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Major Achievements & Outcomes

A novel method for detecting molecular markers useful in wheat was patented.

Participants have begun exploiting the outcomes of the storage project, which show how to avoid the "New Season's Wheat" disruption to bakeries.

Sales and orders of Centre products - primarily WheatRite® - reached six figures in the first real year of commercialisation.

Five PhD students and one MSc student have completed or submitted their theses for examination.

Three thousand tonnes of prime hard wheat were delivered in the Southern wheat belt - an increased income of more than nine million dollars to growers.

The independent economic evaluation of the Centre's program has reached its conclusions and has endorsed the technical direction taken in the Centre.

QAL 2000 New biscuit wheat was launched during the year.

The Z-arm mixer is moving into a commercial phase.

A protocol showing how to blend grists and flours for specific quality effects was presented to industry.

The Great Grain Quality Assurance package was marketed to growers and over 100 signed up in the first year.

The supply of tests that diagnose defects in early breeding material to wheat breeders doubled to more than eighteen thousand.

Extension training of growers and their advisors on the outcomes of quality research has been diversified and extended to all wheat-growing states.

Our "Managing On-Farm Grain Storage" CD-ROM has been distributed across the country.

A detailed technical report on flourmill microbiology has been sent out. Nearly seventy copies were issued, reflecting the importance of this work to industry.

The Quality Wheat CRC mission is to support the commercial development of the wheat growing and products industry - the 'grower to consumer' perspective. The CRC's goals reflect this industry-wide view, while focusing on those specific areas where the CRC has particular value to add to the industry's development.

The CRC's goals are to:

1. Develop new wheats and new products (food ingredients, feed and alternative use) that provide consistency and meet the quality requirements of domestic and export markets.
2. Develop improved diagnostic techniques to accurately identify wheat and product quality consistency at different points in the value added chain.
3. Develop wheat production, handling and processing technology to improve industry capacity to utilise wheat of varying characteristics, thus improving the product performance of these wheats.
4. Improve product consistency and reduce processing costs through accelerated adoption of efficient technology with Quality Management systems.
5. Increase the supply of highly trained and skilled people in the industry and the organisations servicing it.
6. Enhance the competitive ability of the wheat industry research and technological services sectors to build (pre-competitive) knowledge to service Australian and overseas firms.
Quality Wheat CRC Ltd has exceeded the expectations of its stakeholders each year since it was established. Its fifth year was no exception, as this Annual Report demonstrates.

The performance of the organisation against each of seven key success criteria is well summarised by Bill Rathmell in the Managing Director’s report.

Four observations might be made about the nature of the Company’s burgeoning performance:

- The early research and commercial success of the business in areas such as quality assurance, “hi-tech” diagnostics (including WheatRite®) and biotechnology has gathered further momentum, with real products and services now being sold in the commercial marketplace;

- A significantly higher proportion of the research base of the Company is beginning to deliver, with a much wider array of commercially valuable outcomes beginning to be taken up in the industry. Notable are the production of Prime Hard wheat in the South; the release of a biscuit-wheat targeted at the North; the application of new science-driven insights into quality management of wheat during storage; and the development of the first science-based blending protocol for grists and flours;

- The Company is now delivering commercially-valuable outcomes at all levels of the supply-chain, precisely as it was planned to do when first set up. For example, wheat breeders are benefiting from new CRC discoveries in biotechnology; farmers from new seeds and crop husbandry techniques; handling companies and flour millers from new insights into the biological transformation of wheat during storage; biscuit makers from a more diversified (and thus more reliable) raw material supply base; noodle manufacturers stand to gain from enhanced performance of noodle wheats during manufacturing; and wheat traders and marketers are beginning to see the potential for a clearer focus on higher value milling wheats from a broader and thus more predictable supply base; and

- Despite the rapid emergence of commercial outcomes, the Company continues to strengthen its portfolio of basic science and human capital for undertaking future research and development. This is reflected in further new patent applications and the growing numbers of postgraduate students undertaking and successfully completing their studies.

A consistent theme of the past five Chairman’s Reports has been the role of Quality Wheat CRC Ltd in the context of a fast-changing domestic wheat and food industry. The industry is itself evolving from a series of separate discrete businesses, each focussed horizontally (a legacy of past regulatory regimes), towards a more vertically integrated structure. This is being achieved through mergers, acquisitions, strategic alliances of various types and, importantly, through the emergence of new businesses.

Such vertical integration facilitates effective supply-chain management, which is essential if the Australian industry is to continue to grow and prosper in an increasingly competitive global marketplace. The industry’s future depends on highly focussed commercial management of businesses at all levels of the supply chain, with efficient and responsive relationships between them, coupled with technologies that create higher value, on a sustainable basis, at each and every level.
The pace of the industry’s commercial evolution will not slow in the foreseeable future. At the same time, its structure continues to be affected by the regulation of export marketing and the legacy of some past domestic regulation. Quality Wheat CRC Ltd has proven to be a very effective entity in this ambiguous commercial operating environment, spawning the adoption of value-creating technologies at each level of the chain, with some of its innovations affecting performance at many levels.

The Company’s research program and its commercial relationships have evolved very effectively during the first five years of its life, although some of the necessary changes have been hard won. Some of the challenges have stemmed from the evolving structure of the research and development “industry” in Australia, as well as from the structural characteristics of the wheat, food and associated services industries. Some, however, have been generated by the structure of Quality Wheat CRC itself.

The past year has been a fertile one in terms of understanding and addressing these last-noted constraints on the future performance of the business. This has been done in the context of charting the future course of the Company, following the scheduled end of Commonwealth CRC funding.

The outcome of this work has been a decision to substantially change the Company’s future research program, structure and governance, capitalising on successes to date, but also addressing past limitations. Since the end of the 1999-2000 financial year, these proposed changes have been embodied in an application for future Commonwealth funding under the CRC program.

Participants, research personnel, CRC management and the Board have all been called upon to continue to perform at a high level, while simultaneously developing a new future for the business. Achieving a consensus on the future of the Company has placed many existing relationships under stress. Without exception, however, all have risen to the challenge. A new blueprint has been endorsed, while at the same time we have achieved another year in which prior expectations have been exceeded.

I would like to record my appreciation to all involved with the CRC, but especially to Bill Rathmell and to the Board, for their commitment, patience and wisdom.

Geoff Miller
Chairman
It is hard to improve on the excellent momentum that Quality Wheat CRC has achieved and on which I reported last year. Nevertheless in its science, and in the commercial exploitation of the science, the Company has added further to an already impressive list of achievements.

Increased interactions between groups (commercial and research)
- New science projects involving the WA SA and Queensland State agriculture agencies have started.
- New research projects involving cross-site collaborations between commercial and research Participants have also started (e.g., on milling technology and pasta quality).
- Three distributors have been appointed worldwide for WheatRite®, and a small electronics company has built a prototype reader.
- The Hungarian collaboration (Z-arm mixer and other laboratory instruments) is moving into a commercial phase.
  - The Great Grain Quality Assurance (QA) package (a three-way collaboration with oilseeds and pulse groups) has been marketed to growers and over 100 have signed up in the first year.
  - Extension training of growers and their advisors on the outcomes of quality research has been diversified and extended to all wheat growing States.

Commercially important outcomes and commercialisation of outcomes
- Sales and orders of Centre outcomes reached six figures in the first real year of commercialisation (primarily WheatRite® from QWIP, our wholly owned subsidiary).
- The supply of tests that diagnose defects in early breeding material to Australian and overseas wheat breeders doubled to more than eighteen thousand.
- Following from a CRC project, 300,000 tonnes of Prime Hard wheat were delivered in the Southern wheat belt—representing an increase of >$9M in the income of growers.
- The first version of a protocol showing how to blend grists and flours for specific quality effects was presented to industry.
- Bulk handling companies, domestic users of wheat and AWB Ltd are now discussing how best to exploit the outcomes of the storage project, which show how to maintain quality in wheat up to a year and avoid the “new season’s wheat” disruption to bakeries.

Increasing intellectual property (IP) portfolio
- New patents were filed in three areas. A novel method for detecting molecular markers polymorphic (i.e., useful) in wheat resulted from work by one of our PhD students, as did a second patent on novel proteins discovered in proteome research. The WheatRite® patent was also filed internationally.
- QAL 2000 new biscuit wheat was launched during the year.
- Important research projects again provided breeding material (germplasm) with a number of valuable benefits to farmers, processors, and consumers such as resistance to rain damage, improved bread, noodles and biscuits and improved factory efficiency. The potential gross value of some of these benefits is large (in the $2-$60M per annum range in Australia alone).

Increased technology transfer within the wheat industry
- Over 230 copies of the “Managing On-Farm Grain Storage” CD-ROM have been sold and the CD was highlighted across the country. We have also provided market quality and food safety/QA material to TopCrop, which is proving an ideal vehicle for communicating CRC outcomes to growers.
A total of fourteen grower-oriented articles in Australian Grain and nitrogen fertilization regime demonstrations have been used to help growers achieve premium quality grades.

One and two day wheat quality/market awareness courses were held in five locations. The latest QWCRC newsletters and receipt quality fact sheets were supplied on these courses. WheatRite®, Great Grain QA, and wheat quality, nitrogen management and Prime Hard wheat production booklets and the grain storage CD are promoted.

The outcomes from the storage and blending projects, which show how to maintain quality in wheat up to a year old and in grist and flour mixtures, have been communicated to the domestic millers and to the bulk handlers at senior levels at workshops.

Detailed technical reports have been issued to Participants covering the method for improving the prediction of processing performance of blended grist or flour and flourmill microbiology. Nearly seventy copies of the latter were issued, reflecting the importance of this work to the industry.

Increased impact of the Centre’s education and training programs

Five PhD students and one MSc student have completed or submitted their theses for examination. Two others are due to submit soon. Most have taken up positions within the wheat industry. One negotiated an exchange to Rutgers University, USA. Two have filed patents of potential commercial importance. There are currently 10 other postgraduate students in the CRC.

Five undergraduates were awarded scholarships last summer. One of them carried out the first cloning and sequencing of a durum wheat enzyme, so a screening assay for breeding programs can be developed. Another wrote software to integrate the various functions of the Z-arm mixer.

Financial commitment from industry

A number of new proposals for additional complementary research have again been accepted by the GRDC. In addition, the budget developed for the core activities of the Centre is about $400,000 above the original Commonwealth Agreement.

Provision of an efficient and selective research management infrastructure

The independent economic evaluation of the Centre’s program led by Prof Gordon MacAulay has reached its conclusions and has endorsed the technical direction taken.

Staffing levels have remained the same as last year yet the Centre has prepared an application for a second period of Commonwealth funding - the Value Added Wheat CRC - whilst continuing all normal management and administrative tasks.

Once again I emphasise that, impressive as this list is, it actually largely represents the new successes since my report last year - most of the things in last year’s list are still going on as well! The last item on the list draws attention to the major task that has occupied my own time since the millennium began. In drawing up the Value Added Wheat CRC bid I have been heartened by the fact that the overwhelming majority of existing Participants wish to be active in the new Centre, and there are newcomers too. The Value Added Wheat CRC will have more Participants in it than QWCRC does, albeit with a smaller Board. This enthusiasm for the concept of a new Company, exploiting new science, remains high despite, or perhaps because of, the increasing speed of the technical social and economic changes to which the wheat industry has been subjected. They include diverse factors such as the application of biotechnology to wheat breeding, mergers, acquisitions, privatisations, rationalisations, food safety concerns and the ever-shifting terms of trade in Australian and in world agriculture.

In conclusion, it has been a very active and successful year again for QWCRC, and I’d like to thank all the scientists involved, the members of the Senior Management Group, and the Headquarters staff (Alan, Clare, Helen and Mary) for their continued enthusiasm and support. Special thanks also to John Crosbie, Chris Hudson, Paul Loneragan and Bob Wotzak who resigned as directors during the year. If we have made progress, it is because of the dedication of all those involved, and their determination to meet our goals.

Dr Bill Rathmell
Managing Director
The Centre was established in July 1995 under the Commonwealth Government’s Cooperative Research Centres program by agreement between the Participants (Centre Agreement) and with the Government (Commonwealth Agreement). In the first two years of operation the research was managed under a three program structure. However, it was felt that more effective program management could be achieved by establishment of a five program structure whereby the education program (coordinated by the Centre’s Education and Training officer) was absorbed within the relevant programs. This structure has been operational since 1997 and the merits of this decision have been confirmed.

The Participants

Five commercial and six non-commercial organisations.

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QWCRC Board

The CRC Board of Directors comprises representatives of the CRC participants, the Managing Director and an independent Chairperson.

The Board determines the strategic direction the Centre will take and sets specific performance milestones for the core research programs.

It also oversees management of the CRC (in particular management of program outcomes), the Centre’s staff, researchers and financial matters and approves the Centre’s Annual Operating Plan and the Annual Report.

Board membership comprises (as at 30/6/2000):

**Members Representing**

- Dr G Miller - Chairman
- Dr W Rathmell - Managing Director
- Dr G Robertson - Agriculture Western Australia
- Dr P Jeffrey - Arnott’s Biscuits Ltd
- Mr T Kent - AWB Ltd
- Mr N Marran - BRI Australia Ltd
- Dr J Huppatz - CSIRO Plant Industry
- Dr M Dunbier - Crop & Food International
- Mr P Schutz - George Weston Foods Ltd
- Mr N Stenvert - Goodman Fielder Ltd
- Prof J Lovett - Grains Research & Development Corporation
- Dr L Cook - NSW Agriculture
- Prof R Tanner - University of Sydney

The Executive Committee

The Board is assisted by an Executive Committee comprising the Chairman, Managing Director, and three other Board members.

The Executive Committee:

- manages the various aspects of the activities of the CRC as determined by the Board from time to time and
- carries on the business of the Board between Board meetings.

The Managing Director

The Managing Director is a member of the Board and is responsible for management of the Centre.

- provides leadership to the Centre;
- ensures that Centre funds are used in accordance with the budget in the Annual Operating Plan;
- monitors and keeps the Board informed of the Centre’s performance;
- supervises the Program Managers and
- identifies new research opportunities.

The Senior Management Group

A Senior Management Group (SMG), comprising the Managing Director, the Program Managers and the Business Manager, plus representatives from any research provider not otherwise represented on the Committee, oversees management and evaluation of the Centre’s total operations through:

- identifying and prioritising activities against industry needs;
- monitoring program performance;
- developing administrative policies and procedures for the Centre as a whole and
- assisting the Managing Director in development of annual budgets, and performance reporting for the Centre, advising the Managing Director on issues to be raised with the Board, and on effective means of responding to specific concerns or requests.
During the year, projects in the Quality Wheat CRC program were evaluated along with GRDC projects in the GRDC Quality Wheat program. Professor Gordon MacAulay (professor of Agricultural Economics, Sydney University) in conjunction with consultants from The Centre for International Economics (CIE) conducted a two-phased project with the first phase providing an economic model of the grains industry to be used for the analysis. It is now available for the evaluation of quality wheat projects.

This study, done jointly by the Centre and GRDC also involved staff from most of the other commercial Participants of the Centre as well as the research providers. The overall emphasis of the Centre’s research program was confirmed and quantitative evidence of its value was provided.

CRC Subsidiary
To help exploit and commercialise R&D outcomes Quality Wheat CRC established, a fully owned subsidiary QW Investments Pty Ltd. The Directors of this company are Dr William Rathmell and Mr Alan Ellis.

The CRC’s management structure is illustrated above.
Dr Bill Rathmell  
Managing Director, Quality Wheat CRC Ltd
Riverside Corporate Park, 51 Delhi Road, NORTH RYDE NSW 2113
Bill Rathmell joined Quality Wheat CRC as its Managing Director at the end of 1995. Between 1991 and 1995 Bill was Research & Development Director of SES Europe, a supplier and breeder of agricultural seeds based in Belgium. Prior to that, he was Exploratory Plant Science Manager at ICI’s Agricultural Research Station in the UK. He is adjunct Professor in the Faculty of Agriculture in the University of Sydney. He has also held a number of academic posts in the USA and Europe.

Mr Tony Kent  
Manager, Research and Development, AWB Ltd
GPO Box 4562, MELBOURNE VIC 3001
Tony Kent is Manager of Research and Development at AWB Limited, responsible for providing strategic direction to AWB’s portfolio of grain-related research and commercialisation investments. Since joining AWB in 1996 he has held positions in product development and management of the product marketing area. In these roles he worked closely with Australian public wheat breeding programs providing advice on the emerging quality requirements of Australian wheat markets. Prior to his recent appointment as Manager of R&D, he was Manager of Global Market Development. Before joining AWB, Tony accumulated over 20 years of experience in research, advisory and management roles in food crop production and marketing in Australia and South East Asia.

Mr Norman Marran  
Chairman, BRI Australia Ltd
Riverside Corporate Park, 51 Delhi Road, NORTH RYDE NSW 2113
As well as being Chairman of BRI Australia Ltd (formerly the Bread Research Institute of Australia), Norman Marran is also Chairman of the Grains Research and Development Corporation’s Northern Regional Panel, a Director of Rural Co. Ltd, and formerly a director of the Australian Wheat Board and member of the Wheat Research Council. A chartered accountant by profession, with experience in agribusiness and grains research and development, he has spent most of his working life in agriculture. Initially he was a pioneer of the Australian cotton industry, as Chairman and CEO of Ausscott Ltd. He also has a strong background in oilseeds, as a long term director of Cargill Australia Ltd.

Dr Michael Dunbier  
Chief Executive Officer, Crop & Food International
Gerald Street, LINCOLN NEW ZEALAND
Michael Dunbier is Chief Executive of Crop and Food International based in Christchurch, New Zealand. He was formerly a Director of the Grains Research and Development Corporation and the New Zealand Foundation for Research, Science and Technology.
Board of Directors

Professor John Lovett
Managing Director, Grains Research and Development Corporation
40 Blackall Street, BARTON ACT 2604

Appointed Managing Director of the Grains Research & Development Corporation in September 1994, John Lovett was formerly Professor of Agronomy in the University of New England. He has experience in science and technology, communications, environmental matters and the management of research and development. He served as Chairman of the Oilseeds Research Council, becoming Deputy Chairman of the Grains Research & Development Corporation in October 1990.

Mr Nick Stenvert
Research Director, GF Milling & Baking
2 Smith Street, SUMMER HILL NSW 2130

Nick Stenvert has worked with Goodman Fielder Milling & Baking for 12 years in various capacities. He was appointed Research Director in 1999 following the merger with Bunge Defiance. Prior to this he has had extensive experience in the cereal industry both in Australia and overseas. He worked with BRI Australia for a period of 15 years and has been involved in all aspects of cereals ranging from research, wheat breeding, testing, processing, product development and end product application, including work in Asia and Middle East.

Dr Peter Jeffrey
Technical Manager, Arnott’s Biscuits Limited
11 G George Street, HOMEBUSH NSW 2140

Dr Peter Jeffrey has been the Technical Manager at Arnott’s/Campbell’s since August 1997. In this role, Dr Jeffery is responsible for Applied Research, Regulatory Affairs and Nutrition, Product Development Support and Technical Services. Of particular interest, he is responsible for ensuring that Arnott’s are using quality biscuit wheat. Before Arnott’s, he spent 6 years with Smiths Snackfoods, and 8 years with Nestle, in Australia, USA and France in a variety of roles in Technical Services, Research and New Product Development. Dr Jeffery has a BE Hon 1 (Chem Eng) and a PhD in Bioprocess Engineering from UNSW.

Mr Peter Schutz
Divisional Chief Executive, Weston Technologies
74 - 76 Redfern Street, WETHERILL PK NSW 2164

Peter Schutz is CEO of Weston Technologies, a division of George Weston Foods Ltd. Peter has 25 years management experience in the food industry including brewing, food ingredients, baking, edible oils and technology. He is also a director of BRI Australia Ltd.

Professor Roger Tanner
P N Russel Professor of Mechanical Engineering
University of Sydney, SYDNEY NSW 2006

Roger Tanner began his career in England in the aero-engine industry. Subsequently he has held academic appointments as Professor of Engineering in England, USA, France and Australia. His personal research is in rheology, which is the science of deformation and flow of materials, and especially in the application of large computing efforts to solve practical problems in shaping materials. Professor Tanner has been a director of several CRCs and companies. He has served as the Pro-Vice-Chancellor (Research) at the University of Sydney and also as the Foreign Secretary of the Australian Academy of Science.

Dr John Huppatz
Assistant Chief, CSIRO Plant Industry
GPO Box 1600, CANBERRA ACT 2601

John Huppatz is a graduate of the University of Adelaide with a Ph.D. in organic chemistry. His research career with CSIRO Plant Industry involved structure/activity relationships and mechanisms of action of chemicals affecting plant growth, in particular herbicides and plant growth regulators. His broader interests include the biochemistry and molecular biology of plant growth and development. He is currently Deputy Chief of CSIRO Plant Industry.

Dr Lindsay Cook
Chief, Division of Plant Industry, NSW Agriculture
161 Kite Street, ORANGE NSW 2800

Lindsay Cook obtained a B.Ag Science from Melbourne and a PhD from New England. He spent a post doctoral year at Oregon State University. He researched pasture seed production problems in the Victorian Department of Agriculture before moving to New South Wales to lead the seeds section for NSW Agriculture. In this position he was responsible for seed certification and registration schemes and the seeds laboratory. Subsequently, he was appointed Principal Agronomist (Cereals) and Director of Plant Production Research. He currently holds the position of Chief, Division of Plant Industries. This division undertakes NSW Agriculture’s research and extension programs for all field crops, pastures and rangelands, annual and perennial horticulture, and in soil management, irrigation water management and land use planning.
A n important success criterion for the Centre is that it promotes research linkages and co-operation amongst its own Participants as well as with outsiders (commercial and researchers). The first part of the Performance Indicators section later in this Annual Report contains a five-year description in some detail of the progress we have made in developing cooperative linkages. There are many examples and the latest ones are summarised here:

1. Most of the projects with cross-site interaction initiated in previous years have continued. We have maintained previous years’ momentum and added several new projects of which a partial list follows:
   - Collaboration with Agriculture Western Australia, also involving fertiliser suppliers, designed to determine environmental effects, especially micronutrient deficiency, on quality and permit management and extension strategies to be further improved in that state.
   - A project, which has industry involvement, to study novel approaches to increasing conditioning efficiency and thereby mill performance.
   - An extension of the existing work to greatly refine benchmarking data on durum/pasta quality and to provide knowledge for incorporation into durum breeding has considerably enhanced Commercial Participant involvement.
   - The new CRC/GRDC project on strategies to replace cake flour chlorination also has commercial commitment.
   - Building on the success of, and strong industry support for, the flour mill microbiology project, new work to assess the microbiological safety of end products from Australian wheat and flour also involves Commercial Participants.

2. Projects within the Centre that involve people from non-Participant organisations have also continued this year. The list now includes:
   - An “extension” project to develop the agronomic basis for producing premium quality wheats in South Australia.
   - Another CRC/GRDC project to identify key quality characteristics required by bread manufacturers using the sponge and dough process in the same Program involves extensive collaboration with the Leslie Research Institute, Queensland DPI.
   - The number of diagnostic kits provided to wheat breeders around Australia and in Mexico has risen to more than eighteen thousand.
   - We have also appointed distributors in France and in the United States for the WheatRite® kit.
   - We have initiated new work with two Australian SMEs. They are Byron Australia, on the creation of novel foods from Centre germplasm, and Real Time Engineering, who have designed a prototype reader for the WheatRite® kit.
   - The “Prime Hard in the South” project, which this year gave large ($9M) commercial benefits to growers involved Incitec fertilizers, Pivot Agriculture, and agencies from Victoria and South Australia as well as many Centre Participants.
   - In addition, our links with the CRC for Molecular Plant breeding have developed, with new research collaborations under discussion, and the Managing Director serving on the Industry Advisory Committee of the Adelaide-based Centre.
   - The Economic Evaluation project involved most of the Commercial Participants, all of the research providers and an outside agency, the Centre for International Economics.

3. Links with research groups within and outside Quality Wheat CRC have also been established through newly started, wholly or partially GRDC-funded research projects complementary to CRC-funded work. In the year under review we have commenced the following GRDC-sponsored projects, which add to the ongoing ones reported in previous years:
   - Strategies to replace cake flour chlorination. This project has strong industry support.
   - Similarly, a project to identify key quality characteristics required by bread manufacturers using the sponge and dough process involves extensive collaboration with the Leslie Research Institute, Queensland DPI.
   - Improving milling quality by understanding the relationship between soluble fibre content and yield and by seeking new sources of variation in this and in grain size characteristics. Involves close collaboration with the CRC for Molecular Plant Breeding (National Wheat Molecular Marker program).
   - Understanding the influence of glycation of proteins on quality deterioration in storage enabling better prediction of the suitability of stored grain. Involves a new research group at Sydney University.
   - Developing protocols for incorporating into breeding programs genetic variation in xanthophyll content and in its propensity to oxidation, which degrade the colour of Asian noodles.
4. There has been a continued high level of effort this year put into workshops, seminars and publications specifically designed to enhance technology transfer between Participants and to outside commercial and research entities, for example:

- There was strong interest in the wheat quality/market awareness courses this year, following a promotional article published in Australian Grain and notification of agronomists through e-mail networks. Five courses were held and five more plus four nitrogen fertilization regime demonstrations are planned.
- QWCRC newsletters and receival quality fact sheets are supplied on all of these courses. WheatRite®, Great Grain Quality Assurance, and wheat quality, nitrogen management and Prime Hard wheat production booklets and the grain storage CD are promoted.
- Workshops on the outcomes from the storage project, which show how to maintain quality in wheat up to a year and avoid the “new season’s wheat” disruption to bakeries, have been held in two states.
- Nearly seventy copies of the report on the mill microbiology project were issued, reflecting the response to this work by the industry, both in relation to the installation of Quality Assurance protocols for flour mills, and understanding the sources and acceptable levels of microbial contamination.

5. Links with groups outside the Centre and overseas have been strengthened by our commercialisation endeavours.

- The Great Grain Quality Assurance system was launched commercially this year at the Agriculture Australia conference in August by the Minister of Trade and was taken up by over 100 growers.
- Fourteen grower-oriented articles have been published in Australian Grain this year and the second issue of the SA newsletter, Premium Quality Wheat News, has also been produced. In addition, articles about Centre activities have appeared in The Land (3), Rural Weekly, the Australian Farmers’ and Dealers’ Journal and Ground Cover (3).

- The national and international links resulting from WheatRite® and Great Grain are mentioned above. The appointment of overseas distributors for WheatRite® has been particularly significant in this respect.
- Last year’s commercialisation activities with Monsanto (U.S.A.) and with the Hungarian Institute for R&D (OMFB) have continued, in the latter case with proposals being developed to market the Zarm mixer.
- Further evaluation of the “waxy” wheat has again involved a non-Participant company as well as Participants in the CRC. Work with the non-Participant company has shown that waxy wheat can be used to create novel foods and an agreement for commercialisation is being negotiated.
The development of new wheat varieties with novel processing and manufacturing qualities remains a key focus of the CRC research and development program. Such wheats are important to enhance the total level of production and value-adding opportunities of the Australian wheat industry. They are also important to deliver research and development benefits in wheat quality to both producers and the processing industries, and as a vehicle for commercialisation of much of QWCRC’s intellectual property, nationally and internationally. In this respect, in Program 1, we are placing particular emphasis on ensuring that the research findings of the CRC and its partners, which can be delivered to industry via breeding, are made available for commercial use as quickly as possible. We are doing this directly by the joint development of new wheats with breeders, or indirectly, through the development of more efficient breeding technologies.

At present, only a minority of the germplasm projects of QWCRC involve transfer of genes by genetic engineering into the new wheats (i.e. genetically modified organisms or GMOs). In the longer term more such projects could be included when the technical capability exists, if there were market demand and public and government acceptance of such projects.

Program Aims
The objectives of the program, which focuses breeding on value added industry requirements, are thus fourfold. The first is to screen both cultivated wheats and their wild relatives for novel sources of natural variation for a range of wheat quality attributes, and to characterise this variation at the physiological, biochemical and genetic levels. The second is to tag the genes responsible for this variation using cutting edge molecular marker techniques. The third is to develop rapid breeding protocols using molecular markers and doubled haploid technology, while the fourth is to use these rapid protocols to develop new cultivars for specialty quality markets.

Fig 1.1 - Frequency distribution of B-granule content (volume % of starch) in 400 doubled haploid lines of Vulcan x Kewell grown in controlled-environment chambers

<table>
<thead>
<tr>
<th>Targets and Milestones Achieved</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doubled haploid population of Vulcan x Outlier 67 obtained</td>
<td>04/00</td>
</tr>
<tr>
<td>Disomic and ditelosomic addition lines of Aegilops peregrina (a zero-B species) in wheat examined</td>
<td>04/00</td>
</tr>
<tr>
<td>F2 populations of Outlier 67 x Janz and Sunstate and QAL2000 harvested</td>
<td>04/00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Projected Research for next 2 years</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microsatellite analysis of Vulcan x Kewell doubled haploids</td>
<td>06/01</td>
</tr>
<tr>
<td>Novel synthetic hexaploids restored to fertility and characterised</td>
<td>06/01</td>
</tr>
<tr>
<td>Quality testing of doubled haploid populations</td>
<td>06/02</td>
</tr>
</tbody>
</table>
**Background and Objectives**

Asian noodle colour and colour stability are important for consumer appeal. Critical factors controlling colour include the initial brightness of flour and noodles, the degree of bran and germ contamination, the xanthophyll and flavonoid content, and the stability of both the noodle brightness and the yellow colour. Our focus is on improving the colour of yellow alkaline noodles (YAN) by manipulating xanthophylls and flavonoids, and by reducing factors such as oxidative darkening.

**Manipulation and recombination of specific components of colour will facilitate production of speciality or ingredient wheats, wheats with novel colour characteristics and wheats that allow more flexibility in marketing.**

**Progress**

Genetic variants for each of the traits in Table 1.2 are being backcrossed to Sunco (YAN benchmark cultivar). Doubled haploids will combine the new trait rapidly with low rates of darkening and good processing quality. We found flavonoids were produced in early and mid-grain development in the seed coat and germ tissues respectively. In contrast to xanthophyll and apigenin diglycoside compound stability in noodles over 48 hrs, some non-apigenin flavonoids were slowly oxidised in both white salted noodles (WSN) and YAN. Xanthophylls in WSN were co-oxidised via lipoxygenase, depending on the age of the starting flour. Antioxidants greatly reduce this oxidation. Durum breeders have selected for very stable yellow pigment, and screening for low lipoxygenase bread wheat germplasm has commenced.

