Proceedings of the 10th Australian Barley Technical Symposium, 2001

Modification of an IEC Mash Bath to Optimize the Recovery of Brewers Extract

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Abstract

The amount of brewers extract that can be recovered from malt is arguably the most important malt quality characteristic. For mixing during mashing, the IEC mash bath conventionally uses magnetic stirrer bars stirred at 400 rpm, which appear to grind the malt grist to produce fine particles. In collaboration with the mash bath manufacturer (IEC), we have developed a "pivoted paddle" that is driven by magnets at 90 rpm (speed required by the EBC procedure) to overcome this problem. The suggested absence of "fines" improved the efficiency of the lautering stage of the procedure. No significant difference in extract recovery was observed with the conventional mash bath configuration, however we recommend this modification for the IEC mash bath for the following two reasons. First, stirring at 90 rpm fulfils the requirements of the EBC hot water extract protocol, thereby allowing direct comparison with results performed in other place by the EBC protocol. Second, the improvements in lautering rates may more likely reflect malt performance under brewery mashing conditions, in which every effort is made to minimize the formation of fines. This configuration would also save time. The modifications can easily and inexpensively be made to existing equipment.

Introduction

The amount of brewers extract that can be recovered from malt is the most important malt quality characteristic because it is a key parameter in determining the amount of alcohol that brewers can produce. Maltsters selling malt and barley breeding programs seeking to improve extract levels rely on small scale (5-50g) simulated mashing tests using a mash bath to estimate malt extract levels. For mixing during mashing, the IEC mash bath uses magnetic stirrer bars rotated at 400 rpm which appear to grind the malt grist to produce fine particles during mashing. These "fines" were expected to reduce the efficiency of the lautering stage in the procedure, but it was not known what effect this will have on the recovery of extract. In collaboration with the mash bath manufacturer (IEC), we have developed a "pivoted paddle" that is driven by magnets at 90 rpm to overcome this problem. By these modifications to the IEC mash bath we have been able to emulate the stirring conditions in the EBC recommended procedure (EBC 1997). These modifications enable the IEC mash bath to mimic the stirring conditions that are obtained using the European-style overhead stirring mash baths which are significantly more expensive to manufacture.

This report describes a trial that compares the newly designed paddles with conventional 35mm and 47mm magnetic stirrer bars, and hand stirring of mashes. The trial also tested two different stirring speeds, 90 rpm and 400 rpm, in the IEC mash bath, to determine which stirring speed was most efficient for malt extract recovery and for duration of the lautering stage for both the EBC (1997) and IoB (1997) laboratory scale hot water malt extract procedures.

The objective of the trial is to give recommendations to the manufacturer and the Australian malting industry for the optimal configuration of magnetically stirred mash baths and the stirrers used in them.

Materials and Methods

Malt Samples

Five commercial malt samples were obtained from Australian maltsters (Sloop, Schooner, Picola, Franklin and Gairdner). The malts were ground in a Bühler Miag disc mill at EBC specification of 0.2 mm or IOB specification of 0.7 mm. The samples were ground immediately before use.

