Producing a Quality Malt from Hulless Barley

M.J.Edney[1] and B.G.Rossnagel[2]
[1] Grain Research Laboratory, Canadian Grain Commission, Winnipeg, MB, Canada
[2]Crop Development Centre, University of Saskatchewan, Saskatoon, SK, Canada

Abstract
The significantly higher levels of extract from hulless barley malt offer tremendous economic potential for the brewery. In the past this advantage has been negated by a need for intact hulls to act as a filter bed in the lautering process. New technologies for spent grain separation, such as pressure mash filters and centrifugation, have increased interest in hulless barley malt. Another concern has been the potential for embryo or acrospire loss during malting due to the missing protection of the hull, and low malt friability was thought to be an indication of such loss. However, research with the Canadian hulless variety, CDC Dawn, indicated that poor friability values were not explained by embryo loss. The Calcofluor test showed that modification had reached the distal end in over 90% of the kernels. Inadequate malting conditions were then postulated as a cause of poor friability possibly due to higher percentages of ß-glucan and protein in hulless barley. Improved friability results were obtained when steep-out moistures or germination times were increased, but values still did not reach the commercially acceptable range. However, the use of hammer mills in preparing malt for new separation technologies will reduce the need for as high a level of malt friability and the commercial use of hulless barley malt with its high extract levels will be possible.

Introduction

Hulless barley malt offers a tremendous opportunity for the brewing industry. Economic savings can be realized through significantly higher extract levels and improvements in beer quality may be possible with the absence of undesirable hull compounds such as tannins and other polyphenols. In the past, the use of hulless malt has been restricted because of a need for intact hulls in the efficient operation of lauter tuns. However, with the advent of newer technologies for spent grain separation, such as mash filters and centrifuges, there has been increased interest in the advantages of hulless barley malt (Evans et al. 1998).

The malting of hulless barley, however, presents a number of challenges due to differences in chemical and physical characteristics. The missing hull makes the barley susceptible to embryo damage during handling and malting. The loss of embryo, at an inopportune time, can prevent adequate endosperm modification. Water uptake is much quicker during steeping of hulless barley compared to covered barley (Singh and Sosulski 1985). Bhatty (1996) also found hulless barley to be harder than covered malting barley. Malting conditions have to be altered in order to adequately process hard, steely barley (Briggs 1981). Higher steep-out moistures and longer germination times may be required. Kilning may also cause a problem. Without the protection of a hull, high kilning temperatures may cause hulless malt to be extra hard due to case-hardening (Thomas 1986).

Evans et al. (1999) indicated some distinct advantages for hulless barley malt. However, the same group (Evans et al. 1998) found strong disadvantages to the use of under-modified hulless barley malt. The present study investigated solutions to the poor modification indices seen in hulless barley malt. The possibility of embryo loss was investigated with the Calcofluor modification test. The effect of altered malting conditions, including high steep-out moistures and longer germination times, was investigated. The effect of the high protein content of hulless barley, on modification, was also investigated.

Materials and Methods

Experiment 1 – Calcofluor Modification
Experiment 1 investigated the possibility that poor modification indices were a result of lost embryos and thus incomplete germination. The barley used in this experiment was CDC Dawn that had a relatively low level of protein (12.8% DM), good germination (95%) and a low level of adhering hull (<1%). The sample was obtained from a commercial producer and was grown in central Saskatchewan (1997). Past experience had shown CDC Dawn was the Canadian hulless cultivar with the best potential for producing a high quality malt. A sample of Harrington barley, sourced from a commercial malthouse, was included for comparison. In all experiments, barley was sized and only material remaining on a 6/64" screen was malted.

In Experiment 1, barley was steeped, germinated and kilned in Phoenix Micro-Maltings. The standard steeping schedule (Table 1) was used. Germination was for 96 hours at 14°C. Kilning conditions are listed in Table 2.

Table 1. Steeping conditions used in Experiments 1, 2 and 3. Times given in hours.