**Targets and Milestones Achieved**

- Genetic variants for xanthophyll and flavonoid content: 09/99
- Oxidation/stability of xanthophylls and flavonoids in noodle sheets: 12/99
- Synthetic wheats screened for flavonoid content: 03/00

**Projected Research for next 2 years**

- High xanthophyll/low PPO wheat germplasm: 06/01
- Identification of sources of low lipoxygenase: 06/01
- Determination of chromosomal location of flavonoid synthesis genes: 06/02
- High flavonoid/low PPO germplasm: 06/02

---

**TABLE 1.2**  **IDENTIFIED MECHANISMS WITH POTENTIAL TO INCREASE COLOUR IN YELLOW ALKALINE NOODLES**

<table>
<thead>
<tr>
<th>Desired Outcome</th>
<th>Source Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decreased noodle darkening</td>
<td>Lines derived from a Sunco/Tasman population and germplasm with extremely low polyphenol oxidase (PPO) levels.</td>
</tr>
<tr>
<td>Increased grain flavonoid content</td>
<td>Existing synthetics, new synthetics derived by combining newly identified high flavonoid T. tauschii and high flavonoid T. durum accessions, Avocet/Sunvale derivatives whose flavonoid content exceeds either of the parents.</td>
</tr>
<tr>
<td>Xanthophyll content increased to that of durum wheats</td>
<td>Lines derived from Sunco/Indis and Sunco/Durum cultivars.</td>
</tr>
</tbody>
</table>

**TABLE 1.3**  **FLOUR AND NOODLE YELLOWNESS (CIE b*)**

<table>
<thead>
<tr>
<th></th>
<th>Flavour White Salted Noodle</th>
<th>Yellow Alkaline Noodle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0hr</td>
<td>2hr</td>
</tr>
<tr>
<td>Sunco/Indis Derivative</td>
<td>18.1</td>
<td>31.6</td>
</tr>
<tr>
<td>Sunco</td>
<td>9.90</td>
<td>13.7</td>
</tr>
<tr>
<td>Kamilaroi</td>
<td>20.3</td>
<td>29.8</td>
</tr>
</tbody>
</table>

**FIG 1.4** - Development and stability of yellow colour (CIE b*) in YAN prepared from Sco/Tas 46, a Sunco/Tasman derivative with yellow colour and colour stability that exceeds either parent.

**FIG 1.5** - Frequency distribution of grain flavonoid content in progeny derived from Avocet/Sunvale (high x high flavonoid) and Avocet/Sunfield (high x low flavonoid). Flavonoid contents of Sunfield, Sunvale and Avocet were 0.45, 0.63 and 0.66 OD units respectively.

---

**Project 1.1.2 - Manipulation of the yellow colour of Asian alkaline noodles**

**Project Leader:** Daryl Mares
**Project 1.1.3/5 (fused) - Genetic dissection of flour processing properties**
Project Leaders: Rudi Appels and Ian Batey

**Background and Objectives**
Starch functionality is among the top five quality priorities in Australian wheat breeding, with the need to improve starch viscosity in combination with other quality traits. Through this project, in association with the National Wheat Molecular Marker program, we aim to accelerate breeding for starch quality by identifying and protecting markers for granule bound starch synthase (GBSS)-independent aspects of starch swelling volume and hence, noodle quality. The markers and functionality tests will help define starch quality attributes for Plant Breeders Rights and for marketing. This improved technology and characterisation will facilitate consistency of supply of specific starch qualities in wheat flour.

**Progress**
Through wide collaboration, we are refining the 885, 445 and 101 marker Cranbrook x Halberd, CD87 x Katepwa and Sunco x Tasman genetic mapping datasets, and the Egret x Sunstar cross is being started. Statisticians are processing field data on doubled haploids preparatory to integrating quality trait loci into the maps. Twenty new microsatellites from 185 doubled haploid Sunco x Tasman lines have been recorded. Cranbrook x Halberd and CD87 x Katepwa mapping is essentially complete. Targeting microsatellite isolation technologies are helping assign linkage groups to chromosome numbers in the CD87 x Katepwa cross. Quantitative data on starch characteristics that vary in the doubled haploid lines will be analysed using the genetic maps. A new analysis of starch from the Cranbrook x Halberd lines has revealed a QTL for A:B granule ratio, potentially useful in project 1.1.1.

**Targets and Milestones Achieved**

<table>
<thead>
<tr>
<th>Targets and Milestones Achieved</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify AFLP/gene markers for specific traits</td>
<td>06/00</td>
</tr>
<tr>
<td>Position new markers into genetic map of wheat</td>
<td>06/00</td>
</tr>
<tr>
<td>Confirm the markers for starch properties in Cranbrook X Halberd cross</td>
<td>12/99</td>
</tr>
<tr>
<td>Complete the isolation and analysis of starch from a cross between 2 parents with the same 4A-GBSS status</td>
<td>06/00</td>
</tr>
</tbody>
</table>

**Projected Research for next 2 years**

<table>
<thead>
<tr>
<th>Projected Research for next 2 years</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete major segments utilizing genetic maps to analyse traits such as milling yield, flour colour, protein content and quality, starch properties and flour extensibility</td>
<td>06/01</td>
</tr>
</tbody>
</table>

**Project 1.1.4 - Molecular markers for wheat quality**
Project Leader: Matthew Hayden

**Background and Objectives**
Molecular markers are an important tool in cereal research for cultivar identification, genetic studies and marker-assisted breeding. Whilst codominant PCR-based markers are preferred, their development requires prior knowledge of DNA sequence. This information is both costly and time-consuming to generate. New technologies allowing the rapid development of codominant markers without prior knowledge of DNA sequence are therefore required. The aims of this project are to develop novel techniques for generating simple sequence repeat (SSR) microsatellite markers, and to develop methods for discovering and genotyping single nucleotide polymorphisms (SNPs). Use of these techniques will enable us to generate a suite of markers for use in QWCRC and GRDC programs.

**Progress**
We have developed two novel techniques for generating SSR markers without prior knowledge of DNA sequence. The Selectively Amplified Microsatellite (SAM) assay allows rapid generation of informative markers and targeted development of markers for chromosomal regions of interest. The second technique enables cost-efficient and rapid development of large numbers of markers, whose informativeness is unknown. This is achieved through a 25-fold increase in sequencing throughput compared to traditional techniques that characterise only one SSR locus per plasmid clone, and the capacity to develop a SSR marker for approximately AU$20. The utility of both techniques has been demonstrated with the development of SSR markers in bread wheat.

**Targets and Milestones Achieved**

<table>
<thead>
<tr>
<th>Targets and Milestones Achieved</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Develop and apply two new SSR isolation methods</td>
<td>04/00</td>
</tr>
<tr>
<td>63 new SSR markers for the GRDC and waxy parents</td>
<td>05/00</td>
</tr>
</tbody>
</table>

**Projected Research for next 2 years**

<table>
<thead>
<tr>
<th>Projected Research for next 2 years</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimise new SSR isolation methods</td>
<td>12/00</td>
</tr>
<tr>
<td>Continued development of SSR markers for GRDC and QWCRC projects</td>
<td>07/01</td>
</tr>
<tr>
<td>Develop methods for SNP discovery and genotyping</td>
<td>07/01</td>
</tr>
</tbody>
</table>
### Project 1.1.7 - Development and application of waxy wheats

**Project Leader:** Peter Sharp

**Background and Objectives**

To take advantage of DNA technologies and evaluate their feasibility in Australian wheat breeding programs, we are undertaking Marker Assisted Selection (MAS) waxy wheat breeding. Line DHWx12 was used as the donor parent of the null alleles of the three waxy loci and Janz, Goldmark, NP150, and Silverstar were used as recurrent parents. DNA markers are being used both for selection of the waxy genes and to re-select the background from the recurrent parents. The objectives are to introgress the waxy genes into Australian elite cultivars by means of MAS and to evaluate and optimise MAS in spring wheat breeding programs.

**Progress**

We have developed a number of sequence-tagged site (STS) and microsatellite markers for MAS of the waxy genes, including one codominant marker for each of the three waxy loci. These are useful to select the waxy genes in backcross populations. More than 400 microsatellite markers have been analysed in the parental lines, using up to 20 markers per family for selection of the recurrent parent background. Marker selected backcross plants have been backcrossed successively to the recurrent parents. We now have advanced backcross seed lines (BC4), and more than 1000 BC3 doubled-haploid seed lines with varied genotype (partial to full waxy) at the waxy loci. In addition, we have produced kilograms of seed of doubled-haploid BC2waxyNP150 (partial to full waxy) of waxy-Janz (F5 families) for evaluation by industry.

<table>
<thead>
<tr>
<th>Targets and Milestones Achieved</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAS-BC3 plants</td>
<td>07/99</td>
</tr>
<tr>
<td>Doubled-haploid BC2NP</td>
<td>12/99</td>
</tr>
<tr>
<td>Seed increase of doubled-haploid BC2NP</td>
<td>07/99</td>
</tr>
<tr>
<td>Field trial of waxy-Janz seed lines (F4 families)</td>
<td>07/99</td>
</tr>
<tr>
<td>MAS-BC4 seed lines</td>
<td>07/99</td>
</tr>
<tr>
<td>Doubled-haploid BC3 of different recurrent parents</td>
<td>07/99</td>
</tr>
</tbody>
</table>

### Project 1.1.8 - Development and application of wheat microsatellite markers

**Project Leader:** Peter Sharp

**Background and Objectives**

Development of informative DNA markers in Australian wheat cultivars will benefit both researchers and breeders. In collaboration with the National Wheat Molecular Marker Program, a large number of DNA markers, mainly microsatellites, have been evaluated. To evaluate informativeness of the markers, a set of 12 GRDC wheat parental lines is used, and six mapping populations are used for construction of genetic maps. The objectives are to search for informative DNA markers for different purposes, to validate their use in breeding programs, and to develop wheat genetic maps. The maps will be useful in locating and identifying economically important genes for quality traits and for disease and rust resistance.

**Progress**

More than 200 microsatellite markers of different origins have been analysed. The polymorphic markers are scored on mapping populations with the major effort on the Cranbrook x Halberd population. We have contributed more than 40 microsatellite markers to date set on this population. DNA samples from populations involving the crosses Sunco/Tasman and CD87/Katepwa are now ready for analysis. We have evaluated a small set of the markers for variety identification of wheat cultivars, and have generated and deposited more than 1000 Expressed Sequence Tag (EST) sequences in the International Triticeae EST Cooperative (ITEC) database. The sequence data is also a good source for developing EST microsatellites.

<table>
<thead>
<tr>
<th>Targets and Milestones Achieved</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score WMC microsatellites on GRDC parental lines</td>
<td>12/99</td>
</tr>
<tr>
<td>Score WMS microsatellites on GRDC parental lines</td>
<td>12/99</td>
</tr>
<tr>
<td>Analyse and refine pre-scored microsatellites</td>
<td>cont.</td>
</tr>
<tr>
<td>Arrival of third set of WMC microsatellites</td>
<td>04/00</td>
</tr>
<tr>
<td>Finish major work on Halberd/Cranbrook mapping population</td>
<td>05/00</td>
</tr>
</tbody>
</table>

### Projected Research for next 2 years

<table>
<thead>
<tr>
<th>Projected Research for next 2 years</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grow Egret/Sunstar population and extract DNA</td>
<td>10/00</td>
</tr>
<tr>
<td>Evaluate further WMC microsatellites on GRDC parental lines</td>
<td>12/00</td>
</tr>
<tr>
<td>Evaluate multiplex PCR for microsatellites</td>
<td>12/00</td>
</tr>
<tr>
<td>Develop EST microsatellites</td>
<td>12/00</td>
</tr>
<tr>
<td>Evaluate EST microsatellites</td>
<td>06/01</td>
</tr>
<tr>
<td>Validate multiplex PCR for mapping populations</td>
<td>06/01</td>
</tr>
<tr>
<td>Screen microsatellites on Sunco/Tasman and CD87/Katepwa</td>
<td>12/02</td>
</tr>
</tbody>
</table>
Project 1.1.9 - Marker assisted selection for sprouting tolerance and late maturity α-Amylase (LMAA)
Project Leader: Mui-Ken Tan

Background and Objectives
Two microsatellite markers were found to possess significant linkage to the two recessive genes controlling pre-harvest sprouting tolerance of AUS1408. The preliminary information was utilised for further mapping of two doubled haploid populations, one derived from Janz/AUS1408, and the other from Cascade/AUS1408. The 3DL chromosomal region that controls sprouting tolerance in AUS1408 has been further characterised. LMAA is independent of pre-harvest sprouting and is controlled by a recessive gene located on the long arm of chromosome 6B. LMAA expression is variable and highly sensitive to temperature.

Progress
Ten new 3D-specific microsatellite markers were screened on Janz/AUS1408 and Cascade/AUS1408 mapping populations in pre-harvest sprouting tolerance work. Five were polymorphic for each set of parents, and differed slightly between the 2 populations. The markers are currently being screened for more precise mapping of the trait. The Janz/AUS1408 mapping population has been bulked based on genotypic data of microsatellite markers to be used for amplified fragment length polymorphism (AFLP) analysis, and preliminary screening has begun. Four 6BL microsatellite markers and two other STS markers were screened on 30 Spica/AUS1408 lines for linkage to LMAA. Five markers were polymorphic on the parents, and four formed into a linkage group mapping in the same order as corresponding markers on the Opata85 x W7984 map, suggesting marker development is progressing towards the gene. Due to environmental sensitivity, another typing of the LMAA trait is planned this season.

Targets and Milestones Achieved

<table>
<thead>
<tr>
<th>Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Five more polymorphic microsatellite markers found for more precise mapping</td>
<td>05/00</td>
</tr>
<tr>
<td>of pre-harvest sprouting tolerance in AUS1408</td>
<td></td>
</tr>
<tr>
<td>Formation of a four 6BL microsatellite marker</td>
<td>05/00</td>
</tr>
<tr>
<td>linkage group for LMAA on the Spica/AUS1408 population</td>
<td></td>
</tr>
</tbody>
</table>

Projected Research for next 2 years

<table>
<thead>
<tr>
<th>Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mapping of polymorphic microsatellite markers for both sprouting tolerance</td>
<td>12/01</td>
</tr>
<tr>
<td>and LMAA</td>
<td></td>
</tr>
<tr>
<td>AFLP analysis for better characterisation of both traits and search for</td>
<td>06/02</td>
</tr>
<tr>
<td>new markers (e.g. factor for temperature dependent LMAA expression)</td>
<td></td>
</tr>
</tbody>
</table>

---

Project 1.1.10 - Breeding soft wheats for Northern Australia
Project Leader: Lindsay O’Brien and Shakir Shah

Background and Objectives
The aim of this project is to develop new soft wheat cultivars for biscuit and cake production which are suited to production in northern Australia. This will enhance continuity of supply, an ongoing concern for the domestic processing industry. Yield evaluation will occur over three years using sites distributed from northern Victoria to the Queensland border. Quality evaluations prior to release are to be undertaken collaboratively in the CRC by Goodman Fielder (milling and physical dough testing) and Arnotts (biscuit test baking).

Progress
The first soft wheat cultivar developed by this program was named QAL2000 and was released by the CRC Managing Director at a field day at Narrabri in early October. QAL2000 is a high yielding, rust resistant soft biscuit wheat with the good agronomic attributes of short, strong straw and early maturity. When yield was evaluated (above), QAL2000 showed better production than existing hard wheat cultivars. Combined with its early maturity, this makes it ideally suited for plantings by cotton growers, who can then use the lower soil fertility conditions that prevail following cotton cropping, together with timely irrigation to achieve the low protein content (<9.5% wheat protein) desired by biscuit makers. Pre-release quality evaluation facilitated end-user satisfaction for rapid uptake.

Targets and Milestones Achieved

<table>
<thead>
<tr>
<th>Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>New variety named; breeders, millers and biscuit makers agree to release</td>
<td>09/99</td>
</tr>
<tr>
<td>Large scale seed increase of new variety undertaken</td>
<td>12/99</td>
</tr>
</tbody>
</table>

Projected Research for next 2 years

<table>
<thead>
<tr>
<th>Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continue regional testing of advanced breeding lines with high yield potential and excellent soft biscuit quality to identify the next release</td>
<td>12/00</td>
</tr>
</tbody>
</table>
Project 1.1.11 - Genetic variants for soft wheat quality
Project Leader: Lindsay O'Brien and Shakir Shah

Background and Objectives
Currently, dough conditioners, flour treatments or additives are used to improve the processing quality of soft wheat flour for biscuit and cake production. It is desirable to develop novel breeding lines that could improve processing quality without the need for such treatments. The aim of this project is to develop lines which make use of genetic variation at the high and low molecular weight glutenin loci and the waxy loci of soft wheat cultivars. Small scale quality testing will be used on seed from the breeding lines to provide early guidance on end-utility.

Progress
Doubled haploid lines derived from second backcross material, varying for null high molecular weight glutenin alleles at the Glu 1A, 1B and 1d loci, were planted in the field during 1999. Sufficient seed was produced to enable small scale quality testing to evaluate the working hypotheses of this project. Large quantities of seed were produced for lines varying in granule-bound starch synthase composition. These lines have potential to be used as additives for a range of noodle products where they improve textural properties. We have now begun work to combine the different levels of genetic variation in protein composition with those for starch composition.

Project 1.1.12 - Soft wheat breeding for South Eastern Australia
Project Leader: Helen Allen

Background and Objectives
The irrigation area of southern NSW is Australia’s major biscuit wheat growing region. NSW Agriculture targets the Coleambally and Murrumbidgee Irrigation areas for development of soft wheat varieties suitable for Prime Soft and ASW soft grades. Quality types sought include those with weak extensible doughs for semi-sweet biscuit production, ASW soft wheats suitable for cracker production, and soft wheats for cookie, cake and pastry products. Assessment of crossbreds is a major component of the project and includes evaluation of soft wheat lines from other breeding programs for yield performance and quality. Tests are also being developed to identify and screen for desirable qualities.

Progress
In soft wheat trials on 40 entries at 5 sites in southern NSW, 23 are specific lines for semi-sweet biscuit production and 5 stronger lines are suitable for cracker production. After huge production losses in 1999, growers seek a high yielding, leaf rust resistant replacement for Triller. Blackpoint due to high rainfall and humidity was extremely high throughout the irrigation area and in the trial plots. Each variety was screened for blackpoint susceptibility. Lines M5635, with dough strength higher than Snipe, but acceptable semi-sweet biscuit quality, and M5631, suitable for cracker biscuits, with dough strength, pasting properties and flour colour equal to Rosella, will both be released in October. A biscuit bake test developed at Wagga Wagga Agricultural Institute will be evaluated by a number of laboratories.

Targets and Milestones Achieved

<table>
<thead>
<tr>
<th>Targets and Milestones Achieved</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete preliminary industry evaluation of new sources of genetic variation for starch composition and start large scale seed increase.</td>
<td>07/99</td>
</tr>
<tr>
<td>Large scale seed increase complete; distribute for industry evaluation.</td>
<td>03/00</td>
</tr>
<tr>
<td>Doubled haploid derivatives varying in protein composition increased in the field and seed available for small scale quality evaluation.</td>
<td>12/99</td>
</tr>
</tbody>
</table>

Projected Research for next 2 years

<table>
<thead>
<tr>
<th>Targets and Milestones Achieved</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Further doubled haploid derivatives with different protein variant combinations will be planted and increased to produce seed to evaluate the hypotheses of this project. Combining the variation for both starch and protein variation that has been created has commenced. Evaluation of this material will allow breeding strategies to be developed.</td>
<td>03/00</td>
</tr>
</tbody>
</table>

Targets and Milestones Achieved

<table>
<thead>
<tr>
<th>Targets and Milestones Achieved</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Release of Prime Soft variety M5635</td>
<td>10/00</td>
</tr>
<tr>
<td>Release of ASW soft variety M5631</td>
<td>10/00</td>
</tr>
</tbody>
</table>

Projected Research for next 2 years

<table>
<thead>
<tr>
<th>Targets and Milestones Achieved</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Develop a method suitable for the selection of semi-sweet biscuits</td>
<td>09/00</td>
</tr>
<tr>
<td>Complete textural research on biscuit doughs for selection of Prime Soft wheat</td>
<td>06/01</td>
</tr>
</tbody>
</table>
**Project 1.1.13 - Hybrid Wheat**
*Project Leader: Lindsay O’Brien*

**Background and Objectives**
Hybrids offer an effective means of intellectual property protection and of increasing grain yield. Those from Sunprime R&D, of which the University of Sydney is half owner, offer yield advantages of around 10% over the best conventional varieties. The parents of these hybrids are agronomically adapted lines with good hybrid production characteristics into which novel quality traits identified by QWCRC could be introgressed for commercial exploitation. The aims of this project are to evaluate the efficacy of using this technology for future commercialisation of novel quality genes, to develop an efficient means of developing new hybrid wheats and to identify new heterotic yield groups as receptors for novel quality genes.

**Progress**
Over 200 new hybrids were made during the 1999 season using a chemical hybridising agent. Parents used covered Australian hard and soft grained varieties and advanced breeding lines, the best parents from a current hybrid wheat program and high yielding Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT) -developed wheats. These will be evaluated at a range of testing locations in the 2000 season. Information will be collected to enable understanding of the basis of the heterosis that is expressed. Crosses were made to transfer QWCRC quality genes into parents of future hybrids.

---

**Targets and Milestones Achieved**

<table>
<thead>
<tr>
<th>Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sufficient seed of over 200 new hybrid combinations produced to test for new heterotic groups.</td>
<td>12/99</td>
</tr>
<tr>
<td>First round of crossing to transfer novel genes to hybrid parents completed.</td>
<td>12/99</td>
</tr>
<tr>
<td>Heterosis experiments planted at 3 sites.</td>
<td>06/00</td>
</tr>
</tbody>
</table>

---

**Projected Research for next 2 years**

<table>
<thead>
<tr>
<th>Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detailed plant observations and performance information gathered to analyse the basis of the heterosis.</td>
<td>12/00</td>
</tr>
</tbody>
</table>

---

**Projected Research for next 2 years**

<table>
<thead>
<tr>
<th>Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assess and modify current wheat x maize crossing techniques for wheat doubled haploid production</td>
<td>02/00</td>
</tr>
<tr>
<td>Modify media composition and embryo harvest techniques for higher percentage of in vitro embryo survival and haploid plant development</td>
<td>02/00</td>
</tr>
<tr>
<td>Assess current chromosome doubling techniques for doubling efficiencies</td>
<td>05/00</td>
</tr>
<tr>
<td>Produce doubled haploids for CRC breeding and associated programs at PBI, Cobbitty and Narrabri</td>
<td>2000-2002</td>
</tr>
<tr>
<td>Improve haploid production and chromosome doubling efficiencies</td>
<td>2000-2002</td>
</tr>
<tr>
<td>Assess selection efficiency improvement with available/suitable markers at the haploid stage</td>
<td>2000-2002</td>
</tr>
</tbody>
</table>

---

**Project 1.1.14 - Development of wheat doubled haploid production system**
*Project Leader: Don Marshall*

**Background and Objectives**
Wheat doubled haploids (DH) can be realistically utilised in breeding programs only if the efficiency rate is cost effective. Efficiency is influenced by donor plant conditions, their types, crossing procedure, rescue and culture of embryos, haploid plant development and chromosome doubling methods. The aim of this project is to optimise each of the critical steps. We will assess and modify current wheat x maize crossing techniques for increased efficiency of wheat doubled haploid production, modify media composition and embryo harvest techniques for higher percentage of in vitro embryo survival and haploid plant development, assess and modify current chromosome doubling techniques for increased doubling efficiencies, and service the breeding and associated programs by producing DH as required.

**Progress**
Currently workable DH production via the wheat x maize system has been achieved. Various maize types and cultivars (17) were assessed for their suitability. To gain an understanding of genotype response variation, various crosses and cultivars of wheat were used as donor plants. Growth conditions for both wheat and maize genotypes have been assessed and optimum conditions have been identified. Infrastructure is being re-organised and necessary modifications made to increase capacity. DH technique efficiency in each season has been assessed. Haploid plants have been regenerated and chromosome doubling techniques have been used.
Project 1.1.15 - Assessing the importance of high levels of amylose in wheat starch on human glycaemic index
Project Leader: Fred Stoddard

Background and Objectives
There is a considerable body of literature demonstrating the benefits of higher food amylose content on the glycaemic index. Higher amylose has been associated with lower, broader peaks in the release of both glucose and insulin to the blood. This sustained lower level release is considered to be physiologically better than brief, high peaks, and may potentially aid management of diabetes, heart disease and some cancers. Correlation with the glycaemic index has not yet been done in wheat. The present study is aimed at providing the validation required before we embark on a serious program to enhance amylose content in bread wheats.

Progress
Germplasm surveys have previously identified Gallipoli and Katepwa as outstandingly high in amylose content, at around 35%, with Minto a couple of percent less. Hard wheats with a relatively low amylose content include Hartog, about 22%, and others which are null for GBSS-4A. A crop of Gallipoli, a very old Australian variety, failed to yield at Narrabri in 1999. Katepwa, a Canadian wheat, is one of the parents used in the GRDC molecular mapping populations and a kilo of flour has been promised. Arrangements are in place for the glycaemic index testing at the University of Sydney’s Human Nutrition Unit.

Targets and Milestones Achieved Date
Suitable wheats identified 07/99
Flour obtained 07/00

Projected Research for next 2 years Date
Breads produced and glycaemic index tested 08/00

Project 1.1.17 - Improving the milling quality of Australian wheat
Project Leader: Don Marshall

Background and Objectives
Australian wheat has a reputation for being free milling and producing a high yield of white flour. To establish a marketing advantage with respect to milling quality, it is essential that genetic advances in milling quality be maintained. Through this project we aim to determine the genetics of milling yield, fibre content, water absorption and pentosan content. We seek to identify new sources of high milling yield and its relationship to fibre content, and to establish variation for pentosan content and water absorption. We will also evaluate the potential of large grained wheats for enhanced milling yield, grain protein content and seedling vigour.

Progress
Through an extensive literature search, we have identified a set of putatively high milling wheats which are unrelated to current germplasm used by Australian breeding programs. This material has been planted and will be assessed for milling quality. Sets of material with large grain size have also been sourced and planted. Parent wheats for examination of the genetics of milling quality have been chosen and planted for crossing.

Targets and Milestones Achieved Date
Large seeded germplasm assembled for planting. 04/00
New sources of high milling yield identified and sourced. 04/00

Projected Research for next 2 years Date
Evaluate reputed new high milling wheats 04/01
Evaluate milling quality of large grained wheats 06/01
Establish variation for water absorption and pentosan content 06/02
The concept of the Cooperative Research Centre offers the opportunity to achieve unique outcomes for Australian industry because it facilitates collaboration between a diversity of research and user organisations, working in formal relationships that have not previously been possible. The collaborative element is especially evident in this program, as research towards consistent wheat quality requires interactions throughout the production chain - growing, harvesting, storage, through to eventual blending and processing (Table 2.1). Adoption of research findings is also essential at all these stages of industry activity.

Beneficiaries of research adoption also extend throughout the production chain. In the past year, early aspects of QWCRC research have become translated into increased incomes for the growers involved. Improved consistency of quality and consequent processing efficiencies are also being realised by processors.

This program also emphasises technology transfer of research outcomes, including up-to-date information on the grain-quality attributes sought by processors and the technologies needed to produce, store and distribute grain of the required quality. In this way, a culture of quality consciousness is being established among producers, advisers, grain handlers and marketers in the Australian wheat industry. Our successes in this area are detailed in the Education section.

Program Aims
The overall aim is to improve consistency and continuity of supply of grain of suitable quality to markets. This is addressed by establishing improved approaches to farm management during growth, especially for the production of premium-attracting grain, by minimising quality fluctuations due to the effects of environmental stresses, and by developing test methods, such as for rain damage, for use at harvest. Following harvest, quality can be managed by optimising storage conditions, and by 'intelligent' blending to achieve quality specifications. In these ways, we aim to maximise the short- and long-term profitability of growers, and to enhance processing and product quality, thereby improving primary production flexibility.

<table>
<thead>
<tr>
<th>TABLE 2.1</th>
<th>THE WIDE RANGE OF ORGANISATIONS INVOLVED IN ASPECTS OF PROGRAM 2 ACTIVITIES INDICATES THE VALUE OF THE CRC CONCEPT.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organisation</td>
<td>Grow</td>
</tr>
<tr>
<td>CSIRO Plant Industry, North Ryde</td>
<td>*</td>
</tr>
<tr>
<td>CSIRO Plant Industry, Canberra</td>
<td>**</td>
</tr>
<tr>
<td>NSW Agriculture, Wagga Wagga</td>
<td>**</td>
</tr>
<tr>
<td>NSW Agriculture, Tamworth</td>
<td>**</td>
</tr>
<tr>
<td>Agriculture WA, Northam</td>
<td>**</td>
</tr>
<tr>
<td>Agriculture WA, Perth</td>
<td>*</td>
</tr>
<tr>
<td>Other State Agriculture Departments</td>
<td>*</td>
</tr>
<tr>
<td>AW B Ltd</td>
<td>*</td>
</tr>
<tr>
<td>BRI Australia Ltd</td>
<td>*</td>
</tr>
<tr>
<td>Goodman Fielder Milling and Baking</td>
<td>*</td>
</tr>
<tr>
<td>George Weston Foods</td>
<td>*</td>
</tr>
<tr>
<td>Arnotts</td>
<td>*</td>
</tr>
<tr>
<td>University of Sydney</td>
<td>*</td>
</tr>
<tr>
<td>University of Western Sydney</td>
<td>*</td>
</tr>
<tr>
<td>APAF, Macquarie University</td>
<td>*</td>
</tr>
<tr>
<td>CSIRO Stored Grain Research Lab.</td>
<td>*</td>
</tr>
<tr>
<td>AMRAD</td>
<td>*</td>
</tr>
<tr>
<td>Real Time Engineering</td>
<td>*</td>
</tr>
</tbody>
</table>

The last five organisations (and 'other' State Departments of Agriculture) are collaborating institutions, not members of Quality Wheat CRC.
Project 2.1.1 - Protein composition during grain filling and post-harvest storage  
Project Leader: Ferenc Bekes

Background and Objectives
For a long time, industry has been frustrated by major quality changes associated with the transition to new-season’s wheat. Experiments indicate that quality changes during storage (especially at higher temperatures) make a major contribution to these problems. The aim of the current work is to determine how these changes can be avoided in practice, to provide raw materials of more consistent quality for processing. Molecular developments occurring during grain filling continue and are involved in the quality changes during storage. Accordingly, this project includes research both before and after harvest (Fig 2.2). Studies on protein deposition in the developing grain will contribute to our understanding of how final dough quality is determined.

