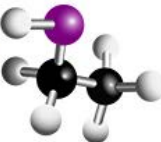
At 60°F

- Allow beer to reach VDK specification, lower temp to 60°F
- Harvest/drop yeast and drop pellets in top of FV manway
- Rouse with CO₂ from bottom of FV 48 hours post-DH
- Crash 7-10 days post DH (brand dependent)



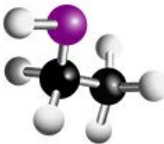
Measuring Attributes

- DMA35: monitor gravities daily until beer is crashed
- Spectrophotometer - Vicinal Diketones (VDK): ASBC-Beer25 (Broad Spectrum VDK)
 - Diacetyl belongs to VDK chemical group that give an undesirable buttery, butterscotch-like flavor
- Microscope: ASBC-Yeast4



History

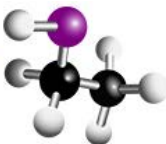
- 1893: Diastase in hops was reported
 - “We are now to ascertain how far the sugars of the hop are accountable for the after-fermentation induced of dry hopping” *Morris and Brown. “The Brewers Guardian.”*
- 1941: Brown and Morris’s work is confirmed. There are one or more factors that operate in stimulating “after fermentation” during dry-hopping
 - “commercial hops contain a little active maltase and from that it would seem probable that a portion of the reducing sugar which is produced by dry-hopping a dextrinous beer, is glucose derived by the action of hop maltase on maltose” *Walker et.al. “The Diastatic Activity of Hops Together with a Note on Maltase in Hops.”*



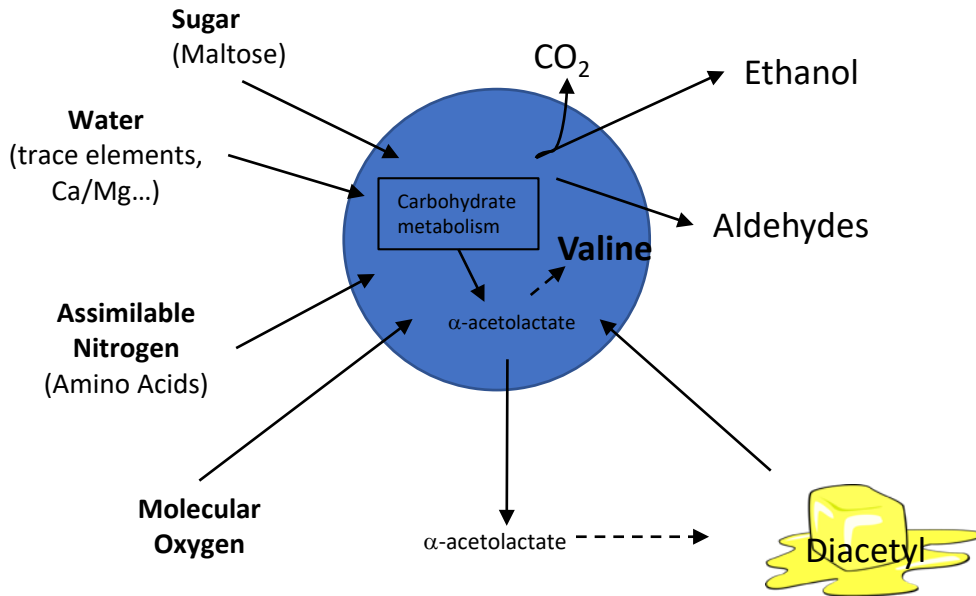
Fermentation biochemistry

Lewis and Young, "Brewing"

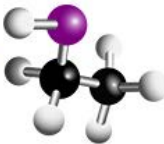
- Yeast metabolic pathways are influenced by the composition of the environment
- Factors with the greatest influence on the production of minor metabolites are:
 - **Amino acid content and amount**
 - Presence of molecular oxygen
 - **High fermentation temperatures**
 - **Mixing or agitation of fermentation**
 - Speed at which yeast is separated from beer



