Brewhouse Stats

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1 Introduction

The purpose of this document is to gather together various brewhouse statistics from my homebrew setup and from polls I have conducted on brewing forums.

These results are not meant to be prescriptive and there is no reason why you should expect the same numbers, you might get significantly different - at the end of the day what matters is **enjoying the beer you brew**. As an example of the variation seen between brewers and brew setups, Ray Daniels reports that he has seen hop utilization vary by a factor of 2 (17% to 35% in a 60 minute boil when measured by laboratory analysis[1]) and also [2].

It is fair to say that knowledge of these numbers isn't necessary to produce good beer, just because you don't measure it, doesn't mean you aren't brewing good beer consistently.

Contents

1 Introduction **1**
1.1 Links 2

2 Efficiency over time **2**
2.1 Efficiency outliers 3

3 Mashtun water losses **5**

4 Boil off **7**

5 Batch vs Fly sparge poll results **7**

List of Figures

1 Mash efficiency over time 4
2 Efficiency vs mill gap (mm) 5
3 Water loss (L) vs grain mass (kg) 6
4 Boil off (L) vs pre boil volume (L) 7
5 Mash efficiency box plots 9
6 Comparison between batch and fly sparger efficiency. 10
7 Comparison of efficiency results between brewboard and aussiehomebrewer polls. 11
8 Milled grain - gap: 0.9 mm using smooth rollers 12

1.1 Links

My setup itself is described at brewiki.org. Some of the pages that are most relevant to this article include:

- The mashtun and the sparge technique I use are described at BatchSparge.
- RollerMill, it is possible that the smooth (not knurled) rollers of my DIY mill have some influence on efficiency.

2 Efficiency over time

Figure 1 shows my mash efficiency for batches I have brewed since late 2004. The salient features of these numbers include:

- My "normal" mash efficiency is around 85%.
- I was achieving around 90% then for WA_APA_5 I opened my mill gap a little so the mash and batch sparge would runoff a little quicker.
- Since that point my efficiency has been reasonably consistent at 85%, with the exception of three outliers, Stout02, WA_APA_8_01 and Wheat_4.
- The line fit excludes Wheat_4 - see note below about mill gap.

2.1 Efficiency outliers

A little variation in each brew is quite manageable, it is homebrew after all, not megabrew. Massive changes in efficiency on the other hand are problematic and for me, it is important to figure out what is going on with a view to avoiding it in the future.

In the first two cases the beer was still very drinkable and I chose not to adjust the gravity with DME additions. With Wheat_4 the post boil gravity was so low (1.034) that I decided to add DME to the fermenter. The compromise here was that adding DME to a wheat beer is going to dilute the wheat - this is the kind of compromise you need to make if your brewday is all over the place.

In the case of Stout02, the mash bed just did not seem to set properly. One possible cause for this is that with my current batch sparge technique I am in the habit of mashing out and when I finish adding the mash out water I stir, recirculate a couple of litres then drain. I get the feeling that after a stir there may be a need to let the bed settle for a few minutes before starting the runoff. Also, I might have been a little careless in the recirculating step, disturbing the grain bed too much when pouring the wort back in.

With WA_APA_8_01 it was not so initially obvious although the drop in efficiency was fairly dramatic. Apart from substituting Vienna for Munich malt, I had brewed that recipe several times before. As it turns out when brewing Wheat_4, I thought the crush looked a little dark (not so much exposed starch) and I was getting some slippage on the mill, a check with the feeler gauge after brewing confirmed that the gap had somehow slipped out to 1.4 mm so it has been set back to 0.9 mm.

From my experience and from what others have told me, mill gap setting appears to be one of the biggest, if not the biggest, factor in mash efficiency. For reference purposes, I have included a closeup image grain crushed at a 0.9 mm gap, see figure 8.

Supporting the importance of mill gap wrt to efficiency is WA_APA_7-02, the first brew after closing up the mill gap where I hit an efficiency of 90%. The runnoff was quite slow and I am likely to open the gap out to 1 mm to help speed up procedings.

