Evaluation of the impact of wildland fire on hops

Development of a non-targeted analytical method to detect smoke-derived contamination

ASBC
THE SCIENCE OF BEER

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Authors

Brandon Sandoval (Presenting)
M.Sc. Student
Department of Horticulture

Katie Nasiatka, M.Sc.
Analytical Research Core
Colorado State University

Dr. Jacqueline Chaparro
Research Scientist
Department of Horticulture

Stacey Williams
Analytical Chemist
New Belgium Brewing Co.

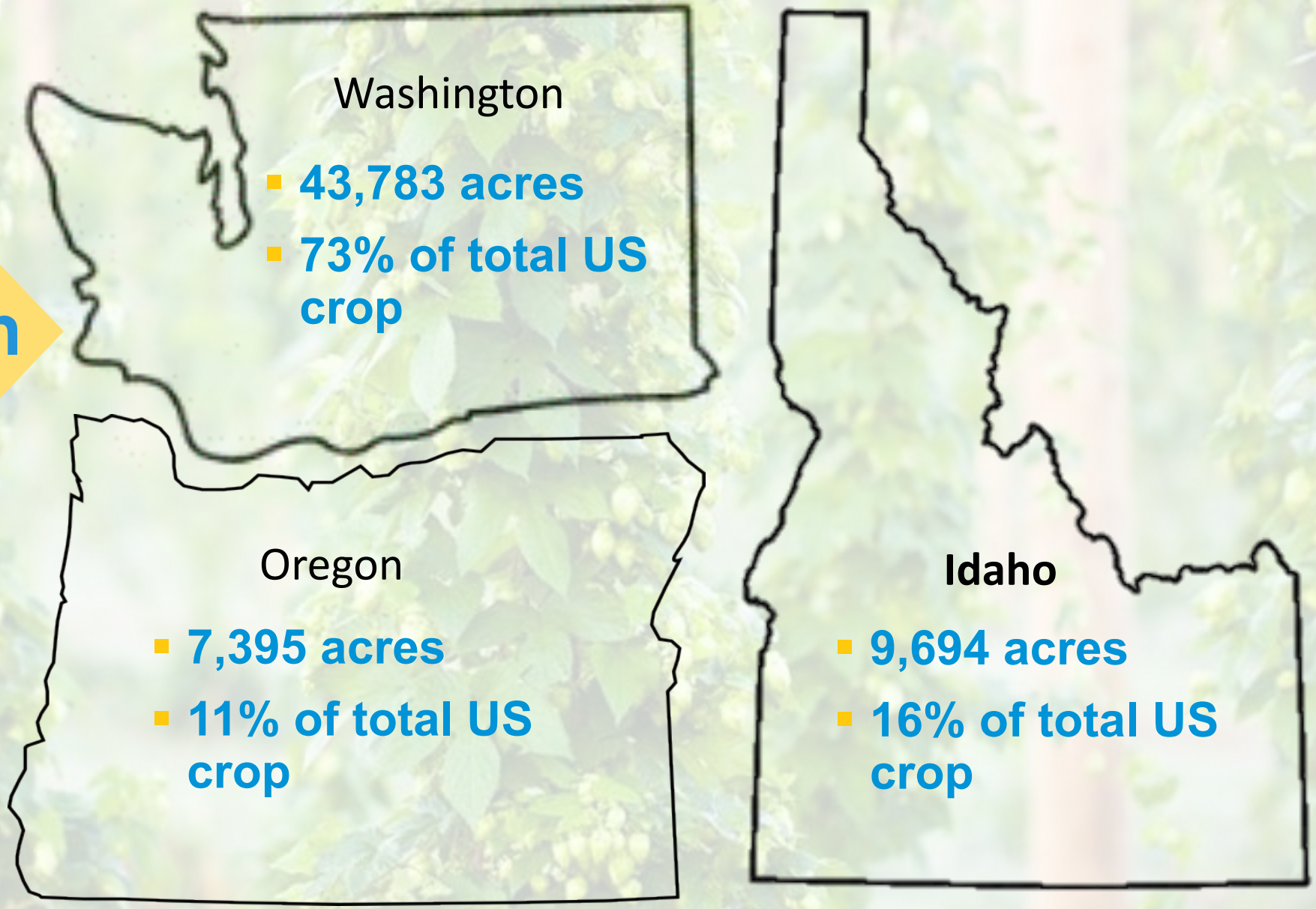
Dr. Jessica Prenni, PI
Professor
Department of Horticulture

US Hop Production 2021

40% global hop acreage

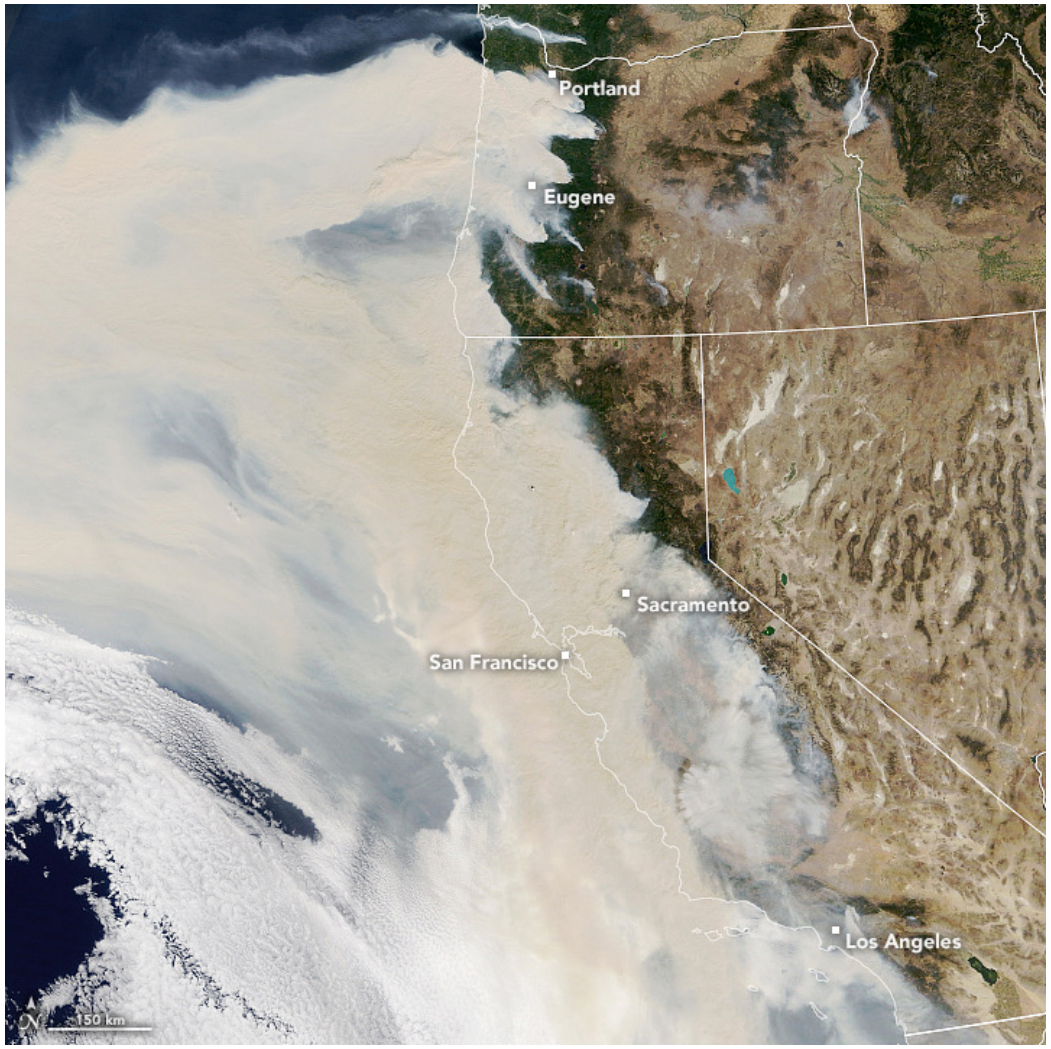
2021 Statistical Report - Hop Growers of America

