The use of NIR spectroscopy to predict husk content and percent skinnings in barley

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Introduction

The characteristics of the husk of barley are important factors for the grain, malting and brewing industries. 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.[1] Malt extract is also one of the most important parameters used by breeders, maltsters and brewers to rate the quality of a new malting variety. High levels of malt extract are desirable and recent research has shown a possible association with low husk content.[2]

There is however a number of potential limitations associated with low husk content. These include an increased tendency for weather damage and pre-harvest sprouting and an increased likelihood of embryo damage. A thinner husk can increase skinning damage 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.[1] Husk content and high skinnings may therefore also cause problems in controlling the germination process during malting, leading to over-modification. Most importantly for the brewing industry, husk is also needed to form the filter bed during lautering and low levels may therefore impact on the brewing process.

Traditional methods of measuring these two parameters are time consuming, destructive and in the case of percent skinnings, based on human observation, which can be subjective. Whole grain NIR spectroscopy can therefore offer the advantage to breeders of high throughput, non-destructive screening.

In this preliminary study, whole grain NIR calibrations were developed to predict husk content and percent skinnings. Implementation of these calibrations will ensure breeders can select for increased malt extract without an associated increase in percent skinning.

Methods

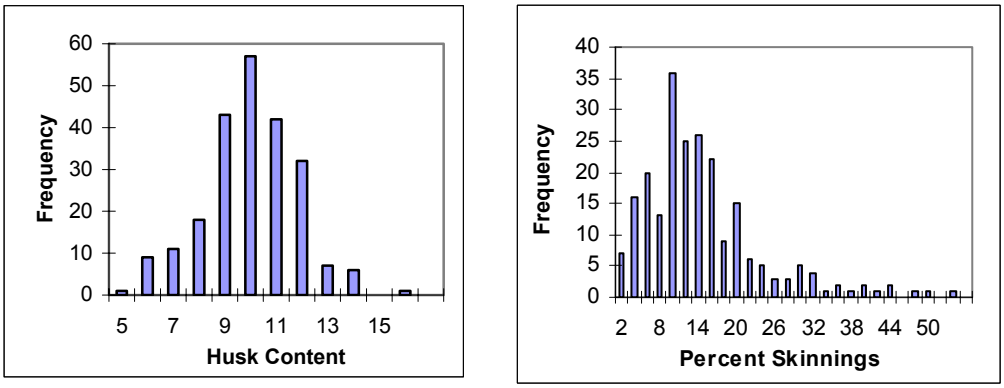
Grain samples

Two hundred and twenty seven barley samples were obtained from a number of early and late generation trials within the South Australian Barley Improvement Program (SABIP). This data set was comprised of:

- 42 samples from the 1999 season Stage 4 breeding trials
- 111 samples from the 2000 season Stage 1 breeding trials
- 74 samples from the 2001 season Stage 4 breeding trials

Varieties were specifically chosen to represent a range of husk contents (5.0–15.1%) and percent skinnings (2–53%) (Figure 1).

Near Infrared Spectroscopy: Proceedings of the 11th International Conference.

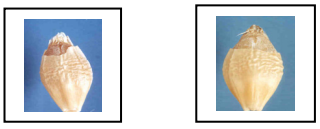


(a) (b)

Figure 1. Frequency distributions of samples within the calibration sets for a) husk content and b) percent skinnings.

Barley quality analysis

Barley samples were screened over a 2.5 mm screen. The husk content of barley was determined using a scaled down version of the standard European Brewery Convention (EBC) method.[3] To assess husk damage, percent skinnings was determined using the Australian Barley Board classification skinning protocol.[4] Figure 2 shows grain, which is sound and non-skinned. Figure 3 shows skinning damage to the protective husk of the barley grain. Any grains with the husk partly or completely removed from the two thirds of the grain closest to the germ end, are counted as skinned. Barley can be classified as skinned if it exhibits characteristics such as awn skinning, split back, pearled, split skirt and either side or back skinning.



Sound Sound

Figure 2. Sound, non-skinned barley grains.

Awn skinning Split back Pearled Split skirt Side skinning Back skinning

Figure 3. Skinned barley grains.

