



Analysis of Mashing in the Brewery

Introduction

The brewing process can generally be defined as 4 key steps; Mashing malted barley (possibly with other cereal additions), boiling and bittering of the resulting sweet wort, fermentation of the boiled wort and then conditioning of the resulting beer before packaging. All of these steps are important in producing great beer; however they are all redundant without a well-executed mash. In this process, the malted barley is steeped in hot water for approximately an hour in order to activate certain enzymes that break down the complex starches of the grain to fermentable sugars.

The end-point of the mash process is not typically measured in the microbrewery; however specific gravity will usually be taken after transferring the sweet wort into the copper to ensure that the mash has produced the desired amount of sugar for the style of beer.

Project

The Long Man Brewery is situated on Church Farm in Litlington. Based in the South Downs National Park it prides itself on producing fine Sussex Ales with the core aim of environmental sustainability. This is achieved in almost all processes of the brewery from growing the barley used in the beer, sourcing the water from a bore hole on the farm and powering the Brewhouse using a bank of 100 solar panels.



The aim of this project was to run an analysis of the mash process using the BeerLab across 3 styles of Long Man beer with a view that it may be possible to reduce the mashing time and improve process efficiency. The study looked into the production of fermentable sugars versus starch alongside measurements of pH and temperature as well as free amino nitrogen (FAN). The idea was to show that in a couple of hours of sampling and analysis we could demonstrate what is happening in the mash tun in terms of sugar production from the mashing enzymes and its correlation with pH and temperature changes (if any).

Results

Best Bitter

The first mash tested was for the Long Man Best Bitter, the process involved mashing in with a strike temperature of 73°C (which took 20 minutes), mixing the mash and starting the timer. A sample from the mash tun was taken using a wort sampler from the same spot in the mash every 10 minutes, with a sample being taken at minute 0 (immediately after mashing in had finished). Once the sample had been taken it was immediately chilled in ice water to halt the mash process and prevent further fermentable sugar production.

As you can see from Figure 1, the Best Bitter gave exactly the kind of results that we were expecting. The sugar and starch gradually increase in the first 10 minutes of the mash as they are both dissolving in the wort and then when the enzyme activity reaches its peak the starch concentration drops at 20 minutes whereas sugar continues to rise. From 20 minutes up to the point of sparging, the fermentable sugars appear to reach a plateau where the maximum concentration of sugar is reached for this particular recipe – the starch however, gradually increases (complex starch that cannot be broken down by mashing enzymes will dissolve into the wort).

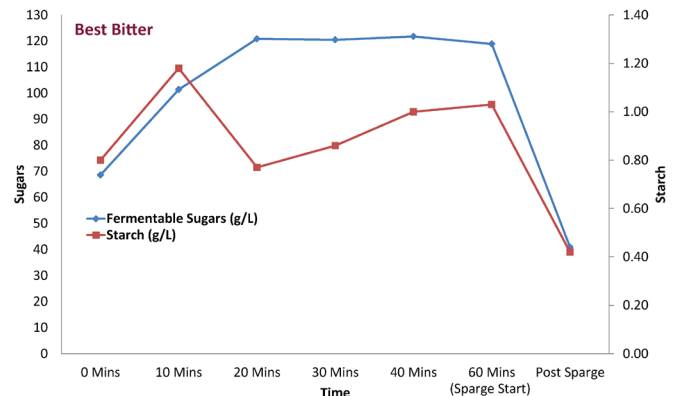


Figure 1: Best Bitter - Sugar & Starch vs Time

If the main purpose of the mash process is to convert starches in the barley grain to fermentable sugars, then it could be argued that the Best Bitter mash would be finished after just 20 minutes.

When looking into how the Best Bitter produced such a successful mash, it is can be easily attributable to the correlation of temperature and pH with respect to enzyme activity. Figure 2 shows the temperature and pH of the mash samples from the 'Start' of the process at minute 0 to the 'Finish' of the process at minute 60. On the graph are the activity regions of two enzymes – α -amylase and β -amylase, which are both key in the reduction of starch to sugar and the Best Bitter mash spends the majority of the time sitting directly in the activity regions of both enzymes.