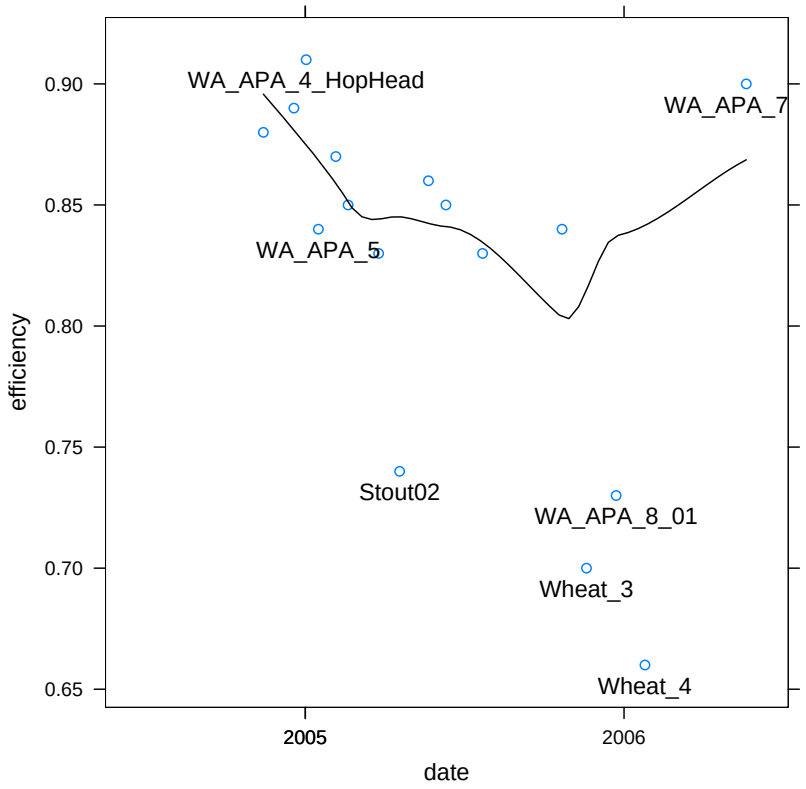

Figure 1: Mash efficiency over time

```
> median(b$efficiency, na.rm = TRUE)
[1] 0.845
```

Since after tightening up the the mill I had some useful data on effect of gap on efficiency, I decided to take a closer look. Figure 2 shows the result. Apart from Stout02 all the data fits close to a straight line. Please keep in mind there are other variables that come into this:

- Roller surface texture and material (mine are smooth hardwood).
- The style of beer brewed. I happen to brew lots of ales in the 1.040 to 1.060 gravity range.

to mention just a few.

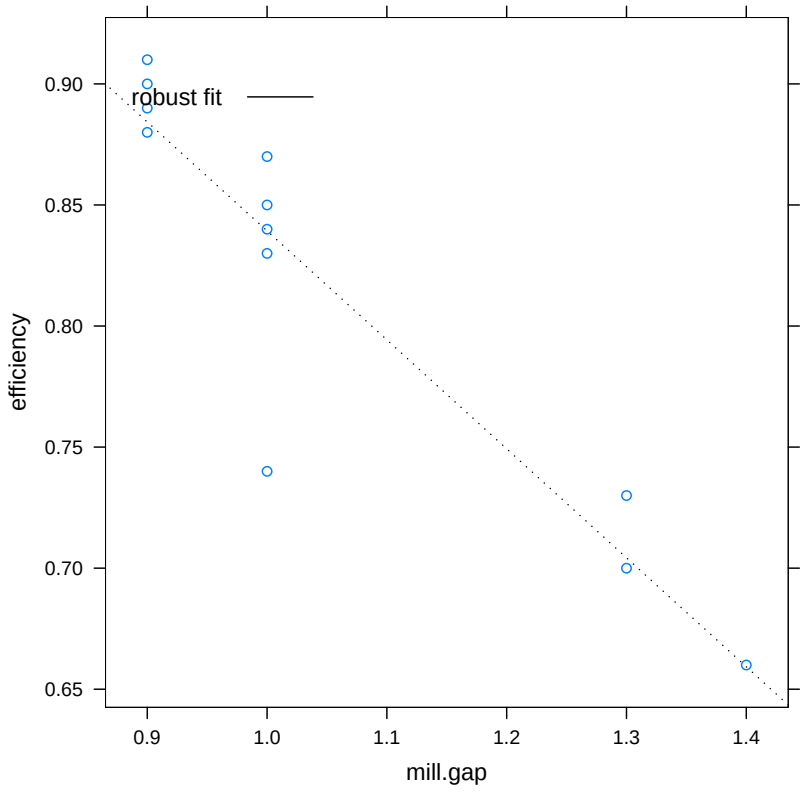

Figure 2: Efficiency vs mill gap (mm)