US Hop Production 2021



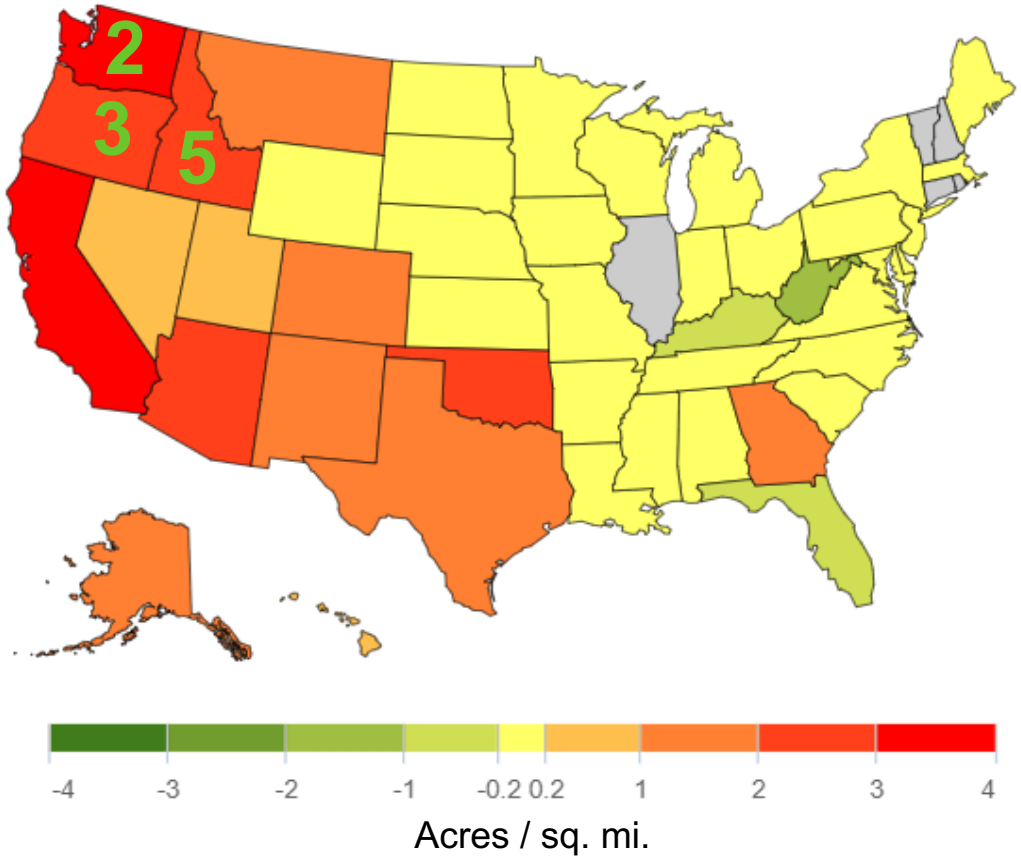
USDA National Hops Report (December 2021)

Wildfire Severity



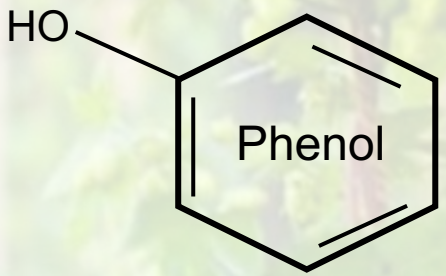
NASA – NASA Earth Observatory

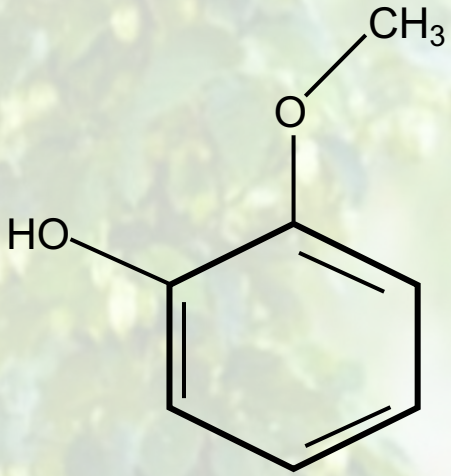
Change In Annual Burned Acreage By State
Years 1984 – 2001, 2002 - 2020



