Quality Wheat CRC Ltd  
Program Review for Industry  

Monday - 19 October 1998  

Venue: BRI Australia  

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Executive Summary
C. Johnson

Quality Wheat CRC research was reviewed for Industry Participants in a workshop setting. Discussion was invited after each presentation, and further comments arising from the information presented in this booklet would be welcomed by QWCRC.
Microbiology and the Flour Milling Process

Ailsa Hocking reviewed the results of an extensive microbiological sampling study of mills, 2 in Qld, 3 in NSW, 2 in Vic. and 1 in WA. The aim is to provide industry with guidelines to enable them to set their specifications on the microbial burden of incoming grain and mill hygiene.

Five rounds of sampling have now been completed. This represents >400 samples analysed. Of the gamut of tests performed (see attached overheads), the standard plate count, Bacillus spp., coliform and mould counts were presented in this meeting.

In the standard plate count, bran, germ and pollard fractions from the outer layers of the grain gave highest counts, while flour and semolina were much cleaner.

In contrast, for Bacillus spp., which has robust spores, counts were still present in flour, though there were more counts in exterior fractions.

Coliform and mould distribution were less predictable, and gave an indication of hygiene in the mill. The types of mould found at the end of the process were different from the input types, and came from the conditioners and break rollers. Coliforms were more likely to have come from bird droppings on incoming grain and rodents than from the conditioning water supply.

Counts were of the order of $10^2$ cfu/g, which is acceptable, being well below the $10^3$-$10^4$ range where concern arises. Australian flour is cleaner in this regard than European flour.

Discussion:

For removal of bacteria and moulds from the outer surfaces of incoming grain, physical methods such as scouring and debranning are the only realistic ways. UV is unlikely to be effective, as it needs a smooth surface.

Although it would be logistically difficult to study the effect of the conditioning water, this may be informative. Hygiene and maintenance of conditioning bins is conducive to buildup of microbial burden. Ventilation is critical.

Heating of wheatgerm can be effective, but again, hygiene in downstream steps is critical.

Industry representatives want to know how to set realistic specifications, what the risks are, and how to deal with them. AWB does not currently emphasise microbial load on grain. For the Japanese market, where specifications are high, flours are low ash, and consequently contain less of the outer layer of the wheat where the bulk of the bioburden resides. Mycotoxins are not a particular problem in Australia. This issue is best addressed through a HACCP plan. It would be useful to obtain some Alternaria samples from the current wet season in S.Qld, and store them for analysis when funding can be found. AWB expressed interest in this.
Key points: Mill Microbiology

- Competition: Campden Chorleywood
- Input / Modifications:
  - Enhance: Effect of conditioning water
  - Comparisons with other food products. Help to set realistic specifications
  - Counts after baking (Pilot milling extension)
  - Flour storage, part, bagged flour
  - Ways to reduce counts prior to milling:
    - Heat, Scouring, Chloride washing, Debranning
- Decrease
- Relevance: Plans to extend research? – e.g. “harvest quality service”
- Opportunities: Similar research re. mycotoxins- best addressed in HACCP plan?
  - 1998 “odd” season: our research should take advantage – AWB Ltd could do at Werribee
- Applications:
- Outcomes: Recommendations for specifications
  - See last transparency from presentation.
- Benefits:
- Company specific applications: AWB Ltd applications? – Not to date
  - Microbiological specifications for export flours

Recommendations:
- use an abrasive cleaning method to remove Bacillus spp. from incoming grain
- avoid use of grain contaminated with rope mould, as spores carry through the whole process
- improve mill hygiene at the conditioning bins by adequate aeration
- attention could be paid to surface properties of conditioning bin lining to minimise buildup of mould, possibly borrowing from GMP in cleanroom facilities (Warm, smooth, surfaces minimising condensation and pockets for buildup)
- attention at the first break stage
- Answer the question: “How does the microbial load in the end products compare with those of other food ingredients?” This would give manufacturers an accurate perspective for the interpretation of the results presented in the final report.

Actions:
It is highly likely that a 2 year extension to this project, to address points raised in discussion, would be fully supported by QWCRC Industrial Partners.

