# Implementing Sensory Methods to Detect Hop Smoke Taint

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ASBC
THE SCIENCE OF BEER

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# Workshop Agenda

**Background and Introduction**

- AQI data 2020 vs. 2021
- Industry collaborations

**Group Sensory Training**

- Lexicon and reference standards
- 5-minute break

**Hop Sample Assessment**

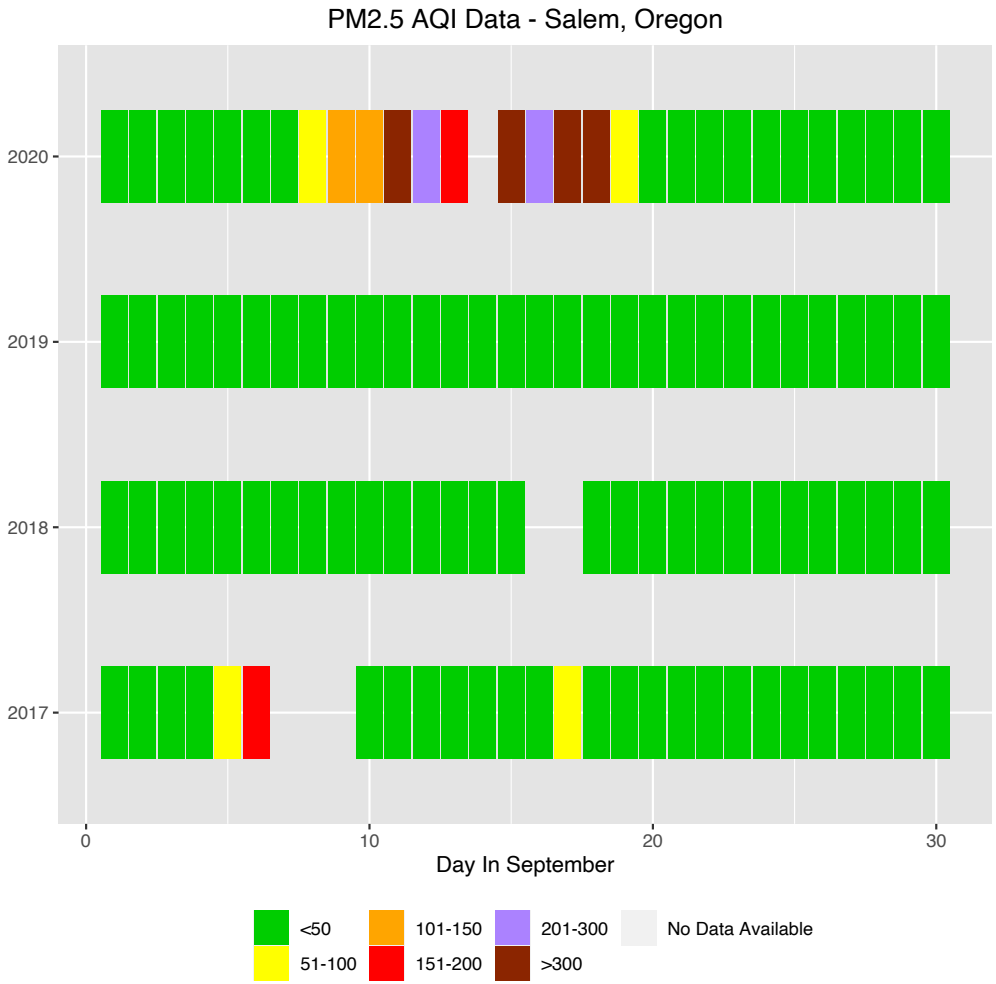
- 5-minute break for data analysis

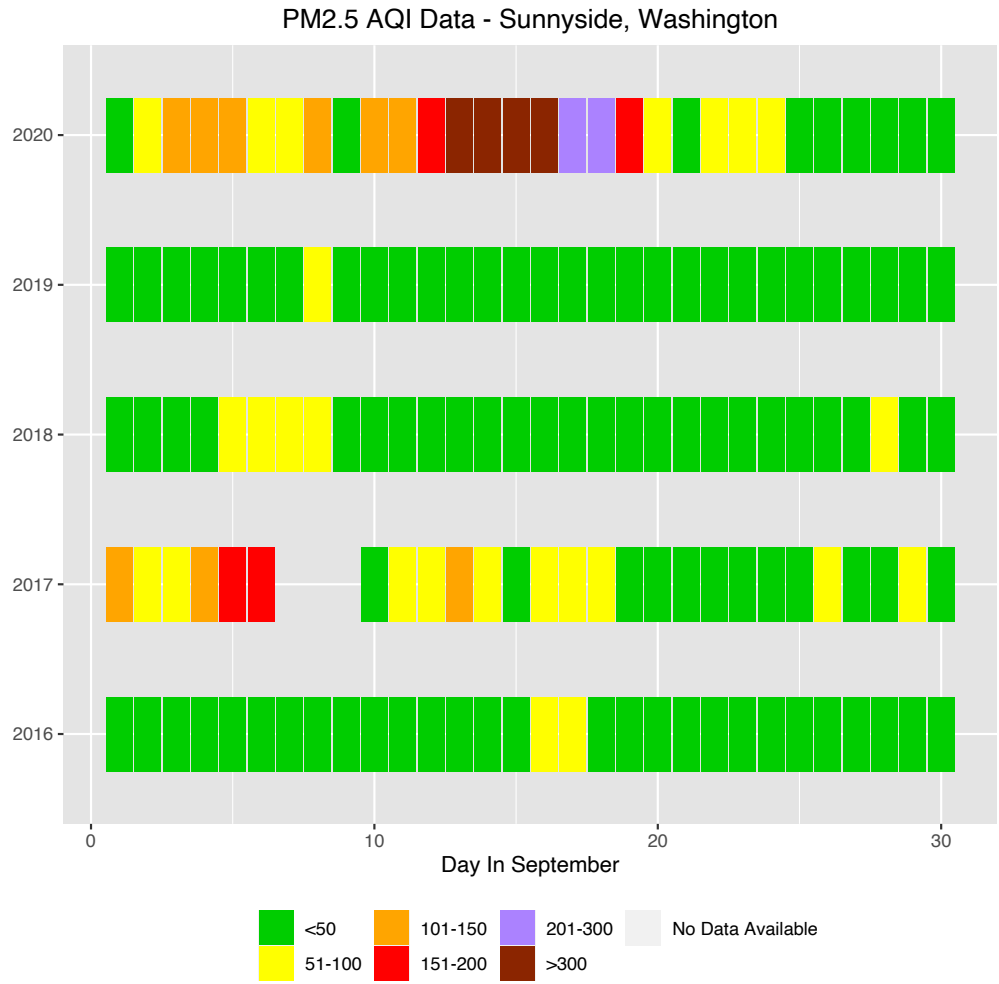
**Results and Discussion**

# Background and Introduction

Wildfires in the PNW

# Unprecedented levels of smoke

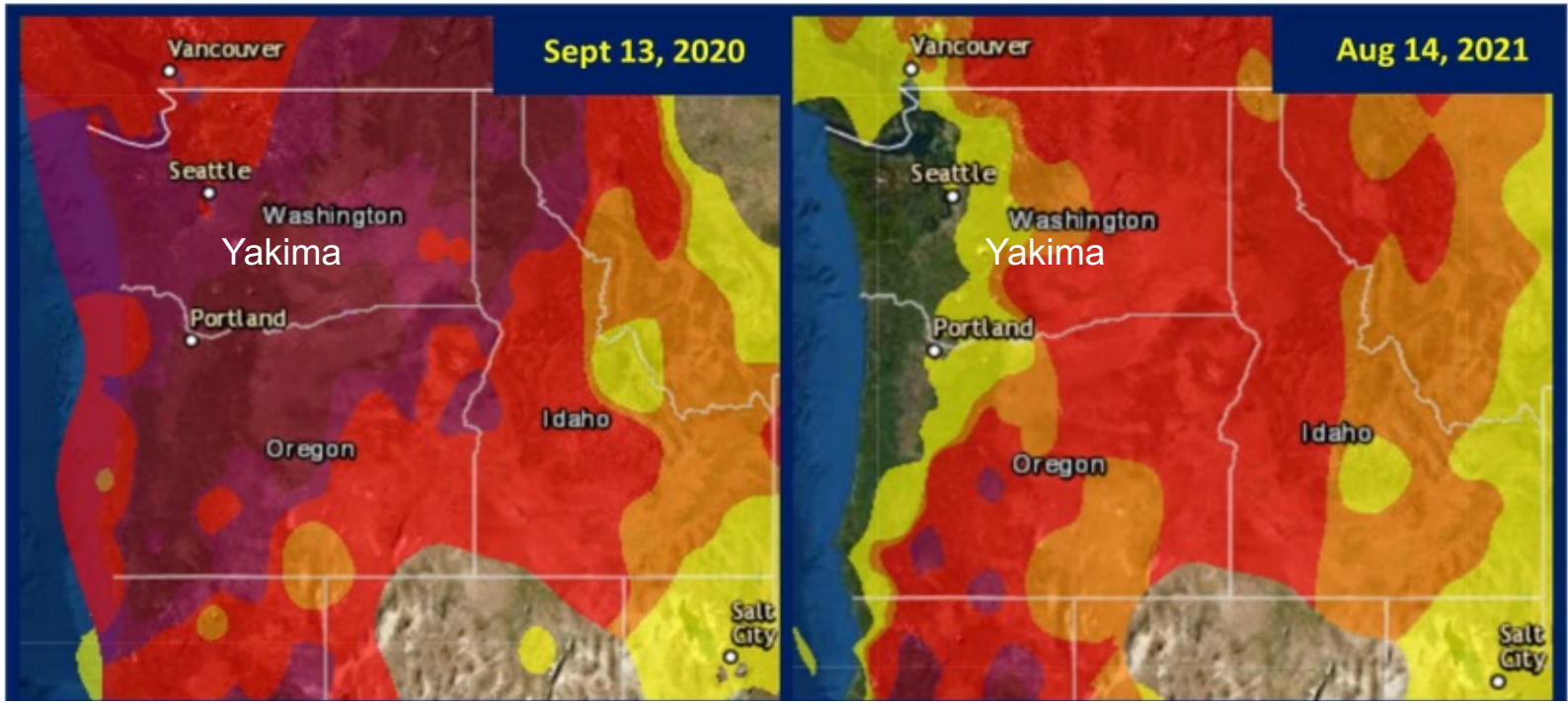