Progress
Synthesis of high-molecular-weight (HMW) subunits of glutenin commences slightly before that of the low-molecular-weight (LMW) subunits (Fig 2.3). HMW subunits may form a ‘backbone’ upon which the LMW subunits form ‘branches’. The period from 15-21 days after anthesis (flowering) is critical for polymeric protein formation in the endosperm, and coincides with a rapid, significant increase in average polymer size (Fig 2.4). The extent of this increase seems to be significantly related to the HMW-glutenin subunit composition, but it was also visible in a triple-null line containing only LMW-glutenin subunits.

Storage at 23°C (or below) inhibited changes in grain quality throughout 12 months in laboratory experiments, provided this temperature was achieved during the first 70 days of storage (Fig 2.5). In practice, this could be achieved effectively by aeration. Reduction to 29°C was not sufficient to prevent the quality changes.

Research - Program 2

<table>
<thead>
<tr>
<th>Targets and Milestones Achieved</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clarify the timing of HMW and LMW subunit synthesis at 8-12 days post-anthesis on a new sample set of +++ +, +, and — lines</td>
<td>12/99</td>
</tr>
<tr>
<td>Complete storage experiments (in lab) to simulate aeration</td>
<td>12/99</td>
</tr>
<tr>
<td>Storage outcomes reported at industry workshop and individual meetings; protein synthesis, with proteome results, reported at Gluten 2000 in Bristol, UK</td>
<td>04/00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Projected Research for next 2 years</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Write up protein studies</td>
<td>12/00</td>
</tr>
<tr>
<td>Storage (23°C - 42°C) to obtain data for a mathematical model to describe the rate of change of quality</td>
<td>04/01</td>
</tr>
<tr>
<td>Lab-scale storage of multiple varieties/protein contents, stored at 38°C and at 4°C</td>
<td>03/01</td>
</tr>
</tbody>
</table>
Project 2.1.2 - Improved consistency and continuity of supply for markets
Project Leader: Helen Allen

Background and Objectives
Financial returns to wheat-growers depend on the combination of grain yield and premium payments for quality. A major objective of CRC research and extension has been to increase opportunities for growers to achieve grain-quality targets that would provide premium payments. These efforts have centred on regions where there have not been traditional opportunities for such premiums, including south-eastern Australia and parts of the Western Australian wheat belt. Through field trials, we have developed farm-management recommendations for implementation by growers in such regions. On-going research is aimed at elucidating the underlying basis of relationships between dough-quality, protein content and growth environment, especially fertiliser treatments and various stresses (Fig 2.6).

Progress
At a special symposium of the 49th Australian Cereal Chemistry Conference, Western Australian increases in the proportion of grain achieving premium-paying quality (Fig 2.7) were reported, along with final outcomes of the Prime Hard in the South project. In the 1999/2000 harvest, over 300,000 tonnes of Prime Hard wheat were delivered to 44 receival sites south of the Lachlan River and shipped from Port Kembla. A significant amount of wheat (82%) in southern NSW was received into premium grades, partly reflecting better management practices that have increased protein content across all grades. The increases in premium payments for Prime Hard wheat in southern NSW were worth about $9,000,000 to the growers. New varieties with the Prime Hard quality type, suited to southern regions, are being developed to augment this success.

<table>
<thead>
<tr>
<th>Targets and Milestones Achieved</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete reporting on Prime Hard in the South project</td>
<td>06/99</td>
</tr>
<tr>
<td>Quality testing of grain samples from further trials</td>
<td>06/00</td>
</tr>
<tr>
<td>Evaluate and report on 1999/2000 harvest of southern Prime Hard and WA premium grades</td>
<td>03/00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Projected Research for next 2 years</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality-test grain from further trials</td>
<td>12/00</td>
</tr>
<tr>
<td>Complete northern NSW crop nutrition project</td>
<td>02/01</td>
</tr>
</tbody>
</table>

Fig 2.6 - Effect of disease (Fusarium crown rot) and water availability on grain protein content, in relation to nitrogen status. The three lines represent low (red) and high (blue) disease levels, and average of all sites (green), illustrating how disease reduces both water and nitrogen use efficiency. Available water should be matched by N supply at sowing to ensure the production of Prime Hard wheat.

Fig 2.5 - Simulated aeration of grain shows that it can reduce the temperature of stored grain to below 23°C, thereby preventing quality loss during storage.

Fig 2.4 - FFF analyses of the least extractable protein from immature endosperms indicates that the average size of the glutenin polymers increases progressively during grain filling.

Fig 2.7 - FFF analyses of the least extractable protein from immature endosperms indicates that the average size of the glutenin polymers increases progressively during grain filling.
Project 2.1.3 - On-farm diagnostics for maximising grower returns
Project Leader: Colin Wrigley

Background and Objectives
Pre-harvest sprouting reduces the processing quality of wheat grain, due to the effects of the increased amylase activity on starch during all forms of heat processing. The Falling Number test is the standard method for quantifying the severity of sprout damage, and it is used to specify the extent of downgrading of rain-damaged grain. A feature of sprout damage is that its effects are neither spread evenly across a paddock, nor between paddocks. The development of the CRC's WheatRite® test card now permits the harvesting of sound grain separately, free from the sprouted grain that would otherwise downgrade the whole crop.

Progress
The WheatRite® card has been used successfully to reduce the delivery of sprouted grain in several practical farm situations. In one case of a rainy harvest, a $200 outlay for two dozen test cards resulted in an estimated increase of $40,000 for the property's wheat harvest by avoiding contamination of sound grain with sprouted grain. Distribution arrangements have been made with agents in Australia, USA and Europe. ReadRite, a small scanning instrument which can be interfaced with a printer or computer, has been developed for quantitative recording of WheatRite® card results (Fig 2.10). This should facilitate official adoption of the WheatRite® kit by the wheat industry.

<table>
<thead>
<tr>
<th>Targets and Milestones Achieved</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>International demonstrations and distribution arranged</td>
<td>12/99</td>
</tr>
<tr>
<td>Card scanner developed</td>
<td>04/00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Projected Research for next 2 years</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adapt WheatRite® kit to a wider range of grain types, e.g. barley, rye, long grain</td>
<td>10/00</td>
</tr>
<tr>
<td>Develop new types of test kits e.g. for wheat disease detection</td>
<td>06/02</td>
</tr>
</tbody>
</table>

*This project was transferred to Program 5 in January 2000*

### TABLE 2.9
**MOST COMMON IDENTITIES FROM PROTEOME STUDIES OF IMMATURE WYUNA WHEAT**

<table>
<thead>
<tr>
<th>pH 4-7</th>
<th>pH 6-11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gladiins</td>
<td>36</td>
</tr>
<tr>
<td>Glutenin subunits</td>
<td>9</td>
</tr>
<tr>
<td>Protein disulfide isomerase</td>
<td>14</td>
</tr>
<tr>
<td>Amylase/trypsin inhibitors</td>
<td>28</td>
</tr>
<tr>
<td>Total Spots</td>
<td>690 immature [650 mature]</td>
</tr>
</tbody>
</table>

Fig 2.7 - Increases in the percent of the Western Australian wheat crop achieving premium-paying grades in recent years.

Fig 2.8 - Influence of nitrogen application and soil potassium on screenings, at Gnowangerup, WA.
Project 2.1.4 - Reducing the dough-weakening effect of heat stress
Project Leader: Colin Wrigley

Background and Objectives
Temperature fluctuations during grain filling are known to affect grain quality and resulting dough properties at maturity. The Australian wheat belt experiences lengthy periods of above-optimal temperatures (daily maxima of over 20°C) and short periods of heat shock (a few days of over 32°C). These two types of stress have been simulated in controlled-environment experiments to provide grain quality and composition data. Field experiments during the relatively cool seasons of 1998 and 1999 were unsuccessful, but other experiments have shown that the extent of heat stress reaction is genotype-dependent. We therefore seek to identify tolerant genotypes, elucidate the molecular mechanisms involved, and provide relevant methodology and germplasm for breeding.

Progress
Many families of advanced (F4) lines from heat-tolerant x susceptible crosses have been harvested and are being glass-house tested to characterise their degree of heat tolerance. The resulting grain will undergo dough and biochemical testing and molecular marker analyses. With improved proteome methodology for wheat proteins, high resolution two-dimensional maps showing about 1,300 polypeptides have been produced from the immature endosperm of the heat-susceptible wheat Wyuna (Fig 2.11). N-terminal amino acid sequence obtained from over 300 of these polypeptides has enabled identification of many of the proteins (Table 2.9). A few specific polypeptides are present in association with heat tolerance. Patent cover has been obtained.

Fig 2.10 - ReadRite, an electronic scanner to provide the results from the WheatRite® test cards as Falling Number equivalents

Fig 2.11 - Proteome map of polypeptides (pH 4 to 7 range) from immature Wyuna endosperm. Numbered spots have been submitted to N-terminal sequencing. This is one of two such maps, the other covering polypeptides with isoelectric points in the range 6 to 11.

Project 2.1.5 - Flexibility of wheat use
Project Leader: Helen Allen

Background and Objectives
The components of this project were developed as a result of grower initiatives and workshops arranged by GRDC, with the overall objective of providing flexibility in the production of quality grades of wheat. The first project involved growing and quality-testing a range of wheat types at diverse sites for regional and national benchmarking of quality potential. Other parts involve investigating biochemical and genetic explanations of environmental variations in quality, and attempts to manage within-paddock variation in quality. The final aspect involved development of principles and models to predict the outcome of blending wheat quality types for specific ends. Most of these component projects are near completion.

Progress
For benchmarking, 15 varieties of diverse quality type are being grown at 12 sites around Australia in successive seasons. Evaluation of quality attributes and products from the first year's material suggests lower than expected variation in quality, but further seasons' results are required before conclusions can be drawn. In rapid response to the severe frost of the 1998 season, a grain grading solution was developed. The large-grained fraction was satisfactory for milling and baking, while the pinched grain was suitable for feed (Fig 2.12). Mathematical models for blending have been developed to describe the quality attributes of multiple flour or grain blends as a function of the chemical makeup of the components.

<table>
<thead>
<tr>
<th>Targets and Milestones Achieved</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finalise proteome methodology; identify at least 300 polypeptides; patent their N-terminal sequences</td>
<td>03/00</td>
</tr>
<tr>
<td>Identify polypeptides associated with heat-shock tolerance</td>
<td>05/00</td>
</tr>
<tr>
<td>Characterise several current varieties according to heat-shock tolerance</td>
<td>12/99</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Projected Research for next 2 years</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characterise polypeptides as potential markers for heat tolerance</td>
<td>12/00</td>
</tr>
<tr>
<td>Heat shock advanced crosses and doubled haploid lines; determine dough-strength changes</td>
<td>06/01</td>
</tr>
<tr>
<td>Characterise crosses/ doubled haploids for possible heat stress markers</td>
<td>12/01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Targets and Milestones Achieved</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaluate 1998 season samples' quality tests in bench-marking trials</td>
<td>09/99</td>
</tr>
<tr>
<td>Provide industry with simple varietal guide to predict blending outcome</td>
<td>12/99</td>
</tr>
<tr>
<td>Review overall progress and interactions for the set of project parts in association with industry</td>
<td>03/00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Projected Research for next 2 years</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide final reports for the Prime Hard in the South, managing within-paddock quality variation, and the blending aspects of this project</td>
<td>09/00</td>
</tr>
<tr>
<td>Complete quality testing of grain from 1999 and 2000 growing seasons</td>
<td>09/01</td>
</tr>
</tbody>
</table>
Project 2.1.6 - Field trials of temperature-controlled grain storage  
Project Leaders: Peter Gras

**Background and Objectives**

Laboratory-scale experiments (in Project 2.1.1) have led to successful elucidation of the causes of quality loss during storage (Fig 2.5). This work also identified aeration of stored grain as a practical and cost-effective means of overcoming the problem. As a result, industry collaborators suggested that pilot-scale experiments should be undertaken to demonstrate the practical out-working of the laboratory-based conclusions. Accordingly, milling companies in the CRC undertook to provide additional resources to permit storage and monitoring of grain at twinned storages, so that the effects of aeration could be compared with non-aerated conditions, in practical situations.

**Progress**

A pair of 800 tonne storages of wheat at Narromine, only one being aerated, were compared following the 1998/99 harvest. After only 20 days, the temperature of the aerated grain had fallen to 24°C, whereas the non-aerated grain was still above 27°C after 70 days’ storage. In comparison to the deterioration in quality processors normally experience, there was no quality loss for the aerated grain. Partly because of the unusually moderate initial temperature of the grain (just less than 30°C), baking quality results for the non-aerated grain were not conclusive. Following meetings in May and June, 2000, the major milling companies and GrainCorp agreed that aeration will be used for domestic grain in the 2000/01 harvest.

**Fig 2.12 - Frost-affected grain before grading to separate the large grains (shown to mill and bake well) from the pinched grain (demonstrated to be satisfactory for animal feed).**

---

Project 2.1.8 - Examining the effects of environment and crop management on wheat quality

Project Leaders: Wal Anderson

**Background and Objectives**

When given clear guidelines based on sound research and adequate economic incentives, farmers adjust practices and manage environmental risk to produce higher grain yields and improved quality. In Western Australia, yields have risen steadily for the last decade and premium wheat grade production has risen from 15% to over 40% (Fig 2.7). The aim of this project is to establish the effects on wheat quality of environmental variables, including seasonal temperature and water supply, and of choice of soil type and rotation, sowing time and supply of macro- and micro-elements. Grain samples from ongoing field and controlled-environment experiments are analysed, using facilities at the new Northam laboratory.

**Progress**

The Northam laboratories have been constructed and equipped, and initial calibration has been undertaken. Appointment of a suitably qualified cereal chemist is expected in July 2000. Earlier research highlighted significant crop management implications for grain quality. For example, where soil-potassium levels are adequate, nitrogen can be applied at up to 80 kg/ha N without significantly increasing the grain screenings (single season, single site). Where potassium is deficient, however, increasing nitrogen application caused higher levels of screenings, in this case, to more than the 5% segregation limit (Fig 2.8). The further implications for other aspects of grain quality need to be investigated.

---

**Targets and Milestones Achieved**

**Date**

- Report on differences in grain quality due to storage 12/99
- Commence further field trials N/A*
- Meet with wheat industry representatives to seek agreement to adopt aeration for domestic grain 06/00

**Projected Research for next 2 years**

**Date**

- Grow initial glasshouse samples, receive grain from field experiments 12/00
- Complete first grain, flour and dough measurements 06/01
- Produce project report

---

**Research - Program 2**

**Targets and Milestones Achieved**

**Date**

- Establish laboratory at Northam 01/00
- Install and calibrate laboratory equipment 05/00

**Projected Research for next 2 years**

**Date**

- Grow initial glasshouse samples, receive grain from field experiments 12/00
- Complete first grain, flour and dough measurements 06/01
- Produce project report

---

* Further field trials not completed following cool 1999 harvest
Australian white wheats are acknowledged worldwide for their free milling characteristics and good flour colour. Despite their good milling potential, white branred wheats can suffer by comparison with red wheats, especially in Asian markets, where ash, rather than flour colour, is the main criterion of flour purity. Milling performance is affected by both varietal and seasonal characteristics. The annual pilot scale millings provide timely information which is used by marketers and millers on both the domestic and export markets. Some of the techniques currently under investigation in this program could offer new opportunities for improving milling quality in terms of both conditioning regimes and extraction rate.

The project, Microbiology and the flour milling process, has now been completed, and the report has been widely distributed and adopted throughout the milling industry, signifying its importance to the commercial partners.

Program Aims
The objectives of the program are:

- to provide the commercial partners, breeders and cereal researchers access to the latest season’s milling information on commercial grades and new varieties;
- to use new milling technologies and methods of measurement to produce flours with varying levels of wheat bran components which will have application in potentially increasing flour extraction rates without sacrificing quality; and
- to evaluate potential new wheat conditioning regimes.

Project 3.1.3 - Pilot Milling Studies
Project Leader: Michael Southan

Background and Objectives
This ongoing project provides the commercial partners of the CRC with up to date information on pilot milling performance, flour characteristics and end product quality for Australian wheat grades and new wheat varieties. It forms the basis for the technical milling advice, which is valued by overseas customers of Australian wheat. This advice is important, as customers need to be informed of any seasonal changes in performance or characteristics. Samples of the pilot milled flour are made available for the commercial partners’ or AWB Ltd customer evaluation, and for use in other CRC projects or by the breeders.

Progress
The 1999/2000 harvest resulted in generally lower grade wheats from wet weather at harvest. As a result there was difficulty in obtaining samples of sufficient quality for pilot milling trials. Samples milled were two new hard varieties, Baxter and Kennedy, a new strong soft variety, Sunsoft, and 7 hard and 2 soft grade samples. The straight run flour extraction rates are shown in Fig 3.1, and varied from 73.8% for the Albany Soft 1 to 79% for the High Protein APW from Port Adelaide.

The next round of samples to be pilot milled and tested will be chosen after consultation with AWB Ltd and the commercial partners.

Program 3A: Processing of Wheat and Wheat Products (Milling)
Program Manager: Ms Di Miskelly

**Program Aims**

Provide a scientific basis for technical information used in flour milling in the domestic and overseas markets, as well as providing feedback to breeders and other researchers.

Use new technologies to modify the milling process, and provide the commercial partners with timely and useful information for further application.

**Fig 3.1 - Pilot Mill 1999-2000 Flour Yields**

<table>
<thead>
<tr>
<th>Targets and Milestones Achieved</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilot millings of 1999/2000 season wheats completed</td>
<td>04/00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Projected Research for next 2 years</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final report for 1999/2000 season wheats published</td>
<td>10/00</td>
</tr>
<tr>
<td>Pilot millings of 2000/01 season wheats completed</td>
<td>04/01</td>
</tr>
<tr>
<td>Final report for 2000/01 season wheats published</td>
<td>10/01</td>
</tr>
</tbody>
</table>
Project 3.1.4 - Microbiology and the flour milling process
Project Leader: Ailsa Hocking

Background And Objectives
This project was initiated in response to an industry need for baseline data on the current microbiological status of the Australian flour milling industry. The aims of the project were to determine the distribution of spoilage and pathogenic microorganisms throughout the milling process, to assess the fate of microorganisms entering the mill on incoming wheat and to propose practical guidelines for end products. The results will be used by mills in development of their HACCP (Hazard Analysis Critical Control Points) food safety plans.

Progress
Samples spanning the entire milling process, from wheat intake to finished products, were tested through the project. Results indicated that the microbiological quality of the incoming wheat largely determined the ultimate microbiological quality of the finished products. Mill hygiene also contributed. It was found that the microbiological quality of Australian flour compares favourably with that of the USA, and was better than published results on European flour. Based on the study, acceptable microbiological limits have been proposed for flour, semolina, wheat germ and bran. Following completion of the project in September 1999, a comprehensive report (QWCRC report No. 37) was prepared and widely distributed.

Fig 3.2 - Cumulative Bran Curve for Conventional and Debranned Hard Wheat

Project 3.1.5 - Use of new technology to aid mill process control
Project Leader: Michael Southan

Background And Objectives
Optimisation of grist rate, that is, the quantity of wheat required to produce one tonne of flour, is of commercial value to flour millers. The current constraint on improvement of flour extraction is the deleterious effect of bran on end product quality. Wheat bran has two main fractions, pericarp and aleurone. The aim of this project is to use the Satake Peritec debranning machine prior to pilot milling to produce wheat flour samples with a range of flour yields and aleurone and pericarp concentrations for use in downstream processing.

Progress
Because of breakdown of the Dipix Microscopic Imaging System with which we had intended to measure the aleurone and pericarp in the flours, it was decided to determine the phytic acid content by a wet chemical method. (Phytic acid is mainly concentrated in the aleurone layer.) The method was successfully developed at Weston Food Laboratories. Together with Branscan measurements, the phytic acid method was subsequently used in the analysis of flour mill streams and mill products from wheats which had been subject to different levels of debranning prior to milling. Product testing - bread, noodles and steamed bread - was also undertaken on the flours. Some flour yield improvements were obtained on debranning without a major change in bran contamination or product quality.

This project is due for completion in June 2000.
Project 3.1.6 - Investigations on increasing the conditioning efficiency of wheat
Project Leader: Michael Southan

Background And Objectives
Wheat conditioning is an essential step for optimal milling performance. The process involves the addition of water to grain to increase the moisture content to between 14 and 17%, depending on grain hardness. At this moisture content, flour yield is maximised while minimising bran contamination during milling. The aims of this new project (commenced January 2000) are to investigate methods, either physical or chemical, which may significantly reduce the conditioning time of wheat, and to investigate ways to increase the flour yield significantly by enhancing separation of the bran from adhering endosperm.

Progress
There have been numerous publications on the conditioning of wheat. A comprehensive review of the literature has shown that there have been many studies on water penetration through the grain, the rate of penetration and factors that affect that rate. However, there is very little literature regarding chemical conditioning although a few researchers have used aerosols and food acids. Initial work has been concentrated on investigating the rate of water penetration after conditioning, using physical measurements. In future work, we will look at ways of making the conditioning process more efficient by using both a physical and a chemical approach on two wheat types, hard and soft.

<table>
<thead>
<tr>
<th>Targets and Milestones Achieved</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete literature review</td>
<td>03/00</td>
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</table>

<table>
<thead>
<tr>
<th>Projected Research for next 2 years</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Determine the effect of alternative mechanical processes on the conditioning times of samples of soft and hard wheats</td>
<td>09/00</td>
</tr>
<tr>
<td>Pilot mill hard and soft wheats which have been conditioned by mechanical methods</td>
<td>01/01</td>
</tr>
<tr>
<td>Conduct flour quality test on pilot-milled wheats and test end products</td>
<td>02/01</td>
</tr>
</tbody>
</table>
The grain foods processing industry needs modern systems for real time measurements, during processing, of product properties and processing parameters. This will maximise food product quality and value and lead to more fully automated food manufacturing, more consistent higher quality products, and greater efficiency and profitability.

This program comprises three projects. "Process measurement and control for dough mixing and makeup plants" involves studies of the mixing of dough and what happens to it as it passes through the makeup plant. Sheetig is an important processing step in the manufacture of bread, ethnic flat breads, pastry, biscuits, noodles and tortillas. "Oven technology to optimise product quality and improve efficiency" involves developing a complete process control system for baking, using existing and newly developed technology to measure process variables and product quality. "Rheology of yeasted doughs" is a PhD project in which new ways to measure the fundamental physical properties of full-formula doughs are being developed, so that the effects of all ingredients, including yeast, are accounted for when making these measurements. Use of these new methods will allow us to understand how yeast contributes to the development of dough, and will ensure that measurements and predictions of dough properties will be more industrially relevant.

**Program Aims**

The aims of the program are to understand the relationships between industrial and laboratory scale mixing and baking, and the effects of processing on a range of baked-product quality attributes.

Through understanding, develop new integrated control systems for commercial bakeries, including systems that will enable remote monitoring and management of bakeries.

**Project 3.4.1 - Process measurement and control for dough mixing and makeup plants**

**Project Leader:** Nigel Larsen

**Background And Objectives**

The goal of this project is to facilitate the ability of food manufacturers to add value to cereal-based food products, by defining, predicting and reducing the industrial processing requirements, and improving the quality of these foods. We can do this through research to improve understanding of the relationships between laboratory scale and industrial scale mixing. We also aim to define how dough rheological properties affect the outcomes of mixing and makeup plant processes. Quality Wheat CRC has developed a unique experimental program of research on dough sheeting, in which we have been studying chemistry-rheology interactions.

**Progress**

Dough elasticity makes predictability of sheeting processes poor when scaling from the benchtop to a production line. The role of elasticity was demonstrated by sheeting two different doughs at two different speeds. For bread dough, the exit sheet thickness was always larger than the roll gap (Fig 3.1). This spring back was greater at faster speeds but the elastic effects were small when the sheeting was less severe. With play-dough, which has low elasticity, the sheeting process was dominated by the elastic effect of low elastic control, but even this low elasticity still greatly influenced the sheeting process.

**Fig 3.1 - The effect of roll speed and dough elasticity on the thickness of sheeted dough.**

**Program 3B: PROCESSING OF WHEAT AND WHEAT PRODUCTS (BAKING)**

**Program Manager:** Dr Nigel Larsen

**PROGRAM 3B OBJECTIVES**

To understand the relationships between industrial scale and laboratory scale dough processing and baking, and the effects of processing on a range of baked-product quality attributes.

Through understanding, develop new integrated control systems for commercial bakeries, including systems that will enable remote monitoring and management of bakeries.

**Targets and Milestones Achieved**

- Define effect of elasticity on sheet properties using two doughs with known elastic properties
- Present dough sheeting research results to an international food engineering conference

**Projected Research for next 2 years**

- Define the effects of processing parameters (such as speed and roll diameter) on dough sheet properties
- Establish the sheeting energy requirements for optimum dough properties as a function of processing parameters
- Measure effects of air inclusion on sheeted dough properties and the effects of sheeting on dough bubble structure

**Date**

- 03/00
- 04/00
- 06/01
- 06/01
- 06/02
Project 3.4.2 - Oven technology to optimise product quality and improve efficiency
Project Leader: Thomas Adamczak

Background and Objectives
In view of the need to obtain automatic control of baking parameters, the Advanced Advisory and Control System for Bakeries has been developed. The Product Quality Indicator data acquisition system is a part of this package. Its function is to monitor details of product and production parameters from the bakery. The Product Following Section module was developed to monitor exactly when certain products enter different sections of the production line. To enable remote communication with the bakery computer, a computer system using the internet has been established. Feedforward/feedback control will be used with burners to enable better control of oven temperature.

Progress
A Product Quality Indicator (PQI) has been developed, and a single page report which includes production recommendations has been designed. A central PC logs the data, some of which is processed in real time. Both analysis of the production data and optimisation and adjustment of burner operation can be performed remotely. The travelling high temperature humidity probe has been improved, though few manufacturers have yet purchased the version suited for biscuit production. Other elements designed and tested include The Vision System to capture the images of the product leaving the oven and The Weighing System for evaluation of the weight of the product before cooling.

Targets and Milestones Achieved

<table>
<thead>
<tr>
<th>Projected Research for next 2 years</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete Control System Software (Advanced Version)</td>
<td>11/00</td>
</tr>
<tr>
<td>Implement Integrated Control and Optimisation System (software and hardware) in a commercial bakery</td>
<td>04/01</td>
</tr>
<tr>
<td>Verify the predictive oven control model in single burner operation</td>
<td>05/01</td>
</tr>
<tr>
<td>Test loaf stability indicator</td>
<td>07/01</td>
</tr>
<tr>
<td>Modify prover operation to induce flexibility and allow for real time control of final height</td>
<td>08/01</td>
</tr>
<tr>
<td>Modify oven design to allow full control of initial and final stage of baking</td>
<td>11/01</td>
</tr>
<tr>
<td>Modify cooler design to allow constant cooling air parameters and constant final crumb temperature</td>
<td>03/02</td>
</tr>
</tbody>
</table>

Projected Research for next 2 years

Rheological characterisation of yeasted bread dough made from another four at low and large strains/shear

Characterisation of chemically leavened doughs to determine the relative influence of density changes

Constitutive modelling of the rheological properties of yeasted doughs utilising the model developed from non-yeasted doughs

Project 3.4.4 - Rheology of Yeasted Doughs
Project Leader: Nigel Larsen (Marcus Newbery, PhD student)

Background and Objectives
Very little is known about the rheology of fermenting doughs and almost nothing is known about their fundamental rheology. Despite the central importance of yeast in producing the distinctive aerated structure of many baked products, most rheological studies of doughs ignore the effect of yeast. Knowledge of yeasted dough rheology will assist in transferring research information to the bakery floor and in understanding and controlling the operation of today's automated bakery operations. This project's central aim is to investigate the rheology of fermenting dough using fundamental shear and elongational rheological techniques.

Progress
Since active yeast would complicate and confound interpretation of fundamental rheological measurements, a means of inactivating yeast within the fermenting dough was required. Following thermal inactivation of yeast, rheological measurements of yeasted dough were possible. Low strain measurements did not reveal any significant fermentation-induced changes in yeasted doughs, confirming previous insights into the limited ability of such measurements to differentiate flour types. However, large strain measurements revealed a progressive decrease in the maximum shear and elongational viscosity of yeasted doughs as fermentation proceeded. Accompanying this, a greater proportion of large insoluble protein aggregates were observed in yeasted doughs as fermentation proceeded.

Targets and Milestones Achieved

<table>
<thead>
<tr>
<th>Targets and Milestones Achieved</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development of pre-conditioning techniques to improve reproducibility in rheological measurements</td>
<td>07/99</td>
</tr>
<tr>
<td>Measurements of protein aggregate composition of yeasted dough</td>
<td>11/99</td>
</tr>
<tr>
<td>Comprehensive rheological characterisation of yeasted doughs at low and large strain/shear</td>
<td>03/00</td>
</tr>
<tr>
<td>Presentation of research work as a poster at 7th International Wheat Gluten Workshop, Bristol, United Kingdom</td>
<td>04/00</td>
</tr>
</tbody>
</table>

Projected Research for next 2 years

Rheological characterisation of yeasted bread dough made from another four at low and large strains/shear

Characterisation of chemically leavened doughs to determine the relative influence of density changes

Constitutive modelling of the rheological properties of yeasted doughs utilising the model developed from non-yeasted doughs
With the international trend towards convenience foods, new food products must be simple and rapid to prepare. Fortunately many wheat based products have been adapted to suit this trend. Behind this trend there is a need to deliver finished products to meet tighter quality specifications. To meet these requirements food manufacturers are demanding tighter raw material specifications.

The aim of this program is to understand wheat based products from the perspective of consumers and food processors, identifying what is important to consumers and what the food processor must do to achieve these demands. This means examining the effect of processing and raw materials on finished product quality. The information must then be distilled to determine which wheat quality traits are most important to the food processor.