Comment added:
Rachel Johnson, of Globex International, a wholly owned subsidiary of Grainco, reported at the Australian Postharvest Technical Conference, Canberra, May 1998, how hygiene issues in the Gladstone terminal were addressed to achieve a dramatic improvement, leading to Certification Assurance. It may be valuable to borrow from this experience. (ph 07 4972 2033)
Starch quality: A/B Granule and Amylose/Amylopectin

Hon Yun reviewed studies aimed at developing systems for the manipulation of starch components of flour, and their chemical and structural characteristics and role in bread quality. Definition of the optimum starch composition, and the potential for replacing other ingredients by manipulating starch properties were two goals. Straight-run flour samples used were Batavia and Cadoux (reference), and Banks, Batavia, Hartog and Sunco from Gilgandra (GL) or Myall Vale (MV). Of these, Batavia, Cadoux and Hartog are Null 4A, while Banks and Sunco are Normal 4A. Analyses included swelling power, Do-Corder mixing property, specific volume, bread texture analysis, crumb softness and crumb springiness. Starch damage and B granule content were also presented.

Results indicated a difference in bread quality with different starch quality, and that properties other than starch damage appeared to affect bread quality. Bread quality was altered if different starch A granules were used, water absorption increased as B granule content increased, because intact granules hold water on the surface, and B granules have a larger surface area to volume ratio. The starch A:B granule ratio also affected the bread quality.

In future work, more extreme starch properties will be investigated, further texture testing performed, a biscuit baking trial done with different A:B granule ratio, and the effect of amylose/amyllopectin ratio on baking will be investigated using waxy wheat starch, maize and rice starches. (Please refer to the slides for detailed information.)

Discussion
The conflicting results on specific volume were queried. The better data came from the first experiment, but a larger sample set is required. With regard to Peter Gras’ results from last year, Ken Quail was confident of the data in this presentation as the sources of starch and the methods of granule separation are known.

DAI Suter saw future work on waxy wheat as particularly important. Questions such as the effect of 100% amyllopectin on the firmness / crumb softness / springiness / staling of bread should be resolved, and it is important that this work should continue. There is likely to be 0.5–1 tonne of waxy wheat available this season to be divided among Participants for processing evaluation.

Fred Stoddard will have gram quantities of material from a doubled haploid cross available in a few months, and samples this time (Oct.) next year. Lindsay O’Brien has near isogenics uniform for HMW background, with variable null.

DAI Suter queried staling etc from an Industry standpoint: What are the levels, how reliable is the effect, and can you get the same effect with cheaper ingredients? These are the questions to be answered for a realistic appraisal of utility.
Key points: Starch Quality

- Competition
  : Michigan State University, Washington State University (commercial quantities of waxy wheat), University of Nebraska, Japan – Hirano’s studies

- Input / Modifications
  - Enhance
    : Investment in CRC research. Waxy wheats, particularly with respect to staling. Discussion among participants as to who does what with '98 ½-1 tonne -What happens with longer fermentation? -F. Stoddard has samples with 10-30% A:B granule range (from single cross)
  - Decrease
  - Relevance
  - Opportunities

- Applications
  - Outcomes
    : When questions as to staling, technical performance, have been answered definitively
  - Benefits
    : benefits packaged in the raw material

- Company specific applications

Actions:
- Coordinate/discuss among Participants as to who does what, and how with 1998 harvest of waxy wheat.
- The project needs a definitive answer to the question whether waxy wheats, in appropriate backgrounds, will increase or decrease staling in baked products.

Note added:
Experiments on pea flour by Lakshmi Iyer, Agrifood Technology, reported at the Cereal Chemistry Conference in Cairns, August 1998, indicated its utility in circumstances similar to waxy wheat flour. This should be noted as a competitor product.
Frozen dough: accelerated storage

Ken Quail discussed the advantages of frozen dough for central and remote production, so that few skills and little space were required at bakcoff, such as at in-store bakeries. In the US, the turnaround time is only about a week, while in Australia, a shelf life of 4-6 months is required. This poses problems, which are the project aims: to extend shelf life, to develop a rapid test to evaluate shelf life, and to develop a help system to support manufacturers.

