

Optimal Hop Harvest Timing

SARE Project FNC18-1148



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BACKGROUND: Hop farming is growing in Midwestern agriculture, composed of many small farmers. As craft brewing has grown, so has demand for ingredients. Brewers express strong desire for local hops, but demand quality that meets industry standards for chemistry and excellent aroma and flavor. Much of this is determined by growing practices, particularly harvest timing. Hops have an optimal harvest time, and exhibit noticeable increase, peak and decrease of chemical components that affect crop quality. Large commercial growers in the Pacific Northwest (with decades of experience and scientific staffs) know these optimal harvest windows, but it's proprietary information, unknown to Midwestern growers, and may vary by region, even if we had their data. Those growers acknowledge harvest ranges from 18% to 26% dry matter content, unique to each variety. Determining what those numbers are for leading varieties here will greatly improve the economic viability of this high value specialty crop by ensuring the highest quality and therefore most competitive hop. As growers gain required knowledge and experience, quality, demand and profit will increase.



PROBLEM: Determine the optimal harvest timing of the most popular hop varieties grown in Ohio.

PROJECT OBJECTIVES

Determine the optimal harvest timing of ten of the most popular hop varieties grown in Ohio.

Share findings widely with other growers across the Midwest and Northeast through website, social media and conference presentations.

Share findings with the Ohio Craft Brewers Association to promote advances in quality, and encourage other state's growers to do the same with their affiliated brewers associations.

DESIGN: Growers picked a 60 gram sample of designated varieties weekly, commencing at 19% dry matter content and continuing until 26% dry matter content. Growers vacuum sealed a 30 gram sample of each variety, and shipped to a Advanced Analytical Research in Madison, WI for analysis, which conducted American Society of Brewing Chemist methods Hops-12, Hops-13, Hops-14, Hops-17, Hops-4C, which provided us with % alpha Acids, cohumulone, % beta Acids, colupulone, beta-pinene, myrcene, linalool, caryophyllene, farnesene, humulene, and geraniol levels, moisture dry matter, Hop Storage Index, and total oil content (mL/100g).



**AROMA QUALITY (AQ)
HOP QUALITY REPORT**

ADVANCED ANALYTICAL RESEARCH

Customer: Brent Tarkenton, Jeremy Nepper
Sample ID: Hop Cascade
Variety: Cascade
Certifying Officer: Jack Lile - Lab Manager

Date: 10/26/2019

Parameter	Value	Typical Range	Unit
% Moisture	8.1	8 - 12%	%
Total Oil (mL/100g of DM)	3.92	3.8 - 5.2 mL	mL/100g
Humulone	30.2	30 - 35%	%
Adelta-Acid of DM	2.86	3.5 - 4%	%
Beta-Acid of DM	3.92	4.0 - 7.0%	%

AROMA QUALITY (AQ)		% Acid	
% Precursor	2.35	0.50 - 0.80%	%
% Humulone	12.25	10.00 - 10.00%	%
% Adelta-Acid	11.75	0.00 - 0.00%	%
% Humulene	22.25	10.00 - 20.00%	%
% Geraniol	2.85	0.00 - 0.00%	%
% Beta-Pinene	1.85	1 - 8	%
% Myrcene	22.15	15.0 - 30.0	%
% Linalool	1.15	0 - 1.0	%
% Caryophyllene	11.05	0 - 30	%
% Farnesene	17.05	0 - 300	%
% Humulene	22.25	0 - 100	%
% Geraniol	2.85	0 - 1	%

Signature: *[Signature]*
Brent Tarkenton, Lab Manager - THE Certified Chemist

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**HOP AROMA QUALITY (AQ)
CERTIFICATE OF ANALYSIS**

ADVANCED ANALYTICAL RESEARCH

Customer: Brent Tarkenton, Jeremy Nepper
Sample ID: Hop Cascade
Variety: Cascade
Certifying Officer: Jack Lile - Lab Manager

Date: 10/26/2019

Parameter	Value	Unit
Hops-4C Moisture Analysis	8.1	%
Hops-4C % Dry Matter	91.9	%
Hops-4A Alpha and Beta Acids by HPLC	6.82	%
Hops-12 Hop Storage Index	1.24	mg/100g
Hops-13 Essential Oil by Steam Distillation	4.92	mL/100g
Hops-14 Alpha and Beta Acids by HPLC	6.82	%
Hops-17 Hop Essential Oil by GC-MS	4.92	mg/100g

Signature: *[Signature]*
Jack Lile, Lab Manager - THE Certified Chemist

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Growers also dried 30 grams to 8-10% moisture, vacuum sealed, labelled and froze for later use at a brewers' sensory evaluation panel. We compiled the lab results of each variety in a data table, determining when each reached its peak values for data points important to brewers, according to moisture content.



