

Implications of Thin Husk in Barley

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Introduction

Malt extract is one of the most important parameters used by breeders, maltsters and brewers to rate the quality of a new malting variety. The amount of extract a malting variety can produce in the brewhouse will always be of crucial economic importance. High levels of malt extract are therefore desired by the malting and brewing industries. Although in recent years newer varieties such as Franklin and Arapiles have shown significant increases in malt extract, the improvement in the quality of Canadian and European varieties during the mid 1980's was not matched by Australia. Subsequently by the early 1990's Australia's share of the important Japanese market had fallen from 33% to 19% (Powell, 1997). This loss in market share can be largely attributed to the lower levels of malt extract in Australian varieties.

Strategies for the breeding of high extract varieties has included the use of mapping populations, doubled haploid and marker assisted selection. These strategies are showing success with barley breeding institutions in Australia now having very promising crosses at advanced stages within their programs.

Recent research has shown a possible association between high levels of malt extract and thin husk. In particular, malt extract and husk content have been found on the same region of barley chromosome 2H for the Haruna Nijo x Galleon mapping population (Collins *et al.*, this proceedings). The husk consists of two outer layers, which surround and adhere to the entire grain. The palea is the husk layer on the ventral side of the grain and the lemma is at the dorsal or back side of the grain (Stuart, 1997). Haruna Nijo, one of the parents in the mapping population has both high malt extract and a thin husk.

There are a number of potential problems associated with thin husk. The husk provides physical protection for the grain and the growing acrospire. Thin husked varieties may therefore have an increased tendency for weather damage and preharvest sprouting, and an increased likelihood of embryo damage and skinning during harvesting and subsequent grain handling. The husk may also help in part to physically restrain the acrospire and the swelling of the grain during germination (Stuart, 1997). Thin husk may therefore cause problems in controlling the germination process during malting, leading to overmodification. Husk is also needed to form the filter bed during lautering, and low levels may therefore impact on the brewing process.

In addition, there are the related issues of skinning and hull adherence. The high extract Canadian variety, Harrington, although of excellent malting quality has a loosely adhering husk and is highly susceptible to skinning. As with thin husk, skinning of the grain has a number of adverse effects on malting. These include reduced uniformity and germination during the malting process, embryo damage, mould growth and numerous grain handling problems (Aidun *et al.*, 1990). Hull adherence has in fact been identified by the Brewing and

Malting Barley Research Institute in Canada as the most important quality problem to address (Edney, 1999).

In terms of economy of processing it is therefore important that substantial gains in high extract are achieved and maintained, but that they are not obtained at the expense of husk content and adherence (Powell, 1997). Of particular interest to the South Australian Barley Improvement Program is the promising high extract line WI-3102, which has a characteristic thin crinkled husk. The purpose of this study was to compare barley varieties with a wide range of husk contents and to investigate the relationships between husk content, skinning, germination and malt quality.

Materials and Methods

Barley Samples

A total of 34 barley genotypes were chosen from a number of experiments from the 1998 Stage 2 and Stage 3 trials grown at Brinkworth in South Australia. Included in this sample set were WI-3102 and 14 other promising high extract lines available in the South Australian Barley Improvement Program, derived from Haruna Nijo. There were also 17 commercial varieties including 6 feed and 11 malting types (Table 1).

Barley Quality Analysis

Grain protein (GP) was measured using a Technicon Infraalyzer 400 Near Infrared (NIR) instrument, which has been calibrated using the Kjeldahl method (Analysis Committee of the EBC, 1998) as the reference. Thousand grain weights, and the germinative energy of barley were assessed using standard European Brewing Convention (EBC) methods (Analysis Committee of the EBC, 1998). Germinative energy was assessed directly after harvest in December, in March and just prior to malting in April. The husk content of barley was determined using a scaled down version of the standard EBC method (Analysis Committee of the EBC, 1998). To assess husk damage, percent skinning was determined using the Australian Barley Board classification skinning protocol (Australian Barley Board classification manual, Version 2.0).

Micromalting

Barley samples were screened over a 2.2mm screen. 50gm of each sample was micromalted in a Phoenix Automatic Micromalting System without the use of additives. The following micromalter schedule was used: (i)Steep and Air Rest, 7:8:9 hours at 15°C, (ii)Germination, 94 hours at 15°C, and (iii)Kilning, 30-40°C for 9 hours, 40-60°C for 4 hours, 60-70°C for 2 hours and 70-80°C for 4.5 hours (unpublished data). Grain hydration during the malting process was assessed using the boiled grain method (Landau *et al.*, 1995).

