Proceedings of the 10th Australian Barley Technical Symposium, 2001

Pre-release characterisation of the malting profile of WI-3102

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Introduction

Improvement in malt extract is an important goal of the South Australian Barley Improvement Program (SABIP), since high levels of malt extract are highly desired by the malting and brewing industries. In order to match the quality of Canadian and European barley varieties, breeders have used strategies such as mapping populations, doubled haploids, summer nurseries and marker assisted selection. As a result, promising high malt extract lines are now in advanced stages within the SABIP.

WI-3102 is a doubled haploid line derived from the cross WI2808// (Skiff/Haruna nijo). It has a semi-dwarf plant type conferring good standing ability and resistance to head loss. It is also resistant to cereal cyst nematode - a trait which previously had proven difficult to combine with high malt extract. It is best adapted to the medium and higher rainfall areas of SA and the Wimmera where it outyields Schooner but produces lower yields than Gairdner.

In variety trials since 1996, it has consistently averaged 1% higher malt extract than Franklin and 2-3% higher than Schooner. Viscosity and wort beta glucan are excellent, although diastatic power and fermentability are low. These characteristics however, indicate potential for the domestic brewing market, probably for low-mid alcohol beer production. It has a characteristic crinkled husk, which is thin. Recent research has shown an association between high levels of malt extract and thin husk. However, there can be potential problems associated with thin husk, including pre-harvest sprouting and embryo and skinning damage. The Malting and Brewing Industry Barley Technical Committee (MBIBTC) in its guidelines, has a 5% maximum upper limit for skinned grain per weight on a ½ litre sample (MBIBTC, 1998). NACMA has a skinning limit of 10% (NACMA, 1996) and ABB Grains had a limit of 15% maximum count for the 1999/2000 season (ABB Grain, 1999). In Canada, Harrington barley is often criticized for `peeling", or "skinning" as it is known in Australia. The Canadian breeders consider peeling resistance as one of their highest priority traits (Edney, 1999). In European varieties there is a wide range in skinning susceptibility, including popular varieties such as Alexis and Scarlett, which are prone to this problem (Baumer *et al*, 1998). In contrast, this has not been an issue

with malting varieties well adapted to southern Australia such as Schooner, Sloop or Stirling. It is important for the Australian industry to assess the benefits (i.e., higher extract) and risks of this attribute of WI 3102 before its release. This paper reports a series of experiments conducted over two seasons to investigate the possible relationships between husk content, skinning, germination and malt quality in WI 3102 and its progeny.

Materials and Methods

Barley Samples

a) Husk studies

A total of 37 barley genotypes were chosen from 23 sites grown across South Australia. This data set was comprised of:

- 34 samples from the 1998 season Brinkworth SABIP Stage 2 and 3 breeding trials
- 16 samples from the 1999 season Brinkworth SABIP Stage 3 breeding trials
- 16 samples from the 1999 season Yeelanna SABIP Stage 3 breeding trials
- WI-3102 and Schooner from 21 SARDI Stage 4 sites from the 1999 season

Data from 23 of the genotypes are presented in this paper (Table 1).

b) WI-3102 commercial crop evaluation

A total of 11 barley samples were analysed from crops grown for the commercial malting and brewing evaluation of WI-3102 (Table 2). There were 4 crops grown in South Australia and 2 crops in Victoria, however samples from different paddocks were analysed separately. Crops were later pooled for commercial evaluation.

c) WI-3102 crosses

One hundred and seventeen barley samples were chosen from a number of experiments from the 2000 Stage 1 trials grown at Pinery in South Australia. Included in this sample set were 86 selections of the cross WI-3102//Keel/Fitzgerald and 17 selections of the cross Keel/Gairdner//WI3102. There were also seven commercial varieties including Barque, Franklin, Gairdner, Keel, Mundah, Schooner and Sloop used as controls. These samples were analysed for a range of quality parameters including percent skinning, husk content and IOB malt extract. These selections were also visually assessed for husk type (smooth or wrinkled husk) and whether they had excellent, good or poor hull adherence.

