The Northern Craft Brewers

"We Live We Brew"

HOP VARIETIES: USES AND SUBSTITUTION

BY IAN PRIDDEY

The following article is based upon a talk given to the Northern CBA's meeting on 27 April 2002 at 'Brupaks', Huddersfield.

BACKGROUND

My interest in hop varieties increased in 1985 when on my first trip to the USA I visited the Anchor Brewery in San Francisco and fell in love with their Liberty Ale, heavily hopped with the floral American variety Cascade. By 1988 I was growing Cascade and Goldings hops at home and soon had half a freezer full of home grown hops, plus samples of new American varieties sent to me by a friend working in an American micro-brewery. There seemed little point in buying more hops, which led me to experiment with substituting hop varieties in existing recipes based upon what I had available. But how to substitute varieties?

CLASSIFICATION OF HOP VARIETIES BY USE

When I started brewing in 1980 I used to think in terms of aroma and bittering hops. As the number of varieties increased and higher alpha acid varieties came along it seemed to make sense to consider some hops as being dual purpose, whilst the new super-alpha acid hops were clearly bittering only, as they often had undesirable/rough aromas. Cascade is considered primarily as an aroma hop but as my own substitutions showed it made a perfectly good bittering hop and can thus be considered as a dual-purpose hop. I remember giving samples of a home brewed beer with Cascade as the bittering hop to an American friend whom detested the typical Cascade characteristic. He enjoyed the beer and didn't detect Cascade as its aroma characteristics had been boiled off. To complicate matters some high alpha acid varieties that are not considered good to use as the sole hop variety can be used in small amounts to contribute to a pleasant aroma. For example, I like to add some Chinook pellets for aroma, which contributes to a nice citrus/grapefruit character. Furthermore, there are now new high alpha acid varieties such as Horizon, Magnum, Simcoe and Warrior which are claimed to have good aroma characteristics such that they can be used to make a good single hop variety beer. These classifications always had their limitations but I think they have become increasingly less useful.

IMPLICATIONS FOR USE AND SUBSTITUTIONS

If the old way of classifying hops into aroma, dual-purpose and bittering purposes is now of limited value where does this leave us when considering hop varieties and their substitution? There is now more scope for experimentation and substitution as the number of varieties available has increased but more care needs to be taken in regard

to how much to use as the range of alpha acid percentages has increased. In thinking about hop varieties and how to formulate recipes to give us the desired beer I find it more useful to think in terms of the desired level of overall bitterness plus the type and intensity of the hop flavour/aroma. There are several ways that science can help guide us here but especially at the craft brewing level it ultimately comes down to our knowledge of the ingredients and our vision of what we desire the beer to be like.

CALCULATING FOR SUBSTITUTIONS – ALPHA ACID UNITS

My first attempt at controlling for the different alpha acid strength of hops to achieve a similar level of bitterness was based on the Hop Utilisation Summary Table and concept of Alpha Acid Units per gallon as described in Dave Line's 'The Big Book of Brewing'. For an example of how this works let's look at my 1062 OG Strong Ale that came first in the last Northern CBA competition. For 1.5 gallons (designed for racking into a demijohn for secondary fermentation) I used 3 additions of hops, all of 0.5 oz. Firstly 5.5% Cascade for the bittering addition (60 minutes boil), secondly 5.0% Goldings for the flavour addition (20 minutes boil) and thirdly 4.1% Crystal for the aroma addition (pellets added to primary fermenter).

1) 0.5oz x 5.5% Alpha Acid = 2.75
2) 0.5oz x 5.0% Alpha Acid = 2.50
3) 0.5oz x 4.1% Alpha Acid = 2.05

= 7.30 Alpha Acid Units.

Divide by 1.5 gallons = 4.87 Alpha Acid Units per gallon.

Now Dave Line doesn't give a guide for Strong Ale but the nearest is Barley Wine of starting gravity 1060 to 1080 with a recommended 5 to 7 Alpha Acid Units per gallon. As I did not want the hops to dominate in a 1062 gravity Strong Ale this seemed about right to me.