Yeast Metabolism

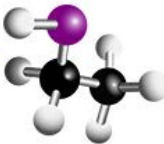


- Amino Acids (AA) are essential for yeast metabolism
- Diacetyl production in beer is related to biosynthesis of valine
 - α -acetolactate is excreted by yeast and non-enzymatically converted to VDKs
- In dry hopped beer most AA in the wort have been assimilated
- Yeast may be forced to autonomously produce their own amino acids in a nutrient depleted environment



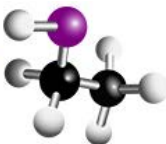
Secondary Fermentation

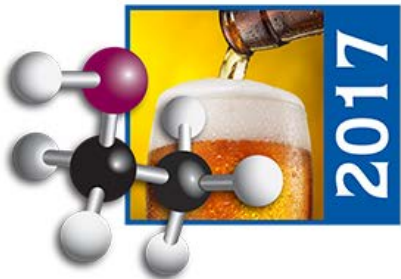
- A slower process at lower temperatures which follows primary fermentation
- Increased VDKs in fully attenuated beer after dry hop suggests yeast are utilizing added sugar in a nitrogen deprived environment and are autonomously producing AA



Experiment

- Beer was dry hopped at fermentation temperatures or at temperatures 8-10°F lower
- After KO samples were collected daily
 - Cells were counted
 - Beer was filtered
 1. Distilled and VDK measured
 2. Apparent extract was measured





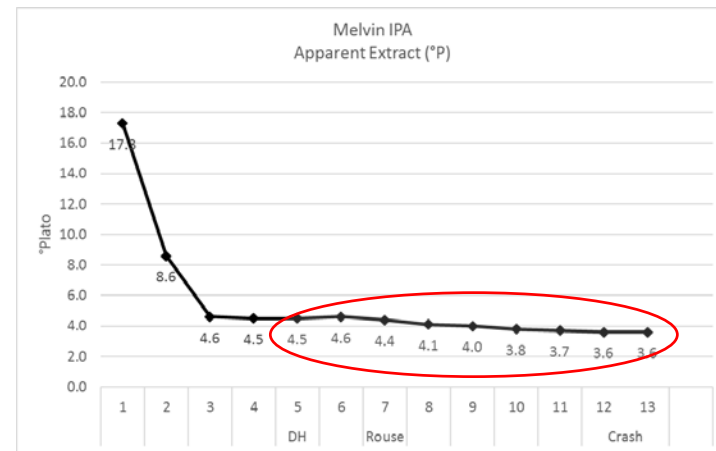
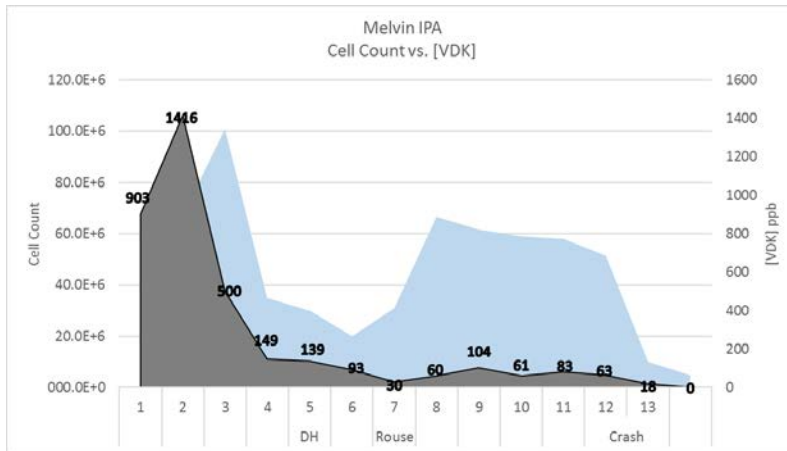
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Results

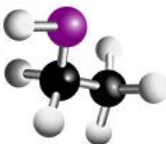
VDK concentrations increase and gravity decreases after dry hopping at fermentation temperature (70°F)



