Proceedings of the 10th Australian Barley Technical Symposium, 2001

Lautering: malt factors and their use in barley breeding

Chris Ford[1], Doug Stewart[2], Peter Healy[3] and Evan Evans[1]

[1]Department of Plant Science, Adelaide University, Waite Campus PMB1, Glen Osmond, SA 5064
[2]Adelaide Malting Company, Cavan, SA 5094
[3]Lion-Nathan Australia, Milton, QLD 4007

Abstract

Lautering remains a bottleneck in brewery operations. The malt factors contributing to reduced performance in the lauter tun have been incompletely characterised, and breeding of barleys with improved brew-house performance largely overlooked. By gaining a complete understanding of the processes involved, malt characteristics that promote or retard lautering can be targeted within existing breeding programs to produce barleys more closely attuned to the needs of brewers. A laboratory-scale lautering device with a capacity of 1 kg malt has been built, which replicates the grain bed depth and run-off rates of commercial lauter tuns. Lautering performance is assessed by recording differential pressure across the grain bed. The effects of barley variety, malting, milling and mashing conditions, and parameters of lauter tun operation are being assessed for their contributions to lautering performance. Preliminary results have shown that it is possible to discriminate the lautering performance of malts using the small-scale device developed. A number of Australian malts have been examined, and the outcomes of these trials will be presented. By operating the device at temperatures used commercially, it has been possible to minimise interference from β-glucans, and thereby more accurately examine those malt factors of importance to lautering in the brewery.

Introduction

The common thread linking each new malting variety released by barley breeders is an improvement in levels of extract or diastase activity when compared with the variety to be replaced. Traditionally this is achieved through selection specifically for these factors, with little or no emphasis placed on the likely performance of the variety when it is malted and passes into the brew-house. Modern-day brew-houses may operate at up to 10-12 brews per day, and it is generally accepted that the rate-limiting step of the processes from `milling to chilling' lies with the separation of sweet wort and spent grains following mashing. The means by which this is achieved has varied with brewing styles and the advent of hydraulically actuated press-filters, but in each case there is a premium to be had by recovering the maximum extract in the minimal cycle time.

In the unending quest for improved malting barley varieties, there has to the best of our knowledge been no attempt made to select directly for improved performance during the wort separation process. We have recently started a research project that aims for the first time to provide barley breeders with a measurable parameter for the prediction of potential efficiency in the wort separation process. This will be achieved by developing an operational understanding of the most common form of wort separation, namely lautering, and determining the role of individual barley and malt factors in the process. Subsequently, tests to detect the presence or absence of desirable or deleterious components will be developed or adopted from existing analytical protocols, and applied to barley lines undergoing evaluation within our breeding programs.

Lautering research and development - a brief historical perspective

The heyday for lautering research on a laboratory scale seems to have been the period of 20 years or so between about 1970 and 1990. Both before and since that time, few if any reports of new developments or understandings in lautering have appeared. During the 1970s, several papers were published that described the development of increasingly sophisticated laboratory-scale lautering vessels. These were often of all-glass construction, and were designed to allow the assessment of a number of factors in apparatus that mimicked the salient features of brewery lauter vessels. For instance, Crabb and Bathgate (1973) and Bathgate et al (1975) reported the construction and operation of a combined mash and lauter vessel with a capacity of 1 kg malt. The equipment incorporated a host of control units and measurement devices to allow monitoring of wort run-off rates and differential pressure across the bed of spent grains, and was capable of discriminating between two malts with quite similar specifications. Similar, although less complex designs were reported also by Huite and Westermann, (1974), Webster (1981), Armitt et al, (1984) and Laing and Taylor (1984).

It is interesting to note that 20 years ago, Webster and Portno (1981) stated that `the lautering performance of malt is a factor of increasing economic significance...any incidence of poor lautering will inevitably ...lead to loss of valuable extract and low brew-house yield'; yet it remains largely a matter of serendipity if a new barley variety performs well during the wort separation process. The outcome of their work was the derivation of an expression that allowed the prediction of wort run-off times from a set of malt parameters, namely the grist mean particle size, the sedimentation value, wort viscosity and the volume of fine particles.

The control of lautering

The outcome of the research summarised in the previous section has been the determination of a list of factors that in various ways have an impact on lautering efficiency. The measurement of lautering efficiency has been achieved by several means, including time to achieve the run-off of a pre-determined wort volume (Webster and Portno, 1981), differential pressure across the grain bed (Laing and Taylor, 1984) and integration under the curve of differential pressure against filtration time (Armitt et al, 1984).