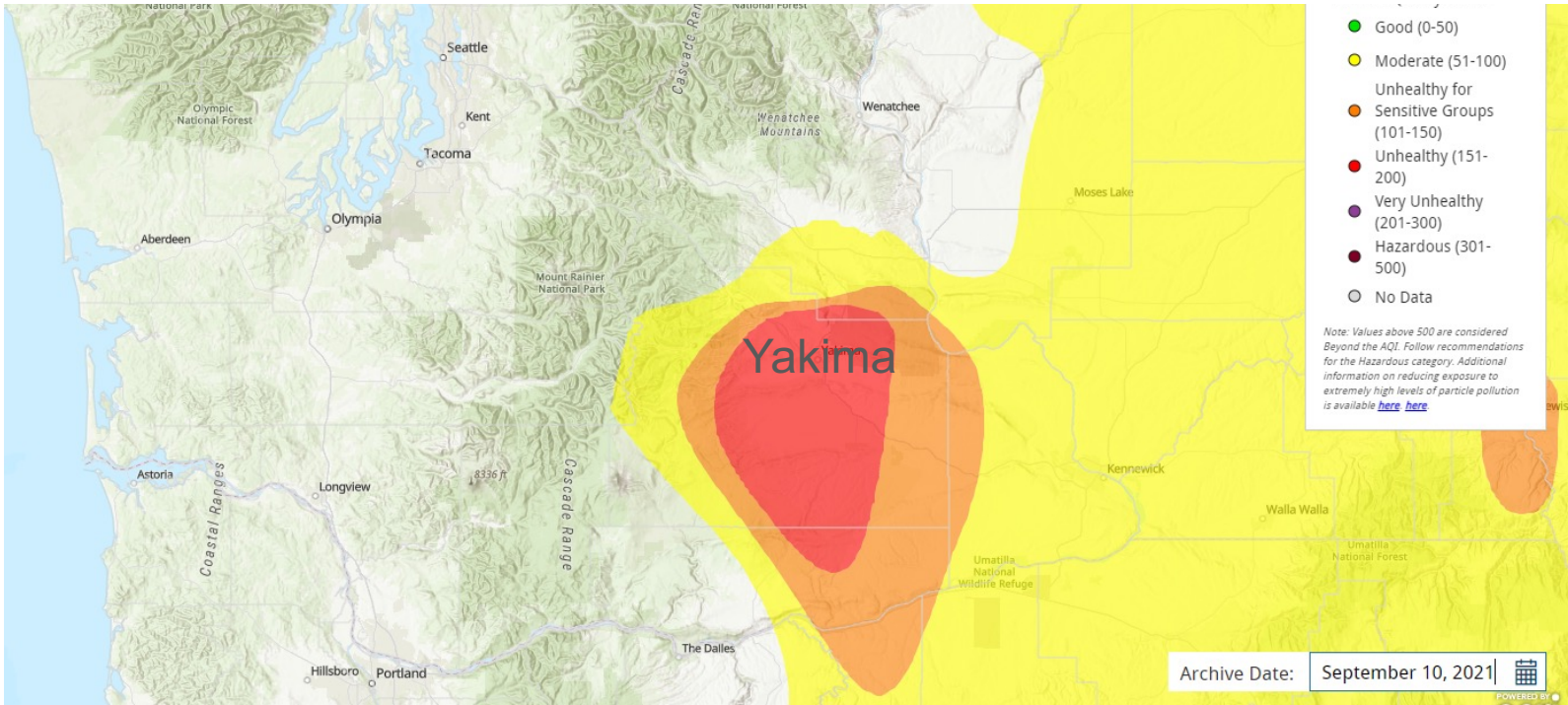




Daily AQI values for Salem, OR and Sunnyside, WA during the month of September

# Air Quality Index: 2020 vs. 2021

- Land mass affected by wildfire smoke September 13, 2020 vs. August 14, 2021. Areas of unhealthy AQI (≥ 200) was more isolated in 2021.



