Foreword

The core activity of Rice Quality V is the assessment of breeding lines for various physical and chemical quality traits at different generations of the breeding program. This work culminates with the release of new Australian rice varieties such as Sherpa. The comprehensive development of breeding lines that includes both agronomic and quality benefits ensures that all sectors of the rice marketing value chain involved in the production and supply of rice from the growers to grain processors to marketers will be profitable and sustainable.

All operating funding for the project was received from RIRDC excluding travel costs for international travel. Travel costs to international conferences, were supplemented by a Young Researcher Travel Scholarship from the RACI Cereal Chemistry Downunder and a Travel Grant from the EH Graham Centre. Inkind contributions were received from SunRice in conducting some analyses and in provision of market advice is gratefully acknowledged.

This report is an addition to RIRDC’s diverse range of over 2000 research publications and it forms part of our Rice R&D program, which aims to develop a better understanding of the basis of rice quality to aid variety selection and to maintain quality in the light of climate change.

Most of RIRDC’s publications are available for viewing, free downloading or purchasing online at www.rirdc.gov.au. Purchases can also be made by phoning 1300 634 313.

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About the Author

After graduating in 1998 with a Bachelor of Science (Hons) from The University of Sydney, Dr Rachelle Ward worked in the pharmaceutical industry for several years before joining NSW Agriculture as a Technical Officer in the Rice Cereal Chemistry laboratory in 2001. During this period she undertook post graduate studies at The University of Sydney and spent some time at IRRI conducting her research. In 2007, Rachelle was awarded a PhD on her thesis titled ‘Impact of temperature and carbon dioxide on rice grain quality’. Rachelle commenced duties as Rice Cereal Chemist with Industry and Investment NSW at Yanco in January 2008.

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Abbreviations

AOAC  Association of Official Analytical Chemists

HRY  Head Rice Yield or Millout measured as the proportion of whole grain retrieved following the rice milling process.

I&I NSW  Industry & Investment NSW

INQR  International Network for Rice Quality

MAS  Marker Assisted Selection

NIRS  Near InfraRed Spectroscopy

RPD  Ratio of Standard Error of Prediction to Sample Standard Deviation

RRAPL  Rice Research Australia Pty Ltd

QEP  Quality Evaluation Program
Executive Summary

What the report is about

Provision of rice varieties with superior quality attributes and a ready market is the basic necessity for the continued sustainability of Australian rice growers and the overall rice industry. Project Rice Quality V runs parallel with Project Rice Improvement III to ensure that released varieties such as Sherpa have both the grain quality and agronomic performance that will enable the approximately 4000 rice growers in the Murrumbidgee, Coleambally and Murray Irrigation Areas to be productive, have market entry and be able to command competitive process for their produce.

This report is structured according to the original objectives of Rice Quality V. Chapter 1 reports on the routine Quality Evaluation Program (QEP) and associated non-research activities that have improved the flow of samples throughout the QEP. Chapter 2 summarises, research activities related directly to the QEP that have the real potential to facilitate earlier and more comprehensive decision making such as evaluation of molecular markers. Chapters 3-6 highlight adjunct research that expands knowledge into contemporary rice quality issues that can help focus on interactions that may indentify new rice varieties with specific quality traits. Chapter 7 reports on activities undertaken and milestones reported on throughout the duration of Rice Quality V that pertains to the public awareness of the program.

Who is the report targeted at?

The report provides information for the wider rice community on the work conducted to identify rice crossbreds with appropriate qualities for particular markets. The audiences for the Farmers Newsletter and scientific papers are more technical, and this report offers the opportunity to impart the knowledge to a broader audience. The report also documents for posterity the advancements made so that future rice quality teams do not duplicate the work done.

Where are the relevant industries located in Australia?

The Australian rice industry is currently centred in the Murrumbidgee, Coleambally and Murray Irrigation Areas of southern NSW. There has been recent interest coming from northern Australia particularly tropical and sub-tropical Australia. In New South Wales, there are approximately 4000 rice growers and production during this project has ranged from 19,000 tonnes in 2007/08 to 700,000 tonnes in 2010/11.

The beneficiaries of the research are the rice producers who can be assured that any new rice variety has the intrinsic qualities suitable for target markets.

Background

Reduced rice production levels in recent years prompted a period of intense reflection on the options available to effectively streamline the Quality Evaluation Program without compromising, and in some respects improve, the quality of the crossbred assessment processes.

The ideal window to perform the Quality Evaluation Program is 6 weeks after harvest and prior to sowing in October. Milling typically begins in mid May or early June and results of all subsequent quality analyses completed and delivered to breeders by late January. Care has been taken to identify bottlenecks in the process and to minimise sample handling through better planning with breeders, tactical employment of casual staff, improved sample management and reduced sample preparation.
**Aims/objectives**

There were 3 core objectives of Rice Quality V:
(a) Perform the routine Quality Evaluation Program in a timely manner.
(b) Continue to improve the efficiency, accuracy and cost of the Quality Evaluation Program
(c) Continue to conduct research that compliments and develops the scope of the Quality Evaluation Program.

The purpose of these objectives was to broaden the scope of the Quality Evaluation Program, speed the delivery of data to breeders and to revise existing facilities, data management and equipment to minimise potential sources of error in the accumulation of data. Over time, these efficiencies will allow better decision making by the rice breeders and ultimately the release of better varieties in more regular intervals.

**Methods used**

Methods used in Rice Quality V form the basis of our Quality Management System and form part of the ISO 9001 accreditation of the I&I NSW cereal chemistry laboratories.

**Results/key findings**

The main outcome of the project is the accurate and efficient delivery of quality data to rice breeders to enable better selections. Examples of improvements include
- the evaluation of five new analytical techniques to either replace or add to the pool of grain quality assessments that can be adopted at short row and plot stage
- retrofitting existing cold storage to minimise storage induced changes to grain qualities,
- updating software and computers to minimise data entry and thus error, and
- the restructuring of sample management between the rice breeding section and rice quality laboratory.

In 2011, these improvements contributed to the release of a new variety. On March 2 2011, Sherpa was released at the Rice Field Day at Yanco Agricultural Institute. Sherpa has a similar rice quality to Amaroo and can fulfil existing medium grain markets but has superior agronomic performance with a higher degree of cold tolerance. The faster maturity of Sherpa will improve water usage.

**Implications for relevant stakeholders**

The Australian rice industry will directly benefit from the release of Sherpa rice as a new medium grain variety with quality that will supplement its agronomic and cold tolerance advantages.

The benefits from the efficiency improvements made to the Quality Evaluation Program and additional data it will generate will continue as a legacy of Rice Quality V in the future development of improved rice varieties.

In this way the rice improvement – rice quality team contributes to productivity growth in the industry to underpin a competitive industry and strong rural communities.
Recommendations

- That the Rice Quality Evaluation Program continue to be supported by RIRDC and the rice industry to ensure all new rice varieties released have qualities suitable for market that augment their agronomic improvements.

- Consideration be given to capital expenditure to purchase a SeedCount to replace the Cervitec and provide an objective measure of physical grain qualities.

- Investigate improvements to noise levels in mill room.

- Investigate the masking of lipids to better estimate amylose content in brown rice.

- Fully adopt NIRS to measure protein content.

- Validate the fgr marker for fragrance.

- Continue to evaluate the quality of grain produced in northern Australia to ensure compatibility with market specifications.

- That the research team be supported to attend national and international conferences to communicate research conducted and learn from others better (cheaper, easier, quicker) ways of conducting quality assessments.
Introduction

Background to the project

Rice Quality V is the latest project that has focused over 15 years research towards the provision of rice quality data on breeding lines. Throughout the establishment of Rice Quality programs, over 10 varieties have been released including Sherpa which was released during Rice Quality V. Evaluating rice quality involves the ongoing maintenance and establishment of infrastructure and tools that provide the Yield Stability and Rice Improvement Programs with better decision-making options to select for more refined quality types.

The routine crossbred assessment component of Rice Quality V provided the Yield Stability and Rice Improvement Programs with data on the physical and cooking qualities of rice at various stages of the breeding program. The research component of rice quality during Rice Quality V has focused on small projects that were designed to revise existing methodologies to fast track sample throughput while improving on the accuracy of the data.
Objectives

The Project Objectives of Rice Quality V were:

(a) Perform the routine Quality Evaluation Program (QEP) in a timely manner.
The Quality Evaluation Program involves the measurement of physical and cooking attributes of crossbred breeding lines. Each year, the Program:

- screens around 4000 lines for parameters that have significant industry benefits:
  - mill out (or HRY) - measures the propensity to cracking and therefore influences returns to SunRice;
  - grain dimensions - determine the likely market segment (medium grain or long grain);
  - chalk content and grain colour - attributes influencing price.
- analyses approx 400 lines for gelatinisation temperature and CTm, and 300 lines for viscosity and amylose content - which are predictors of cooking quality and hence market position. CTm refers to a DNA repeat sequence that in the I&I NSW program’s germplasm is a good indicator of cooking quality and potential market segment.
- maintains the ISO 9001 accreditation it first received in 2006.

Currently QEP activities require 510 days of labour; however with the proposed efficiencies outlined below for the QEP, the labour input should be significantly reduced.

(b) Continue to improve the efficiency, accuracy and cost of the Quality Evaluation Program

(i) Physical Properties. Mill out is an important industry parameter that influences profitability. It is an essential selection parameter that is currently done at around F6 stage when sample size constraints can be met. The ability to predict mill out on brown grain, instead of white grain would improve screening efficiency by reducing the number of samples that require actual milling. The purchase of the Cervitec Grain Inspector has enabled the chalk, length and width measurements to be measured simultaneously by one operator. In the lifetime of this proposal, through collaborations with the manufacturer and the International Network for Rice Quality (INQR) we will extend the capacity of the Cervitec instrument to include grain cracking on long grain and translucency on all grains.

We will use this new grain cracking application to predict mill out by screening brown grain and correlate the data with mill out obtained from current white grain measurements. This knowledge will allow us to potentially predict mill out in early generation crosses (~F4 stage) by screening a small sample of brown grain. This study will capitalise on the data obtained through the routine Quality Evaluation at very modest additional cost (each year, 3 weeks of labour to screen brown rice grain prior to milling and data analysis).

(ii) Method Development. Another manner in which timeliness of data will be improved is by Near Infrared Spectroscopy (NIRS) to predict cooking quality. About half the effort and expense in QEP is involved in conducting chemical analyses to predict cooking qualities. NIRS is a means of rapidly and simultaneously measuring quality parameters in grain. It should therefore be possible to measure amylose content and possibly viscosity and develop a quick and rapid screen for some cooking quality parameters. We aim to investigate the option of correlating NIRS spectra with cooking qualities (amylose and viscosity) on breeding lines analysed as part of QEP. This component of Rice Quality V will involve collaboration with Brian Dunn (Precision Agriculture). Depending on the initial evaluation of using NIRS, we will expand the trial to include gelatinisation temperature, nitrogen content and moisture content. It is expected this work will be completed in a short time frame with the main requirement being several days for sample preparation.
(c) Continue to conduct research that compliments and develops the scope of the Quality Evaluation Program.

(i) Molecular Assisted Screening. As technology and knowledge improves, the range of molecular markers for different quality and agronomic traits will expand. Budget constraints will preclude serious implementation of new markers however we will endeavour to keep abreast of literature. We will also monitor the data generated from the Quality Evaluation Program for potential linkages between phenotype and genotype to exploit the germplasm for further candidate markers to include in our MAS, for example, grain cracking traits.
Methodology

The general methodology of cereal chemistry can be summarised as in the box below. It is imperative to realise that there is not a direct link between synthesis and function. Several studies have linked synthesis data (e.g., Molecular Assisted Selection (MAS)) directly to functional properties of rice and arrived at incorrect conclusions. The methods used in the Quality Evaluation Program (QEP) are documented as part of the Quality Management System which underpins ISO9001 accreditation.

<table>
<thead>
<tr>
<th>Synthesis (or, Genetic Makeup) ↔</th>
<th>Structure (Grain components) ↔</th>
<th>Function (Functional Quality)</th>
</tr>
</thead>
</table>

Under ISO 9001 accreditation and within each of the three components above, the Rice Chemistry Team is capable of successfully performing a wide range of experimental methodologies. There is a Standard Operating Procedure (SOP) and associated risk assessment (SWMS) for each of the methods used on a routine basis. During research, the SOPs and SWMSs are used as a guide. The projects of Rice Quality V utilise a large selection of the methods noted below.

**Synthesis.** The synthesis component of the equation refers to the processes from gene through to enzyme. We have the capacity to perform Molecular Assisted Screening on breeding lines, and have been screening breeding lines for CT repeat sequence for several years to estimate amylose content and potential cooking class. We also have the opportunity to use the sequencer (CEQ 8000) at I&I NSW in Wagga Wagga to conduct further detailed genetic sequence studies on our breeding lines and research for the development of additional markers. We have the capacity to extract proteins and separate the enzymes on a protein gel so we can compare the DNA to the protein transcribed by the DNA.

**Structure.** The grain dimension is measured by a combination of Cervitec and 1000-grain weight. Colour is measured with a spectrophotometer (Gardner). Grain cracking is also a structural parameter measured by the Cervitec (medium grain only) and the Grain Spec. A rice grain is composed of ~90% starch (we measure amylose by iodine), ~8% protein (outsourced and measured by NIR or LECO) and ~1% lipids (literature). The structure of starch is measured by Size Exclusion Chromatography (SEC). Proteins are analysed the same way as enzymes (above). Proteins could also be measured on our high Performance Liquid Chromatograph (HPLC).

**Function.** The functionality of rice refers to its cooking qualities. Gelatinisation temperature is measured by the Differential Scanning Calorimeter, viscosity by the Rapid Visco-Analyser, texture and retrogradation by the Lloyd test and fragrance by the Gas Chromatograph.
Chapter 1

Quality Evaluation Program – Routine assessment of rice crossbreds

Addresses the objective a: Perform the routine Quality Evaluation Program in a timely manner.

The Quality Evaluation Program (QEP) runs alongside the rice breeding program and delivers both physical and cooking quality information on the breeding lines at either the short row or plot stage of the breeding program. The QEP demands approximately 70% of resources from the project and is the basis of objective a of Rice Quality V. Table 1.1 is a summary of the range of routine analysis as well the number of samples analysed during the project.

<table>
<thead>
<tr>
<th>Breeding Stage</th>
<th>Routine analysis performed</th>
<th>Year 1 - 2007/08 season</th>
<th>Year 2 - 2008/09 season</th>
<th>Year 3 - 2009/10 season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plots</td>
<td>Viscosity and amylose content</td>
<td>196</td>
<td>558</td>
<td>1065</td>
</tr>
<tr>
<td>Plots</td>
<td>Milled and physical assessment</td>
<td>2422</td>
<td>3823</td>
<td>3869</td>
</tr>
<tr>
<td>Short Rows</td>
<td>CT and gelatinisation temperature</td>
<td>773</td>
<td>960</td>
<td>927</td>
</tr>
</tbody>
</table>

Table 1.1: Routine analysis and sample number conducted in the Quality Evaluation Program.

The exponential rise in the number of plots undergoing viscosity and amylose content over the three years of this project corresponds to the phenotyping of material that underwent marker aided selection as early as the F2 generation, prior to its commencement. In addition to providing quantitative measure of advance material for lucrative grain types such as long grain, this pursuit also enforced the efficiency molecular markers can have on a breeding program when such techniques are embraced early on in the selection process.

Release of Sherpa

A new Australian rice variety was released at the 2011 Field Day. From a grain quality perspective, Sherpa is essentially an Amaroo replacement (see Appendix 1). The main point of difference is the need for growers to take care with harvest date to achieve a maximum Head Rice Yield. All other physical and cooking quality traits are consistent with Amaroo across many sites and seasons.