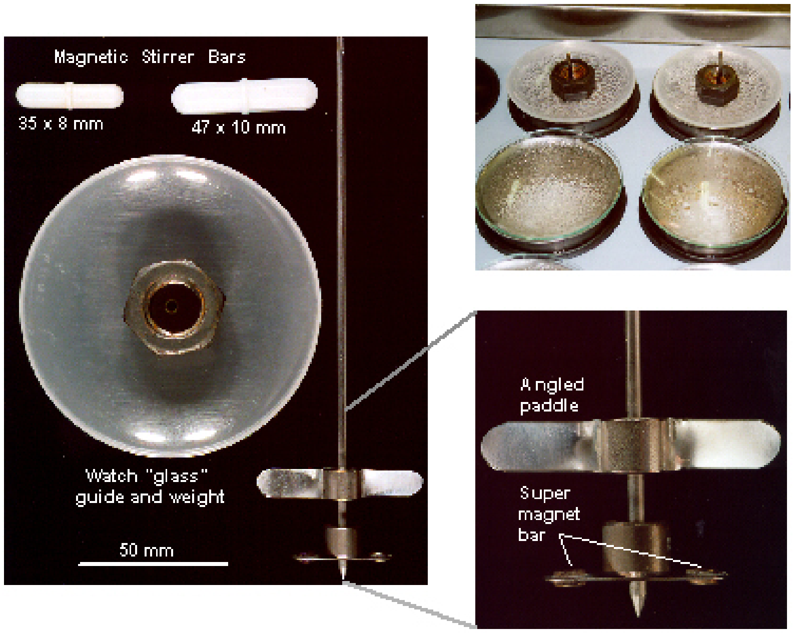
Extract determination procedures

An IEC (Melbourne VIC) automated mash bath was used for the determination of malt hot water extract for the recommended EBC (1997) and IoB (1997) methods. The resulting extracts were analyzed by an Anton Paar densitometer to calculate potential extract. Experiments were in triplicate, and stirrer types were randomly allocated within each trial.

Stirrer Types

The malt mashes were stirred with a 35 x 8 mm or 47 x 10 mm magnetic stirrer bars, a pivoted paddle, or were hand stirred at ten minute intervals. The stirring speed was set at 400 rpm or 90 rpm for the stirrer bars and 90 rpm for the pivoted paddle. The design of the pivoted paddle is illustrated in Figure 1. The various stirrers were randomly allocated to the beakers within the experiments.

Figure 1: Pivoted paddle stirrer and magnetic stirrer bars.



Results and Discussion

It was found that neither magnetic stirrer design, stirrer bar size or rotation speed gave a significant difference in hot water extract recovered with either the EBC or IoB recommended procedures (Tables 1-4). However, it was clearly shown that the stirring variable had a significant impact on the rate of lautering (Tables 3 & 4), with fastest being the paddle followed by the 35 mm and then the 47 mm bar at 400 rpm. Use of the stirrer bars at 90 rpm improved the rate of lautering (data not shown). Although all magnetic stirring devices were observed to mix the mash adequately, it was evident that increasing the rotation speed from 90 to 400 rpm and stirrer bar size from 35 to 47 mm increased the degree of "vortex" observed in the mash. The paddle alone achieved adequate stirring without forming a large vortex. These observations are consistent with the formation of "fines" during mashing by the grinding action of the stirrer bars which subsequently impedes mash lautering. In addition, the vortex produced by the stirrer bars may result in oxidation that reduces the rate of lautering by increasing the amount of oberteig-layer material produced (Poyri et al., 2000).

A closer inspection of the extract recovery results in comparison with the lautering times reveals some interesting trends. Table 1 and 2 suggest that the extract recovery was generally higher at 90 rpm than at 400 rpm. Interestingly, the magnetic stirrer bars at 90 rpm gave the highest extracts compared to the paddle. Examination of the extract results for the five different malts with the EBC and IoB procedures (Tables 3 & 4) suggests that there are two competing effects whose interaction subtly determines the extract level. The production of fines appears both to retard lautering thus reducing extract recovered, but also increases extract recovery by further grinding of the grist to improve the solubilization of extract from grist material, particularly where malt modification is not complete. This hypothesis is supported by the IoB extract results (coarse grind), which generally show that the paddle stirring gave the lowest average extract (Table 4). In comparison, in the EBC extract results (fine grind) the paddle tended to give the highest extract in malts that were high extract and which were presumably well modified. Therefore, this analysis suggests that the grinding action of the stirrer bars may impact upon the determination of fine/coarse extract difference which many brewers find useful in assessing the consistency of malt modification and ease of extract recovery.

Table 1: Extract values from EBC mash procedure using Sloop 1.48cP and varied stirring types. Extract values are not significantly different (P<0.05).

Stirring Method	**Extract (%)**
hand stir	78.42
35mm bar / 400 rpm	78.86
47mm bar / 400 rpm	79.34
Paddle / 90 rpm	79.09
35mm bar / 90 rpm	79.60
47mm bar / 90 rpm	79.62

Table 2: Extract values from IOB mash procedure using Sloop 1.48cP and varied stirring types. Extract values are not significantly different (P<0.05).