NIR calibration development

A NIRSystems 6500 scanning spectrophotometer in conjunction with WINISI II, Version 1.0 software was used to develop the calibrations. Whole grain barley samples were scanned in duplicate with the second scan being a repack of the first. Spectra were subsequently averaged. Absorbance data was measured in reflectance mode using the whole 400–2500 nm-wavelength range. The modified partial least squares (PLS) regression method was used to develop the calibrations. SNV and detrend scatter correction was applied with a 2, 4, 4, 1 (2 = 2nd derivative, 4 = gap, 4 = smooth, 1 = smooth2) math treatment. Calibrations were validated using cross validation.

Results and discussion

Table 1 shows the results of the calibrations developed for prediction of husk content and percent skinnings in barley, in conjunction with the statistics of cross validation. The calibration for predicted husk content is shown in Figure 4, which gave an encouraging correlation coefficient of 0.857. Figure 5, shows the calibration produced for predicting percent skinnings. The correlation coefficient for this parameter was lower (R = 0.766) but was considered promising, in view of the difficulty associated with the visual reference method. Validation on an independent set of samples has not been carried out. It is anticipated that these calibrations will be tested on samples from the 2002 growing season. Williams[5] suggests that a *RPD* value (ratio of standard deviation to standard error of cross validation) of at least 3.0 would be considered suitable for a calibration to be implemented within a breeding program. The *RPD* values for these calibrations are much lower, however, these may improve by adding to the existing calibration set and through an expansion in distribution and range, particularly for percent skinnings. Figure 1(b) shows there is a need to expand the percent skinnings calibration set with samples from the higher end of the range.

Table 1. Calibration and cross validation statistics, including number of samples (*N*), standard deviation (*SD*), correlation coefficient (*R*), standard error of cross validation (*SECV*) and ratio of *SECV* to *SD* (*RPD*).

Quality Parameter	N	Mean	*SD*	*SEC*	*R*	*SECV*	*RPD*
Husk content	226	9.7	1.75	0.71	0.857	0.93	1.9
Percent skinnings	221	14.0	8.3	4.88	0.766	5.33	1.6

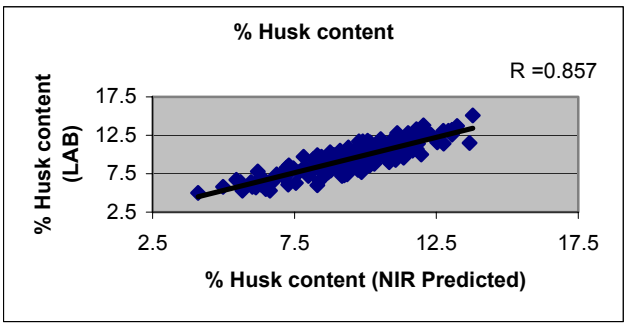


Figure 4. Scatter plot of NIR predicted % husk content v laboratory determined % husk content.

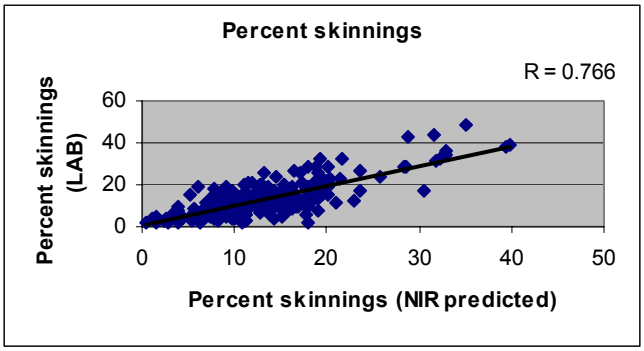


Figure 5. Scatter plot of NIR predicted percent skinnings v laboratory determined percent skinnings.

Conclusion

NIR prediction has made substantial progress as a tool for early generation screening. In the SABIP in particular, where malt quality whole grain NIR calibrations have been employed since 1996, it allows a further 8,000 samples to be screened per season, that would otherwise only be tested for agronomic parameters. Whole grain NIR calibrations to predict husk content and percent skinnings have now also been developed and show considerable promise. After calibration expansion and further validation it is expected that these calibrations will also be implemented into the SABIP.

The ability to predict husk content and percent skinnings in combination with important malt quality parameters such as malt extract offers a great advantage to barley breeders. High throughput, non-destructive screening of early generation samples will ensure that breeders can select for varieties with low husk content and high malt extract but without the possible associated detrimental increase in percent skinnings.

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 also like to thank the members of the South Australian Barley Improvement Program for their assistance with sample preparation and analysis.

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