Facility improvements

A range of infrastructure related improvements were made to both the research lab (location of all the chemistry or cooking analysis of the grain) and to the mill room (location of the milling and physical quality analysis of the grain) during Rice Quality V. These improvements have enabled samples to be analysed in a more uniform environment and staff to work in a comfortable environment with reduced sample handling.

Sample storage

Research Lab. Based on the results from the storage trial presented in Chapter 4, the temperature control room in the research lab was fitted out with shelving to house the short row and plot samples at a constant temperature prior to chemical analysis (Figure 1.1). The temperature chosen for the room is 20 °C which is sufficient to prevent any storage induced changes to grain quality. This facility also mirrors that used in SunRice Appraisal centre for tempering of quality samples prior to milling and
reflects an attempt to align protocols with commercial industry. Storage of samples in the cool room also allows for better pest management and makes for a much tidier/organised workplace.

Mill room. A cool room linking the mill room to the physiology lab was converted to a temperature control room that is now used to temper the paddy rice prior to milling (Figure 1.1). This has significantly reduced the congestion in the milling area, sample handling and reduced the down time while waiting for samples to reach optimal milling temperature immediately before milling. More importantly, controlled tempering should reduce any temperature and moisture induced variability in the results.

Figure 1.1: Sample storage in the mill room and research laboratory

Equipment

Noise Audit. A noise audit run primarily on equipment in the mill room and on grinders was conducted to ensure that all equipment was operating at a safe standard. Results showed that the mill room is operating at the upper acceptable threshold of 85 dB (A). Staff have been issued with ear protection but this is the last line of defence. It is hopeful that the improvements to mill equipment and the installation of temperature control will minimise noise in the mill room.

Research Lab. The computer and software for the DSC was updated to allow data to be directly entered into the common database which has eliminated the need for duplication of data entry and thus possible sources of error (Figure 1.2). The updated software has yet to be explored for additional features, although the ability to measure enthalpy would only be possible with the purchase of a 5 decimal place balance (we have 4 dp balances).

Figure 1.2: Old and new computer and software for the DSC.

Replacement grinders were evaluated. Each cooking quality assessment (Table1.1) has a unique sample preparation based on particle size of the flour. To minimise this extensive sample preparation and as grinders are getting old and noisy, with the amalgamator breaking down in the 2009/2010 QEP season, a range of grinders were evaluated (Chapter 2, Amylose). After discussions with Cereal Chemists around the globe at IRC (~see Chapter 7, Appendices) an Udy mill was purchased late in RQV and will be evaluated in the next project.
Mill Room. The indent machine used to separate brokens from unbroken milled grain is slowly becoming the bottleneck of the mill room and is unsuitable for some grain dimensions. After a visit to the SunRice milling platform to consider their lab scale indent machine, the indent cylinder has been connected to a motor with variable speed and with an internal timer (see Figure 1.3). The new indent set-up is likely to run much quieter than the old set-up of 78 db and reduce the overall noise levels in the mill room. The new indent will be operational during the 2010/11 mill season and will be reported on in the next Rice Quality project. Scientifically, the variable speed on the indent is expected to enable the separation of broken and whole grains in short grain samples which has historically been very problematic. In Figure 1.3 note the lighter/smaller motor with reduced number of pulleys and belts making the indent a safer, streamlined instrument.

Figure 1.3: Old and new indent machine set-up

![Old and new indent machine set-up](image)

Facilities

Research Lab. I&I NSW Minor Works funding has enabled the remaining bench tops, shelves and cupboards in the research labs to be updated (Figure 1.4). An office adjoining a lab has been converted to a balance room whereby the air-conditioning vent has been modified to prevent destabilisation of the balance.

Figure 1.4: Old and new benchtops and cupboards

![Old and new benchtops and cupboards](image)

Mill room. I&I NSW Minor Works funding of $20 000 has allowed a much needed and appreciated installation of appropriate air conditioning (Figure 1.5). This will overcome many OH&S issues such as those illustrated in the picture below and maintain samples at a constant temperature and also minimise noise as the facility will be located outside the mill room. Split systems will be installed in each of the mill rooms, so rooms can be run individually which is useful in summer to maintain computers.
Communication

Improved communication between the rice breeders and cereal chemists resulted in a reduction in the sample transfers between the two groups. While this may seem trivial, it significantly reduced the amount of sample handling and in the case of short rows enabled short row data to be delivered to rice breeders on Dec 1 2010 rather than in late January as was the case in previous years, and plot data delivered to breeders on Feb 1 2011.

Communication with industry was diversified with several applications developed with Mr Russell Ford at Rice Research Australia Pty Ltd (RRAPL) and Mr Philip Williams at SunRice (see Chapter 2, Applications). Evaluation and possible implementation of image analysis equipment has been discussed with Australian Grain Storage (AGS) (Ms Close – see Chapter 2, Seedcount).

Staff

As mentioned in the acknowledgements, throughout Rice Quality V the reduced budget lead to a reliance on casual staff rather than a core of full-time staff. This arrangement provided uncertainty for the staff themselves and required significant training, paperwork and management. In terms of the overall running of the lab, continuity between seasons, general maintenance and satisfying OHS/QMS requirements proved difficult. Ultimately, results were delivered and a ramp-up of the number of samples analysed throughout the project was possible (Table 1.1).
Chapter 2

Quality Evaluation Program – Research

Addresses the objective b: Continue to improve the efficiency, accuracy and cost of the Quality Evaluation Program

Options to improve the QEP (objectives 1b and c) explored were:

- Seedcount – an image analysis approach to measuring length and width; thickness; chalkiness; colour; kernel weight; broken grains; both in number and as distribution ranges.
- Amylose content – by modifying the sampling procedure
- Using DNA markers for SSIIa, amylase content, chalk, fragrance, blast resistance.
- And utilising Near InfraRed Spectroscopy (NIR) to develop a nitrogen calibration for milled rice or milled rice flour and to develop calibrations for cooking and physical properties of rice.

The stages at which these tests can be applied are identified in red in Fig 2.1 which compares the existing QEP as conducted in 2010 and how it could look in the near future.

During the life of this project the SSIIA marker and the fragrance marker were routinely adopted; the Seedcount evaluated and an NIR calibrations for N content developed ready for adoption by the next project phase. The adoption schedule is summarised in Table 2.1.
### Table 2.1: Samples analysed each year for the research objectives of Rice Quality V that could be incorporated into the Quality Evaluation Program.

<table>
<thead>
<tr>
<th>Additional evaluation</th>
<th>Program Objective</th>
<th>Year 1 – 2007/08 season</th>
<th>Year 2 – 2008/09 season</th>
<th>Year 3 - 2009/10 season</th>
<th>Adoption into the QEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seedcount</td>
<td>b (i)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NIR – N calibration</td>
<td>b (ii)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NIR – physical or chemistry qualities</td>
<td>b (ii)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SSIIa marker</td>
<td>c (i)</td>
<td>236</td>
<td>278</td>
<td>192</td>
<td></td>
</tr>
<tr>
<td>fgr marker</td>
<td>c (i)</td>
<td>28</td>
<td>79</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Amylose Content**

Amylose content has been a long term cornerstone measurement made at the plot stage of the breeding program (Figure 2.1). The drawbacks of this measurement are in the sample preparation. Amylose content is measured on milled grain, so can be applied at the plot stage only, and requires a finer particle size than other tests conducted at this stage. To alleviate this identified bottleneck and by evaluating amylose content measured on brown grain (ie, earlier in the breeding program at the short row stage) a series of experiments were conducted.

Usually samples are ground using the cyclotec for viscosity and the amalgamator for amylose. Figure 2.2a compares results when amylose is measured on ground flour using the cyclotec with using ground flour from the amalgamator. Statistical analysis using students t-test indicates no significant difference (P>5%) between the populations so the option to use milled flour prepared by the cyclotec is acceptable. This method of preparation will eliminate 3 hours of grinding time per 60 samples or around 50 hours of preparation time per season.

Figure 2.2b compares results measured by two technicians both using the same amalgamator milled samples. Students t-test indicated these were significantly different (P>5%) which indicates that operator differences need to be considered when conducting the test.

**Figure 2.2:** Amylose content of milled rice flour prepared by amalgamator and cyclotec (a) and by two technicians using milled flour prepared by amalgamator (b).
Even though huge time savings can be made by using the cyclotec, alternative grinders available were used in an attempt to improve the result. Figure 2.3 shows the amylose content of the cyclotec, A10, A20 (used by SunRice), ball mill and rockwell compared to the amalgamator milled rice. Again, the amylose content of samples prepared by cyclotec correlate the best out of all three grinders evaluated. The A20, even though tested on a small number of samples, proved to be the worst comparison to the amalgamator milled samples which highlights the need for technology transfer between SunRice and Industry and Investment NSW.

**Figure 2.3: Amylose content of milled rice flour prepared by 5 different grinders and compared to the amylose content of amalgamator ground sample.**

Unfortunately, Figure 2.4 clearly shows that measuring amylose content on brown grain does not work. This is because the lipids from the lipid rich bran layer compete with the iodine and a lower absorbance and thus lower amylose content is observed. The likelihood of measuring amylose content using existing methodologies at the short row stage is low. Instead, some work into masking the competition from lipids is warranted in future research projects.

**Figure 2.4: Amylose content of amalgamator milled flour compared with amylose content of brown grain ground using three different grinders.**

**Seedcount**

In response to the current image analysis system (Cervitec) being superseded and thus unsupported in the near future, during the 2009/10 QEP milling season a Seedcount instrument was borrowed from GrainTec P/L and evaluated using breeding lines at the plot and short row stage. **Plot samples.** Figure 2.5 shows that the length and width dimension correlate well with image analysis and the Seedcount chalk impact values correlate well with the Cervitec chalk content value.
Figure 2.5: Grain dimension (a and b) and chalk content (c) of plot breeding lines examined by Seedcount

Short Row samples. Currently the physical qualities of short row breeding lines are evaluated by the eye of a senior Technical Officer and given a score ranging from 1 to represent ‘chook feed’ and 5 to represent beautiful rice. The possibility of replacing this subjective method with an objective method was evaluated. The SeedCount was able to provide objective measures on chalk, brokens, grain brightness, grain yellowness, grain length and grain width with varying degrees of precision and repeatability. However, because the subjective assessment is combining all parameters at once into a consolidated score it was difficult to sensibly compare and rationalise the two. This therefore comes done to a question of deciding what is required and useful in making the assessments - a consolidated score or individual parameters

There is potential for the Seedcount software to report on the distribution of grain dimension so the breeders can select for grain dimension uniformity (results not shown) or avoid mixed or impure harvested short rows.

Of the Seedcount parameters, broken grains and colour were evaluated by comparing with Head Rice Yield and colour as measured by the BJK Gardner used in the current QEP. The broken grain was evaluated with the prospect of using the figure to predict Head Rice Yield (millout) at the short row stage as this application could significantly reduce the number of samples that continue into the labour intensive, plot stage milling component of the QEP. From Figure 2.6 it is clear that broken grain content is not discriminated in a medium grains sample but the application is a possibility amongst long grains. The broken grains value was also evaluated to determine if it could replace the archaic indent machine. From Figure 2.6 it appears that it cannot. Consequently the indent will continue to be used until the Seedcount software is upgraded and trays are redesigned.

Figure 2.6: A comparison of Head Rice Yield against the percent of whole broken grain
NIR

Near InfraRed Spectroscopy (NIRS) Analyses

The objective b (ii) of Rice Quality V was to develop a series of NIRS calibrations that could contribute to increase the scope and/or efficiency of the QEP. Calibrations were developed on whole brown grains, whole milled grains and ground-milled grain for a range of physical and chemistry quality attributes.

Nitrogen calibration. Using milled and ground samples prepared for viscosity measurements, a subset of samples from each year of the project were analysed for nitrogen (N) content using the LECO instrument at SunRice. %Protein was calculated as %N x 5.95 as per the AOAC method 14.068 (AOAC 1980). It was found that ground-milled grain produced the most accurate calibration. To capture as wide a range of protein levels as possible, samples were sourced from the traditional farming regions, N fertiliser trials and rice grown in northern Australia. Figure 2.7 shows that each year more data has been added to the calibration to ensure the calibration is viable over a nitrogen range of 1 – 2 %, equivalent to a protein content range of 6 to 14 %. The associated $R^2$ values and RPD (Ratio of Standard Error of Prediction to Sample Standard Deviation) are shown in Table 2.2. Protein data was supplied to breeders on a sub-sample of breeding lines in 2007/08, and all breeding lines in 2008/09 and 2009/10. This information will be particularly useful to breeders as different farming practices and nitrogen recommendations come into play and as the rice industry explores various growing regions outside the Murrumbidgee, Murray Valley and Coleambally Irrigation Areas.

Figure 2.7: NIRS calibration and validation relationships for %N of ground-milled rice produced by accumulating data after each harvest.

<table>
<thead>
<tr>
<th>Year</th>
<th>Sample Number</th>
<th>Validation Method</th>
<th>Calibration R²</th>
<th>RPD</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007/08</td>
<td>44</td>
<td>Cross</td>
<td>99.3</td>
<td>12</td>
</tr>
<tr>
<td>2008/09</td>
<td>81</td>
<td>Test Set</td>
<td>98.85</td>
<td>9.57</td>
</tr>
<tr>
<td>2009/10</td>
<td>122</td>
<td>Test Set</td>
<td>98.46</td>
<td>8.23</td>
</tr>
</tbody>
</table>

Table 2.2: Summary of Coefficient of Determination ($R^2$) and Range RPD (Ratio of Standard Error of Prediction to Sample Standard Deviation) of % nitrogen calibration and validation conducted throughout the Rice Quality V program.

From a grain quality perspective, knowing the nitrogen content provides an extra tool for interpreting viscosity traces and understanding the influence of temperature and nitrogen on the uptake of nitrogen into the grain (see Chapter 7 for evidence).

Grain quality calibrations. In 2007, 2008 and 2010 NIRS was also explored as a possible way to predict a range of physical and cooking properties of brown and milled grain as well as ground milled grain. These included yellowness index, chalk, Head Rice Yield (millout), grain dimensions, amylase
content, hardness, and viscosity parameters of setback, pasting temperature, peak, final and trough viscosity. Calibration parameters are shown in Table 2.3. These results indicate that there is potential to use NIRS for some parameters with reasonably high $R^2$ values although RPD values are low for confident use. This comes down to a question of what screening efficiency the breeders are prepared to tolerate. Discussions with cereal chemists at the 3rd International Rice Congress indicate that they have had similar results trying to calibrate the NIRS for quality parameters and generally it is not used for other than grain N content.

<table>
<thead>
<tr>
<th>Quality character</th>
<th>Sample presentation</th>
<th>Sample source</th>
<th>Calibrated to</th>
<th>$R^2$</th>
<th>RPD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chalk % (Arborio not included)</td>
<td>Brown grain</td>
<td>1 year</td>
<td>Cervitec</td>
<td>0.42</td>
<td>1.32</td>
</tr>
<tr>
<td>Millout %</td>
<td>Brown grain</td>
<td>1 year</td>
<td>Mill/Indent</td>
<td>0.15</td>
<td>1.09</td>
</tr>
<tr>
<td>Chalk % (Arborio not included)</td>
<td>Brown grain</td>
<td>1 year</td>
<td>Seed count</td>
<td>0.33</td>
<td>1.22</td>
</tr>
<tr>
<td>% broken grain</td>
<td>Brown grain</td>
<td>1 year</td>
<td>Seed count</td>
<td>0.14</td>
<td>1.08</td>
</tr>
<tr>
<td>Length</td>
<td>Brown grain</td>
<td>1 year</td>
<td>Seed count</td>
<td>0.71</td>
<td>1.88</td>
</tr>
<tr>
<td>Colour (YD)</td>
<td>White grain</td>
<td>3 year</td>
<td>Spectrophotometer</td>
<td>0.66</td>
<td>1.72</td>
</tr>
<tr>
<td>Chalk % (Arborio included)</td>
<td>White grain</td>
<td>3 year</td>
<td>Cervitec</td>
<td>0.79</td>
<td>2.21</td>
</tr>
<tr>
<td>Setback</td>
<td>Ground white grain</td>
<td>2 year</td>
<td>RVA</td>
<td>0.61</td>
<td>1.59</td>
</tr>
<tr>
<td>Amylose %</td>
<td>Ground white grain</td>
<td>2 year</td>
<td>Iodine binding</td>
<td>0.72</td>
<td>1.89</td>
</tr>
</tbody>
</table>

Table 2.3: NIRS calibration parameters $R^2$ and RPD for a number of quality indicators.