Malt Quality Analysis

All malt quality parameters were assessed using standard analytical methods (Barley Quality Report, 1997 season). Hot Water Extract (HWE) was analysed by a small scale version of the recommended EBC fine grind method (Macleod *et al.*, 1991). Viscosity was determined on the HWE sample using an AMV 200 rolling ball viscometer. Malt protein (MP) was measured using a Technicon Infraalyzer 400 Near Infrared (NIR) instrument, which has been calibrated using the Kjeldahl method (Analysis Committee of the EBC, 1998) as the reference. Diastatic Power (DP) was measured using a rapid small scale variation of a standard starch digestion followed by measurement of reducing sugars with a para-hydroxybenzoic acid hydrazide reagent (PAHBAH). Alpha amylase was measured on an

aliquot of the DP extract heat treated to denature beta-amylase and re-assayed as for DP. Beta amylase was then calculated from DP minus alpha-amylase. Wort beta glucan was measured using a Megazyme kit assay. A spectrophotometric method recommended by the American Society of Brewing Chemists (ASBC) was used to assess soluble protein (ASBC, 1992). The ratio of soluble protein to malt protein was then calculated to determine Kolbach Index.

Statistical Analysis

Simple correlations between husk content, skinning and other malt quality parameters were undertaken using the statistical package, Agrobases99 for Windows.

Table 1. Barley samples included in husk study.

Variety/Line	Quality Type
Arapiles	Malt
Barque	Feed
Chebec	Feed
Fitzgerald	Feed
Franklin	Malt
Gairdner	Malt
Galleon	Feed
Monarch	Malt
SA93013 = Sapporo	Malt
Schooner	Malt
Skiff	Feed/Malt
Sloop	Malt
Venture	Malt
Vic 9524 = Arapiles/Franklin	Malt
WA5040 = Kinukei-21/Unicorn	Malt
WB190R = Wyalong	Malt
WI-2976 = (Clipp*CPI-18197)*WI-2645)/19/1	Feed
WI-3102 = (WI-2808*(Skiff *Haruna Nijo))/D40	Promising High Extract
Harrington	Malt
Haruna Nijo	Malt
BX92;017-36 = ((Haruna Nijo/Skiff)-42)/Galan	Promising High Extract
BX92;023-13 = ((Haruna Nijo/Skiff)-42)/(KM-745)	Promising High Extract
BX92;026-89 = ((Haruna Nijo/Skiff)-42)/Natasha	Promising High Extract
BX92;037-26 = ((Haruna Nijo/Skiff)-72)/Heran	Promising High Extract
BX92;037-4 = ((Haruna Nijo/Skiff)-72)/Heran	Promising High Extract
BX92;040-32 = ((Haruna Nijo/Skiff)-72)/(KM-BR-52)	Promising High Extract
BX92;042-25 = ((Haruna Nijo/Skiff)-72)/ Natasha	Promising High Extract
BX92;042-27 = ((Haruna Nijo/Skiff)-72)/ Natasha	Promising High Extract
BX92;044-25 = ((Haruna Nijo/Skiff)-72)/ Sissy	Promising High Extract
BX92;044-27 = ((Haruna Nijo/Skiff)-72)/ Sissy	Promising High Extract
BX92;066-40 = ((Skiff/Haruna Nijo)-102)/ Jubilant	Promising High Extract
BX92;097-2 = ((Skiff/Haruna Nijo)-46)/ Natasha	Promising High Extract
BX92;098-33 = ((Skiff/Haruna Nijo)-46)/ Rubin	Promising High Extract
BX92;100-32 = ((Skiff/Haruna Nijo)-46)/ Terno	Promising High Extract

Results and Discussion

Correlation coefficients between husk content, skinning and malt and wort quality parameters are shown in Table 2. The results confirm the findings of Collins *et al.* that there is a significant negative correlation (-0.578, $P < 0.001$) between husk content and malt extract.

There is also a significant negative correlation between husk content and water sensitivity (8ml test) especially in the March assessment. It is possible that the thicker husk may act as a physical barrier thereby protecting the grain or lessening its water sensitivity. Although there does not appear to be an association with dormancy (4ml test), Collins *et al.* (personal communication) has found a relationship between husk content and germination at the 24hr stage, which subsequently declines as germination proceeds. There is also a strong positive correlation between husk content and 1000 grain weight. There is a tendency therefore, for larger heavier grains to have a higher husk content. Furthermore there is a negative relationship between husk content and DP and beta amylase. A negative relationship also existed between husk content and viscosity, possibly reflecting the sample set used in this study. Normally barley with higher husk content would be expected to have a lower rate of modification, which may contribute to higher viscosity.

The results in Table 2 also show that skinning is positively correlated with malt extract and soluble protein and negatively correlated with wort beta glucan. As with husk content, this seems to be a modification issue through increased water access, with skinned grain modifying better and therefore having higher extract and soluble protein and less wort beta glucan. There is also a negative correlation between skinning and 1000 grain weight, with the weight of grain being much less if it is highly skinned.

Table 2. Correlation coefficients between skinning, husk content and other quality traits.

