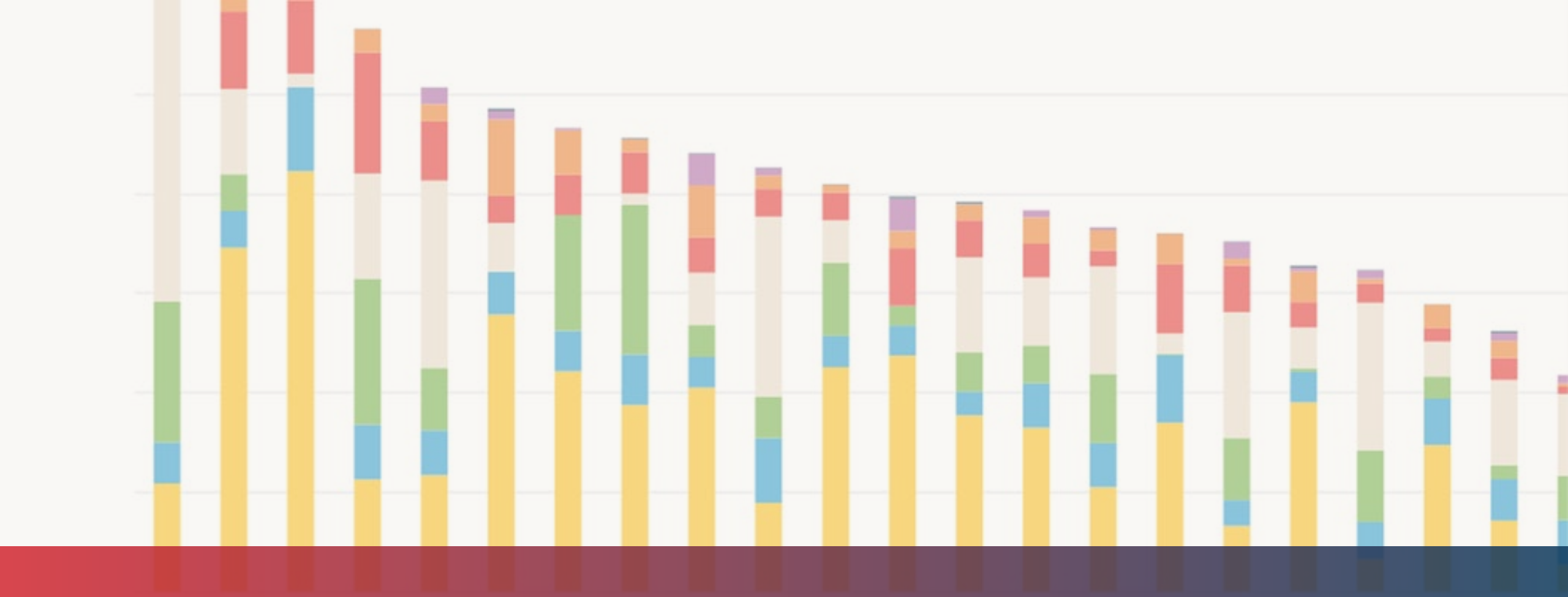

Survivable Compounds

Jacqueline Brummett

HOP & BREW SCHOOL

Presentation Overview

Analytical Journey

- What are the survivables?
- Past and present analytical instrumentation
- Data availability

Survivables Chart

- CY24 Chart
- Utilization

Geraniol Biotransformation

- What is it?
- Current research at YCH

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What are the survivables?

- The ‘survivables’ are beer soluble compounds derived from hops that survive the brewing process.
- The current target compounds include:
  - Linalool
  - Geraniol
  - Isobutyl isobutyrate
  - Isoamyl isobutyrate
  - 2-nonanone
  - Methyl geranate
  - 3-mercaptohexanol (3MH)

Survivable Compounds

Geraniol

- Monoterpene alcohol
- Can survive late boil and whirlpool additions
- Rose-like and citrus aromas

Linalool

- Monoterpene alcohol
- Commonly survives the brewing process
- Strong fruity and floral aromas

2-nonanone

- Ketone
- Can be sweet and fruity
- Can be cheesy, buttery or waxy

Methyl geranate

- Methyl ester
- Fruit and floral aroma

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Survivable Compounds

Isobutyl isobutyrate

- Hop derived ester
- Fruity and pineapple aromas

Isoamyl isobutyrate

- Hop derived ester
- Fruity and tropical aromas

2-methylbutyl isobutyrate

- Hop derived ester
- Fruity aromas specifically apricot

3-mercaptohexanol (3MH)

- Sulfur-containing compound
- Tropical, grapefruit and passionfruit aromas

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Where It All Began

- The original survivables data was collected on this instrument.
- Agilent 6890N GC and a 5975B MS
- Analyzed 1100 hop samples during harvest 2018
- Analyzed ~640 between harvest 2019 and 2020
- Analyzed 600+ beer samples since 2018

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Research Ramp-Up

- Survivables analysis was transferred into the newest instrument in 2019
- Agilent 7890B GC, 7200 MS with a quadrupole time-of-flight (Q-ToF) and a sulfur chemiluminescence detector.
- Data from this instrument helped develop the Cryo Pop® blend.