# Crop Year 2020 Research

## Hop Analysis

- Wildfire smoke affects hop aromatic profiles
- Smoky lots fall within normal distributions of Alpha, HSI, and TO

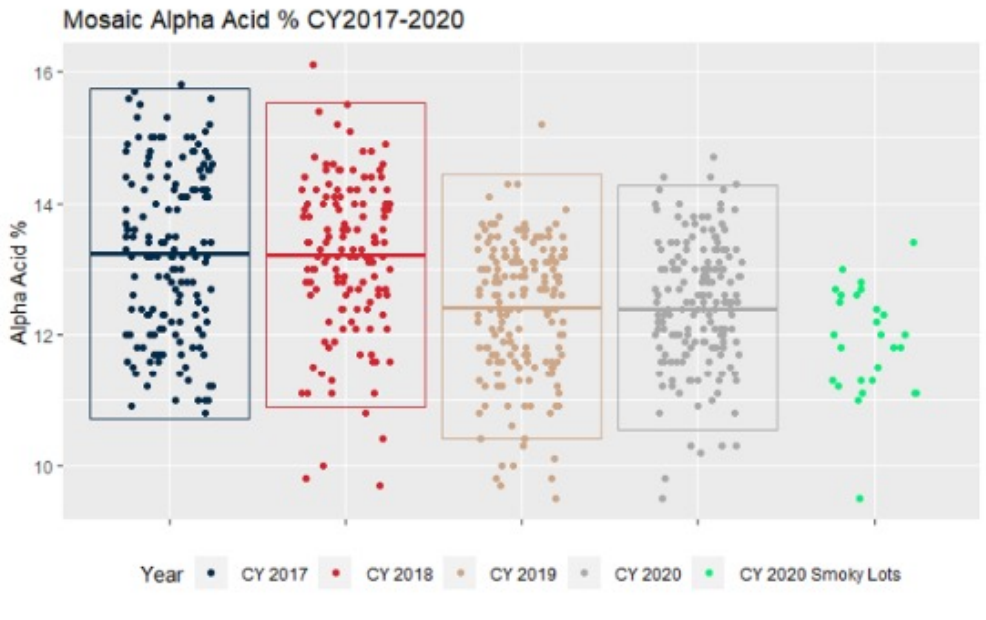
## Remediation Methods

- Storage, Processing, Re-kilning

## Brewing Trials

- Whirlpool, Dry Hop, Dry Hop Blending, Extract

## Hop Industry "Sensory Smoke Summit"



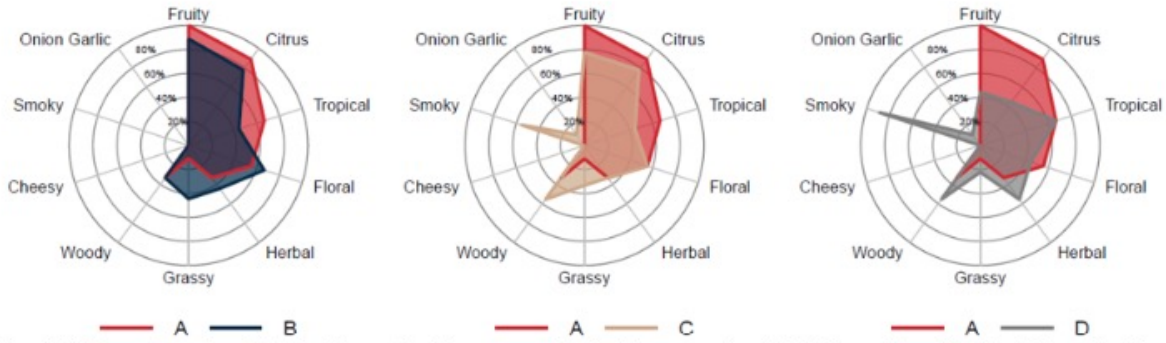




Figure 7.4 Percentage of panelists (n = 9) reporting the presence of major flavor complexes in dry hopped beer. The Control condition beer (A) is compared against beers dry hopped with an increasing proportion of smoky hops (B-D).

