PEARLING AND SKCS ANALYSIS OF AUSTRALIAN BARLEY FOR THE ASIAN FOOD MARKET.

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INTRODUCTION

Australian barley sold to the Asian food market (apart from malt) is mainly pearled for use either as a rice extender, in the production of miso paste or for the Japanese spirit, shochu. The shochu market is the most profitable of the Asian staple foods to Australian barley producers. Barley that meets shochu grade will suit the majority of Asian food market requirements. Pearling quality is of greatest importance to buyers of shochu quality barley. Measurements of pearling quality using a small-scale pearler are laborious and qualitative. The Single Kernel Characterisation System from Perten Instruments has been under investigation, to quantitatively measure barley uniformity and determine its usefulness in predicting pearling quality. Previously, we found that SKCS could be used to predict pearling yield, screenings less than 2.0mm and broken kernels (Washington *et. al*., 2001). Since these findings were based on a two-year study only, Pearling and SKCS analysis was performed over four years to validate the use of SKCS as a predictor of pearling quality. The diverse climate and soil types unique to South Australia have enabled a thorough investigation of grain quality for the shochu market.

South Australia and Western Australia currently export Schooner (SA) and Stirling (WA) to Japan for shochu. Each variety provides unique properties desirable to shochu manufacturers. However, there is a need to investigate the quality of other varieties and breeding lines in order to select grain that provides consistent uniformity over diverse environmental conditions. A calibration to predict hardness using Near Infrared (NIR) Spectroscopy was investigated as a useful rapid screening tool at the silo. In this paper we discuss the environmental conditions, varieties and breeding lines most suitable for production of premium shochu grade barley.

MATERIALS AND METHODS

Up to 8 types of barley (breeding lines and varieties) grown at 4 different SA sites during 1999-2002, and Schooner grown at 20 sites during 1999-2002 were tested for grain hardness, moisture, weight and diameter using two (Perten Instruments) SKCS 4100 machines, situated at BRI Australia Ltd, North Ryde NSW and ABB Grain Ltd, Adelaide, SA. Duplicate samples, were pearled on two different Satake, small-scale pearling machines (owned by ABB Grain Ltd and University of Adelaide, SA), using a procedure previously described in Washington *et al*, 2001. Pearling machines were set at 1150rpm, the grit size of the wheel used was either #30 (old machine) or #36 (new machine) and samples were pearled for 6 (old machine) or 7mins (new machine).

Whole grain β-glucan, as % dry weight, was determined using the Megazyme β-glucan enzyme kit (McCleary method). Whole grain protein was determined by NIR.

A total of 272 samples were scanned on a NIRSystems 6500 spectrophotometer with calibrations developed using WINISI software. Whole grain barley samples were scanned in duplicate and the spectra subsequently averaged. Samples were specifically chosen to represent a wide range of environments and genotypes over a number of seasons (1998-2001). Statistical analysis was performed by Biometrics SA.

RESULTS AND DISCUSSION

Comparison of SKCS and pearling machines

By necessity, samples were analysed using two different Satake machines and two different SKCS Instruments. Therefore it was important to compare a data set on all machines and correct for any differences between them. Good correlations were found between the two pearling machines (R^2 for pearled broken kernels%=0.79, pearling yield% (pyield%)=0.75, pearled screenings<2.0%=0.68, n=12). However, the wheel grit size and pearling time needed adjustment on the new machine to account for wear and tear on the old wheel. 21 duplicate grain samples were tested on the two SKCS Instruments. SKCS data for hardness was highly correlated (R^2=0.98). Statistical adjustments were made when comparing data.

Using SKCS as a tool for predicting pearling quality

Data obtained from Schooner samples (2 reps, 4 years, 20 sites n=168) showed a number of correlations between pearling characteristics and SKCS hardness (hard) (Figure 1) i.e. pyield%, <2.0mm% (tsc) and broken% (tbrok). Correlations were also found between pyield% and <2.0mm% as well as pyield% and broken%. An expected correlation was found between SKCS weight (wt) and diameter (diam). Whole grain protein and β-glucan (bbg) content were not correlated with any trait except each other (not shown). All correlations take into account that two different SKCS and pearling machines were used to analyse the data.

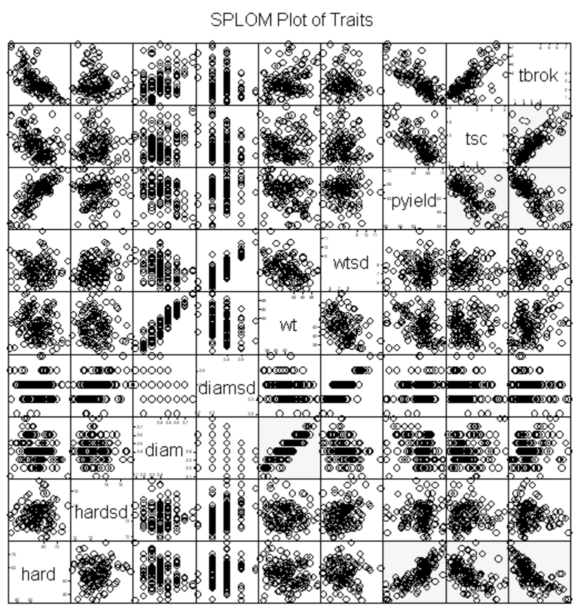

Figure 1. Scatter-plots of SKCS and pearling traits (Schooner samples)