We assembled a panel of craft brewers from Cincinnati's Rhinegeist Brewing, Madtree Brewing, Taft's Brewing, Brink Brewing, Urban Artifact Brewing and Fibonacci Brewing, which collectively have won numerous medals at the Great American Beer Festival and other major competitions. They conducted blind evaluations of each variety using the American Society of Brewing Chemists Method Hops-16 (Hop Grind) for hop aroma evaluation. Brewers evaluated and ranked the samples for best aromatic properties within a variety, taking notes on their characteristics. We compiled their scores and added to our pivot chart to determine optimal hop harvest timing for these factors.



While we lack the number of tests or scientific rigor to call our results definitive, we believe we have very useful data on several varieties.

PROJECT FINDINGS

Optimal harvest dry matter depends on goal: Alpha acids or oil content

Brewer sensory aligns with oil content

24-25%: Cascade, Centennial, Chinook, Galena, Nugget

23-24%: AlphAroma, CTZ

Current harvest practice

Many growers are picking too early (grassy chlorophyll aroma)

Many growers are not drying/packing properly (cheesy/musty aroma)

Some growers picking too late (oniony/garlicky)

Ohio hop oil profiles are a bit different than PNW oil profiles

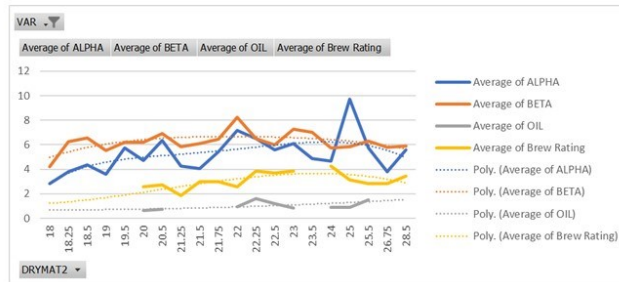
Ohio Cascade \neq PNW Cascade; Myrcene, B-Pinene lower in Ohio

All others in range

Creates different flavor/aroma profile. Growers could make it a selling point.

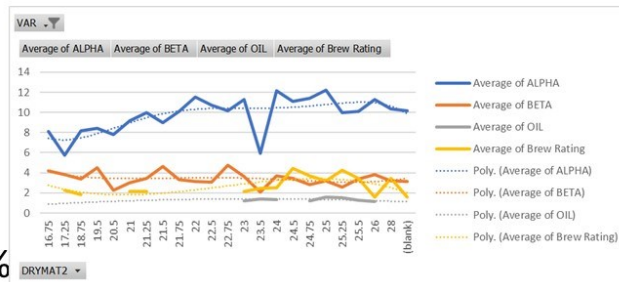
Cascade

DRY MATTER FOR PEAK
 Alpha Acids: 23.5-24.5%
 Beta Acids: 22-23%
 Oil Content: 24-25%
 Brewer rating: 24-25%



Chinook

DRY MATTER FOR PEAK
 Alpha Acids: 24-26%
 Beta Acids: 21-23%
 Oil Content: 24-25%
 Brewer rating: 24.5-25.5%



