

## Final Technical Report

J Robert Serrine, Ph.D.  
Michigan State University Extension  
8527 E. Gov Center Dr.  
Suttons Bay, MI 49682  
Email: [serrine@msu.edu](mailto:serrine@msu.edu)  
Phone: 231-256-9888

Grant 20\*1799 - Investigating the Terroir-Influenced Quality Attributes of Hops (*humulus lupulus*)

### Goals and Objectives

The craft brewing sector has increased exponentially over the last several years. The state of Michigan is no exception- there are more breweries in Michigan than there were in the entire United States in the 1980's. In total, Michigan beer production accounts for nearly \$1 billion and 10,000 jobs in total economic contributions (Miller et al., 2019). These figures demonstrate the importance of investment in Michigan's beer value chain. Much of the growth in demand can be attributed to an increase in consumer preference for flavor-forward, hop heavy India Pale Ales (IPAs). Of the four primary ingredients in beer (water, malt, hops, yeast), hops are the main contributor to flavor and aroma. Because of hops' chemical complexity, maintaining consistent flavor and aroma in beer can be difficult- this represents a major quality control issue for brewers. Research suggests that many factors influence hop aroma: genetics, environment, and production practices. Cultivar, alpha/beta acids, total oil, and Hop Storage Index are typical measures of hop quality; a key variable commonly omitted is geographic location/terroir. Because terroir can impact hop brewing values, more nuanced testing of hop oil profiles is necessary. Our project seeks to utilize descriptive sensory and analytical techniques to determine how growing location may affect hop brewing values. This information will help hop producers improve quality and consistency and ultimately increase sales.

For the last century U.S. hop production has been concentrated in the Pacific Northwest (Washington, Oregon, and Idaho). One consequence of the exponential increase in craft brewing is increasing consumer demand (and therefore brewer demand) for locally sourced hops, which has fueled the establishment of hop acreage in new regions. Michigan has emerged in the forefront of the re-emerging hop-growing states, ranking 4<sup>th</sup> in hop acreage (HGA 2019). Nielsen Craft Beer Insights suggests that organoleptic properties (sensory characteristics such as flavor and aroma) are key drivers of consumer demand for craft beer (Watson, 2017). With geographically distinct soils and environmental conditions, Michigan hops may provide unique flavor profiles that brewers can leverage in an increasingly competitive marketplace, as evidenced by Brewmaster Matt Brynildson's use of Michigan-grown hops in Firestone Walker's Luponc Distortion Revolution No. 006. Brynildson suggests "This beer showcases what happens when you take two familiar Northwest hop varieties and grow them 2,000 miles to the east. The typical piney, dank attributes of these hops are transformed into something much brighter, with a racy citrus quality. It's a perfect example of how terroir plays

into hop growing, and how it ultimately shapes beer flavor and aroma”. Investigating hop quality attributes that contribute to quality differences and consumer liking in craft beer will provide critical information to hop producers and brewers.

We used lab analytics, descriptive sensory analyses, and economic surveys to address the following objectives: 1) Improve hop quality and consistency, and 2) Determine unique hop aroma and flavor profiles that help brewers produce flavorful beer that consumers prefer.

- Hypothesis 1: Hops from different regions will have distinct *terroir*-influenced quality attributes.
- Hypothesis 2: Terroir-influenced hop quality attributes will result in single-hop beers with distinct organoleptic properties.
- Hypothesis 3: Consumer preference will vary based upon terroir-influenced hop attributes.

### Results, Conclusions, and Outcomes

*Hypothesis 1: Hops grown in different regions will produce distinct terroir-influenced quality attributes.*

Descriptive hop sensory and oil profile analyses demonstrated evidence of marked differences among hop cultivars based upon growing location (Figures 1-3).