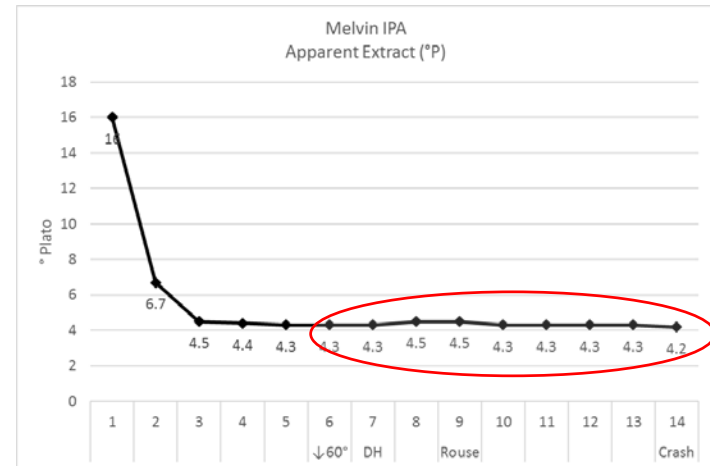
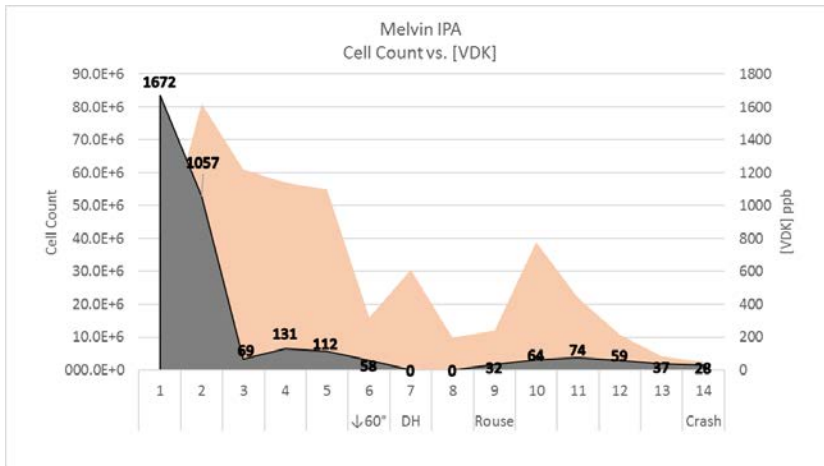
Post rousing:

- ↑ Cell Count
- ↑ [VDK]
- ↓ Apparent Extract

The data here suggests Melvin IPA undergoes secondary fermentation when dry hopped at 70°F



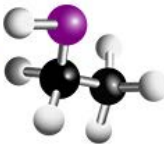
Secondary fermentation can be subdued by decreasing the temperature to 60°F before dry hopping



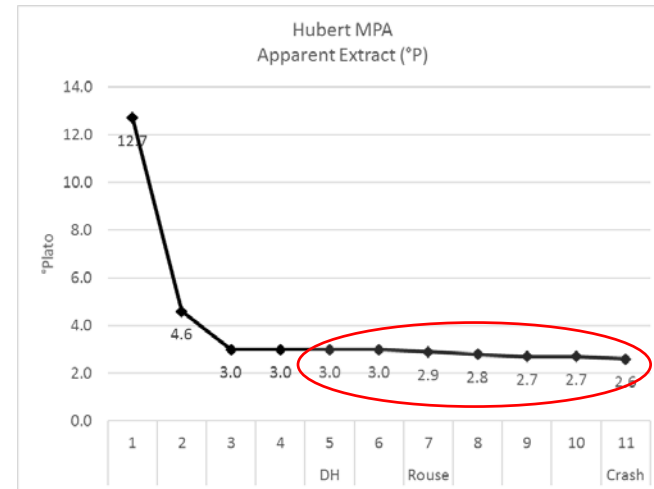
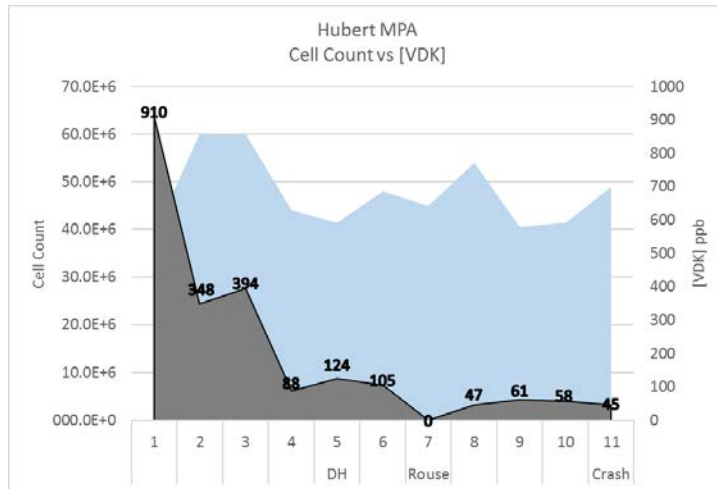
↓ 60°F before DH & Post-rousing:

