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Dry hopping's effect on beer foam

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Introduction

The major contributors to beer foam are hop acids and malt proteins. Most brewers are familiar with the foam enhancing properties of isoalpha acids, tetrahydro-isoalpha acids, hexahydro-isoalpha acids, and alpha acids. However, given the recent popularity in dry-hopping, some craft brewers are experiencing poor beer foam. The reduction in beer foam due to dry hopping could be due to a number of factors including a change in hop acid composition[1], the incorporation of hop oils or the incorporation of hop lipids/fatty acids. To better understand these affects, beer foam was tested via the Nibem Foam Stability Test before and after dry-hopping. Also, non-dry hopped beers were spiked with a variety of hop acids, hop oil, and fatty acids and foam tested to determine if any of these are responsible for the reduction in beer foam and what craft brewers can do to remedy it.

Methods

Foam stability testing was conducted on beers at room temperature using the Nibem-30 foam stability method of EBC 9.42.[2] Samples of beer, before and after dry hopping, were analyzed by HPLC for hop acids using Phenomenex Kinetex 2.6 um, 50mm x 4.6 mm column and the HPLC method of EBC 7.9.

Bottles of commercial beer were treated with diluted aqueous solutions of either alpha acids, humulinones, isoalpha acids, and beta acids prepared from a 20% AlphaExtract (Hopsteiner), or 30% Iso-extract (Hopsteiner). Humulinones and purified beta acids were prepared in our lab.

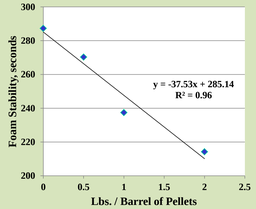
Lipids and fatty acids from 6% ethanol-water extracts of hop pellets were saponified with 45% NaOH and then analyzed by HPLC using an in-house method to be published. Linoleic acid was determined at 202 nm using the preceding HPLC column.

A pilot-scale IPA was brewed and dry hopped with 1 and 2 lbs /barrel of Cascade hop pellets, carbonated and bottled. To some bottles were added tetrahydroiso-alpha acids, diluted from a 10% Tetra Iso-extract (Hopsteiner).

Effect of Dry Hopping on Foam Stability

Dry hopping a commercial ale, assaying 44 ppm iso-alpha acids by HPLC, with Cascade hop pellets resulted in a near linear drop in Nibem foam stability when tested at 20 °C, Figure 1.

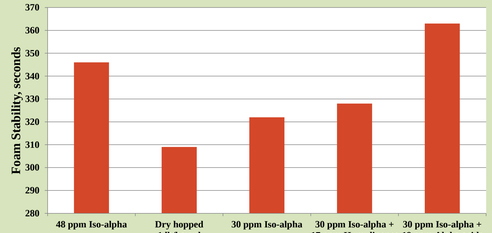
Figure 1. Effect of Dry Hopping on the Nibem Foam Stability on an IPA



Effect of Hop Acid Composition on Foam Stability

A beer containing 48 ppm isoalpha acid (HPLC) had its Nibem Foam tested before and after dry hopping with 1 lb Cascade hop pellets / barrel beer for three days. Dry hopping caused a 37 second reduction in beer foam stability and caused a change in the hop acid composition of the beer. HPLC analysis of the dry hopped beer showed it contained 30 ppm of isoalpha acid, 17 ppm of humulinones, and 19 ppm of alpha acid[1]. To see what effect isoalpha acids, humulinones and alpha acids had on beer foam, a 30 ppm iso-alpha acid beer was prepared as well as a 30 ppm isoalpha acid + 17 ppm of humulinone beer, and finally a 30 ppm isoalpha acids + 19 ppm alpha acid beer, with each having their beer foam measured. The results in figure 2 show that a loss in isoalpha acid concentration results in a loss in beer foam stability and the incorporation of 17 ppm humulinone does little to improve that foam. When 19 ppm of alpha acids were added to the 30 ppm isoalpha acid beer the foam stability was better than the pre-dry hopped beer. These results show that the loss is foam stability was not due to the change in hop acid composition but due to something else.

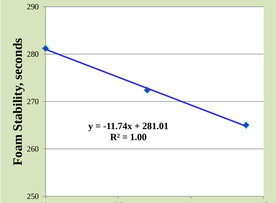
Figure 2. Effect of hop acids and dry hopping on the Nibem Foam Stability of a high BU ale



Foam Negative Hop Compounds

Dry hopping is used to impart hop oils into beer. However when pure myrcene and pure linalool were added to beer they had almost no effect on Nibem foam stability of that beer (1-2 second decrease with 0.5 ppm myrcene or linalool). The only identified hop compound found to decrease the foam stability of beer was beta acids; see Figure 3. However beta acids are not the major contributor to the decrease in beer foam stability. When 2 lbs of cascade hop pellets were added per barrel of beer only 0.9 ppm of beta acids got into the beer and thus only contributed about a 14% decrease in foam stability; Fig. 3.

