

Ontario Benchmark Project



*Determination of alpha and beta characteristics
on key commercial hop varieties*

Final Technical Report

November 27, 2015

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Introduction

Ontario Hop Growers' Association (OHGA) is a not-for-profit horticultural association; recognized by the Ontario government in 2013 to represent the interests of hop growers in Ontario. Formed in 2011, by a group of volunteers, the association was formally recognized by the Ontario government in 2013 under the Agricultural and Horticultural Organizations Act.

The Ontario Benchmark Project was crafted to help OHGA in establishing benchmarks for Ontario grown hops that help answering the following questions, "What is an Ontario hop? What are the alpha and beta characteristics on key commercial varieties when grown in Ontario?"

This report provides the results of analytical tests conducted on hop samples of key commercial varieties from different regions in Ontario.

Methods

Study parameters

Participating growers were selected by the OHGA board of directors based on region of origin and comprised a good representation of the following nine varieties: Mount Hood; Willamette; Saaz (US) or Sterling; Chinook; Cascade; Hallertauer (US); Nugget; and Centennial. A total of 60 samples was expected: each hop variety sample was to be sent to Niagara College from the same grower, three times (early, mid- and late-season). In other words, 20 samples were to be tested three times, representing each of the three harvest seasons, resulting in 60 total samples.

Sample collection

Each participating grower was provided with a 'Hop Sample Collection Kit', by email and regular mail, which outlined the correct procedures for harvesting, storing and shipping samples to Niagara College for analysis. The followings were the agreed upon conditions for these samples:

- a) Mature cultivars shall be selected (over 3 years)
- b) Hop cones shall be harvested in 3 periods of time: Early-season (Aug. 10-21), Mid-season (Aug. 24-28) and Late-season (Sep. 7-11)
- c) Representative samples of each harvest time must be taken and dried (about 10% moisture)
- d) At least 50 g of dried samples shall be packed (light protected and –ideally- vacuum sealed), and properly labeled, using the pre-printed labels provided to growers by Niagara College (NC) in the 'Hop Sample Collection Kit'.

Receiving samples

Hop samples were received and all pertaining information was recorded in the respective form. A unique identifier (code number) was assigned to each sample. Gross weight of the package was determined and recorded as well. Samples were kept at freezing temperature (-20 °C) for a maximum of one week until enough samples arrived to run the analytical tests.

Sample analysis

On the day of analysis, prior to beginning testing all sample packages were removed from the freezer and placed on the lab benchtop for about one hour in order to reach room temperature. Packages were opened and Hop samples were placed in individual containers for examination. The weights of empty packages were then recorded to establish the net weight of the samples.

A representative sample of about 5 g was separated for moisture content analysis. Immediately before the analysis, another representative sample was ground up for determination of α and β -acids content, as well as Hop Storage Index (H.S.I.).

Moisture content (%) was determined using an automated moisture analyzer (Mettler-Toledo HE73). This methodology was previously validated against the American Society of Brewing Chemist –ASBC- protocol (Hops-4C) with identical results. Content of α and β -acids were determined by UV-Spectrophotometry according to the ASBC protocol (Hops-6A). H.S.I. was established according to the ASBC protocol (Hops-12). All samples were tested in duplicates.

Statistical analysis

Descriptive statistics such percentage, mean and standard deviation (SD) were calculated; samples showing values of α -acid content > 2 % above or below the expected range (by hop variety) were arbitrarily considered outliers and, therefore, not included in the statistical analysis. Due to the small size of the sample, no inferential statistics was attempted.

Results and discussion

A total of 10 growers participated in the study by providing 39 hop samples. Despite the fact that hop ‘cones’ were requested, 8 (21%) of the samples were received as hop ‘pellets’. Nine hop varieties were tested; Cascade and Saaz represented one-third of the samples. According to their location, samples from Eastern Ontario represented 15% of all samples, whereas Central and South-West regions accounted for 46 % and 41 %, respectively. Hop samples represented the three harvest seasons previously described; however, the number of samples from middle and late-season were very similar and accounted for 85 % of them; conversely, only 15% of samples were harvested during early-season. Out of 39 samples, 8 (20 %) were harvested from young cultivars (2 years or less).

Analytical tests

Detailed results (raw data) can be found in Appendix 1. Table 1 shows a summary of results from all analytical tests performed.