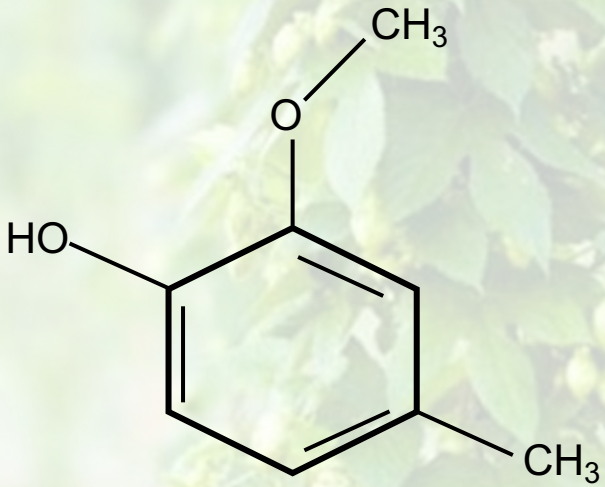
Climate Change Indicators - epa.gov

Volatile Phenols

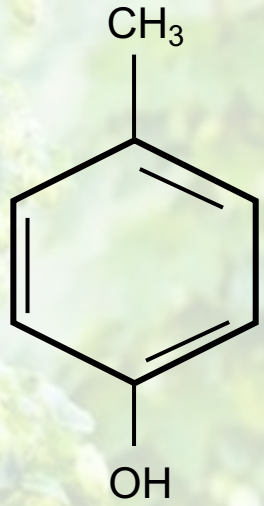




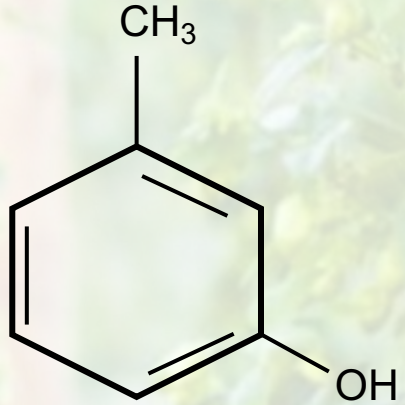
Guaiacol



4-Methyl guaiacol

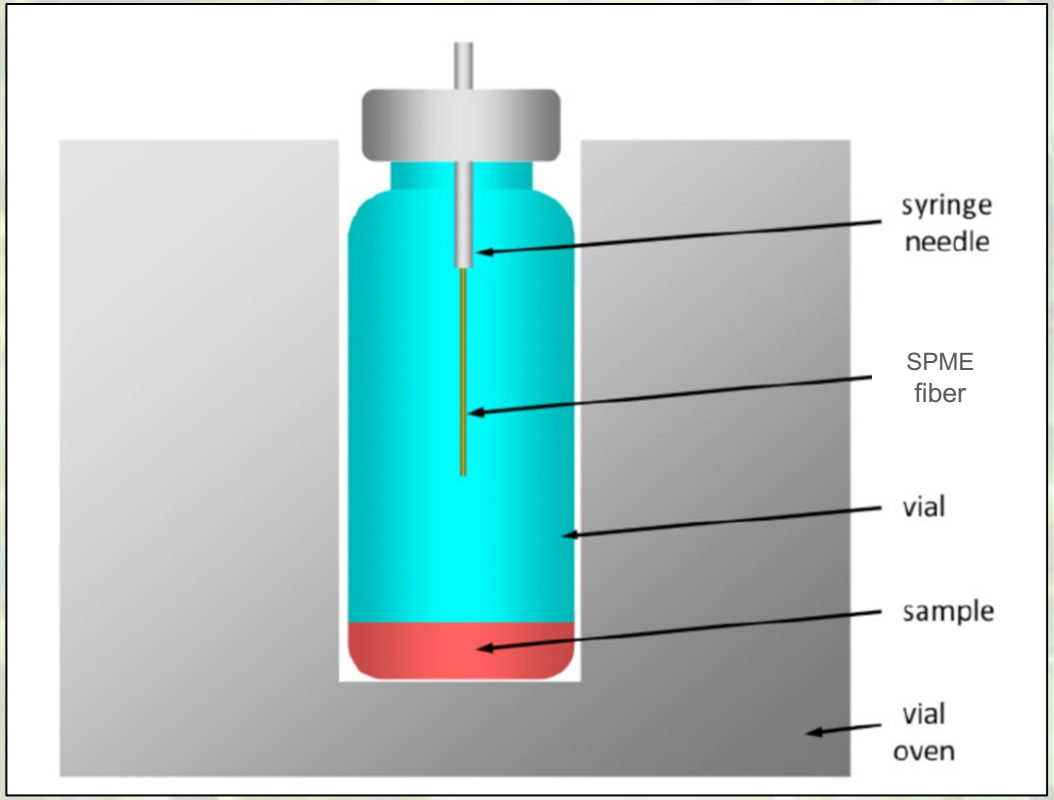


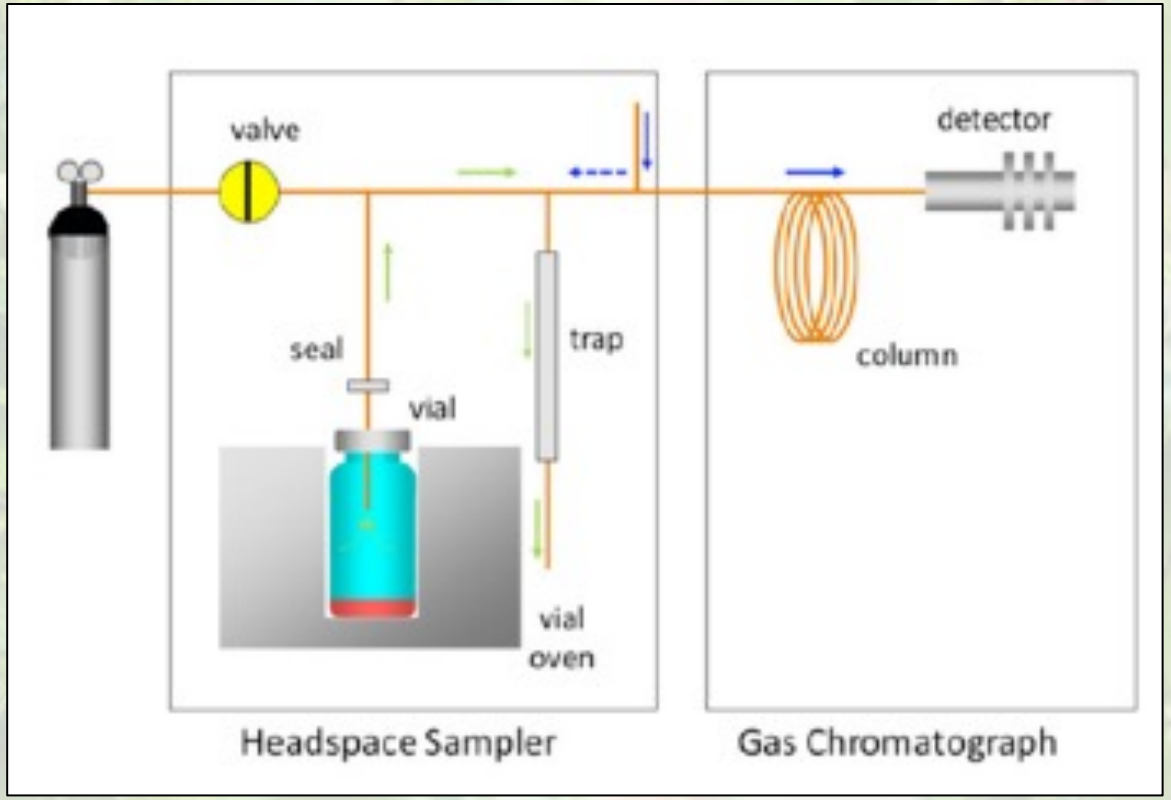
p-Cresol



m-Cresol

Solid Phase Microextraction Headspace Gas Chromatography (SPME HS GC-MS)





Mass Spectrometry

National Environmental Satellite Data and Information Service - NOAA

Characterizing Smoke-Taint

We hypothesize that multiple smoke-derived compounds can be identified within the volatile profile of smoke-exposed hops through non-targeted SPME HS GC-MS.

Targeted SPME HS GC-MS

Stacey “Smoke ‘Em” Williams and Justin “The Iron Dragon” Alexander

A HS-SPME Arrow/GC-MS Method for Determination of Smoke-Taint Related Volatile Phenols in *Humulus lupulus*

Williams, S., & Alexander, J. (2021). A HS-SPME Arrow/GC-MS method for determination of smoke taint-related volatile phenols in *humulus lupulus*. *Journal of the American Society of Brewing Chemists*, *80*(2), 128–135. https://doi.org/10.1080/03610470.2021.1937779

Goal

To develop and validate a **non-targeted** chemical profiling method that can be used to **characterize smoke-taint in hops**; evaluating the impact of wildfire smoke.

Objectives

1. Develop a **non-targeted** method for detection of volatile compounds that are characteristic of wildland fire smoke on hops using Headspace gas chromatography – mass spectrometry (GC-MS).

2. Validate the method using “real world” hops that were exposed to wildland fire smoke during the 2020 growing season and compare to sensory methods.

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Objective 1: Experimental Design

Non-Exposed Hops

Cascade

Centennial

Smoke Exposure Treatments

Non-targeted SPME GC-MS and Data Analysis

Yakimahief.com

Objective 1: Experimental Design

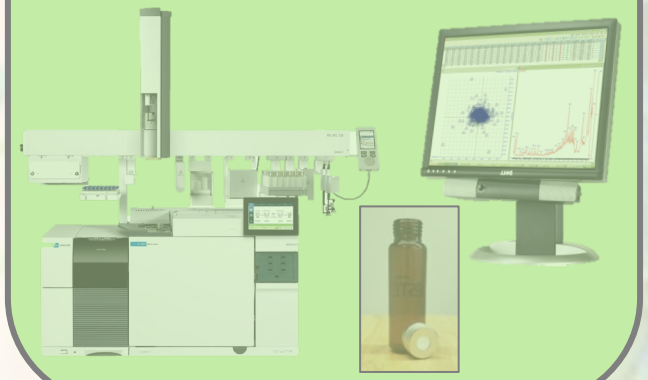
Non-Exposed Hops

Cascade

Centennial

Smoke Exposure Treatments

Non-targeted SPME GC-MS and Data Analysis



Yakimahief.com

Objective 1: Smoke Treatments

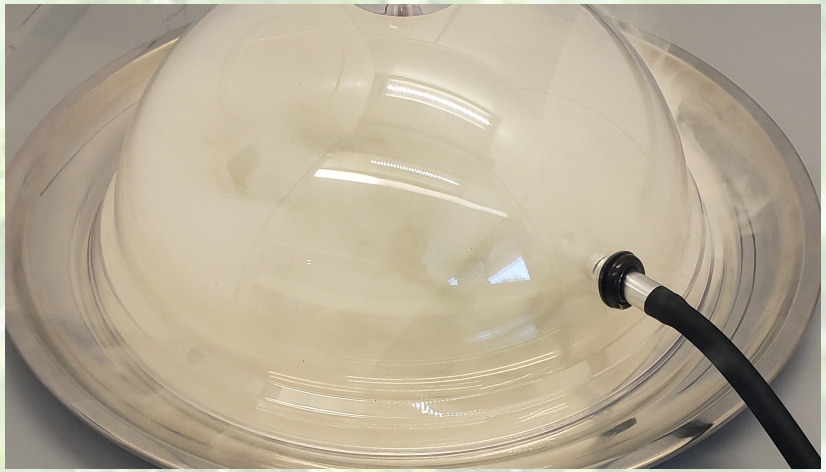
Two Cultivars

Cascade Centennial

Four Fuel Types

Yakimahief.com

Objective 1: Smoke Treatments



Method

- 2 grams of fuel per treatment
- 15 minutes of smoke exposure
- Cultivars treated independently

Objective 1: Experimental Design

Non-Exposed Hops

Cascade

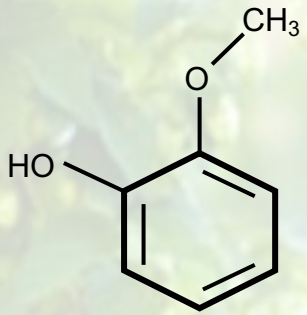
Centennial

Smoke Exposure Treatments

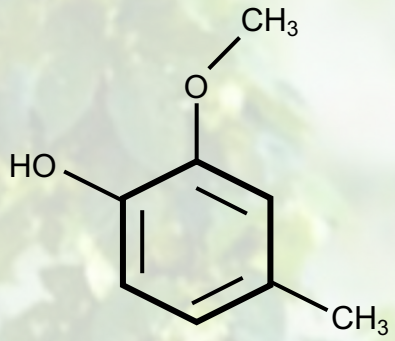
Non-targeted SPME GC-MS and Data Analysis