Stirring Method	**Extract (%)**
hand stir	77.41
35mm bar / 400 rpm	78.17
47mm bar / 400 rpm	77.58
Paddle / 90 rpm	78.11
35mm bar / 90 rpm	78.25
47mm bar / 90 rpm	78.47

Table 3: Extract values from different malts using EBC mash procedure and various stirrers. Extract values are not significantly different (P<0.05) within variety. Lautering times are significantly different between stirrer types.

Malt Variety	**Stirring Method**	**Lautering time 200ml wort (min)**	**Extract (%)**
Franklin	35mm bar / 400 rpm	6.25	83.0
Franklin	47mm bar / 400 rpm	11.94	83.6
Franklin	Paddle / 90 rpm	3.92	83.7
Gairdner	35mm bar / 400 rpm	6.36	82.4
Gairdner	47mm bar / 400 rpm	15.50	82.1
Gairdner	Paddle / 90 rpm	3.42	82.8
Picola	35mm bar/ 400 rpm	6.58	82.8
Picola	47mm bar/ 400 rpm	18.92	82.6

Picola	Paddle / 90 rpm	3.44	82.2
Schooner	35mm bar/ 400 rpm	8.17	80.1
Schooner	47mm bar/ 400 rpm	14.75	81.0
Schooner	Paddle / 90 rpm	3.92	79.8
Sloop	35mm bar/ 400 rpm	5.58	81.1
Sloop	47mm bar/ 400 rpm	13.33	80.7
Sloop	Paddle / 90 rpm	2.93	80.0

Table 4: Extract values from different malts using IOB mash procedure various stirrers. Extract values are not significantly different ($P<0.05$) within variety. Lautering times are significantly different between stirrer types.

Malt Variety	Stirring Method	Lautering time 200ml wort (min)	Extract (%)
Franklin	35mm bar/ 400 rpm	9.2	82.3
Franklin	47mm bar/ 400 rpm	18.8	83.1
Franklin	Paddle / 90 rpm	6.9	81.7
Gairdner	35mm bar/ 400 rpm	9.1	81.6
Gairdner	47mm bar/ 400 rpm	13.0	82.5
Gairdner	Paddle / 90 rpm	5.6	81.3
Picola	35mm bar/ 400 rpm	11.0	81.8
Picola	47mm bar/ 400 rpm	17.4	82.2
Picola	Paddle / 90 rpm	6.3	81.3
Schooner	35mm bar/ 400 rpm	21.8	79.4
Schooner	47mm bar/ 400 rpm	30.0	80.2
Schooner	Paddle / 90 rpm	9.8	78.9
Sloop	35mm bar/ 400 rpm	11.4	79.6
Sloop	47mm bar/ 400 rpm	18.3	78.6
Sloop	Paddle / 90 rpm	5.3	79.0

Summary

Although no significant differences in extract recovery were observed in this trial with the conventional mash bath configuration, we recommend using the pivoted paddle stirring at 90 rpm because it matches the specification for the widely used EBC hot water extract protocol. In addition, this new configuration would appear to reduce the production of fines as a consequence of stirring so as to increase the efficiency of lautering and possibly give a more realistic determination of the fine/coarse difference extract parameter. We suggest that these modifications be strongly considered for all new IEC mash baths manufactured but also recognize that there is no imperative for existing mash baths to be modified. If the owner of existing mash baths deems that the modification is worth while, they can be easily and relatively inexpensively made to existing equipment.

Acknowledgements

We would like to thank the GRDC for provision of financial support, Adelaide University for the provision of a Summer Studentship Scholarship to Tamara Hadaway, Bernard Hodson (IEC) for assistance with design of paddles and modifications to mash bath, Neil Bungey for manufacture of prototype paddle, Australian maltsters for provision of malt samples and Prof Andrew Barr for constructive suggestions.

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