# Industry Collaborations

**Hop Analysis – Industry Efforts**

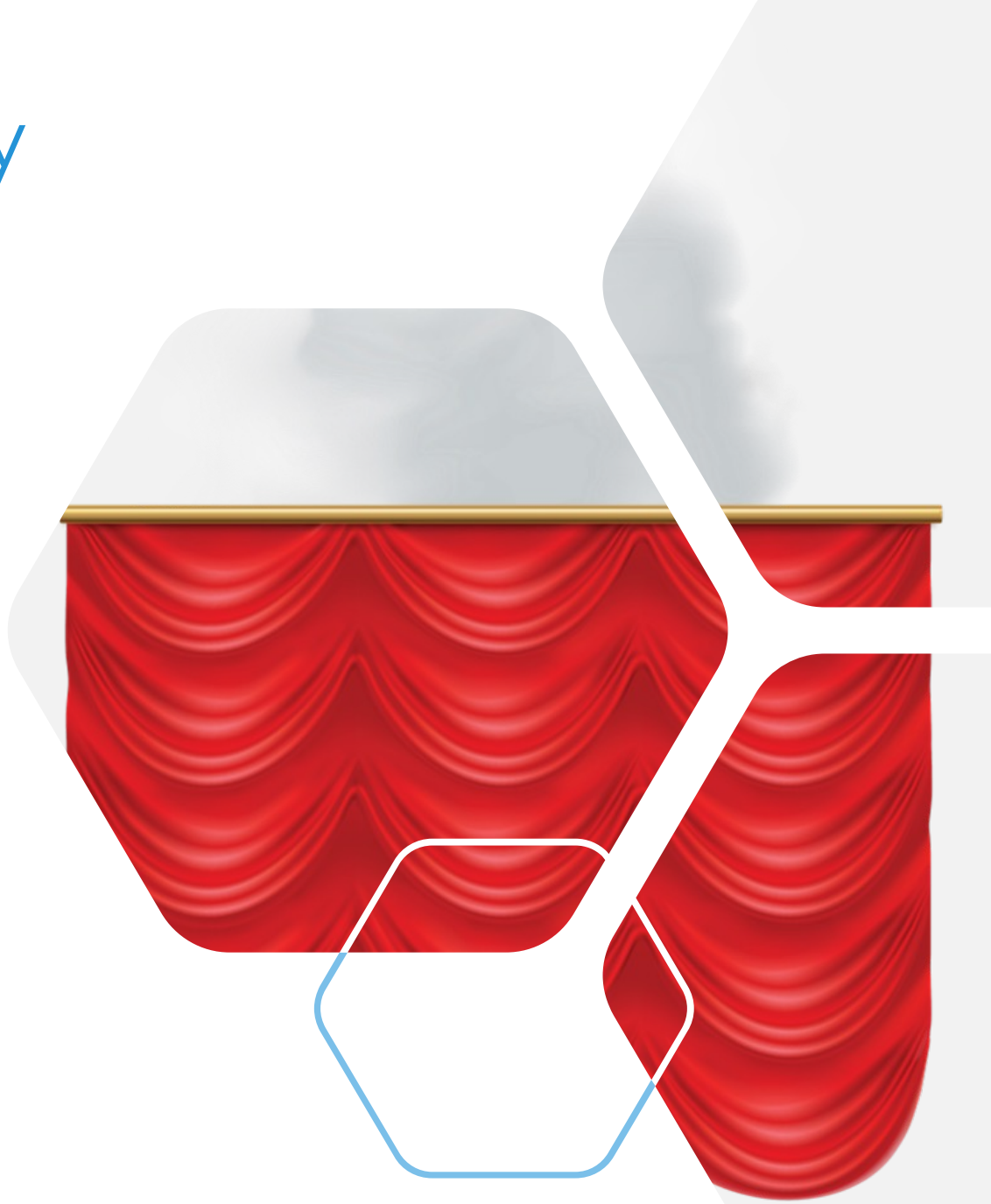
- Trial "slurry" method vs. ASBC Grind
- Panelist training and validation of lexicon
- HRC Project: OSU/New Belgium/YCH/JIH
- Brewing Summit Sessions:
  - Analytical I at 1:30 p.m - 2:45 p.m
  - Smoky beer on tap at Yakima Chief Hops booth
    - 'Smosaic' – ask for it by name

# So, you want (need) to build a lexicon

Good luck with that!