Table 1. Selected barley varieties included in 1998 and 1999 husk experiments

Variety/Line	1998 trials	1999 trials
Arapiles	x	x
Barque	x	x
Chebec	x	
Fitzgerald	x	
Franklin	x	x
Gairdner	x	x
Galleon	x	
Monarch	x	x
SA93013 = SBWI-1 = Lofty Nijo	x	x
Schooner	x	x
Skiff	x	
Sloop	x	x
Venture	x	x
Vic 9524 = Arapiles/Franklin	x	x
WA5040 = Kinukei-21 = Unicorn	x	
WB190R = Wyalong	x	
WI-2976 = Keel	x	
WI-3102 = (WI-2808*(Skiff *Haruna Nijo))/D40	x	x
Harrington	x	x
Haruna Nijo	x	x
BX92;037-26 = ((Haruna Nijo/Skiff)-72)/Heran	x	
BX92;042-27 = ((Haruna Nijo/Skiff)-72)/Natasha	x	
BX92;026-89 = WI-3284 = ((Haruna Nijo/Skiff)-42)/Natasha	x	x

Table 2. WI-3102 commercial crop evaluation samples

ID	Line	Farmer	State	Details
1a	WI3102	Day	SA	Paddock 1
1b	WI3102	Day	SA	Paddock 2
1c	WI3102	Day	SA	Paddock 3
2a	WI3102	Crawford	SA	Fordvale Pastoral 3102a
2b	WI3102	Crawford	SA	Fordvale Pastoral 3102b
3	WI3102	McCormack	SA	Tarlee

4	WI3102	Johns	VIC	
5a	WI3102	Jasper	VIC	Irrigation 1
5b	WI3102	Jasper	VIC	Irrigation 2
5c	WI3102	Jasper	VIC	Paddock 9
6	Arapiles	Jasper	VIC	

Barley and Malt Quality Analysis

All barley and malt quality parameters were assessed using standard analytical methods, typical of the analysis conducted on Stage 4 variety trials in the SABIP (Barley Quality Report, 1999 season). Samples were micromalted using the standard protocol used by the Waite Barley Quality Evaluation Laboratory (Barley Quality Report, 1999 season). NIR Hot Water Extract (HWE) was assessed using calibrations developed on a NIRSystems 6500 scanning spectrophotometer (Roumeliotis et al, 1999). 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. Germination counts were also carried out August, October, December and February of the following season. The husk content of barley and malt 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 (ABB Grain, 1998). Milling energy was determined using a Comparamill. Hardness, diameter, weight and moisture were assessed using a Single Kernel Characterization System (SKCS 4100). Grain hydration during the malting process was assessed using the boiled grain method (Landau *et al*., 1995).

Statistical Analysis

For the husk study, multiple linear regression models were used to test the relationship between husk content, skinning, germination and malt quality. Fitted regression coefficients for each quality trait were tested for significant differences between coefficients and zero. All non-significant terms were systematically removed to obtain a model that contained all traits that significantly contribute to the overall multiple regression model for either husk content, skinning or germination.

Results and Discussion

Husk studies

For percent skinning, analysis of variance showed significant differences between average skinning between 1998 and 1999 seasons, however there was no significance between sites within each year. There are also significant variety effects, however no significant variety interactions for varieties across years or sites. Mean percentage skinning over 2 years (1998-1999) is shown in Table 3. WI-3102 was not significantly

different to Schooner. Haruna nijo, which is also a thin husked variety, had an average skinning of 11.2% and Skiff 4.0%. In Haruna nijo crosses percent skinning ranged between 3.0 and 43.0. Feed varieties such as Barque, Chebec, Galleon and Skiff all had low percent skinning. A multiple linear regression model was applied to determine the key associations between skinning and malt quality. The following malt quality parameters were shown to be affected by skinning: grain hardness, grain diameter, micromalter moisture at 48hours, malt loss, b (grain colour intensity), WBG, SP, KI and HWE-NIR.

Table 3. The mean percentage skinning and husk content of 23 selected barley genotypes in 1998-1999

Variety/Line	% Skinning	% husk
Arapiles	9.7	8.63
Barque	5.0	11.22
Chebec	5.5	12.25
Fitzgerald	6.0	10.10
Franklin	23.0	8.12
Gairdner	7.3	8.53
Galleon	5.0	12.10
Monarch	20.8	8.62
Lofty Nijo	3.7	8.70
Schooner	17.3	8.31
Skiff	4.0	10.35
Sloop	12.7	9.62
Venture	14.0	8.57
Vic 9524	9.7	9.60
WA5040	19.0	9.10
Wyalong	4.0	10.85
Keel	7.0	14.35
WI-3102	25.9	6.86
Harrington	35.2	9.42
Haruna Nijo	11.2	7.88
BX92;037-26 = ((Haruna Nijo/Skiff)-72)/Heran	38.0	10.60
BX92;042-27 = ((Haruna Nijo/Skiff)-72)/Natasha	3.0	8.60
BX92;026-89 = WI-3284 = ((Haruna Nijo/Skiff)-42)/Natasha	18.2	7.22
LSD 5%	**15.6**	**1.38**