* Significant at (P<0.05), ** Significant at (P<0.01), *** Significant at (P<0.001)

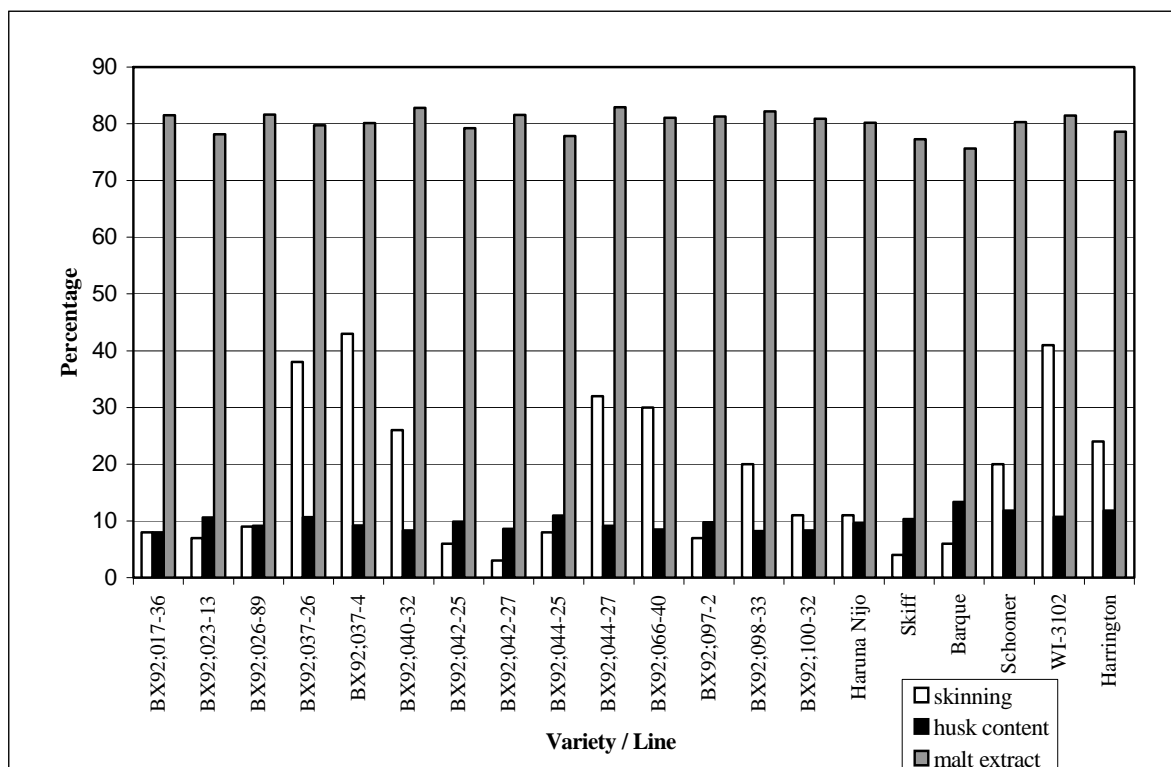
ns Not Significant

	Husk Content	Skinning
Skinning		
Husk Content		-0.189 ns
Grain Protein	-0.041 ns	-0.103 ns
Hydration Score	0.241 ns	0.088 ns
4ml Germination December	-0.141 ns	0.094 ns
4ml Germination March	-0.203 ns	0.086 ns
4ml Germination April	-0.201 ns	-0.210 ns
8ml Germination December	-0.350 **	0.214 ns
8ml Germination March	-0.517 ***	0.087 ns
8ml Germination April	-0.413 **	0.081 ns
1000 Grain Weight	0.335 **	-0.261 *
Malt Extract	-0.578 ***	0.345 **
Viscosity	-0.343 **	-0.069 ns
Wort Beta Glucan	0.091 ns	-0.306 *
Soluble Protein	-0.226 ns	0.255 *
Kolbach Index	-0.174 ns	0.097 ns
Diastatic Power	-0.284 *	-0.060 ns
Alpha Amylase	-0.001 ns	-0.180 ns
Beta Amylase	-0.303 *	-0.039 ns
Malt Protein	0.058 ns	-0.073 ns

The correlation between skinning and husk content was not significant. This prompted further investigation, with the husk content, skinning and malt extract results of 14 breeders lines incorporating Haruna Nijo and Skiff with promising high extract being examined. The results in Figure 1 show although the husk contents of these crosses are low and quite similar, skinning levels vary widely. Malt extract levels are generally high, hence it seems that it is possible to select lines with low husk content, high extract and good hull adherence. Further,

this suggests that there may need to be differentiation between skinning and hull adherence. WI-3102 and Harrington for example have intact husks but because they are loosely adhering they are more prone to skinning. Hull adherence may therefore need to be assessed separately from skinning.

Figure 1. Skinning, husk content and malt extract results for 14 Haruna Nijo derived crosses plus Haruna Nijo, Skiff, Barque, Schooner, WI 3102 and Harrington controls.



Conclusion

This preliminary study emphasizes the complex relationship between husk content, skinning, hull adherence and malting quality. The results confirm the findings of Collins *et al.* that there is an association between low husk content and high malt extract, however it is clear that high extract should not be achieved at the expense of higher skinning or hull adherence. Although there does not appear to be a relationship between skinning and husk content, the preliminary findings in the Haruna Nijo derived crosses suggest that it is possible to have low husk content and low skinning. Skinning and hull adherence and their relationship however need to be further defined. The use of an oat dehuller to measure the degree of hull adherence will be investigated. Furthermore, the possible role of germination inhibiting factors associated with the husk will also be examined.

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