Yakimahief.com

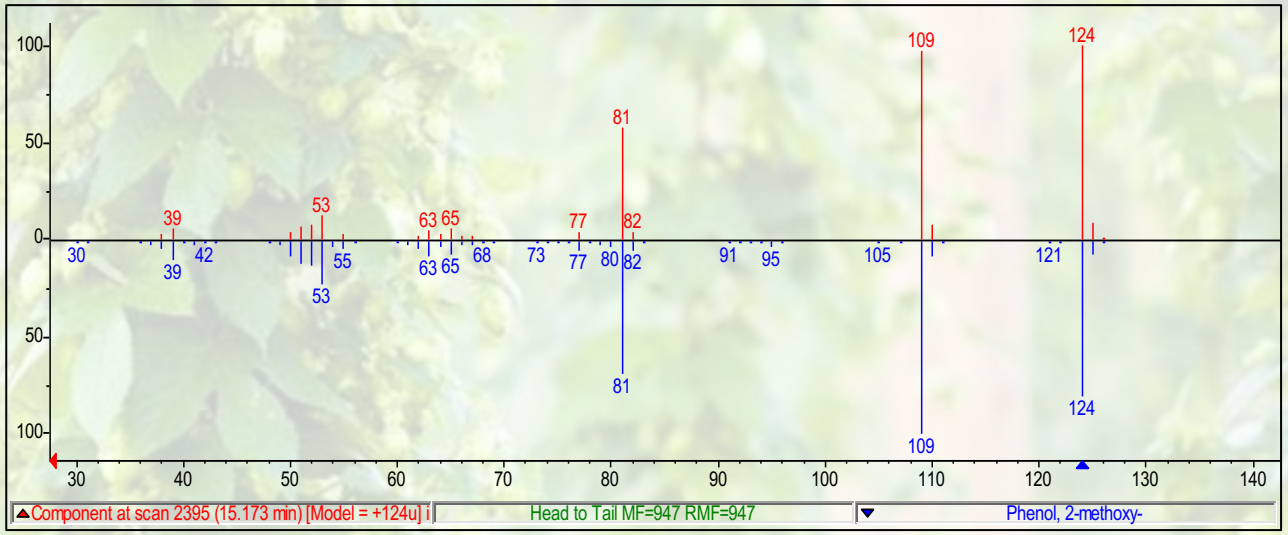
Objective 1: Preliminary Data

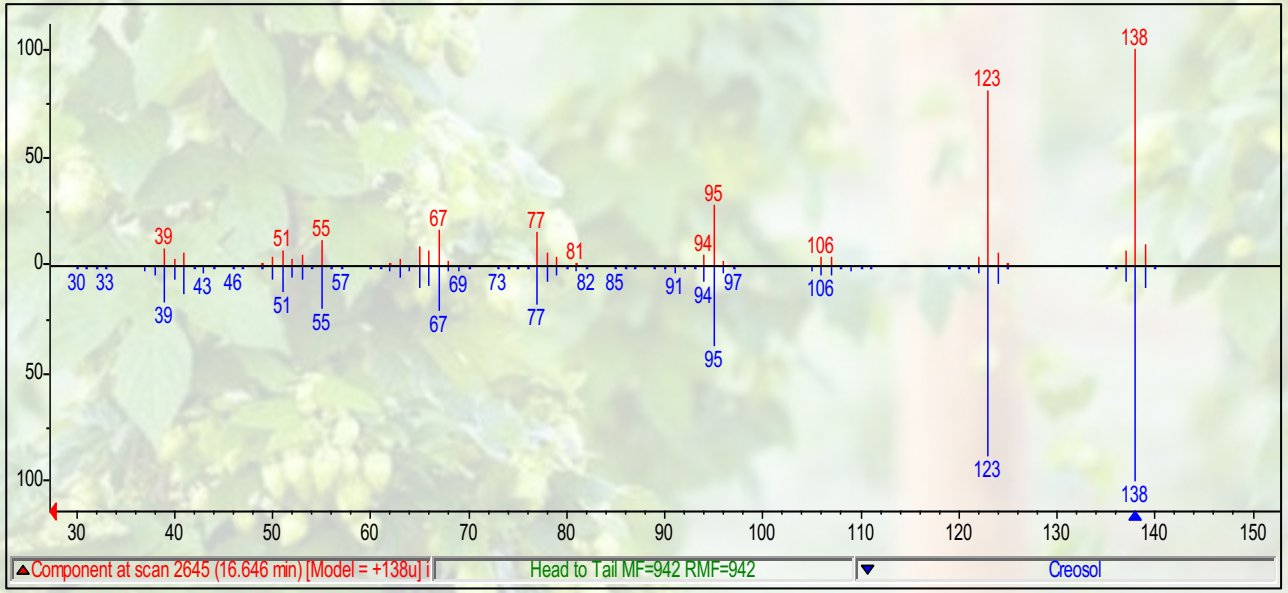


Guaiacol

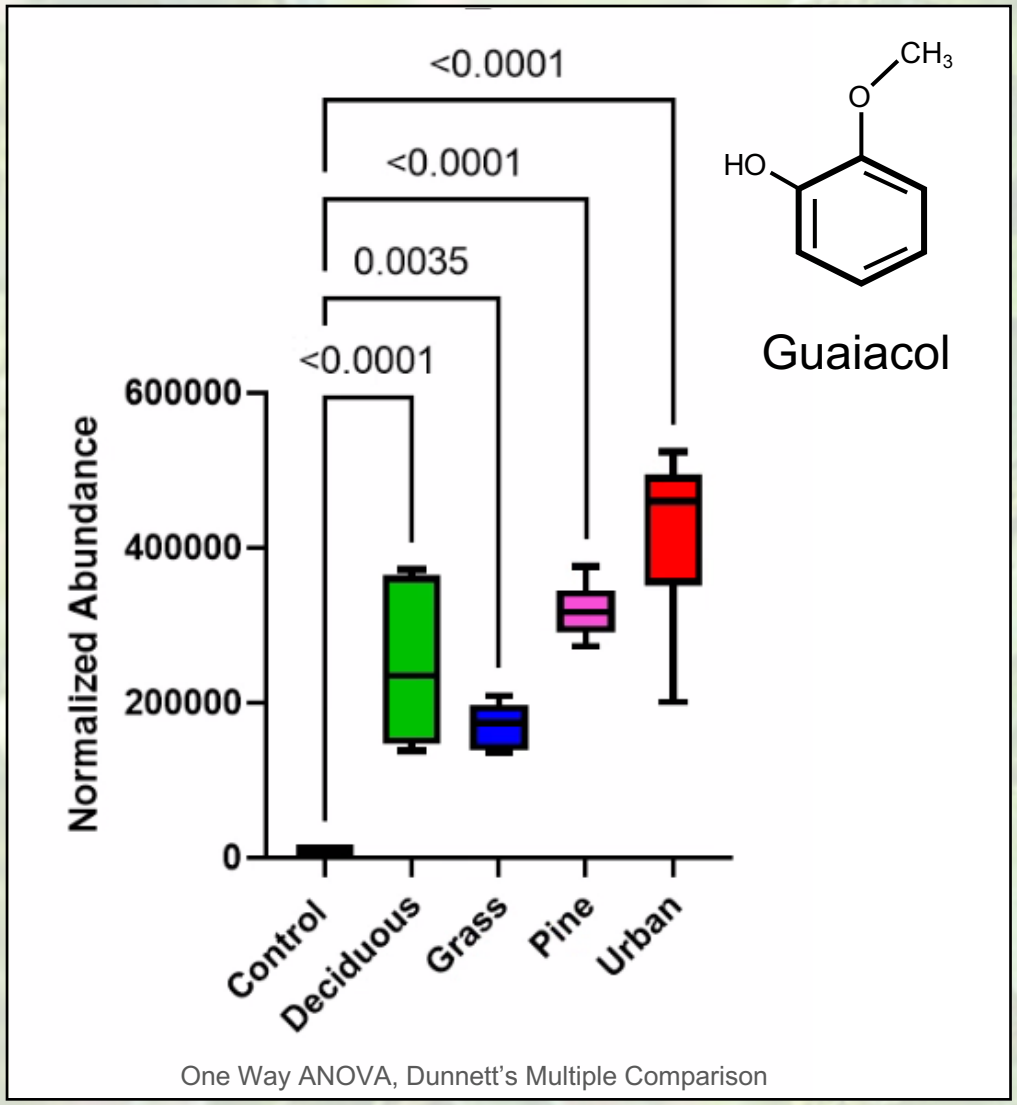


4-Methyl guaiacol

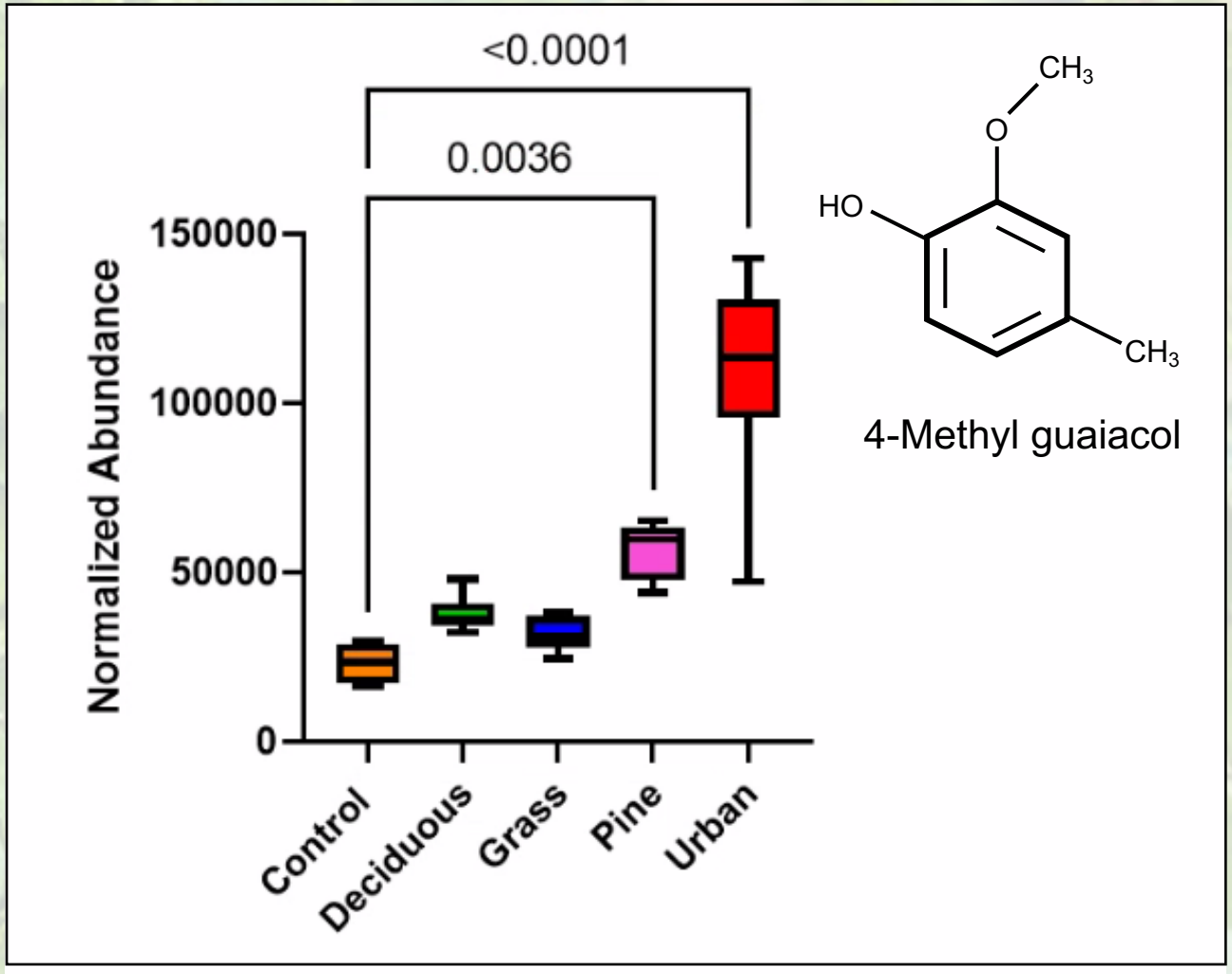




Objective 1: Preliminary Data



One Way ANOVA, Dunnett's Multiple Comparison