Starch Synthase Ila (SSIIa) markers

NOTE: The first year of this work was presented at the 59th Australian Cereal Chemistry Conference held from 27-30th September 2009 in Wagga Wagga, NSW.

Gelatinisation temperature is indicative of the cooking time of a rice variety. Gelatinisation temperature requires little sample so is measured on samples from short rows as part of the QEP. When a histogram of the distribution of gelatinisation temperature data from the breeding population in short rows is smoothed to a line graph, a clear tri-modal distribution becomes evident. The low gelatinisation temperature distribution ranges from 62 to 72 °C every year, while the delineation between the second and third distributions varies between seasons as seen in Fig 2.8. Note that the entries in each year do change which could have an effect on the distribution.
Gelatinisation temperature is usually measured using a Differential Scanning Calorimeter. At a cost of around $3.00 per sample for consumables, the requirement of a specific piece of instrumentation and a specific specialised sample preparation to perform the test this was a prime target to be replaced by a cheaper, quicker assay using the available SSIIA molecular marker. The evaluation of this marker satisfies objective \( c(i) \) of the Rice Quality V program.

It was important to ensure that the phenotype the marker was evaluating was accurate. Several potential sources of error associated with the measurement of gelatinisation temperature were identified and each factor was evaluated. While variety was expected to contribute significantly to variance in gelatinisation temperature, the water-flour ratio of the sample and the day effect made large contributions. The maximum expected error was estimated as being less than 0.5 °C (Table 2.4). Given the range of gelatinisation temperatures in the short row breeding lines (Figure 2.8), a maximum possible experimental error of 0.5 °C will not alter the overall distribution of breeding lines.

<table>
<thead>
<tr>
<th>Identified Error Source</th>
<th>ANOVA</th>
<th>Error Range Max Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stand Time</td>
<td>Not significant</td>
<td></td>
</tr>
<tr>
<td>Block effect ie 10 samples / batch</td>
<td>Not significant</td>
<td></td>
</tr>
<tr>
<td>Variety</td>
<td>Significant</td>
<td>expected</td>
</tr>
<tr>
<td>Flour-Water ratio</td>
<td>Significant</td>
<td>0.5 °C</td>
</tr>
<tr>
<td>Day effect (over 6 days)</td>
<td>Significant</td>
<td>0.4 °C</td>
</tr>
</tbody>
</table>

Table 2.4: Experimental error associated with the measurement of gelatinisation temperature

Gelatinisation temperature is the temperature at which the crystalline region of amylopectin melts. The crystalline region of amylopectin is composed of A-chains which range between a degree of polymorphism of 12 – 36 whereby the length is determined by the amount and activity of the Starch Synthase IIa (SSIIa) gene. Within the SSIIa gene there are two polymorphisms reported to control the length of those A-chains and for the basis of molecular markers to predict gelatinisation temperature (Waters et al., 2006 and Umemoto et al., 2002). The Single Nucleotide Polymorphism (SNP) 3 marker is an A/G substitution and the Di-Nucleotide Polymorphism (DNP) 4 marker is a GC/TT substitution that both result in a change in amino acid. Varieties with a high gelatinisation temperature are reportedly related to a G/GC haplotype while low gelatinisation temperature lines are described by the G/TT and A/GC haplotype, while the A/TT haplotype as unreported. Clearly, these markers are not sufficient to differentiate between the three gelatinisation classes present in the breeding lines (Figure 2.8) but as the only markers available, and RIRDC funded markers, they were evaluated to at least differentiate between the low and higher gelatinisation classes.
SSSIIa markers were trialled over 3 years of the QEP and there are several points of interest originated from the results summarised in Figure 2.9. It is evident that the delineation between high and low gelatinisation temperature varies each year even though samples were grown at the one location and the soil variability is limited. This suggests a definite genotype x environment interaction that is not captured by markers and it is unknown whether some breeding lines are more sensitive to environmental influence and are those phenotypes that are the outliers, or if the outliers indicate the marker classification is flawed. Some examples of known non-genotype causes for variable gelatinisation temperature include high temperatures during the grain filling period can increase by 3 °C, and high N soils can cause a decrease. The need for greater understanding of the genotype x environment x farming practice interaction is not able to be understood using current QEP breeding lines however this research could be readily be captured in a secondary research project. Such knowledge will have a significant impact on grain quality in a particularly hot year, with a change in farming practice or if the rice industry were to expand the growing region – all reasonable eventualities for the Australian rice industry.
Breeding lines were chosen randomly in 2007/08 and 2008/09 seasons, whereas in 2009/10 breeding lines were chosen specifically to answer some outstanding issues based on the suitability of the SSIIa marker for inclusion in the QEP. For example, there is a market need to capture a long grain with intermediate gelatinisation temperature but this has been an elusive quest since the release of Langi, and Figure 2.10a highlights one possibility to chase that breeding line. In this sample set from 2009/10, chosen on the basis of long grains with a gelatinisation temperature range of 70 – 76 °C (based on the intermediate peak of Figure 2.10), it appears that long grains with a marker combination of G/GC can identify this quality type. Figure 2.10b is a theoretical review of the gelatinisation temperature of progeny from of parents with intermediate gelatinisation temperature which shows that it is not possible to breed for varieties with intermediate gelatinisation temperature with parents with that phenotype.

Another question raised during the evaluation of the SSIIa marker is the discovery of an as yet unreported haplotype A/TT which was evident in both the 2007/08 and 2008/09 breeding lines. This haplotype consistently was in the low gelatinisation temperature category. The parentage of these A/TT haplotypes suggested that a strong Japanese background could be the underlying reason. In 2009/10 this idea was further explored with breeding lines with known Japanese parentage selected for
SSIIa marker screening. Figure 2.10 clearly shows that in this selection of breeding lines, no A/TT combination was found and both low and high gelatinisation temperatures were observed.

**Fragrance (fgr) marker**

The fragrance marker (fgr) was evaluated on several putative fragrant breeding lines although without an operational gas chromatograph the marker was not able to be validated with wet chemistry, therefore results should be interpreted with caution. Figure 2.11 shows results from crossbreds tested in 2008/09 and 2009/10.

**Figure 2.11: Crossbreds and parental lines separated by the fgr marker in 2008/09 (a) and 2009/10 (b).**

References


Chapter 3

Storage Trial

Addresses the objective c: Continue to conduct research that compliments and develops the scope of the Quality Evaluation Program.

NOTE: This work was presented at the 59th Australian Cereal Chemistry Conference held in 2008 and briefly mentioned in the Rice Quality IV report but in complete form here

Abstract

Knowledge about changes in rice grain quality during post harvest handling can influence decisions about the final use of the rice. The effect of storage temperature and time on viscosity was assessed on milled samples of seven Australian rice varieties that differ in gelatinisation temperature, grain dimensions and amylose content. The pasting temperature, peak and final viscosity derived from viscosity traces were similar for the 4 °C and 20 °C storage temperatures, but differed for grain stored at 37 °C. The response to storage at 37 °C differed amongst varieties. It is important to acknowledge that grain dimension, amylose content, gelatinisation temperature all contribute the varying response to storage.

Introduction

Rice is mostly consumed as a whole milled grain in a range of very diverse cuisines. In eastern Asia a soft-cooking rice is desired, whereas in southern Asia firmer rices are preferred (Faruq et al., 2003). Storage time increases the firmness of cooked grain, so rice is generally eaten fresh in eastern Asia but stored in southern Asia. Grain storage between seasons can ensure that mills are run throughout the year which will secure local employment and constant product supply. Where rice is used for value-adding, changes during storage have to be considered since uniform quality between batches is a key factor for consistent end products. Postharvest operations may even be manipulated to achieve target end use (Fan et al., 1999). Knowledge of the changes in quality during post harvest handling is integral to the successful marketing of rice. Research findings on milled rice will also be influenced by postharvest storage of samples.

Rice quality can be assessed at the molecular, structural and functional level. On a molecular level, several Single Nucleotide Polymorphisms (SNPs) are being utilised in breeding programs to predict gelatinisation temperature (Umemento et al., 2002; Waters et al., 2006) and amylose content (Hirano et al., 1998; Isshiki et al., 1998); and the dinucleotide repeat (CTn) in the non-coding region of the Waxy gene is used to describe cooking class (Ayres et al., 1997). On a structural level, grain dimensions are a key quality trait that breeders select for in new varieties. The cellular organisation of the grain somewhat determines the amount, type and distribution of lipids and proteins in the grain (Matsuo and Hoshikawa, 1993). On a functional level, the cooking properties of the grain are largely described by viscosity traces and gelatinisation temperature. Viscosity traces are related to the cooked texture of the grain (Juliano et al., 1964a; Juliano et al., 1964b), which is in turn determined mainly by amylose
content. Gelatinisation temperature defines the time required to cook the grain (Faruq, Mohamad et al., 2003) and contributes to the final texture of the cooked grain (Waters, Henry et al., 2006).

Storage trials for rice have been conducted in temperate and tropical regions to reflect the local storage conditions, the number of harvests per year and/or the end-use of the grain (Dhaliwal et al., 1991; Patindol et al., 2005; Sowbhagya and Bhattacharya, 2001). Such storage trials have generally considered three storage temperatures typically around 4 °C, 20 °C and 37 °C, over storage periods ranging from several months to several years. These previous trials focused on functional properties such as viscosity and gelatinisation temperature to explain any changes in starch. Research has also targeted changes in the structure of proteins and lipids, and interactions with starch, to understand the changes in functional properties of flour (Dhaliwal, Sekhon et al., 1991; Patindol, Wang et al., 2005; Zhou et al., 2003a; Zia-Ur-Rehman et al., 1995). In most storage trials only a few varieties over a limited storage period were examined, without acknowledgement that the response to storage time and temperature could be unique to certain quality characteristics of the rice or be varietal. This paper will use seven varieties stored for an extended period to explore the relationships between specific rice grain quality traits and subsequent changes during post-harvest storage.

**Experimental**

**Materials**

Six Australian varieties and one advanced breeding line were used in this study: Amaroo, Doongara, Illabong, Langi, Quest, Reiziq and YRL125. Samples were sourced from SunRice. Paddy rice was stored at 16 °C until the samples were milled in the commercial mill. The breeding line YRL125 is a cultivar developed within the Australian Rice Breeding Program. YRL125 was stored as paddy in ambient temperatures until milled with a Magill No 2 mill. The broken grains were removed from the sample and the whole grain white rice reserved for analysis. Protease from Sigma (P-5147 Type XIV) and RO water was used throughout this study.

**Methods**

Milled whole grain rice of each variety was divided into three bulk samples, packaged in zip lock plastic bags and stored in sealed containers at one of three temperatures: constant 4 °C, 20 °C and 37 °C. Samples were exposed to minimum light in dark temperature-controlled rooms. Every 3 months over a 21 month period, a sub-sample of the milled grain was taken from each bulk sample and ground with a Cyclotec mill (Hoeganaes, Sweden) fitted with a 0.5 mm screen. The flour was immediately assessed in duplicate for quality characteristics.

**Grain Characteristics**

At 0 month and 21 months storage, the amylose content was determined by iodine binding (Juliano, 1979). DNA was extracted using a modified method described by (Fulton et al., 1995). The CTn repeat (Bligh et al., 1995) and the G/T SNP (Ward, 2007) were then determined. At 21 months storage, the nitrogen content was determined by the Dumas method (ASTM E191-64) and protein content calculated as % N x 5.95 (AOAC 1980, 14.068). Gelatinisation temperature for each variety is the mean of six seasons of field-grown plots from the breeding program.

**Gelatinisation Temperature**

At 21 months, gelatinisation temperature was measured on a flour (5 mg) and water (10 µL) mixture with a Differential Scanning Calorimeter (DSC Mettler Toledo 822°). The temperature of the instrument increased at a rate of 10 °C per min from 50 °C to 100 °C, and the peak of the endotherm was recorded as the gelatinisation temperature.
Viscosity Parameters

Viscosity traces were collected with the Rapid Visco Analyser model 4D+ using the AACC 61-02 method. Every 3 months, viscosity traces were taken in duplicate, with the average recorded. For the viscosity trace with protease, the same AACC 61-02 method was used, with the addition of protease and an extended initial stirring time of four minutes (Martin and Fitzgerald, 2002).

Four viscosity parameters will be discussed in this study:

1. Pasting temperature as the temperature at which viscosity of the flour slurry in the RVA canister increases by 24 cP over a 0.6 °C increment (defined to correlate with gelatinisation temperature for routine analysis).
2. Peak viscosity defined as the maximum viscosity recorded between 2 and 10 min of the RVA run or between 6 and 14 min for the protease treatment;
3. Final viscosity defined as the viscosity after the slurry has been at 50 °C for one minute, and;
4. Setback defined as the difference between final viscosity and peak viscosity.

Results

Grain Characteristics

The cooking type, amylose characteristics, protein content and gelatinisation temperature of each of the seven varieties are summarised in Table 3.1. Amaroo, Illabong, Quest and Reiziq are all medium grain rice cultivars, with Illabong classified as an Arborio-type variety (having larger grains with distinct opaque or chalky centres). These varieties have a low gelatinisation temperature of around 66°C. Langi, YRL125 and Doongara are all long grain rice cultivars, with a higher gelatinisation temperature of 74°C. For ease of discussion, throughout the remainder of this study, the Medium grain varieties will be referred to as Group M varieties, and the Long grain varieties will be referred to as Group L varieties. All Group M varieties have a CTn of 19 while the Group L varieties have CTn of 19, 18 and 14 for Langi, YRL125 and Doongara respectively. All varieties except Doongara, carry a T at the splice site of intron 1 of the Wx gene which confers low Granule Bound Starch Synthase I (GBSSI) expression and low amylose content (Isshiki, Morino et al., 1998; Sano, 1984). Doongara carries a G at the splice site and has 10 times higher GBSSI expression and an intermediate amylose content. The protein content for all varieties ranged from 6.9 to 8.4%.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Cooking Type</th>
<th>Amylose characterisation*</th>
<th>Protein Content (%)</th>
<th>Gelatinisation Temperature** (ºC)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Content</td>
<td>CT</td>
<td>SNP</td>
</tr>
<tr>
<td>Amaroo</td>
<td>Medium grain, soft cooking</td>
<td>20.2</td>
<td>19</td>
<td>T</td>
</tr>
<tr>
<td>Illabong</td>
<td>Medium grain, Arborio</td>
<td>21.7</td>
<td>19</td>
<td>T</td>
</tr>
<tr>
<td>Quest</td>
<td>Medium grain, soft cooking</td>
<td>19.1</td>
<td>19</td>
<td>T</td>
</tr>
<tr>
<td>Reiziq</td>
<td>Medium grain, soft cooking</td>
<td>20.5</td>
<td>19</td>
<td>T</td>
</tr>
<tr>
<td>Langi</td>
<td>Long grain, soft cooking</td>
<td>18.4</td>
<td>19</td>
<td>T</td>
</tr>
<tr>
<td>YRL125</td>
<td>Long grain, very soft cooking</td>
<td>17.6</td>
<td>18</td>
<td>T</td>
</tr>
<tr>
<td>Doongara</td>
<td>Long grain, firm cooking</td>
<td>24.3</td>
<td>14</td>
<td>G</td>
</tr>
</tbody>
</table>

Table 3.1: Quality characteristics of each variety used in this study.