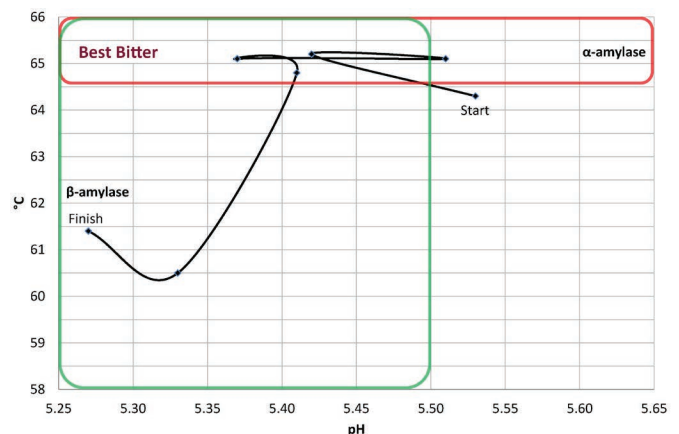


Figure 2: Best Bitter - pH vs Temperature

Long Blonde

The second mash tested was the Long Man Long Blonde, the same sampling procedure was followed as with the Best Bitter – taking a sample every 10 minutes, with a sample being taken at minute 0 through to the start of sparging at 60 minutes and after sparging had finished.

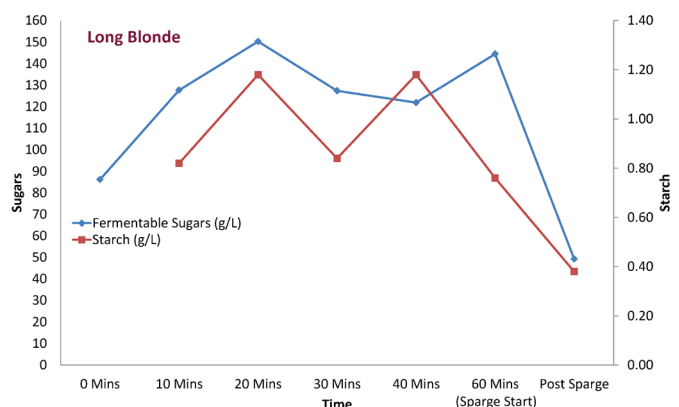


Figure 3: Long Blonde - Sugar & Starch vs Time

The results shown in Figure 3 depict a clear difference between the mash for the Long Blonde when compared to the mash for the Best Bitter. The mash for the Long Blonde showed a similar rise in sugars and starch as with the best bitter, however this was followed by a drop in starch (as it was broken down by enzymes). This was accompanied by a drop in sugar and then a subsequent rise in starch.

On the day of brewing the Long Blonde, it is important to note that the temperature of the mash tun was particularly unstable, starting at around 65°C but very quickly dropping to 62°C before rising and stabilising at around 63°C. Again, looking at the pH/temperature profile of the mash in Figure 4, it appears that with the temperature variance of the mash tun there was also a significant increase in pH, which holds the mash outside of the optimum enzyme activity areas for a large period of the mash.

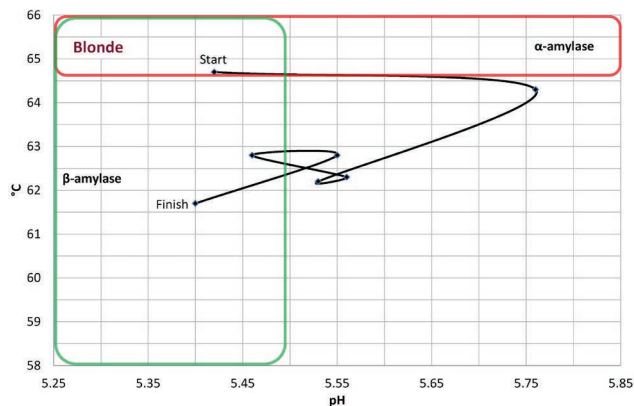


Figure 4: Long Blonde - pH vs Temperature

When comparing Figure 3 and Figure 4, the time that the mash spent outside optimum enzyme activity parameters correlates well with a drop in sugar concentration and a spike in starch concentration. Further to this the mash finishes well within favourable pH/temperature conditions for β-amylase, bringing the sugar concentration back up at minute 60 and dropping the concentration of starch.