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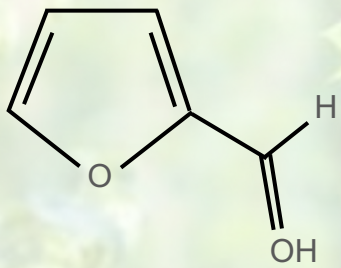
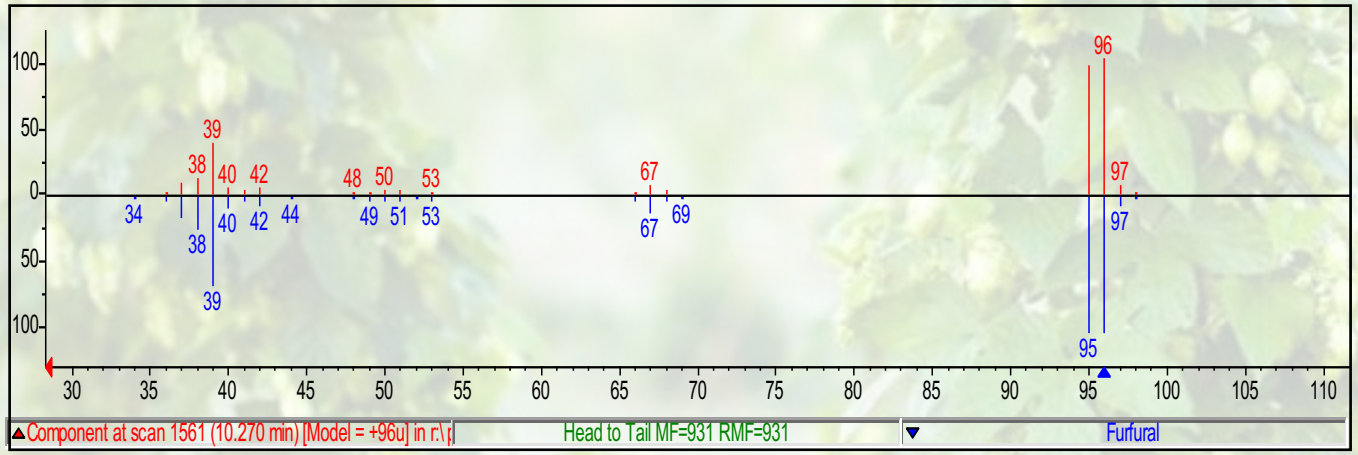
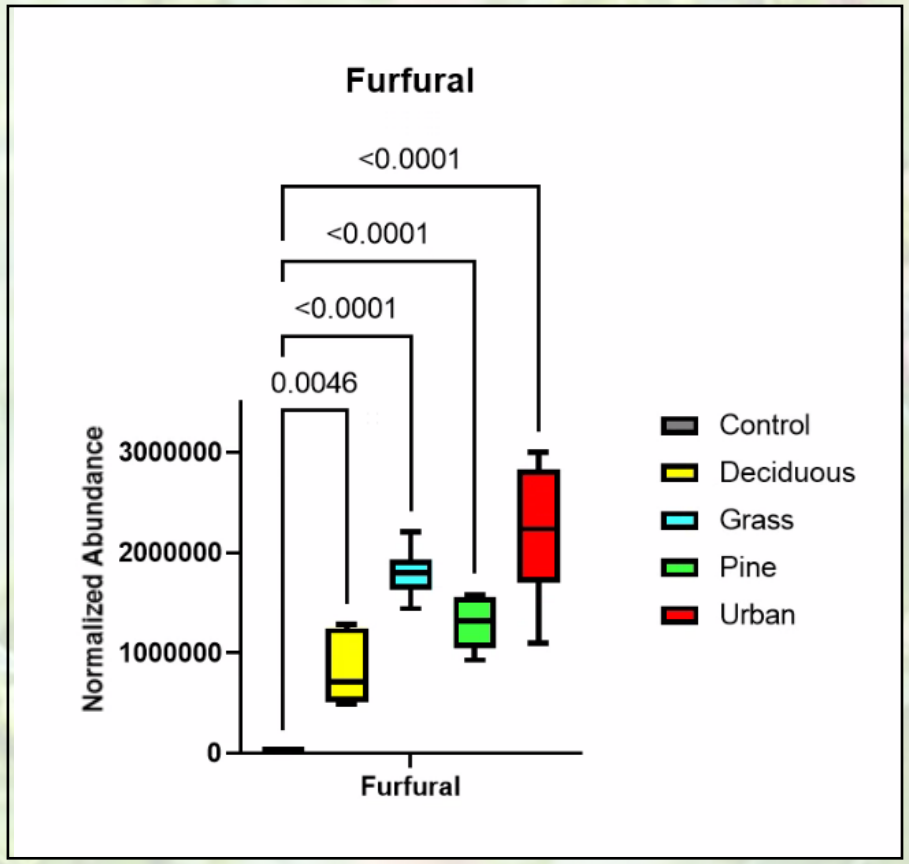


Furfural





Summary

Objective 1: Develop a **non-targeted** method for detection of volatile compounds that are characteristic of wildland fire smoke on hops using Headspace gas chromatography – mass spectrometry (GC-MS).