*CT microsatellite repeat is indicative of cooking type; SNP refers to the G/T Single Nucleotide Polymorphism at the splice site of intron 1 Waxy Gene. **Gelatinisation temperature represents the mean over 6 seasons of quality evaluation data
Pasting and gelatinisation temperature

Figure 3.1 demonstrates that pasting temperature changes with rice slurry concentration (a) and a comparison of pasting temperature with gelatinisation temperature at 21 months storage (b). In Figure 3.1b, the line of equality shows that the gelatinisation and pasting temperature were interchangeable for varieties stored at 4 °C and 20 °C but not for varieties stored at 37 °C. These observations were affirmed by a paired t-test to show that gelatinisation temperature and pasting temperature were not significantly different for the 4 °C and 20 °C stored samples. At a storage temperature of 37 °C, the measurements were significantly different (p-value < 0.001), with the mean pasting temperature recorded as 7.1 °C higher than the mean gelatinisation temperature.

Figure 3.1a: Pasting temperature from the RVA traces of two varieties over a range of rice slurry concentrations. The two varieties have different gelatinisation temperatures: low gelatinisation temperature (black circle) and high gelatinisation temperature (hollow circle). The dotted line represents the rice slurry concentration defined by the AACC 61-02 method.

Figure 3.1b: Pasting and gelatinisation temperature of all varieties stored for 21 months. Three storage temperatures were examined in this study: 4 °C (triangle symbol), 20 °C (diamond symbol) and 37 °C (square symbol). The solid line represents the line of equality between pasting temperature and gelatinisation temperature.

The pasting temperatures of freshly-ground samples are presented in Figure 3.1. For all varieties stored at 4 °C and 20 °C there was no change in pasting temperature throughout the entire storage trial. For milled rice stored at 37 °C, changes in the pasting temperature of the Group M and Group L varieties differed. The pasting temperature of Group M varieties remained unchanged until a sharp increase in pasting temperature after 9 months storage, whereas the pasting temperature for the Group L varieties stored at 37 °C increased immediately. Also featured in Figure 3.1 is the pasting temperature of the milled rice stored for 21 months and treated with protease. These results show that when proteins are hydrolysed, the pasting temperature is similar to that at 0 months storage.
Figure 3.1: Pasting temperature of seven varieties measured every three months over a 21 month storage trial. Three storage temperatures were examined in this study: 4 °C (solid triangle symbol), 20 °C (solid diamond symbol) and 37 °C (solid square symbol). The pasting temperatures of varieties treated with protease at 21 months are represented by the hollow symbols.

Peak, Final Viscosity and Setback

Changes with storage time in peak and final viscosity and the setback (final minus peak viscosity) of the Group M varieties are summarised in Figure 3.2, and of the Group L varieties in Figure 3.3. For each storage temperature Group M varieties exhibited similar trends in each viscosity parameter across the range of storage times (Figure 3.3). At both 4 °C and 20 °C storage temperatures, the peak viscosity increased at a slightly higher rate than the final viscosity to result in minimal decrease in
setback. The Group M varieties stored at 37 °C showed a maximum peak viscosity after 3 months storage, followed by a gradual decrease with further storage, while the final viscosity steadily increased throughout the entire storage trial. The changes in peak and final viscosity at 37 °C are reflected in a gradual increase in setback after 3 months storage. For Group L varieties stored at 4 °C and 20 °C, the peak and final viscosity changed in the same direction and magnitude over time, and the setback remained constant. When Group L varieties were stored at 37 °C, the peak viscosity decreased either immediately or after 3 months storage to a peak viscosity below that recorded at 0 months.

Figure 3.3: Peak, final and setback viscosity (cP) of Group M varieties measured every three months over a 21 month storage trial. Three storage temperatures were examined in this study: 4 °C (triangle symbol), 20 °C (diamond symbol) and 37 °C (square symbol).
Figure 3.4: Peak, final and setback viscosity (cP) of Group L varieties measured every three months over a 21 month storage trial. Three storage temperatures were examined in this study: 4 °C (triangle symbol), 20 °C (diamond symbol) and 37 °C (square symbol).

To examine the contribution of proteins to viscosity at different storage temperatures, each variety stored for 21 months was treated with protease and the viscosity trace recorded. All varieties displayed the same response to protease treatment, with only the trace for Quest shown (Figure 3.4). It is clear that without proteins, the viscosity traces collected at the three storage temperature were almost identical and generally lower than the viscosity traces of stored flour (Figure 3.5b versus 3.5a).

Discussion

Pasting and gelatinisation temperature

Pasting temperature is often considered to be synonymous with gelatinisation temperature presumably because swelling occurs between the onset (T_o) and peak (T_p) of an endotherm (Sowbhagya et al., 1994; Tester and Morrison, 1990). Pasting temperature is defined here as the temperature that corresponds to a 24 cP increase in viscosity over a 0.6 °C temperature increment. A 24 cP increase in viscosity is easy to detect in a concentrated system – that is, when there is limited water to act as a plasticiser to buffer the swelling flour particles (Teo et al., 2000; Zhou et al., 2003b). In Figure 3.1a, at high concentrations a low pasting temperature is measurable and the difference between a variety with a low and high gelatinisation temperature is clear – as the concentration decreases, the pasting temperature is detected after the actual swelling event with both converging to the same pasting temperature. Gelatinisation temperature (T_p) is the temperature relating to the melting of the a-chains of amylopectin whereby the longer the a-chains the higher the gelatinisation temperature (Umemoto,
Yano et al., 2002; Waters, Henry et al., 2006) and the more water is absorbed. (Tester and Morrison, 1990). Gelatinisation temperature has been shown to vary only slightly with changes in concentration (Iturriaga et al., 2004), and can only be interchanged with pasting temperature at a specific and constant starch-water ratio, or a certain water availability (apparent concentration).

Throughout the storage trial, the pasting temperature and gelatinisation temperature for all varieties stored at 4 °C and 20 °C remained relatively unchanged (Figure 3.1). As pasting temperature and gelatinisation temperature were similar (Figure 4), it can be safely assumed that no changes in the structure of amylopectin, amylose, protein or lipids occurred at 4 °C and 20 °C. Similar studies for stored flour and milled rice stored at 4 °C and 25 °C showed an increase in gelatinisation temperature of less than 1 °C (Teo, Abd. Karim et al., 2000; Zhou, Robards et al., 2003b) while a study on rough (paddy) rice stored at 4 °C and 21 °C showed an increase in gelatinisation temperature of around 3 °C (Patindol, Wang et al., 2005).

The gelatinisation temperature, and thus amylopectin structure, remained unchanged for all varieties stored as milled grain at 37 °C (Figure 3.2 and comparable to Table 3.1). It has been reported that gelatinisation temperature was unchanged for starch (Patindol et al., 2005), but an increase was observed for flour (Patindol, Wang et al., 2005; Teo, Abd. Karim et al., 2000). Pasting temperature increased for all varieties stored at 37 °C. When proteins were hydrolysed by protease (as they can during storage (Dhaliwal, Sekhon et al., 1991)), the pasting temperature was closer to that recorded at 0 months to indicate that proteins largely account for the increase in pasting temperature (Figure 3.1). Storage proteins in a freshly milled sample are largely hydrophilic and bind water, therefore reduce the amount of available water for starch to swell (Matveev et al., 2000). Upon storage the oryzenin can become more hydrophobic due to an increase in molecular size through oxidation of cysteine groups whereby the additional folding reduce the capacity to bind with starch and water (Chrststl, 1990b). The ‘apparent concentration’ becomes more dilute and so the fine detection of swelling particles becomes difficult to detect, and a higher pasting temperature observed (Figure 3.1a).

Figure 3.1 shows nicely that pasting temperature remains the same for Group M varieties until 9 months and then increases, whereas for Group L varieties the pasting temperature recorded immediately increased beyond the actual swelling/pasting event.

It was reported that during 12 months storage the ratio of cysteine (-SH) to cystine (-S-S-) bonds decreased more for the medium grain than the long grain (Chrststl, 1990b) – a result confirmed here in the first 12 months (Figure 3.1). Over 21 months storage, this difference is not as apparent as an increase of more than 8 °C in pasting temperature was recorded for Group M and L varieties. Illabong has a smaller increase in pasting temperature- maybe the air pockets in chalky grain create more surface area for water absorption and pasting is detected at lower temperature.

**Peak Viscosity**

Starch, proteins and lipids and their interactions determine the swelling capacity of the flour, and it is the balance between swelling and shear that defines the peak viscosity. Consistent with previous studies (Juliano, Camgampang et al., 1964b), at 0 months the peak viscosity was negatively correlated with the amylose content of the varieties. Total amylose content has been shown to remain unchanged throughout a 6 month storage trial (Zia-Ur-Rehman, Yasin et al., 1995), yet in Figures 3.3 and 3.4 the peak viscosity varied due to storage time and temperature. Therefore the correlation between amylose and peak viscosity is only valid for freshly milled rice with minimal storage.

A review of the literature has suggested that the initial increase in peak viscosity in the first 3 months storage for all varieties has been attributed to a reduced activity of α-amylase (Dhaliwal, Sekhon et al., 1991; Zia-Ur-Rehman, Yasin et al., 1995) and an increased free fatty acid content from the hydrolysis of lipids (Yasumatsu et al., 1964). After 3 months storage at 37 °C, the peak viscosity decreased more rapidly for Group L than Group M varieties. This observation could be attributed to different distributions of proteins and lipids in the grain (Matsuro 1993) or to different rates of protein and lipid
degradation between long and medium grains (Wenchao et al., 1998). For example compared to medium grains, long grains were shown to have a higher conversion of lipids to fatty acids, with the conversion rate reduced after 3 months (Dhaliwal, Sekhon et al., 1991; Zia-Ur-Rehman, Yasin et al., 1995). With more lipid-amylose complex opportunities for amylose (Gidley Zhou) and less water absorbed by protein (Martin and Fitzgerald, 2002), more water is available to dilute or reduce the ‘apparent concentration’ of the system. At 4 °C and 20 °C, the same processes described for the first 3 months storage at 37 °C can occur but at a much slower rate. For example, lipid hydrolysis was more evident at 37 °C than at 4 °C (Zia-Ur-Rehman, Yasin et al., 1995).

Figure 3.5 shows that when flour is treated with protease the viscosity curve is lower (equivalent to a less concentrated system, (Bhattacharya and Sowbhagya, 1979) and all storage induced changes to peak viscosity are eliminated. Proteins can be located on the granule surface (Baldwin, 2001) and when these proteins oxidise (Chrastil, 1990a) it is possible for protein to form a partial shell around the granule and restrict swelling. An example of a granule bound protein is GBSSI, whereby the amount of enzyme expressed is correlated with the amylose content of the variety (Sano et al., 1986). Free amylose (as distinct to lipid-amylose complexes) swells inside the granule until around 80 °C, and then leaches into solution to either complex with lysophospholipids (Morrison et al., 1993) or fatty acids. As lipids degrade throughout the storage trial, there is presumably more free amylose that swells inside the granule, and so the amylose cannot interact with the rice slurry and a reduction in the peak viscosity is expected. Doongara has high amylose content (Table 3.1) with a high amount of GBSSI and, compared to other varieties in this study, the lowest peak viscosities recorded (Figure 3.3 and 3.4).

Figure 3.5: Viscosity traces of Quest (a) and Quest treated with protease (b). The peak (P) and final (F) viscosity of the viscosity trace is noted. Three storage temperatures were examined in this study: 4 °C (light grey line), 20 °C (dark grey line) and 37 °C (black line).

**Final Viscosity**

Final viscosity is measured after the rice slurry has cooled to 50 °C, whereby the increase in viscosity from the trough is due to the loss of energy on cooling (Bhattacharya and Sowbhagya, 1978) plus the network capacity of the system. Storage at 4 °C and 20 °C resulted in a slight increase in final viscosity, whereas storage at 37 °C caused a further increase in all varieties except Doongara. Again, proteins play a key role. In a stored sample the proteins are mostly hydrophobic and bind little water, so more water is available for starch during the analysis and allows more amylose to leach into solution. It is the leached amylose that strongly contributes to the network capacity of the cooled gel (Gidley, 1989). The decrease in final viscosity of Doongara can be explained by the higher amount of GBSSI (Table 3.1) that limits the amount of amylose leached into the solution and the main cause for the weaker gel matrix.
Setback

Setback is the difference between the final and peak viscosity (Juliano, Camgampang et al., 1964b). Setback is often the only parameter of the viscosity curve that is considered because the setback of the viscosity curve has long been used to describe the amylose content (Juliano, Bautista et al., 1964a; Juliano, Camgampang et al., 1964b). At 0 months storage, the result showed a positive relationship between amylose content and setback ($r = +0.87$, relationship not shown). That relationship remained after 21 months storage at 4 °C ($r = +0.95$), is hardly correlated at 20 °C ($r = +0.36$) and negative at 37 °C ($r = -0.91$). For rice stored at or below 20 °C, the peak viscosity and final viscosity both increased slightly to result in very similar setback. In this case, to report only setback would mask the storage induced changes to peak and final viscosity and any associated functional properties like texture. For rice stored at 37 °C the peak viscosity generally decreased and final viscosity increased, with the opposing direction of change exaggerated in an increased setback.

In summary, the assumption that setback and amylose correlate, is only valid for fresh or cool stored rice. Setback for stored rice reflects the changes in protein composition and the balance of amylose in the form of free and lipid-bound amylose as described for peak and final viscosity.

Conclusions

Post-harvest storage influences grain quality, and the most useful tool to witness changes in grain quality is the viscosity trace. The viscosity trace reflects the interaction between starch, protein, lipids and water. A set of grain quality assumptions based on these interactions are regularly used by breeders, industry and marketers. While these assumptions remained true for grain stored at temperatures below 20 °C, the assumptions became invalid for milled rice stored at 37 °C; for example, amylose content does not correlate with peak viscosity anymore, neither with setback. Varieties in this study responded differently to storage time and temperature depending on their gelatinisation temperature, amylose content or grain dimensions. To prevent any storage-induced changes to grain quality, it is recommended that milled rice be stored below 20 °C. This study emphasises that knowledge of post-handling storage of grain (including during drying, storage sheds, transport, etc) is essential to make decisions on the use of grain by industry, marketers and research.

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Chapter 4

Lipids Study

Addresses the objective c: Continue to conduct research that compliments and develops the scope of the Quality Evaluation Program.

NOTE: This work was presented at the 60th Australian Cereal Chemistry Conference held in 2010

Introduction

The lipid and fatty acid (FA) content of milled rice is less than 1 % (w/w), yet lipids have a significant affect on cooking properties. A major feature of aged rice is an increase in saturated fatty acids and FA with shorter chain length (Deka et al., 2000) that can cause a different flavour and firmer rice.

To understand the role of FA in aged rice, many studies have adopted re-constitutional methods whereby lipids have been added to starch that may have already undergone some structural changes upon purification. To alleviate this problem, this study used rice flour as the base to which a range of FAs differing in chain length and saturation were added.

Recognising that the main interaction of lipids with flour is via lipid-amylose (LAM) complexes, the iodine binding of the paste upon cooling was determined (Kaur and Singh, 2000).

Material and Methods

Material: Rice flour was collected from the 2009 harvest. The aged rice (Fig 4.2) was harvested in 2007, stored at 37 ºC as rice flour and the viscosity measured every 3 months. Both rice flours are of the same variety.

Viscosity curve: Four fatty acids at various amounts were added directly to an RVA canister, to which 3g flour and 25g water were added according to method AACC 61 - 02. Fatty acids used in the study are the saturated FAs palmitic (16:0) and stearic (18:0), and the unsaturated FAs oleic (18:1) and linoleic (18:2).

Iodine Binding (Absorbance): 5g of an RVA paste was diluted with 25ml of 60 ºC warm water, centrifuged, mixed with KI/I2 solution and the absorbance read at 690 nm. Modified version of AACC 61 – 03.

Hardness: Hardness is the force required for a probe to puncture the gel made by the RVA (Philpot et al., 2006).

