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ESCAPING THE EVENT HORIZON OF ATTENUATION CONTROL'S "BLACK HOLE"

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Introduction

Achieving a proper level of attenuation is important for any beer. Diminished attenuation can be caused by two likely evils; low wort fermentability or poor yeast performance. This can place brewers on the wrong side of the attenuations "black hole" event horizon.

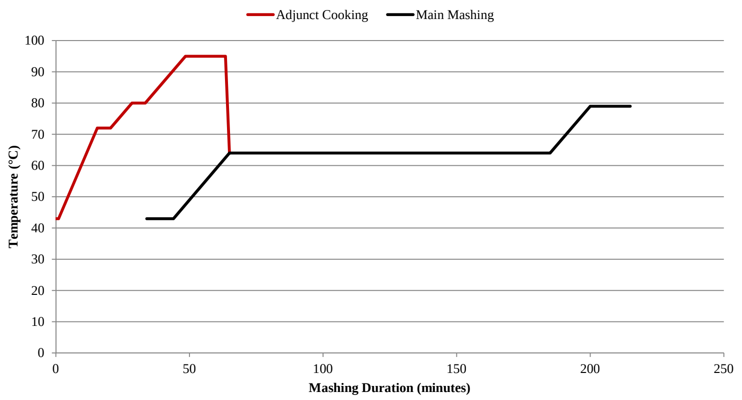
Either the wort's sugars fail to contain sufficient and/or appropriate fermentable sugar types, or the yeast is in a poor state of health, i.e. pitching rate, aeration and nutrition levels can all conspire to reduce the yeast's viability. Medium to high attenuation levels can be attained by increasing the level of fermentable sugars, but at the risk of changing the composition of the sugar profile – and in turn adversely affecting the yeast (Pfisterer et al, 1978; Stewart, 2006).

This study aims to clarify some of the potential gain and pitfalls when applying glucoamylases during mashing.

Methods

The tests were performed in a system with 45/55% corn/malt. Five percent of the malt part was mixed with the corn for the adjunct cooking. Water to Grist Ratio (WGR) both for adjunct cooking and main mashing was 3.7 : 1. A saccharification pause of 2 hours at 64° C/147° F was held and mashing was performed at pH 5.4. Enzymes were added at mashing-in in the main mash.

The mashing profile used:



Analysis

The main analytical focus was to investigate the effect of the composition of fermentable sugar types, as represented by the Degree of Polymerization (DP); DP1[a], DP2[b] and DP3[c], on the RDF level.

a)Predominantly glucose b) Predominantly maltose c) Predominantly maltotriose

Sugar Profile determination (% total)

DP1, DP2, DP3 and DP4+ was determined after mashing according to a modified EBC method 8.7 using a Gilson HPLC; Column: Rezex RSO-oligosaccharide Ag+ (4%).

Real Degree of Fermentation (RDF-Classic)

Real Degree of Fermentation (RDF) in fermented samples was measured according to EBC method 9.2.6 using an Anton Paar (DMA 5000).

Results and Discussion

It is well known that introduction of glycoamylase during mashing converts more of the dextrins to simple sugar types and thereby creating higher amounts of fermentable sugars in the wort. Hence, with increasing dosage of glucoamylase typically an increase in RDF level is observed.

This relation is presented in Figure 1, where RDF increased as a function of glucoamylase addition over the dosage range 1.0 to 5.5 kilogram/tonne (kg/t), corresponding to 2.2 to 12.1 lbs/t of grist.

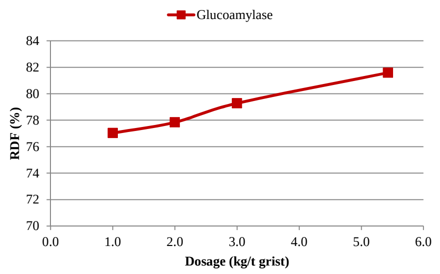


Figure 1 RDF as function of increasing glucoamylase dosage.

At conditions similar to those from Figure 1, a more detailed dose response study was performed. The dosage of the glucoamylase was increased with smaller intervals. These results are shown in Figure 2.

The detailed dose response study gave rise to the occurrence of "black holes" appearing in the curve of RDF as a function of enzyme dosage. Decreasing RDF values arose as function of increased dosage of glucoamylase! This decrease in RDF was observed only for limited dosage intervals, as RDF values subsequently increased again with further dosage increase.

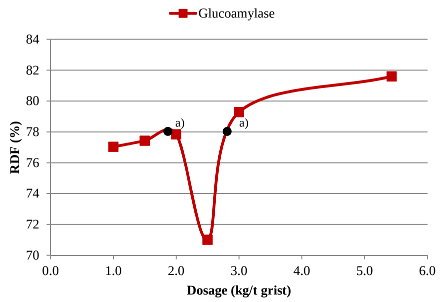


Figure 2 Detailed study of glucoamylase influence on RDF.
a) Same RDF achieved at two different glucoamylase dosages.

Consequently, similar RDF values were obtained at two radically different glucoamylase dosages, i.e. we escaped the event horizon! Analysis of these similar, albeit different wort samples showed their sugar profiles to be significantly different, Figure 3.