3 Mashtun water losses

Figure 3 shows the losses between the mashtun and the kettle. The solid line shows a straight line fit through all points

```
(Intercept)  grain.mass
 -0.8098107   1.3793250
```

and the dotted line uses `lqs` for a more robust fit (ignoring outliers).

```
(Intercept)  grain.mass
   0.549505    1.188119
```

The second method appears to be more in line with figures I have seen quoted (1.1 L/kg) and if I set my brewday calcs according to that then I am less likely to be short in the kettle.

The blue line is for comparison and is simply a 1.1 L/kg straight line (zero dead volume).

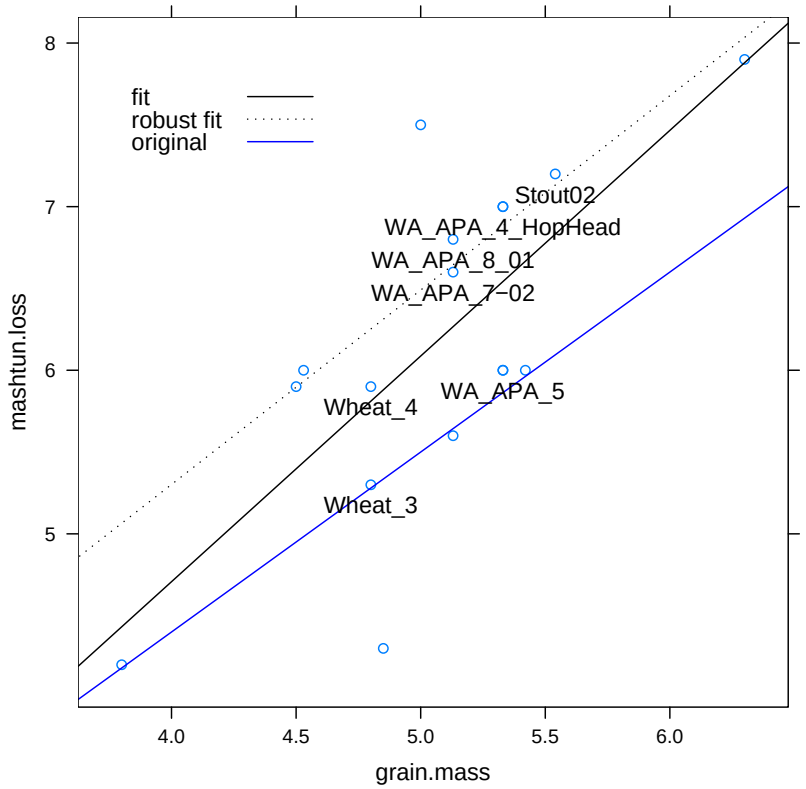

Figure 3: Water loss (L) vs grain mass (kg)