In most cases, the parameters controlling lautering efficiency can be split into physical factors and those derived from barley and malt. The purely physical parameters include the effects of grain bed geometry (shallow beds filter more quickly than deep ones), temperature (higher temperature equates to faster run-off, but at the cost of extraction of lipids and, from the husks, tannins), flow rate (lautering is a combination of filtering of first worts from spent grain and leaching of soluble sugars into the sparge water; at excessive flow rates there is insufficient time for adequate leaching to occur) and the size of the particles that make up the grain bed (smaller particles give better extraction but a lower flow rate). Successful lautering is therefore a compromise between these and other factors, superimposed on which are the effects arising from the mash that is to be separated.

Lautering research for the new millennium

It is clear that although no consensus exists by which effective and efficient behaviour of malt during lautering may be completely predicted, a considerable body of knowledge exists that describes specific factors important in the process. Our research will focus first on gaining an understanding of the particular barley or malt factors that are associated with efficient lautering. When this has been achieved, we will be able to provide to the Australian barley breeding community tools by which new varieties may be selected with improved performance in the brew-house.

Materials and Methods

Design of the laboratory-scale lauter tun used in this study was based on several devices reported in the literature. The main design considerations were the need to mimic brewery conditions of malt loading, grain column dimensions and run-off flow rates, while simultaneously measuring meaningful parameters of malt performance during lautering. It was decided to work with approximately 1 kg malt per trial, using both free-flow and pumped run-off of worts to determine the best set of experimental lautering conditions.

Similarly, a number of parameters for measuring grain bed performance were chosen. These included differential pressure across the grain bed, the volume of wort collected and the decrease in depth of the grain bed. A glass column 900 mm long with an internal diameter of 80 mm was cut and fitted with Perspex ends. A false bottom of commercial manufacture (a kind gift from Briggs of Burton Ltd.) with an aperture of ca 10% was fitted into a 100 mm diameter Quickfit flask lid and the entire lower assembly was fastened to the column using wing nuts and bolts. An attemperating glass jacket was sealed in place and tested for water tightness. Attemperating water was pumped from a thermostatically controlled water bath, and the complete small-scale lauter tun (SSLT) mounted onto a trolley to allow secure and easy access. Malt was milled using a Valley 2-roll home-brew mill, with roll diameters of 31.75 mm, driven by a cordless electric drill running at 350 rpm. Conditions for mashing were based on the Small Scale Brewing protocol developed previously in the laboratory (Stewart et al, 1998), and a grist:liquor ratio of 3:1 was chosen accordingly. Lautering performance was assessed by measuring the differential pressure across the bed of spent grains by way of a water manometer connected beneath the false bottom; in later developments was supplemented with an electronic pressure transducer connected via an analogue-to-digital converter to a laptop computer. The height of water in the manometer was compared to the height of liquid within the lauter vessel at regular intervals following mash transfer and the recirculation and run-off that follows. The differential pressure was plotted against time, or when comparing lautering trials at different run-off rates, against the volume of wort passed through the grain bed. The use of rakes or knives was decided against in the design of the SSLT; the proportion of the grain bed surface area cut would be much larger than that occurring in a commercial lauter, thereby causing disproportionate increases in bed channel to grain bed ratio.

Results and Discussion

Two laboratory lautering protocols were devised to reflect the different strategies by which Australian brewers manage wort run-off:

(i) A constant-rate recirculation, run-off and sparge at relatively low (30-40 ml min^{-1} for 50 cm^2 false bottom, equivalent to ca 3.6 to 4.8 hl m^{-2} hr^{-1}) or higher, 80-100 ml min^{-1} (equivalent to 9.6 to 100 hl m^{-2} hr^{-1}) flow rates

(ii) ii) An initial free-flow run-off (ca 600 ml min^{-1}, equivalent to 72 hl m^{-2} hr^{-1}) for 15-30 secs followed by recirculation, run-off and sparge at 80-100 ml min^{-1} (equivalent to 9.6 to 100 hl m^{-2} hr^{-1}) (see Figure 2)

Using a constant run-off rate, a clear difference in differential pressure was seen for the two rates, but a ca 20% increase in the final depth of spent grains occurred at the lower rate. The difference in maximum differential pressure across the spent grains bed between the two run-off rates was only 0.35 psi, suggesting that accurate discrimination of malts by this protocol would be very difficult

An initial free-flow run-off with the outlet tube placed 35 cm above the false bottom gave a higher differential pressure for the same malt than with constant-rate run-offs.

Additionally, the final height of the spent grains bed was lower, suggesting that bed formation was more complete using this protocol than with a constant-rate run-off.