- ↑ Cell Count
- ↑ [VDK]
- ↓ Apparent Extract

The effects of the secondary fermentation are reduced when FV temp is lowered before Melvin IPA was dry hopped



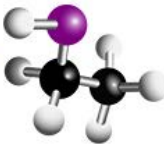
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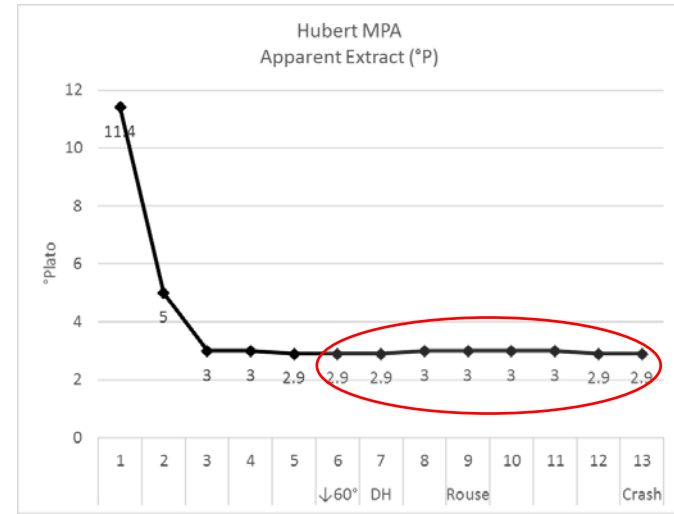
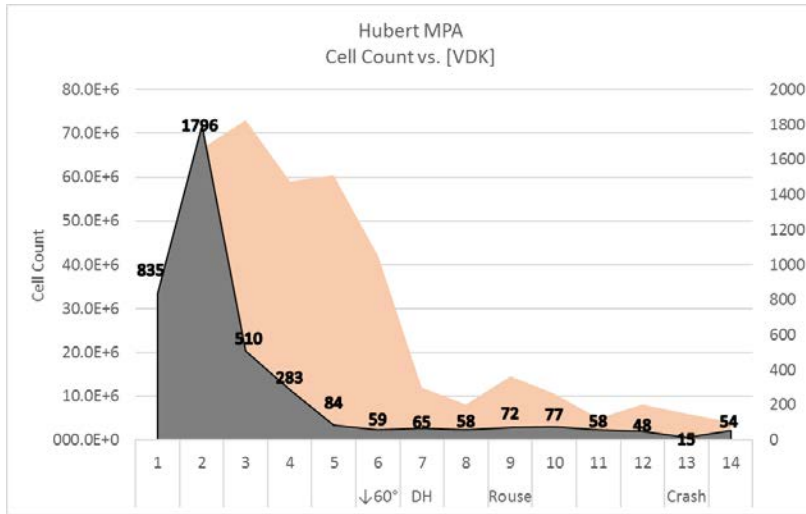
Post rousing:

- ↑ cell count
- ↑ [VDK]
- ↓ gravity

The data here suggests Hubert MPA undergoes secondary fermentation when dry hopped at 70°F