Discussion addressed what this work is adding to what is already on the market. Opportunities exist with pre-proofed croissants. The antifreeze protein needs to be assessed either way. In general, there was little interest from Participants.

This being the case, it may be better to go further afield, eg. To approach Sara Lee, DeliFrance, supermarkets, or Baker’s Delight. Other opportunities could exist at convenience stores and petrol stations. Cookie dough is another major growth area, while rolls of frozen bread dough are currently available.

One advantage of frozen dough is minimising space constraints. Opportunities may exist in Asian pan breads in the first instance. Experiments to date have been done on Western formulations of dough.

Key Points: Frozen Dough / Accelerated Storage

- Competition
- Input / Modifications
  - Enhance: Potential of antifreeze protein needs to be proven
  - Decrease: Project runs till July '99
  - Relevance: Canvas utility further afield to non-CRC members?
- Opportunities: Similar research re. mycotoxins- best addressed in HACCP plan?
- Applications
- Outcomes
- Benefits

- Company specific applications: Markets – consumer, retail
  What do industrial participants want now?

Action:
- We need to go to industry and see who wants to use the results of frozen dough research.
Dough Mixing / Dough Sheeting

Nigel Larsen reviewed recent progress in the commercial use of measures of dough development, such as power consumption, for process control. He designed his experimental strategy using Plackett-Burman mathematics to reduce the number of tests to be run from 64 (2^6) to 16 (8 duplicate runs) for 6 variables. Variables included flour strength, water, improver, yeast, salt and oil levels. Results on external and internal features of the loaves were assessed. Regression analysis was carried out to find variables with significant effects at P<10%. The size of each statistically significant effect was calculated. Experience with the system must still be called into play to interpret results correctly, especially when there are confounding effects (such as the yeast response noted) when using a statistical approach. Plackett-Burman experiments provide a means of screening to identify which variables should be studied in more detail.

The largest effect on dough development was due to water, with flour, yeast and salt also significant. Water was the only variable that affected power consumption. Effects on colour were also assessed. L-b* was significantly affected by all variables except water, and was more “responsive” than L or b* readings alone.

The original project ran from July 1995 – June 1998, but with the renewed FFfRST contract, will run 4 – 6 years. It is linked with rheological studies in Project 3.4.4 (Rheology of yeasted doughs) and 5.1.3 (Small-scale, fundamental mixing/rheology) research at the University of Sydney, and will include sheeting, a component of bakery make-up plant processes. A customised dough sheeter will be used. It has adjustable roll gaps (1-30 mm), sheet thickness measurement, variable roll speeds (2-200 rpm), interchangeable rolls (roll diameters 40-270 mm), load cells to measure separation forces between rolls and torque on each roll, and computer interfacing for control and recording measurements.

Discussion:
The length of the sheeting rolls will be 600 mm. They are reversible, though that is incidental to the intent of the experiment. This technology could be sold on to the rubber and metal industries, as the process is similar. We could investigate relationships with, and similarities to APV’s Supermoulder. Sheeting development is very much more efficient. In Asia, there are mixers with rollers inside the mixing bowl. There was interest in the detail, such as pressure board length, etc. Different manufacturers have different methods of moulding, and a study comparing these methods in terms of energy input to dough would be useful.
Key Points: Mixing / Sheeting

- Competition
  - APV's "Supermoulder"
  - Asian mixers with rolls inside

- Input / Modifications
  - Enhance
    - Different methods of rolling up dough in moulders
    - Length of pressure board and effects in moulders
  - Decrease
  - Relevance
  - Opportunities

- Applications
  - Outcomes
    - Benefits

- Company specific applications

Action:
- Discussion on applications within specific companies, and their specific research requirements, is needed.
Oven Technology to Optimise Product Quality and Improve Efficiency

Thomas Adamczak presented a very impressive demonstration of on-line oven monitoring systems for crust colour and height display, weight loss, and humidity, and the integrated control and optimisation system.

The system allows the user to zoom in from a graph on any region of interest, to examine trends, parameters, loaf appearance, crumb structure etc. at that point. Digital cameras and scanners set up at appropriate points in the production process provide data.