CTZ

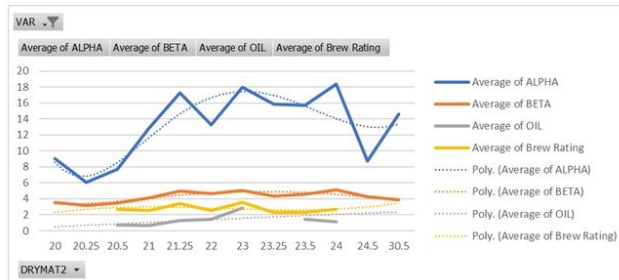
DRY MATTER FOR PEAK

Alpha Acids: 22.5-23.5%

Beta Acids: 21-24%

Oil Content: 23-24%

Brewer rating: 23%



Centennial

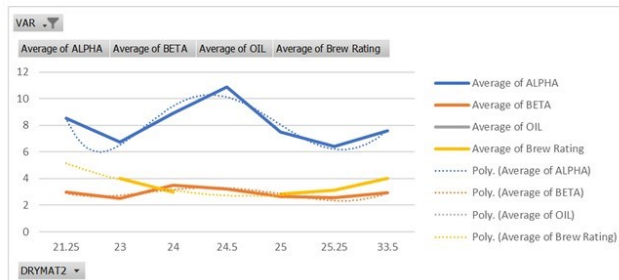
DRY MATTER FOR PEAK

Alpha Acids: 24-25%

Beta Acids: 24-25%

Oil Content: N/T

Brewer rating: 25-26%



AlphaAroma

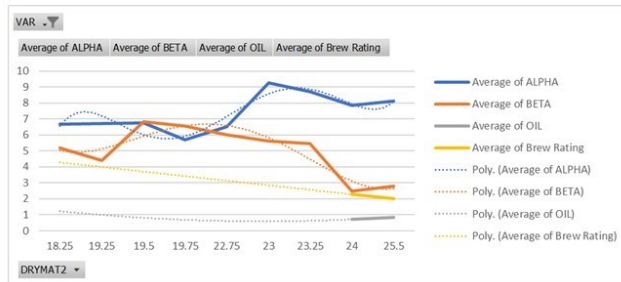
DRY MATTER FOR PEAK

Alpha Acids: 23.5-24.5%

Beta Acids: 20-21%

Oil Content: 23-24%

Brewer rating: 23-24%



Galena

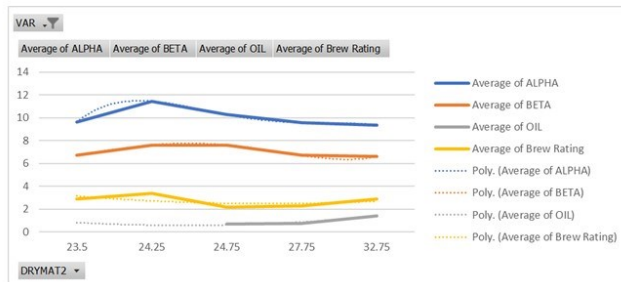
DRY MATTER FOR PEAK

Alpha Acids: 23.5-24.5%

Beta Acids: 24-25%

Oil Content: 25-27%

Brewer rating: 24-25%



Nugget

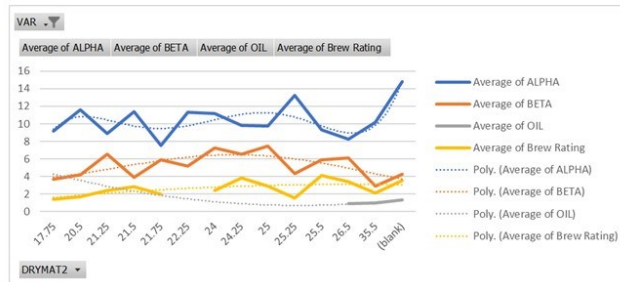
DRY MATTER FOR PEAK

Alpha Acids: 24-25%

Beta Acids: 23.5-25%

Oil Content: N/T

Brewer rating: 24-25%



Cascade

VAR	ALPHA	BETA	OIL	Brew Rating	B Pinene	Myrcene	Linalool	Caryophyllene	Farnesene	Humulene	Geraniol
CAS	9.72	5.85	0.88	3.14	3.91	256.55	6.73	123.94	98.61	219.65	2.75
CAS	7.18	8.24	0.93	2.57	3.48	261.29	5.38	125.21	115.33	280.98	1.73
CAS	6.4	5.82	0.91	4.29	3.48	262.41	5.78	120.2	77.76	255.4	2.62
CAS	5.76	5.74	0.73	3.71	2.69	209.88	4.17	98.42	55.6	200.93	1.57
CAS	6.09	7.29	0.84	3.86	2.37	172.78	5.43	107.16	90.35	241.54	1.92
CAS	4.73	6.04	0.58	2.86	2.11	158.39	3.3	70.49	57.03	165.14	1.01
CAS	5.04	5.66	0.73	2.29	1.99	130.21	4.37	111.8	64.85	255.11	1.71
CAS	5.03	6.69	0.75	2.71	1.57	114.04	4.75	112.38	92.51	259.18	2.38

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