



The Benefits of Hop Blending During Dry-Hopping Webinar

March 7, 2019 | Q&A Session

Dr. Scott Lafontaine (Oregon State University)
Dr. Kiyoshi Takoi (Sapporo Breweries, Ltd.)

1. Which yeast strains are known to facilitate hop biotransformation during fermentation?

Dr. Takoi A:

We have no published data. However, several German researchers have tried it. For example...
(wileyonlinelibrary.com) DOI 10.1002/jib.523

https://www.brewingscience.de/index.php?tpl=table_of_contents&year=2018&edition=0005%252F0006&article=91457

Dr. Lafontaine A.:

Hop biotransformation is a rather broad term. Aglycons (particularly, geraniol, linalool, α -terpineol) can also be liberated from odorless glycosides via yeast enzymatic activity and a study by Dr. Sharp at Oregon State University showed that different yeast strains have varying capacities to hydrolyze glycosides. However, his study and a study by Cibaka et al. showed that hop glycosides likely have only a minor contribution on the overall hoppy aroma in beer. Although it is uncertain how harvest maturity impacts glycoside concentrations in hops.

Sharp et al. <https://onlinelibrary.wiley.com/doi/full/10.1002/jib.418>

Cibaka et al. <https://doi.org/10.1094/ASBCJ-2017-2257-01>

2. Dr. Takoi. Have you looked at the synergy of volatile thiols with non-fruity hops, such as Hallertauer mittlefrüh, Saaz, Tettnanger?

Dr. Takoi A:

We have tried to examine many pairings of hop-derived flavor compounds and/or hop varieties for evaluating sensory synergy. However, flavor compounds containing in traditional aroma hops, for example terpene hydrocarbons and their derivatives, might not be enhanced by volatile thiols. On the other hand, in recent study, we found that geranic acid which was identified from Sorachi Ace hops could enhance the flavors of not only geraniol derivatives but also such traditional terpenoids.

<https://pubs.acs.org/doi/abs/10.1021/acs.jafc.8b04395?journalCode=jafcau>

3. Would there be an impact in these scores with increase dry hopping rates in American craft? For example, 2-3 #/bbl

Dr. Takoi A:

We have carried out brewing trials with relatively low hop dosages. However, I think that the impact of biotransformation and/or release (from precursors) of flavor compounds could be effective even in increased hop dosage conditions. And I think, such yeast-related processes requires a certain fermentation/storage period, described in my presentation. So, dry-hopping

period is another important factor. For example, it is expected that New England IPAs might contain less hop-derived hydrocarbons and more yeast-related compounds, because of their relatively early dry-hopping timings.

Dr. Lafontaine A:

Here is a link to a study where we investigated the efficiency of aroma and volatile extraction at a range of different dry-hopping rates (0, 0.5, 1, 2, and 4 lb/ US barrel).

<https://doi.org/10.1002/jib.517>

Although for this project we only used a single variety, Cascade, to dry-hop beers. In general what we observed is that as the dry-hopping rate increases there seems to be diminishing returns from the hops you are using for dry-hopping (from both an aroma and volatile extraction perspective) and there seemed to be a sweet spot between 1 lb/barrel (3.86 g/L) and 2 lb/barrel (8 g/L). The quality also changes as the dry-hopping increased becoming more herbal/tea in character and less citrus character at the higher rates.

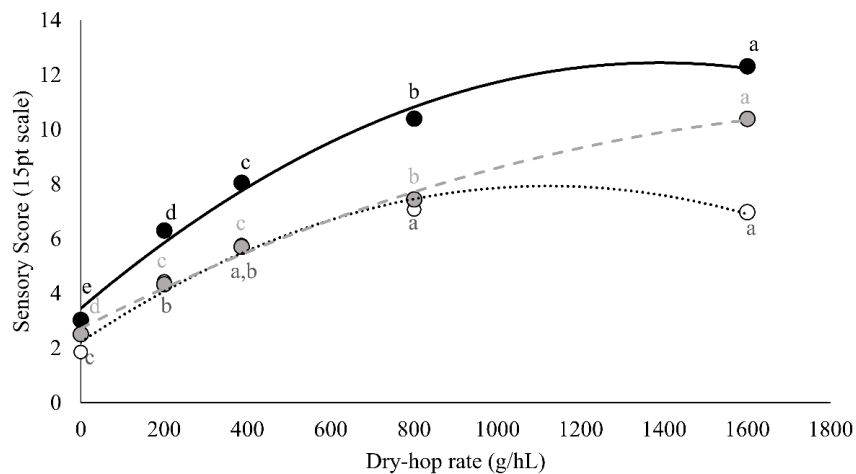


Figure 1. Mean values of overall hop aroma intensity (OHAI; black circles), Citrus (white circles) and Herbal/tea (gray circles) sensory attributes vs dry-hopping rate. Letters associated with the markers in the figure indicate statistically significant groupings (Tukey's HSD tests p-value < 0.05).