APA

The last mash analysis was on the Long Man APA, once again following the same sampling procedure every 10 minutes from minute 0, through to minute 60 at the start of sparging and a sample taken at the end of sparging.

This mash was much more similar to the Best Bitter, as shown in Figure 5, with the fermentable sugars taking slightly longer to reach the highest concentration for this particular recipe. The concentration of starch for this mash started much higher than in the previous 2 examples, which can be attributed to the temperature and pH beginning slightly outside the optimum enzyme activity areas when looking at Figure 6.

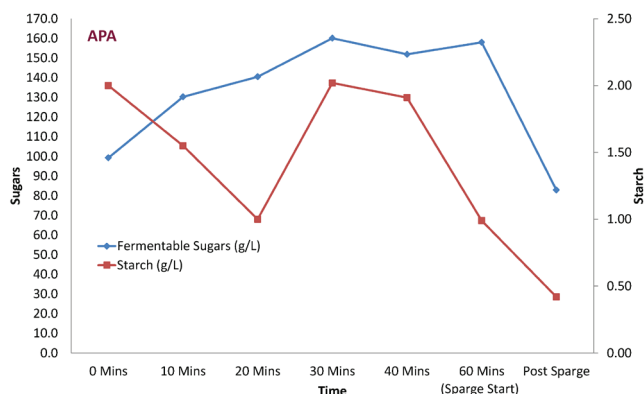


Figure 5: APA - Sugar & Starch vs Time

Following this, the starch declines as it is broken down by α-amylase and β-amylase and then increases as the sugar reaches a maximum concentration, as is also seen in the Best Bitter, Figure 1.

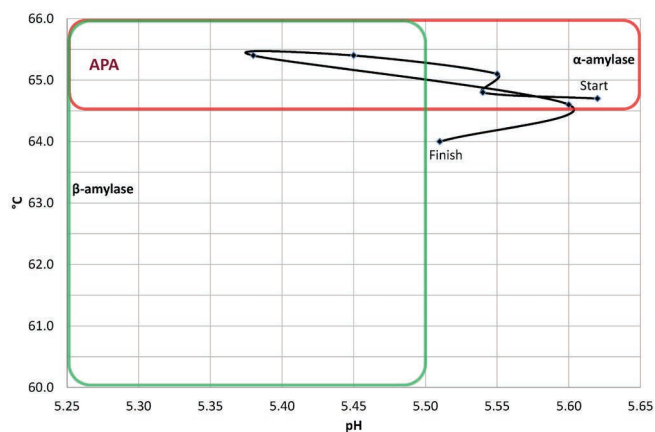


Figure 6: APA - pH vs Temperature

Conclusion

By using the BeerLab it was possible to analyse the mash process of 3 styles of beer in terms of fermentable sugars, starch, pH, and FAN, providing results in under an hour with the view that it may be possible to improve brewing efficiency by cutting down the mash time. Our analysis showed good correlation between the production of fermentable sugars and the optimum pH and temperature of the starch digesting enzymes α-amylase and β-amylase, which also saw the reduction of starch.

A sample of each beer was taken post-boil and tested for FAN showing that 2 out of the 3 beers were on the lower end of the recommended nitrogen limits for healthy yeast growth. By knowing the FAN content of each brew, yeast nutrient can be adjusted to ensure healthy yeast-growth, avoiding stuck fermentations – saving time and yeast.

The results for fermentable sugars and starch from the Best Bitter give the greatest example of how it may be possible to shorten the mash time, freeing up approximately 15 minutes per brew and improving efficiency in the brewery. Adding to this data by running further analysis of each brew using the BeerLab will illustrate any day-to-day variations with the sugar production in each mash, making it easier to action these time savings. When Long Man is brewing twice a day, this could free up an extra 30 minutes a day, valuable time when the working day begins at 4am.

References

- [The effects of Mashing Temperature and Mash Thickness on Wort Carbohydrate Composition], MULLER R., J. Inst. Brew., 1991, Vol. 97, pp. 85–92
- PALMER J. J., How to Brew: Everything You Need to Brew Beer Right The First Time, 3rd Edition, Brewers Publications, 2006.

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