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Established Analytical Method

- New GCMS with SCD system installed in late 2021 to development a more efficient method of analysis.
- Agilent 7890B GC, 5977B MS and SCD.
- This system utilizes the total oil samples already produced by the QC lab.
- This method has been in use for reporting survivables since 2022.

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Data Availability

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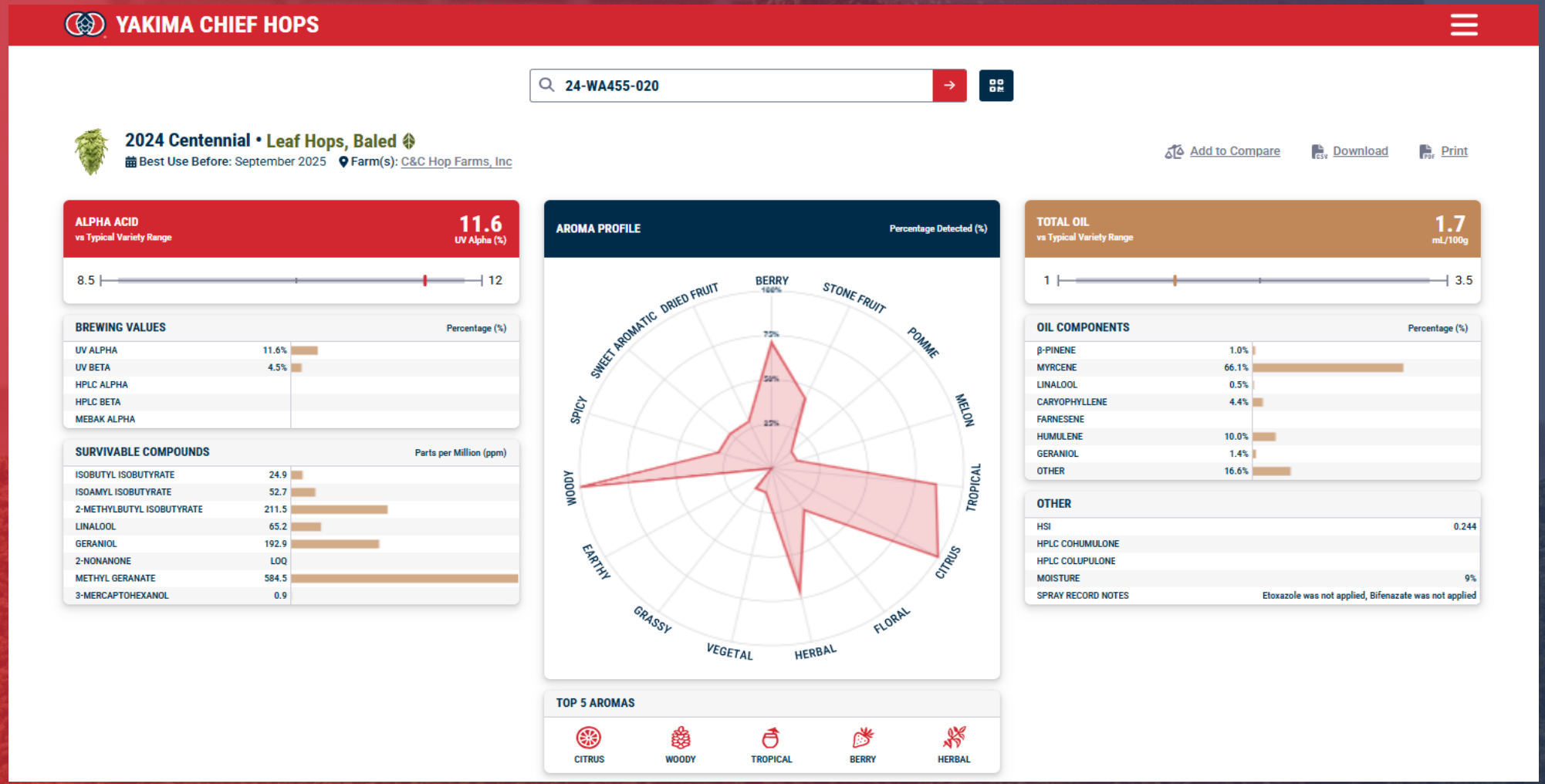