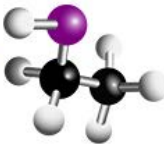
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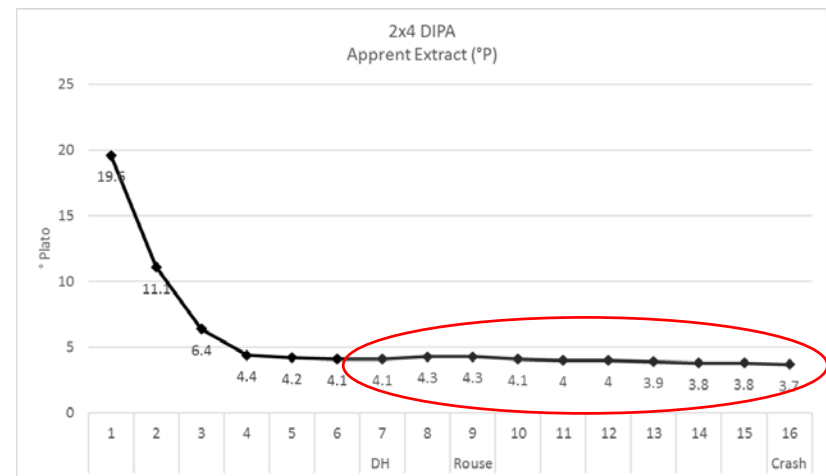
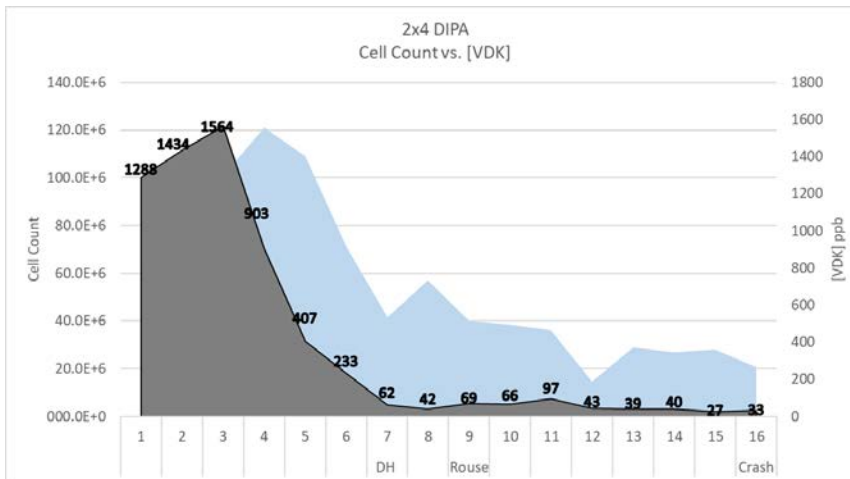
↓ 60°F before DH & Post-rousing:

- ↑ Cell Count
- ↑ [VDK]
- ↓ Apparent Extract

The effects of the secondary fermentation are reduced when FV temp is lowered before Hubert MPA was dry hopped



VDK concentrations increase and gravity decreases after dry hopping at 68°F



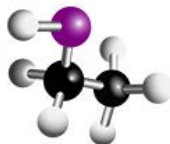
Post rousing:

-↑ cell count

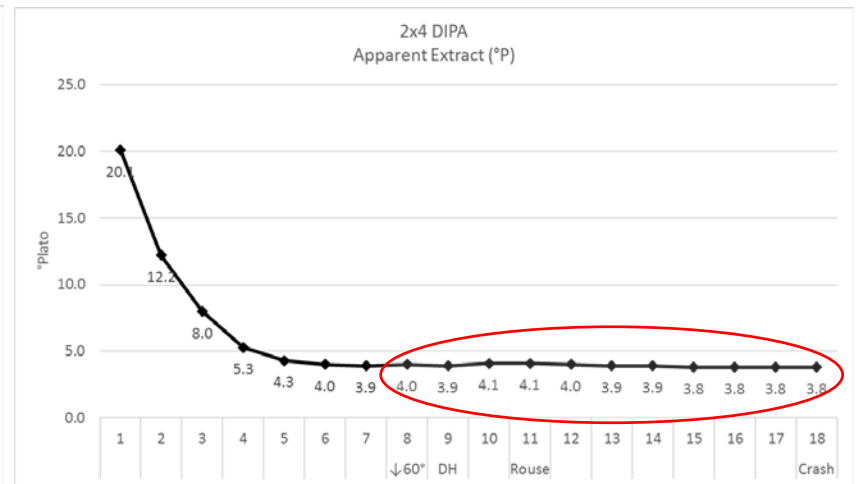
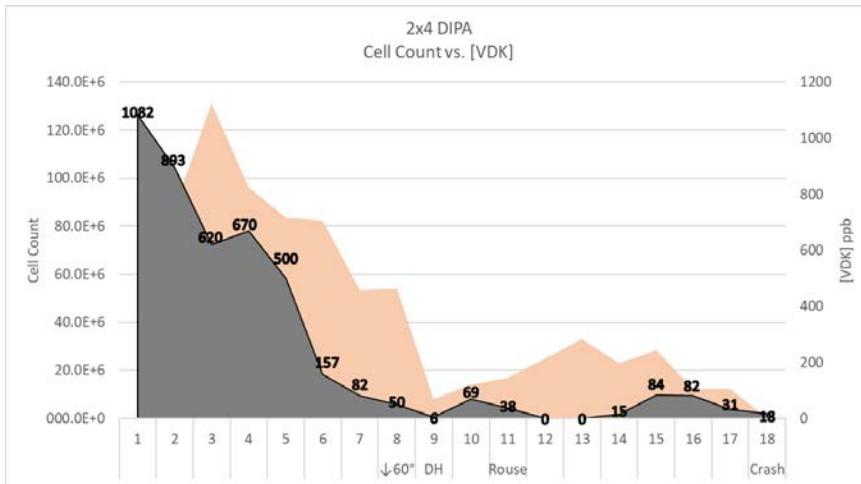
-↑ [VDK]

-↓ Apparent Extract

The data here suggests 2x4 DIPA undergoes secondary fermentation when dry hopped at 68°F



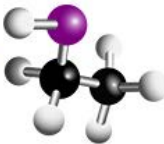
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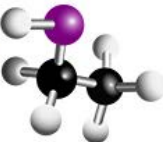
! 60°F before DH & Post-rousing:

- ↑ Cell Count
- ↑ [VDK]
- ↓ Apparent Extract

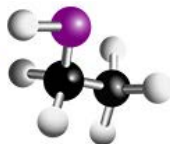
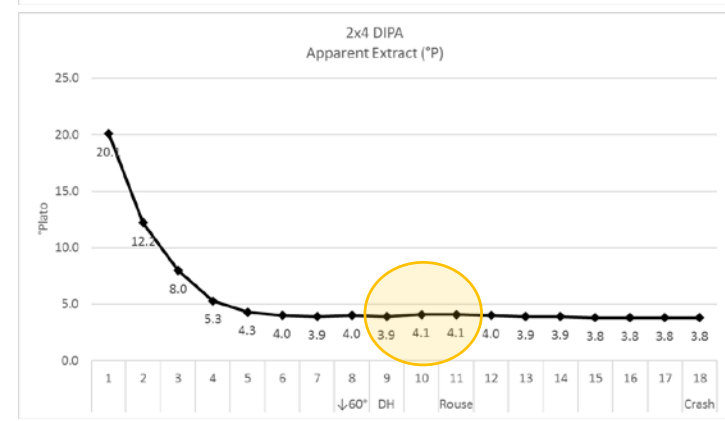
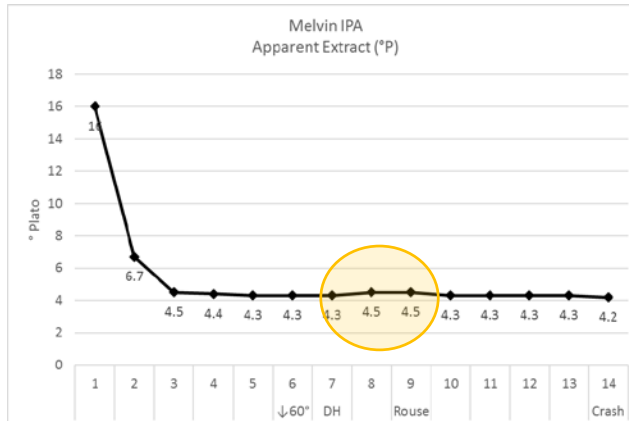
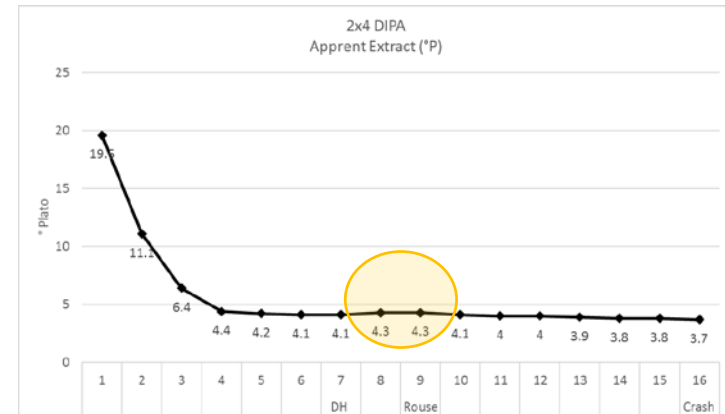
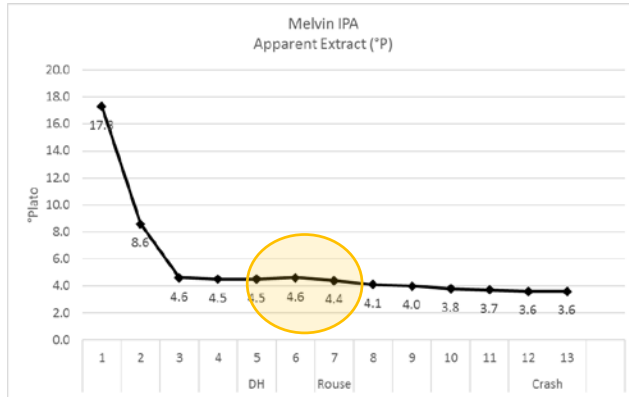
The effects of the secondary fermentation are reduced when FV temp is lowered before 2x4 DIPA was dry hopped



**Beers are undergoing fermentation
post dry hopping as suggested by
VDKs and Apparent Extract**

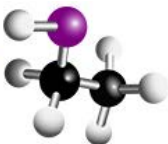


There is an observed increase in gravity of approximately 0.1-0.2°P post-DH



Conclusions

- Lowering the fermentation temperature
 - subdues the production of the metabolite diacetyl
 - subdues the decline in apparent extract observed during secondary fermentation
- The apparent extract increases after adding hop pellets and before stirring the yeast and hops
- This data is suggestive of secondary fermentation in the presence of agitated yeast after dry hopping



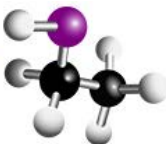
Future experiments

- Measure FANs daily
- Measure Valine daily
- Enzyme specific assays
 - Isolate enzyme responsible
- Carbohydrate metabolism



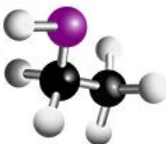
Discussion

- The large amount of hops used in hop forward breweries is potentially the reason for the exaggeration of the secondary fermentation
- A slight increase in gravity after DH and before stirring yeast → enzymatic activity
 - Unfermentable sugar conversion
 - Hops have enzymatic activity
 - Maltase
- Microorganisms
 - *Saccharomyces diastaticus*
 - Presence of undetectable microorganism



WHY do we care??

- Brewers Association reports
 - 2015: 4,326 pubs/microbreweries & 178 regional breweries
 - 2016: 14% increase in pubs/microbreweries & 4% increase in regional breweries
- Smaller breweries do not have the lab power to study secondary fermentation
 - Affects quality of product – prolonged diacetyl
- Regional breweries need to be aware
 - Affects planning and production schedules



Thank You

- Melvin Brewing Team
- American Society of Brewing Chemists
- Kate Devine, Russian River Brewing
- Dan Driscoll, Avery Brewing



Questions???