	Wet Steep	Air Rest	Wet Steep	Air Rest	Wet Steep	Air Rest	Wet Steep	Air Rest	Wet Steep
Standard Steep	10	18	8	12					
Long Steep	10	18	2	5	2	5	2	4	
Extended Steep	6	2	4	12	4	4	4	4	4

Experiment 2- Steeping and Germination Conditions
Experiment 2 investigated the effect of steep-out moistures and germination times on the quality of hulless barley malt. The CDC Dawn described in Experiment 1 was used in this experiment.

The barley was steeped in a separate micro-steep system at 14°C using one of 3 different schedules (Table 1). The steeped barley was germinated and kilned in a Phoenix Micro-Maltings. Germination took place at 14°C for either 96 hours (short) or 120 hours (long). Kilning conditions are listed in Table 2.

Table 2. Kilning conditions used in Experiments 1, 2 and 3. Times given in hours

	30°C to 48°C	48°C	48°C to 65°C	65°C	65°C to 80°C	80°C	Total Time
Kilning	6	16	8	10	2	6	48

Experiment 3 – Protein
Experiment 3 investigated the effect of barley protein levels on friability levels in hulless malt. Samples for this experiment included the CDD Dawn from Experiment 1 as well as CDC Dawn samples obtained from the 1996 Western Canadian Hulless Barley Cooperative trials, from three breeder's plots grown in Saskatchewan (1995 & 1996) and from one breeder's plot grown in Giessen, Germany (1998).

The samples were steeped, germinated and kilned in a Phoenix Micro-Maltings. The standard steeping schedule of Table 1 was used. Germination was for 96 hours at 14°C. Kilning conditions are listed in Table 2.

Malt Analysis
Hulless barley malt was analysed for fine extract, ß-glucan, viscosity, soluble protein, diastatic power and friability using standard methods of the ASBC (1992). Calcofluor modification testing was according to the methods of the EBC (1998).

Results
Experiment 1
Calcofluor results indicated that CDC Dawn was modified to the distil tips of 93.5 % of the kernels (Table 3). The hulless barley malt was even more homogeneous and better modified than malted Harrington. However, the CDC Dawn sample showed very low friability values indicating a less mealy endosperm in the malt than Harrington malt with its higher friability value.

Table 3. Modification indices for samples malted in Experiment 1.

		Calcofluor	
	Friability (%)	Modification (%)	Homogeneity (%)
CDC Dawn	37.7	93.5	78.1
Harrington	73.2	89.8	76.7

Experiment 2
Results from Experiment 2 indicated the effect of malting conditions on endosperm modification of hulless barley (Table 4). Longer steeping times lead to higher steep-out moistures. The barley steeped with the extended program reached a steep-out moisture of 51.6 %. Higher steep-out moistures resulted in higher friability and Kolbach Index values and lower levels of ß-Glucan. These are all indications of better modified malt. Longer germination times only lead to more compete modification when steep-out moistures were low. The most modified malt was produced when the extended steeping regime was combined with long germination. Higher steep-out moistures and longer germinations did increase malt losses but levels of extract increased. Diastatic power, remained relatively constant over the varying malting schedules.

Table 4. Results from malt analysis of CDC Dawn malted under different malting conditions.

	Steep-out Moisture (%)	Fine Extract (%)	Diastatic Power (°L)	Friability (%)	ß-Glucan (ppm)	Kolbach Index (%)	Malt Yield (%)
Standard Steep – Short Germ	43.4	86.1	172	44.2	533	34.2	89.3
Standard Steep – Long Germ	43.5	86.3	174	51.3	333	37.2	87.7
Long Steep – Short Germ	46.5	86.5	188	60.3	141	38.2	87.5
Long Steep – Long Germ	45.1	86.7	180	60.9	160	39.6	85.7
Extended Steep – Long Germ	51.6	87.3	165	74.0	44	48.2	80.4

Experiment 3

Higher barley protein levels resulted in lower friability values (Table 5). The samples with lower protein showed lower levels of diastatic power with the European malt showing the lowest level. Extract levels did not appear to be related to protein with the samples tested.