However, this system will only work if you use a "typical distribution" of hops for the style throughout the boil. If all the hops had been added at the beginning of the boil it would still be a 4.87 Alpha Acid Unit per gallon brew but the bitterness would be excessive with little hop flavour or aroma. If you want to brew to a given level of bitterness this system is probably too limited and you may want to try estimating bitterness in terms of the International Bitterness Unit system.

CALCULATING FOR SUBSTITUTIONS – INTERNATIONAL BITTERNESS UNITS (IBU's)

This system is based not on the amount of hops used in the brewing as in Alpha Acid Units but upon the amount of isomerised alpha acid that actually gets into the beer, measured as mg per litre (parts per million). There are several ways of writing the formula that will give you an estimation of the IBU. I stress estimate as the true IBU can only be determined by analysis which is beyond most craft brewers. Having to make assumptions about your percentage utilisation (the amount of available alpha acid that becomes isomerised and goes into solution in your beer) and the percentage of alpha acid in home grown hops as well as allowances for changes during storage of all hops, gives plenty of scope for errors to creep in. Nevertheless, it should get you roughly where you want to be. If your beer comes out tasting more or less bitter than intended, try adjusting your target IBU accordingly next time.

The formula that I use is that given in Fred Eckhardt's 'The Essentials of Beer Style: a catalog of classic beer styles for brewers and beer enthusiasts'. Although many of the examples are American it is a useful reference for the amount of bitterness to be aiming for. First if you work in Imperial measures, convert to metric and work out your hop ratios in terms of grams per litre for each addition. Returning to my Strong Ale example the hop additions are 14.18 grams and the volume is 6.81 litres, giving a ratio of 2.082 grams per litre.
Next estimate your % utilisation. For hops boiled for 60 minutes assume 28%, maybe up to 30% if boiled for 90 minutes. However I would not recommend boiling hops for longer than 90 minutes and personally I do not think that there is any overall advantage in boiling hops for over an hour. Hops boiled for 15 to 20 minutes will have 8 to 12% utilisation. I generally assume 10% utilisation for this flavour addition. Those added for less than 5 minutes boiling or at the end of the boil will contribute little bitterness but I generally assume 5% utilisation. If using hop pellets your utilisation is likely to be a little higher, so instead of 28, 10, and 5% you may want to assume 30, 12, and 6% utilisation.

Having got this far the formula is:
IBU = G/L hops x Alpha Acid % x Utilisation % x 1,000

Going back to my Strong Ale example with additions of 5.5% Cascade, 5% Goldings and 4.1% Crystal the calculations look like this:

1) 2.082 x 5.5% = 0.1145 x 28% = 0.0321 x 1,000 = 32.1 IBU
2) 2.082 x 5.0% = 0.1041 x 10% = 0.0104 x 1,000 = 10.4 IBU
3) 2.082 x 4.1% = 0.0853 x 5% = 0.0043 x 1,000 = 4.3 IBU
Add together the three individual contributions to = 46.8 IBU

Now compare this with the Alpha Acid Unit per gallon where the first, second and third additions all contributed similar amounts of AAU's closely related to the strength of the hops. Here, when looking at bitterness alone, the contribution is significantly influenced by the length of the boil such that the majority of the bitterness is provided

by the first addition of Cascade hops. The Goldings and Crystal do contribute some bitterness but their role is primarily to contribute hop flavour and aroma

I rarely make strong beers so this formula is usually as far as I go. However, you probably know that as your wort gets stronger, the alpha acid in the hops is less easily isomerised so less gets into your beer. Effectively the % utilisation drops and this formula becomes increasingly inaccurate as wort gravities increase above 1050.

CALCULATING FOR SUBSTITUTIONS – IBU's WITH CORRECTION FOR HIGH GRAVITY WORTS.