CY2024 Chart

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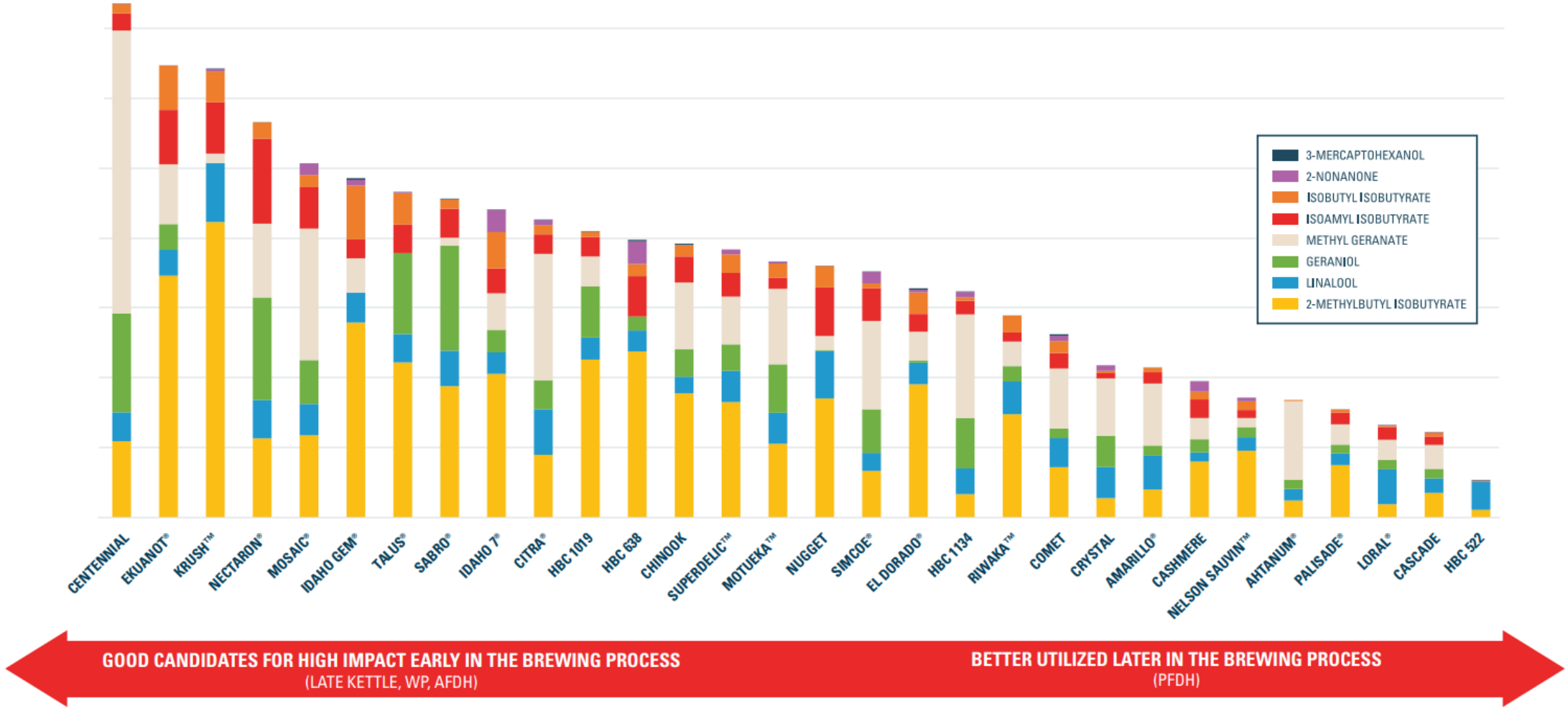

Chart Utilization: Addition Timing

Use high survivables hops early (or late)

- Hops with higher concentrations of survivable compounds are likely to be more successful when used earlier in the brewing process (late kettle, WP or AFDH)
- Krush® would be a better choice than Loral®

Use low survivable hops late

- Hops with lower concentrations of survivable compounds will likely be more successful when used later in the brewing process (PFDH).
- Cashmere or Palisade® would have a better impact when used later.

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Chart Utilization: Addition Timing

Load wort streams with high survivables early

- High concentrations of survivables in whirlpool and active fermentation dry hopping can create conditions necessary for beneficial biotransformation.
- A whirlpool addition of Idaho 7® with AFDH of Sabro® and Simcoe® is likely to yield a huge flavor impact.

Blend hops to maximize beneficial concentrations

- Focus on balancing high concentrations when creating blends.
- Loral® is high in linalool and Talus® is high in geraniol, the two of them are likely to work well in concert. Loral® and Crystal are both high in linalool and would therefore likely create a less dynamic and more one-dimensional blend.

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Geraniol Biotransformation

- Investigating the biotransformation of geraniol during fermentation using a deuterated (isotopically flagged) chemical standard
- First time this phenomenon has been studied using a deuterated chemical standard
    - Essentially leaves a ‘flag’ behind wherever the compound was involved in a chemical reaction
- Citronellol is the main final product of this phenomenon
- Reaction pathways involved
    - Reduction into citronellol
    - Esterification (acetylation) into citronellyl acetate and geranyl acetate
    - Hydrolysis of acetate products back into citronellol and geraniol

THANK YOU!

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