4 Boil off

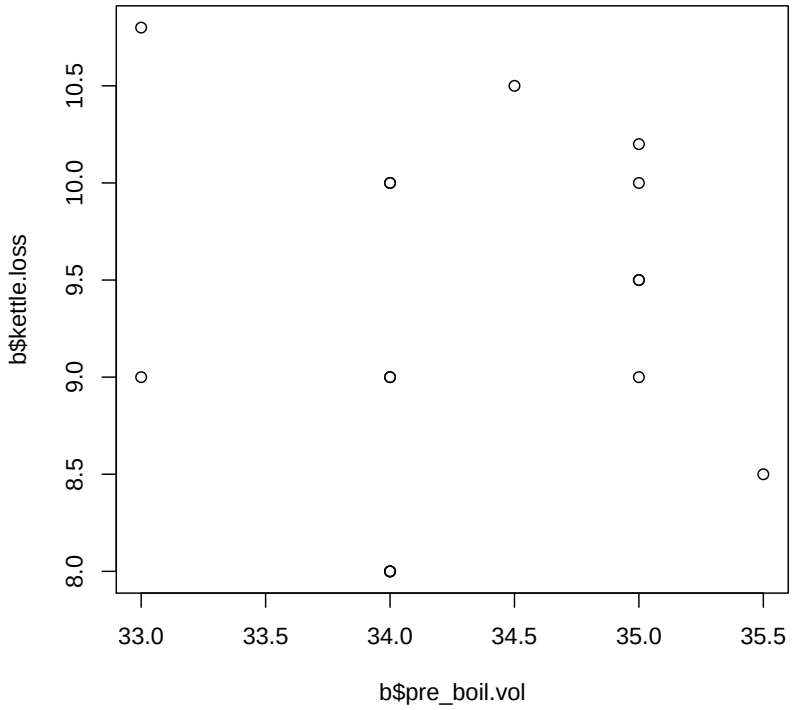

Figure 4: Boil off (L) vs pre boil volume (L)

5 Batch vs Fly sparge poll results

Many Web forums have a poll facility. I ran a poll on aussiehomebrewer.com and brewboard.com to investigate what sparge method and what mash efficiency brewers were getting. Due to the configuration of aussie homebrewer limiting the number of questions per poll, I had to separate the batch [4] and fly [5] questions into two different polls. The brewboard poll [3] was contained in a single topic. People were requested to vote only if they had a reasonably stable efficiency (say consistent results in at least 3 consecutive brews).

There were a total of 168 respondents:

	ahb	bb	Sum
batch	38.00	63.00	101.00
fly	25.00	42.00	67.00
Sum	63.00	105.00	168.00

The proportion of batch spargers in each country[1] were almost identical (just over 60%).

The consensus among homebrewers seems to be that that fly sparging is more efficient so I ran a `t.test` on the data:

```
        Welch Two Sample t-test

data:  meth$fly$efficiency and meth$batch$efficiency
t = 2.7175, df = 151.496, p-value = 0.003672
alternative hypothesis: true difference in means is greater than 0
95 percent confidence interval:
 1.200377      Inf
sample estimates:
mean of x mean of y
 77.64925  74.57921
```

Which indicates that fly sparg*ers* (I use the term rather than fly sparg*ing* deliberately) manage a slightly higher average efficiency. Looking at figure 5 however shows that the median efficiency is the same for both groups.

Note that the data is quantized, respondents had to select a range of efficiency where the bins were 5% wide

[1] Brewboard and aussiehomebrewer are predominantly, although not exclusively, frequented by residents of the USA and Australia respectively.

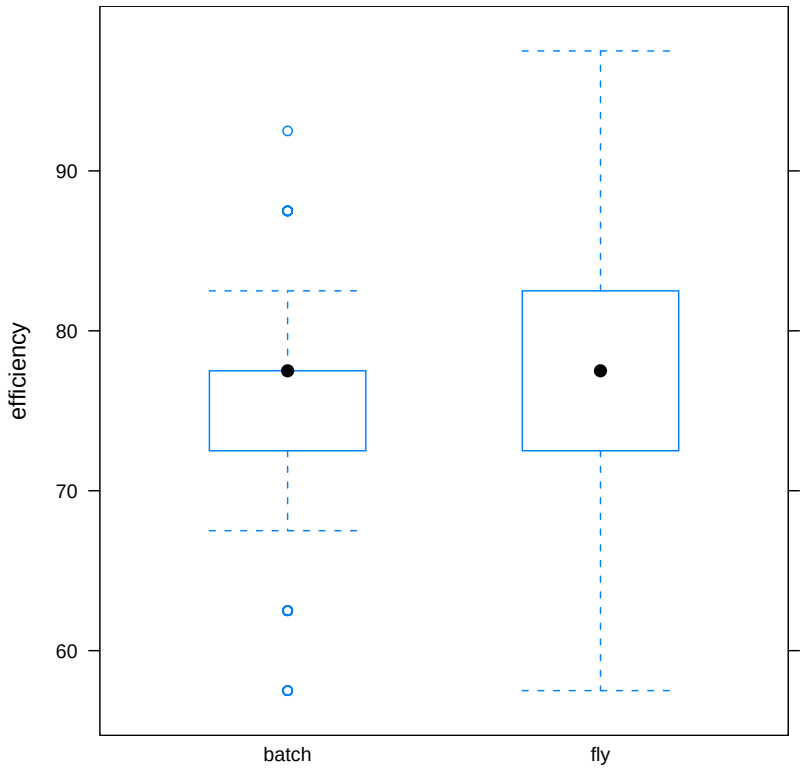

Figure 5: Mash efficiency box plots

Figure 6 shows the efficiency achieved by brewers of the two methods. One interesting thing to note that there are a few low ball batch sparge efficiency values (less than 60%). I can only speculate at the reasons here:

- Fly spargers may represent a more experienced group of brewers and therefore have better control of their process. I say that because new brewers often find the low "cost of entry" of batch sparging with an esky attractive.
- The polls didn't specify exactly "which method" of batch sparging qualified. These may represent some *no sparge*[2] entries (although people generally report even lower efficiencies for *no sparge*. I suspect that there is a significantly lower variation in the basic fly sparging process, equipment may vary but the approach of continuously

[2]No sparge means making beer from the mash runoff. The advantages of this approach are, a) very quick and simple, and b) you start with a higher gravity wort. The disadvantage is less sugars are extracted which means you use a little more grain.

sparging the grains until the desired gravity is reached is a feature of this method. With batch sparging variation can occur in how many batch sparges are applied (I only sparge once) and the volume split of each runoff.

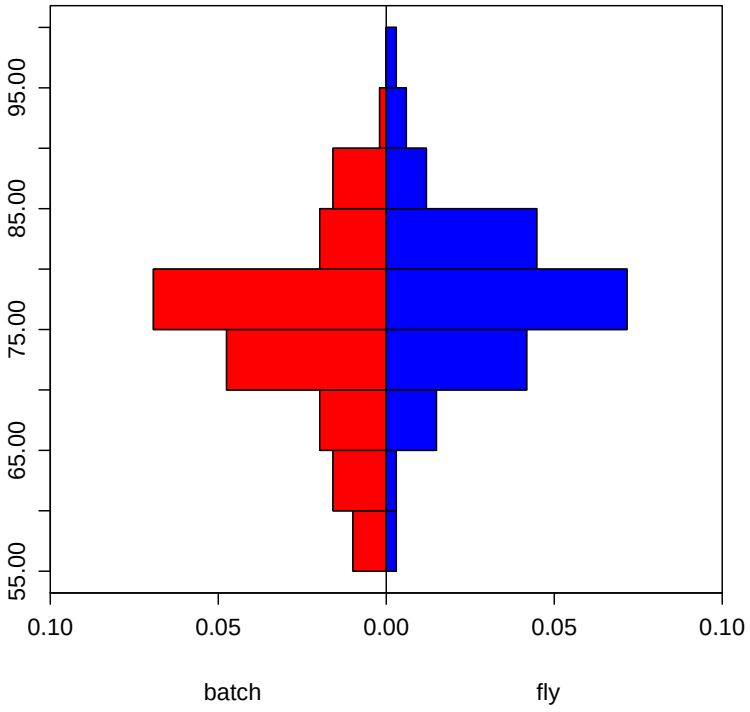

Figure 6: Comparison between batch and fly sparger efficiency.

Figure 7 shows method efficiency plots grouped by source (AHB vs Brewboard).