Ray Daniels in an article 'Hop Fundamentals' in 'Zymurgy' Vol 24 No 6, November/December 2001 gives a formula for calculating IBU's with a correction factor. This is calculated as follows:

Correction Factor = 1 + [(gravity of boil minus 1.050) divided by 0.2]

So in my Strong Ale the Correction Factor becomes:

1 + [(1.062 minus 1.050) divided by 0.2]
1 + [0.012 divided by 0.2]
1 + 0.06 = 1.06

Going back to my Strong Ale the first addition of Cascade now looks like this:

$$\text{IBU} = \frac{\text{G/L x Alpha Acid \% x Utilisation \% x 1,000}}{\text{Correction Factor}}$$

$$\text{IBU} = \frac{2.082 \times 5.5\% \times 28\% \times 1{,}000}{1.06} = \frac{32.1}{1.06} = 30.3$$

Similarly, the IBU for the second and third additions drops to 9.81 and 4.06, giving a corrected IBU of 44.2, 2.6 IBU's less than the previously calculated 46.8 IBU. Given the variation created by minor changes in estimates of % alpha acid and utilisation you may not consider this important. Equally you may wish to control for one factor which can be calculated, especially if you are brewing even stronger beers where its influence will become more significant.

OTHER CONSIDERATIONS FOR SUBSTITUTION – AROMA AND COHUMULONE

So far we have looked at three increasingly sophisticated ways of judging the amount of hops to use based upon their alpha acid levels. It doesn't therefore matter how high the alpha acid content of the hops is as long as you take this into account when calculating how much to use when designing a new recipe or substituting varieties in an existing recipe. What now matters is the hop flavour and aroma you get from the hops. If you are not sure about a new variety, brew a standard Pale Ale and hop

entirely with the new variety. What beers might you want this character in, what beers might it give a welcome contribution to? Don't worry too much if it is intended for the first bittering addition as it is unlikely to significantly influence the final beers hop flavour or aroma.

Gerard Lemmen's in 'Veteran Voice: An Outspoken View on Hops' (in the aforementioned
'Zymurgy' issue) gives some suggestions for substitutions for similar hop characteristics:

Cascade, Amarillo;
Crystal, Mount Hood, Liberty, Ultra, Hallertau;
Fuggles, Tettnanger, Wilamette, Styrian Goldings;
Galena, Tomahawk, Columbus, Zeus, Brewers Gold, Bullion, Chinook;
Northern Brewer, Nugget;
Sterling,Czech Saaz;
Horizon, Magnum, Simcoe.

One additional factor that may be worth taking into account is the Cohumulone level of your hops. The Cohumulone % tells you what portion of the total alpha acid content is contributed by the alpha acid Cohumulone. High levels of Cohumulone are thought to produce a harsh, unpleasant bitterness and may have a negative impact upon head retention. Admittedly it is a somewhat controversial theory but there is a view that when making well-hopped beers, say of above 25 IBU's, the Cohumulone levels need to be relatively low.

High Cohumulone hops include: Admiral, Bullion, Cascade, Eroica, Galena, Herald, Pioneer, Target and WGV.

Low Cohumulone hops include: Challenger, Crystal, Hallertau, Liberty, Mount Hood, Northdown, Northern Brewer, Phoenix, Czech Saaz and Tettnanger.

This is a somewhat arbitrary classification and inbetween lie mid Cohumulone varieties such as Bramling Cross, Chinook, Columbus, First Gold, Fuggles and Goldings.

Now I've tried several beers hoped solely with Target and found them somewhat rough - could this be part of the explanation as Target is high in Cohumulone? As another example take my Strong Ale where a high Cohumulone Cascade (range 33 to 40% Cohumulone) was used in combination with a mid Cohumulone Goldings (26 to 32%) and a low Cohumulone Crystal (20 to 26%). For a commercial example the sadly discontinued Thomas Hardy's Ale, with a massive 75 IBU, was hopped with Challenger, Goldings and Northdown, all relatively low in Cohumulone levels. To take us back to where I started, a similar balancing act is believed to be carried out in Anchor Liberty Ale, quoted by Fred Eckhardt at 45 IBU's. Here where the Cascade character is desired, the initial bittering is thought to be provided by the low

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Cohumulone Northern Brewer (20 to 30%) producing a high IBU beer with the characteristic hop profile of the high Cohumulone Cascade that remains delicate and smooth. These examples seem to fit in with the Cohumulone theory but I'd be interested to hear of other brewers' experiences. Knowledge, theories and calculations should help guide you with the choice and amount of hops to use but it's not an exact science and there remains plenty of scope for experimentation and the ''Brewers Art''.