Standard deviations (sd) for all SKCS traits were not correlated with any of the pearling traits. Therefore average hardness is a better indicator of pearling quality than variation in hardness or size within a sample. Previously, we found that the coefficient of variation for hardness, "Hard CV", was highly correlated with pearling quality (Washington *et al*, 2001). This was determined using two varieties (Schooner and Sloop) that exhibited either good or poor pearling quality, combined with good or poor uniformity of hardness. When looking at extremes in pearling or SKCS uniformity data it is easy to find correlations for these parameters. At the silo, only a single variety will be tested and pooled. Therefore, it is more important to select for grain of similar size and hardness when pooling, than to be concerned about individual sample uniformity.

Pearling quality and Environment
Schooner from 20 sites and 5 varieties from 3 sites produced exceptional quality grain in the year 2000 i.e. high hardness and pearling yield and low screenings <2.0mm and broken kernels (Figure 2a). This may be explained by the fact that seeding commenced early at optimal conditions in 2000 and lower rainfall was recorded at harvest time (Nov-Dec) (Figure 2b) compared to the other three years. No significant correlations were found for SKCS hardness and growing season rainfall data (Data not shown). However, a small but significant correlation ($p<0.006$) was found for hardness standard deviation and rainfall for Sept-Oct and September rainfall ($p<0.02$) (averaged over 4 years). Only Schooner data is shown for brevity, all other variety data showed the same trends.

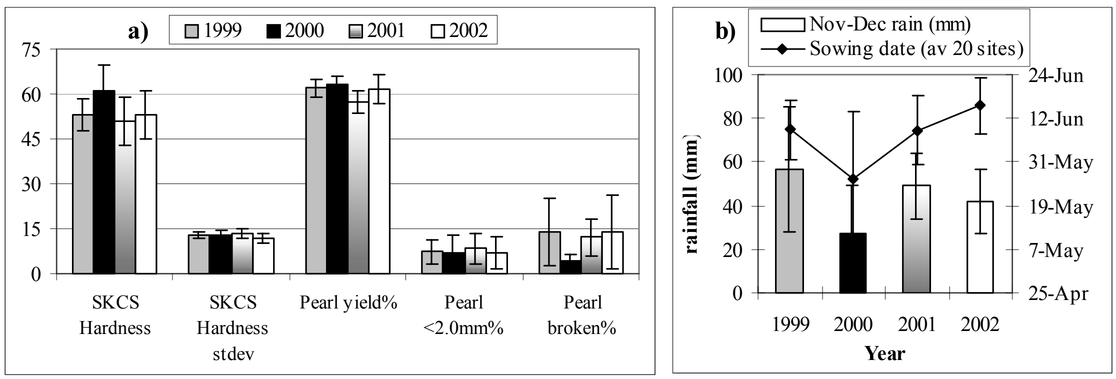

Figure 2. (a) Average SKCS hardness & standard deviation and pearling quality for 1999-2002 seasons. (Schooner, 2 reps averaged over 20 sites). (b) Average time of sowing and mean November-December rainfall over 20 sites.

Varietal differences
PCA analysis of 8 genotypes also showed correlations between SKCS hardness and pearling quality (Figure 3a). A positive correlation was found between “hard”, “pyield” and “bbg” and a negative correlation between “hard” and “broken", screenings <2.0mm% (X2mm) and grain weight (wt). The numbers on the BiPlot identify a single genotype, year and site. Samples exhibiting good pearling quality (e.g. Franklin, Schooner, Torrens) sit to the right of the BiPlot and poor quality samples sit to the left (e.g. Sloop, SloopSA).

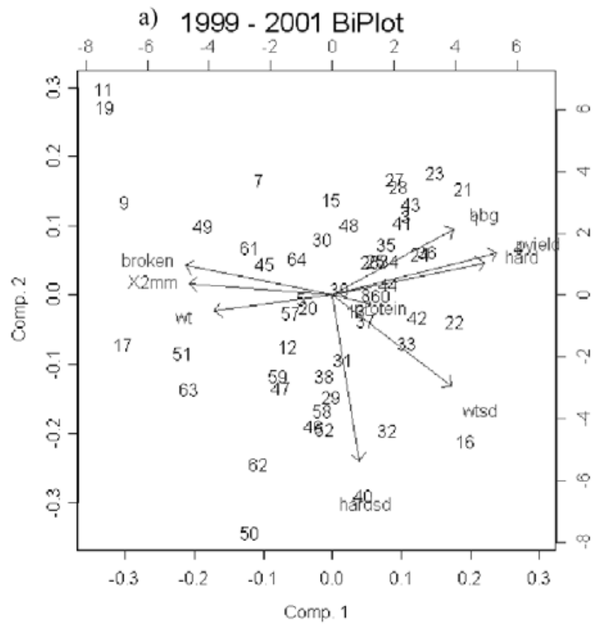

Figure 3. (a) 1999-2001 BiPlot showing PCA analysis of pearling quality, SKCS traits, grain protein and β-glucan for 8 genotypes of barley over 4 years and 4 sites (average of 2 reps).