Analysis of variance showed that there were significant differences in husk content between the 1998 and 1999 seasons. Rainfall statistics from Brinkworth in 1998 (311mm, average husk content 10.66%) and in 1999 (368mm, average husk content 7.23%) show that environment may play a role in determining the husk content between seasons. There were also significant differences in husk content between sites, with site averages ranging between 5.85 at Brentwood and 10.66 at Brinkworth in 1998(data not shown). Significant differences were also found in husk content between varieties (Table 3). WI-3102 had on average 1.5% less husk content than Schooner and 7.5% less than the feed variety Keel. In terms of key associations with malt quality, the parameters found to be most affected by husk content were milling energy, grain moisture, DP, AA, Beta, MP, Viscosity, HWE-NIR and EBC HWE. Regression analysis also showed a significant negative linear relationship between skinning and husk content.

WI-3102 commercial crop evaluation

In 2000, MBIBTC Stage 2 evaluation of WI-3102 barley pilot brewing trials carried out by Carlton and United Breweries, showed no obvious processing problems or product quality issues. This trial assessed 8kg of malt, and produced very high malt extract with good beta glucan levels. As a result of these trials it was recommended that WI-3102 be evaluated on a commercial scale. WI-3102 is currently undergoing Stage 3-4 MBIBTC evaluation and commercial brewing results this year which will enable industry to make a decision on its future release.

Laboratory malt quality analysis of the WI-3102 commercial crop samples (MBIBTC Stage 3-4) confirm the findings of laboratory analysis within the SABIP (since 1996) as well as industry testing (Table 4). Malt extract is high whilst viscosity and WBG is excellent. DP and fermentability (AAL) are low. In the Victorian crops in particular, WI-3102 (samples 5a, 5b, 5c) was on average 3.9 % higher in malt extract than Arapiles and 1.5% higher than sample 4.

Table 4. Malt quality analysis of WI-3102 commercial crop samples from the 2000 harvest

ID	Line	State	DP	AA	Beta	MP	SP	KI	HWE	VISC	FAN	WBG	AAL	FRI
1a	WI3102	SA	466	125	341	11.3	5.2	45.6	82.2	1.63	213	193	78.9	67.5
1b	WI3102	SA	460	123	337	11.0	4.9	44.5	81.8	1.63	182	199	79.2	69.8
1c	WI3102	SA	381	113	268	9.9	4.8	48.4	82.1	1.65	192	193	78.2	78.6
2a	WI3102	SA	406	107	299	9.9	4.7	48.0	80.8	1.59	183	70	79.0	80.5
2b	WI3102	SA	419	120	299	9.9	4.8	48.7	81.4	1.57	180	78	78.0	80.1
3	WI3102	SA	440	127	313	9.7	5.2	52.9	83.6	1.55	224	3	80.7	84.1
4	WI3102	VIC	659	134	525	15.1	6.0	39.5	79.9	1.56	202	130	78.1	47.8
5a	WI3102	VIC	486	139	347	10.8	5.3	49.2	82.1	1.58	219	19	n/a	72.2

5b	WI3102	VIC	343	109	233	10.7	5.6	52.3	82.1	1.60	217	33	78.2	85.3
5c	WI3102	VIC	376	127	249	11.2	6.1	54.0	82.7	1.58	246	3	80.7	86.2
6	Arapiles	VIC	711	102	609	12.2	5.7	46.6	78.4	1.57	228	125	81.2	62.9

Analysis of the skinning, grain colour, grain weight, germination and husk characteristics of the WI-3102 commercial crop samples was also carried out (Table 5). Percent skinning ranged from 4-21% in the SA crop samples. In the Victorian crops, skinning ranged from 16-30%, however this was comparable to Arapiles, which had 18% skinning. Husk contents were varied, but generally lower in the Victorian samples. The husk content of the WI-3102 samples did not differ greatly after the malting process. In the germination analysis, WI-3102 showed no dormancy and low water sensitivity.