- Method **adapted** from **Williams & Alexander (2021) and modified for a novel non-targeted analysis.**
- Successful **detection** of common **smoke-taint** markers known to the wine industry
- Non-targeted approach enabled detection of other smoke-derived compound in hops

Goal

To develop and validate a **non-targeted** chemical profiling method that can be used to **characterize smoke-taint in hops**; evaluating the impact of wildfire smoke.

Objectives

1. Develop a **non-targeted** method for detection of volatile compounds that are characteristic of wildland fire smoke on hops using Headspace gas chromatography – mass spectrometry (GC-MS).

2. Validate the method using "real world" hops that were exposed to wildland fire smoke during the 2020 growing season and compare to sensory methods.

Objective 2: Experimental Design

Crop Year 2020

Non-targeted SPME GC-MS and Data Analysis

Consumer Sensory Panel

Yakimachief.com

Objective 2: Experimental Design

Crop Year 2020

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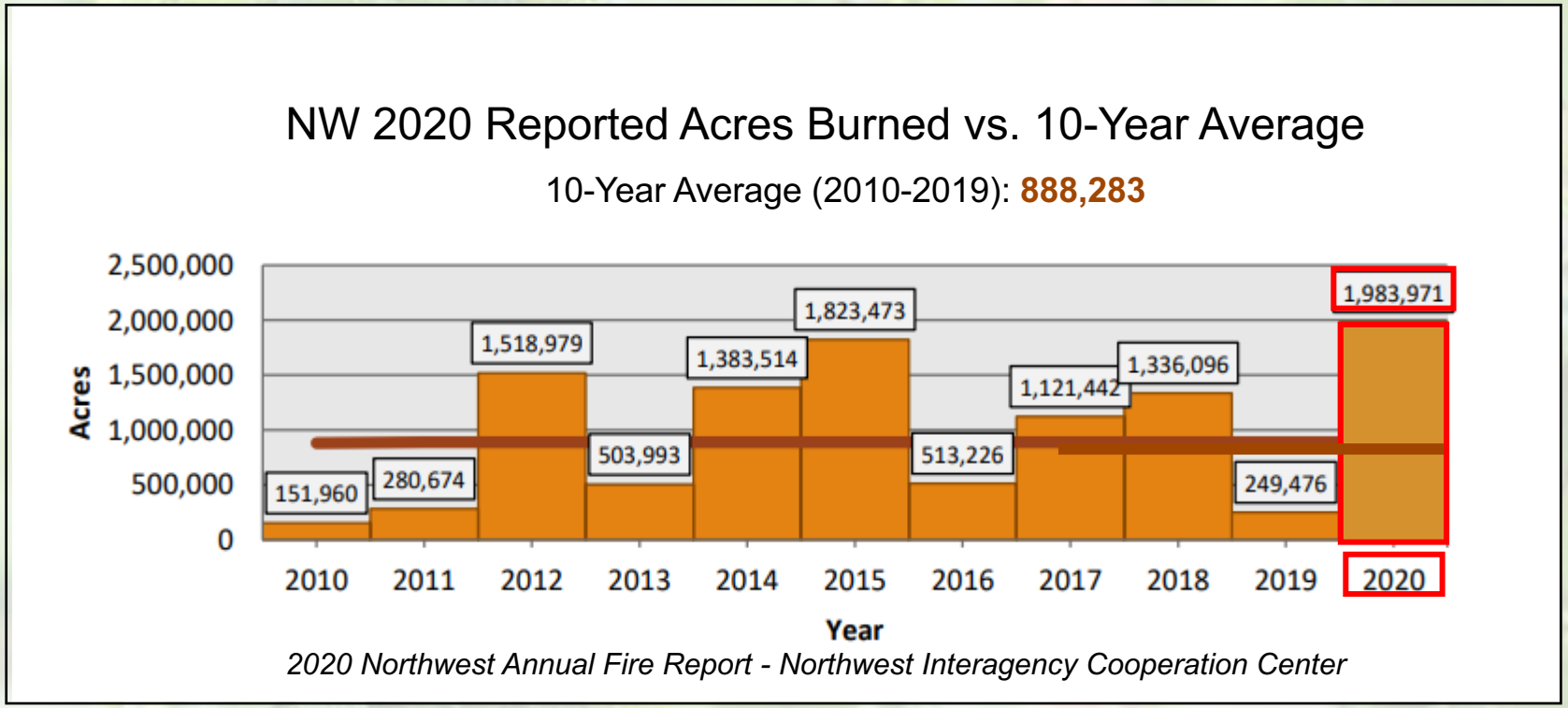
Objective 2: Crop Year 2020



Objective 2: Crop Year 2020

Smoke Reported at Harvest:

- None
- Medium
- High

Yakimachief.com

Objective 2: Experimental Design

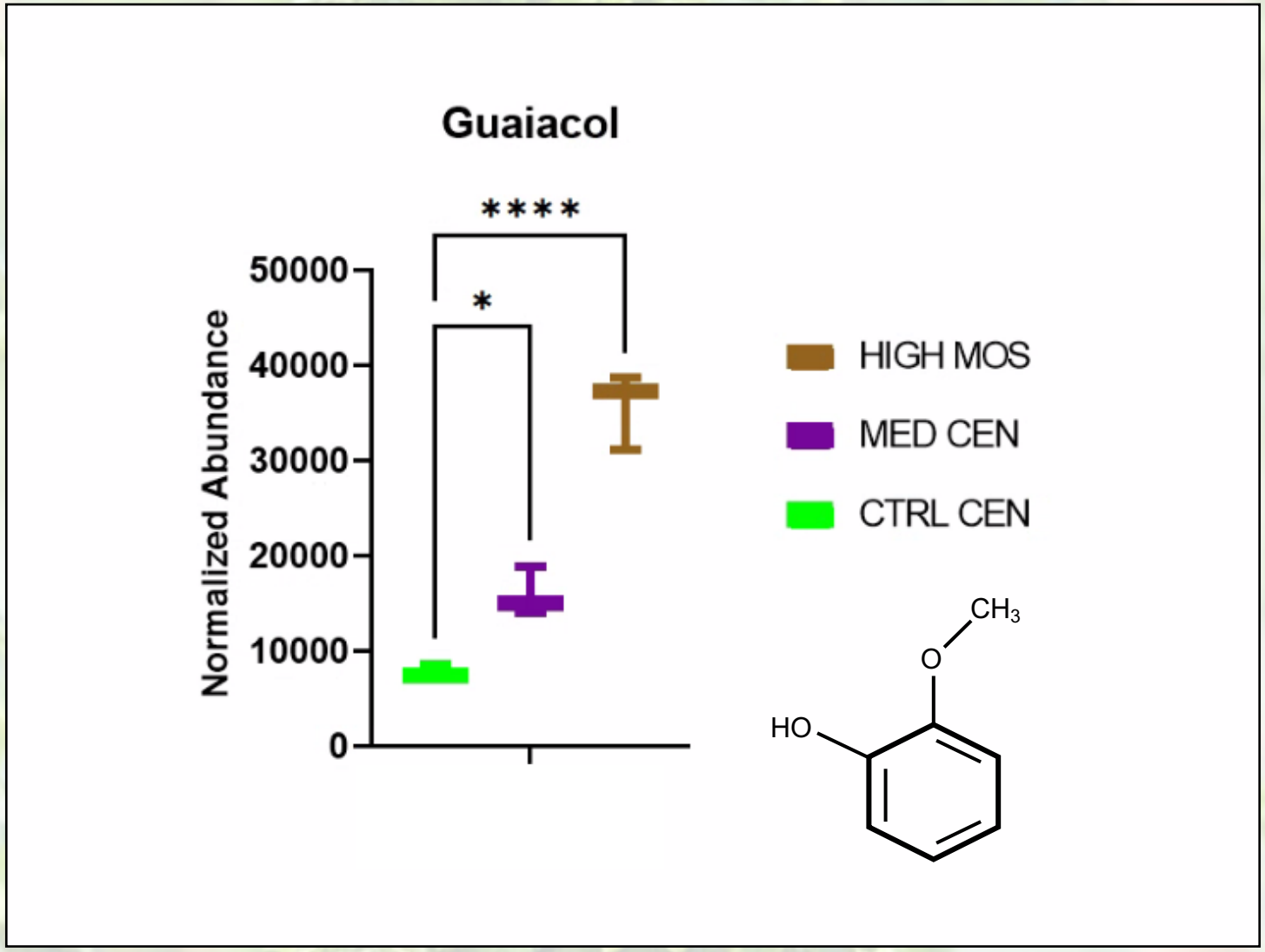
Crop Year 2020

Non-targeted SPME GC-MS and Data Analysis

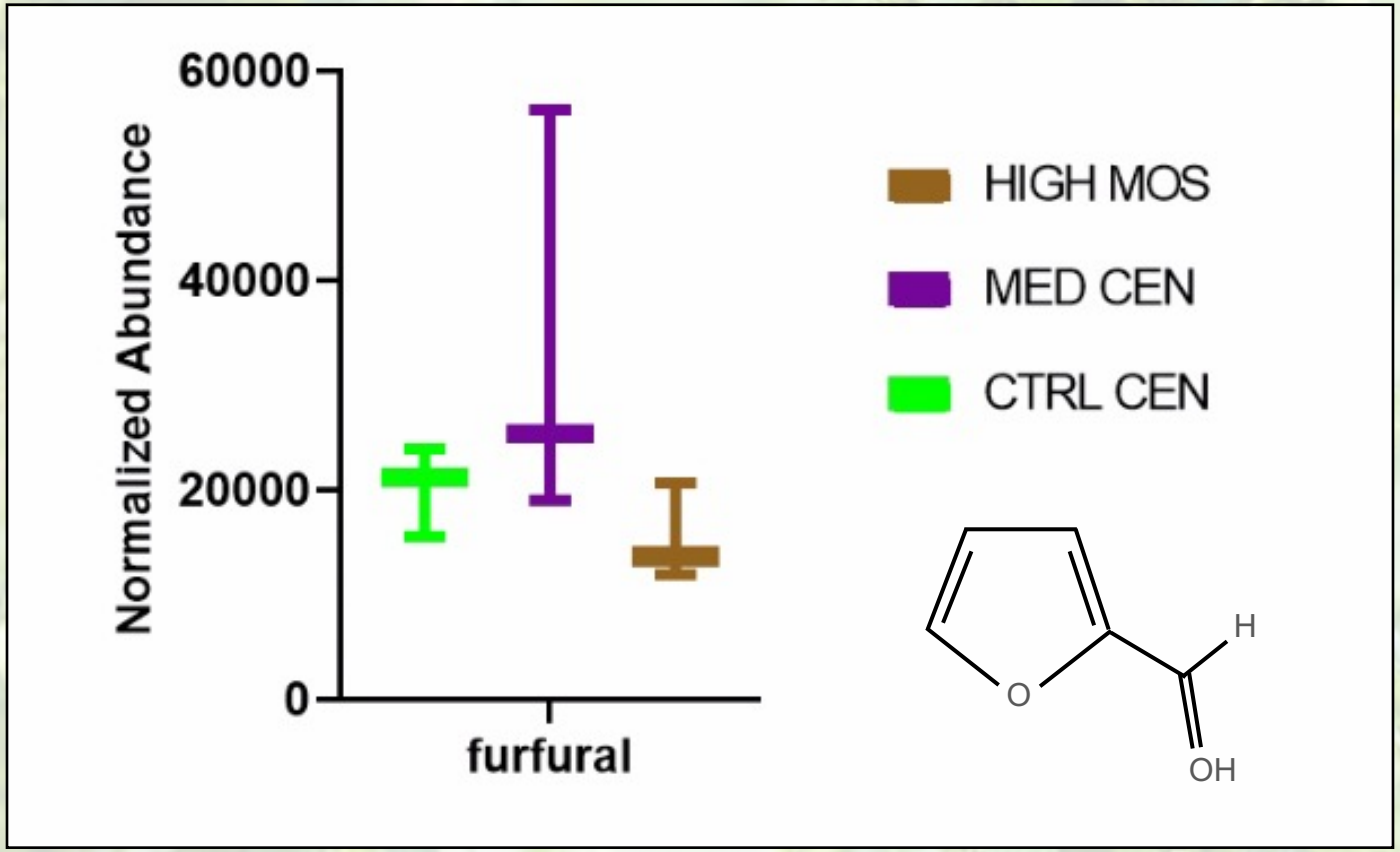
Consumer Sensory Panel

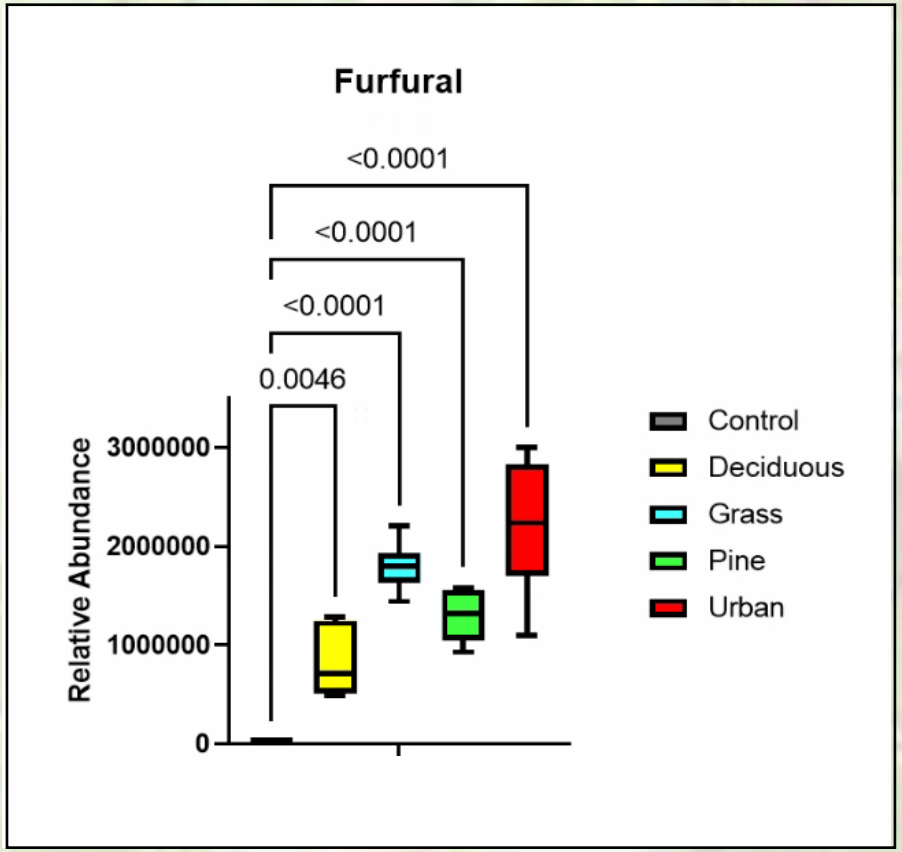
Yakimachief.com

Objective 2: Preliminary Data



Objective 2: Preliminary Results





Objective 2: Experimental Design

Crop Year 2020

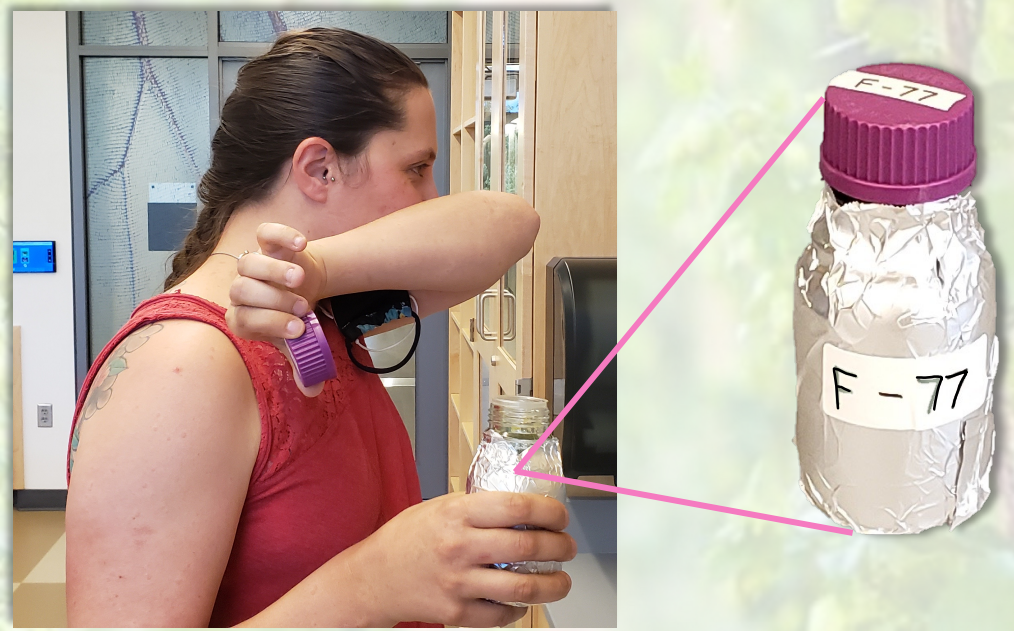
Non-targeted SPME GC-MS and Data Analysis