The wheat specifications developed through this program can be used to target wheat for discerning markets. Delivering the quality demanded by markets increases Australia’s competitiveness and potential to attract higher prices. The specifications can also be used as targets for wheat breeders to develop new wheats, which better meet market requirements. Understanding the food manufacturing process and interactions between the raw material and the process can also be extremely helpful in supporting processors using our wheat.

**Program Aims**

To develop raw material specifications and processing knowledge for major wheat based products.

To enable the Australian wheat industry to better meet consumer demands for product quality.

To enable sale by specification and the targeting of more discerning markets.

**Program 4 Objectives**

To develop raw material specifications and processing knowledge for major wheat based products.

To enable the Australian wheat industry to better meet consumer demands for product quality.

To enable sale by specification and the targeting of more discerning markets.

**Project 4.1.1 - Defining starch quality for enhanced performance of baked products**

**Project Leader**: Hon Yun

**Background and Objectives**

Starch forms the major component of wheat flour and makes an important contribution to bread character. In this project we are seeking to identify how changes in wheat starch characteristics affect baked quality. In addition to this work on bakery products, Dr Hon Yun has linked to a GRDC project seeking to characterise the role of starch components for Asian noodles. Thus, we have achieved a number of synergies, as the sample preparation methods are similar.

**Progress**

This year saw the completion of work on starch granule ratio which demonstrated the significant advantage of an increased ratio of smaller starch granules, as this lead to increased bakery water absorption and softer bread crumb. The approach of using fractionation and reconstitution techniques has enabled the team to identify a breeding target without having to wait for appropriate genetic material. This principle has also been applied to the study of waxy wheat material, which had poor gluten properties. By separating the starch and using it in a number of products, it has been possible to identify potential applications in bread and noodles (Fig 4.1). We are now using these results to focus the assessment of more advanced waxy material in a range of food products.

**Fig 4.1 - Starch gel firmness for blends including waxy wheat starch**

<table>
<thead>
<tr>
<th>Targets and Milestones Achieved</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment of A:B starch granule ratio effects on bread making</td>
<td>09/99</td>
</tr>
<tr>
<td>Assessment of waxy wheat (98/99 harvest) for bread and noodles</td>
<td>10/99</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Projected Research for next 2 years</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment of waxy wheat (99/00 harvest) for bread and noodles</td>
<td>09/00</td>
</tr>
<tr>
<td>Assessment of waxy wheat (00/01 harvest) for bread and noodles</td>
<td>07/01</td>
</tr>
<tr>
<td>Assessment of A:B starch granule ratio effects on biscuit making</td>
<td>02/02</td>
</tr>
</tbody>
</table>
TABLE 4.2  EFFECT OF COMPONENT SUBSTITUTION ON PASTA QUALITY

<table>
<thead>
<tr>
<th>Durum Base Substitution</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waxy (0-3% amylose) starch from either barley, maize or wheat</td>
<td>Flour with shorter mixing times, higher peak resistance and Rmax and lower extensibility than durum only. Pasta much less firm and generally stickier.</td>
</tr>
<tr>
<td>High amylose (75%) maize starch</td>
<td>Pasta stickiness and cooking loss decreased.</td>
</tr>
<tr>
<td>Glutens conferring different dough strengths at same protein content</td>
<td>Stronger gluten produced firmer, less sticky pasta.</td>
</tr>
<tr>
<td>Gluten from extra strength Glenlea</td>
<td>Pasta firmer than the best durum wheats.</td>
</tr>
<tr>
<td>Vary only total protein content (8-20%)</td>
<td>Dramatic increase in pasta firmness with increase in protein, more pronounced than using different glutens.</td>
</tr>
</tbody>
</table>

Project 4.1.2 - Improvement of frozen and par baked products
Project Leader: Ken Quail

Background and Objectives
Frozen dough for bread and pastry products offers the convenience of fresh bake-off that has appeal in both domestic and export markets. The major limiting factor is the shelf life of the frozen dough. These products lose viability during frozen storage due to deterioration of yeast activity, damage to the gluten structure by ice crystals, chemicals leached from the yeast cells and moisture migration. The purpose of this study was to examine the viability of extended storage times.

Progress
As results from the study largely confirmed those reported in the literature, work on this project was wound down during the year. No significant advances in the extension of shelf life beyond three to four months were discovered. Following the “best practices” identified in the literature, we were able to achieve a shelf life of 8-12 weeks beyond this level. Several practices were identified, which will be incorporated into future work. We are surveying tetraploid species for improved quality attributes to further improve Australian durum wheat.

Project 4.1.3 - Better durum grain for premium pasta
Project Leader: Mike Sissons

Background and Objectives
In 1999, Australian production of durum reached almost 1 million tonnes, well in excess of domestic requirements. Our research is aimed both at understanding the basis of quality differences and devising rapid predictive tests. This is important to help breed durum wheat of consistent quality, which will ensure Australia meets market requirements into the future. In this project we are attempting to define the role of starch in pasta quality and to understand at the molecular level the contribution of semolina components to quality. We also aim to develop small-scale predictive tests for quality (Fig 4.4). Finally, we are surveying tetraploid species for improved quality attributes to further improve Australian durum wheat.

Progress
Using our model dough system, we altered only one component at a time and tested the effect on quality (Table 4.2). These results have implications for breeding programs. The starch properties of the tetraploid semolina samples have been characterised, several showing an amylose content greater than normally found in durum starch. Some had a very low breakdown with a high setback, characteristic of starch from wheats used for yellow noodles. The RVA may be useful in selecting lines with suitable starch properties. As with wheat starch, gelatinisation temperature does not appear to be related to either amylose content or viscosity. The range of gelatinisation temperatures (49-57°C) is slightly lower than normal for wheat starch (53-62°C), but there is still considerable overlap.

Projected Research for next 2 years

<table>
<thead>
<tr>
<th>Targets and Milestones Achieved</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaluate SKCS milling prediction on 1997/98 breeders’ lines</td>
<td>12/99</td>
</tr>
<tr>
<td>Evaluate role of individual components for pasta texture</td>
<td>06/00</td>
</tr>
<tr>
<td>Examine starch properties of tetraploid samples and relate to quality</td>
<td>12/99</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Projected Research for next 2 years</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using model doughs, study effects of glutenin:gliadin ratio and high-low molecular weight glutenin ratio on quality</td>
<td>06/01</td>
</tr>
<tr>
<td>Complete sensory evaluation of spaghetti from different countries to benchmark Australian pasta</td>
<td>12/00</td>
</tr>
<tr>
<td>Apply new predictive tests (Skew MW GS allele scoring) for gluten strength; SKCS prediction of semolina mill yield; rapid instrumental tests to mimic sensory) to durum breeding program</td>
<td>06/02</td>
</tr>
<tr>
<td>Continue evaluation of new durum from crosses between elite germplasm and selected tetraploids with superior quality attributes</td>
<td>06/02</td>
</tr>
</tbody>
</table>
Project 4.1.4 - Optimisation of the Processing Strategy for Utilising Australian Wheat in Instant Noodles

Project Leader: Nasir Azudin

Background and Objectives
The success of instant noodles reflects the high value consumers place on convenience. This year there will be over 40 billion packs of instant noodles consumed throughout the world. This constitutes a total wheat requirement in excess of 4.6 million tonnes, representing a highly significant market which is still growing. The aim of this project is to address the current technical problems faced by flour millers and instant noodle manufacturers when using Australian wheat in the production of instant noodles.

Progress
Alkali amount had a more significant impact on instant noodle colour and texture than alkali composition, though sodium hydroxide results clearly differed from carbonate use. Increased rain damage, using grain sprouted in a rain simulator, decreased raw noodle colour and raised oil uptake during frying but the impact on cooked colour was minor. Work on the effect on noodle texture is still in progress. The influence on instant noodle cooking time and texture of supplementing with a range of commercial starch types was examined. Types, desirable for reducing cooking time, were identified. With these starch additions, there was also a decrease in noodle firmness.

Project 4.1.5 - Microbiological Safety of End Products from Australian Wheat and Flour

Project Leader: Ailsa Hocking

Background and Objectives
Whilst noodles, breadcrumbs and steamed bread represent a growing sector of the market for Australian wheat flour both domestically and internationally, various aspects of their microbiological safety remain relatively unknown. We aim to determine the microbiological status of a range of domestic and imported noodle products currently in the market. We will determine the influence of initial flour microbiological quality on the safety of end-product noodles, and will also optimise production parameters for shelf-stable and dried noodles by challenge testing and shelf-life studies. This will contribute to improved understanding of the relevant safety issues in noodle and breadcrumb manufacturing processes and for commercial noodle and steamed bread products.

Progress
A survey of sixty domestic and imported noodle products has been completed. Many of the imported long-life shelf stable noodles, particularly udon, were cleanest microbiologically. Hokkien and fresh yellow alkaline (with and without egg) noodle types contained the highest microbial loads. In collaboration with Agrifood Technology, a series of fresh noodles was produced from downgraded wheat, milled conventionally, and with high and low debranning, through project 3.1.4. Each batch of noodles was assessed microbiologically during and after production. Little difference was found between the microbiological quality of noodles made from debranned wheat and wheat milled conventionally (Fig 4.5). The process developed produces long life shelf-stable noodles of high quality.

Targets and Milestones Achieved

<table>
<thead>
<tr>
<th>Targets and Milestones Achieved</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assess impact of alkali concentration and composition</td>
<td>04/00</td>
</tr>
<tr>
<td>Assess effects of selected commercial starch on instant noodles</td>
<td>06/00</td>
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</table>

Projected Research for next 2 years

<table>
<thead>
<tr>
<th>Projected Research for next 2 years</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete study of effects of rain damage on instant noodles</td>
<td>12/00</td>
</tr>
<tr>
<td>Study effect of gums and emulsifiers on instant noodles</td>
<td>08/01</td>
</tr>
<tr>
<td>Examine usage of steamed and dried noodles</td>
<td>02/02</td>
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</table>

Targets and Milestones Achieved

<table>
<thead>
<tr>
<th>Targets and Milestones Achieved</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assess microbiological status of noodles from downgraded wheat flour</td>
<td>12/99</td>
</tr>
<tr>
<td>Survey marketplace domestic and imported noodles</td>
<td>03/00</td>
</tr>
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</table>

Projected Research for next 2 years

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<tr>
<th>Projected Research for next 2 years</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Challenge and shelf life studies on longlife and dried noodles</td>
<td>09/00</td>
</tr>
<tr>
<td>Studies on microbiological safety of bread crumb manufacture</td>
<td>06/01</td>
</tr>
<tr>
<td>Steamed bread studies</td>
<td>09/01</td>
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</tbody>
</table>


**Project 4.1.6 - Strategies to replace flour chlorination as a treatment for cake flours**  
**Project Leader:** Ken Quail

**Background and Objectives**  
Chlorine gas is currently used to treat cake flours in Australia to enhance flour performance for cakes made with a high ratio of sugar (Fig 4.6). This treatment was banned in the United Kingdom last year and Australia is expected to follow suit in the near future. The opportunity exists to produce commercially viable alternatives to chlorine treatment. These would not only find immediate uptake on the domestic market but would open up significant opportunities to provide “clean” (chlorine treatment free) products for export.

**Progress**  
A series of twenty flours, representing chlorinated flour and the same flour without chlorination, has been obtained from industry partners. The samples have been evaluated thoroughly to identify the key attributes determining the performance of chlorinated flour. The major effects of chlorine were to lower pH, modify the starch pasting properties and reduce the elastic properties of dough formed from the flour. Detailed analysis of the proteins has been less revealing than anticipated, and it is presumed that modification to the proteins has caused changes in conformation rather than size distribution. A sponge cake method, which provides effective discrimination between the chlorinated and non-chlorinated flour, has been established. We are currently examining changes to starch properties to match those achieved by chlorination.

<table>
<thead>
<tr>
<th>Targets and Milestones Achieved</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Establish benchmarks for chlorinated cake performance</td>
<td>02/00</td>
</tr>
<tr>
<td>Develop chemical characterisation for impact of chlorine on flour</td>
<td>04/00</td>
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</table>

<table>
<thead>
<tr>
<th>Projected Research for next 2 years</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characterise starch, protein and lipids from chlorinated flours</td>
<td>09/00</td>
</tr>
<tr>
<td>Assess ten most promising alternative treatment options</td>
<td>09/01</td>
</tr>
<tr>
<td>Optimise most promising treatments and their combinations</td>
<td>03/02</td>
</tr>
</tbody>
</table>

**Project 4.1.7 - Australian wheat for the sponge and dough bread making process**  
**Project Leader:** Ken Quail

**Background and Objectives**  
North and south-east Asian countries employ the sponge and dough bread making process for their pan/volume bread production. This bread making process requires strong wheat with good processing tolerance. Most Asian markets consider that Australian Prime Hard wheat does not have appropriate quality for this process, so they import wheat from either the U.S. or Canada. This project is aimed at determining what potential Australia has to service this expanding and high value wheat market.

**Progress**  
We have established cooperation with an overseas bakery employing the sponge and dough method, to develop appropriate test baking methods and to benchmark flour performance. This will enable us to establish criteria for acceptability of wheat/flour for the sponge and dough process. The project involves collaboration with the Lesley Institute in Queensland, who have sown trial plots of specific material targeted for this market. It includes very strong wheats with high extensibility, as these are the traits considered important. Another component of the study has included an evaluation of bread crumb texture as the sponge and dough process is considered to produce crumb with superior strength and softness.

<table>
<thead>
<tr>
<th>Targets and Milestones Achieved</th>
<th>Date</th>
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</thead>
<tbody>
<tr>
<td>Complete assessment of bread texture methods</td>
<td>03/00</td>
</tr>
<tr>
<td>Assess test baking methods for sponge &amp; dough processing</td>
<td>06/00</td>
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<table>
<thead>
<tr>
<th>Projected Research for next 2 years</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete benchmarking of overseas flours and competitor wheats</td>
<td>12/00</td>
</tr>
<tr>
<td>Develop predictors for sponge and dough performance</td>
<td>10/01</td>
</tr>
<tr>
<td>Develop small scale tests, suitable for breeding programs, to assess sponge and dough performance</td>
<td>05/02</td>
</tr>
</tbody>
</table>
Project 4.1.8 - Noodle and frozen pastry sheet speckiness and control of contributing grain components

Project Leader: Ken Quail

Background and Objectives
Occurrence of dark specks in Asian noodles, pasta or pastry sheets lowers their consumer acceptance significantly. The specks are taken into consideration in the overall assessment of product appearance. Until recently, these specks were not measured separately, but were included in overall colour measurements. They can be related to bran contamination and enzymes associated with the bran, which cause increased darkening as the noodle or pastry sheet is aged. Through this project we are seeking to relate the occurrence of bran components in flour to the specks observed in noodles and pastry sheets. The aim is then to develop strategies to reduce the occurrence and impact of the specks.

Progress
A method for measurement of speck occurrence in raw noodle sheets has been developed. This method employs a digital imaging system known as Branscan, which was designed to measure specks in flour and semolina (Fig 4.7). Measurement of the relationship between specks and overall product colour indicates that speck occurrence follows the loss of noodle sheet brightness quite closely. This indicates the impact specks have on overall colour. The results also show the effect of flour extraction rate on product speckiness, and the relationship between ash and speck measurements. Staining techniques have been selected to differentiate the impact of pericarp and aleurone on product speckiness.

Targets and Milestones Achieved

<table>
<thead>
<tr>
<th>Task</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refine method for the evaluation of product speckiness</td>
<td>12/99</td>
</tr>
<tr>
<td>Quantify the impact of flour extraction rate on product speckiness</td>
<td>06/00</td>
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</table>

Projected Research for next 2 years

<table>
<thead>
<tr>
<th>Task</th>
<th>Date</th>
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<tbody>
<tr>
<td>Identify non-endosperm components contributing to specks</td>
<td>06/00</td>
</tr>
<tr>
<td>Develop strategies to reduce speckiness</td>
<td>09/01</td>
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</table>
The focus of Program 5 on flour and dough components and their interaction underpins much of the research elsewhere in the CRC. Its purpose is to provide a basis for breeding for quality by developing our understanding of the relationship between flour composition and dough processing properties. Much of the enhanced understanding generated can be used to develop breeding targets, or for development of diagnostic tests using antibodies and DNA probes (interactively with Program 1). Given the variable concentrations and high sequence homologies of many of the flour proteins which are targets of these diagnostics, new methods based on antibody engineering are being used to manipulate the specificity and sensitivity of assays. Several assays for products of key genes are already being provided to breeding programs for routine screening. Our development of small-scale equipment for dough mixing, extension and baking has given us tools to explore the role of individual flour polypeptides and starch components. Together with research aimed at differentiating dough behaviour in terms of fundamental rheological parameters, this should enable laboratory screening to better predict commercial bakery performance of flours, and enable processing conditions to be more objectively manipulated to suit different end-products.

Program Objectives

- To provide a basis for breeding for quality by understanding the relationship between flour composition and dough processing properties.
- To study the products of genes from sources outside cultivated wheat for novel effects on dough function.
- To better predict commercial bakery performance of flours.

**Program 5 Objectives**

To provide a basis for breeding for quality by understanding the relationship between flour composition and dough processing properties.

**Background and Objectives**

Existing approaches to relating flour composition to dough and baking properties have major limitations. Statistical correlations between dough parameters and genetic composition have been developed, but their reliability depends on the particular sample set. There have also been difficulties in detecting quantitative relationships, and the mechanism of effects of particular gene products is not explained. In this project, two different approaches are utilised. In the incorporation/addition test, the composition of a base flour is altered systematically by enriching the flour with well-characterised individual flour components, while in a new “model dough” approach, we have been developing the methodology for building up flours from a minimum number of individual components.

**Progress**

An in vitro method developed for preparative scale production of artificial glutenin polymers utilizes controlled environment oxidation. The functionality of in vitro-produced polymers was tested in a small-scale model dough system, and was related to the treatment of the proteins prior to, during and after in vitro polymerization. When added as the only polymeric component in a reconstituted model dough, in vitro polymers mimicked the dough development and breakdown of native glutenin. Manipulating the ratio of high:low molecular weight glutenin subunits (HMWGS:LMWGS) altered the molecular weight distribution of in vitro polymers (Fig 5.2). This suggests utility in investigating the effects of glutenin polymer size on dough function and flour end-use quality.

**Targets and Milestones Achieved**

<table>
<thead>
<tr>
<th>Task</th>
<th>Date</th>
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<tbody>
<tr>
<td>In vitro polymerisation to provide glutenin that is functional in the model dough establishment of critical molecular weight characteristics</td>
<td>12/99</td>
</tr>
<tr>
<td>Expression and purification of single HMWGS in suitable amounts for model dough experiments</td>
<td>06/00</td>
</tr>
</tbody>
</table>

**Projected Research for next 2 years**

- Project ended due to prioritisation of funding | 06/00 |
Background and Objectives

Despite the obvious commercial relevance, we know rather little about the behaviour of doughs in precise rheological terms. Laboratory equipment such as the Mixograph, Farinograph, and Extensograph provide empirical rheological information on dough behaviour. However, lack of understanding of fundamental dough rheology can lead to inconsistent observations between these instruments and complicate selection in breeding programs. It can also lead to inconsistencies between the laboratory and the bakery results, and difficulties in understanding relationships between flour composition and rheological behaviour. We are tackling this by developing and utilizing equipment for small-scale dough testing, and by undertaking an extensive investigation of the fundamental rheological analysis of dough.

Progress

Large-amplitude oscillatory shearing flow data for a water-flour dough agreed well with model predictions, when analysed using a recent constitutive equation for bread dough, which treats dough as solid (Figure 5.3). The non-linear response of the material, even at low amplitude 0.05, is mainly due to its strain softening behaviour, and cannot be predicted by a shear rate dependent model. Westons weak/strong flour types were distinguished on the basis of viscometry, stress relaxation, extensionsal viscosity, and, novelly, by creep compliance and oscillatory flow. The extensional test shows usual strain-hardening and also demonstrates the dependence of sample diameter on a double exponential with time. Novel measurement techniques for dough sample diameter during extensional testing permit accurate calculation of extensional stress and hence extensional viscosity, eliminating a major source of error. Preliminary relaxation time spectra have also been obtained.

Fig 5.1 - Mixograph and extension curves of flour samples with different HMW-GS composition. The samples (Lawrence et al., 1989) are derivatives of a Gabo/Olympic line (+,+,+), containing HMW-GS of 1,7+8,5+10. Simple, double and triple nulls for the Glu-1A, B and D loci are indicated by -. Flour protein content and glutenin:gliadin ratio were adjusted by starch and gliadin addition, so differences in functional properties are related to the differences in glutenin composition only.

Fig 5.2 - Mixing curves of model doughs made from identical amounts of starch, solubles, gliadin and in vitro polymerised artificial glutenin polymers made from 80% LMW-GS and 20% HMW-GS (Dx5 or Dy10) produced by bacterial expression.

Fig 5.3 - Agreement between constitutive bread dough model predictions and experimental data. Model predictions (lines) agree with experimental data (circles) at varying amplitudes δ, and 1 Hz oscillation frequency, including the sharp transition points in the stress/strain curves.
Project 5.1.4 - Molecular diagnostics for wheat quality
Project Leader: Amanda Hill

Background and Objectives
The aim of this project is to capture the results of research generated within the CRC by developing simple methods for rapid and objective testing of quality attributes. For example, major breeding programs and CIMMYT now annually use approximately 9,000 of our 1RS translocation screening tests for detection of rye introgression into wheat (Fig 5.4). The tests under development can also be used across the supply chain by grain growers, handlers and processors. Our delivery systems utilize antibody-based methods and encompass established hybridoma technology for monoclonal antibody production as well as gene technology for engineered antibodies with unique characteristics.

Progress
A newer test to determine the allelic source of the range of high molecular weight glutenin subunits will provide early generation assessment of wheat quality in breeding programs. This test has been optimized for discrimination of wheat lines with the allelic pairs of subunits 1Dx5-1Dy10 from those with 1Dx2-1Dy12. The former lines provide stronger dough properties and superior bread-making quality. The screening test for detection of α-amylase synthesised as a result of the late maturity amylase (LMA) gene will provide a valuable tool for breeders when it is released in August (Fig 5.5). A new gene associated with the hardness locus has been identified, and the stages at which hardness can be detected during early wheat development have been determined.

Fig 5.4 - The 1RS translocation screening test includes two monoclonal antibody-based enzyme-linked immunosorbent assays (ELISA) for detecting translocations of the short arm of chromosome 1 of rye in wheat lines.

Fig 5.5 - The late maturity alpha-amylase phenotype usually manifests as a proportion of grain showing high amylase activity, as demonstrated by the dark green colour in the microwells.

Project 5.1.5 - Characterisation and introgression of novel storage protein genes
Project Leader: Peter Sharp

Background and Objectives
Gluten storage proteins play a significant role in bread making quality. Previous studies of 173 accessions of Triticum tauschii have revealed greater variation in the HMW glutenin and gliadin subunits compared to gluten subunits in bread wheat. SDS polyacrylamide gel analysis of accession AUS18913 showed a large omega gliadin subunit, called T12.4, encoded by GlidT12, and accession CPI110750 a small HMW glutenin subunit, called T12.4, with unusual biochemical properties. This project is aimed at characterising the T1 and T12.4 genes, introgressing the genes into bread wheat, expressing them in-vitro and isolating the products for evaluation in small scale testing.

Progress
A PhD student, Mohammad Hassani, was appointed in late March and commenced work on the project. Primers to amplify the T12.4 gene were prepared and PCR conditions optimised. Primers to amplify the T1 gene have also been prepared. Parental seed has been planted for crossing in the current season and BC2F2 materials (Synthetic L/18913 x Kite) were tested for Sr26.

Targets and Milestones Achieved

<table>
<thead>
<tr>
<th>Target</th>
<th>Date</th>
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<tbody>
<tr>
<td>Undertake literature review</td>
<td>06/00</td>
</tr>
<tr>
<td>Commence strategy to clone T1 and T12.4 genes</td>
<td>06/00</td>
</tr>
<tr>
<td>Obtain and sow T. tauschii lines required for crossing</td>
<td>06/00</td>
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Projected Research for next 2 years

<table>
<thead>
<tr>
<th>Project</th>
<th>Date</th>
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<tbody>
<tr>
<td>Provide LMA and glutenin allele tests to CIMMYT and all breeding programs</td>
<td>12/00</td>
</tr>
<tr>
<td>Determine functionality/stability relationship for expressed antibodies</td>
<td>06/01</td>
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<tr>
<td>Rapid diagnostics for cereal disease identification available</td>
<td>06/02</td>
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Projected Research for next 2 years

<table>
<thead>
<tr>
<th>Project</th>
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<tbody>
<tr>
<td>Sequence T1 and T12.4 genes</td>
<td>12/01</td>
</tr>
<tr>
<td>Introgress these genes into bread wheat</td>
<td>12/01</td>
</tr>
</tbody>
</table>
Project 5.1.6 - The effects of protein composition on dough rheology
Project Leaders: Roger Tanner and Nhan Phan-Thien

Background and Objectives
This project utilises novel theoretical knowledge and methods developed in earlier QWCRC projects (Table 5.6 and below). In research on modelling dough behaviour, a model using the constitutive equation (project 5.1.3) will be implemented, to explore effects of varying parameters. The extension process will be simulated in the tensiograph, and transient and three-dimensional computer codes for bread dough mixing processes will be implemented. In work to relate flour chemical composition to dough rheological properties, protein content and composition will be altered via supplementation with purified components (project 5.1.1), applying the 2g Mixograph and prototype equipment developed in project 5.1.3. There will also be systematic comparison of doughs produced by small-scale and traditional pin- and Z-armed mixers. Development of novel, small-scale methods for constant strain-rate dough testing will entail determination of dough parameters on established, larger scale equipment and on the new, constant strain-rate micro-extension tester.

Progress
Starch-gluten interaction, gluten dough rheological properties, and the effect of various HMW-GS were investigated using stress sweep, frequency sweep, stress relaxation, shear viscometry and elongational tests for functional properties. Gluten differed from flour in its linear visco-elastic limit and had larger shear and elongational viscosities. The dynamic rheological properties of flour were greater than those of gluten. Increase in starch in a gluten-starch complex resulted in a lower linear visco-elastic limit. Rheological tests also showed that HMW-GS contributed to strength and stability. The functional properties determined by rheological instruments correlated well with end-product quality as measured by baking and cutting force tests of cooked noodles.

TABLE 5.6 - EQUIPMENT SPECIALLY ADAPTED FOR DOUGH ANALYSES

<table>
<thead>
<tr>
<th>Equipment</th>
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<tbody>
<tr>
<td>Bohlin strain-controlled rheometer (two torsional heads)</td>
</tr>
<tr>
<td>Carrimed stress-controlled viscometer</td>
</tr>
<tr>
<td>United SSTM-5000 Universal Tension and Compression Testing machine</td>
</tr>
<tr>
<td>Micro-Fourier Rheometer</td>
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</table>

Fig 5.7 - Effect of protein content on the texture of cooked noodles produced on a prototype noodle-making machine. Protein content of flour was systematically altered by starch and gluten addition.

Fig 5.8 - Alteration of protein composition in the different phases of noodle making, determined by SE-HPLC.

Targets and Milestones Achieved Date
Apply flour component/function methods, specifically extension testing 12/99

Projected Research for next 2 years Date
Reassemble flour test 12/00
Measure variation of strain 06/01
Project 5.1.7 - Structure of glutenin macropolymer in commercial low-water (noodle) doughs and products
Project Leader: Ferenc Bekes

Background and Objectives
The overall aim of this project is to gain an understanding of the role of particular flour components in determining key structures within pan bread and noodle end-products. This will help relate variability in wheat flour function to structure, and contribute to an understanding of the basis of out-of-specification performance of doughs. Small-scale dough testing, biochemical and high-resolution microscopical methods are used together to study the structural changes in the glutenin protein macropolymer during the process of noodle making.

Progress
A small-scale noodle-making machine and reconstitution techniques specifically developed for noodles have been successfully adapted for this study. A reversible reduction/oxidation procedure to incorporate glutenin subunits into the polymeric glutenin has been optimised for noodle making. Microscopic techniques for the preparation of samples from noodle have been also developed. In noodles produced from flours with systematically altered chemical composition, the effects on noodle texture of protein content, glutenin to gliadin ratio and the HMW-GS composition of flour have been investigated (Fig 5.7). The alteration of the size distribution of polymeric proteins during noodle making and cooking has been monitored using size exclusion HPLC methods (Fig 5.8).

Fig 5.9 - Discrimination of Queensland wheat varieties using existing monoclonal antibodies. Antigens were prepared by extraction of wholemeal with 50 % propanol. The MAb 82208 was used as capture antibody in combination with various HRP-labeled tag MAbs.

Fig 5.10 - Differentiation of 14 GBSS 4A-null wheat varieties (left side of graph) from 16 GBSS 4A-positive varieties (right side of graph) using a simple sandwich ELISA. Antigen was prepared by extraction of wholemeal at room temperature using 8M urea. The capture antibody was MAb 91484, specific for GBSS. The tag antibody was an HRP-labelled rabbit polyclonal serum specific for the 4A allele of GBSS. The mean positive/negative ratio for the test was 5.4.

Fig 5.11 - DNA calibration of Field Flow Fractionation protein separation method for estimation of the real molecular size of very large protein polymers.

<table>
<thead>
<tr>
<th>Targets and Milestones Achieved</th>
<th>Date</th>
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<tbody>
<tr>
<td>Develop suitable methodology to monitor changes in macromolecular structure of proteins during noodle making</td>
<td>12/99</td>
</tr>
<tr>
<td>Determined relationship between changes in polymeric structure and processing behaviour of low-moisture doughs</td>
<td>06/00</td>
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<thead>
<tr>
<th>Projected Research for next 2 years</th>
<th>Date</th>
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<tbody>
<tr>
<td>Using scanning electron microscopy contrast ultrastructural changes in the protein polymer during mixing and extension in flours differing in glutenin subunit composition</td>
<td>12/00</td>
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<tr>
<td>Evaluate immunomicroscopy use for labelling specific glutenin and gliadin subunits in commercial doughs, cooked noodles and bread</td>
<td>12/00</td>
</tr>
<tr>
<td>Label expressed proteins to determine their localisation within simple/ model doughs</td>
<td>07/01</td>
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</table>
Project 5.1.8 - Field diagnostics for wheat varietal identification

Project Leader: Kevin Gale

Background and Objectives
The wheat industry has a requirement for a rapid, field-based test for variety identification. This test is needed to improve segregation at receival, according to end-use, and for royalty payment purposes. Domestic wheat buyers could also use the test for routinely checking wheat identity. Within any one state, up to 50 varieties are grown in significant quantities. Our aim is to develop a panel of diagnostic antibodies, for which Australian varieties are clear positive and negative responders. Eight independent antibodies will give 256 possible combinations of reactivity and thus provide a unique bar-code for each variety when deployed in the immunochromatography format used for WheatRite®.