Given the results that Dr. Takoi and I presented (provided you are targeting the right blends), there is the potential for blend hopping to be a way to decrease dry-hopping rates, while promoting overall aroma intensity.

Also, adding to Dr. Takoi's answer. While a higher level of biotransformation would be expected in beers with more hop/ fermenting beer contact time. A recent study by Maye et al. (link below) shows that there are extremely high concentrations of hop hydrocarbons in NEIPAs. In general filtered beer styles generally have very low concentrations of hop hydrocarbons and Maye hypothesized that the haze (protein and polyphenol) matrix served to emulsify these volatiles and keep them in solution.

<https://www.mbaa.com/publications/tq/tqPastIssues/2018/Pages/TQ-55-4-1218-01.aspx>

4. **Have either of them applied these to hop aroma qualities in finished product over shelf life? Blends that are more aromatically stable?**

Dr. Takoi A:

The changes in flavor intensities during storage of finished products might differ depending on types of hop flavor compounds. In the case of monoterpene alcohols, the intensities of these compounds gradually decreased during storage. In addition, the flavors of monoterpene alcohols could be masked by staling flavors. I think that the flavor of 4MSP could be felt in staled beers, in comparison with those of other hop-derived flavor compounds. So, it is expected that a beer made with blend-hopping using 4MSP-rich hops could be more aromatically stable.

Dr. Lafontaine A.:

While we have not looked at this directly. A study done by Brad Barnette in the Shellhammer Laboratory at Oregon State (still in review) showed what I think a lot of brewers see. Hop aroma diminishes overtime and staling flavors become more pronounced. I agree with Dr. Takoi that blend-hopping during dry-hopping could be a way to promote hop aroma intensity and possibly stability. It is also possible that different hop varieties have different levels of anti-oxidant potential. However, this comes with a caveat because there is research that shows that thiols (4-MSP) are extremely reactive and this makes dissolved oxygen concentration in package beer a very important consideration. DO should be a key quality marker and kept low in packaged hop-forward beers.

Roland et al. thiol reactivity research - <https://www.ncbi.nlm.nih.gov/pubmed/27688176>

5. **Is there an opportunity to extract the flavors to simulate and blend these terpenes and volatile thiols to give enhanced tropical and other flavors?**

Dr. Takoi A:

If hops extracted by CO₂ and/or ethanol, any precursors could not almost extracted because of their hydrophilicity. So, by using any hop extracts, only free-form of flavor compounds could be available. I am afraid that it is very restricted test condition.

Dr. Lafontaine A:

There is tremendous potential to utilize this type of approach as we start to better understand the chemical drivers of hop flavor and aroma, not only from hop extracts but from other botanicals as well.

6. **Do extracts behave similarly to pellets?**

Dr. Takoi A:

Hop extracts in general contain selected high hydrophobic components derived from hops. However, the precursors of monoterpene alcohols and volatile thiols are more hydrophilic. So, in hop extracts, free forms of flavor compounds are dominant. I think that the behavior of flavor compounds might change during fermentations using between hop pellets and extracts.

7. **Was the hop storage index of their source hops analytical material assessed for these trials?**

Dr. Takoi A:

We used fresh hop pellet/powder materials and don't assess the hop storage index of many hop samples, we used. However, in unpublished data, prolonged storage of hop pellets, for example Cascade, resulted in less-characteristic beers. I think, the longer the hop storage period is, the less-characteristic the beers made with storage hops are.

Dr. Lafontaine A:

For those unfamiliar, hop storage index (H.S.I.) is the ratio of absorbance at 275nm to the absorbance 325nm when the alkaline methanol extract is evaluated with a UV spectrophotometer

See ASBC MOA Hops 12 <http://methods.asbcnet.org/summaries/hops-12.aspx>

While people use H.S.I. as a general index of oxidation, the ratio was not really intended to be used as a metric for the aroma quality of hops. This ratio really refers to the bitterness potential/quality of hops because the max absorbance of humulinones (oxidized α -acids) occurs at 275nm, while the max absorbance of humulones (α -acids) occurs at 325nm. As humulones oxidize to humulinones the absorbance at 325nm decreases while the absorbance at 275nm increases. Therefore, the H.S.I. increases as humulones oxidize. However, this may or may not have any direct relation to the oxidation of the volatiles that drive hop aroma and flavor in beer.

The hops used on our study were not analyzed for H.S.I. Upon receiving the hops from Crosby Upon arrival at Oregon State University, the hops were repackaged in high barrier foil pouches, purged of air using nitrogen, sealed and stored cold (-20 °C) until dry-hopping and chemical analysis. We did analyze and report the total oil content of the hops at the time of dry-hopping as well as the composition of the essential oil.

ASBC members have access to the [on-demand webinar](#)