The software can be operated, and the process can be controlled, from a remote location.

Discussion:
Bread colour was measured online with this equipment, and verified with a hand-held Minolta L. Image analysis is another option, but it is costly, and the system presented is available now, with no delay. Westons are trialling the system and are very excited about it.

Thomas will shortly be making this available in CD-ROM form as a demonstration so Partners can explore its potential for their applications.

Key Points: Oven Technology

- Competition : Use of on-line colour meters for biscuits
  IFM CRC

- Input / Modifications
  - Enhance :
  - Decrease :
  - Relevance :

- Opportunities : Application of image analysis systems??

- Applications
  - Outcomes : (T. Adamczak)-Involve company QC people in development of sampling “plans”; development of procedures for this project

- Benefits
- Company specific applications

Action:
- (T. Adamczak)-Involve company QC people in development of sampling “plans”; development of procedures for this project.
Microbiology and the Flour Milling Process

Aisa Hocking
Quality Wheat CRC: Project 3.1.4

Microbiology and the Flour Milling Process

Project staff:

Ailsa Hocking - Project Leader (10%)
Lana Berghofer - Microbiologist (100%)
Edward Jansson - Microbiologist (10%)

Aims and purpose:

To monitor the distribution of wheat microflora through the milling process, milling products and distribution chain.

To provide the milling industry with data for guidelines for microbiological specifications for end products.
History - grew out of HACCP projects:

- Lack of information about microbiological status of various mill fractions and quality of end products
- Need for microbiological criteria for CCPs
- Need for better information about microbiological quality attainable for products, particularly for export customers

Methods:

- Rely on co-operation and collaboration with milling companies: GFBM, Weston Milling, Bunge Defiance
- Regular sampling of 8 mills: Qld (2), NSW (3), Vic (2), WA (1) - nine – ten week cycle
- Samples from wheat at intake, through to end products: 10-12 samples per mill
- BRI Pilot mill for intensive sampling of streams from downgraded wheat
Microbiological testing:

- Standard plate count
- Thermophilic plate count
- Coliforms
- *E. coli*
- *Salmonella*
- *Bacillus* species
- *Bacillus cereus*
- Mesophilic aerobic spores
- Yeasts
- Moulds

Water activity is measured on all samples
The Project commenced in October 1997 – where are we now?

- Almost 5 rounds of mill samples have been completed

- Over 400 individual samples from 8-9 participating mills have been analysed

- Regular reports are sent to all mills, with consolidated reports for each sampling round going to all participating companies and other CRC interested parties

- No Pilot Milling studies were carried out during the first year, due to lack of suitable wheat [down-graded and good quality wheat from the same area]

- An intensive study of one mill was substituted for the Pilot Milling study this year. Over 50 samples were collected during a single milling run, from incoming wheat to final bulk product out-turn.
Results from the mill surveys
Standard Plate Count

Mill A

Mill B

Mill D

Sample site

Round 1  Round 2  Round 3  Round 4  Round 5

Sample site

Round 1  Round 2  Round 3  Round 4  Round 5

Sample site

Round 1  Round 2  Round 3  Round 4
Results from the mill surveys

*Bacillus* species

**Mill A**

**Mill B**

**Mill D**
Results from the mill surveys
Mount counts

Mill A

Mill B

Mill D

Sample site

Round 1 — Round 2 — Round 3 — Round 4 — Round 5
Microbiological status of end products – Standard Plate Count

Flour

Wheatgerm

Bran
Microbiological status of end products – *Bacillus* species

**Flour**

**Wheatgerm**

**Bran**
Microbiological status of end products – Coliforms

Flour

Wheatgerm

Bran
Microbiological status of end products – Mould counts

Flour

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Wheatgerm

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<td>3</td>
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Bran

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The coming year:

- Continue sampling from the mills during the 1998-99 harvest
- BRI Pilot Milling – comparison of top quality and downgraded wheat
- Intensive sampling from another mill?