Results and Discussion

As shown in Figure 4.1, the only viscosity parameter responsive to additions of palmitic acid was final viscosity – an observation true for all other fatty acids examined in this study. In a study on aged rice (Figure 4.2), at 12 months the peak viscosity was similar to the fresh sample, and the final viscosity had increased by over 1000 cP. The similar results shown in Figure 4.1 and 4.2 show that it is feasible to use this as a rapid and quantitative method to explore the aging process of rice.
Palmitic acid (16:0) has the greatest absorbance of all FA at 6mg to suggest little formation of LAM but above 12 mg of FA added has a very low absorbance to suggest that after a certain concentration the shorter chain saturated fatty acid can readily form LAM (Fig 4.3). This is somewhat reflected in the final viscosity whereby an increase in final viscosity is only observed after additions of > 12 mg of FA (Fig 4.4). Aged rice is known to increase in palmitic acid\(^1\) so there is a fine threshold before noticeable increases in final viscosity will be evident.

For FA with a chain length of 18, the pattern of decreased absorbance with increased addition of FA is similar implying a comparable degree of LAM formation has occurred. The formation of LAM is independent of the degree of saturation of the FA (Figure 4.3) – a result in contrast to reconstitution studies that report that saturated fatty acids are favoured over unsaturated FA in the formation of LAM (Zhou et al., 2007).

Figure 4.3: Absorbance of amylose from rice flour with additions of fatty acids
It was suggested that the presence of LAM causes junction zones to be further spaced within a gel matrix and this is the underlying cause for an increase in final viscosity in starch (Copeland et al., 2009). However even though the inferred LAM of all C18 FA is similar, the final viscosity is less responsive with increasing unsaturation in FA (Figure 4.4). Further research into the concept of the role of LAM in viscosity is warranted in a holistic viscosity system that includes water dynamics.

**Figure 4.4: Final viscosity of rice flour with additions of fatty acids**

Hardness is a direct measure of the gel strength. Independent of chain length or saturation of the FA, Figure 4.5 shows that with 6mg of added FA the gel is softer than the flour. Increased FA addition increased hardness to a peak and with further FA additions the gel begins to soften again. This differs from the effect of increased addition on final viscosity (Figure 4.4) and suggests that the networking created by the LAM is actually weakly associated. Observations made during the experiment support this as the gel appeared thick yet did not exhibit elastic properties and was a split/brittle gel upon puncturing.

**Figure 4.5: Hardness of rice flour with additions of fatty acids**

**Conclusions**

Addition of FA to flour is a valid method to understand the aging process of rice. It is important to approach research into aged rice from many directions. A high final viscosity can be indicative of a highly networked gel, but the gel may have no strength.

**References**

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Philpot et al., 2006. Environmental factors that affect the ability of amylose to contribute to retrogradation in gels made from rice flour. J. Agric. Food Chem., 54 (4), 5182 – 5190

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Chapter 5

Tempering Trial

Addresses the objective e: Continue to conduct research that compliments and develops the scope of the Quality Evaluation Program.

NOTE: This work was presented at the 3rd International Rice Congress in 2010

Introduction

Stress fissures in rice grains and subsequent poor Head Rice Yield (HRY) originate from absorption and desorption of moisture during grain filling or from post-harvest handling (Siebenmorgen et al., 1998; Iguaz et al., 2006). Most research to improve HRY has focused on the latter. Here we focus on the environmental stress that can occur pre-harvest.

Pre-harvest evaporation rates, rainfall events and individual variety influence grain filling and the associated moisture content of the grain. Often the grower has to gamble between the moisture content of the crop and the forecasted weather to decide when to harvest the grain. To reduce this risk to growers, post harvest options to overcome inopportune pre-harvest conditions are considered.

Tempering the grain above the glass transition temperature to relieve any moisture gradient induced stress fissures is adopted to improve HRY in rice subjected to harsh drying (Dong et al., 2010; Cnoossen et al., 2003). Here the same technique is explored to alleviate environmental induced reduction in HRY.

Material and Methods

Material: Four medium grain varieties with ~20% amylose content and a gelatinisation temperature of ~68 °C were grown in the 2007/08 and 2009/10 season. Fig 5.1a shows the two sowing dates and the harvest date in 2007/08 and Fig 5.1b shows the sowing date and harvest date for 2009/10.
Tempering treatment: Paddy rice was dried gently in ambient temperature to 14 % moisture then packaged in double sealed zip-lock bags. This ensured constant moisture content of the sample throughout the trial (paired t test).

Brown and paddy rice were stored constantly at 10 °C and 17 °C to mimic industry, with some of those stored at 17 °C tempered at 35 °C (glassy state) and 60 °C (rubbery state) for 1 hour (2007/08 trial) and either 1, 2 or 3 hours at 35 °C and 60 °C (2009/10 trial).

Head Rice Yield (HRY): HRY is calculated as the percent of milled whole grain rice derived from 150 g of paddy rice. Based on a 10 % degree of milling the maximum HRY that can be achieved is ~70 %.

Statistical validation: A multiphase, partially replicated design was used. Each season was analysed separately by fitting a linear mixed model with variety, tempering (4 trt in 2008, 8 trt in 2009/10), grain type, bay (2009/10 only), all their interactions and experimental structure fitted as random. Variance components were used to calculate the percentage of variation explained. Relevant effects were tested using a chi squared change in log likelihood test. The model was used to predict the average HRY for each variety.
Results and Discussion

The 2007/08 trial involved two sowing dates and a single harvest date with a hot spell during grain filling (Figure 5.1a). Table 5.1 shows that the early sown rice varieties (Bay 8) have harvest moistures ~5 % lower than those sown later (Bay 2), yet all except Jarrah produced high HRYs.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Bay 8 Harvest Moisture</th>
<th>Bay 2 Harvest Moisture</th>
<th>Bay 8 Days to Flower</th>
<th>Bay 2 Days to Flower</th>
<th>Bay 8 Predicted HRY</th>
<th>Bay 2 Predicted HRY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jarrah</td>
<td>17.6</td>
<td>19.4</td>
<td>101</td>
<td>95</td>
<td>51.8</td>
<td>69.6</td>
</tr>
<tr>
<td>M205</td>
<td>19.9</td>
<td>24.9</td>
<td>110</td>
<td>103</td>
<td>70.8</td>
<td>71.6</td>
</tr>
<tr>
<td>Quest 19</td>
<td>18.9</td>
<td>23.7</td>
<td>106</td>
<td>105</td>
<td>64.1</td>
<td>70.5</td>
</tr>
<tr>
<td>Reiziq</td>
<td>17.5</td>
<td>23.4</td>
<td>105</td>
<td>104</td>
<td>65.7</td>
<td>70.9</td>
</tr>
</tbody>
</table>

Table 5.1: Harvest moisture, days to flowering and predicted Head Rice Yield in 2007/08

Jarrah flowered much earlier than the other varieties and recorded a low harvest moisture which translated to a poor predicted HRY. Yet when Jarrah was harvested at a higher moisture (similar to that of early sown varieties) the predicted HRY reached the maximum theoretical HRY.

In 2009/10 a warmer vegetative period shortened the days to flowering, similar to the late sown trial of 2007/08 (Figure 5.1). Rainfall events delayed harvest, resulting in harvest moisture well below the early sown in 2007/08. As expected, the predicted HRY was poor (Table 5.2).

<table>
<thead>
<tr>
<th>Variety</th>
<th>Harvest Moisture</th>
<th>Days to Flowering</th>
<th>Predicted HRY for 2009/10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jarrah</td>
<td>15.7</td>
<td>94</td>
<td>58.5</td>
</tr>
<tr>
<td>M205</td>
<td>15.7</td>
<td>103</td>
<td>65.7</td>
</tr>
<tr>
<td>Quest 19</td>
<td>15.0</td>
<td>101</td>
<td>60.7</td>
</tr>
<tr>
<td>Reiziq</td>
<td>14.6</td>
<td>101</td>
<td>57.7</td>
</tr>
</tbody>
</table>

Table 5.2: Harvest moisture, days to flowering and predicted Head Rice Yield in 2009/10

This confirms that harvest moisture and variety have an influence on HRY, and highlights events that can lead to harvest at moisture below 24 %. This result is captured in Table 5.3 which shows that the bay (harvest moisture) and variety explained 44.5 % of variance (p-value < 0.001) in 2007/08 and the variety explained 69.03% of variance in 2009/10.

<table>
<thead>
<tr>
<th>Fitted Effect</th>
<th>2007/08</th>
<th>2009/10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bay (ie. Early (Bay2) or late sown Variety</td>
<td>35.05</td>
<td>-</td>
</tr>
<tr>
<td>Bay x Variety</td>
<td>44.56</td>
<td>-</td>
</tr>
<tr>
<td>Grain Type (brown v paddy)</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Bay x Grain Type</td>
<td>0.00</td>
<td>-</td>
</tr>
<tr>
<td>Variety x Grain Type</td>
<td>0.03</td>
<td>0.01</td>
</tr>
<tr>
<td>Bay x Variety x Grain Type</td>
<td>0.14</td>
<td>-</td>
</tr>
<tr>
<td>Tempering</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Grain Type x Tempering</td>
<td>0.00</td>
<td>0.07</td>
</tr>
<tr>
<td>Variety x Grain Type x Tempering</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Experimental Structure eg field rep,</td>
<td>9.07</td>
<td>29.13</td>
</tr>
<tr>
<td>Residual</td>
<td>0.71</td>
<td>1.76</td>
</tr>
</tbody>
</table>

Table 5.3: Percent variation explained by various fitted effects
Tempering above the glass transition temperature was not able to alleviate stress fissures in the grain caused pre-harvest (Table 5.3). That is, stress fissures that occur pre-harvest are irreversible and cannot be alleviated post-harvest.

In an effort to improve water use efficiency, the Australian rice industry is shifting towards shorter duration varieties such as Jarrah which are clearly more vulnerable to harvest conditions (Table 5.1 and 5.2). In short duration varieties, grain filling shifts towards the warmer period of the Australian summer and introduces other complexities such as higher incidence of chalk (again this reduces HRY). This struggle between efficient water use and maximum HRY cannot be overcome post-harvest so more emphasis needs to be placed on the introduction of tolerance mechanisms pre-harvest.

**Conclusions**

The opportunity to utilise tempering techniques to improve the HRY of crops that have been harvested too late, or harvested after a wet grain filling period, can not been achieved.

**References**


Dong et al., 2010. Effect of drying and tempering on rice fissuring analysed by integrating intra-kernel moisture distribution. J. Food Engineering, 97, 161-167

Iguaz et al., 2006. Influence of handling and processing of rough rice on fissures and head rice yields. J. Food Engineering, 77, 803-809

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Chapter 6

Grain quality of rice from northern Australia

Addresses the objective c: Continue to conduct research that compliments and develops the scope of the Quality Evaluation Program.

Introduction

This report is a brief summary of the grain quality of several of the major Australian rice varieties grown across Australia in 2008/09. The preliminary report is limited to data on the primary grain qualities, and limited to a few varieties that were common to all sites. Further studies to broaden the scope of the grain qualities tested and the diversity of germplasm (that is, those suited to both the temperate and tropical regions) are imperative for a consensus on the identification of varieties that will have potential in the northern regions of Australia.

Grain quality is reported on eight Australian rice varieties grown in three locations across Australia: Yanco, Mackay and Ord. While Yanco is in a temperate region with soil conditions being consistent across the region, it was observed that considerable field variation exists at Mackay and Ord. To illustrate this point, Figure 6.1 shows field variation in RVA viscosity measured on samples from each location.

Figure 6.1: Field variation in viscosity on samples from Yanco (a), Mackay (b) and Ord (c).

To quickly compare varietal performance at each location, and to be certain that conclusions for each dataset are consistent throughout the dataset, only the results of one plot from each location are used (see Table 6.1). If required, a full report can be made available after some statistical analysis have been completed.
Table 6.1: Variety sample identification

<table>
<thead>
<tr>
<th>Variety</th>
<th>Grain</th>
<th>Yanco</th>
<th>Mackay</th>
<th>Ord</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amaroo</td>
<td>YRA09 2-16</td>
<td>NT09MG 1-34</td>
<td>Plot 4</td>
<td></td>
</tr>
<tr>
<td>Bengal</td>
<td>YRA09 25-10</td>
<td>NT09MG 2-11</td>
<td>na</td>
<td></td>
</tr>
<tr>
<td>Earl</td>
<td>YRA09 27-3</td>
<td>NT09MG 1-36</td>
<td>na</td>
<td></td>
</tr>
<tr>
<td>Reiziq</td>
<td>YRA09 25-3</td>
<td>NT09MG 2-32</td>
<td>na</td>
<td></td>
</tr>
<tr>
<td>Quest</td>
<td>YRA09 3-6</td>
<td>NT09MG 2-2</td>
<td>Plot 2</td>
<td></td>
</tr>
<tr>
<td>Doongara</td>
<td>YRB09 14-9</td>
<td>NT09LG 1-37</td>
<td>Plot 1</td>
<td></td>
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<tr>
<td>Langi</td>
<td>YRB09 4-4</td>
<td>NT09LG 1-06</td>
<td>Plot 3</td>
<td></td>
</tr>
<tr>
<td>Kyeema</td>
<td>YRB09 4-17</td>
<td>NT09LG 1-14</td>
<td>na</td>
<td></td>
</tr>
</tbody>
</table>

**Physical qualities**

The physical properties of grain are shown in Table 6.2. The samples grown in Mackay stand out for their higher millout and lower chalk values. The chalk values in samples from the Ord are high – this is thought to be due to immature grains rather than being a temperature effect. Such could be overcome with earlier sowing. Grain dimensions are maintained across the different locations. Grain yellowness remained relatively consistent across locations.

Table 6.2: Grain dimensions of eight varieties grown at three locations

<table>
<thead>
<tr>
<th>Variety</th>
<th>Grain</th>
<th>Length (mm)</th>
<th>Width (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Yanco</td>
<td>Mackay</td>
</tr>
<tr>
<td>Amaroo</td>
<td>Medium</td>
<td>5.45</td>
<td>5.42</td>
</tr>
<tr>
<td>Bengal</td>
<td>Medium</td>
<td>5.77</td>
<td>5.73</td>
</tr>
<tr>
<td>Earl</td>
<td>Medium</td>
<td>5.60</td>
<td>5.53</td>
</tr>
<tr>
<td>Reiziq</td>
<td>Medium</td>
<td>5.94</td>
<td>5.83</td>
</tr>
<tr>
<td>Quest</td>
<td>Medium</td>
<td>5.56</td>
<td>5.63</td>
</tr>
<tr>
<td>Doongara</td>
<td>Long</td>
<td>6.72</td>
<td>6.60</td>
</tr>
<tr>
<td>Langi</td>
<td>Long</td>
<td>6.72</td>
<td>6.66</td>
</tr>
<tr>
<td>Kyeema</td>
<td>Long</td>
<td>6.69</td>
<td>6.52</td>
</tr>
</tbody>
</table>

Table 6.3: Head Rice Yield, chalk and yellowness of seven varieties grown at three locations

<table>
<thead>
<tr>
<th>Variety</th>
<th>Head Rice Yield (Millout) (%)</th>
<th>Chalk (%)</th>
<th>Yellowness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yanco</td>
<td>Mackay</td>
<td>Ord</td>
</tr>
<tr>
<td>Amaroo</td>
<td>59.0</td>
<td>73.1</td>
<td>56.3</td>
</tr>
<tr>
<td>Bengal</td>
<td>58.0</td>
<td>67.4</td>
<td>na</td>
</tr>
<tr>
<td>Earl</td>
<td>55.3</td>
<td>41.4</td>
<td>na</td>
</tr>
<tr>
<td>Reiziq</td>
<td>70.4</td>
<td>68.5</td>
<td>na</td>
</tr>
<tr>
<td>Quest</td>
<td>70.8</td>
<td>62.3</td>
<td>57.9</td>
</tr>
<tr>
<td>Doongara</td>
<td>55.7</td>
<td>64.2</td>
<td>35.4</td>
</tr>
<tr>
<td>Langi</td>
<td>59.4</td>
<td>66.0</td>
<td>58.0</td>
</tr>
<tr>
<td>Kyeema</td>
<td>49.0</td>
<td>60.0</td>
<td>na</td>
</tr>
</tbody>
</table>

Table 6.1: Variety sample identification

Table 6.2: Grain dimensions of eight varieties grown at three locations

Table 6.3: Head Rice Yield, chalk and yellowness of seven varieties grown at three locations
Cooking qualities

Cooking qualities are classified into structural and functional properties. Structural properties typically include amylose and protein content and their associated structures. Cooking properties include viscosity curves, texture and gelatinisation temperature that provide insight into the quality class of each line.