Table 1. Summary of results from all analytical tests performed, per hop variety

VARIETY	α % [‡]	SD	β % [‡]	SD	H.S.I. [‡]	SD	% Moisture [‡]	SD
Cascade	5.25	1.42	5.82	0.88	0.22	0.02	10.25	5.20
Centennial	10.08	1.49	4.41	0.89	0.28	0.03	8.69	3.54
Chinook	11.74	1.34	3.18	0.30	0.25	0.01	10.76	3.26
Fuggles	4.48	0.78	3.52	0.73	0.22	0.02	29.58	16.70
Hallertauer	4.70	2.08	2.83	0.44	0.27	0.01	6.49	0.99
Mount Hood	4.32	1.28	5.85	0.80	0.23	0.01	11.40	6.21
Nugget	11.87	n/a	4.72	n/a	0.25	n/a	7.77	n/a
Saaz	4.57	0.85	4.74	0.89	0.21	0.01	22.87	10.72
Willamette	4.23	0.67	4.56	1.25	0.25	0.02	10.49	2.23

[‡] Mean values; SD = Standard deviation. Outlier values were not considered in the calculation.

Out of all parameters measured, moisture content in the samples showed the largest variability; it ranged from 3.06 to 46.23 % ($M= 13.74$, $SD = 9.83$). Color in hop cones varied from green-yellowish to brown. Hop color was significantly associated to moisture content ($p= 0.004$). Moisture content in green-yellowish samples was lower ($M= 9.85$, $SD = 3.99$) compared to those in brown samples ($M= 26.71$, $SD = 12.94$). This comparison is depicted in Figure 1.

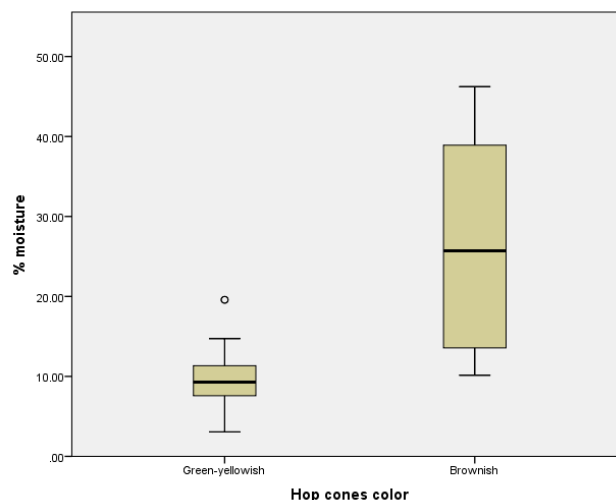


Figure 1. Moisture content in 39 hop samples tested, according to their color

In regards of H.S.I. (ASBC), 38% of the samples had index values ≤ 0.22 (“good keeper” according to ASBC’s protocol) whereas in 20% of them index values were ≥ 0.26 (“poor keeper”); almost half of the samples had their index values falling in between these qualitative categories. A moderate negative

correlation was found between H.S.I. and moisture content, although the latter would explain only 25 % of the variation found in the storage index (Figure 2).

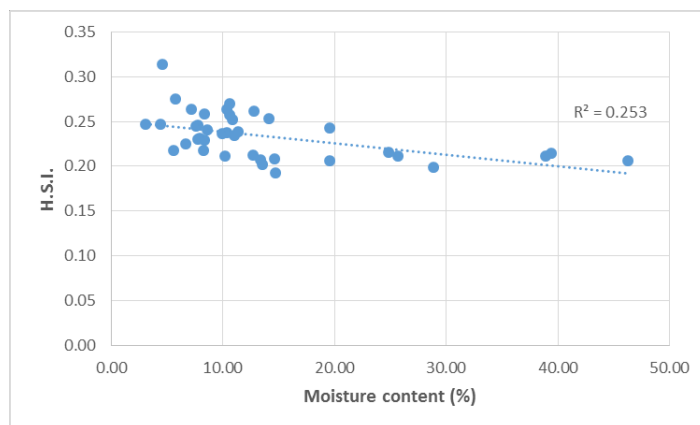


Figure 2. Correlation of moisture content and Hop Storage Index in 39 hop samples tested

The content of α and β -acids varied from sample to sample depending on type of variety. Detailed results can be found in Appendix 1. We lacked information about the expected value range of β -Acids content in each variety, hence discussion of results is focussed only on α -Acids.

Out of 9 varieties tested, mean values of α -Acids content in 8 (89 %) varieties were in the expected range. Mean values obtained in the Mount Hood variety was 4.32 %, which is a little bit lower than the expected range (5-8 %); it's noteworthy that half of samples of this variety came from very young cultivars and had lower content of α -Acids. However, due to the small sample size, whether young cultivars will usually have lower values than mature cultivars is yet to be determined and warrants further investigation.