Consumer Sensory Panel

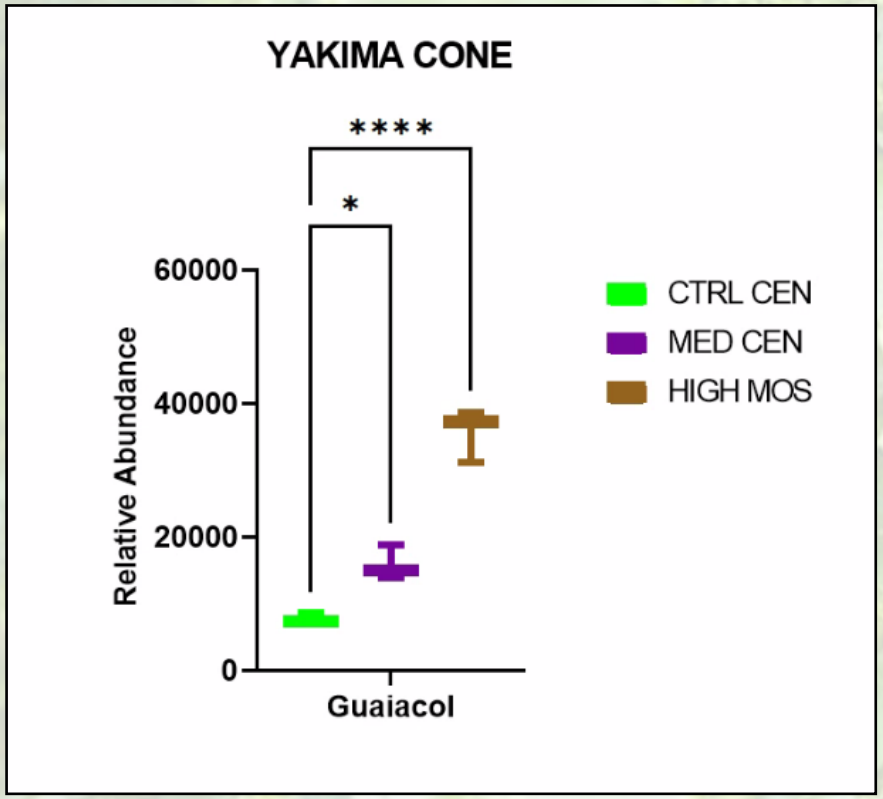
Yakimachief.com

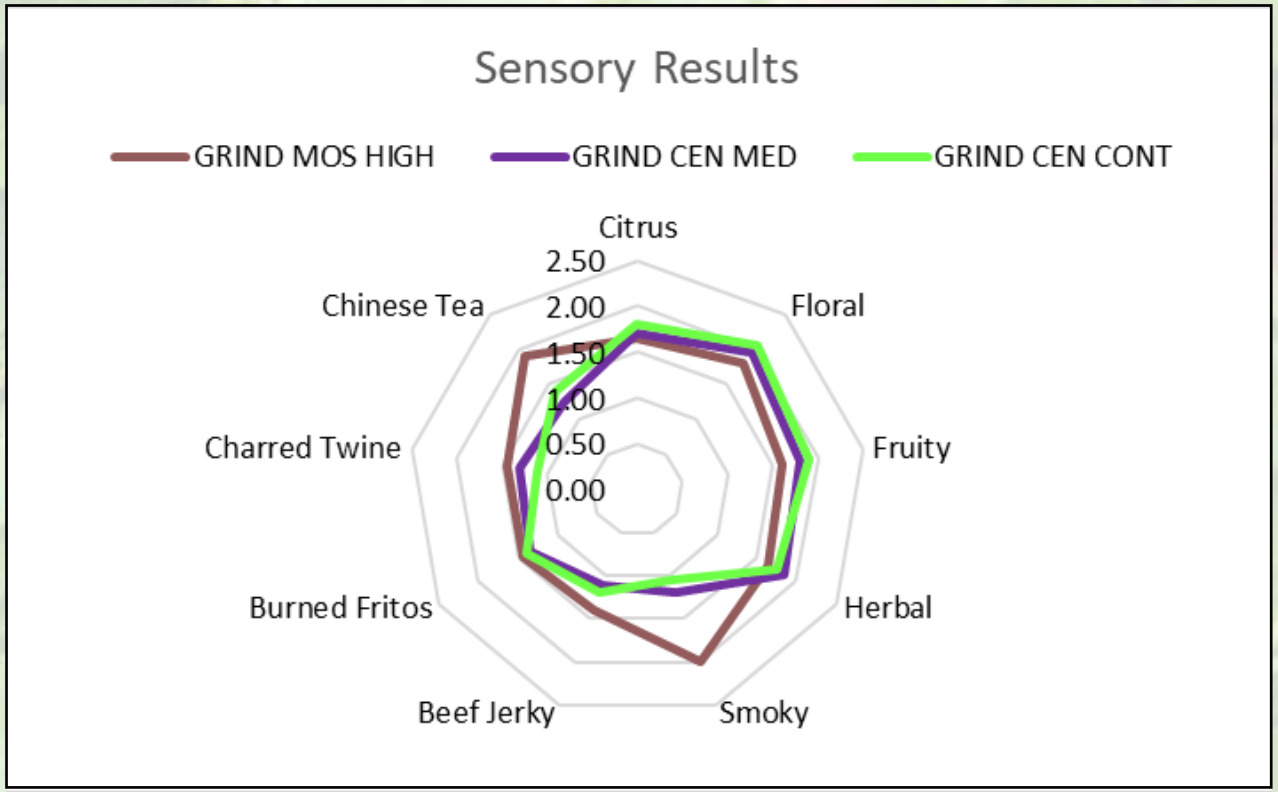
Objective 2: Sensory Panel

- Ten panelists
- One training + three sensory sessions
- Two prep methods
  - Hop grind
  - Slurry



Objective 2: Comparing Analyses





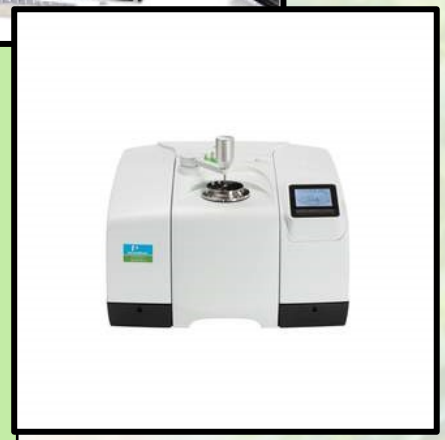
Summary

2. Validate the method using “real world” hops that were exposed to wildland fire smoke during the 2020 growing season and compare to sensory methods.

- Detected common smoke-taint markers, although in much lower abundance, using non-targeted method in “real-world” samples.
- Furfural also detected, although no significant variation detected
  - Near limit of detection
- Chemical analysis is representative of sensory

Future Work

- Translate non-targeted data to a targeted method that can be validated with real world samples.
- Look at different types of molecules using different analytical approaches
- Explore how smoke-derived compounds impact the chemistry and sensory profile of individual cultivars



Acknowledgements

Coauthors: Katie Natsiatka, Dr. Jacqueline Chaparro, Stacey Williams, & Dr. Jessica Prenni

Justin Alexander of New Belgium Brewing; Katie Fromuth of the Brewers Association; Tiffany Pitra of Yakima Chief Hops; Jeff Dailey of John I. Haas, Inc.; Dr. Sahar Bagheri Toulabi, Janina Bowen, Rachel Jones, Beth Mitchell, Valerie Seitz, and Tyler Richards of Colorado State University.

American Society of Brewing Chemists

Yakima Chief Hops