Table 6.4 is a summary of the amylose and protein content of a selection of rice grown at the three locations around Australia. Excluding Earl, the amylose content for samples from Mackay and Ord are similar while the protein contents from Yanco and the Ord are similar. The amylose content at Mackay and Ord is low and is consistent with a hot grain-filling period as reported for those regions. The protein content for Mackay is high and reflects the high nitrogen input into the soil demanded by the history of the site.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Grain</th>
<th>Amylose (%)</th>
<th></th>
<th>Protein (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Yanco</td>
<td>Mackay</td>
<td>Ord</td>
</tr>
<tr>
<td>Amaroo</td>
<td>Medium</td>
<td>19.0</td>
<td>13.7</td>
<td>13.2</td>
</tr>
<tr>
<td>Bengal</td>
<td>Medium</td>
<td>16.8</td>
<td>14.8</td>
<td>na</td>
</tr>
<tr>
<td>Earl</td>
<td>Medium</td>
<td>17.4</td>
<td>15.8</td>
<td>na</td>
</tr>
<tr>
<td>Reiziq</td>
<td>Medium</td>
<td>16.8</td>
<td>11.7</td>
<td>na</td>
</tr>
<tr>
<td>Quest</td>
<td>Medium</td>
<td>19.3</td>
<td>13.3</td>
<td>12.3</td>
</tr>
<tr>
<td>Doongara</td>
<td>Long</td>
<td>25.6</td>
<td>23.5</td>
<td>21.9</td>
</tr>
<tr>
<td>Langi</td>
<td>Long</td>
<td>18.8</td>
<td>13.5</td>
<td>12.1</td>
</tr>
<tr>
<td>Kyeema</td>
<td>Long</td>
<td>17.0</td>
<td>14.9</td>
<td>na</td>
</tr>
</tbody>
</table>

Table 6.4: Structural properties of grain (Protein determined by October 2009 NIR calibration)

Viscosity curves have been generated for each variety and compared to Yanco (Figure 6.2 for medium grains and Figure 6.3 for long grains). The stable amylose and protein content of Earl is reflected in similar viscosity curves, while substantial variation in viscosity curves exists for all other varieties. Variation in the viscosity curves can be explained, in part, by the composition of the grain. Typically, a high amylose content can be seen as a positive setback (that is, final viscosity is higher than peak viscosity), and an increase in soil N can change the protein content and suite of proteins and cause a lower peak viscosity. However, these ‘rules of thumb’ do not explain the viscosity curves of samples sourced from the Ord and further investigations are warranted.

As expected, the amylose content and structure of the grain are proportional to the hardness of the gel. As such, Mackay and Ord grown samples were softer than those from Yanco (Table 6.5).

<table>
<thead>
<tr>
<th>Variety</th>
<th>Yanco</th>
<th>Mackay</th>
<th>Ord</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amaroo</td>
<td>1.05</td>
<td>0.69</td>
<td>0.66</td>
</tr>
<tr>
<td>Bengal</td>
<td>1.09</td>
<td>0.63</td>
<td>na</td>
</tr>
<tr>
<td>Earl</td>
<td>1.21</td>
<td>0.62</td>
<td>na</td>
</tr>
<tr>
<td>Reiziq</td>
<td>1.02</td>
<td>0.69</td>
<td>na</td>
</tr>
<tr>
<td>Quest</td>
<td>1.37</td>
<td>0.60</td>
<td>0.65</td>
</tr>
<tr>
<td>Doongara</td>
<td>2.83</td>
<td>3.10</td>
<td>1.93</td>
</tr>
<tr>
<td>Langi</td>
<td>1.44</td>
<td>0.60</td>
<td>0.67</td>
</tr>
<tr>
<td>Kyeema</td>
<td>1.03</td>
<td>0.59</td>
<td>na</td>
</tr>
</tbody>
</table>

Table 6.5: Hardness of the cooled gel
Figure 6.2: Viscosity traces of medium grains
Figure 6.3: Viscosity traces of long grains
Chapter 7

Presenting Rice Quality to a wide audience

Communicating the outcomes and outputs of all objectives.

Addresses the milestones reported on in the Annual Progress Reports.

Conferences

2008

With the support of a Young Researcher Travel Scholarship from the RACI Cereal Chemistry Downunder, Rachelle Ward was able to accept the invitation to speak at the American Association of Cereal Chemists held in Hawaii in 2008. The work presented was derived from Rachelle’s PhD rather than work funded by Rice Quality V and is included here because of its origins in previous Rice Quality projects and relevance to the current Rice Quality V project.

Title: Peering through the lens of diversity for different traits of rice quality

Authors: Ward, R. M. §, Waters, D. †, Naredo Y. †, Philpot, K. §, McNally, K† and Fitzgerald, M. A. †

§ NSW Department of Primary Industries, Yanco Agricultural Institute, Yanco NSW 2703 Australia
† Southern Cross University, Lismore NSW Australia
† International Rice Research Institute, Los Baños, The Philippines

Abstract: Amylose content defines many eating and cooking properties of the rice grain. There are three classes of amylose based on iodine-binding of the amylose: > 25 % is considered a high amylose content, 25 – 18 % is an intermediate amylose content and < 18 % are low amylose varieties. Currently, there are two screening tools available to classify rice. The CT repeat in the flanking region of intron 1 of the Waxy gene can explain around 80 % of the variation in the US germplasm. A G/T substitution at the splice site of intron 1 can differentiate between the low amylose content varieties (< 18 % amylose) and the high and intermediate amylose varieties (> 18%), but is unable to differentiate between the high and intermediate amylose varieties. Amylose may be further classified by a second substitution identified within intron 1. Preliminary data suggests that the SNP is capable of differentiating between varieties of intermediate and high amylose content.

Title: Impact of temperature and carbon dioxide on the quality of rice

Authors: Ward, R. M. §, and Fitzgerald, M. A. †

§ NSW Department of Primary Industries, Yanco Agricultural Institute, Yanco NSW 2703 Australia
† International Rice Research Institute, Los Baños, The Philippines

Abstract: The impacts of global warming and climate change on rice have featured strongly in both scientific literature and the media. Previous research has generally focused on the impact of climate change on yield with information on rice quality being neglected. Given that grain quality drives the both the global and local marketplace, it is important that some emphasis should also be placed on the affects of climate change on rice grain quality. In this study four rice varieties were grown in four controlled environments: ambient (380 ppm) and elevated (780 ppm) carbon dioxide levels, and during the reproductive stage each carbon dioxide group was further divided into two temperature regimes, 25/19 °C or 30/20 °C (day/night temperatures). Overall temperature was the dominating climatic feature driving down the amylose content in Wx Varieties, and the high nitrogen fertilization rate skewed the overall ratio of amylose and amylopectin. Changes in the structure of starch were matched by changes in functional qualities. The viscosity curve parameters of immediate retrogradation and
setback decreased with temperature but remained unchanged by the carbon dioxide level. The physical dimensions and weight of the grains remained unchanged with environmental treatment however less chalk was observed in elevated carbon dioxide levels. Overall it is clear that temperatures during the reproductive stage have the dominant affect on rice grain quality and increased carbon dioxide levels do very little to ameliorate those negative effects.

Rachelle Ward presented a poster co-authored by Margrit Martin at the 58th ACCC titled ‘Changes in cooking properties of milled Australian rice during three different storage temperatures’. This work is featured in Chapter 4.

2009

Rachelle Ward was part of the organising committee for the 59th Australian Cereal Chemistry Conference (ACCC) held in Wagga Wagga. In keeping with the theme of the conference and as the conference was held nearby the heart of the rice industry, Rachelle initiated a rice industry tour of taking in Industry & Investment NSW, SunRice and a local winery. Approximately 20 people attended the tour and the feedback was very positive.

Margrit Martin and Rachelle Ward presented a poster at the 59th ACCC titled ‘Determination of gelatinisation temperature for the rice breeding program’. This work is featured in Chapter 2 under the sub-heading Starch Synthase IIa markers.

2010

To the International Vitamin Conference held in Copenhagen in February 2010, Jayashree Arcot presented a poster titled ‘Fortification of Folic Acid in Rice Under Parboiling’ authored by Karrie Kam, Rachelle Ward and Jayashree Arcot.

A poster authored by Margrit Martin, John Oliver and Rachelle Ward was presented by John Oliver at the 60th Cereal Chemistry Conference held in Melbourne. The poster was a summary of the work presented in Chapter 5.
The poster titled ‘Impact of folic acid – fortification of rice using parboiling on colour of rice co-authored by Karrie Kam, Rachelle Ward, Robert Driscoll and Jayashree Arcot was the recipient of the student poster prize at the 60th Cereal Chemistry Conference held in Melbourne.

A poster titled ‘Predicting rice grain quality by NIR’ co-authored by Brian Dunn and Rachelle Ward was presented at the 14th Australian Near Infrared Spectroscopy Conference in Adelaide.

Rachelle Ward supported by a Travel Grant from the EH Graham Centre and Margrit Martin supported by RIRDC presented a poster at the 3rd International Rice Congress in Vietnam in November 2010. The poster is a summary of the work presented in Chapter 6. Travel reports of this trip were made available to RIRDC and are in the Appendix.

Field Days

It is extremely important to have presence and recognition by District Agronomists at Field Days and public events that are attended by the grower. To achieve this, not only does the cereal chemistry team attend the field days, we also present posters and the occasional talk to the growers. At the 2011 Field Day, the cold tolerant variety Sherpa was released. Cereal chemistry presented a poster with the quality data relating to the new variety, set up a tasting station and distributed a summary sheet where all quality attributes were defined. This summary sheet aimed at highlighting the complex discipline of taste testing.
Publications

2008

**CCD Newsletter** – a RACI publication November 2008

2009

*Publication* – A publication based on an International Network for Quality Rice project

*Conference Proceeding* - Proceedings of the 59th Australian Cereal Chemistry Conference 2009
C.Blanchard, D. Pleming and H.Taylor
Determination of Gelatinisation Temperature for the Rice Breeding Program. M.Martin and R. Ward

*Primefacts* - an Industry & Investment NSW publication

The Primefact 908 titled ‘Rice Cereal Quality’ was written to inform and promote the activities and potential of the cereal chemistry section at Yanco Agricultural Institute. The Primefact has been disseminated at field days, RIRDC workshops, industry tours, visitors and current and new staff.

2010

*Agriculture Today* – an I&I NSW publication

‘Enriching rice with folic acid to lift health’

*Rice Today* April-June 2010 edition – an IRRI publication

‘The trouble with rain’ featured an article on the state of play of Australian rice research.

*in progress:* - Proceedings of the 60th Australian Cereal Chemistry Conference 2010

Visitors

*PhD students*

Karrie Kam – a UNSW student co-supervised by Rachelle Ward has spent a total of 3 weeks working in the cereal chemistry lab working on a project that aims to improve the nutritional quality of rice by parboiling brown rice with folic acid. While at Yanco, Karrie has conducted physical and chemical analysis on the parboiled rice she prepared at UNSW. Karrie is due to complete her PhD at the beginning of 2011.

Shabana Kasem, a PhD student from Southern Cross University analysed her *wildtype* rices at Yanco Agricultural Institute.

*School work experience students*

In 2008 and 2010, several students from Leeton High School and Yanco Agricultural College undertook their work experience at Yanco Agricultural Institute. Students were offered hands-on experience performing supervised tasks within the Quality Evaluation Program.
In 2008, an Austrian agricultural exchange student visited for 4 days and was actively involved in various tasks within the QEP.

Yanco Experimental Farm celebrated its centenary over the October 2008 long weekend. The cereal chemistry section was opened to the public and a brief description of our work was given.

A description of the Industry Tour connected to the 59th Australian Cereal Chemistry Conference is described above.

Russell Ford (RRAPL), Helen Taylor (I&I NSW), Ian Godwin (UQ), Jayashree Arcot (UNSW), Chris Blanchard and Len Wade (CSU) have visited Yanco with the opportunity to develop projects for external funding in mind. Several applications have been developed to capitalise on such collaborations but to date none have been successful.

On invitation, Kellie Close (SunRice) visited the cereal chemistry lab to use the Seedcount to open the opportunity for technology transfer and better communication between SunRice and I & I NSW.

Develop and edit manuscripts with Professor QunYu Gao from Southern China University of Technology. There are three papers submitted on the physical modification of mung bean starch to improve its capacity as an improved food ingredient.

**Other**

**Occupational Health and Safety (OHS)**

The laboratory adopted the Risk Management Database (RMD) as required by the I&I NSW OHS policy. The RMD program is a register of Safe Working Method Statements (SWMS), a chemical register and associated Hazardous Substance Risk Assessments (HSRA) and Material Safety Data Sheets (MSDS), Personal Protection Equipment (PPE) log, maintenance requests and register, and safety and eye shower monitoring.

A considerable amount of time has been required to implement the RMD. To date, a significant amount of chemicals have been disposed of to reduce the associated paperwork required to store chemicals, majority of SWMS related to active Standard Operating Procedures (SOP) are in place and have been read and signed by new casual staff, PPE logs have been completed with each new staff member, maintenance requests adopted and showers and eye bath monitoring is up to date. Outstanding is a complete chemical register, HSRA and MSDS database which will be an on-going task.

**Quality Management System (QMS)**

Since 2006, the cereal chemistry lab has held ISO:9001 accreditation as required by I & I NSW. The accreditation is in place to ensure the integrity of the data produced by the laboratory. The main reference documents for the QMS are the SOPs that define all the methodologies used within the QEP, the annual Rice Cereal Chemistry Management Reviews and the calibration of equipment registers. The accreditation also assists with training and care of staff.

**Biometric support**

An objective of Rice Quality VI will be to upgrade the framework of the Rice Improvement/Quality Evaluation Program two-phase field/milling design to include a third-phase which incorporates the chemical or cooking quality analysis of plot and short row breeding lines to accommodate some of the variation already noted (eg gelatinisation temperature). For this to occur, the time of a dedicated biometrician needs to be budgeted for and allocated to the rice-based research programs conducted at
Yanco Agricultural Institute. This will alleviate the current delay between conducting a designed trial and receiving the analysed results which currently can take up to 24 months.
Results

The 3 core objectives of Rice Quality V:

(a) Perform the routine Quality Evaluation Program in a timely manner.

(b) Continue to improve the efficiency, accuracy and cost of the Quality Evaluation Program

(c) Continue to conduct research that compliments and develops the scope of the Quality Evaluation Program.

In relation to objective (a) all results were presented to breeders within the time frame expected as outlined in Chapter 1. This contributed to the release of a new variety, Sherpa, released at the Rice Field Day at Yanco Agricultural Institute on March 2 2011. Sherpa has a similar rice quality to Amaroo and can fulfil existing medium grain markets but has superior agronomic performance with a higher degree of cold tolerance. The faster maturity of Sherpa will improve water usage.

In relation to object (b) the main outcome of the project has been the accurate and efficient delivery of quality data to rice breeders to enable better selections as outlined in Chapter 2. Improvements include

- the evaluation of five new analytical techniques to either replace or add to the pool of grain quality assessments that can be adopted at short row and plot stage. In particular marker assisted selection was introduced routinely for the Starch Synthase IIa enzyme as a key emasure of stach quality; and the fragrance marker fgr was evaluated;
- retrofitting existing cold storage to minimise storage induced changes to grain qualities;
- updating software and computers to minimise data entry and thus error; and
- the restructuring of sample management between the rice breeding section and rice quality laboratory.