The main difference between the two sugar profiles was that DP1 increased at the expense of DP2 when going from the lower dosage to the higher dosage of glucoamylase. Why did we then see a decrease in RDF level? Both DP1 and DP2 are considered fermentable! However, at a dosage of 2.0 kg/t (4.4 lbs/t) the DP1 level had reached 60% of the total extract which may be the limit for this yeast's suppression. This might be different for other yeast strains (Stewart et al, 1997). Due to a majority conversion of DP1 to alcohol, the yeast gradually lost its capability to convert DP2. This loss in capability exceeded what the glucoamylase could compensate for.

Hence, escaping the "black hole" would require significant dosage increase of glucoamylase.

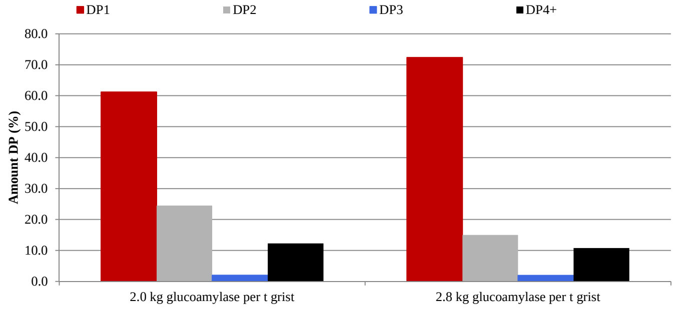


Figure 3 Sugar profile represented by DP from 1 to 4+ for two different wort samples providing same RDF level.

Results and Discussion-cont.

Instead of escaping the "black hole", the hole can be filled in by using an optimized blend of different enzyme activities.

The results in Figure 4 show that RDF increased with increasing dosage over longer dosage intervals when using an optimized enzyme blend than could be achieved merely with glucoamylase. RDF levels obtained via the optimized enzyme blend are comparable albeit higher than those for glucoamylase and maintain these higher levels beyond the observed glucoamylase "black hole".

However, observation highlights that the optimized enzyme blend suffers a similar "black hole" event to that of glucoamylase, just at higher dosage levels. This suggests that if brewers wish to attain the medium RDF values the optimized enzyme blend is favourable, whereas for high RDF levels one has to return to glucoamylase.

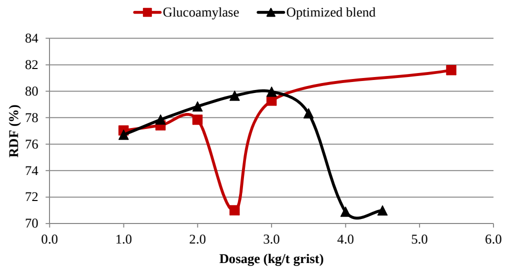


Figure 4 RDF as function of dosage for two different enzyme products; glucoamylase and an optimized enzyme blend.

The "black hole" most probably occurs due to alcohol induced suppression of the yeast concurrent with Phaweni et al, (1993), and occurs for both enzyme products at the same concentration of DP1 at approximately 60%, as given in Figure 5a.

However, when using an optimized enzyme blend the curves furthermore showed that similar RDF level was achieved with lower percentage DP1 (Fig. 5a) but higher percentage DP2 (Fig. 5b) compared to the use of the glucoamylase.

Thus, by creating different sugar profiles in the wort, different RDF levels were achieved prior to yeast suppression.

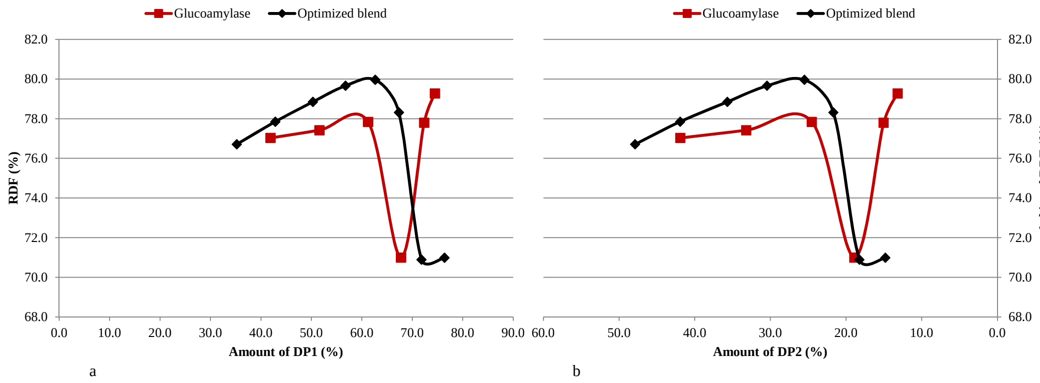


Figure 5 RDF as function of percentage DP 1 (a) and percentage DP2 (b) provided during mashing by glucoamylase and an optimized enzyme blend .

Conclusion

This study shows that:

- Control over attenuation can be kept by side stepping the "black holes" originating from different types of enzymes to reach desired RDF levels.
- Wort sugar profile alone because of its influence on overall yeast performance cannot be used to give accurate RDF level prediction.
- Low to medium RDF level are best served by the optimized enzyme blend. This gives both desired RDF levels but also shields the yeast from unnecessary stress.
- High to very high RDF levels are best served with glucoamylase providing high or very high percentages of DP1.

Know your yeast – know your enzyme – know your sugar profile – you get your desired RDF!

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