A total of seven samples were not considered in the mean and SD calculations because their values were not congruent with the alleged variety. These samples were re-tested and lab results came in with no difference. As a matter of illustration, one of the "Willamette" samples had approximately 14 % α -Acids while the expected range for this variety is 4-6 %. In some cases it's suspected that mislabelling occurred, whereas in others, it might be an erroneous variety identification.

Table 2 shows a summary of α -Acids results in each variety according to the harvest period. Additionally, in Table 3 are summarized results according to the crop location. Unfortunately, no statistical inferences can be made due to the small sample size.

Table 2. α -Acids %[‡] in hop samples, per harvest season

VARIETY	Early	Middle	Late
Cascade	6.54	6.05	4.28
Centennial	8.36	11.00	10.88
Chinook	n/a	10.64	12.29
Fuggles	3.56	4.84	4.68
Hallertauer	n/a	6.17	3.24
Mount Hood	n/a	4.24	4.40
Nugget	n/a	11.87	n/a
Saaz	3.89	4.88	4.95
Willamette	n/a	4.58	3.52

[‡] Mean values are provided. Outlier values were not considered in the calculation.

Table 3. α -Acids %[‡] in hop samples, per crop location

VARIETY	Central	South- West	East
Cascade	6.99	4.32	4.54
Centennial	8.36	n/a	n/a
Chinook	13.23	10.99	n/a
Fuggles	5.42	4.17	n/a
Hallertauer	n/a	6.17	3.24
Mount Hood	5.40	3.24	n/a
Nugget	11.87	n/a	n/a
Saaz	4.21	4.94	n/a
Willamette	4.86	3.91	n/a

[‡] Mean values are provided. Outlier values were not considered in the calculation.

Conclusions

The present study provides a baseline data of α and β -acids content in some hop varieties being grown in Ontario. Nevertheless, data should be interpreted with caution, considering the variables described earlier.

Moisture content in samples showed a high variability. In the present study, moisture was significantly associated to the brown color in hop cones and pellets although it did not negatively affect the Hop Storage Index. However, in an anecdotal way, it was also noticed that brown cones have lost the characteristic hop aroma which arises concern of its potential effect on hops' essential oil content. More investigation is needed in this regard.

In almost all of the varieties tested, the content of α -acids was consistent with the expected referenced values. The small sample size makes it challenging to extrapolate conclusions regarding significant differences in α -acids content according to the harvest season and crop location. Nonetheless, this can be explored with a larger and better distributed sample in the future. For this purpose, the hop cones, rather than pellets, are considered the most valuable format for analysis.

Finally, some "outliers" found in this study might represent a wrong variety identification rather than a mislabelling case. There is merit in addressing this issue so that OHGA's members can be certain on which hop variety they are growing at their farms.