Table 5 Results from malt analysis of different samples of CDC Dawn with varying levels of barley protein.

Source of CDC Dawn	Barley Protein (%)	Fine Extract (%)	Diastatic Power (°L)	Friability (%)
Breeder Europe – 1998	12.0	85.7	72	63.1
Breeder Canada – 1996	12.0	86.5	158	51.8
Barley Coops Canada - 1997	12.3	84.9	219	42.3
Producer Canada – 1997	12.8	86.1	172	44.2
Breeder Canada – 1996	13.6	84.3	172	44.5
Breeder Canada – 1995	14.3	85.1	190	32.9

Discussion

Hulless barley malt showed good potential with high levels of malt extract and good levels of diastatic power (Tables 4 and 5). The malt also showed very low friability values suggesting incomplete modification of the barley possibly due to poor germination or loss of germination during malting. However, the CDC Dawn used for Experiments 1 and 2 had an acceptable level of germination (95%) and good results from the Calcofluor modification test suggested that loss of embryos was not a problem. Therefore, it seemed unlikely that poor friability values were a result of embryo damage caused by the handling or malting of hulless barley. The low friability could result from unmodified sections within the endosperm due to a structure that was difficult to modify. Palmer (1972) observed such a phenomena with the variety Julia which required extra care at malting in order to ensure complete modification.

The hulless barley malt produced with higher steep-out moistures and longer germination times in Experiment 2 showed higher friability values (Table 4). Other quality parameters, such as low ß-glucan levels and higher Kolbach Indexes, also indicated a better modified malt. This suggested that the harder endosperm structure of hulless barley (Bhatty 1996) could be better modified with special malting conditions. Briggs (1981) noted that steely-type barley needed higher steep-out moisture to complete modification but that higher malt losses would result. Higher losses were observed in the present study. Reduced levels of extract, which had also been observed with high steep-out moistures (Briggs 1981), were not observed in this study.

The need for special malting conditions may have been related to protein. Higher protein barley produced malt with poorer friability (Table 5). Possibly higher protein affected endosperm structure rendering it more difficult to modify. The European CDC Dawn appeared to have an endosperm structure that was the easiest to modify. Environment, therefore, may play a key role in defining endosperm structure. Therefore, breeding a hulless barley cultivar with an endosperm that is easily modified may prove to be difficult.

The study showed that better modified hulless barley malt can be produced with high steep-out moistures and long germination times. These conditions produced higher malt losses but increases were minimal. Malting low protein hulless barley was also found to be helpful in producing a better modified malt. More research into endosperm structure of hulless barley could help breeders develop cultivars with better malting characteristics. Research may also show that hard hulless malt is related to case hardening. In the end, though, poor friability

values may not even be a problem when processing hulless malt in breweries due to the use of hammer mills, versus roller mills, when preparing malt for mash filters and centrifuges.

References

Bhatty, R.S. (1996). Cereal Chemistry **73**, 75-80.
Briggs, D.E., Hough, J.S., Stevens, R. and T.W. Young (1981). Malting and Brewing Science. Volume 1 Malt and Sweet Wort. Chapman & Hall, London.
Evans, D.E., Stenholm, K., Vilpola, A., Home, S. and G. Hughes (1998). MBAA Technical Quarterly **35**, 189-195.
Evans, E., Vilpola, A., Stewart, D.C., Stenholm, K., Pöyri, S., Washington, J.M., Barr, A.R. and S. Home (1999). MBAA Technical Quarterly **36**, 375-382.
Palmer, G.H.(1975). Journal of the American Society of Brewing Chemists **33**, 174-180.
Thomas, D.A. (1986). Journal of the Institute of Brewing **92**, 65-68.
Singh, T. and F.W. Sosulski (1985). Journal of Food Science **50**, 342-346.
ASBC (1992). *Methods of Analysis*, 8th ed. The American Society of Brewing Chemists, St. Paul.
EBC (1998). *Analytica-European Brewery Convention*, Verlag Hans Carl Getränke-Fachverlag, Nürnberg.