



QCL AND HACKNEY BREWERY Late/Dry-Hopping - IBU Value

Introduction

Over the years, a number of different analytical techniques have been employed by the brewer in order to monitor the process of brewing such as pH, density, microscopy etc. More recently, UV/Vis spectrophotometry has been used to determine the bitterness of beer, giving a value to bitterness called International Bittering Units (IBUs), values of which are typically between 0 - 100. By having a measurable number associated to bitterness, micro-breweries can track the consistency of their brewing batch-to-batch as well as ensuring that they are brewing to specification.

The distinctive bitterness in beer is achieved from the hops added to boiling wort during the brewing process, where compounds in the hop leaf called alpha-acids (primarily humulone) undergo isomerisation to produce iso- α -acids (isohumulone) as shown in Figure 1. By using spectrophotometry, the absorbance of an extracted beer sample taken at 275 nm can be converted to give you the IBU value (which is roughly the concentration of iso- α -acids in ppm).



Figure 1: Formation of Humulinones

This traditional method for measuring bitterness often requires a laboratory with a laboratory technician, UV/Vis spectrophotometer, water bath, glassware, solvents etc. and can take anywhere from 15 to 30 minutes. Using the BeerLab, the bitterness of a beer sample can be recorded in approximately 6 or 7 minutes and can be performed by anyone.

A recent article published in the MBAA Technical Quarterly by Maye, Smith and Leker¹ demonstrated that over time, there was a formation of humulinones (see Figure 1) in Hops and Hop Pellets from oxidation of humulones, which had also been found in beers that had been dryhopped.

Maye *et al* showed that humulinone is around two thirds as bitter as isohumulones and as such contributed to the final bitterness of dryhopped beers. The chemical structure of humulinone is very similar to that of isohumulone, apart from the functional groups as highlighted in red and green (Figure 1) and because of this, the absorbance at 275 nm is also very similar, meaning that humulinone contributes to measured IBUS.

Taking all of this into account, it is easy to see (contrary to popular belief) that dry-hopping can and does contribute to the bitterness of beer.

Project

Established in 2011, Hackney Brewerys beers are a mix of modern and traditional styles. From starting as a cask ale brewery the product range has expanded to embrace kegged, bottled and latterly canned beers. UK malt and hops are used, as well as ingredients from the USA, New Zealand and Europe, all traceable back to source.

The brewhouse uses 100% green energy that comes from windmills, keeping the carbon footprint as small as possible, and energy recapture technology reclaims heat that would otherwise be lost during the brew.

Excess transfer water is saved during cleaning and local farmers collect spent grain for animal feed. The brewery champions the London Living Wage scheme and is actively involved in local community charities.



The aim of this project was to use the BeerLab to measure the IBU value of two Hackney beers during late-hop additions (hops added right at the end of the wort boil) and during dry-hopping (hops added during fermentation) with a final IBU measurement taken on the finished product. It was thought that the study would give a number of IBUs that could be picked up from late-hopping and subsequently a number of IBUs that would be picked up during dry-hopping, to ultimately provide a rough late/dry-hop 'utilisation' that could be applied to different recipes when brewing to specification.

Results

For the study, a wort sample was taken before any late-hop additions and cooled to room temperature before the bitterness was analysed using the BeerLab. At the end of boil, the wort was chilled to 80°C before being transferred to the FV. During this time a sample was taken from the copper every 5 minutes and bitterness analysed on the BeerLab. During transfer to the FV, a sample was taken from the FV every 15 minutes and bitterness analysed on the BeerLab. After transfer to the FV, yeast was added and a sample was analysed for bitterness before and after each dry-hopping, with a final sample taken for analysis from the finished packaged product.

Kapow!

The first beer analysed was Hackney Kapow! A beer with no traditional bittering as no hops are added during the wort boil, all bitterness and hop character in the beer comes from late/dry-hopping. It came as no surprise that before any late-hop addition at Time X (see Figure 2) there were 0 IBUs, similarly when the first late-hop addition was added Time 0 there were also 0 IBUs.

From the end of boil, right through to the end of transfer into the FV it is clear to see that there is a steady increase in IBU value as the wort in the copper remains in contact with the late addition hops, picking up 55 IBUs of bitterness.



Figure 2: Kapow!

After the transfer to FV, yeast is added and 3 days later a sample was analysed for bitterness prior to the first dry-hop addition, showing the IBU value had dropped during fermentation. This is due to iso-alpha-acids (which are not particularly soluble in water) 'sticking' to the yeast and dropping out of the beer, which is further aided by the drop in pH that is accompanied by fermentation.