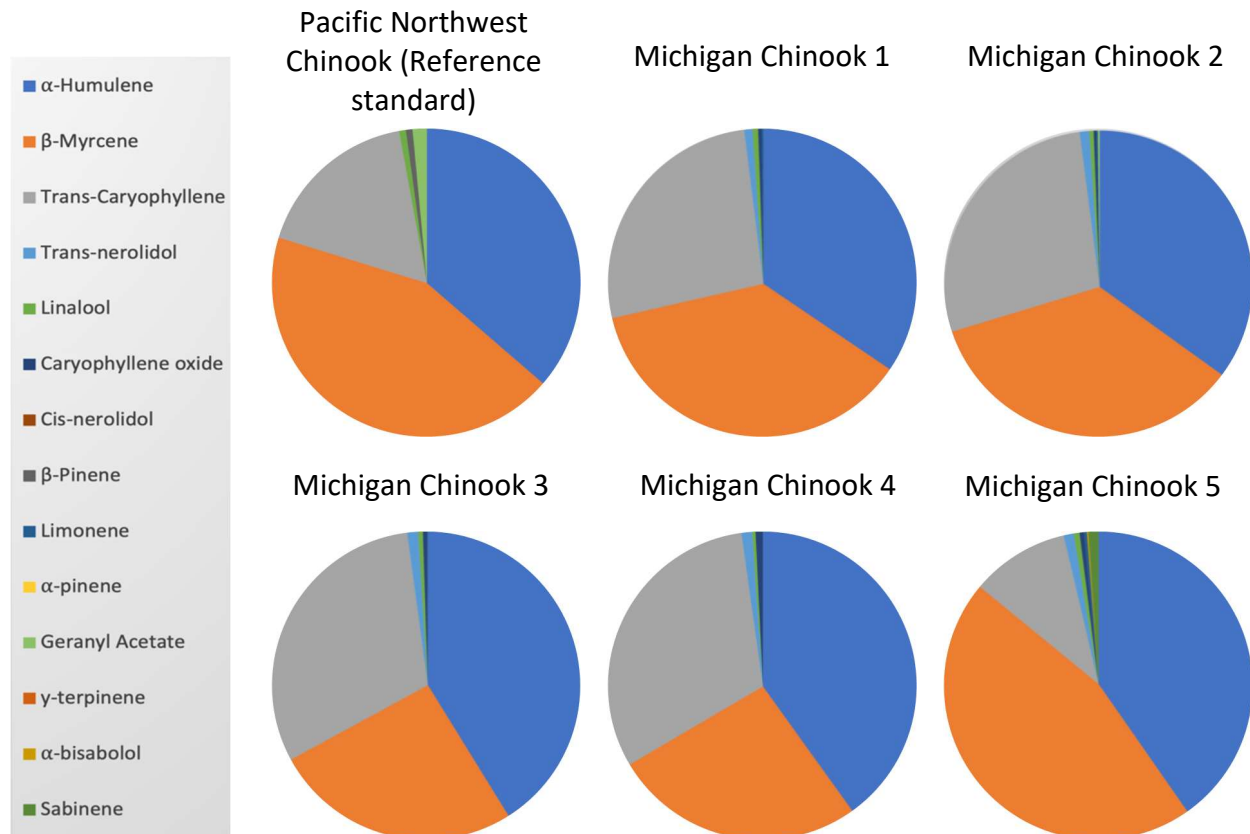


Figure 1. 2020 harvest Chinook hop oil profiles from 5 locations across Michigan and Chinook reference standard from 2016 Yakima Chief Hop Variety Handbook. Michigan hop oil profile completed by Cambium Analytica July 2021.



Figure 2. 2020 harvest Chinook hop sensory analysis results from 5 locations across Michigan. Sensory analysis performed by UVM NW Crops & Soils Sensory Practice July 2021.