# The probl… err… opportunity

- Most quality issues with hops are pretty well understood due to 100+ years of farming in the Yakima Valley –
- The high AQI timing aligned with hop ripening was unprecedented –
- Hops have complex aromatic chemistry with many compounds in higher concentration and with significantly lower sensory thresholds than smoke-related phenols –
- **Smoke-taint generally doesn't smell… smoky… so we needed to do some serious research into what smoke can smell like**



# Smoke Taint/Sensory in Hop Literature

- Almost non-existent
- Historical references to kilning practices and contamination but nothing actionable

William Marshall – *Rural Economies of the Southern Counties, 1798*

*Hop driers had to suffer, "…the scorching heat of their kilns, the dusty sweat of heavy stoking…the acrid fumes of burning sulphur, [and] the sticky black resin of hops[.]"*

Minutes from Parliament – *May 11 , 1901*

*The fumes of the fuel pass through the Hops? Yes; hence the necessity of good anthracite coal… It is impossible for any sulphur to get into the hops in any appreciable quantity… I suppose to use any gas coke would be likely to spoil the aroma of the hops. We have always been able to produce a satisfactory article… by the use of the best anthracite coal.*

John Harris – MBAA TQ vol. 37, no. 1, 2000

***Hop Rubbing Descriptors***
*Defects and Off Aromas*
*Kerosene (from kiln)*

# Smoke Taint/Sensory in Hop Literature

**'Acrid'** is useful but sulfur was purposely added to the kilns for bleaching purposes (this and remained standard practice for over a century)

Exogenous smoke can **'spoil'** the aroma… but does this mean '**suppress**' or something else?

An actual contemporary account! An actual potential aroma standard!

William Marshall – *Rural Economies of the Southern Counties, 1798*

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***Hop Rubbing Descriptors***
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# Smoke Taint/Sensory in Brewing Literature

- Limited to phenol content in beer:
  - As a source of bitterness / astringency from hops
  - Flavor as a product of POF+ fermentation
  - Descriptors were largely repetitive and non-representative of our early experiences
- *Wine literature was similarly repetitive and limited in representation

**Table 29**
Organoleptic properties and thresholds of hydroxycinnamic acids derived compounds

| Phenolic compounds | Organoleptic characteristics | Threshold in beer (mg/l) |
|---|---|---|
| 4-Vinylguaiacol | Clove, phenolic, bitter | 0.25*; 0.30** and *** |
| 4-Ehylguaiacol | Clove, phenolic, sweet | 0.13* and ** |
| 4-Methylguaiacol | Medicinal, burned | 0.20* |
| Guaiacol | Phenolic, burned | 0.70* |
| Eugenol or 4-Allylguaiacol | Clove, dental, disinfectant | 0.20* |
| Isoeugenol or 4-Propenylguaiacol | Clove, dental, disinfectant | 0.10* |
| Vanillin | Vanilla | 0.50* |
| Acetovanillone | Vanilla | 0.50* |
| 4-Vinylphenol | Phenolic, bitter, astringent | 0.20* |
| 4-Ethylphenol | Cresol | 0.10* |
| 4-Methylphenol | Medicinal, phenolic | 0.20* |
| Phenol | Phenolic, cresol | 0.30* |
| 4-Vinylsyringol | Smoked, burned | 0.50* |
| 4-Ethylsyringol | Smoked, burned | 0.50* |
| 4-Methylsyringol | Smoked, burned | 0.50* |
| 4-Propylsyringol | Smoked, burned | 0.50* |
| 4-Allylsyringol | Smoked, burned | 0.50* |
| 4-Propenylsyringol | Smoked, burned | 0.25* |
| Syringol and syringaldehyde | — | — |

— = Not determined; * (3); ** (152); *** (11).

Callemien & Collin – Structure, Organoleptic Properties, Quantification Methods, and Stability of Phenolic Compounds in Beer

# Smoke Taint/Sensory in Molecular Chemistry

- Now we're cooking with… fire…
  - Diverse sensory descriptors for the target compounds produced by forest fires –
    - Descriptive!
      - Discriminable!
        - Generalizable!
          - …way too many!

**Table 11**
**SENSORY DESCRIPTIONS OF VARIOUS SMOKE-ASSOCIATED PHENOLS**

| Compound | Optimum sensory concentration (mg/100 mℓ) | Odor description | Flavor description |
|---|---|---|---|
| Dimethylphenol | 0.9 | Phenolic, like ink, aromatic, sweet | Phenolic, sharp, charred sweet, dry |
| 4-Methylguaiacol | 1.9 | Sweet, like vanilla, fruity, like cinnamon, somewhat smoky, pleasantly sharp, phenol tones | Sweet, like vanilla, caramel-like, aromatic, pleasant smoke tones, burning |
| Guaiacol | 3.75 | Phenolic, smoky, aromatic, sharp, sweet | Phenolic, sharp, spicy smoked-sausage-aromatic, sweet, dry |
| Syringol | 7.50 | Smoky, spicy, aromatic, smoked-sausage, phenolic, sharp, sweet | Phenolic, smoky, freshly charred wood, like whiskey, dry, sharp |
| *o*-Cresol | 7.5 | Phenolic, sweet-fruity, aromatic, like caramel, smoked-sausage | Sweet, sharp, unpleasant smoky, burning |
| Isoeugenol | 9.8 | Sweet-fruity, like vanilla, like rhubarb, phenolic | Sweet-fruity, mild smoke, dry, sharp |