Progress
Our library of antibodies against wheat proteins was screened for combinations with widely different levels of reactivity between different varieties. One combination identified effectively split varieties into positives and negatives and appears to be linked to the puroindoline A locus (Tag 79115, Fig 5.9). Other combinations, for which the growth environment also influenced the results, gave a range of reactivities for different varieties (Fig 5.9). One antibody developed was specific for the Wx-B1 allele of granule bound starch synthase (GBSS), and so linked to the superior Udon noodle quality trait. As approximately half of Australian cultivars lack this allele, this antibody represents a good variety marker (Fig 5.10).

<table>
<thead>
<tr>
<th>Targets and Milestones Achieved</th>
<th>Date</th>
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<tbody>
<tr>
<td>Assess panel of existing MAbs in sandwich ELISA</td>
<td>12/99</td>
</tr>
<tr>
<td>Identify peptide sequences showing varietal polymorphism</td>
<td>06/99 assay 06/00 pilot</td>
</tr>
<tr>
<td>Develop sample preparation method</td>
<td>11/99 assay</td>
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Projected Research for next 2 years

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<tr>
<th>Projected Research for next 2 years</th>
<th>Date</th>
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<tbody>
<tr>
<td>Survey Australian cultivars for variation within puroindoline B</td>
<td>07/00</td>
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<tr>
<td>Convert GBSS and hardness ELISAs to high throughput ICT format</td>
<td>06/01</td>
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<tr>
<td>Generate wheat lipoygenase antiserum; develop quantitative assay</td>
<td>06/01</td>
</tr>
<tr>
<td>Test synthetic peptides specific for allelic forms of puroindoline B (pin B)</td>
<td>12/01</td>
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</table>
Project 5.1.9 - Polymer size and shape in cereal processing
Project Leader: Ferenc Bekes

Background and Objectives
Size distribution and shape of wheat flour protein and starch biopolymers are strongly related to end-use quality. However, the extremely large size of the polymeric glutenin proteins makes extraction, without altering their chemical structure and functionality, technically difficult. It is therefore essential to develop and apply methodologies to investigate these parameters. Flow Field Flow Fractionation (FFF) provides such information on polymers, and is applied in this project to develop new techniques for use in structure/function studies. Because of difficulties dissolving wheat endosperm polymer components fully without altering their size distribution, our primary aim is to develop methods for quantitative extraction of glutenin and carbohydrate polymers.

Progress
We developed a method, using a new solvent system and different sonication time treatments, to estimate the “native” size distribution of polymeric glutenin fractions. The apparent average molecular weights are extrapolated to zero sonication time, enabling characterisation of the size distribution. To estimate the molecular size of glutenin polymers, DNA and dextran standards were used to calibrate FFF in the very large molecular size range for which no protein standards were available (Fig 5.11). Applying these methods, size and size distribution measurements on biopolymers in a wide range of samples were obtained for several projects in programs 1, 2 and 5 (Fig 5.12).

Project 5.1.10 - Benchmarking mixing and extension measurements
Project Leader: Peter Gras

Background and Objectives
Early selection of new wheat quality requires new instruments capable of measuring dough properties with as little flour as possible. Current very-small scale test instruments are not suitable for routine measurement of water absorption, or for use with soft wheats or those with low protein content, although they represent at least half of Australian production. As the Z-arm configuration is advantageous for wheats of low strength and/or protein content, a mixer requiring just four grams of flour has been constructed. It will be used to obtain benchmark data for end-use quality prediction, and to recommend conditions for small scale mixing property determination and extension testing regimens.

Progress
Using only four grams of flour, results from the Z-arm mixer correlated excellently with those from the large scale Valorigraf and Farinograph ($R^2 > 0.9$, both cases Fig 5.13). Maximum resistance and water absorption were effectively linearly related over the usual range, and mixing times were much shorter. The small instrument required only a single mix with a standard water addition, a considerable saving in time and flour requirements. Correlations with mixing times on the two larger instruments were high (both $R^2 > 0.9$). Precision depended on whether water addition was done by hand (typical standard error 0.5 water absorption units). The computedrivered, variable speed extension tester has reached design specifications, readily achieving speeds of 30 cm/sec, corresponding to extension rates greater than those in a Mixograph or horizontal bar mixer.

Targets and Milestones Achieved

<table>
<thead>
<tr>
<th>Projected Research for next 2 years</th>
<th>Date</th>
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<tbody>
<tr>
<td>Establish relationship of FFF-determined glutenin polymer size with functional properties such as extensibility and Rmax</td>
<td>12/00</td>
</tr>
<tr>
<td>Monitor size changes during bread and noodle-dough development</td>
<td>12/00</td>
</tr>
<tr>
<td>Test model structures of glutenin molecules using in vitro polymerisation and material supplied by the model dough project</td>
<td>06/01</td>
</tr>
<tr>
<td>Determine glutenin shape via various physical biochemistry techniques to assess correlation with change in molecular weight</td>
<td>06/01</td>
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Projected Research for next 2 years

<table>
<thead>
<tr>
<th>Targets and Milestones Achieved</th>
<th>Date</th>
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<tbody>
<tr>
<td>Establish reliable method for size measurement of cereal proteins and carbohydrates</td>
<td>12/99</td>
</tr>
<tr>
<td>Establish reliable method for calibration to real molecular size</td>
<td>05/00</td>
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<tr>
<td>Complete final mixing trials for comparison of instruments</td>
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</table>
The Education and Training Program spans projects across the Research Programs, particularly Programs 2 and 5. Industry-relevant postgraduate and continuing education helps to attract researchers and maintain their focus. In support of this aim, we also conduct a program of workshops, site tours and symposia for undergraduates and graduates in science/ agricultural science, and employees in the cereal industry with an appropriate technical background and experience.

Several projects are aimed at increasing grower and adviser awareness of the importance of wheat quality, of its management, and of developments in wheat-quality research. The "Q uality W heat for Q uality Foods" course staged at locations in SA, Vic., rural NSW and Qld has been so well received that expansion was necessary. Q W CRC also sponsors the attendance of key influencers at "Milling for non-Millers" courses run by BRI Australia Ltd. Several of these key influencers in WA have been instrumental in setting up "W heat Q uality" and "The Asian Experience" courses for growers.

The consumer-driven requirement for quality assurance of produce is also served well by the grower awareness we are raising through these courses. Our CD-ROM on grain storage on-farm, which promotes HACCP-based management practices, and "Great Grain", a system for quality assurance on-farm, were both launched in spring 1999.

Program Aims
Q W CRC aims to develop a well-trained and high quality technical and professional workforce that can contribute effectively to the wheat industry. This means ensuring information on best practice, research outcomes and market awareness is available to growers, advisers, handlers, processors, manufacturers and researchers. It is a two way process and involves monitoring developments across the industry, distilling relevant resource materials, and most importantly, building an effective trainer and adviser network for effective information flow. Q W CRC grants postgraduate scholarships and vacation studentships to attract new researchers to the industry across diverse fields including agricultural and food sciences, and molecular and mechanical engineering.

Project 5.2.1 University-based training for the cereal industry
Project Leader: Les Copeland

Background and Objectives
Industry-relevant postgraduate and continuing education is necessary to attract and maintain a well-trained and high quality technical and professional workforce for succession and innovation in the industry. The postgraduate students of QWCRC are distributed among the research programs in projects bringing them into contact with many disciplines and organisations. A workshop on scientific communication, intellectual property, industry orientation and supervisory skills is provided annually to better equip them for employment in the industry. Other target groups of this education project are undergraduates and graduates in agricultural science or science, and employees in the cereal industry with an appropriate technical background and experience.

Progress
Six postgraduate students completed or submitted their theses for examination and two are due to submit soon. The three new postgraduate students starting in the third quarter bring the current total to twelve, and the cumulative total in the life of the CRC to 33. Most have taken up positions within the wheat industry (See table 6.1).

Attendees from Goodman Fielder, Starch Australasia, CSIRO Plant Industry Sydney University and QWCRC postgraduate students were attracted to a workshop on dietary fibre in July 1999. In May 2000, Goodman Fielder Technical Centre and Mill staff conducted a site visit, providing students, CRC and associated staff with a valuable perspective on wheat quality for processing requirements.

A workshop on Polymer Colloids in Cereal Science was run jointly with the Key Centre for Polymer Colloids at the University of Sydney in June 2000. External speakers from the University of NSW, Monash University and the Food and Grocery Council of Australia joined QWCRC collaborators and Key Centre staff. The 48 attendees included 10 from industry, 7 from other CRCs and food research institutes in NSW, 12 Key Centre staff and students and 19 from QWCRC participant organisations. Significant cost recovery was achieved, and the attendees reported an exceptionally high level of satisfaction with the course. The postgraduate workshop covering scientific communication, industry and supervisory skills followed this, adding value to postgraduate education at QWCRC.
<table>
<thead>
<tr>
<th>Student</th>
<th>Degree</th>
<th>University</th>
<th>Thesis Title</th>
<th>Date Commenced</th>
<th>Supervisors</th>
<th>Funding Source</th>
<th>Subsequent Employment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ali Mohammadkhani</td>
<td>PhD</td>
<td>Sydney</td>
<td>Amylose content in rye and diploid and tetraploid wheat relatives</td>
<td>Mar-93</td>
<td>Prof Don Marshall Dr Fred Stoddard</td>
<td>Iranian government</td>
<td>Iranian government</td>
</tr>
<tr>
<td>Anthea Wooding</td>
<td>PhD</td>
<td>Sydney</td>
<td>Agricultural strategies to reduce dough mixing requirements</td>
<td>Mar-93</td>
<td>Dr Fin MacRitchie Dr Colin W rigley Dr Fred Stoddard Prof Don Marshall</td>
<td>Crop &amp; Food Research NZ</td>
<td>Crop &amp; Food Research NZ, Australian National University, matenrity</td>
</tr>
<tr>
<td>Christine Konik</td>
<td>PhD</td>
<td>Sydney</td>
<td>Starch characterisation of synthetic wheats and their parents</td>
<td>Jul-93</td>
<td>Dr Fred Stoddard Prof Don Marshall</td>
<td>GRDC junior research fellowship</td>
<td>CSIRO Plant Industry</td>
</tr>
<tr>
<td>Hun-sun Hwang</td>
<td>PhD</td>
<td>Sydney</td>
<td>High protein wheat</td>
<td>Feb-94</td>
<td>Dr Peter Sharp</td>
<td>GRDC</td>
<td>Horticulture consulting</td>
</tr>
<tr>
<td>Naomi Pollard</td>
<td>PhD</td>
<td>Sydney</td>
<td>Functionality and protein characterisation of lupin flours</td>
<td>Mar-94</td>
<td>Dr Fin MacRitchie Dr Colin W rigley Dr Fred Stoddard Prof Don Marshall</td>
<td>GRDC</td>
<td>W heat product quality research, Goodman Fielder</td>
</tr>
<tr>
<td>Xia Li</td>
<td>PhD</td>
<td>Sydney</td>
<td>Soft wheat quality</td>
<td>Jan-95</td>
<td>Dr Daryl Mares</td>
<td>GRDC</td>
<td>Arnotts research scientist, maternity</td>
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<tr>
<td>Yasmine Wang</td>
<td>PhD</td>
<td>Sydney</td>
<td>Noodle colour</td>
<td>May-95</td>
<td>Dr Daryl Mares</td>
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<td>Noodle quality research, Agriculture WA</td>
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<tr>
<td>Zhao Xiaochun</td>
<td>PhD</td>
<td>Sydney</td>
<td>Waxy wheat lines</td>
<td>Aug-95</td>
<td>Dr Peter Sharp</td>
<td>GRDC</td>
<td>Post-doctoral fellowship, Rice CRC / University of Sydney</td>
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<tr>
<td>Cristina Gianibelli</td>
<td>PhD</td>
<td>Western Sydney</td>
<td>New proteins for improving wheat quality</td>
<td>Dec-95</td>
<td>Dr Fin MacRitchie Dr Colin W rigley</td>
<td>Argentinian Government / QWCRC</td>
<td>GRDC-funded post-doctoral fellowship in wheat research, CSIRO Plant Industry</td>
</tr>
<tr>
<td>Jaswinder Singh</td>
<td>PhD</td>
<td>Sydney</td>
<td>Chromosomal control, antibody development and characterisation of non-gluten proteins in wheat</td>
<td>Feb-96</td>
<td>Dr John Skerritt Dr Peter Sharp</td>
<td>QWCRC</td>
<td>Post-doctoral fellowship in plant-microbe interaction, Australian National University</td>
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<tr>
<td>Megan Lindsay</td>
<td>PhD</td>
<td>Sydney</td>
<td>Structure of the glutenin macropolymer in wheat flour and dough</td>
<td>Feb-96</td>
<td>Dr John Skerritt Dr Robyn O verall</td>
<td>QWCRC</td>
<td>Post-doctoral fellowship in genetics of durum wheat salt tolerance, CSIRO Plant Industry</td>
</tr>
<tr>
<td>Michael Partridge</td>
<td>PhD</td>
<td>Sydney</td>
<td>Development of antibody probes for glutenin subunits</td>
<td>Feb-96</td>
<td>Dr John Skerritt Dr Daryl Mares</td>
<td>QWCRC</td>
<td>Visiting fellowship, wheat protein interaction, Rutgers University, NJ; Post doctoral research scientist, cell biology, integrins / signal transduction) Columbia University, Pathology Dept.</td>
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<tr>
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<td>University</td>
<td>Thesis Title</td>
<td>Date Commenced</td>
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<td>Funding Source</td>
<td>Subsequent Employment</td>
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<tr>
<td>Matt Hayden</td>
<td>PhD</td>
<td>Sydney</td>
<td>Udon noodle quality: genetic factors</td>
<td>Mar-96</td>
<td>Dr Peter Sharp</td>
<td>QW CRC</td>
<td>GRDC post-doctoral fellowship, wheat molecular markers</td>
</tr>
<tr>
<td>Surjani Uthayakumaran</td>
<td>PhD</td>
<td>Sydney</td>
<td>Structure/function studies on systematically altered</td>
<td>Mar-96</td>
<td>Dr Ferenc Bekes, Prof Don Marshall</td>
<td>QW CRC</td>
<td>Post-doctoral fellowship, dough rheology, University of Sydney</td>
</tr>
<tr>
<td>Steven Zounis</td>
<td>PhD</td>
<td>NSW</td>
<td>Frozen dough products</td>
<td>Jun-96</td>
<td>Dr Ken Quail, Dr Mike Wotton</td>
<td>QW CRC</td>
<td>Dough research at BRI Australia</td>
</tr>
<tr>
<td>Kevin Liu</td>
<td>PhD</td>
<td>Sydney</td>
<td>Fluid mechanics and dough rheology</td>
<td>Jul-96</td>
<td>Dr Nhan Phan-Thien</td>
<td>QW CRC</td>
<td>Global positioning systems development for agriculture, Agrecon, Canberra University</td>
</tr>
<tr>
<td>Cindy Cassidy</td>
<td>PhD</td>
<td>Sydney</td>
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<td>Aug-96</td>
<td>Dr Daryl Mares</td>
<td>QW CRC</td>
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<tr>
<td>Paul Chow</td>
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<td>Aug-96</td>
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<tr>
<td>Gasiram Rema</td>
<td>MSc.Agr.</td>
<td>Sydney</td>
<td>Effects of starch granule size distribution on</td>
<td>Jan-97</td>
<td>Dr Hon Yun, Dr Bob Caldwell</td>
<td>GRDC</td>
<td>W heat product research, BRI Australia</td>
</tr>
<tr>
<td>Nicole Kerr</td>
<td>M.Ag.</td>
<td>Sydney</td>
<td>Prime Hard Quality</td>
<td>Jan-97</td>
<td>Dr Lindsay O’Brien</td>
<td>GRDC</td>
<td>Key role in grain quality assurance, Agriculture WA</td>
</tr>
<tr>
<td>Ranjana Sarker</td>
<td>M.Ag.</td>
<td>Sydney</td>
<td>Survey of amylose content of primitive wheats and wheat</td>
<td>Mar-97</td>
<td>Dr Fred Stoddard</td>
<td>Self-funded</td>
<td>PhD student, University of Sydney, wheat molecular markers</td>
</tr>
<tr>
<td>Kym Turnbull</td>
<td>PhD</td>
<td>Sydney</td>
<td>Molecular markers for grain hardness and water</td>
<td>Jul-97</td>
<td>Dr Sadiq Rahman, Dr Peter Sharp</td>
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<tr>
<td>Daniel Skylas</td>
<td>PhD</td>
<td>Sydney</td>
<td>Reducing effects of heat stress on wheat quality</td>
<td>Oct-97</td>
<td>Dr Brad Walsh, Prof Les Copeland</td>
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<td>Andrew Verrell</td>
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<td>W heat quality and yield in Northern Australia</td>
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<tr>
<td>Dennis Murray</td>
<td>M.Ag.</td>
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<td>Role of hydrogen bonds in dough rheology</td>
<td>Feb-98</td>
<td>Dr Ferenc Bekes, Prof Les Copeland</td>
<td>QW CRC</td>
<td>Dough property research, CSIRO Plant Industry</td>
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<tr>
<td>Marcus Newberry</td>
<td>PhD</td>
<td>Sydney</td>
<td>Yeasted dough rheology</td>
<td>Feb-98</td>
<td>Dr Nigel Larsen, Dr Nhan Phan-Thien</td>
<td>QW CRC</td>
<td>current</td>
</tr>
<tr>
<td>Patricia Chong</td>
<td>PhD</td>
<td>ANU</td>
<td>Structure of glutenin macropolymer in bread/noodle</td>
<td>Jan-99</td>
<td>Dr Ferenc Bekes, Prof Adrienne</td>
<td>QW CRC</td>
<td>current</td>
</tr>
<tr>
<td>Laila Daqiq</td>
<td>PhD</td>
<td>Sydney</td>
<td>Polymer size and shape in cereal processing</td>
<td>Feb-99</td>
<td>Dr Ferenc Bekes, Dr Fred Stoddard</td>
<td>QW CRC</td>
<td>current</td>
</tr>
<tr>
<td>Talsir Hubraq</td>
<td>PhD</td>
<td>Sydney</td>
<td>The effects of protein composition on basic and applied</td>
<td>Feb-99</td>
<td>Dr Ferenc Bekes, Prof Roger Tanner</td>
<td>QW CRC</td>
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<th>University</th>
<th>Thesis Title</th>
<th>Date Commenced</th>
<th>Supervisors</th>
<th>Funding Source</th>
<th>Subsequent Employment</th>
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<tr>
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<td>Mar-96</td>
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<td>GRDC post-doctoral fellowship, wheat molecular markers</td>
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<td>Jul-96</td>
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<td>Aug-96</td>
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<td>withdrew</td>
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<td>Dr Mike Wotton</td>
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<td>Effects of starch granule size distribution on</td>
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<td>GRDC</td>
<td>W heat product research, BRI Australia</td>
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<td>Sydney</td>
<td>Prime Hard Quality</td>
<td>Jan-97</td>
<td>Dr Lindsay O’Brien</td>
<td>GRDC</td>
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<td>Mar-97</td>
<td>Dr Fred Stoddard</td>
<td>Self-funded</td>
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<td>Sydney</td>
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<td>Jul-97</td>
<td>Dr Sadiq Rahman, Dr Peter Sharp</td>
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<tr>
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<td>Sydney</td>
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<td>Oct-97</td>
<td>Dr Brad Walsh, Prof Les Copeland</td>
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<td>Andrew Verrell</td>
<td>Sydney</td>
<td>W heat quality and yield in Northern Australia</td>
<td>Feb-98</td>
<td>Dr Lindsay O’Brien</td>
<td>QW CRC</td>
<td>current</td>
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<tr>
<td>Dennis Murray</td>
<td>Sydney</td>
<td>Role of hydrogen bonds in dough rheology</td>
<td>Feb-98</td>
<td>Dr Ferenc Bekes, Prof Les Copeland</td>
<td>QW CRC</td>
<td>Dough property research, CSIRO Plant Industry</td>
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<tr>
<td>Marcus Newberry</td>
<td>Sydney</td>
<td>Yeasted dough rheology</td>
<td>Feb-98</td>
<td>Dr Nigel Larsen, Dr Nhan Phan-Thien</td>
<td>QW CRC</td>
<td>current</td>
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<tr>
<td>Patricia Chong</td>
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<td>Structure of glutenin macropolymer in bread/noodle</td>
<td>Jan-99</td>
<td>Dr Ferenc Bekes, Prof Adrienne</td>
<td>QW CRC</td>
<td>current</td>
</tr>
<tr>
<td>Laila Daqiq</td>
<td>Sydney</td>
<td>Polymer size and shape in cereal processing</td>
<td>Feb-99</td>
<td>Dr Ferenc Bekes, Dr Fred Stoddard</td>
<td>QW CRC</td>
<td>current</td>
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<tr>
<td>Talsir Hubraq</td>
<td>Sydney</td>
<td>The effects of protein composition on basic and applied</td>
<td>Feb-99</td>
<td>Dr Ferenc Bekes, Prof Roger Tanner</td>
<td>QW CRC</td>
<td>current</td>
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</table>

47
### TABLE 6.1  QWCRC POSTGRADUATE STUDENTS ENTER INDUSTRY (continued)

<table>
<thead>
<tr>
<th>Student</th>
<th>Degree</th>
<th>University</th>
<th>Thesis Title</th>
<th>Date Commenced</th>
<th>Supervisors</th>
<th>Funding Source</th>
<th>Subsequent Employment</th>
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<tbody>
<tr>
<td>Deidre Lewis</td>
<td>MSc</td>
<td>NSW</td>
<td>TBA: Biotechnology</td>
<td>Feb-00</td>
<td>Currently under</td>
<td>QWCRC</td>
<td>current (P/T), dough property research, CSIRO</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>negotiation for project in 2001</td>
<td></td>
<td>current</td>
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<tr>
<td>Manoj Mazumder</td>
<td>PhD</td>
<td>Sydney</td>
<td>New genetic sources of high milling yield</td>
<td>Feb-00</td>
<td>Dr Lindsay O'Brien</td>
<td>GRDC</td>
<td>current</td>
</tr>
<tr>
<td>Mohammad Hassani</td>
<td>PhD</td>
<td>Sydney</td>
<td>Novel storage protein</td>
<td>Mar-00</td>
<td>Dr Peter Sharp</td>
<td>QWCRC</td>
<td>current</td>
</tr>
<tr>
<td>Mizanur Rahman</td>
<td>PhD</td>
<td>Sydney</td>
<td>Glycation</td>
<td>Apr-00</td>
<td>Prof Les Copeland</td>
<td>GRDC</td>
<td>current</td>
</tr>
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</table>

**Advanced PhD student**

Marcus Newberry demonstrates dough rheology to workshop attendees.

### TABLE 6.2  VACATION SCHOLARSHIPS 1999/2000

<table>
<thead>
<tr>
<th>Student</th>
<th>Project Title</th>
<th>Supervisor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renelle Jeffrey</td>
<td>Phytate Determination in Different Fractions of Wheat Bran</td>
<td>Jane Blakeney, Weston Food Laboratories</td>
</tr>
<tr>
<td>3rd year, USyd</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rebecca Ferris</td>
<td>Examination of Hardness Genes in Cereals</td>
<td>Kym Turnbull, Sadequr Rahman, CSIRO Plant Industry</td>
</tr>
<tr>
<td>3rd year, UQld</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ann Strobel</td>
<td>Development of Antibodies to Lipoygenase in Durum Wheat</td>
<td>Kevin Gale, CSIRO Plant Industry</td>
</tr>
<tr>
<td>3rd year, UQld</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Derek Puah</td>
<td>Integrating Control of the Z-Arm Dough Mixer</td>
<td>Peter Gras, CSIRO GQRL</td>
</tr>
<tr>
<td>4th year, USyd</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kevin Yee</td>
<td>Introducing Automatically Controlled Baking Zones to Optimise Oven Performance</td>
<td>Thomas Adamczak, BRI Australia</td>
</tr>
<tr>
<td>3rd year, USyd</td>
<td></td>
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</tbody>
</table>

Vacation scholarships were awarded to 5 outstanding undergraduates to work on mini-projects relevant to QWCRC research programs during the university summer vacation (Table 6.2). They submitted reports upon completion. Highlights included:

- Cloning and sequencing of durum lipoxygenase, which will lead to antibody design and test development for breeding programs, and

- Production of software to integrate the pump, temperature controller and electronic recording Z-arm mixer.

The self-contained mini-projects provided the students with valuable research training, and with a perspective on the variety of careers available within the industry, through Quality Wheat CRC linkages.

Sarah Peel, recipient of an undergraduate scholarship, stood first in the 3rd year of the BScAgr degree at the University of Sydney.

### Targets and Milestones Achieved

<table>
<thead>
<tr>
<th>Project</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organise intensive short courses on a relevant aspect of cereal science</td>
<td>07/99</td>
</tr>
<tr>
<td>Organise postgraduate industry and communication skills workshop and symposium</td>
<td>07/00</td>
</tr>
<tr>
<td>Provide 5 vacation scholarships to exceptional undergraduates</td>
<td>11/99</td>
</tr>
<tr>
<td>Organise site visits to industry participants</td>
<td>05/00</td>
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</table>

### Projected Work for next 2 years

<table>
<thead>
<tr>
<th>Project</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide 5 vacation scholarships to exceptional undergraduates</td>
<td>11/00</td>
</tr>
<tr>
<td>Organise intensive short courses on a relevant aspect of cereal science</td>
<td>02/01</td>
</tr>
<tr>
<td>Organise site visits to industry participants</td>
<td>05/01</td>
</tr>
<tr>
<td>Organise postgraduate industry and communication skills workshop and symposium</td>
<td>06/02</td>
</tr>
</tbody>
</table>
**Project 2.1.7 - Premium Quality Wheat in South Australia**

**Project Leader:** Michael Wurst

**Background and Objectives**

Through this project, QWCRC is supporting extension for a larger SA project, which has established industry links between PIRSA, AWB Limited, Quality Wheat CRC, Durum Growers Association, San Remo, Barilla and millers, clarified target areas for AH 13 and Durum 1, and established 12 Premium Wheat grower groups. The aims are to build the premium wheat sectors AH 13% and durum 12% plus in South Australia, so that production satisfies the premium markets and producers capture adequate rewards.

Opportunities for value adding to premium quality wheats will also be sought, and there will be collaboration with other states for more efficient use of information where appropriate.

**Progress**

Our demonstrations of nitrogen fertiliser regimes for grain quality at Hart, Eyre Peninsula and Yeelana focus field sites emphasize Prime Hard in lower rainfall areas, and durum in higher rainfall areas. The first two issues of the newsletter, "Premium Quality Wheat News", have been produced and distributed to growers. Wheat marketing updates accompanied features on nitrogen and trace element monitoring and management to optimise yield and protein. We also contributed information on end-use quality, QA, and contacts to assist production of a TopCrop "Grain Quality Ute Guide" for completion in spring. This enhances the booklet’s major focus on receival quality.

**Targets and Milestones Achieved**

<table>
<thead>
<tr>
<th>Create awareness</th>
<th>06/99</th>
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<tbody>
<tr>
<td>Establish 8-10 Premium Wheat Growers Groups</td>
<td>07/99</td>
</tr>
<tr>
<td>Publish first newsletter and develop support material</td>
<td>08/99</td>
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</table>

**Projected Work for next 2 years**

<table>
<thead>
<tr>
<th>Publish newsletter</th>
<th>06/01</th>
</tr>
</thead>
<tbody>
<tr>
<td>Train District Agronomists in TOPCROP principles, group facilitation and use of electronic data bases and establish grower groups</td>
<td>07/00</td>
</tr>
<tr>
<td>Release Grain Quality Ute Guide</td>
<td>09/00</td>
</tr>
<tr>
<td>Analyse crop data, produce checking cards, develop technical packages</td>
<td>06/01</td>
</tr>
</tbody>
</table>

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**Project 2.2.1 - Value added training for key influencers**

**Project Leader:** Michael Southan

**Background and Objectives**

Wheat quality information will be better disseminated through the industry if key influencers in the value-adding chain understand the total process from grower to consumer. To facilitate understanding of market requirements, the CRC sponsors places on BRI’s Milling for non-Millers course. Demonstrations of wheat quality evaluation show participants how differences in wheat quality influence the milling process. Different quality specifications exist for various products, and awareness will assist producers and breeders to target appropriate goals. Quality Wheat CRC maintains contact with this network of key influencers to enhance effective extension of new information.

**Progress**

Quality Wheat CRC sponsored the attendance of 6 “key influencers” on BRI Australia’s highly regarded Milling for non-Millers courses in 1999-2000. Excellent feedback was received from attendees, who included Beverley O’Neill, a cereal scientist from Arnotts, Dennis Murray who has just completed a Masters degree with QWCRC, and Sonia Richards from BRI. Sonia is now involved in delivery of the highly successful Quality Wheat for Quality Foods course (project 2.2.2). Key wheat quality extension staff from Agriculture WA who were unable to attend in March due to field work commitments will attend a course scheduled early in the new financial year.

**Targets and Milestones Achieved**

<table>
<thead>
<tr>
<th>Previous attendees join QWCRC network of advisers</th>
<th>04/00</th>
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</thead>
<tbody>
<tr>
<td>6 key influencers trained</td>
<td>06/00</td>
</tr>
</tbody>
</table>

**Projected Work for next 2 years**

| Replaced by project 2.2.2 | 07/00 |
Project 2.2.2 - Quality wheat for quality manufactured products
Project Leaders: Michael Southan, Ben Curtis

Background and Objectives
Progressive growers who know about the processor's needs can make better informed decisions. Through short courses in wheat processing, attendees are shown how and why wheat quality factors influence end product quality. Around 20 growers, bulk handlers and farm advisers attend each course, which includes 'hands-on' training in wheat quality evaluation relating to particular end products. Growers see what domestic and export markets their wheat ends up in and the reasons for certain receival standards. Discussion of the choice of varieties suitable for the end market, and agronomy to achieve quality targets round out the courses.