Appendix 1. Test results from 39 hop samples

N°	FARMER	VARIETY	YEAR PLANTED	HARVEST DATE	PERIOD	LOCATION	TEST DATE	α %	β %	H.S.I.	% Moisture	COMMENTS
1	002	Saaz	2012	18-Aug-15	E	Central	15-Sep-15	3.20	4.22	0.20	13.56	Brownish (about 65 %) + Olive Green
2	002	Saaz	2012	23-Aug-15	M	Central	15-Sep-15	4.15	5.26	0.20	28.85	Brownish (All)
3	008	Hallertauer	2013	28-Aug-15	M	SW	22-Sep-15	6.17	3.14	0.28	5.79	Green-Yellowish
4	002	Saaz	2012	07-Sep-15	L	Central	22-Sep-15	5.29	6.27	0.21	10.15	Olive Green + Brownish (about 40 %)
5	003	Fuggles	2011	23-Aug-15	M	Central	22-Sep-15	5.42	4.11	0.26	8.38	Pellets
6	003	Mount Hood	2011	23-Aug-15	M	Central	22-Sep-15	5.07	5.89	0.23	7.75	Pellets
7	003	Nugget	2011 + 2013	23-Aug-15	M	Central	22-Sep-15	11.87	4.72	0.25	7.77	Pellets
8	003	Willamette	2011	23-Aug-15	M	Central	22-Sep-15	4.86	6.00	0.23	8.34	Pellets
9	005	Fuggles	2013	21-Aug-15	E	SW	25-Sep-15	3.56	2.47	0.21	46.23	Brownish (All)
10	005	Fuggles	2013	28-Aug-15	M	SW	25-Sep-15	4.27	3.59	0.21	38.91	Olive Green + Brownish
11	005	Fuggles	2013	11-Sep-15	L	SW	25-Sep-15	4.68	3.91	0.22	24.80	Olive Green + Brownish
12	005	Saaz	2013	21-Aug-15	E	SW	25-Sep-15	4.59	3.76	0.21	39.36	Brownish (All)
13	005	Saaz	2013	28-Aug-15	M	SW	25-Sep-15	5.60	4.48	0.21	25.70	Olive Green + Brownish
14	005	Saaz	2013	11-Sep-15	L	SW	25-Sep-15	4.62	4.49	0.21	19.59	Green-Yellowish
15	006	Chinook	2014	26-Aug-15	M	SW	25-Sep-15	10.64	2.83	0.26	10.61	Green-Yellowish
16	006	Chinook	2014	09-Sep-15	L	SW	25-Sep-15	11.34	3.32	0.25	14.10	Pellets
17	006	Mount Hood	2014	26-Aug-15	M	SW	25-Sep-15	3.42	6.09	0.21	12.69	Green-Yellowish
18	006	Mount Hood	2014	07-Sep-15	L	SW	25-Sep-15	3.07	4.74	0.24	19.57	Pellets
19	006	Willamette	2014	26-Aug-15	M	SW	06-Oct-15	4.30	3.96	0.26	12.79	Brownish (All)
20	006	Willamette	2014	07-Sep-15	L	SW	06-Oct-15	3.52	3.71	0.26	10.35	Pellets
21	004	Cascade	2010	22-Aug-15	E	Central	06-Oct-15	6.54	5.83	0.25	4.44	Green-Yellowish
22	004	Cascade	2010	27-Aug-15	M	Central	06-Oct-15	7.45	6.51	0.25	3.06	Green-Yellowish
23	004	Cascade	2010	02-Sep-15	L	Central	06-Oct-15	10.35	4.37	0.23	7.90	Green-Yellowish
24	004	Centennial	2012	24-Aug-15	E	Central	06-Oct-15	8.36	3.39	0.31	4.61	Green-Yellowish
25	004	Centennial	2012	31-Aug-15	M	Central	06-Oct-15	11.00	4.86	0.27	10.61	Green-Yellowish
26	004	Centennial	2012	11-Sep-15	L	Central	06-Oct-15	10.88	4.99	0.25	10.85	Green-Yellowish
27	004	Hallertauer	2010	31-Aug-15	M	Central	06-Oct-15	8.66	4.44	0.23	6.67	Green-Yellowish
28	004	Hallertauer	2010	10-Sep-15	L	Central	06-Oct-15	14.25	4.21	0.24	10.36	Green-Yellowish
29	004	Chinook	2012	11-Sep-15	L	Central	14-Oct-15	13.23	3.38	0.25	7.58	Green-Yellowish
30	004	Mount Hood	2010	10-Sep-15	L	Central	14-Oct-15	5.72	6.66	0.22	5.57	Green-Yellowish with Brown Spots
31	004	Willamette	2015	11-Sep-15	L	Central	14-Oct-15	13.97	4.19	0.23	11.00	Green-Yellowish
32	007	Cascade	2012	24-Aug-15	M	SW	14-Oct-15	4.65	6.49	0.21	14.59	Green-Yellowish
33	007	Cascade	2012	07-Sep-15	L	SW	14-Oct-15	4.56	6.08	0.21	13.36	Green-Yellowish
34	010	Hallertauer	2013	07-Sep-15	L	East	14-Oct-15	3.24	2.52	0.26	7.19	Green-Yellowish with Brown Spots
35	010	Cascade	2013	07-Sep-15	L	East	14-Oct-15	4.54	5.86	0.19	14.72	Green-Brownish
36	009	Cascade	2014 + 2015	21 & 28-Aug-15	L	SW	14-Oct-15	3.75	4.12	0.24	11.34	Pellets
37	001	Nugget	2012	20-Aug-15	E	East	16-Oct-15	5.93	5.34	0.24	8.63	Green-Yellowish
38	001	Nugget	2012	25-Aug-15	M	East	16-Oct-15	5.08	5.23	0.22	8.24	Green-Yellowish
39	001	Nugget	2012	13-Sep-15	L	East	16-Oct-15	7.59	4.85	0.24	9.94	Green-Yellowish

Note: Samples in red color were consider outliers and, therefore, not included in the mean and SD calculation

Appendix 2. Expected values of α -Acids content (%) in hop varieties tested

VARIETY	α -Acids %
Cascade	4-7
Centennial	9-11
Chinook	11-14
Fuggles	4-6
Hallertauer	3.5-5.5
Mount Hood	5-8
Nugget	11-16
Saaz	3-4.5
Willamette	4-6

Source: OHGA (<http://www.ontariohopgrowersassociation.ca/resources/hop-cultivars/>)