Development of barley varieties and processing techniques for improved performance in Asian and other food markets

Summary

Pearling and Single Kernel Characterisation System (SKCS) analysis of barley quality for the Japanese food market revealed that hard types tend to produce higher sound kernel ratios after pearling than soft malting lines. Schooner is preferred by shochu manufacturers for its pearling quality. No new malting lines exceeded Schooner for pearling quality when grown in South Australia. The key environmental impact on pearling quality is grain filling conditions. Targeted breeding and selection for shochu quality are required to maintain current market share and premiums.

Large scale malting and brewing of Torrens® hulless barley provided a positive outcome to brewers.

Hulless waxy germplasm shows promise for flat breads, rolled barley and noodles with strong interest shown from food companies.

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Conclusions
Fundamental research to examine the potential for soft grain types in pearling applications is required. Analysis of Victorian Department of Primary Industries (VicDPI) and University of Adelaide (UA) germplasm has suggested that selection for malting quality favours soft grain types, however little work has been undertaken to assess optimisation of the pearling process for these barley types.

Hulless barley with waxy or high amylose starch offers new opportunities in food applications that could be developed into high value marketing options for Australian growers. Initial small scale product development and assessment of potential health benefits have been completed. Efforts in the development and commercialisation of waxy hulless barley are well advanced. High amylose barley offers greater commercial potential, however further effort in breeding and product development is required.

Recommendations
Strategic investment in developing the selection tools and genetic knowledge to pursue food opportunities for barley should be continued.

Relationships with key Japanese companies should be formalised to drive market focussed research and development (R&D) efforts in pearling and shochu manufacturing in conjunction with current breeding efforts.

Outcomes
Pearling applications for barley, in particular shochu production, currently provide growers in southern Australia with a high value marketing option for Schooner and Stirling crops. The current project has contributed to understanding the environmental and agronomic factors that impact on pearling quality. This has resulted in a range of communication and extension activities for growers aiming to meet the demanding quality specifications required by the market.

Extensive analysis of pearling quality of mainstream breeding lines has questioned the potential for standard barley breeding to deliver varieties suitable for the premium shochu market. Advanced breeding lines and new varieties are unlikely to replace Schooner barley as the preferred variety for shochu production, even though the agronomic and malting quality of new varieties is likely to drive a replacement of established barley varieties grown in southern Australia. Significant interest
from key Japanese companies suggests there is an opportunity to develop commercially focused R&D to support the development of varieties suited to the shochu market which has been dominated by Australian barley but is now the subject of intense pressure by the Canadian Grains Commission.

The current project has also provided specific quality evaluation and small scale product development for a range of food applications for hulless barley. There is significant interest from a range of food processing companies in utilising the health benefits of hulless waxy barley by incorporation into new and existing food products. Barley biscuits, flat bread, and rolled barley were produced to a commercial standard for a human food trial to determine the glycemic index (GI) of waxy barley products. Waxy barley lines developed by the UA Barley Program with the support of this project are approaching commercial release. Larger scale product development will continue in collaboration with food companies, and successful results are expected to provide growers with a high value niche production opportunity.

Commercial opportunities for barley in food products are rapidly growing. The health claims for barley beta-glucan have now been recognised in the US by the Food and Drug Administration (FDA). Glycemic index (GI) is now used in marketing food products in Australia, with the first low GI white breads launched in 2006. Hulless barley with the high amylose starch type is ideally suited to this application. The current project has optimised testing methods for high amylose, characterised exotic germplasm, and supported the development of molecular markers. The UA Barley Program has developed high amylose germplasm with superior grain size and agronomic profiles to alternative materials.

Establishment of significant hulless barley production could support adoption by the brewing industry. The current project has coordinated plant scale malting and brewing trials demonstrating major benefits in conjunction with mash filtration.

Achievements/Benefits

Australia currently exports approximately 200,000 tonnes per annum of barley to the Japanese staple food market, mostly for shochu manufacture. This project has aimed to build on the successful strategy of industry partnerships pioneered in the malting sector, to develop a comprehensive strategy to direct, fund and manage research in breeding, quality testing, agronomy and market development aimed at improving shochu barley for southern Australia. The market for pearling and shochu manufacturing in Japan is very profitable (prices exceed malting prices) and growing at 4-5% per annum. To capitalise on these opportunities and ensure the viability of the barley industry outside of the malting and brewing sector, rapid progress with the breeding, agronomy, end use characterisation and market development of shochu barley varieties must be achieved. Both desirable and undesirable qualities have been identified by the South Australian Barley Improvement Program (Project UA453) in the current export varieties for this market. Recently, ABB Grain and Grain Pool Western Australia formed a marketing alliance named ‘Grain Australia’ which will negotiate deals for the Japanese shochu market. Currently, Schooner from SA, Victoria and New South Wales and Stirling barley from WA (50% Schooner:50% Stirling) are sourced for the majority of this market. The bulk of market grade Schooner barley is sourced from the Eyre Peninsula in SA. Grain Australia currently supplies Japan with 70-80% of shochu grade barley with GrainCorp making up the remainder. Results obtained from project UA453 in conjunction with Japanese collaborators (Sanwa Shurui laboratories and Takenouchi grain processors) using pearling and SKCS tests, have shown that these varieties differ with respect to processing characteristics and that the environment in which they are grown significantly affects the final grain quality. A greater understanding of these differences is required to produce higher quality varieties that exhibit optimum pearling characteristics. New lines from Stage 3 and 4 breeding populations, including WA and VIC breeders’ lines and collaborative trial lines (i.e. lines from all states) using pearling and SKCS tests were screened with the intention of providing potential new lines for varietal selection.