Outcomes:

- Better understanding of factors contributing to microbiological status of products:
  - quality of incoming grain
  - contribution from existing mill microflora
  - mill hygiene
- Data for microbiological specifications for end products
Starch quality: A/B Granule and Amylose/Amylopectin

Hon Yun & Ken Quail
Starch quality: A/B Granule and Amylose/Amylopectin

Hon Yun & Ken Quail

Aims

- To develop systems for the manipulation of the starch components of flour
- To investigate chemical and structural characteristics of starch components during bread making procedures and to define the role of starch in its components for bread quality
- To define the optimum starch composition for bread quality
- To examine the potential of replacing other ingredients by manipulating starch properties

Contents

- Parent flour
  - Physico-chemical properties
  - Baking quality
- Prime starch reconstituted flour
  - Mixture of Batavia gluten, water soluble and tailing starch with 10 different prime starches
- Prime starch granule reconstituted flour
  - Varietal difference between Banks and Hartog
  - A granule 100%, 50%, 0% baking trial

Flour Samples (Straight-Run)

- Reference: Batavia, Cadoux
- Gilgandra (GL): Banks, Batavia, Hartog, Sunco
- Myall Vale (MV): Banks, Batavia, Hartog, Sunco

Range of Chemical Properties

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<th>Min</th>
<th>Max</th>
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<tr>
<td>Protein Content</td>
<td>9%</td>
<td>13.3%</td>
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<tr>
<td>Amylose Content</td>
<td>18.9%</td>
<td>25.1%</td>
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<tr>
<td>Starch Damage</td>
<td>5.2%</td>
<td>9%</td>
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Granule Bound Starch Synthase 4A Gene Status

- Null 4A (6 samples)
  - Batavia, Cadoux
  - Batavia GL & MV
  - Hartog GL & MV
- Normal 4A (4 samples)
  - Banks GL & MV
  - Sunco GL & MV
Swelling Power

Baking Condition
- 40g flour (14% mb)
- 1g yeast, 0.8g salt, 0.4g improver
- Mixing at 100rpm in Do-Corder
- 5 min floor resting
- Dough make-up
- 1h proofing (35°C, 85% RH)
- Baking at 240 °C for 12min under tin

Do-Corder Mixing Property

Specific Volume

Bread Texture Analysis

Crumb Softness
Crumb Springiness

Flour Separation
- Gluten
- Water-Solubles
- Starch
  - Prime Starch
  - Tailing Starch

Prime Starch Property

Starch Damage

B granule Content

Swelling Power
Prime Starch Reconstituted Flour
With Batavia gluten, water solubles and tailing starch

Do-Corder Mixing Property

Prime Starch Reconstituted Bread

Bread Structure of Batavia

Batavia Base and Banks Prime Starch

- GL
- MV
Crumb Softness (24hrs)

Crumb Springiness

Specific Volume

Correlation between Starch Damage and Springiness

Starch Granule Reconstituted Flour

RVA Peak Viscosity
Swelling Power

Starch B Granule Effect on Baking

Do-Corder Mixing Property

Granule Reconstituted Bread

Batavia Base and Batavia Prime Starch
- 100% A
- 50%A+50%B
- 100% B

Specific Volume
Specific Volume

Crumb Softness

Crumb Springiness

Results

- Difference in bread quality with different starch quality
- Starch properties other than starch damage appear to affect bread quality
- Different bread quality from different starch A granule
- Water absorption increases as B granule content increases
- Starch granule A to B ratio affects bread quality

Future Work

- More extreme starch properties
- Further texture test with square loaf bread
- Biscuit baking trial with different A/B granule ratio
- Amylose/amylopectin ratio effect on baking (waxy wheat starch, maize and rice starches)
Frozen Dough Technology

Ken Quail, Steven Zounis, Rob Solomon
Frozen dough technology
Ken Quail, BRI Australia, Wheat CRC
Steven Zounis, PhD Wheat CRC
Rob Solomon, CSIRO, Wheat CRC

Frozen doughs
- Why frozen dough
- Aims
- Frozen dough background
- Rapid storage test
- New tests (Steven Zounis)
- Improvement in shelf life
- Croissants
- Future work

Advantages of frozen dough
- Central production
- Remote production
- Few skills required at bake off
- Less space required at bake off