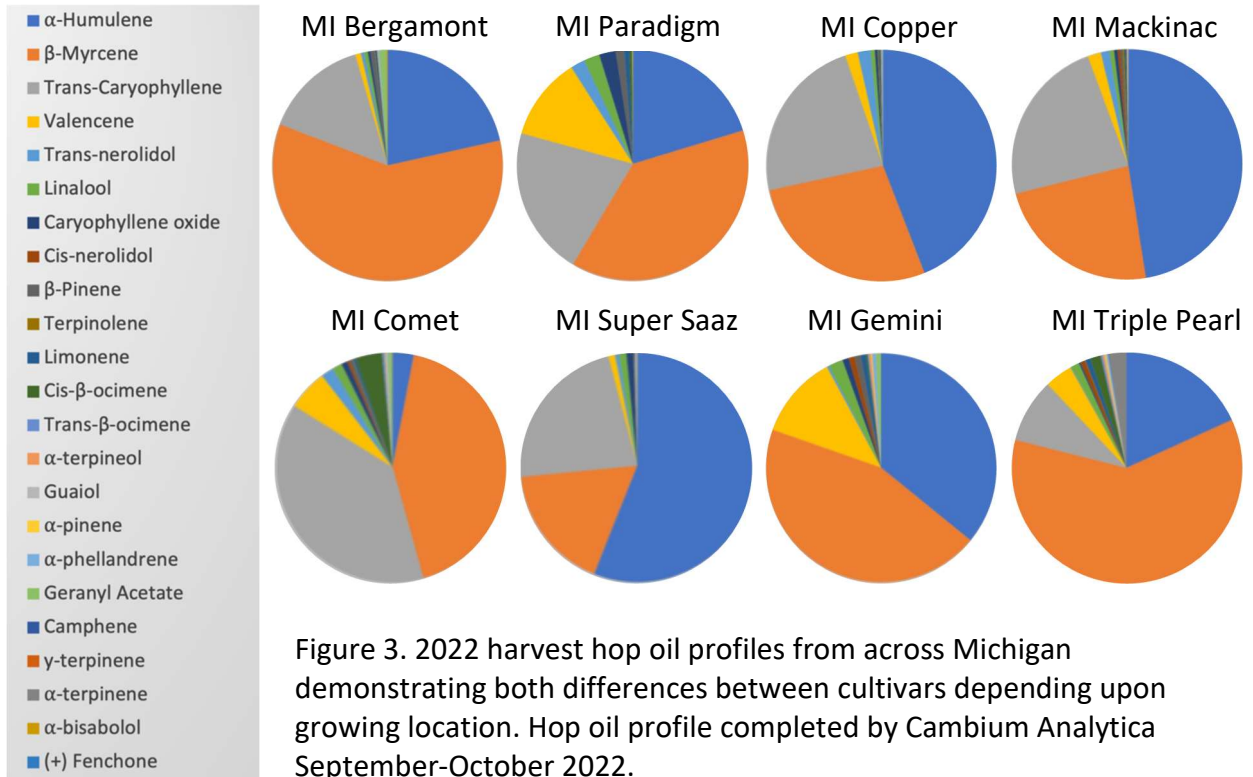


Figure 3. 2022 harvest hop oil profiles from across Michigan demonstrating both differences between cultivars depending upon growing location. Hop oil profile completed by Cambium Analytica September-October 2022.

*Hypothesis 2: Terroir-influenced hop quality attributes will result in single-hop beers with distinct organoleptic properties.*

While there were slight differences in organoleptic properties of the single hopped beers, results of blind taste tests and sensory analyses (N=59) were inconclusive. Given the limited number of panelists, we could not state that significant sensory differences were detected across the beer samples. Preference for each of the four beers varied only slightly. For future studies increasing the dry-hopping rate may accentuate organoleptic distinctions and increasing the number of panelists may provide more conclusive results.

*Hypothesis 3: Consumer preference will vary based upon terroir-influenced hop attributes.*

Because the results from hypothesis 2 failed to reach the level of significance, we were unable to determine if consumer preference varied based upon terroir-influenced hop attributes. However, the results from our multi-state brewer survey (N=74) suggests that brewers will pay up to a 35% premium for local hops because they believe: in supporting local growers, that consumers will pay a premium for beer with local ingredients, and that local hops taste different from hops grown in other states.