In relation to objective (c) research was conducted on

- the effect of storage on cooking qualities;
- effect of free fatty acids on RVA viscosity curves;
- tempering as a meand to improve Rice Head Yield; and
- grain quality of northern Australian trials.

These results are reported in Chapters 3-6

Chapter 7 outlines the various ways outcome and outputs from Rice Quality V and rice quality in general has been communicated to a wider audience.
Implications

The Australian rice industry will directly benefit from the release of Sherpa rice as a new medium grain variety with quality that will supplement its agronomic and cold tolerance advantages.

The benefits from the efficiency improvements made to the Quality Evaluation Program and additional data it will generate will continue as a legacy of Rice Quality V in the future development of improved rice varieties.

In this way the rice improvement – rice quality team contributes to productivity growth in the industry to underpin a competitive industry and strong rural communities.

The evaluation of quality in trials in northern Australia will ensure compatibility with market specification thereby opening opportunities for growers in those regions.

The creation of the partnership between I&I NSW, RIRDC and SunRice to co-invest in rice breeding and rice quality will stabilise the financial uncertainties of the Rice Quality program and further contribute to these benefits.

Recommendations

- That the Rice Quality Evaluation Program continue to be supported by RIRDC and the rice industry to ensure all new rice varieties released have qualities suitable for market that augment their agronomic improvements.
- Consideration be given to capital expenditure to purchase a SeedCount to replace the Cervitec and provide an objective measure of physical grain qualities.
- Investigate improvements to noise levels in mill room.
- Investigate the masking of lipids to better estimate amylase content in brown rice.
- Fully adopt NIRS to measure protein content.
- Validate the fgr marker for fragrance.
- Continue to evaluate the quality of grain produced in northern Australia to ensure compatibility with market specifications.
- That the research team be supported to attend national and international conferences to communicate research conducted and learn from others better (cheaper, easier, quicker) ways of conducting quality assessments.
Appendices

Travel Reports of Dr Rachelle Ward and Margrit Martin re attendance at the 3rd International Rice Congress, Vietnam, November 2010.
Overseas travel report

To attend the 3rd International Rice Congress and the 2nd International Network for Quality Rice symposium

Dr Rachelle Ward
Cereal Chemist
Productivity and Food Security Research Branch,
Yanco Agricultural Institute, Yanco NSW 2703

Travel supported by the EH Graham Centre Conference Support Grant and research funded by the Rural Industries Research and Development Corporation

NOVEMBER 2010
Title: Overseas travel report

Template prepared by:
Erin Curran, Executive Secretary, Executive Services, Orange

First issued December 2007
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Section 1: One Page Summary

Name of Officer, Position, Location

Officer: Dr Rachelle Ward
Position: Cereal Chemist
Location: Yanco Agricultural Institute

Purpose of Travel

- To attend and present at the 3rd International Rice Congress, to keep abreast of the research conducted around the world and to develop new research ideas, and to develop and maintain a relationship with international researchers.
- To participate in the 2nd International Network for Quality Rice symposium

Itinerary

The overseas travel commenced on 06/11/2010 and finished on 13/11/2010. Between these dates I visited:

- The National Convention Centre, Ha Noi, Vietnam for the 3rd International Rice Congress and a meeting with members of the International Network for Quality Rice.

Benefits and Outcomes of the Travel

Attendance at the International Rice Congress (IRC) enabled the opportunity to listen to presentations not only on rice quality but also on topics ranging from policy, research directions for the 21st century and post-harvest handling of rice. Exposure to this range of topics surrounding rice production provided the global backdrop of where the NSW rice industry fits into the big picture. Over 1300 delegates from more than 60 countries attended the congress, so there was great opportunity to re-connect with researchers from my days at IRRI and The University of Sydney and the chance to meet researchers from a diverse background.

Key Recommendation(s)

1. That opportunity to broaden researchers’ knowledge base about global issues pertaining to sustainable rice production be encouraged via attendance at international, rice focused meetings.

2. That, where possible, the cereal chemistry laboratory at Yanco be involved in method development as part of the International Network for Quality Rice. The next project will be dedicated to the establishment of a method to measure gelatinisation temperature.

3. That seed money be available to apply for external funding to conduct research into grain quality issues that will result in production of consistent and superior grain quality. For example, investing in a research project that links instrumental analysis with sensory analysis using the CSU Wine and Grape sensory lab, investing in research that understand the branching mechanism of amylose that leads to low amylose content when the grain filling coincides with high temperatures, and be readily available for international research collaborations (eg, host a Pakistani PhD student for 6 months).

Funding Organisation(s)

Travel was kindly supported by a $2000 Travel Grant from the EH Graham Centre, and research was funded by Rural Industries Research and Development Corporation.
Attend and present at the International Rice Congress (IRC2010) and to participate in the International Network for Quality Rice Symposium (INQR)

Section 2: Body of Report

Background

Government Priority

Presentation at the 3rd International Rice Congress contributed to the NSW State Plan objectives of:

- Our economy grows stronger – supporting jobs and attracting business investment
  
  By attending the Congress and learning about current research trends and outcomes, I believe I have a better capacity to apply more informed and refined research skills to the development of new rice varieties that can better sustain and improve the economy of our local rice industry and community. For example, through discussions with fellow cereal chemists I learnt that NIR is not a useful analytical beyond nitrogen and moisture content of grain.

- Our children are better educated, our people more skilled and we are known for our research and innovation.

Attendance and presentation at an international congress is a vital learning opportunity for researchers. Exposure to direct grain quality research and associated research can only enhance our knowledge and focus our attention towards more refined research milestones. A UNSW student I am co-supervising, Karrie Kam, was able to attend the conference and together we were able to clearly place her research in the global context. Karrie’s PhD is focused on enhancing the nutritional quality of rice by including folic acid in the soaking step of the parboiling process. In contrast, the cereal chemists in Africa are tailoring their work towards standardising and providing similar equipment to the small scale rice producers so their individual product is all is similar standard.

The overall outcomes of this travel contribute to the following Industry and Investment NSW strategic goals:

- Competitive and productive industries
  
  The strength of the Australian rice industry is its ability to produce high yielding medium grain rices that can satisfy an array of global markets. This can only be achieved through the continued improvement of methodologies and associated research that can be incorporated into the breeding program. Attendance and presentation at the Congress is one of many ways to achieve this because there is opportunity to engage in informal conversation about various topics with researchers and share advice on problems they may have and gain advice on issues we may have. For example, as our instrumentation is hitting its used by date I now know exactly which grinder to purchase which reduces a source of difference when comparing results from other rice chemistry labs throughout the world.

- Sustainable use of natural resources
  
  Much needed research is required to ensure that the rice industry is sustained throughout periods of prolonged drought, high temperatures, possible reductions in inputs such as fertilisers, increased demand on natural resources such as land and water and changes in market share and needs. Knowledge of these constraints to rice production is the first step of achieving a sustainable industry, next is to create linkages with other research programs to develop research projects that can directly address some of these issues. At
Attend and present at the International Rice Congress (IRC2010) and to participate in the International Network for Quality Rice Symposium (INQR)

the Congress, I learnt about the varied constraints on the local industries around the world such as the fact that labour is cheaper than instrumentation so the labs are set up to reflect that and am thinking about options to develop them into projects or at least opportunities to share experiences and knowledge with those people.

Attendance and presentation at an international conference enabled Industry and Investment NSW to be represented on an international level. Participation at the conference and associated meetings provided an opportunity for Industry and Investment NSW professional staff to establish linkages with fellow research providers such as the members of the INQR. All benefits will ultimately lead to new directions and better focus for future research programs.

Industry Relevance

The NSW Rice Industry produces rice to the value of approximately $6-800M per annum when production is not limited by drought. The industry is unique in that the receivals, storage, milling, packaging and marketing is all carried out by the Ricegrower’s Cooperative which is owned by all of the rice producers in southern NSW. Thus the value of production is largely retained within the rice growing region. As 85-90% of the rice is exported, the industry is also earns significant export dollars for New South Wales. By world standards the average yields are high, around 10 tonnes per hectare for the 2006 harvest.

Due to the size of the Australian rice industry, opportunities to share knowledge amongst the global rice community and to collaboration opportunities are quite limited. The International Rice Congress was co-ordinated by the International Rice Research Institute (IRRI) and the extensive topics covered by the conference attracted a diverse range of delegates. Over 1300 delegates from 60 countries were in attendance, so the exposure to researchers from Africa, North and South America and Asia were endless and indeed a very valuable experience.

Discussions with fellow cereal chemists about the range of rice they analyse and the various techniques used to analyse their product was fruitful in many ways from deciding which grinder to purchase to the needs of consumers and therefore research objectives of each country. Presentations given at the IRC ranged from policy development, which research avenues are necessary to tackle in the 21st century to ensure a rice supply to sustain the growing population, and the need to empower women at all levels of agriculture from sowing the crop through to senior research levels.

Interestingly, there were often around 60 delegates listening to grain quality presentations at the congress which is in stark contrast to the number of presentations typically given at cereal chemistry conferences (<20 delegates). This refreshing participation rate was very exciting as the diversity of views and the research needs and constraints of each participant were able to be shared. Participation in the 2nd meeting of the International Network for Quality Rice (INQR), my first, strengthened the relationships with members and also highlighted the presence of the Australia rice industry and opportunities to contribute to the overall objective of unifying the methodologies adopted by rice quality labs around the globe. This interaction is valuable from a basic problem such as which grinder is best for small volume samples right through to discussions on matching experimental techniques to specific consumer markets around the world.

An example of the benefits of sharing knowledge comes from the announcement of a new ISO method to measure amylose content was released. This method made progress on the analytical component of the methodology but largely ignored how the various sample preparations (ie different grinders and therefore flour particle sizes) can impact on the result. So when the need arises to purchase new equipment, then access to and discussions with other cereal labs allows an opportunity for our sample preparation to be directly comparable to other labs and allow us to directly compare results with the confounded affects of sample preparation. This has
Attend and present at the International Rice Congress (IRC2010) and to participate in the International Network for Quality Rice Symposium (INQR)

benefits both in the research arena but also trade when amylose content is/should be a basic quality parameter considered in the purchase of rice.

Travelling Officer

My role within Industry and Investment NSW as the rice cereal chemist is to primarily support the rice breeding team in the delivery of new rice varieties that consistently yield rice with a high Head Rice Yield (millout) and superior grain quality that matches consumer markets. Achieving this primary objective begins with, but is not limited to, regular revisions of the Quality Evaluation Program such as evaluation of markers, streamlining processes, maintenance of equipment and keeping abreast of new technologies as well as support research targeted towards, post-harvest research in response to different farm management systems trialled and even different rice growing locations.

Objectives of the Travel

- To attend and present at the 3rd International Rice Congress, to keep abreast of the research conducted around the world and to develop new research ideas, and to develop and maintain a relationship with international researchers.
- To participate in the 2nd International Network for Quality Rice symposium

Detailed Itinerary

Table 1 provides a summary of travel, including institutions visited.

Table 1 Country and institution visited

<table>
<thead>
<tr>
<th>Country</th>
<th>Institution</th>
<th>Date From</th>
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Major Activities

Activity 1

*Attendance to the 3rd International Rice Congress.* The conference program was extensive with six concurrent programs running over 3 days. There were two days of rice quality talks – the grain quality session and the INQR meeting. These series of talks attracted around 60 delegates and although occasionally repetitive in topic there was opportunity before and after each session to engage with rice chemists from a diverse background. The sessions that I found most enlightening were the opening ceremony that included presentations by the Prime Minister of Vietnam and sessions run in the ‘Priorities for International Rice research in the 21st Century’ stream which gave an overview of the global status of rice production and what needs to be achieved. The issues raised that most impressed upon me is the need to empower women at every stage in agriculture and that it is mainly women who work in grain quality, that the questions that were raised 20 years ago as a point of
Attend and present at the International Rice Congress (IRC2010) and to participate in the International Network for Quality Rice Symposium (INQR)

urgency appear to be the same ones raised today with the exception of climate change related issues, that rice is a significant cultural part in the lives of many rice producers around the world (even in Leeton we have a rice festival every second year) and that grain quality was always mentioned as a key research objective but the finer details of that objective were not discussed.

Activity 2

Presentation at the Congress. We presented a poster titled ‘Post Harvest Treatment of Rice to Improve Head Rice Yield’ which attracted interest from a Pakistani who, on the behalf of his colleague, asked about opportunities for a 6 month research stay at Yanco.

The following is the Abstract of the presentation given:

POST HARVEST TREATMENT OF RICE TO IMPROVE HEAD RICE YIELD

Rachelle Ward, Margrit Martin and Elizabeth Mudford

Opportunities to increase Head Rice Yield exist within the post harvest treatment of grain. Drying grain prior to milling can cause a decrease in Head Rice Yield, although studies have shown that tempering the grain can alleviate and in some cases increase the Head Rice Yield. This study extends upon previous studies that temper rice above the transition temperature to alleviate the stress in the grain that creates cracks upon drying.

In this study, four Australian medium grain rice varieties were harvested at various grain maturities. Grain was dried in ambient temperature and humidity conditions to achieve a moisture content of 15% - the ideal moisture for milling and storage. Both paddy (rough) and brown grain were prepared for tempering to assess the role of the hull during tempering. Grain was exposed to tempering conditions used to reflect commercial appraisal lab and tempering conditions used in literature. Changes to the Head Rice Yield and physical qualities of the grain will be discussed in a commercial context.
Attend and present at the International Rice Congress (IRC2010) and to participate in the International Network for Quality Rice Symposium (INQR)

Margrit Martin (left) and Rachelle Ward (right) presenting their poster

Activity 3

As all the grain quality delegates were staying in the same hotel there was endless opportunity to engage in conversation with cereal chemists from Benin, Indonesia, America, India, Paraguay, Japan and more. This was an invaluable experience as I learnt about the type of research conducted by each chemist as well as some technical information which will be very handy as we begin to upgrade certain pieces of lab equipment. For example, as I will mention later, a survey of INQR members suggested that the Udy grinder is the most common and effective grinder available, that NIR to determine cooking qualities of rice is not a viable option to explore, and emphasised the opportunities that can occur through collaborations. Given the diversity of chemists, I also enjoyed talking about the coupling of cultural practices with the various analytical techniques and even how each chemist came to be in their position.

Benefits and Outcomes of the Travel

Benefits to NSW

Access to relevant and contemporary technology, methodology and research to assist the rice industry

1. capitalise on research that should sustain productivity on a regional level, and
2. sustain a vibrant agricultural community while minimising the footprint left on the environment.

Benefits to Industry

Knowing that the Australian rice industry has enormous capacity to deliver high quality new varieties, I learnt that we must also understand and appreciate at a deeper level the cultural background to the countries that we ultimately trade our rice with. That is, the classic G x E interaction should include x C to ensure the real success of the rice varieties we release. From a breeding perspective, a clear understanding of the market and the markets use of the rice (eg cooking techniques) would be beneficial in developing the spectrum of grain quality analysis conducted on the breeding lines during the lead up to release.