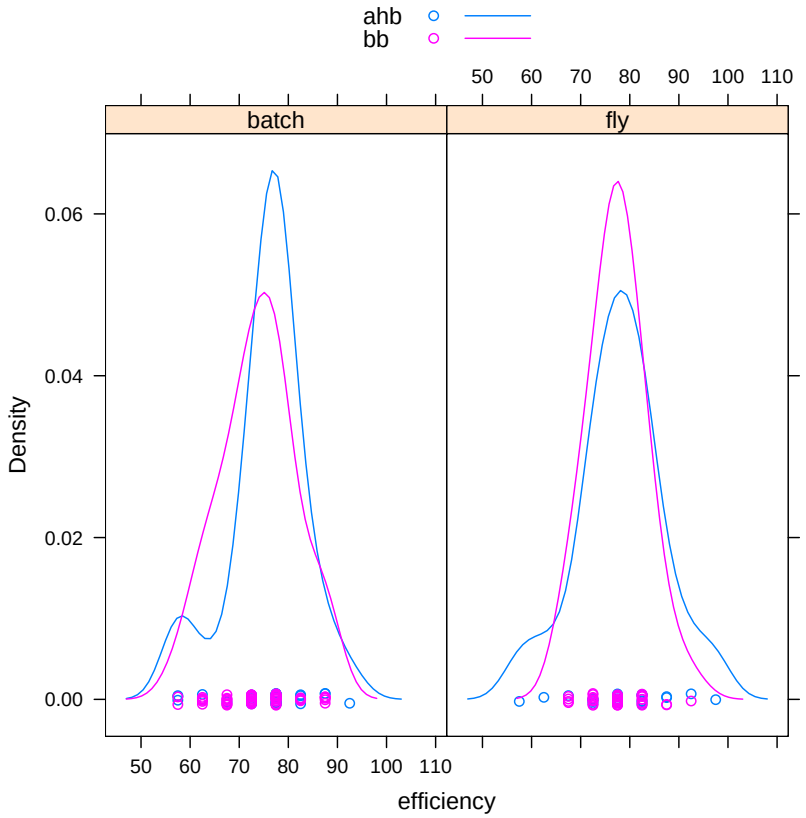

Figure 7: Comparison of efficiency results between brewboard and aussiehomebrewer polls.

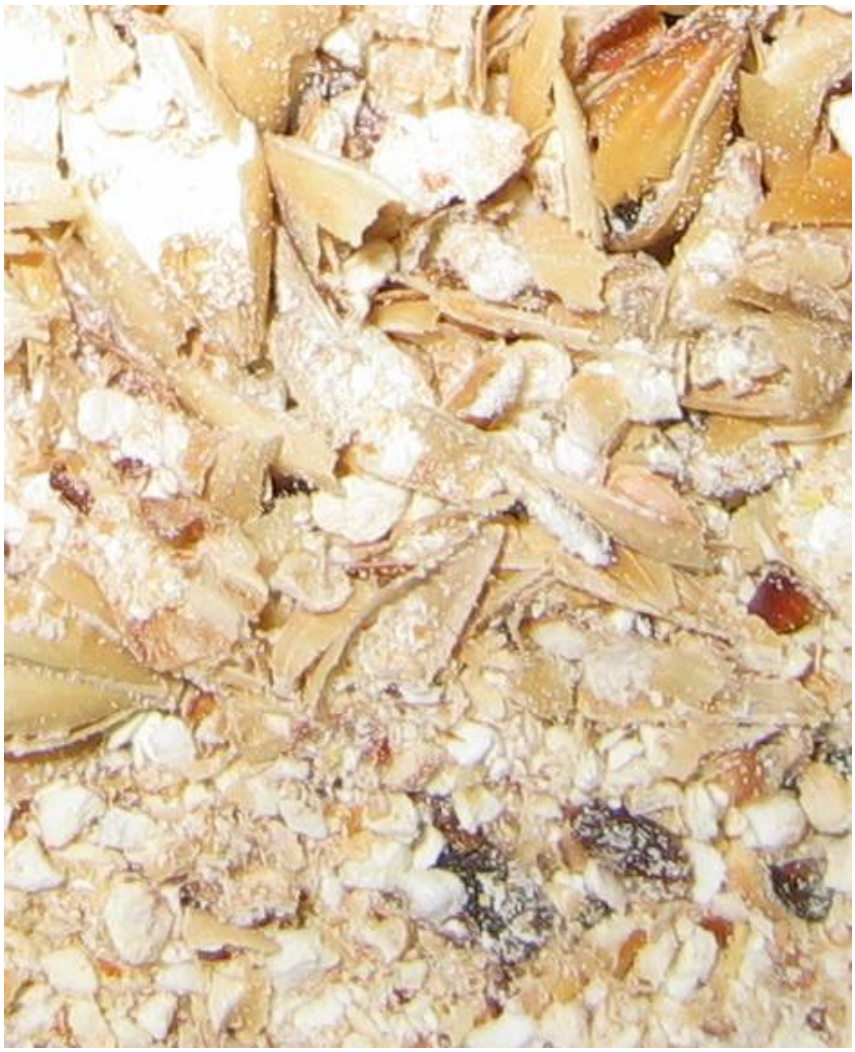

Figure 8: Milled grain - gap: 0.9 mm using smooth rollers

References

[1] Designing Great Beers, Ray Daniels, Brewers Publications, 2001. p77.

[2] Hop Utilization Page, Glenn Tinseth

[3] Brewboard "mash efficiency study"

[4] Aussiehomebrewer.com Mash Efficiency Study (batch)

[5] Aussiehomebrewe.com Mash Efficiency Study (fly)