For more information see: Untapping Terroir: Experimental Evidence of Regional Variation in Hop Flavor Profiles. MBAA TQ 59(1). 2022. Pp.7-16. <https://doi.org/10.1094/TQ-59-1-0408-01>

## **Work Accomplished/Methods**

The following techniques were used to determine the effects of growing location/terroir on hop quality attributes.

2020 (April-December)

- Analyzed and published the results of the consumer preference blind taste tests that were conducted at the Great Lakes Hop and Barley Conference in March 2020 (N=47 semi-trained panelists) and a regional brewery (N=12 trained panelists).
- The COVID pandemic prevented us from conducting another round of brewing and consumer preference research. However, we conducted analytics and sensory analysis on 40+ hop samples in 2021-2022 thereby helping growers learn about and potentially leverage the quality attributes of their hops.

2021

- Sourced Chinook hops from multiple farms (WA, OR, NW MI, SE MI)
- GC/MS headspace profiling of hop pellets (Cambium Analytica) and descriptive sensory analysis (University of Vermont and Founders Brewing Co.)
- Completed statistical analyses

2022

- Sourced hops from multiple MI farms
- GC/MS headspace profiling of hop pellets (Cambium Analytica)
- Completed statistical analyses
- Outreach and education: See Communication Activities, Accomplishments, and Impacts
- Sourced lab distillation equipment to refine hop quality chemical analysis

## Time Span

Original Grant Period: 4/1/2020- 7/31/2021. Approved extension through 12/31/22. Project activities were carried out 4/1/2020 – 12/31/22.

## Communication Activities, Accomplishments, and Impacts

Results were provided at grower, brewer, and academic conferences such as the Hop Growers of Michigan Annual Meeting, MI Great Beer State Conference and Tradeshow (2021, 2022), Food Distribution Research Society annual conference (2020), American Hop Convention/Hop Research Council Annual Meeting (2021), MBAA Conference (2021), and the ASBC/MBAA Brewing Summit (2022).

Results were also presented in peer-reviewed academic and trade journals:

- MBAA Technical Quarterly “Untapping Terroir: Experimental Evidence of Regional Variation in Hop Flavor Profiles” (2022)
- Managerial and Decision Economics- “Hopping on the Localness Craze: What brewers want from state-grown hops” (2021)

The project was highlighted in popular press and podcasts in Michigan and beyond.

- Craftbrewingbusiness.com. December 22, 2020
- Hop Queries 4.9, “The future for local hops”. January, 15 2021
- MSU Hop Podcast Episode 2. “MI Hop Terroir”. April 2021.
- Michigan Great Beer State Podcast, Season 3, Episode 7. August 23, 2022.  
<https://www.youtube.com/watch?v=rULOXbMg218>
- Master Brewers Podcast, “Is hop terroir a marketing construct and/or a biophysical reality?”  
<https://www.masterbrewerspodcast.com/250>, June 20, 2022.

Short Term Impacts:

- Increased knowledge of distinct terroir-influenced hop quality attributes (analytical brewing values and descriptive sensory analysis) based upon growing location
- Michigan hop terroir has been the subject of multiple news stories and Michigan hop growers and brewers are using the concept of ‘Michigan Hop Terroir’ to market their products.
- Increased knowledge of consumer preference for single-hop beer flavor and aroma

Medium Term Impacts:

- Hop growers have increased knowledge to leverage the distinct attributes of their hops.
- Growers are using Michigan Terroir as a marketing tool to leverage the distinct quality attributes of their hops.
- Michigan hop growers are marketing their Chinook hops as ‘Michigan Chinook’. This concept is spreading to other cultivars as well.

### **Budget Narrative**

The project was conducted consistent with the budget proposal by the PI and approved by the State of Michigan. No other sources of funding were used for this project under the direction of the PI. In-kind hop donations from Michigan growers amounted to approximately \$400.