The establishment of new interactions with cereal chemists from around the globe and the continuation of existing relationships will ultimately form the foundation to ensure that Australia is well positioned in the global industry and may underpin the possibility of research exchanges and/or research collaborations that can open up opportunities to understand common problems associated with grain quality as well as expand awareness of the cultural aspects of rice research and rice production. With interest from Benin about our Standard Operating Procedures and interest from Pakistan about a student exchange coupled with an interest in parboiling techniques and grain quality in Ghana and India there are certainly opportunities to pursue should appropriate funding opportunities arise in the future.
Attend and present at the International Rice Congress (IRC2010) and to participate in the International Network for Quality Rice Symposium (INQR)

Benefits to Travelling Officer

There were many benefits gained from the overseas travel to Vietnam. These were:

- Gained experience presenting to an international conference
- Through personal contact established links primarily with the collective of INQR members to gain fresh ideas to enhance the research and evaluation of Australian rice quality
- Received exposure to a cross-section of rice-focused research and discussion. This included, but limited to, use of metabalomics to begin to pinpoint the difference between Jasmine and Basmati rice, revising the concept of G x E interactions, the need for sound policy in order to deliver innovative technologies, the need to match private sector benefits with grower benefits and reasons for parboiling around the globe.
- Identified equipment and technologies that will enhance I & I NSW research to underpin a productive industry. For example, a survey of INQR members suggested that the Udy grinder is the most common and effective grinder available, that NIR to determine cooking qualities of rice is not a viable option to explore, and emphasised the opportunities that can occur through collaborations.

Recommendation(s)

1. There are a range of research ideas and potential collaborations that have benefits for both Australia and also developing nations increase the marketability and nutritional properties of rice. Some of these have been alluded to in the text above, but others are originate from drawing pieces of information together from various snippets throughout the conference. The research ideas below are the more achievable and have the greatest impact on the global rice industry:

   a. The research with the UNSW student (Karri Kam) has shown the potential of parboiling to enhance the nutritional quality of rice and parboiling. This is a common technique in both India and northern Africa. It is recommended that collaborative research opportunities be pursued with Dr Rajeswari in India and Dr Gayin in Africa to develop techniques to improve the nutritional quality of rice would be very rewarding.

   b. Another frequent topic throughout the Congress is the need to empower women in agriculture and interestingly the majority of grain quality delegates were women so it would fantastic to develop a women-focused exchange program to allow women to spend time at Yanco for a cultural exchange on rice quality techniques and also rice industry systems which are often under-developed in many rice growing countries.

   c. I would also love to work with SRI (System of Rice Intensification) researchers who focus on an agro-ecological approach to establishing a sustainable and profitable rice industry using existing infrastructure but improved management.

   d. Locally, I think the rice industry would greatly benefit from clear and factual knowledge relating consumer sensory preferences to instrumentation.

2. It is recommended that all researchers have an opportunity to represent Industry and Investment NSW at an international event. The benefits to Australian research is that we can then benchmark our research on an international standard, gain experience at presenting at large conferences, interact with researchers with different backgrounds and thus ideas and an opportunity to become involved in international collaborative projects. That, when appropriate, senior Technical Officers also be given the opportunity to attend international meetings to develop their knowledge and to acknowledge their individual contribution and commitment to research.
Attend and present at the International Rice Congress (IRC2010) and to participate in the International Network for Quality Rice Symposium (INQR)

3. That Industry and Investment NSW, Yanco be involved in INQR working groups to standardise methods for measurement of pasting and gelatinisation temperature. These will enable alignment of the Industry and Investment NSW rice breeding program quality assessment protocols with industry and worlds best practice.

Acknowledgements

Funding Organisations(s)

I’d like to sincerely thank the EH Graham Centre for the $2000 Travel Grant that essentially allowed me to be able to present and attend the Congress.

Thanks to Rural Industries Research and Development Corporation for the financial support of the research and for the remaining funds to travel.

And lastly, thanks to Industry and Investment NSW for permission and support to travel.
Overseas travel report

Attend and present at the International Rice Congress (IRC2010) and participate in the International Network for Quality Rice Symposium (INQR) in Vietnam.

Margrit Martin
Technical Officer
Science and Research

November 2010
Title: Overseas travel report
Template prepared by:
Erin Curran, Executive Secretary, Executive Services, Orange
First issued December 2007
Section 1: One Page Summary

Name of Officer, Position, Location

Officer: Margrit Martin
Position: Technical Officer, Grade 3
Location: Yanco Agricultural Institute, Yanco NSW 2703

Purpose of Travel

To attend and present at the 3rd International Rice Congress and participate in the 2nd International Network for Quality Rice symposium.

Itinerary


Benefits and Outcomes of the Travel

- Attending the Congress gave me the opportunity to present and benchmark our research at the world’s largest gathering of the rice industry.
- Attending the Congress was a unique opportunity to listen to presentations/debates about problems and future research direction to secure global food security.
- At the INQR symposium a new amylose analysis method was launched which is in progress to become an ISO standard method. The direct outcome will be two collaborative research papers on measurement of amylose.
- Interaction with other researchers may lead to a research group from Pakistan doing some work at Yanco and discussions with an exhibitor may lead to Pivot rice irrigation trials in Australia.

Key Recommendation(s)

4. That we adopt and work with the new Amylose method and keep a strong link with INQR.
5. Maintain awareness of research development, mainly progress in molecular marker development

Funding Organisation(s)

The Rural Industries Research and Development Corporation.
Section 2: Body of Report

Background

Presentation at the 3rd International Rice Congress contributed to the NSW State Plan objective of:

- Our economy grows stronger – supporting jobs and attracting business investment

Even though Rice production is relatively low at the moment, rice is still an important crop to NSW farmers and SunRice is recognized as an award winning marketing organization. The development of new varieties through the rice breeding program is seen as the highest priority of the research by the rice industry. By attending the Congress and the INQR meeting I was exposed to the latest tools and developments in rice quality testing which will ultimately contribute to faster release of new varieties and sustain and improve the economy of our local rice industry and community. Of special relevance will be qualitative measurements of sensory attributes where we can address specific consumer demand early in the breeding program instead of expensive taste panel test in advanced breeding lines. Using molecular marker technology for determining gelatinization temperature (GT) early in the breeding program will also speed up the release of a variety.

And the Industry and Investment NSW strategic goals of

- Competitive and productive industries

The Australian Rice industry has its strength in high quality rice varieties, it is therefore imperative to use the latest research tools and know the market specifications and measure them with the same criteria around the globe. As an example chalk content in rice is measured visually or instrumentally and is expressed in many different ways. A body, like the INQR, where rice scientists come together and engage in working out a common definition is the way to move forward, compare and be competitive.

- Sustainable use of resources

Although breeding has long focused on shorter season rice and cold tolerance to save water, alternative management methods like alternate wetting and drying (AWD) and aerobic rices will be part of present and future research. The contact at the Congress with a Pivot irrigation company hopefully proves successful in rice trials and offers another option to save water or at least diversifying farming systems.

Industry Relevance

The NSW rice industry is worth an average of $800 million annually. It is important that our cultivars and processes remain competitive and at world best practice for grain quality. The NSW rice industry actively pursues differentiated product strategies in its export strategy, and each of the targeted markets
has specific guidelines for quality. In an international market where quality and nutrition are increasingly important factors in the saleability of our crop it is vital to stay at the forefront in research. Adopting the new ISO method to measure Amylose content which promises to be more accurate and comparable around the globe will benefit the breeding program and trade. The prospect that the method could lead to an NIR calibration would mean substantial savings in cost and time.

**Travelling Officer**

Attending the International Rice Congress was an opportunity to deepen my knowledge about global issues arising from increasing rice production to keep up with population growth while preserving natural resources. At the same time I was exposed to the latest rice research and future technologies in assessing rice quality which would not be possible in Australia.

**Objectives of the Travel**

- Attend the 3rd International Rice Congress from the 8th November to the 12th November 2010
- Present our research as a Poster titled: *Post Harvest Treatment of Rice to improve Head Rice Yield.*
- Attend the INQR symposium on the 9th November

**Detailed Itinerary**

Table 1 provides a summary of travel.

**Table 2 Country visited**

<table>
<thead>
<tr>
<th>Country</th>
<th>Institution</th>
<th>Date From</th>
<th>Date To</th>
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<tbody>
<tr>
<td>Vietnam</td>
<td>National Convention Centre, Hanoi</td>
<td>7.11.2010</td>
<td>13.11.2010</td>
</tr>
</tbody>
</table>

Day 1: (November 6th) Flight from Narrandera to Sydney with overnight in Sydney

Day 2: Flight to Hanoi with stopover in Ho Chi Minh City

Day 3: Day tour and Registration with Welcome Reception

Day 4: Congress opening Ceremony with the Address of the Prime Minister and the plenary Discussion ‘What is required to sustain the supply of Rice for future generations’. In the afternoon I participated in the INQR Symposium.

Day 5: Session ‘Raising the Yield Potential’ and in the afternoon the attendance of the ‘Quality’ session followed with Gala Dinner in the evening

Day 6: ‘Green Super Rice’ Symposium and in the afternoon the Plenary Closing Session

Day 7: Farewelling participants and final discussions

Day 8: Hanoi to Narrandera via Ho Chi Minh City and Sydney
Major Activities

Activity 1

-I attended two plenary sessions, the ‘Grain Quality’ and ‘Raising the Yield potential’ sessions.

The opening plenary discussion ‘What is required to sustain the supply of Rice for future generations’ highlighted different approaches. The challenge to feed an increasing population while farmland is lost to industrial and housing development, together with climate change and the need of high inputs like fertilizer and pesticides offers the opportunity to choose different approaches. New management practices, which can enlarge plant root systems or increase fertility and water retention of soils are proposed. One speaker has faith in Hybrid rice or rice with C4 photosynthesis. A bold statement that we produce enough, but should waste less stands out for me. A statement made in hindsight of using mass produced food as a commodity to speculate instead of supporting small scale farmers and locally produced food.

The ‘Quality session’ focused on new health traits, investigating the impact of diverse metabolite profiles among rice varieties on infectious disease using animal models, and the search for additional markers related to grain quality. Of particular relevance to the I&I NSW rice breeding program would be an additional marker for gelatinisation temperature (GT), a major cooking quality trait. GT of some varieties is classed as intermediate, but present SNP analysis of the SSIIA gene only separates GT into two classes. Research presented suggested that another enzyme apart from SSIIA is involved in intermediate GT.

On the last day I enjoyed listening to the ‘Green Super Rice’ symposium, where the need to move away from “high yield/high input” was highlighted. The effort to sustain production while conserving resources demands to go back to a broader genetic base where selection is not guided by high input. The Green Revolution, which doubled the rice yield, resulted from a mutant (sd1, a loss of a functional allele encoding Gibberellin). Over 95% of the current rice breeding programs are now carried out on this genetic background. Other traits like grain weight, spikelet fertility and biomass are closely associated with the sd1 gene and potential genetic consequences are highlighted. It is proposed to include lines of different genetic background into all research/breeding for the search of cultivars with less input demand.

Another presentation grabbed my attention where the claim was made that Silica is short in many soils. Research showed that addition of silica can increase yield and reduce pesticide input, i.e. the rice plant is more resistant to disease. As our rice Industry carries out NIR leaf tissue testing for protein I can see the possibility to measure and monitor Si at the same time. I have discussed the prospect with Brian Dunn the officer in charge of NIR tissue testing.

Activity 2

Participation in the INQR Symposium allowed us to see the collated results from the working groups:

-The Amylose project is in the final stage of releasing a new ISO standard method. Until now Amylose was measured by the absorbance of the Iodine-Amylose complex validated against a standard curve made up by potato amylose. Steps in this method varied from country to country either in reaction time or selected wavelength and ignored the absorbance contribution of Iodine-Amylopectin complex in rice.

Additionally commercial potato amylose varied from manufacturer to manufacturer or even between batch numbers. Now, every member of the INQR group receives yearly a set of 5 standard rices with a range of amylose content determined by Size exclusion chromatography. Hopefully globally we can now compare Amylose values and the chance of calibrating a NIR instrument to measure amylose would be the ultimate goal.
- The Physical Quality workgroup has met before and made decisions on common classifications of physical parameters but has now the task to find another instrument. This group has worked intensively with the Cervitec 1625, an instrument to measure physical quality attributes of rice like dimensions, chalk, cracks and brokens. Unfortunately the instrument will no longer be supported or manufactured by the company. Adapting existing instruments from other disciplines was suggested.

- The Sensory workgroup presented preliminary results correlating mainly volatiles to flavour, aroma and taste. This opens hopefully the opportunity to be able to measure subjective quality traits quantitatively in a laboratory instead of expensive taste panel evaluations.

**Activity 3**

During Lunch was the opportunity to present our work and discuss/interact with other participants:

Show casing the range of rice quality testing undertaken in our laboratory made a scientist from Pakistan interested in doing some of their quality work here. Hopefully this will lead to collaboration with that research group.

An Exhibitor from an irrigation company is interested in Pivot rice irrigation trials in Australia and asked for a contact. Peter Snell our rice breeder has shown interest and made initial contact, as he believes ‘the coupling of aerobic varieties with Pivots will offer a lot to existing and potential irrigation areas throughout Australia to widen the diversity of their farming system and hence minimise risk of mono-culture production’.

Syngenta Exhibition had a display where the quality of paddy rice is measured by putting a quantity of paddy rice in water and the floating part is measured as trash or unfilled grain. A method which grabbed my attention as being fast and probably as accurate as the tedious method of separating grains by hand.

**General Observations**

As the congress was huge with 6 concurrent sessions or workshops over 3 days there was limited opportunities to attend diverse sessions. As with most conferences there were many opportunities to network and interact with rice quality researchers from around the world. This was further enhanced by the INQR members staying at the same hotel in Hanoi. This group will work closely on two manuscripts for publication on ‘Measurement of Amylose’.

**Benefits and Outcomes of the Travel**

**Benefits to NSW**

Comparing and adopting new methods, like the measurement of Amylose content or using molecular marker tools for determining gelatinization temperature, ensures that the rice industry stays competitive and at the forefront in research. The breeding program can target specific markets faster and more accurate and in doing so maintain the economic development of rural NSW.

**Benefits to Industry**

Benefits to the Industry will flow on from using the latest research tools. Market demands can be easier defined (e.g. sensory requirements) and faster, cheaper and more accurate responded to (e.g. Amylose method or molecular technology for GT).
Benefits to Travelling Officer

The experience boosted my enthusiasm about rice quality…I feel part of a bigger research group and I feel a sense of recognition by the funding body (RIRDC) to let me take part.

I’m keen now to apply the new Amylose method on our varieties and compare them with existing values. I hope they classify our varieties clearly and are a useful value for the rice breeders.

Recommendation(s)

- Adopt and work with the new amylose method. Amylose content is considered the core cooking quality parameter and should be determined with the same method around the world. As soon as we have adopted the new values I recommend retrying a NIR calibration which was until now unsuccessful.

- Keep a strong link with INQR to reduce the danger of research isolation at Yanco.

- Maintain awareness of research development. Upcoming sensory evaluations, together with new molecular markers for Gelatinisation temperature could make our Quality evaluation program more powerful in selecting new rice varieties.

Acknowledgements

Funding Organisations(s)

I sincerely appreciate the opportunity to attend IRC2010 and the INQR Symposium and wish to thank the Rice Research Committee of the Rural Industries Research and Development Corporation for their support.

Other

I also wish to thank Industry and Investment NSW for the opportunity to participate in these events.

Section 3: Administration

Reconciliation of Expenses

A reconciliation of all expense relating to this travel has been provided to Industry and Investment’s overseas travel section.
Rice Quality V

by Rachelle Ward

Pub. No. 12/027

Provision of rice varieties with superior quality attributes and a ready market is the basic necessity for the continued sustainability of Australian rice growers and the overall rice industry.

Project Rice Quality V runs parallel with Project Rice Improvement III to ensure that released varieties such as Sherpa have both the grain quality and agronomic performance that will enable the approximately 4000 rice growers in the Murrumbidgee, Coleambally and Murray Irrigation Areas to be productive, have market entry and be able to command competitive process for their produce.

The report provides information for the wider rice community on the work conducted to identify rice crossesbreds with appropriate qualities for particular markets. RIRDC is a partnership between government and industry to invest in R&D for more productive and sustainable rural industries. We invest in new and emerging rural industries, a suite of established rural industries and national rural issues.

Most of the information we produce can be downloaded for free or purchased from our website <www.rirdc.gov.au>.

RIRDC books can also be purchased by phoning 1300 634 313 for a local call fee.