The BiPlot for 2002 (Figure 3b) was considered separately because a number of new varieties/breeding lines were tested that year and compared against Schooner. The negative association between "hard" and "broken" and "X2mm" remained. Quality traits were more affected by environment than genotype as shown by site groupings i.e. Mundulla (high protein, poor quality), Brentwood/Wanilla (good quality), Salters springs (poor quality).

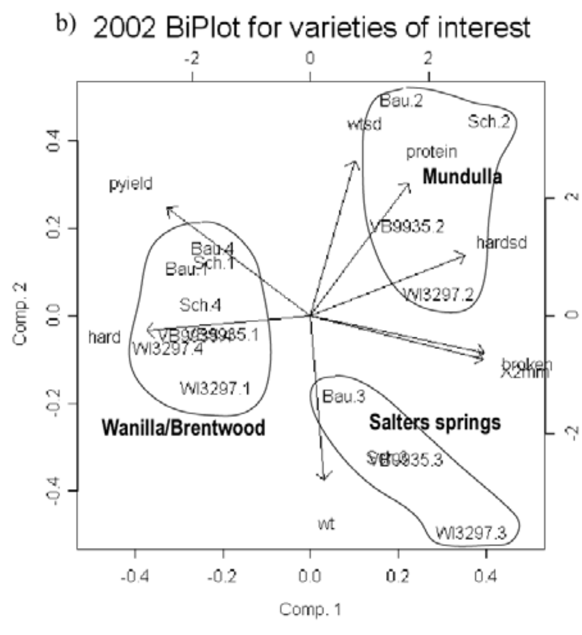

Figure 3. (b) 2002 BiPlot of high quality pearling genotypes over 4 sites showing PCA analysis of pearling, SKCS and grain quality traits.

Bau = Baudin (new WA variety), Sch = Schooner, VB9935 = Victorian breeders line, WI3297 = Waite breeding line (Mn efficient). Numbers refer to site.

The new WA variety Baudin, the Victorian breeders line VB9935 and the Mn-efficient SA-breeders line WI3297 all showed promising results for pearling and SKCS quality, but not a significant improvement over Schooner. Interestingly, both Baudin and WI3297, were both hard types (6.2 and 9.5 hardness points above Schooner respectively when averaged over 4 sites for 2002), but this did not seem to offer any greater advantage over Schooner. However, these varieties could potentially replace Schooner without loss of pearling quality as Schooner is declining in popularity and they offer some agronomic advantages.

NIR results

Calibrations were developed for the prediction of hardness, in conjunction with the statistics of cross validation (Table 1). The best calibrations were those generated when samples were separated by season. A correlation coefficient of (R^2=0.986) was obtained with a RPD (ratio of standard deviation to standard error of cross validation) value of 5.0 from a calibration developed using samples from the 1999 season. A RPD value of at least 3.0 is considered suitable for a calibration to be implemented within a breeding program (Williams, 2001). The 1999 calibration was used to try and predict hardness results from the 2000 and 2001 season samples. Although samples from the 2001 season could be predicted (R^2=0.660, N=116), this calibration had difficulty in predicting 2000 season samples (R^2=0.063, N=50).

Table 1. Calibration and cross validation statistics for NIR calibrations developed for hardness prediction.

Calibration	N	Mean	SD	SEC	R^2	SECV	RPD
1999season	32	48.96	13.93	1.67	0.986	2.74	5.0
2000season	48	58.84	8.35	2.92	0.877	4.86	1.7
2001season	116	51.96	8.97	2.31	0.933	3.48	2.6
99-01seasons	192	53.65	9.96	4.00	0.838	4.50	2.2

CONCLUSION

SKCS proved to be a useful tool for predicting pearling quality of barley. An NIR calibration for hardness could not accurately predict hardness over several seasons.

Agronomic and climatic factors greatly influence grain hardness. Late rain (around harvest time) and sub-optimal seeding conditions appear to have a detrimental effect on grain hardness and pearling quality. Other factors such as foliar disease can also reduce grain quality. Schooner proved to be one of the best over-all performers for maintaining pearling quality over a diverse range of environmental conditions, however, under stress could not meet adequate pearling quality for the Japanese shochu market. Stirling, from WA, has also proved to be a high quality pearling grain, however due its poor adaptation in SA, it was not included in trial sites and could not be directly compared to the varieties tested here.

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