At constant run-off rates, differential pressure (DP) across the spent grain bed varied with flow rate. Maximum DP across the spent grain beds differed by only 0.35 psi between the two run-off rates (Figure 1)

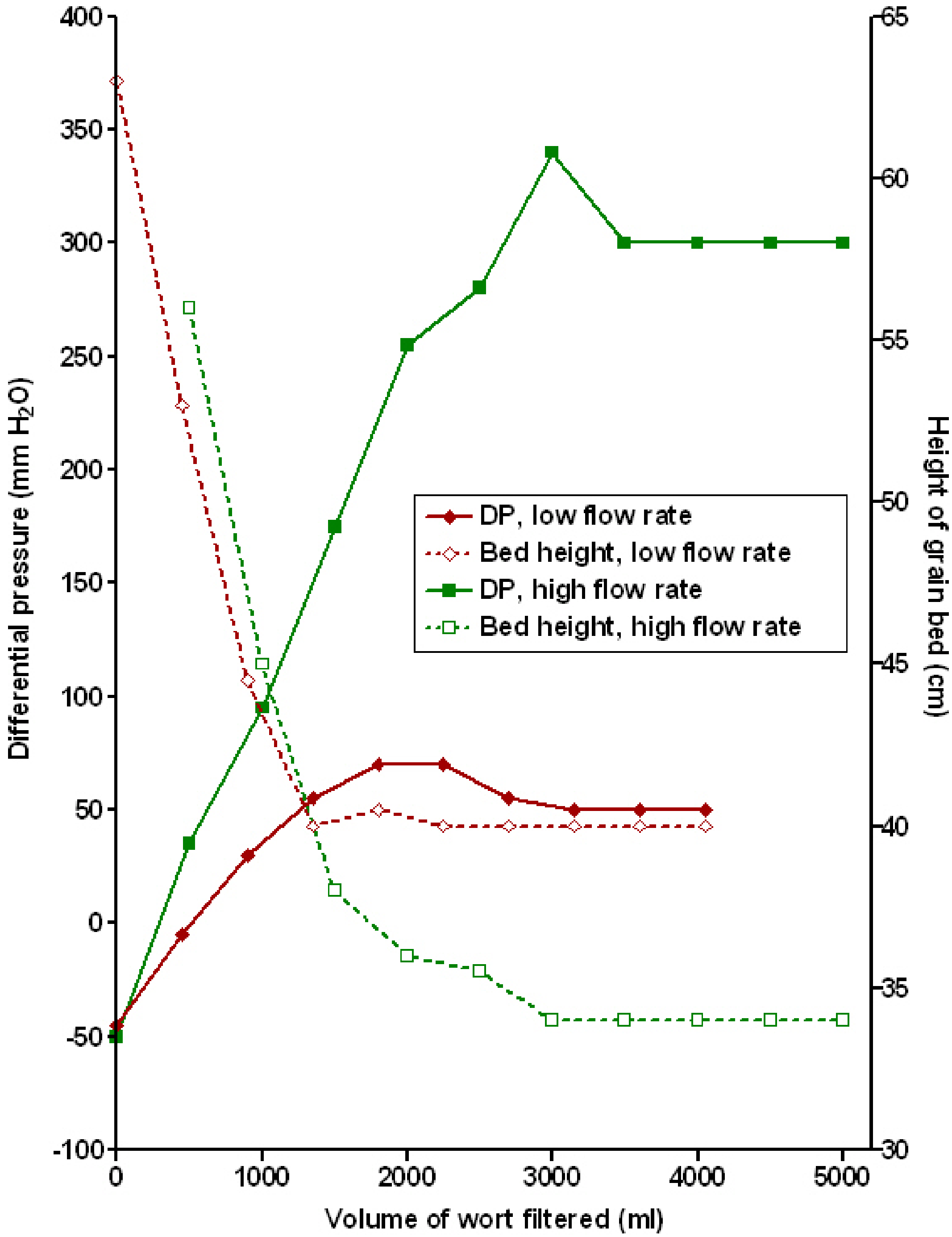

Figure 1 Lautering performance of Sloop malt at two run-off rates.

An initial free-flow run-off gave a higher DP than with constant rate run-offs (Figure 3). Also, the final height of the spent grain bed was lower, suggesting that bed formation was more complete than by constant rate run-off.