Maga – Smoke in Food Processing (1988)

# Smoke Taint/Sensory in Broader Food Research

- The broader food industry has more extensive work regarding smoke-related sensory and lexicon development.
  - ***Ojeda (2002)*** developed a lexicon to evaluate various smoke flavorings used in consumer packaged goods (CPGs)
    - ***Jaffe (2017)*** refined this lexicon into a generalizable language to describe all manner of smoky things (including hops!):
      - Ashy, Woody, Musty/Dusty, Musty/Earthy, Burnt, Acrid, Pungent, Petroleum-Like, Creosote/Tar, Cedar, Bitter, Metallic, and Sour

# Hop Smoke Taint Lexicon Refinement

- Ashy
- Woody
- Musty/Dusty
- Musty/Earthy
- Burnt
- Acrid
- Pungent
- Petroleum-Like
- Creosote/Tar
- Cedar
- Bitter
- Metallic
- Sour

# Hop Smoke Taint Lexicon Refinement

- Ashy
- ~~Woody~~
- Musty/Dusty
- Musty/Earthy
- Burnt
- Acrid

***Many*** varieties should have a Woody character

Redundant

- ~~Pungent~~

Too general – hops ***should*** be pungent

- Petroleum-Like
- Creosote/Tar

Redundant

- ~~Cedar~~

Hops like ***Talus*** are very cedar-like

- Bitter
- Metallic
- Sour

Not part of our observed experience…
But similar to 'Medicinal'

# Hop Smoke Taint Lexicon

- Petroleum/Tar – birch tar oil
- Acrid – heavily burnt caramel
- Savory – beef jerky or soy sauce
- Burnt – burnt sisal twine
- Smoky – Lapsang souchong tea
- Medicinal – 0.001% guaiacol in EtOH
- Artificial BBQ – liquid smoke
- Toasted – heavily toasted bread





# Hop Smoke Taint Lexicon

- **Petroleum/Tar – birch tar oil**
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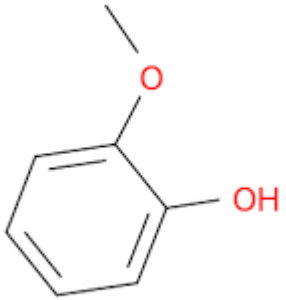





# Group Sensory Training

## Lexicon & Reference Standards

# Lexicon & Reference Standards

## Hop Aroma Complexes

- Citrus
- Tropical
- Stone Fruit
- Berry
- Pine

## Hop Smoke Taint

- Petroleum/Tar – birch tar oil
- Acrid – heavily burnt caramel
- Savory – beef jerky
- Toasted – heavily toasted bread
- Smoky – Lapsang souchong tea
- Medicinal – 0.001% guaiacol in EtOH

# ‘Smoke Break’

5 minutes to recover before sample assessment.

# Hop Sensory Assessment

Put your training to good use!

# What the heck are we doing now?

- We're evaluating six blinded hop samples using Compusense®
- Evaluations will use check-all-that-applies (CATA)
  - Like Draught Lab/Sample Ox → If you smell it, click it
- In between samples, take a break to clear your palate
  - Sniff your towlette or your arm (this is a coffee bean-free zone!)
- Best Panel Practices: This is also a spoiler-free zone!

https://tinyurl.com/brewsummit22smoke

# ‘Smoke Break’

Give us 5 minutes to crunch the numbers!

# Results & Discussion

‘Talk amongst yourselves – don’t get too verklempt’

# BIG REVEAL – Blinding Codes

# Show of hands? Was it obvious?

| | | |
|---|---|---|
| 428 |  | ??? |
| 299 |  | ??? |
| 853 |  | ??? |
| 971 |  | ??? |
| 935 |  | ??? |
| 362 |  | ??? |

# Hopefully it was!

| | |
|---|---|
| 428 | Citra Smoke |
| 299 | Citra Clean |
| 853 | Mosaic Smoke |
| 971 | Mosaic Control |
| 935 | Azacca Smoke |
| 362 | Azacca Control |

# Raw Data

# Bar Charts – Basic Analysis

# Correspondence Analysis / PCoA

# Resources


Callemien, D., and S. Collin. 2009. “Structure, Organoleptic Properties, Quantification Methods, and Stability of Phenolic Compounds in Beer—A Review.” *Food Reviews International* 26 (1): 1–84. https://doi.org/10.1080/87559120903157954.