Since beginning shochu research in 2000, significant achievements have been made in understanding barley quality required for this product. This and the previous project UA453 identified the Perten Single Kernel Characterisation System as a useful tool for predicting barley hardness. This in turn has been correlated with pearling quality. These results have also been confirmed by other researchers in Australia and Japan. The SKCS has been a useful tool enabling the breeding program to select germplasm most suitable for pearling, thus reducing the large numbers of lines to be tested. ABB Grain and Grain Pool WA have also benefited from this tool by using it as a rapid screen for export samples. A near infrared (NIR) calibration has subsequently been developed to assess grain hardness.

In general, barley that is soft (below 50 hardness points) will tend to break during the pearling process, resulting in fines and broken kernels. This contributes to significant losses to the barley processors and in turn the shochu manufacturers who purchase this processed grain. Barley that is hard (above 55 hardness points) tends to produce fewer broken kernels, but this is highly dependent on variety. The range of barley hardness within a sample (the hardness standard deviation) is a good
indication of the uniformity of a sample. A soft barley with a high standard deviation will tend to pearl poorly with low yields and a high percentage of broken kernels. Harder barleys cope better with high standard deviations, however high uniformity is important so that pearl rate is consistent across a sample and individual pearled grains are of a similar size. This is important for the shochu process as this allows uniform penetration of the Aspergillus kawachii mould into the steamed pearled grain. It also allows a uniform steaming rate.

Since 2000, five years of pearl and SKCS data have been collected using Stage 3 and Stage 4 material over numerous South Australian sites. This data set has provided insight into the genetic and environmental influences that affect pearl quality and shochu quality. Environments that produce good quality malt grade barley will produce good quality shochu grade barley. Rainfall at harvest time tends to have a deleterious effect on pearl quality. Important information regarding environmental effects could be further obtained from this data set, however time does not permit this. The approach taken to screen current lines in the SA barley breeding program has failed to identify a replacement for Schooner. Schooner from SA is still favoured by Japanese shochu manufacturers for its flavour and processing characteristics, however its variability for pearl quality over diverse sites and environments creates problems for the pearl processors which leads to complaints and downgrading. Schooner is gradually being replaced by newer malt varieties as favoured by growers. The Canadian Grain Commission has adopted an aggressive approach to try to introduce Canadian varieties into the shochu market.

Stage 3 and 4 trials entries from 1999-2002 from up to four SA sites were analysed using SKCS and pearl tests. ABB Grain Ltd and Japanese processors agree that SKCS hardness is a useful indicator of pearl and shochu quality, as supported by previous research (GRDC project UA453). Discussions with Japanese processors indicate that flavour may be linked to fermentation profiles relating to koji enzyme activity. The flavour differences between Schooner and Stirling may purely relate to their respective hardness. Therefore, hardness is still the preferred selection criteria for Japanese processors. To date, the WA variety Baudina, the VIC breeders’ line VB9935 and the magnesium (Mn) efficient Waite breeding line WI3297 have been identified as promising candidates for shochu evaluation. However, Schooner from SA maritime environments still appears to be the best overall performer for shochu quality.

Over 270 whole grain samples from 1998-2002 were scanned on a NIR Systems 6500 spectrophotometer, in order to determine an NIR calibration for hardness. A calibration for hardness (based on these samples) could not be determined that would accurately predict hardness over a number of seasons. A calibration set based on Schooner alone may be useful for screening Schooner samples at the silo.

AusMalt performed large-scale malting of 52 tonnes of Torrens A hulless barley from 2001 for brewing trials at Coopers Brewery in 2003. Extract brews containing 30% and 50% of Torrens malt were performed. The control plus hulless blend displayed an improvement in brewhouse yield over control batches although the yield was not as high as expected mainly due to high protein levels. Modification values were also satisfactory. Due to the drought in 2002, significant quantities of Torrens barley were not available for malting.

27 populations from the hulless breeding program were tested for waxiness and 450 lines were tested for amylose concentration. Five kilograms of elite waxy lines were sent to Westons Technologies and the Bread Research Institute (BRI) for food analysis. Elite waxy lines and controls were also assessed for oil content before and after pearl.

Other research
Other significant R&D opportunities identified;

1. Tocotrienols and tocopherols were shown to be present at high levels in hulless barley, potentially offering an alternative source of antioxidant compounds for use in cosmetic and nutraceutical products. Interest has been expressed by cosmetic company, Jurlique, in examining the commercial viability of barley as a source of vitamin E.

2. A number of companies are now involved in the commercial production of beta-glucan preparations. The very high levels of long chain beta-glucan present in the waxy and high amylose barley lines potentially offer an inexpensive source material.

3. The establishment of a number of Scotch whiskey distilleries offers potential for hulless barley.

4. There is potential to develop barley varieties optimised for processing in ethanol production.

Intellectual property summary
Mapping data and associated molecular markers for hulless, waxy starch, and high amylose starch have been made freely available to the Australian research and breeding community through the Australian Winter Cereals Molecular Marker Program (AWCMMP) Intellectual Property (IP) register and blackboard system.

Additional information


Washington JM and Box AJ (2004). Variability of Oil Content in By-Products of Australian Barley, 9th International Barley Genetics Symposium, Brno, Czech Republic