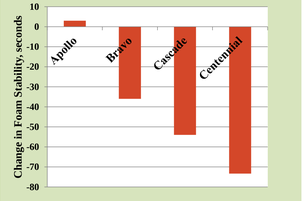
Figure 3. Effect of Beta acids on the Nibem Foam Stability of an IPA beer



Hop Variety and Hop Lipids on Foam Stability

Hop pellets from four different hop varieties were extracted with aqueous-6% ethanol based on a 1 lb/barrel dry hop dosage. This extract was added to beer and caused a drop in Nibem foam stability similar to that obtained with dry hopping with pellets. The aqueous extracts of Centennial, Cascade, and Bravo hop pellets were foam-negative whereas Apollo slightly improved foam stability; see Figure 4. The concentration of linoleic acid (after saponification) in the aqueous extracts positively correlated with the decrease in foam stability. These results indicate that hop lipids are most likely a major contributor to foam-destabilization when one dry hops.

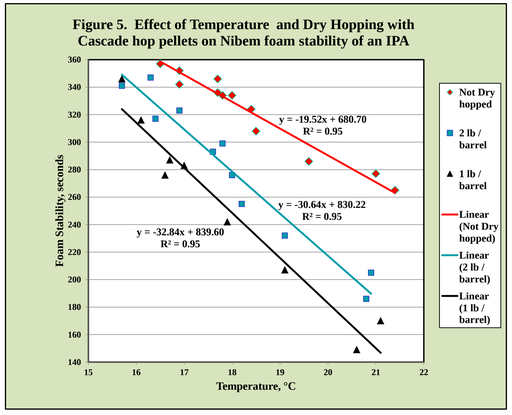
Figure 4. Effect of Hop Variety on Nibem Foam Stability of an IPA



Beer Temperature and Foam Stability of Dry Hopped Beer

The preceding results were all from beer foam tested at room temperature as required by the Nibem foam stability test method, EBC 9.42[2]. However a recent publication showed that beer temperature is a factor when it comes to the foam stability of beer[3]. The Nibem foam stability of dry hopped IPA's were extremely sensitive to temperature as shown in Figure 5. Thus the decrease in foam stability upon dry hopping was much less when testing cold beer vs room temperature beer. Interestingly, some hop acids like alpha acids are more sensitive to temperature when it comes to its foam enhancement effect vs others foam enhancing hop acids[3].

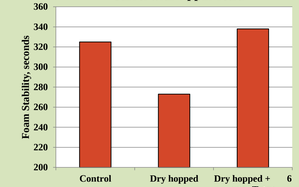
Figure 5. Effect of Temperature and Dry Hopping with Cascade hop pellets on Nibem foam stability of an IPA



Foam Stability Improvement of Dry Hopped Beer

The drop in foam stability of a pilot-scale brewed beer after dry hopping with 2 lbs of Cascade hop pellets per barrel of beer could be reversed by the addition of a foam-enhancing hop acid, such as tetrahydroiso-alpha acids (or Tetra); see Figure 6. The addition of 6 ppm of Tetra not only improved the foam stability of the beer but also contribute about 6 IBU's of bitterness.

Figure 6. Improvement of IPA dry hopped at 2 lbs / barrel with 6 ppm Tetra



Conclusions

Dry hopping results in a decrease in iso-alpha acids and an increase in humulinones and alpha acids. This change in hop acid composition should increase a beers foam stability but doesn't; the reason appears to be due to foam-negative hop compounds, which might be hop lipids. Hop lipids were solubilized in 6% ethanol/water and their concentration was variety dependent. Hop varieties with higher concentrations of solubilized lipids such as Centennial and Cascade caused a greater reduction in beer foam stability when used at the same dose rate as another variety such as Apollo. Beta acids were the only hop acid found to be foam-negative, though its concentrations in dry hopped beers were low and it's effect on beer foam stability small. Temperature also affects the foam stability of dry hopped beers; colder beers had better foam stability than room temperature beers. Finally, brewers who do experience a reduction in beer foam due to dry hopping can reverse this effect by using a foam enhancing hop products like Tetra.

References

1. Maye, J.P., Smith, R.J., and Leker, J. (2016). Humulinone formation in hops and hop pellets and its implications for dry hopped beers. MBAA TQ 53: 23-27.
2. European Brewery Convention Analytica-EBC section 9 Beer method 9.42 Foam stability of beer using the NIBEM-T meter. Fachverlag Hans Carl, Nuremberg, Germany 1998.
3. Maye, J.P., Wilson, R., Smith, R.J. and Schwarz, H. (2014). A natural foam enhancer from hops. Brauwelt International. 146-149.