Table 5. Skinning percentage, husk content, grain colour, grain weight and germination data for the WI-3102 commercial crop samples

ID	Line	State	% skinning	% grain husk cont	% malt husk cont	L*	1000 grain weight	4ml germ Jan	4ml germ April	8ml germ Jan	8ml germ April
1a	WI3102	SA	17	7.7	7.3	61.8	43.6	100	100	90	99
1b	WI3102	SA	13	7.4	7.5	62.3	43.7	100	100	98	100
1c	WI3102	SA	16	7.1	7.6	59.1	44.2	100	100	96	100
2a	WI3102	SA	5	8.1	8.9	58.4	41.1	100	100	85	99
2b	WI3102	SA	4	9.9	9.2	58.0	41.8	100	100	86	100
3	WI3102	SA	21	7.8	7.8	63.9	51.8	100	100	100	100
4	WI3102	VIC	28	4.5	4.9	60.1	38.7	100	100	97	100
5a	WI3102	VIC	18	6.3	6.7	62.7	45.9	100	100	99	100
5b	WI3102	VIC	16	6.7	6.4	62.5	44.3	100	100	99	100
5c	WI3102	VIC	30	6.8	6.8	61.0	44.8	100	100	100	99
6	Arapiles	VIC	18	7.9	7.6	60.0	40.1	99	100	69	93

Maltsters and brewers have indicated strong interest in WI-3102. A 60 tonne batch of WI-3102 barley commercially grown was recently malted by Adelaide Malting Co. Batch analysis showed very high malt extract, excellent viscosity, good wort beta glucan and low DP. Coopers Brewery subsequently used this malt to produce "Pale Ale" with no obvious processing problems to date (Doug Stewart, personal communication).

WI-3102 crosses

WI 3102 is a very attractive prospect as a parent because of its combination of high malt extract, plump grain, semi-dwarf plant type and CCN resistance. However, it is crucial to know if its malt extract and thin husk are inextricably linked to wrinkled husk, which lowers hectoliter weight and increases the risk of skinning and poor hull adherence. In this study which included 86 selections of the cross WI-3102//Keel/Fitzgerald and 17 selections of the cross Keel/Gairdner//WI3102, a wide range of husk contents (6.3 - 11.7%), skinning percentage (2 - 53%) and IOB malt extract (74.5 - 81.0%) was observed. By grouping selections according to husk type, it was shown that a wrinkled husk led to slightly higher skinning (3% more) and lower husk content (0.4% less) which resulted in 0.25% lower malt extract (Table 6). Furthermore, selections characterized by poor hull adherence, had on average 15% higher skinning, 0.8% lower husk content, and only added 0.6% to malt extract levels. The key finding however is that husk type and husk adherence segregate independently and therefore confirm the findings of Roumeliotis *et al.* that it is possible to breed for varieties with smooth husk, low husk content, good hull adherence and high malt extract. Correlation coefficients between husk content, skinning and malt extract were calculated and the results validate the findings of Collins *et al*. and Roumeliotis *et al.*, namely, there is a significant correlation between either husk content or skinning percentage and malt extract (-0.566, $P<0.001$; 0.304, $P<0.001$, respectively). Furthermore, there was a significant negative correlation (-0.328, $P<001$) found between skinning and husk content, which was also found in the husk study.

Table 6. The effect of husk type (smooth vs wrinkled) and hull adherence on the skinning percentage, husk content and IOB extract in a study of 103 selections from WI 3102 crosses.

Husk trait	Class	Mean % skinning	Mean % husk content	Mean % IOB HWE	Number in each class
Husk type	Wrinkled	15	9.21	78.3	62
	Smooth	12	9.64	78.5	41
	LSD 5%	NS	0.39	NS	
Hull adherence	Excellent	8	9.76	78.2	24
	Good	13	9.41	78.3	55
	Poor	23	8.94	78.8	24
	LSD 5%	3.5[1]	0.47[1]	NS	

[1]LSD refers to comparing the minimum and maximum value. Other comparisons require a different LSD calculation.

Conclusion

WI 3102 was evaluated in small plot studies and from commercial scale crops. The analyses conducted confirm that WI 3102 has considerable potential as a malting barley for the domestic market, in the first instance, because of its combination of high malt extract, low viscosity, moderate diastatic power and low attenuation limit. Farmers and maltsters will have to carefully handle the harvest and processing of WI 3102 as its hull is more prone to damage than traditional Australian varieties like Schooner, although it is similar to other premium malting varieties grown overseas. Finally, the potential of WI 3102 as a parent has been established and it seems possible to breed for varieties with smooth husk, low husk content, good hull adherence and high malt extract.

Acknowledgements

This work acknowledges the support of the Malting Barley Quality Improvement Program, a program including Australian university, state government research investment corporations and foundations and malting and brewing companies. The authors would like to thank the members of the South Australian Barley Improvement Program for their assistance with sample preparation and analysis. Many thanks to Silja Home from VTT Finland for milling energy results and Cassandra Black and Joe Panozzo from VIDA for use of their SKCS. Thanks also to Mark Goldsmith from Carlton and United Breweries and MBIBTC for providing the Stage 2 evaluation report on WI-3102 and Doug Stewart from Adelaide Malting Co for personal communication.

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