Progress
There was strong interest in the wheat quality courses this season, following a promotional article published in Australian Grain, and notification of agronomists through email networks. Courses were held in Northam, Walgett, Goondiwindi, Moree and Condobolin, and more are planned for Northam, Toowoomba, Tamworth, Wagga, Griffith, Spring Ridge/Quirindi and venues in SA and Victoria. In Western Australia, Bill Bowden's nitrogen management outcomes were incorporated into the course to help growers target the desired protein levels. QWCRC newsletters, and receival quality factsheets are supplied on all of these courses. WheatRite®, QA, wheat quality agronomy guides and the grain storage CD are promoted.

Targets and Milestones Achieved

<table>
<thead>
<tr>
<th>Projected Work for next 2 years</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eight 1-day and two 2-day Wheat Market Quality courses held in 2000/01 at locations in SA, Vic, Qld and rural NSW</td>
<td>06/01 06/02</td>
</tr>
<tr>
<td>3 courses held in WA</td>
<td>06/01 06/02</td>
</tr>
</tbody>
</table>

Project 2.2.3 - Wheat quality information for producers, agronomists and grain marketers
Project Leader: Clare Johnson

Background and Objectives
Through this project we aim to provide grain growers and agronomists with information on wheat quality and receival testing, for better, cost-effective achievement of the quality required by their end users. Vehicles include fact sheets, newsletters, the web site, slide sets, videos, new product information and booklets summarising agronomic information, particularly resulting from QWCRC-supported research. Displays and brochures are also designed for distribution on courses, at field days and at GRDC grower education days. Articles are regularly published in farm journals, and attention is also paid to building an effective network of farm advisers for effective information flow.

Progress
The Prime Hard in the South booklet was launched by Helen Allen's team and has been circulated among agronomists and industry staff nationally. "Grain Gloss", a grain technology glossary developed by Dr Colin Wrigley, is available on CD. Sixteen articles for growers and advisers were published in farm journals, and a new fact sheet on aeration premiered at Toowoomba Agricultural Show was rapidly in strong demand across the industry. A fact sheet on grading frost-damaged wheat will be available shortly. At several field days, GRDC Grain Expos and adviser updates, publications on QA, WheatRite®, QA, wheat quality agronomy guides and the grain storage CD are promoted.

Targets and Milestones Achieved

<table>
<thead>
<tr>
<th>Projected Work for next 2 years</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Produce articles for farm journals</td>
<td>06/01 06/02</td>
</tr>
<tr>
<td>Provide district agronomists with QWCRC teaching aids</td>
<td>11/00</td>
</tr>
<tr>
<td>Design TopActive modules relating to seasonal issues and recent QWCRC outcomes</td>
<td>06/01</td>
</tr>
<tr>
<td>Obtain accreditation for Advanced Certificate in Cereal Science and launch course</td>
<td>06/01</td>
</tr>
<tr>
<td>Attend GRDC adviser updates and Expos to identify seasonal issues and information needs</td>
<td>01/02</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Projected Work for next 2 years</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 courses held in WA</td>
<td>06/01 06/02</td>
</tr>
<tr>
<td>Produce articles for farm journals</td>
<td>06/01 06/02</td>
</tr>
<tr>
<td>CRC presence at field days and GRDC Grower Education programs, promoting research outcomes</td>
<td>09/99</td>
</tr>
<tr>
<td>Provide DAs with teaching aids</td>
<td>09/99</td>
</tr>
<tr>
<td>Add glossary to Web site</td>
<td>12/99</td>
</tr>
<tr>
<td>Produce farm journal articles, ongoing</td>
<td>03/00</td>
</tr>
</tbody>
</table>
Project 2.2.4 - Maintaining grain quality during on-farm storage  
Project Leader: Clare Johnson

**Background and Objectives**
Since deregulation in 1989, growers are increasingly storing grain on farm for seed, feed, harvest efficiency, or to improve marketing options. Grain must be maintained in peak condition, and food safety standards of end users must be met. There is a lot of scope for control of quality during storage and transport, and our new CD-ROM provides the necessary information. In line with QA principles, food safety issues in storage are dealt with on the CD, and a grain storage risk management process based on HACCP principles is promoted. The CD is a resource for courses and workshops now being developed for accreditation.

**Progress**
"Managing On-farm Grain Storage - effective practices for the delivery of quality assured products", was launched in September and deposited in the National, NSW State and University of Sydney Libraries. Following a favourable independent review, flyers and a slide presentation on the CD were highlighted nationally at the GRDC farm adviser updates by a network of advisers. TopActive modules now being designed will use the CD as a resource. Sales of 235 CDs to date through distributors Alexander College, Tocal, GrainTec and Rural Connect are contributing to cost recovery. The first updates, including QA information, will shortly be posted on the web site hot linked to the CD.

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Project 2.2.5 - National quality assurance on-farm  
Project Leader: Di Miskelly

**Background and Objectives**
Australia and New Zealand Food Authority (ANZFA) hygiene regulations will require food manufacturers and handlers to have HACCP (Hazard Analysis Critical Control Points)-based food safety plans in place. Implementation of HACCP plans is necessary to ensure the chemical, physical and microbiological safety of all food products. Consequently, food processors are beginning to require quality assured raw materials from primary producers. Building on the 1997 Quality Wheat project funded by DIST (Department of Industry, Science and Tourism) and co-ordinated by the Meyers Strategy Group, QWCRC has joined with Pulse Australia and the Australian Oilseeds Federation to produce the "Great Grain" quality assurance system.

**Progress**
Over 100 growers have signed up for the "Great Grain" QA program since its launch in September. John Dines and Graham White's Toowoomba pilot group tested the system. To prepare the growers, aeration, drying and the grain storage CD were promoted. Peter Botta also ran workshops in Victoria promoting sealed storage. An implementation audit of the Queensland group showed growers addressed quality better than food safety issues. Chemical storage, handling and record keeping were the major problems to be followed up, despite all having done a chemicals handling course. Monitoring of TopCrop Cereal and RiceCheck cards should facilitate uptake, and there is ample scope for cooperation with the Grains Council of Australia (GCA) code of practice, "Graincare". An article on QA co-reviewed by QWCRC, Pulse Australia and GCA will be published shortly in Farming Ahead.

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<table>
<thead>
<tr>
<th>Projected Work for next 2 years</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Update CD contents via a website</td>
<td>09/00</td>
</tr>
<tr>
<td>Produce grain storage short course curriculum and materials</td>
<td>09/00</td>
</tr>
<tr>
<td>Maintain liaison with Great Grain and GCA so that the CD contents are aligned with overall QA on-farm</td>
<td>06/02</td>
</tr>
<tr>
<td>Cooperate with project 2.2.5 and with TopCrop for grower workshops</td>
<td>12/00 12/01</td>
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<table>
<thead>
<tr>
<th>Targets and Milestones Achieved</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Launch CD</td>
<td>09/99</td>
</tr>
<tr>
<td>Ensure CD contents are aligned with overall QA on-farm</td>
<td>09/99</td>
</tr>
<tr>
<td>Cooperate with TopCrop and the GRDC grain storage extension program for grower workshops</td>
<td>04/00</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Targets and Milestones Achieved</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Promote trade/certification mark in the food &amp; agricultural industries</td>
<td>01/00</td>
</tr>
<tr>
<td>Develop and/or accredit training programs for facilitators</td>
<td>02/00</td>
</tr>
<tr>
<td>Establish and train pilot group, audit and review documentation and trial</td>
<td>03/00</td>
</tr>
<tr>
<td>Review QA documentation</td>
<td>05/00</td>
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</table>

<table>
<thead>
<tr>
<th>Projected Work for next 2 years</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Documented cost-benefit information for promotion (WA)</td>
<td>09/00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Projected Work for next 2 years</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Documented successful case study</td>
<td>09/00</td>
</tr>
</tbody>
</table>
The creation of the CRC was partly a response to perceptions of fragmentation in research and education services, a product of distance, focus and culture which are particular to the wheat industry in Australia. The structure of the Centre is designed to overcome this fragmentation by establishing a co-operative culture between the participants, whilst retaining a focus on commercially valuable outcomes.

To achieve its goals, the Centre is stimulating fundamental improvements in the collaborative arrangements covering research, education, technology transfer and commercialisation throughout the industry. Some of its successes as a catalyst to improve contacts, information flow and collaboration between scientific and industrial groups are listed in the Cooperative Arrangements section of this Annual Report. The first part of the Performance Indicators section later in this Annual Report also contains a five-year summary in some detail of the progress we have made in developing linkages with users of the research.

Use of the Research by Participants.
Many examples are cited elsewhere in the report - the following is an indicative list:

Use by Researchers:
- The breeder tests for defects (caused by late maturity α-amylase and by the rye chromosome translocation) are being developed and more widely used - eighteen thousand of the latter tests have been supplied free of charge to wheat breeders.
- Forty-six publications were approved for submission to refereed journals during the year, a record.

Use by Growers:
- This year 300,000 tonnes of Prime Hard wheat were delivered in the southern wheat belt - representing an increase of over $9M in the income of growers - following from a CRC project.
- Another project financed and managed within the CRC has shown growers how to increase their return from frost-damaged wheat.
- In the first real year of commercialisation, $60,000 worth of WheatRite® kits were sold into the distribution pipeline, worldwide. A single grower reported $40,000 improvement in earnings as a result of its use.
- Five wheat quality/market awareness courses were held for growers and their advisors in the last year and five more plus four nitrogen fertilization regime demonstrations are planned.
- The Great Grain Quality Assurance system was launched commercially this year and was taken up by over 100 growers.
- The value of the on-going additional GRDC projects directly managed by the Centre is over $600,000 and a further $250,000 worth have started during the year.

Use by Millers, Bakers and other Buyers of Wheat:
- The outcomes from the storage project, which show how to maintain quality in wheat up to a year and avoid the "new season's wheat" disruption to bakeries, have resulted in the bulk handling companies, domestic wheat users and AWB Ltd sitting down together to determine how best logistically to bring it to practice.
- The outcomes of the blending project were transmitted to miller Participants enabling them more efficiently to meet quality requirements through grist and flour blends.
- Nearly seventy copies of the report on the mill microbiology project were issued, reflecting the response of this work by the industry both in relation to the installation of Quality Assurance protocols for flour mills, and understanding the sources and acceptable levels of microbial contamination.
- A workshop on dietary fibre, which included a practical, was delivered in July 1999. There was good interest from industry (16 attendees). A workshop on Polymer Colloids in Cereal Science was run jointly with the Key Centre for Polymer Colloids at the University of Sydney June 6-8, 2000. There were 48 attendees, mostly from industry.

Use of the Research by Groups Outside the Centre and Overseas.
Again many examples are to be found elsewhere in the Annual Report, and most of the selection in the previous list is relevant here too. To avoid repetition of descriptions of the work, the following list is given simply to indicate the scope:
- Research projects in the Centre involve all the wheat growing states of Australia.
- We have also appointed distributors in France and in the United States for the worldwide distribution of the WheatRite® kit.
- We have initiated new work with two small Australian companies. They are Byron Australia, on the creation of novel foods from Centre germplasm and Real Time Engineering, who have designed a prototype reader for the WheatRite® kit.
- We have other on-going research and development agreements with commercial and research groups in the United States, Mexico and Hungary.
Commercialisation of the Research.
The following summary list is confined to the leading examples that have occurred in the last twelve months. The list is divided into the three main business areas of the Centre. Commercialisation here includes instances where the benefit of the research has been passed free of charge to other users for them to exploit commercially. Although the list repeats information elsewhere in this report, it provides a useful summary of our commercialisation activities. This is the first year in which the Centre has really commercialised the outcomes of its research, and the total of sales and orders received has gone into six figures, quite apart from the value of benefit that has been distributed free:

Diagnostics:
- In the first real year of commercialisation, $60,000 worth of WheatRite® kits were sold into the distribution pipeline worldwide. The commercialisation vehicle is QWIP, which continues to be a wholly owned subsidiary of the Centre. About half the tests were used by farmers in Australia, the rest taken prior to first launch in the northern hemisphere by our distributors in the United States and in France.

Germlasm and Varieties:
- QAL2000 biscuit wheat was launched during the year and the process of obtaining Plant Breeders’ Rights was begun.
- The breeder tests for defects (caused by late maturity α-amylase and by the rye chromosome translocation) were developed and more widely distributed. Eighteen thousand of the latter tests have been supplied to Australian and overseas wheat breeders. It is intended to start charging for this service next year.

Technology transfer to Growers and Processors:
- This year 300,000 tonnes of Prime Hard wheat were delivered in the southern wheat belt following from a CRC project. This represents an increase of over $9M in the income of growers.
- Over 230 copies of the “Managing On-Farm Grain Storage” CD-ROM have been sold and the CD was highlighted across the country at GRDC farm adviser updates by a network of advisers.
- The Great Grain Quality Assurance system (developed and marketed with Pulse Australia and the Australian Oilseeds Federation) was launched commercially this year and was taken up by well over 100 growers.
- Five courses on wheat quality/market awareness were held for growers and agronomists.
- Protocols for the more efficient blending of wheat and flour to meet industry quality objectives were issued.
- The outcomes from the storage project, which show how to maintain quality in wheat up to a year and avoid the “new season’s wheat” disruption to bakeries, have resulted in the Bulk Handling Companies, domestic wheat users and AWB Ltd conferring on how to best logistically bring it to practice.
- Cost reductions from the use of our process control hardware and software in a single bakery were estimated by its managers at a $75,000 per annum reduction in product waste and “give away”.
- Nearly seventy copies of the report on the mill microbiology project were issued, reflecting the response to this work by the industry both in relation to the installation of Quality Assurance protocols for flour mills, and understanding the sources and acceptable levels of microbial contamination.
The Centre continues to attract and retain high quality staff. As at 30 June 2000, the Centre had 5 full-time Headquarters staff. In addition, there are some 145 professional research staff seconded from their employers or paid for by the Centre. Their work is central to the activities of Centre. The percentages of each of these researchers’ time allocated to the Centre is listed in Fig 7.1.

Research
Six Program Managers supported by deputy program managers continue to efficiently manage the day to day running of the Centre’s five research programs.

Education, Training and Communication
The Centre’s Education and Training program which is spread across all five programs is managed by Clare Johnson whilst the Communications function is managed by Helen Warwick.

Business Management
Alan Ellis is responsible for the financial function, company secretarial duties, commercialisation of Centre I.P and management of the wheat quality assurance program.

PROGRAM MANAGERS

<table>
<thead>
<tr>
<th>Program</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dr. William Rathmell</td>
</tr>
<tr>
<td>2</td>
<td>Dr. Don Marshall</td>
</tr>
<tr>
<td>3a</td>
<td>Mr. Bob Cracknell</td>
</tr>
<tr>
<td>3b</td>
<td>Ms. Di Miskelly</td>
</tr>
<tr>
<td>4</td>
<td>Dr. Nigel Larsen</td>
</tr>
<tr>
<td>5</td>
<td>Dr. Ken Quail</td>
</tr>
<tr>
<td>6</td>
<td>Dr. Ferenc Bekes</td>
</tr>
<tr>
<td>7</td>
<td>Dr. Lindsay O'Brien</td>
</tr>
<tr>
<td>8</td>
<td>Dr. Colin Wrigley</td>
</tr>
<tr>
<td>9</td>
<td>Dr. Mike Sissons</td>
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<tr>
<td>10</td>
<td>Ms. Amanda Hill</td>
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<tr>
<td>11</td>
<td>Dr. Daryl Mares</td>
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</table>

DEPUTY PROGRAM MGRS

<table>
<thead>
<tr>
<th>Program</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dr. Lindsay O'Brien</td>
</tr>
<tr>
<td>2</td>
<td>Dr. Colin Wrigley</td>
</tr>
<tr>
<td>3</td>
<td>Dr. Mike Sissons</td>
</tr>
<tr>
<td>4</td>
<td>Dr. Mike Sissons</td>
</tr>
<tr>
<td>5</td>
<td>Ms. Amanda Hill</td>
</tr>
</tbody>
</table>

FIGURE 7.1 SPECIFIED PERSONNEL

<table>
<thead>
<tr>
<th>Name</th>
<th>Contributing Organisation</th>
<th>% of working time</th>
<th>Role in Centre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr William Rathmell</td>
<td>CRC Quality Wheat Products and Processes</td>
<td>100%</td>
<td>Managing Director</td>
</tr>
<tr>
<td>Prof. Don Marshall</td>
<td>The University of Sydney</td>
<td>50%</td>
<td>Program 1 Manager</td>
</tr>
<tr>
<td>Mr. Bob Cracknell</td>
<td>AW B Ltd</td>
<td>15%</td>
<td>Program 2 Manager</td>
</tr>
<tr>
<td>Ms. Di Miskelly</td>
<td>Goodman Fielder Ltd</td>
<td>80%</td>
<td>Program 3A Manager</td>
</tr>
<tr>
<td>Dr. Nigel Larsen</td>
<td>Crop &amp; Food International</td>
<td>50%</td>
<td>Program 3B Manager</td>
</tr>
<tr>
<td>Dr. Ken Quail</td>
<td>BRI Australia Ltd</td>
<td>80%</td>
<td>Program 4 Manager</td>
</tr>
<tr>
<td>Dr. Ferenc Bekes</td>
<td>CSIRO Plant Industry</td>
<td>75%</td>
<td>Program 5 Manager</td>
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<tr>
<td>Dr. Lindsay O'Brien</td>
<td>The University of Sydney</td>
<td>50%</td>
<td>Deputy Manager Program 1</td>
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<tr>
<td>Dr. Colin Wrigley</td>
<td>CSIRO Plant Industry</td>
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<td>Deputy Manager Program 2</td>
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<td>Dr. Mike Sissons</td>
<td>NSW Agriculture</td>
<td>60%</td>
<td>Deputy Manager Program 4</td>
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<tr>
<td>Ms. Amanda Hill</td>
<td>CSIRO Plant Industry</td>
<td>55%</td>
<td>Deputy Manager Program 5</td>
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<tr>
<td>Dr. Daryl Mares</td>
<td>The University of Sydney</td>
<td>80%</td>
<td>Sub-program Leader</td>
</tr>
</tbody>
</table>


**PUBLICATIONS**

**Publications, Public Presentations, Public Relations and Communication.**

**Scientific Journals**

*Cereal Foods World, 44: 580 - 586*

Clarke BC, Hobbs M, Skylas D, Appels R. Genes active in developing wheat endosperm.
*Functional & Integrative Genomics, (in press)*

Gianibelli MC, Larroque OL, MacRitchie FW, Rigley CW. Biochemical, genetic and molecular characterization of wheat-gluten proteins.
*Cereal Chemistry, (submitted)*

*Cereal Foods World, 44: 562 - 565*

*Trends in Food Science & Technology, 10: 247 - 253*

*Cereal Chemistry, 77(3): 360 - 369*

*Journal of Cereal Science, 31: 321 - 333*

Phan-Thien N, N exberry M, Tanner R. Non-linear oscillatory flow of a soft solid-like viscoelastic material.
*Non-Newtonian Fluid Mechanics, (in press)*

Richardson EC, Kaiser AK, Piltz JW. The nutritive value of frost damaged wheat for ruminants.
*Australian Journal of Experimental Agriculture, (in press)*

Singh J, Sharp PJ, Skerritt JH. Chromosomal control of albumins and globulins in wheat - a systematic study.
*Journal of Cereal Science, (in press)*

Singh J, Sharp PJ, Skerritt JH. A new candidate protein for high lysine content in wheat grain.
*Science of Food and Agriculture, (in press)*

*Chemistry in Australia, 66(7): 13 - 15*

*Journal of Cereal Science, 30: 267 - 281*

*Journal of Cereal Science, 30: 283 - 301*

*Cereal Chemistry, 77: 4 - 10.*

Skerritt JH, Heywood RH. A 5-minute field test for on-farm detection of pre-harvest sprouting in wheat.
*Crop Science, (in press)*

*Journal of Cereal Science, (in press)*

Solomon RG, Appels R. Stable, high level expression of a type I antifreeze protein in Escherichia coli.
*European Journal of Biochemistry (submitted)*


*Cereal Science, (submitted)*


*Cereal Chemistry, (in press)*

Uthayakumaran S, Stoddard FL, Gras PW, Bekes F. Effects of incorporated glutenins on the functional properties of wheat dough.
*Cereal Chemistry (in press)*

Uthayakumaran S, Stoddard FL, Gras PW, Bekes F. Optimised methods for incorporating glutenin subunits into wheat dough for extension and baking studies.
*Cereal Chemistry (in press)*

*Cereal Chemistry (submitted)*

*Agricultural and Food Chemistry, (in press)*

Veravebeke W S, Larroque O, Bekes F, Delcour JA. In vitro polymerisation of wheat gluten subunits with inorganic oxidising agents. II. 'Stepwise' oxidations of low molecular weight glutenin subunits and a mixture of high- and low molecular weight glutenin subunits.
*Agricultural and Food Chemistry, (in press)*

Verity CK, Hac L, Skerritt JH. Development of a field ELISA for detection of alpha-amylose in pre-harvest sprouted wheat.
*Cereal Chemistry, (in press)*

Wilson AJ, Kavale S. Mixing response of a variable speed 125g laboratory scale mechanical dough development mixer.
*Journal of Cereal Science (submitted)*

*Cereal Chemistry, 76: 800 - 806*

*Plant Varieties and Seeds, 12: 169 - 179*

Wrigley CW, Bekes F. (1999). Glutenin-protein formation during the continuum from anthesis to processing.
*Cereal Foods World, 44: 562 - 565*

*Journal of Cereal Science (submitted)*

Zounis S, O`uail K, J, W`otten M. Effect of final dough temperature on the microstructure of frozen bread.
*Journal of Cereal Science, (submitted)*

**PATENTS ACTIVITY DURING THE YEAR**

<table>
<thead>
<tr>
<th>Title</th>
<th>Application No</th>
<th>Country</th>
<th>Filing Date</th>
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<tbody>
<tr>
<td>Method for identifying useful polymorphic markers</td>
<td>PQ 5872</td>
<td>Australian Prov</td>
<td>28/02/00</td>
</tr>
<tr>
<td>Discrimination of glutenin subunits</td>
<td>PCT/AU/99/00690</td>
<td>International</td>
<td>27/08/99</td>
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<tr>
<td>Wheat Proteins</td>
<td>PQ 6574</td>
<td>Australian Prov</td>
<td>29/02/00</td>
</tr>
</tbody>
</table>


Shah S H, O'Brien L. Quality improvement in wheats developed by The University of Sydney. Wheat Breeder's Assembly, Toowoomba, Qld. Qld. 26th September 2000.


CRC TECHNICAL REPORTS


CRC Project Report No 30. Clare Johnson. Results of tests on Waxy W heat Samples, June 1999. (Confidential)


CRC Project Report No 40. Clare Johnson. Review of Program 5 - Flour and Dough Components and their Interaction. (Confidential)


BOOKS


THESSES


Murray D.J. Changes to the hydrogen bonding of gliadin types: Effects on several quality parameters of a wheat-flour/water dough. Treatise for M.Ag students, Faculty of Agriculture, University of Sydney. March 2000.


NEWSLETTERS

Cameron J. New soft wheat suits cotton rotations. GRDC Advisor Newsletter (Northern Region) September 1999 Edition.


OTHER PUBLICATIONS


Gras P. Improving Grain Quality Faster. Flyer.

Cameron J. New soft wheat suits cotton rotations. GRDC Advisor Newsletter (Northern Region) September 1999 Edition.


AWARDS

During the year under review the Centre or Centre staff/secondees received the following awards:

The Bruce Wasserman Young Investigator Award of the Biotechnology Division, American Association of Cereal Chemists was awarded at the November, 1999, Annual Meeting of the AACC in Seattle, USA, to John Skerritt.

The Harald Perten Prize of the ICC, Vienna, is to be awarded at the 11th ICC Cereal and Bread Congress, Gold Coast, September, 2000, to Frank Bekes and Peter Gras.

Bob Cracknell was appointed President of the ICC (International Association for Cereal Science and Technology, based in Vienna, Austria). He was also made chairman of the committee organising the 11th International Cereal & Bread Congress, to be held in Australia in September, 2000, this being the first time that such an event has been held in the southern hemisphere.

The Founders Award, (presented at the 48th Australian Cereal Chemistry Conference, Cairns, September, 1998) was made to John Ronalds (but not recorded in earlier Reports).

Conference Travel Awards and Conference Attendance Scholarships, provided by the Cereal Chemistry Division of the Royal Australian Chemical Institute (RACI), for the September, 1999, 49th Australian Cereal Chemistry Conference, Melbourne were made to Kim Turnbull (who also received a poster award), Dennis Murray, Marcus Newbury, Daniel Skylas and to Steven Zounis

GRANTS

Additional grant monies were provided by GRDC during the year for research on:

- Australian wheat for the sponge and dough bread making process $304,767
- Strategies to replace flour chlorination as a treatment for cake flours $229,301
- Biochemical and genetic mechanisms for reducing xanthophyll oxidation in Asian noodles $55,451
T

he performance indicators required by the Commonwealth Agreement that set up the Quality Wheat CRC are being met and exceeded. Progress is reported below against each indicator for the first five years. More detail of progress made in the last year is, of course, to be found in the relevant section of the Annual Report. (The indicators have been grouped together where they have overlapping scope. New criteria - indicated with an asterisk - have also been added to reflect the Corporate Strategy drawn up in 1998. The first four years' progress reports are as they appeared in last four Annual Reports.)

1. COOPERATIVE ARRANGEMENTS

An appropriate mix of staff, in terms of disciplines and sub-disciplines, function etc and a mix from the participants, particularly at the North Ryde, Canberra and industry sites. The interchange of personnel among different sites within the Centre.

- Year 1: Particularly good examples of cross-site and cross-discipline mixing are to be found in sub-programs I.7 (NZ Crop & Food, Weston's, BRI and other participants’ staff) and I.23 (Small-scale mixing and baking research at CSIRO North Ryde interacting with the breeding program in Sydney University - sub-program I.3 - and with Arnott’s). 

- Year 2: A major example of cross-site and cross-discipline interchange is in project I.2.3 (the soft wheat germplasm project) which involves staff from all four company Participants’ sites, CSIRO North Ryde and two sites in Sydney University. Other examples are too numerous to list fully; the project to develop mill systems to control starch damage (and hence water absorption and ingredient cost - project I.6.2) and the project to determine the grain storage factors that influence flour quality (project I.2.3) also involved multiple discipline and site collaboration; in the latter case from three CSIRO sites, Sydney University and several industrial sites.

- Year 3: The above examples are continuing; prominent new projects with such cross-site interaction are:
  - Mill microbiology (Project I.3.1.4 involving Food Science Australia, BRI Australia, Goodman Fielder, Bunge Defiance and Weston’s);
  - Extruded products (Project I.4.1.9 involving Food Science Australia, Goodman Fielder and AWF Ltd) and
  - Quality Wheat for Quality Products Course (Project I.2.2.2 involving AWF Ltd, AgriFood Technology BRI Australia, Agriculture WA, the Centre for Agribusiness, Marketing, NSW Agriculture, Weston’s, and others). The examples continue to be too many to list fully.

- Year 4: Again there are several prominent new projects with cross-site interaction that have been included in the budget. Meanwhile most of those initiated in previous years have continued:
  - Project I.4.1.9) to extend the Country Wheat breeding program to the Southern region, this has used and in-kind support from Arnott’s Biscuits, involving from Bunge/Defiance (now Goodman Fielder) and George Weston Foods, and the research is being conducted by the University of Sydney and NSW Agriculture.

- Project (I.2.6) widely supported by industrial Participants to evaluate practical solutions to the control of wheat quality in storage. Bunge/Defiance, Goodman Fielder and George Weston Foods have been active in this project which has also involved staff from CSIRO Plant Industry and from CSIRO Entomology (Stored Grains Research Laboratory).

- Project I.3.1.5 also widely supported, which came out of a brainstorming session, to study novel approaches to the control of mill performance. This is being conducted between commercial laboratories (Goodman Fielder) and BRI Australia.

- Special mention should be made of the “Prime Hard in the South” project which, though not new, received this year very high levels of interest across all Centre Participants, as well as external organisations. Most notable were CSIRO, NSW Agriculture, GRDC, AWF Ltd, Weston’s, Incitec fertilizers, Pivot Agriculture, and agencies from Victoria and South Australia.

- Quality Assurance on farm I.2.2.5 involves staff from Agriculture NSW, Goodman Fielder, Agriculture WA, Queensland DPI, NRE Victoria; in addition to interaction with Quality Farms Australia and its member organisations.

- Year 5: We have maintained previous year’s momentum in cross-site interaction and added several new projects that require this. A partial list follows:
  - An “extension” project to develop the agronomic basis for producing premium quality wheats in South Australia (in Program 2).
  - Collaboration with the Western Australia group, involving eventually fertilisers suppliers, is also in Program 2. It is designed to determine environmental effects, especially micronutrient deficiency on quality and permit management and extension strategies to be further improved in that state.
  - A project which has industry involvement, to study novel approaches to increasing conditioning efficiency and thereby mill performance (Program 3).
  - An extension of the existing work to greatly refine benchmarking data on durum/pasta quality and to provide knowledge for incorporation into durum breeding in Program 4 has considerably enhanced commercial Participant involvement.
  - The new CRC/GRDC project on strategies to replace cake flour chlorination also in Program 4 has commercial commitment.
  - Building on the success of, and strong industry support for; the Mill Microbiology project, work to assess the microbiological safety of end products from Australian wheat and flour in Program 4 also involves Commercial Participants.
  - Another CRC/GRDC project to identify key quality characteristics required by bread manufacturers using the sponge and dough process in the same Program involves extensive collaboration with the Leslie Research Institute, Queensland DPI.

Performance Indicators

The level of participation by industry and research providers in the functioning of the Centre, including the Board and Program Management Committees in project generation, education, technology transfer and applications.

The involvement of researchers and research managers from commercial Participants in steering Centre projects.

- Year 1: Participation has been widespread across the management of all programs, as foreseen in the 1994 CRC Application and in the Commonwealth Agreement.

- Year 2: One current and one former industrial scientist became members of the Centre’s expanded Senior Management Group. Company Participants renewed their commitment despite changes in their organisations such as take-overs, budget cutting and management reorganisations. Research providers pledged to maintain in-kind contributions.