Jaffe, Taylor R., Hongwei Wang, and Edgar Chambers IV. 2017. “Determination of a Lexicon for the Sensory Flavor Attributes of Smoked Food Products.” *Journal of Sensory Studies* 32 (3): e12262. https://doi.org/10.1111/joss.12262.

Kennison, K.r., K.l. Wilkinson, A.p. Pollnitz, H.g. Williams, and M.r. Gibberd. 2009. “Effect of Timing and Duration of Grapevine Exposure to Smoke on the Composition and Sensory Properties of Wine.” *Australian Journal of Grape and Wine Research* 15 (3): 228–37. https://doi.org/10.1111/j.1755-0238.2009.00056.x.

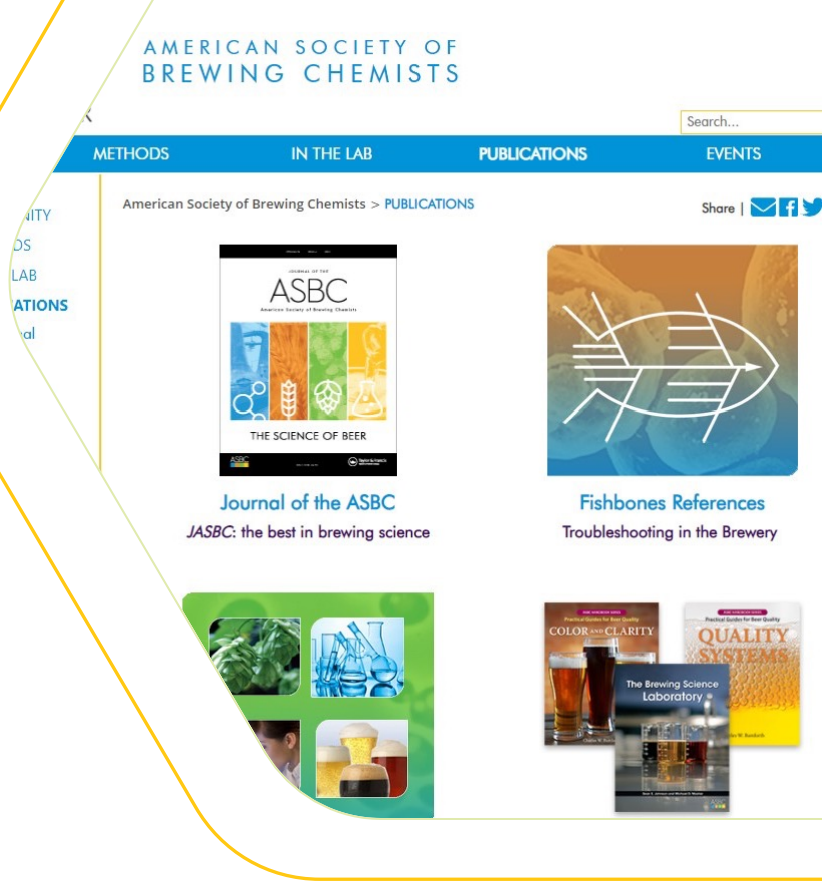
Maga, Joseph A. 1988. *SMOKE IN FOOD PROCESSING*. CRC-Press.

Ojeda, M., P. Bárcenas, F. J. Pérez-Elortondo, M. Albisu, and M. D. Guillén. 2002. “Chemical References in Sensory Analysis of Smoke Flavourings.” *Food Chemistry* 78 (4): 433–42. https://doi.org/10.1016/S0308-8146(02)00154-1.

Parker, Mango, Patricia Osidacz, Gayle A. Baldock, Yoji Hayasaka, Cory A. Black, Kevin H. Pardon, David W. Jeffery, Jason P. Geue, Markus J. Herderich, and I. Leigh Francis. 2012. “Contribution of Several Volatile Phenols and Their Glycoconjugates to Smoke-Related Sensory Properties of Red Wine.” *Journal of Agricultural and Food Chemistry* 60 (10): 2629–37. https://doi.org/10.1021/jf2040548.

Swaney-Stueve, Marianne, Martin Talavera, Tegan Jepsen, Bryan Severns, Robert Wise, and Grace Deubler. 2019. “Sensory and Consumer Evaluation of Smoked Pulled Pork Prepared Using Different Smokers and Different Types of Wood.” *Journal of Food Science* 84 (3): 640–49. https://doi.org/10.1111/1750-3841.14469.

Wang, Hongwei, Edgar Chambers, and Jianquan Kan. 2018. “Sensory Characteristics of Combinations of Phenolic Compounds Potentially Associated with Smoked Aroma in Foods.” *Molecules* 23 (8): 1867. https://doi.org/10.3390/molecules23081867.

# THANK YOU!

Have questions/want to join us?

Contact
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