Figure 2 shows that a sample was analysed for bitterness before the 1st, 2nd, and 3rd dry-hop additions again demonstrating a rise in IBU value, however, this time the fermenting beer is at around 18°C. This suggests that the increase in 20 IBU achieved during dry-hopping could not come from iso-alpha-acids (as this would require heat) and instead has come from other hop constituents such as humulinones, as mentioned above.

Hop additions and the Alpha-acid content for this batch of Kapow! is shown in Figure 3 below.

	1 st Late-Hop	2 nd Late-Hop	Dry-Hop	Alpha-Acid
Hop 1	1.25 Kg	1.25 Kg	6.00 Kg	11.6 %
Hop 2	1.25 Kg	1.25 Kg	5.00 Kg	9.6 %
Hop 3	1.00 Kg	4.00 Kg	6.00 Kg	14.5 %

Figure 3: Hop additions - Kapow!

As you can see 10Kg of late-addition hops contributed to an initial 55 IBUs and when using late-hop timings as 'boil time' in the Brewer's Friend IBU calculator, this should only achieve 42 IBUs at full boil. Further to this 17Kg of dry-hop additions added 22 IBUs at fermentation temperatures bringing the final bitterness of Kapow! to 62 IBU.

APA

The second Beer chosen for analysis was Hackney APA. This beer does contain some traditional bittering with two hop additions during the boil to give an IBU target of around 20 IBU.

As expected, the starting measured bitterness at time X is 20 IBU, followed by a slight increase at Time 0 and 5 minutes after the end of the boil. At this point in sampling, hop leaves from the initial bittering started to block the sampling tap, causing the sample to flow out of the tap very slowly and over a high concentration of hop leaves. This ultimately led to the false high results seen throughout the period of sampling direct from the copper. It is important to highlight sampling integrity here as any samples taken with high hop-leaf content or blocked sample taps can cause erroneous results.

The samples taken from Time 40 to 120 were directly taken from the FV during transfer from the copper, avoiding the issue with a blocked sampling tap and producing similar results to those seen in Kapow! with a steady increase in IBUs from 22 to 27.5.

Once again, addition of yeast and 3 days fermentation saw a drop in IBU to 24, but after a second day of dry-hopping the IBUs rose to 31.5 in the finished packaged product. Hop additions and the Alpha-acid content for this batch of APA is shown in Figure 5.

	1 st Late-Hop	2 nd Late-Hop	Dry-Hop	Alpha-Acid
Hop 1	0.55 Kg	-	-	14.6 %
Hop 2	1.25 Kg	3.75 Kg	5.00 Kg	8.5 %
Hop 3	-	-	5.00 Kg	10.5 %

Figure 5: Hop additions - APA

When looking at these figures, 1.80 Kg of boil hops contribute to the 20 IBU starting point as expected, however it is difficult to see the effect of the late-hop addition due to the blocked sample tap. We do see a slight increase from 21 to 27 IBUs during the transfer to FV, which would most likely have come from the late-hop addition. In this case, 10 Kg of dry-hop addition has given rise to an IBU increase of around 7 IBUs, which when comparing to the Kapow! is less than half the IBUs per weight of hops, but could be attributed to a lower Alpha-acid content of the hops used in APA compared to Kapow!.



Conclusion

Hops are traditionally added to boiling wort during the brewing process to convert humulones to isohumulones, adding bitterness and producing a balance to the naturally sweet flavour of wort. Modern styles of beer have seen an increase in hops added at different stages of the brewing process, including at the end of the wort boil (late-hopping) and near the end of fermentation (dry-hopping). It has been thought that late-hopping and dry-hopping do not contribute to IBUs in beer, however, using the BeerLab Hackney has been able to conduct an investigation into this without the need for a chemical laboratory. We have demonstrated a considerable increase in IBU value from both late and dry-hopping suggesting that alternative compounds present in hops (such as humulinone) do in fact contribute to the IBU value during the brewing process.

References

1. MAYE J. P., SMITH R., Leker J.; MBAA Technical Quarterly, 2016, Vol. 53, pp. 23 – 27.

2. DE KEUKELEIRE D., VERZELE M.; Tetrahedron, 1971, Vol. 27, pp. 4939 – 4945.

3. https://www.brewersfriend.com/ ibu-calculator

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