- Year 3: Scientists working for commercial Participants who are in the Senior Management Group now number three. One senior commercial scientist is seconded for 50% of her time to the Centre at this level. High level of representation on the Board by commercial Participants maintained.

- Year 4: The previous years level of commitment to the management of the Company by the commercial Participants has continued, despite the merger of two of them. All participants remain committed to the overall level of in-kind in the Commonwealth Agreement, and to recovering the earlier shortfall.

- Year 5: The in-kind shortfall has started to recover and will be back to level of the Commonwealth Agreement by the end of the seven-year contract. The commitment of Commercial Participants to the management of the Company has remained at previous levels.
The effectiveness of the Centre (and its component research and educational groups) in interfacing with industry, university and government users of the Centre outcomes.

- Year 1: Industry and university participants and non-participants (overseas companies) are being involved in the development of research and business plans. Examples are the creation of speciality wheat varieties (industry participants and Sydney University), research on process control of starch damage in mills and machinery for wheat processing (overseas machinery manufacturers and BRI). The Centre also participated in the GRDC-funded NIR Centre.

- Year 2: Again the examples have multiplied. During the past year we have managed the scientific part of a DIST-and wheat industry-funded Wheat Quality Assurance program. It has involved states and groups not part of the Centre such as the Grains Council of Australia, Queensland DPI, Pulse Australia and the bulk grain handlers. Quality Wheat CRC Ltd is working with the newly established Co-operative Research Centre for Molecular Plant Breeding centred on the Waite Institute in the University of Adelaide. Further links with research groups outside Quality Wheat CRC have also been established through GRDC-funded research projects complementary to CRC-funded work. Apart from a Wheat Molecular Marker project, we have been successful in applying for and setting up three projects, involving other groups from outside the Centre - the Victorian Institute for Dryland Agriculture (VIDA), and SARDI. Another aspect is the linkage of CRC-funded research with overseas scientists and technologists. In the year under review we have, for example undertaken to supply immunoassay-based testkits to wheat breeders at the Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT - Mexico City) as well as Australian Wheat Breeders for their use in rapid identification of quality characters in early breeding lines.

- Year 3: Virtually all the above two years' examples have continued, and there are now significant additional interactions with old and new collaborators including Food Science Australia, Queensland DPI and GRDC. The continuing QA activity through Quality Farms Australia, assures a high profile involvement and uptake of Centre science by the industry at large, and the increased momentum of our grower training programs has increased use of our output by Agriculture Western Australia.

- Year 4: Again the above examples continue unabated. We have significant new links with CSIRO Entomology Division (SGRL), and new GRDC projects including one on high protein wheat genotypes and durum wheat enzyme, and the data can be used to create an assay for testing a durum wheat enzyme, and the data can be used to create an assay for breeding programs. Another wrote software to integrate the working parts of the Z-arm mixer.

The extent of PhD and Honours candidate involvement in the research activities of the Centre.

- Year 1: Eight new postgraduate studentships started and three undergraduate vacation students appointed.

- Year 2: The number of postgraduates working in the CRC has increased, and Centre staff supervised fifteen. The number of CRC Vacation Scholarships enabling undergraduate students to conduct a small research project in cereal science was increased to five. The proportion carried out in industrial laboratories was also increased (60%). The Centre sponsored an Undergraduate Scholar in Agriculture in the University of Sydney.

- Year 3: Four former PhD students associated with the Centre have moved into related work in industry. The number of postgraduate students is still fifteen.

- Year 4: The number of postgraduate students has risen to eighteen (fifteen fully funded by the Centre), and two have had their theses accepted during the current year. Recruitment and financing for at least four new students to start July-December 1999 has been obtained during the year.

- Year 5: Five PhD students and one MSc student have completed or submitted their theses for examination. Most have taken up positions within the wheat industry. One negotiated an exchange to Rutgers University, USA. There are currently 10 other postgraduate students in the CRC. Five undergraduate students received scholarships last summer. One of them carried out the first cloning and sequencing of a durum wheat enzyme, and the data can be used to create an assay for breeding programs. Another wrote software to integrate the working parts of the Z-arm mixer.

2. RESEARCH & RESEARCHERS

An appropriately balanced portfolio of longer term strategic and applied research developed in close association with industry.

- Year 1: The longer term research goal (number 6) has the heaviest allocation of sub-programs contributing to it, and roughly represents one-third of the Centre's current activity by this measure.

- Year 2: In agreement with industry, we defined projects whose basic justification is to enhance background knowledge as "long-term", and concluded that 24% of the resources of the centre are actually so deployed, and that the proportion was right.

- Year 3: The Board and the CRC Committee (at the Second Year Review) have approved the balance implicit in the above ratio, which has been maintained.

- Year 4: Consistent with policy, support for the longer-term part of the portfolio has been maintained. Industry Participants have taken an increasingly active role in steering the shorter-term part, as a result of their higher representation on the Senior Management Group. Periodic updates on project progress have been given to groups of managers and employees from individual commercial Participants.

- Year 5: The same policies have been continued.

Invitations to present keynote addresses, invited papers and workshops at influential conferences.

- Year 1: The Centre Director has made invited presentations on the work of the CRC to the AIFST Annual Conference, and is currently preparing presentations to three other conferences. Invited presentations have been/are being made to research bodies outside the CRC and internationally. Centre secondees and the Director have participated in farm advisory workshops and in workshops designed to help the allocation of GRDC funding.
Year 2: Levels of such activity increased, with the Centre playing a high-profile role in the group of international conferences that occurred in Sydney during August and September and Canberra in October, namely Cereals '96 and Gluten '96, the International Tritici Mapping Initiative, and the Sixth Australian Wheat Breeding Assembly. The Centre was represented at the International Wheat Quality Conference, Kansas City, USA in May 1997. A CRC program manager gave radio interviews about the growing of Prime Hard Wheat in the southern wheat belt. CRC program and project managers as well as the Director again participated in several GRDC workshops.

Year 3: The Centre played a high-profile role at the 47th RACI Cereal Chemistry Conference in Perth (September 1997), the Managing Director addressed the conference, and numerous other papers and posters were given. Two Centre students (Surjani Uthayakumaran and Steven Zounis) were given bursaries to attend the conference by the Organisers. The Managing Director was invited to share a platform with Norman Borlaug at the ICC Symposium “Genetic Engineering in Cereals”, Vienna, May 1998 (his place was eventually taken by Frank Bekes, representing the Centre), and to address the Flour Millers Conference in Victoria in September 1997. Alan Ellis (Business Manager) played a major role in the Grains Council of Australia Workshop “Quality Assurance in the Grains Industry” (July 1997). One project leader (Rudi Appels) and the Managing Director participated in the strategy workshop of the CRC for Molecular Plant Breeding in June 1997; the MD was appointed to be a member of the Industry Advisory Committee of that Centre.

Year 4: The Managing Director was invited to address the GRDC-sponsored “Research Horizons for Grain Policy Leaders” course in July. He also chaired a session at, and the Centre generally played a major role in “Cereals '98” in Cairns (August). Other prominent CRC people were involved - John Ronalds (received an award) Bob Cracknell (became president of the ICC and a Director of AACCC) and Lindsay O’Brien (co-chair of the organising committee), and two CRC students received awards. Also in August we presented several papers and organised (Colin Wrigley) a symposium at the Annual Meeting of the AACCC. The Managing Director was invited to address the GCA/GRDC conference: “Progressing Grain Crop Improvement for a New Millennium” in September and the South Australian Field Crops Development Board in November 1998. Colin Wrigley contributed to a conference organised by the European Union in Sweden (March 1999) to discuss the commercialisation of food industry research. In the same month Clare Johnson was invited to participate in the CRC for Molecular Plant Breeding in June 1998; the MD was appointed to be a member of the Industry Advisory Committee of that Centre.

Year 5: The Managing Director was invited to sum up the proceedings at the Gluten 2000 workshop in Bristol in April 2000, and to present the following lecture: “Wheat-grain proteomics; the full complement of proteins in developing and mature grain”. For the 49th Australian Cereal Chemistry Conference, Melbourne, September, 1999, Colin Wrigley (CSIRO) was invited to arrange a Symposium on the topic of “Premium Wheats for Non-Traditional Areas”. Following the Conference, Colin Wrigley and Rachel Jackson were invited to conduct a workshop on “Cereal Variety Identification”.

The number and importance of honours and awards bestowed upon Centre staff.

Promotions of Centre secondees to more senior positions within or outside their organisations.

- Year 1: Professor D Marshall (Program 3 leader) and Dr G McMaster were elected fellows of the Australian Academy of Technological Sciences and Engineering in 1995.
- Year 2: The Chairman was appointed adjunct Professor in the Department of Agricultural Economics of the University of New England. The Managing Director was appointed adjunct Professor in the Faculty of Agriculture at Sydney University. Dr Graeme Robertson, a Director, was elected Fellow of the Australian Institute of Agriculture, Science & Technology.
- Year 3: The Council of the University of New England conferred the title of Emeritus Professor on a Centre Director, John Lovett, in recognition of his distinguished academic career. Dr Lindsay O’Brien (Program 1 deputy manager and project leader) received the F B Guthrie award at the 47th RACI Cereal Chemistry Conference in Perth (September 1997) for his outstanding contributions to the science. John Oliver, formerly Program 2 manager in the Centre was promoted to Program Leader (cereal products) in NSW Agriculture.
- Year 4: Dr Kevin Sheridan, a Director, was awarded the AO in the 1999 Queen’s Birthday Honours. Dr Chris Hudson, also a Director, was appointed Adjunct Professor in the Faculty of Natural Resources (Department of Agriculture and Veterinary Science) at the University of Queensland. He was also appointed to the Board of the Australia and New Zealand Food Authority (ANZFA). Dr John Skerritt, a Program Manager was appointed Deputy Director of the Australian Centre for International Agricultural Research (ACIAR). He and three other CRC secondees from CSIRO Division of Plant Industry (Rudi Appels, Frank Bekes and Peter Gras) received awards from the Chief of the Division. Dr Nigel Larsen, a Program Manager, was promoted to Team Leader, Food Quality and Safety at the NZ Institute for Crop and Food Research. Dr Michael Southan, a Centre postdoctoral fellow joined the milling and baking science group of BRI Australia.
- Year 5: The Bruce Wasserman Young Investigator Award of the Biotechnology Division, American Association of Cereal Chemists was awarded at the November, 1999, Annual Meeting of the AACCC in Seattle, USA, to John Skerritt. The Harald Perten Prize of the ICC, Vienna, is to be awarded at the 11th ICC Cereal and Bread Congress, Gold Coast, September, 2000, to Frank Bekes and Peter Gras. Bob Cracknell was appointed President of the ICC (International Association for Cereal Science and Technology) based in Vienna, Austria. He was also made chairman of the committee organising the 11th International Cereal & Bread Congress, to be held in Australia in September, 2000, this being the first time that such an event has been held in the southern hemisphere. The Founders Award, (presented at the 48th Australian Cereal Chemistry Conference, Cairns, September, 1998) was made to John Ronalds (but not recorded in earlier Reports). Conference Travel Awards and Conference Attendance Scholarships, provided by the Cereal Chemistry Division of the Royal Australian Chemical Institute (RACI), for the September, 1999, 49th Australian Cereal Chemistry Conference, Melbourne were made to Kim Turnbull (who also received a poster award), Dennis Murray, Marcus Newbury, Daniel Skylas and Steven Zounis.

Increase in the number of articles accepted for publication in leading scientific journals such as Cereal Science, Cereal Chemistry, Australian Journal of Agriculture Research, Plant Molecular Biology.

- Year 1: Publications are in line with the activities of the participants before the formation of the centre, but in one or two areas (eg dough behaviour modelling in CSIRO) new activity has been stimulated which is in press.
- Year 2: Greatly increased publication activity is reported for the year.
- Year 3: Forty-six refereed publications were approved for submission to refereed journals during the year. This is a sharp increase on last year.
- Year 4: The rate of publication in refereed journals has doubled relative to last year’s level.
- Year 5: Forty-six refereed publications were approved for submission to refereed journals during the year, a record.
Year 1: Centre participants and non-participants (companies, institutes and research providers) are planning new research programs in marker-assisted wheat breeding and noodle quality modified and/or stimulated by Centre activity. A through-chain quality assurance system for the wheat industry is being developed.

Year 2: All the above examples have turned into actual work programs. New examples (again, this is a random selection from a long list) are in the use of centre-derived knowledge by one industry participant for improving performance of its bakery ovens, and by another for identifying flour batches with cake-processing problems.

Year 3: Again the above examples have continued and the new ones have multiplied even more. As a direct result of QWCRG's managed research, AWB Ltd has encouraged exports of prime hard wheat from the Port Kembla zone. We have produced and supported new targeted training courses for growers in Eastern and Western Australia during 1997/8. We have completed research on new methods for controlling water absorption in bakers' flours (i.e. reducing ingredient costs); some of this produced commercially-valuable information being used by Industrial Participants. Our pilot milling project generated useful data for the classification of the new variety Diamondbird. Improvements in flourmills' quality assurance (QA) procedures were stimulated by CRC science, resulting in a workshop attended by large numbers of site-based practitioners. We contributed to the Grains Council of Australia's workshop in July 1997, and joined with other grains industry groups in establishing Quality Farms Australia, to further aid the implementation of QA systems on farm. Centre commercial Participants joined in the evaluation of one of the world's first samples of "waxy" wheat. The uptake, by Australian and overseas wheat breeders, of our diagnostic test (for the rye chromosome translocation "1B/1R") has been good and they have reported it reliable.

Year 4: Again there has been a continuation of the previous examples, and a raft of new ones, the following being typical. Despite adverse climatic conditions for the 1998 season AWB Ltd and growers enthusiastically supported the development of the "Prime Hard in the South" concept, and there was much input from fertilizer manufacturers. The program of grower-oriented training courses and the quality assurance program was expanded. Evaluation of a larger sample of "waxy" wheat was conducted by Participants in the CRC and by non-participant companies, and this provided evidence of new processing benefits to be derived from this type of product. The number of diagnostic tests (for the rye chromosome translocation "1B/1R") supplied to Australian and overseas wheat breeders rose to nearly 9000. The WheatRite rain-damage test kit was evaluated to determine how best logistically to bring it to practice. Disruption to bakeries, have resulted in the Bulk Handling quality in wheat up to a year and avoid the "new season's wheat" income of growers - following from a CRC project.

Year 5: One visiting research fellow from UK (sub-program 1.6).

Year 2: Continued coverage in newspapers, radio and non-learned periodicals, e.g., Food Australia, Ground Cover.

Year 3: This year's coverage included the cropping section of the Stock Journal and Leading Edge bakery and food service journal and the Annual Wheat Newsletter.

Year 4: This year there has been a series of six articles in Farming Ahead, two in Australian Grain, and others in publications as diverse as Rural Weekly and Central and North Burnett Times (Queensland). Also in Food Australia and Cereal Foods World (USA). Support for articles and booklets on wheat quality and relevant agronomy has resulted in articles widely circulated to growers in the Southern and Western wheat belts.

Year 5: Recent QWCRG articles in Australian Grain make a total of fourteen grower-oriented articles this year and the second issue of the SA newsletter, Premium Quality Wheat News, has been produced. In addition articles about Centre activities have appeared in The Land, Rural Weekly, the Australian Farmers' and Dealers' Journal and Ground Cover. Again, support for articles and booklets on wheat quality and relevant agronomy has resulted in articles widely circulated to growers in the South and in the West.

Increase in the number of farmers, companies, agencies or institutions using Centre developed concepts and technology.

Year 1: Eight new postgraduate studentships started and fifteen are supervised by Centre Staff.

Year 2: Continued research on new methods for controlling water absorption in bakers' flours (i.e. reducing ingredient costs); some of this produced commercially-valuable information being used by Industrial Participants. Our pilot milling project generated useful data for the classification of the new variety Diamondbird. Improvements in flourmills' quality assurance (QA) procedures were stimulated by CRC science, resulting in a workshop attended by large numbers of site-based practitioners. We contributed to the Grains Council of Australia's workshop in July 1997, and joined with other grains industry groups in establishing Quality Farms Australia, to further aid the implementation of QA systems on farm. Centre commercial Participants joined in the evaluation of one of the world's first samples of "waxy" wheat. The uptake, by Australian and overseas wheat breeders, of our diagnostic test (for the rye chromosome translocation "1B/1R") has been good and they have reported it reliable.

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Year 5: One visiting research fellow from UK (sub-program 1.6).

Year 2: Obtained a GRDC Visiting Fellowship Award to finance the visit of Professor Z Plaut of the Volcani Institute, Israel.

Year 3 and 4: The Centre has subsidised the activities of the Royal Australian Chemical Institute's (RACI) Cereal Chemistry Division, thereby facilitating the visits of several prominent scientists from overseas. Wim S. Veraverbeke, a visiting PhD student from the Laboratory of Food Chemistry, Katholieke Universiteit, Leuven, Belgium spent 2 months at North Ryde, optimising the conditions of the in vitro polymerisation of glutenin subunits (S.1.1.1).

3. EDUCATION & TRAINING

Increase in the number of PhD and/or Masters candidates conducting their research within the Centre, or through universities associated with the Centre. A future indicator will be the number of PhD and Masters degrees awarded.

Increase in the number of eminent scholars undertaking visits to the Centre.

Year 1: One visiting research fellow from UK (sub-program 1.6).

Year 2: Obtained a GRDC Visiting Fellowship Award to finance the visit of Professor Z Plaut of the Volcani Institute, Israel.

Year 3 and 4: The Centre has subsidised the activities of the Royal Australian Chemical Institute's (RACI) Cereal Chemistry Division, thereby facilitating the visits of several prominent scientists from overseas. Wim S. Veraverbeke, a visiting PhD student from the Laboratory of Food Chemistry, Katholieke Universiteit, Leuven, Belgium spent 2 months at North Ryde, optimising the conditions of the in vitro polymerisation of glutenin subunits (S.1.1.1).

Increase time spent by Centre Participants and their staff in supervising/co-supervising/advising students and the value placed by employers on Centre PhD, Masters and Honours graduates.

Year 1: Eight new postgraduate studentships started and three undergraduate vacation studentships awarded.

Year 2: The number of postgraduates working in the CRC increased, and fifteen are supervised by Centre Staff.

Year 3: Four students who have completed their studies are now working in the industry. The number of postgraduate students associated with the Centre is fifteen.
Year 5: There was strong interest in the above wheat quality/market
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Year 5: Five PhD students and one MSc student have completed or
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undertaken training programs developed with Centre involvement.

Increase in the number of Honours students undertaking research
projects in the Centre research programs and/or in laboratories of
industry partners.

- Year 1: Three undergraduate vacation students appointed.
- Year 2: The number of CRC Vacation Scholarships enabling Honours
students to conduct a small research project in cereal science was
increased to five. The proportion carried out in industrial laboratories
was also increased.
- Year 3: There were seven CRC Vacation Scholars this year (two worked
in industrial laboratories), and there was also an (honours listed)
Undergraduate Scholar at the University of Sydney.
- Year 4: Eight vacation students were given projects this year; three
worked in industry labs (Goodman Fielder, Agrifood Technology and
Weston’s). One was at BRI Australia in a project for commercial
bakeries and two were working on WheatRite field trials for
commercial validation. The other two had a strong industry focus; one
of them subsequently negotiated work in a Participant’s laboratory. The
undergraduate scholarship was continued.
- Year 5: A total of twenty-eight vacation students have now received
Centre sponsorship. Reports have been received from the students
awarded scholarships last summer. One of them carried out the first
cloning and sequencing of a durum wheat enzyme, and these
sequence data can now be used to design peptides against which to
raise antibodies, so a screening assay for breeding programs can be
developed. Another wrote software to integrate the pump, temperature
controller and electronic recording of the Z-arm mixer.

Increase in the number of postgraduate students has risen to eighteen
(fifteen fully funded by the Centre), and two have had their theses
accepted during the current year. Recruitment and financing for seven
new students to start July-December 1999 has been obtained during
the year. Of the recent finishers, three are now working at the University
of Sydney (on Centre related research for which part of the money was
raised by us), one is in Agriculture WA, one is at CSIRO Plant Industry
and one at Arnott’s Biscuits. A number of students have been granted
short (3-6 month) extensions to their scholarships to enable them to
complete their research. The managing Director has joined the
extensive list of Centre Staff who spend time supervising and
examining theses.

Year 5: Five PhD students and one MSc student have completed or
submitted their theses for examination. Two others are due to submit
soon. Most have taken up positions within the wheat industry. One
negotiated an exchange to Rutgers University, USA, earlier this year.
There are currently ten other postgraduate students in the CRC. Again
a number of students have been granted short (3-6 month) extensions to
their scholarships to enable them to complete their research. Because
of the length of time remaining in the Commonwealth Agreement, it
has ceased to be possible to seek new postgraduate research students.

Increase in the number of grain producers and handlers
undertaking short courses and workshops developed and/or
sponsored by the Centre.

- Year 1: Twelve NSW district agronomists and a key agronomy
researcher from WA trained through CRC sponsorship.
- Year 2: Fourteen district agronomists and other growers’ advisers (from
NSW Agriculture, Agriculture WA and from other State departments)
were sponsored to attend the Milling for Non-Millers course at BRI
Australia. Quality Wheat for Quality End Products Courses were
prepared and/or presented to give a wider appreciation of the
influence of growing conditions on wheat quality to farmers in WA, SA,
Queensland and Victoria.
- Year 3: We have produced and supported new targeted Quality Wheat
for Quality End Products training courses (Called Quality Wheat –
Understanding Market Requirements in the West) for growers
throughout Australia during 1997/8, and they have received excellent
feedback from those attending.
- Year 4: The earlier initiatives have continued, increasing numbers of
Quality Wheat for Quality Foods courses being given, and a version
prepared for using at smaller growers’ assemblies where there are less
resources available. This course has now been in all wheat-growing
States, including those not represented in the CRC – Queensland,
Victoria and South Australia. There is now a waiting list for the Western
Australia course, which has become practically self-supporting. We also
co-sponsored an “Asian Wheat Users and Markets” course for (Western)
Australian Farmers in August, and have grower groups involved in the
QA on-farm project.

Year 5: There was strong interest in the above wheat quality/market
awareness courses this year, following a promotional article published
in Australian Grain and notification of agronomists through e-mail
networks. One-day courses were held in Walgett, Goondiwindi, Moree
and Condobolin, a two day course in Northam. One and two day
courses are planned for Toowoomba, Tamworth, Wagga, Griffith, Spring
Ridge/Quirindi, Northam and for venues in SA and Victoria. Nitrogen
fertilization regime demonstrations at Hart, Eyre Peninsula and Yeelana
focus field sites are also planned. QWCRMC newsletters and e-mail
quality fact sheets are supplied on all of these courses. WheatRite®,
Great Grain QA, and wheat quality nitrogen management and Prime
Hard wheat production booklets and the grain storage CD are
promoted.

Increase in the number of current or potential industry employees
undertaking training programs developed with Centre involvement.

- Year 1: One industry employee has submitted a Masters.
- Year 2: Four industry employees and thirteen students attended the
“Wheat Proteins and Dough Properties” course in July 1998. We co-
sponsored the Crawford Fund “Master Class” on biotechnology in
agriculture, attended by influential industry staff. In February 1999 we
held a workshop “Molecular Techniques for Rapid Wheat Breeding”
which was extremely well received. A total of 46 industry managers,
staff and students attended (including five from Agriculture NSW, three
from Arnott’s, and three from BRI Australia). In March 1999 the
centre held a workshop “Tools for Achieving Wheat Quality Targets”used to
promulgate the outcomes of Program 2 to all Participants’ staff. We have
prepared a workshop for July 1999 at which seven industry
employees have made bookings. The Managing Director provided a
segment in the GRDC-sponsored course “Research Horizons for Grain
Policy Leaders” (July 1998).
- Year 3: Five Industry Employees attended a week-long course “The
Chemistry and Biochemistry of Grains” organised by the Centre and
Sydney University.
- Year 4: Four industry employees and thirteen students attended the
“Wheat Proteins and Dough Properties” course in July 1998. We co-
sponsored the Crawford Fund “Master Class” on biotechnology in
agriculture, attended by influential industry staff. In February 1999 we
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which was extremely well received. A total of 46 industry managers,
staff and students attended (including five from Agriculture NSW, three
from Arnott’s, and three from BRI Australia). In March 1999 the
centre held a workshop “Tools for Achieving Wheat Quality Targets”used to
promulgate the outcomes of Program 2 to all Participants’ staff. We have
prepared a workshop for July 1999 at which seven industry
employees have made bookings. The Managing Director provided a
segment in the GRDC-sponsored course “Research Horizons for Grain
Policy Leaders” (July 1998).
- Year 5: A workshop on dietary fibre, which included a practical, was
delivered in July 1999. There was good interest from industry (16
attendees). A workshop on Polymer Colloids in Cereal Science was run
jointly with the Key Centre for Polymer Colloids at the University of
Sydney [June 6–8, 2000. Significant cost recovery was achieved and
there were 48 attendees, mostly from industry. The attendees reported a
high level of satisfaction with the course. On-forum Quality
Assurance development, we supported a series of storage management
workshops throughout Victoria with TopCrop, Victoria Farmers
Federation and Southern Farming Systems groups. Plans were made for
new courses for the coming year including obtaining accreditation of the
Advanced Certificate in Cereal Science course and development of
training modules for oven process control, based on QWCRMC research
outcomes.
Increasing relevance and accessibility of industry targeted training programs.

- Year 1: A National Certificate Course and an Advanced Certificate Course in areas relevant to the centre are in advanced stages of preparation.
- Year 2: Agreement was reached with the University of Sydney to use Centre-designed modules as part of a MAg degree which will be attractive to industrial employees for whom study time is at a premium. The drawing up of the competency standards for plant bakery operatives was completed in collaboration with the National Food Industry Training Council and DEET.
- Year 3: Accessibility has been increased by the recruitment of an effective Education and Training coordinator in the Centre during the year. A National Certificate in Food Processing - Plant Baking is now available. An Advanced Certificate in Cereal Science for Technical Laboratory Personnel is available by distance learning.
- Year 4: Concerted effort has been devoted by the Education and Training coordinator in building a suite of resources and effective links with a broad network of farm advisers. Our web-site is now up and running and the Wheat Quality factsheets have proved valuable to extension officers. A grain storage CD has been prepared for release in spring and was received most enthusiastically by reviewers nationwide. A revised booklet, "Great Grain - Quality Assurance for Grain Growers", has been produced in a joint initiative of Quality Wheat CRC, Pulse Australia and the Australian Oilseed Federation. It is being piloted by a number of grower groups around the country so that refinements can be made.
- Year 5: Over 230 copies of the "Managing On-Farm Grain Storage" CD-ROM have been sold and the CD was highlighted across the country at GRDC farm adviser updates by a network of advisers. TopActive modules on grain hygiene and storage have been designed, which will use the CD as a resource. We have also provided market quality and food safety/QA material to TopCrop. TopActive and TopCrop are proving ideal vehicles for targeting quality training to growers. Great Grain is being marketed and well over 100 growers have signed up for the program in its first year.

4. APPLICATION OF RESEARCH
The degree of adoption and diffusion of concepts developed within the Centre into industry, universities and government users of the research.

- Year 1: Centre participants and non-participants (companies, institutes and research providers) are planning new research programs in marker-assisted wheat breeding and noodle quality, modified and/or stimulated by Centre activity. A through-chain quality assurance system for the wheat industry is being developed.
- Year 2: Again the examples have multiplied. Conceptual areas we have influenced have included the following, in addition to the above: Research to increase the flexibility of wheat use; research to understand and manage the effects of growing and storing conditions on flour quality.
- Year 3: The above examples continue to be important, but new ones have risen to prominence. As a direct result of QWCR-managed research, AWB Ltd has encouraged exports of prime hard wheat from the Port Kembla zone. We have completed research on new methods for controlling water absorption in bakers' flours (ie reducing ingredient costs); some of this produced commercially-valuable information being used by Industrial Participants. Our pilot milling project generated useful data for the classification of the new variety Diamondbird. Improvements in flourmills' quality assurance (QA) procedures were stimulated by CRC science, resulting in a workshop attended by large numbers of site-based practitioners. We contributed to the Grains Council of Australia's workshop in July 1997, and joined with other grains industry groups in establishing Quality Farms Australia, to further aid the implementation of QA systems on farm.
- Year 4: Most of the above examples have again continued, strongly in the case of most examples. New or extended initiatives have included a workshop, convened by Daryl Mares, "Late Maturity α-amylase in Wheat"; to report on his study of Australian breeding material (August 1998 - Program 1). Senior representatives attended this from all the Australian Wheat Breeding programs. In October 1998, representatives of all four manufacturing Participants attended a forum organised by two of the major research providers. Participants to describe the latest results and industry application of the dough rheology work. In March 1999, the workshop, "Tools for Achieving Wheat Quality Targets", was used to promulgate major outcomes of Program 2 to all Participants' staff. The Centre co-supported (with Topcrop Australia) the "Managing Wheat for Quality" and "Nitrogen Management for Wheat....": guidelines materials produced by SARDI for farmers in South Australia. We also supported (with Participants and fertiliser distributors) "Increasing Grain Protein in Southern Crops with Topdressed Nitrogen" - a brochure for growers in the Northern part of the Southern wheat belt. We also published our second industry Newsletter during the year. This document was widely circulated and described outcomes from several Centre projects.
- Year 5: There was strong interest in the wheat quality/market awareness courses this year; following a promotional article published in Australian Grain and notification of agronomists through e-mail networks. Five courses were held and five more plus four nitrogen fertilization regime demonstrations were planned at the time of writing. QWCR newsletters and reception quality fact sheets are supplied on all of these courses. WheatRite®, Great Grain QA, and wheat quality/nitrogen management and Prime Hard Wheat production booklets and the grain storage CD are promoted. Following from a CRC project on the production of premium grades in non-traditional areas, 300,000 tonnes of Prime Hard wheat were delivered in the southern wheat belt - representing an increase of about $9M in the income of growers and they were also shown how to increase their return from frost-damaged wheat. The outcomes from the storage project, which show how to maintain quality in wheat up to a year and avoid the "new season's wheat" disruption to bakeries, have resulted in the Bulk Handling Companies, domestic wheat users and AWB Ltd sitting down together to determine how best logistically to bring it to practice. Nearly seventy copies of the report on the mill microbiology project were issued, reflecting the response of this work by the industry, both in relation to the installation of Quality Assurance protocols for flour mills, and understanding the sources and acceptable levels of microbial contamination. The Great Grain Quality Assurance system was launched commercially this year and was taken up by over 100 growers.