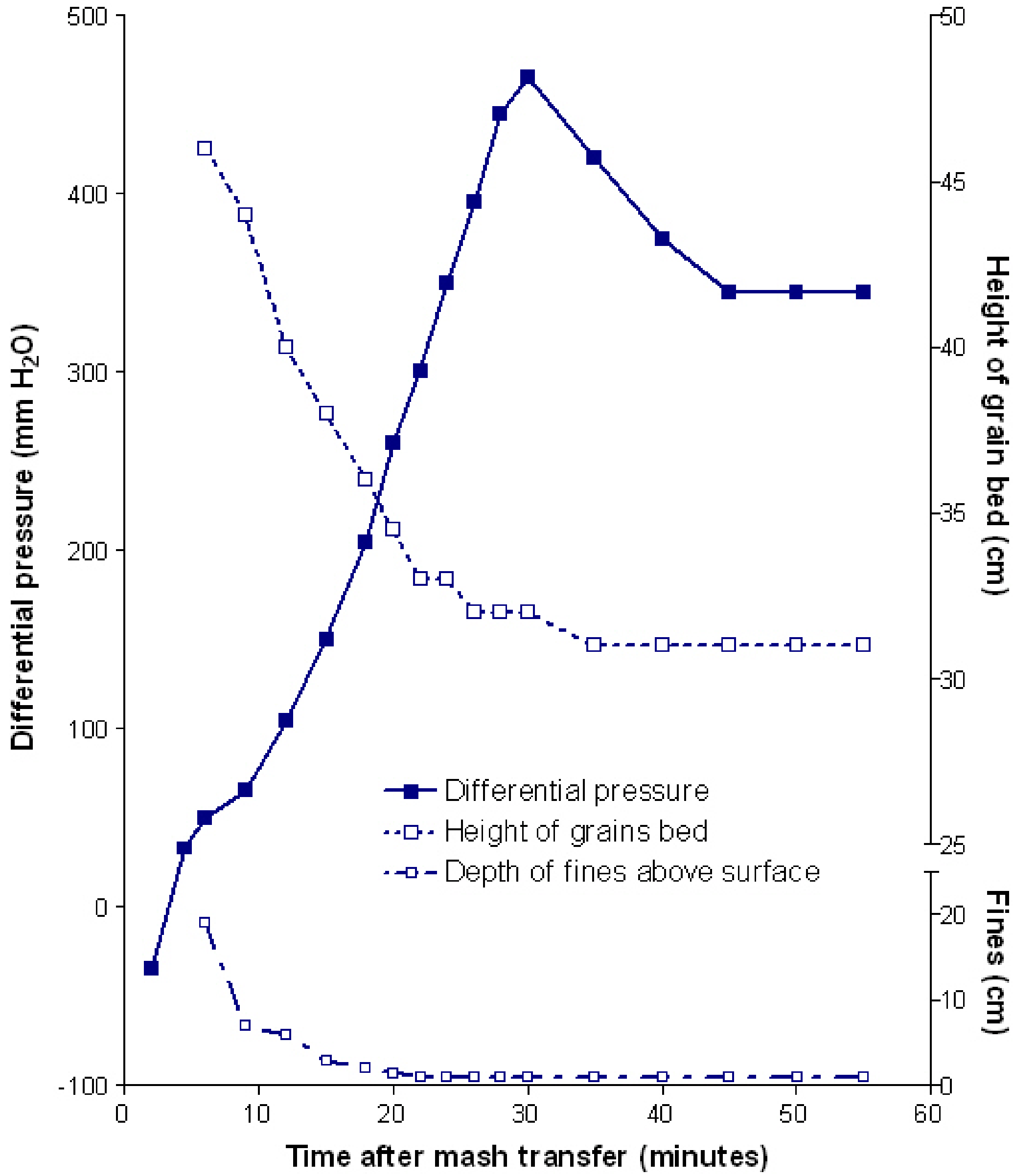

Figure 2. Lautering performance of Harrington malt using a 30-second free-flow run-off to initiate grain bed formation

.

Reproducibility between duplicate runs using either protocol was low, with unacceptably high variation in differential pressure and spent grain bed formation. Further trials are underway in an attempt to improve the reproducibility of the SSLT.

Conclusion

Experimental lautering protocols have been developed that reflect those used in Australian breweries. Only very small differences were seen in the experimental lautering performance of a number of commercial Australian malts. We are currently addressing the remaining technical shortcomings with the experimental lautering apparatus and parameters needed to ensure reliable and consistent data. Our research efforts will now be directed towards the precise determination of malt factors influencing lautering efficiency, and developing assays for their rapid and accurate measurement, thereby providing breeding programs with a valuable tool in the search for improved malting barley varieties.

Acknowledgments

This work is supported by the Grains Research and Development Corporation of Australia.

References

1. Armitt, J.D.G., Healy, P.J. and Coates, K.D. (1984). Proc. 18th Convention, Institute of Brewing (Australia and New Zealand Section), Adelaide, 100-108.
2. Bathgate, G.N., Bennett, H.O. and Crabb, D. (1975). J. Inst. Brewing, 81, 225-231
3. Crabb, D. and Bathgate, G.N. (1973). J. Inst. Brewing, 79, 519-524
4. Huite, N.J. and Westermann, D.H. (1974). Proc. 13th Convention, Institute of Brewing (Australia and New Zealand Section), Gold Coast, 133-149.
5. Laing, H. and Taylor, D.G. (1974). Proc. 18th Convention, Institute of Brewing (Australia and New Zealand Section), Adelaide, 109-114.
6. Webster, R.D.J. (1981). J. Inst. Brewing, 87, 52-56.
7. Webster, R.D.J. and Portno, A.D. (1981). Proceedings of the European Brewery Convention Congress, Copenhagen, 153-160.