The number of CRC developed methods and technologies (eg diagnostic kits) used by the wheat and related food processing industries:

- Year 1: CRC activities in commercial bakeries are beginning to provide management aids to process control (sub-program 1.7). New lines of soft wheat are being made available for commercial evaluation and a direct contribution is being made to the development of suitable test equipment for use in industry (sub-program 1.3). Possible diagnostic kits for rain damage are being studied with a possible commercial partner (2.1).
- Year 2: The progress in the above projects has continued with the development of prototypes of the rain damage kits and the oven probe. The development of the Centre's Intellectual Property portfolio includes genes for use in wheat breeding programs, and there are important advances on early generation screening techniques for use by breeders.
Commercialising Centre Intellectual Property

**Year 4:** In the year we filed domestically and internationally (Canada, Sweden and Australia). The number of diagnostic tests (for the rye chromosome translocation “1B/1R”) supplied to Australian and overseas wheat breeders rose to nearly 9000. The WheatRite rain-damage test kit was also used by breeders to detect germplasm showing the “late maturity α-amylase” defect. Cost reductions from the use of our process control hardware and software in one bakery were estimated as a $30,000 per annum reduction in product waste and a $45,000 per annum reduction in product giveaway. Our Quality Assurance System was developed with others into a pilot Great Grain program that is being evaluated by leading growers. Food companies within and outside the CRC tested our waxy wheat as an ingredient in the creation of novel foods.

**Year 5:** In the first real year of commercialisation, $60,000 worth of WheatRite® kits were sold into the distribution pipeline. About half were used by farmers in Australia, the rest taken prior to first launch in the northern hemisphere by our distributors in the United States and France. The breeder tests for defects (caused by late maturity α-amylase and by the rye chromosome translocation) are being developed and more widely used - eighteen thousand of the latter tests have been supplied free of charge to Australian and CIMMYT wheat breeders. Over 100 growers signed up for the Great Grain Quality Assurance System (developed and marketed with Pulse Australia and the Australian Oilseeds Federation) in its first year of availability.

Establishment of effective mechanisms for protecting and commercialising Centre Intellectual Property

**Year 3:** We have continued development of the rain-damage kit to a simple credit-card format. The uptake, by Australian and overseas wheat breeders, of our diagnostic test (for the rye chromosome translocation “1B/1R”) has been good. We have seen some further progress towards the commercialisation of the oven probe, and marked development of process control concepts and diagnostic services to reduce costs in Partners’ bakeries. Our science was used by one commercial Participant in setting up a new oven installation.

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Performance Indicators

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Establishment of effective mechanisms for protecting and commercialising Centre Intellectual Property

**Year 3:** We have filed two new Australian provisional Patents (one withdrawn) and are working towards several others. We have established QW Investments Pty Ltd (QWIP) to be a partially (minority) owned subsidiary of the Centre to attract investment into the commercial development of Centre Outcomes, and we have reached advanced stages in drawing up contracts for such investment with potential investors. We have developed a business plan for the protection and commercialisation of speciality wheats emerging from Centre science.

**Year 4:** In the year we filed domestically and internationally (Canada, Europe, Japan and the USA) on one patent (food colouring), and filed two new patents covering the WheatRite kit and antibodies that discriminate quality-determining wheat proteins. We have instructed our Patent agents on two other pieces of intellectual property – a novel food product from waxy wheat and a new method to enhance the use of molecular markers in wheat breeding. We have registered the trademark WheatRite in Australia, Canada, Europe, the USA and in other countries. QWIP is now operating to commercialise the WheatRite kit, using Centre funds at present. The first actual sales of other products, such as discrimination and molecular markers, were made during the year. Activity to seek routes for the commercialisation of the waxy wheat and waxy wheats, plus other speciality wheats from Centre science has intensified. We have started to distribute our quality assurance system through Pulse Australia. The series of confidential project reports (containing know-how IP accessible only to Participants) has grown markedly this year.

**Year 5:** Four new patents were filed. A novel method for detecting molecular markers polymorphic (ie useful) in wheat resulted from work by one of our PhD students, as did a second patent on novel proteins discovered in proteome research. The WheatRite® patent was also filed internationally as was the patent on antibodies to distinguish glutenin subunits. The QAL 2000 new biscuit wheat was launched during the year and Plant Breeders’ Rights applied for. Other research projects also provided breeding material (germplasm) with a number of valuable benefits to farmers, processors and consumers such as resistance to rain damage, improved bread, noodles and biscuits and improved factory efficiency. Other commercialisation endeavours (QWIP, WheatRite®, Great Grain) have continued as last year, with successes described elsewhere in this table.

Increasing level of funding, particularly from industry, for Centre projects.

**Year 1:** Additional commitments of >$1M have been obtained from industry and Government to a new wheat quality assurance program. There is increased financial commitment from an industry participant to a speciality wheat-breeding program in the CRC. A grant of $200000 was obtained from NSW State Development for equipment purchase and for the development of the Centre. These items represent an overall increase of funding of around 10% relative to the Commonwealth Agreement.

**Year 2:** Quality Wheat CRC Ltd has again been able to increase the cash and in-kind funding available to it, which has enabled it to strengthen links with bodies other than its twelve Participants. In terms of cash, GRDC monies and the DIST/industry contributions to the Wheat Quality Assurance Program amounted to about $591,000 and $525,000 respectively.

**Year 3:** The funding under management in the Centre was increased by commitments from GRDC grants for research complementary to that already going on. Notably this was for a program to develop high-protein wheat genotypes for S and W regions ($290,000), for an extension to the “Prime Hard in the South” project ($15,000) and for a project entitled “Amelioration of Genetic Factors Which Result in Downgrading of Wheat at Receival” ($873,286). In addition we extended our rôle in the National Wheat Molecular Marker program (a strategic initiative of GRDC) by matching a salary component in Program 1 to a GRDC commitment of $147855 to commence in 1998 to pay for a technician working on marker validation. Year 3 saw the commencement of the “Flexibility of Wheat Use” project representing a commitment of $1,208,617 (like most of the aforementioned projects, over 5 years) by the GRDC. The QA program with DIST was finally completed during the year, with a final funding of $72,000 being obtained to ensure the uptake of the procedures developed in industry.

**Year 4:** A number of new proposals for additional complimentary research have again been accepted by the GRDC. These add a further $430,000 to the value of the research under the management of the Company next year. In addition, the budget developed for the core activities of the Centre is about $400,000 above the original Commonwealth Agreement.

**Year 5:** The value of the on-going additional GRDC projects directly managed by the Centre is over $600,000 and a further $250,000-worth have started during the year. Orders and payments received for the Company’s products have reached over $100,000 in the first real year of commercialisation.
5. MANAGEMENT AND BUDGET

Increasing coherence, clarity and effectiveness of management and financial systems and procedures.

The timeliness and quality of Centre accountability documents and processes.

- Year 1: Complete financial reporting system put in place to satisfy internal and external reporting requirements of the Company. Reporting timetables all met, and recipients satisfied, by the end of the year.
- Year 2: Successful first Audit of the Company and its first Annual Report and Annual Operating Plan published, meeting all required corporate governance standards and laws.
- Year 3: Successful two phase Second Year Review with a panel of distinguished scientists external to the Centre and with the CRC Committee chairman, Dr Geoffrey Vaughan and Secretariat. Successful second Audit of the Company and its second Annual Report and Annual Operating Plan published, meeting all Board-required corporate governance standards and laws.
- Year 4: Again we had a successful third Audit of the Company and its third Annual Report and Annual Operating Plan were published, meeting all Board-required and Commonwealth-required corporate governance standards and laws.
- Year 5: We had a successful fourth Audit of the Company and its fourth Annual Report was published, meeting all Board-required and Commonwealth-required corporate governance standards and laws. The process for preparing the Annual Operating Plan was extended, so as to allow time for commercial Participants to respond to the draft proposals, and Board Approval was obtained prior to the start of the new financial year.

The level of transparency and timeliness of resource allocation and management decisions.

- Year 1: Budgetary allocations for the second year of the Centre's life established by Program Leaders, modified and then agreed at Board level (as the Annual Operating Plan) essentially within a three-month cycle.
- Year 2: New program structure increases transparency of decision making process, by putting related projects under the same manager. Project priorities and new project proposals were debated in open forum involving most Centre secondees, and finalised by the Centre's expanded Senior Management Group. An individual economic evaluation of projects was begun. Annual Operating plan finalised and approved by the Board in time for new budgetary cycle.
- Year 3: Project priorities and new project proposals were debated by an expanded Senior Management Group (including Program Managers' deputies), and finalised by the Centre's management. An individual economic evaluation of projects was continued. The Annual Operating plan was finalised and approved by the Board in time for the new budgetary cycle.
- Year 4: The preliminary report of the economic evaluation of the Centre's program was received. This study done jointly by the Centre and GRDC, involved staff from most of the other commercial Participants of the Centre as well as the research providers. The Senior Management Group and the Board debated new project proposals and project priorities in time for the new budgetary cycle.
- Year 5: The economic evaluation process has now been completed, with a workshop attended by contributing scientists and the preparation by the MD of an Executive Summary for the GRDC and CRC Boards. The conclusions from the study were reported to the December Board meeting and reinforced the scientific direction of the Centre. The process for preparing the Annual Operating Plan was expanded slightly this year to give commercial Participants more chance to propose projects.

An increasing sense of ownership of management outcomes by Centre staff and participants.

- Year 1: Approval from Program Leader to Board level of the first Corporate Strategy document. Research provider participants agree to substantial reallocations of in-kind resources to facilitate Centre objectives, for example wheat breeder and Consortium personnel from NSW Agriculture and Sydney University Intellectual Property searching facilities from industrial participants. Ready acceptance of redirection of specific programs in response to Centre management (examples; sub-programs 1.3, 1.5, 2.3, 2.4, 3.1).
- Year 2: New program structure increases transparency of decision making process, by putting related projects under the same manager. Project priorities and new project proposals were debated in open forum involving most Centre secondees, and finalised by the Centre's expanded Senior Management Group. An individual economic evaluation of projects was begun.
- Year 3: The new program structure is now fully in place, which increases the transparency of decision making process, by putting related projects under the same manager (who is now provided with a deputy). Project priorities and new project proposals were debated by an expanded Senior Management Group, and finalised by the Centre's management. This process was faster than last year's, yet there were no significant problems of transparency.
- Year 4: Research providers and other Participants have shown increased commitment to achieving the in-kind budgets of the Centre. The Senior Management Group and the Board debated new project proposals and project priorities in time for the new budgetary cycle. Members of the Senior Management Group made visits to commercial Participants to present outcomes and discuss research priorities.
- Year 5: Research providers and other Participants have again shown increased commitment to achieving the in-kind budgets of the Centre, which are on track for full recovery. The economic evaluation process has now been completed, with a workshop attended by all contributing scientists. The results of this study were well received at that level. The process for preparing the Annual Operating Plan was expanded slightly this year to give commercial Participants more chance to propose new projects.
The cost effectiveness of the provision of Centre leadership and management services.

- Year 1: Management costs and staffing levels below those foreseen in Commonwealth Agreement and below 5% of overall budget.
- Year 2: Staffing levels remain as low as before, and inadequate for communication and commercialisation activities. Consideration of increased resourcing to cover these issues begun. New project structure implemented which removes two tiers from Centre management structure.
- Year 3: Management staffing has remained as last year, and communication and commercialisation activities have been dealt with as before. Plans have been made to expand staffing levels as part of QWIP (when investment is in place) without adversely affecting Centre overheads.
- Year 4: Staffing levels at head office have remained as last year, and existing staff have dealt with communication and commercialisation activities. We have had an Education and Training co-ordinator working for the full year for the first time.
- Year 5: The existing staff has dealt with all the foregoing items, and in addition prepared an application for the new Value Added Wheat CRC. The high work output of HQ staff suggests overhead costs are at the bare minimum.

The overall Centre

The strength of the Centre and the commitment of the people who are involved in it.

- Year 1: High attendance by all participants' staff at CRC workshops and meetings and support for the CRC by their Board representatives indicates strong continuing commitment to the Centre.
- Year 2: The same continues. Commercial Participants renew their commitment despite take-overs, budget cutting and management reorganisations. Research providers pledge redistributed and maintained in-kind contributions again.
- Year 3: Quantitative measures of the commitment of Participants to the Centre remain high at all levels. We have budgeted for increased in-kind contributions again, and Board, management, and program meetings continue to be well attended. Overall cash from participants is also increased, relative to the Commonwealth agreement.
- Year 4: The above measures continue to show that levels of identity and commitment remain unabated. Increased publicity through articles, newsletters, distribution of videos etc has improved the profile of the Centre in the wider community.
- Year 5: Again the measures of commitment recorded in previous years have shown that enthusiasm about the Centre is still high. Nine of the eleven Participants have expressed interest in continuing their association with the new Value Added Wheat CRC and they have been joined by new agencies in every wheat-growing state and a small high technology company.

The esteem with which the CRC for Quality Wheat Products and Processes is held nationally and internationally.

- Year 1: Renewed interest in participating in CRC programs has been expressed by a number of research providers in States not currently taking part (Victoria, Queensland).
- Year 2: Above organisations now working in Centre projects. The CRC and GRDC secretariats encourage the Centre to work closely with other CRC's on projects that they sponsor. Overseas companies, research organisations and scientists express interest in collaboration with the Centre.
- Year 3: We initiated closer collaborations with the CRCs for Molecular Plant Breeding and International Food Manufacture and Packaging Science, and have received initial inquiries about research collaboration from three multinational companies (Europe and United States-based).

Year 4: Contracts for research collaboration have been signed with an United States-based multinational. New research programs have been developed or have been started with the non-Participant States (Queensland, Victoria and South Australia). The Managing Director has been appointed to the Industry Advisory Committee of the CRC for Molecular Plant Breeding. The Managing Director was invited to address the GRDC-sponsored "Research Horizons for Grain Policy Leaders" course, the GCA/GRDC conference "Progressing Grain Crop Improvement for a New Millennium" and the South Australian Field Crops Development Board. Farmer groups around the country are seeking closer interaction with the Centre.

Year 5: We now have new projects running in all wheat-growing states and each Department of Agriculture has requested to be a Participant in the re-bid to the Commonwealth for a new seven-year term. Our WheateRite® and Great Grain activities and new germplasm has promoted a wider recognition of the Centre's activities, especially amongst growers. Overseas, the importance of the Centre was acknowledged at a recent Gluten workshop in Bristol, UK, at which a high proportion of the invited papers were from Centre secondees, and the Managing Director was invited to sum up the proceedings. We have active WheateRite® distributors in the United States and France, and ongoing research and development agreements with commercial and research groups in the United States, Mexico and Hungary. Our editorial input has been requested for several external publications.

The improved capacity of the wheat and related food industries to produce products of specific quality and increased value for domestic and international markets.

- Year 2: Specific quality germplasm and genes identified and means for introducing them into varieties rapidly established. Development of prototypes of the rain damage kit and the oven probe. CRC activities in commercial bakeries are beginning to provide management aids to process control (sub-program 1.7).
- Year 3: We have continued development of the rain-damage kit to a simple credit-card format. The uptake, by Australian and overseas wheat breeders, of our diagnostic test (for the rye chromosome translocation “1B/1R”) has been good. We have seen some further progress towards the commercialisation of the oven probe, and marked development of process control concepts and diagnostic services to reduce costs in Partners' bakeries. One commercial Participant in setting up a new oven installation used our science. We developed plans for launching new wheats with improved properties in the period 2000-2005. In terms of grower benefits these projects mean better quality wheats for specific products, such as noodles, biscuits etc., reduced risk of rain damage.
- Year 4: Again there has been a continuation of the previous examples, and a raft of new ones, the following being typical. Despite adverse climatic conditions AWB Ltd and growers continued to support the development of the "Prime Hard in the South" concept. The program of grower-oriented training courses and the quality assurance program was expanded. Our quality assurance system was developed with others into a pilot "Great Grain" program that was evaluated by leading growers. Evaluation of a larger sample of "waxy" wheat was conducted by Participants in the CRC and by non-Participant companies. This provided evidence of new processing benefits to be derived from this type of product and its potential as an ingredient in the creation of novel foods. The number of diagnostic tests (for the rye chromosome translocation “1B/1R”) supplied to Australian and overseas wheat breeders rose to nearly 9000. The WheateRite rain-damage test kit was evaluated successfully and extensively by growers throughout the country and also used by breeders to detect germplasm showing the "late maturity α-amylase" defect. Cost reductions from the use of our process control hardware and software in one bakery were estimated as a $30,000 per annum reduction in product waste and a $45,000 per annum reduction in product giveaway.
Year 5: The examples from previous years have continued to increase in importance. This year deliveries of 300,000 tonnes of Prime Hard wheat were made in the southern wheat belt - representing an increase of >$9M in the income of growers. The number of diagnostic kits provided to wheat breeders in Australia and Mexico has risen to more than eighteen thousand. WheatRite® was sold for the first time and a single grower reported $40,000 improvement in earnings as a result of its use. The extent to which industry supported research in the Centre is integrated with education and the extent to which project material is used in teaching and training.

Year 1: Sub-program 2.6 and related work are producing data which will be directly applied to the grower education parts of program 3 (3.1).

Year 2: In the program's reorganisation, all education and training projects are co-managed with the scientific work of the Centre (in new Programs 2, 4 and 5).

Year 3: There has been progress especially with the outcomes from the QA work and the Prime Hard in the South project, in establishing specific programs to transfer the technology to the users as part of the Education and Training function.

Year 4: New or extended initiatives have included a workshop, convened by Daryl Mares, "Late Maturity α-amylase in Wheat", to report on his study of Australian breeding material (August 1998 - Program 1). Senior representatives attended this from all the Australian Wheat Breeding programs. In March 1999, the workshop, "Tools for Achieving Wheat Quality Targets", was used to promulgate major outcomes of Program 2 to all Participants' staff. The Centre co-supported (with Topcrop Australia) the "Managing Wheat for Quality" and "Nitrogen Management for Wheat,..." guidelines materials produced by SARDI for farmers in South Australia. We also supported (with Participants and fertiliser distributors) "Increasing Grain Protein in Southern Crops with Topdressed Nitrogen" – a brochure for growers in the Northern part of the Southern wheat belt. Our quality assurance system was developed with others into a pilot "Great Grain" program that is being evaluated with others through the research program.

Year 5: The Education and Training manager ensures that outputs from the scientific work of the Centre are integrated in publications and workshops produced. Examples this year have been as follows: Over 230 copies of the "Managing On-Farm Grain Storage" CD-ROM, which includes CRC grain storage outcomes and references to the QA program, have been sold and the CD was highlighted across the country at GRDC farm adviser updates by a network of advisers. TopActive modules on grain hygiene and storage have been designed, which will use the CD as a resource. We have also provided market quality and food safety/QA material to TopCrop, TopActive and TopCrop are proving ideal vehicles for targeting quality training to growers. Great Grain is being marketed and well over 100 growers have signed up for the program in its first year. One and two day wheat quality/market awareness courses were held in five locations. The latest QWCRC newsletters and receival quality fact sheets, regularly updated to include current CRC outcomes, were supplied on these courses. WheatRite®, Great Grain QA, and wheat quality, nitrogen management and Prime Hard wheat production booklets and the grain storage CD are promoted. Postgraduate research projects are fully integrated through the research program.

The extent to which the Centre is keeping pace with or, indeed, leading international scientific and technological progress.

Year 1: The majority of sub-programs in the Centre appear to have few, if any national or international competitors and are thus largely "front-runners". Equivalent programs exist in other countries corresponding to sub-programs 1.1 and 2.1 and 2.3 but they are not focussed on Australian Wheat.

Year 2: The following new or developing collaborations with international groups indicate our level of international competitiveness: Work with European based scientists on dough protein components; agreement with a Japanese machinery manufacturer to install an instrument in the BRI Australia Pilot Mill; negotiations with a European machinery manufacturer about a joint project to develop new equipment; supply immunoassay-based test-kits to CIMMYT, Mexico City for use in early breeding lines; research agreement with the Hungarian Institute for R&D to build a small-scale mixing machine; visit of Professor Z Plaut, Volcani Institute, Israel. Also, Crop and Food International increased its in-kind commitment as a participant in the Centre.

Year 3: Nearly all of the above collaborations have all been developed during the year and they have been augmented by interest from European and USA-based agribusiness multinationals with high levels of wheat quality scientific work and expertise. Two of these have commenced negotiations for specific research collaborations with Quality Wheat CRC Ltd.

Year 4: Actual research programs are now well established with agencies in the United States (Monsanto), Mexico (CIMMYT) and Hungary (OMFB). Expressions of interest in the rain-damage test kit have been received from several countries in all the wheat-exporting continents.

Year 5: The importance of the Centre was acknowledged at a recent Gluten workshop in Bristol, UK, at which a high proportion of the invited papers were from Centre secondees, and the Managing Director was invited to sum up the proceedings. We have active WheatRite® distributors in the United States and France, and on-going research and development agreements with commercial and research groups in the United States, Mexico and Hungary initiated last year. We have obtained the Supporting Participation of a Europe-based multinational (Aventis) for the application to the Commonwealth for a renewal of the CRC grant.
DIRECTOR'S DECLARATION
In accordance with a resolution of the directors of Quality Wheat CRC Limited, we state that:

1. In the opinion of the directors:
   (a) the financial statements and notes of the company and the consolidated entity are in accordance with the Corporations Law, including:
      (i) giving a true and fair view of the company's and consolidated entity's financial position as at 30 June 2000 and their performance for the year ended on that date; and
      (ii) complying with Accounting Standards and Corporations Regulations; and
   (b) there are reasonable grounds to believe that the company will be able to pay its debt as and when they become due and payable.

On behalf of the board

Dr W Rathmell
Director

Sydney, August 2000

TO THE MEMBERS OF QUALITY WHEAT CRC LIMITED

SCOPE
We have audited the financial report of Quality Wheat CRC Limited for the financial year ended 30th June 2000, as set out on pages 4 to 16 including the Directors' Declaration. The financial report includes the financial statements of Quality Wheat CRC Limited, and the consolidated financial statements of the consolidated entity comprising the company and the entities it controlled at year's end or from time to time during the financial year. The company directors are responsible for the financial report. We have conducted an independent audit of the financial report in order to express an opinion on it to the members of the company.

Our audit has been conducted in accordance with Australian Auditing Standards to provide reasonable assurance whether the financial report is free of material misstatement. Our procedures included examination, on a test basis of evidence supporting the amounts and other disclosures in the financial report, and the evaluation of accounting policies and significant accounting estimates. These procedures have been undertaken to form an opinion whether, in all material respects, the financial report is presented fairly in accordance with Accounting Standards other mandatory professional reporting requirements and statutory requirements, so as to present a view which is consistent with our understanding of the company and the consolidated entity's financial position and performance as represented by the results of their operations and their cash flows.

The audit opinion expressed in this report has been formed on the above basis.

AUDIT OPINION
In our opinion, the financial report of Quality Wheat CRC Limited is in accordance with:

(a) the Corporations Law including:
   (i) giving a true and fair view of the company and consolidated entity's financial position as at 30 June 2000 and of their performance for the year ended on that date; and
   (ii) complying with Accounting Standards and the Corporations Regulations; and
(b) other mandatory professional reporting requirements.

Ernst & Young

N Wykes
Partner

Sydney, August 2000
AUDITORS REPORT TO:

THE COOPERATIVE RESEARCH CENTRES SECRETARIAT DEPARTMENT OF INDUSTRY, SCIENCE AND TOURISM REPRESENTING THE COMMONWEALTH IN RESPECT OF

THE COOPERATIVE RESEARCH CENTRE FOR QUALITY WHEAT PRODUCTS AND PROCESSES

FINANCIAL INFORMATION FOR THE YEAR ENDED 30 JUNE 2000

SCOPE
We have audited the financial information of The Cooperative Research Centre for Quality Wheat Products and Processes as set out in Tables 1 to 3 of the Annual Report for the year ended 30 June 2000 as required by clause 14(1)(f) of the Commonwealth Agreement. The parties to the Cooperative Research Centre are responsible for the preparation and presentation of the financial information. We have conducted an independent audit of the financial information in order to express an opinion on it to the Commonwealth.

Our audit has been conducted in accordance with Australian Auditing Standards to provide reasonable assurance as to whether the financial information is free of material misstatement. Our procedures include examination, on a test basis, of evidence supporting the amounts and other disclosures in the financial information, and the evaluation of accounting policies and significant accounting estimates. These procedures have been undertaken to form an opinion as to whether in all material respects, the financial information is presented fairly in accordance with Australian accounting concepts and standards and requirements of the Commonwealth Agreement so as to present a view of the sources of funding and the application of funding of the Cooperative Research Centre for Quality Wheat Products and Processes and the application of which is consistent with our understanding of its financial activities during the year and its financial position.

While we have not performed any audit procedures upon the estimates for the next period and do not express any opinion thereon, we ascertained that they have been formally approved by Cooperative Research Centres Committee as required under the Joint Venture Agreement.

AUDIT OPINION
In our opinion, the financial information presented in Tables 1 to 3 present fairly the sources of funding, the application of funding and the financial position of the Cooperative Research Centre for Quality Wheat Products and Processes for the year ended 30 June 2000 in accordance with Australian accounting concepts and applicable Accounting Standards, the CRC Secretariat’s Guidelines for Auditors, and the requirements of the Commonwealth Agreement in terms of Clauses 4 (Contributions) 5(1), 5(2), 5(3) (Application of Grant and Contributions), 9(1), 9(5) (Intellectual Property) and 12(2) (Financial Provisions).

1. The multipliers adopted by the Centre to value in-kind contributions other than salary costs have a sound and reasonable basis and each partner’s component of the Researcher’s Contributions for the period under report have not been provided at least to the value for that period committed in the budget as specified in the Agreement. These details are listed at Table 1 of the financial report.

2. The Grant and the Researcher’s Contributions for the Activities of the Centre and in my professional opinion there appear to be no material reporting irregularities (Clause 5(1)).

3. The Researcher’s allocations of the budgetary resources between Heads of Expenditure has not been lower or higher than the allocation in the budget by $100,000 or 20% (whichever is the greater amount) without prior approval by the Commonwealth (Clause 5(2)).

4. Capital Items acquired from the Grant and Researcher’s Contributions are vested as provided in the Joint Venture Agreement (Clause 5(3)).

5. A statement signed by the Managing Director, to the effect that Intellectual Property in all Contract Material is vested as provided in the Joint Venture Agreement and no Intellectual property has been assigned or licensed without the prior approval of the Commonwealth (Clause 9(1), 9(5)) has been seen by the Auditor.

6. Proper accounting standards and controls have been exercised in respect of the Grant and Researcher’s Contributions and income and expenditure in relation to the Activities of the Centre have been recorded separately from other transactions of the Researcher. (Clause 12(2).
WHEAT RITE®
Rapid test for on-the-spot assessment of weather damage to wheat

Rain at harvest seriously affects the quality of grain. Weather-damaged (pre-harvest sprouted) wheat has a significantly lower market value because bread products have poor colour, loaf structure, volume and crumb texture while noodles have poor colour and cooking characteristics.

The WheatRite® test enables more accurate grading of crops. For instance, grain can be tested from different paddocks and parts of paddocks allowing damaged grain to be harvested separately from better grain, thus avoiding losses from the costly down-grading of the whole crop.

The test is entirely portable and can be performed in the field. No high-tech equipment or special training is required and the result is storable.

READ RITE
Reads the WheatRite® test card in seconds

Developed to read the WheatRite test card, ReadRite, a portable (weighing less than 1kg) instrument reads the test and delivers the result literally in seconds. Validation of results is even easier when the instrument is interfaced with a computer and printer, allowing a permanent record of results to be kept.

GREAT GRAIN
Single on-farm QA program will help Australian farmers meet market demand for best quality grain

The revolutionary single on-farm quality assurance (QA) system called Great Grain has received wide support from progressive Australian farmers, marketers and exporters. Great Grain is a quality management program, combining agreed quality standards with independent verification. It allows growers of cereals, pulses and oilseeds to demonstrate to customers and consumers that they are producing crops safely and responsibly. It is based on internationally accepted HACCP principles (Hazard Analysis Critical Control Points), recognised as the best approach to ensuring food safety. The program can be individually "tailored" to suit different farms whilst at the same time meeting defined criteria to ensure it has market-place accreditation. Grain that is Great Grain accredited will have better acceptance because producers will be able to provide customers with evidence that they are buying the best product available.
Z-ARM MIXER
Micro laboratory instrument enables early assessment of wheat breeding lines

The QWCRC “Z-arm Mixer” project has been a successful collaboration between the Technical University of Budapest (TUB), the commercial company INTER-LABOR, and CSIRO Plant Industry. The TUB have been manufacturers of large-scale recording mixers for the East European market for nearly seventy years. This project combines their technical know-how in Z-arm mixers with CSIRO Plant Industry’s experience in small-scale instrument design.

One of the most important things about this new small-scale mixer is its requirement for just 4 grams of flour, compared to 50-300 grams required for conventional Z-arm machines. This is a significant breakthrough, as it permits testing of early generation progeny from wheat breeding programs, while still leaving enough grain for growing on.

MANAGING ON FARM GRAIN STORAGE
Effective practices for the delivery of quality assured products

This CD, a resource for grain growers, agricultural colleges and extension staff, deals with the gamut of methods and decisions confronting growers who store their own grain. Topics range from receival standards, storage structures, pest identification and control alternatives, to inspection and sampling, grain hygiene and aeration, on-farm safety, grain quality management on-farm, market requirements and storage economics. It also gathers together lists of industry contacts, QA programs and regulatory information, to make things as smooth as possible for interested growers. Updates and useful internet sites are available by hotlink. Workshops on selected topics are currently being developed. The CD is available through Graintec Pty Ltd. (ph 07 4638 7677), Rural Connect (ph 1800 110 044) and Tocal College (ph 1800 025 520).

GRAIN GLOSS
An electronic glossary of terms used in grain science and technology

CD ROM technology has also been captured to fill a need for better understanding of the terms used in the grains industry. The CD contains definitions and explanations of over 4,000 words. Listed alphabetically, the terms in the glossary include virtually everything likely to be encountered in the grain-processing industry anywhere in the English-speaking world, plus terms from many other languages. Words included range from the latest scientific terms to the everyday and ancient.