U.S. Market
- Up to 11 Billion dollars in 1997
- Entry of
  - Pillsbury
  - Heinz
  - Unilever
- Instore bakeries 48% of production

Limitations
- Frozen shelf-life
- Product range
- Cost
- Quality

Yeast
- Intracellular ice
- Solution effects
- Freeze rate
- Storage
Gluten/cell structure

- Ice crystal damage
- Water migration
- Reducing compounds

Processing frozen doughs

- Mix
- Mould
- Freeze
- Store
- Thaw
- Proof
- Bake

CRC Project aims

- To develop a rapid test to evaluate the shelf life of frozen dough products.
- To extend the shelf life of fermented and baked frozen dough products
- To develop a help system to support production of frozen doughs

Loss of shelf life: loaf volume

Loss of shelf life: fermentograph (first hour)

Loss of shelf life: percent
Rapid storage test: Freeze-thaw cycles

- Speeds up moisture migration
- Promotes ice crystal growth

Microwave treatment

Cycle conditions 8hrs -5 C

Cycle conditions 15hrs -5 C

Cycle 3 temps x 3 times

Const vs Cycle

<table>
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<th>Constant</th>
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<tbody>
<tr>
<td>Loaf1</td>
<td>-2.4x + 94</td>
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<tr>
<td></td>
<td>2.3x + 95</td>
</tr>
<tr>
<td>Fer1</td>
<td>-1.8x + 94</td>
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<tr>
<td></td>
<td>-1.6x + 95</td>
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<tr>
<td>Loaf2</td>
<td>-1.2x + 92</td>
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<tr>
<td></td>
<td>1.3x + 94</td>
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Steven Zounis PhD project

- Developing tools that better describe the events during frozen dough storage.
- Dough rheology
- Microscopy
- Protein (depolymerisation)

Plate 1. Dough stored for 1 day @ -20°C. Porous structure with uniform size voids. Continuous gluten network. Starch granules are firmly attached to gluten strands.

Plate 2. Stored for 10 weeks @ -20°C with 8 thaw-freeze cycles. Larger angular voids are present which may represent ice-crystals. Starch granules have become detached from the gluten structure.

Frozen doughs

- Why frozen dough
- Aims
- Frozen dough background
- Rapid storage test
- New tests (Steven Zounis)
- Improvement in shelf life
- Croissants
- Future work
Improvement of shelf life

- Dough mixing
  - dough development
  - dough temp
- Yeast level
  - chemical leavening
- Anti freeze protein
- Additional ingredients

Dough development

- Full dough development is required, this takes considerably longer to achieve at low temperatures.
- For 2 mix times, the rapid test confirmed the effect of mixing with 3 mixing treatments (TTP - 40%, TTP -20% and TTP)

Dough temperature/ mixer type

- Tweedy vs Spiral
- 30C vs 18C

Yeast level

- Loss of yeast activity is generally linear
- More

Chemical leavening

- Supplement yeast activity
  - Trial with calcium acid pyrophosphate did not work
    - not yeast friendly and reaction goes off early - pH???
  - Other leavening agents
    - Encapsulation
      - yeast
      - acid

Antifreeze protein

- CSIRO Plant industry (Rob Solomon)
  - rheology trials promising
- Baking
  - Production of quantity?
  - Purchase?
Criossants

- Benchmarking trial
  - First trial (melt down)

Future work

- Report on work to date
- Anti freeze protein baking
- Assessment of cycle test using Steven’s techniques
- Evaluation of a range of ingredients
  - Chemical leavening
  - Dough conditioning
Processing Wheat and Wheat Products

Di Miskelly & Nigel Larsen
PROGRAM 3

Processing Wheat and Wheat Products

Program 3A
Milling    Di Miskelly

Program 3B
Baking     Nigel Larsen

Projects
3.4.1 Mixers and make-up plant
3.4.2 Oven technology
(3.4.3 Ultrasound applications in dough mixing)
3.4.4 Rheology of yeasted doughs

5.1.3 Small-scale, fundamental mixing, rheology

We have been:

- Relating laboratory scale to industrial scale mixing
- Using monitoring systems such as load cells and power consumption for a range of mixers
- Measuring changes in dough at stages in the make-up plant
- Defining optimum baking conditions for various products
- Reducing energy costs through more efficient control of oven heat and humidity
- Using heat flux, temperature and humidity profile recorders to define best baking conditions for laboratory and industrial ovens
- Developing methods for measuring the rheological properties of yeasted doughs
3.4.1

Process measurement and control for dough mixing and make-up plants

Goal
To be able to use a laboratory system for predicting how a flour will perform in a commercial bakery and to commercially use a measure of dough development for process control

To do this
- Establish means of measuring mixing requirements in laboratory and commercial dough mixers

- Establish means of defining and comparing dough properties (microscopy etc)

- Define what is happening in laboratory mixers as dough develops

- Define what is happening in commercial mixers as dough develops

- Establish the "correlations" between the two types of mixers

- Understand what affects the make-up plant has on dough.
Recent Progress

6/97
- QWCRC Report # 2 “Comparison of industrial and laboratory dough mixers and development”.

7/97

10/97
- Program Reviews - Effects on work input in laboratory scale mixers.
- Developed PhD program for rheology of yeasted doughs (now Project 3.4.4).
- Q1 Report Lotus Notes - Variable speed mixing.

12/97
- QWCRC Report # 6 “International Baking Industry Expo '97”.

1/98
- Q2 Report Lotus Notes - Effects of make-up plant on dough properties.

4/98
- Program Reviews - Summary of work on changes to dough in make-up plant.
- Q3 Report Lotus Notes - Plackett-Burman experiments to screen variables likely to affect measurement of mixing curves.

5/98
- Mechanical Dough Developments Conference “Variable speed mixers and microscopy”.

7/98
- QWCRC Report # 15 “Bubbles in Food” Conference.
- Q4 Report Lotus Notes - “Variable speed mixers and microscopy” paper.
- Symposium on wheat proteins and dough properties “Changes to dough properties during and after mixing”.

10/98
- QWCRC Newsletter (in press) - “Bakery dough damage”.
- Program Reviews - Project 3.4.1.
Project Goal

To be able to use a laboratory system for predicting how a flour will perform in a commercial bakery and to commercially use a measure of dough development for process control.

Measurement of dough development during mixing

- Power consumption
- Dough probe
- (NIR)

Power consumption mixing curve - industrial horizontal mixer
If this type of mixing curve is used for process control, what factors effect observable/measurable changes in the mixing curves during production?

We can make a list of some likely “variables” in a production situation:

- Flour strength
- Water
- Improver
- Yeast
- Salt
- Oil

How can we experimentally screen these variables for their “effects” on mixing curves (and also on product quality)?

- $2^6 (= 64)$ trials would be needed to test all combinations of these 6 variables at 2 different levels each

- A Plackett-Burman design allows us to screen all 6 variables in an 8 run design

<table>
<thead>
<tr>
<th>Run</th>
<th>Flour</th>
<th>Water</th>
<th>Improver</th>
<th>Yeast</th>
<th>Salt</th>
<th>Oil</th>
<th>Dummy</th>
<th>Effect 1</th>
<th>Effect 2</th>
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</thead>
<tbody>
<tr>
<td>1</td>
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<td>+</td>
<td>+</td>
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</table>

Choice of + and - levels for each variable

- Eg, water + is 2% higher than optimum, - is 3% lower than optimum
Results

- External and internal features of the loaves
- Regression analysis to find variables with "statistically significant" effects
  - Choice of P<10% for "significance"
- Calculating the size of the effect of each statistically significant variable

The size of the effect of each variable is the difference between the effect at its - level and the effect at its + level.

<table>
<thead>
<tr>
<th></th>
<th>Flour</th>
<th>Water</th>
<th>Improver</th>
<th>Yeast</th>
<th>Salt</th>
<th>Oil</th>
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</thead>
<tbody>
<tr>
<td>L</td>
<td>-</td>
<td>-</td>
<td>-6.52</td>
<td>4.47</td>
<td>-</td>
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</tr>
<tr>
<td>b*</td>
<td>-</td>
<td>-</td>
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<tr>
<td>L-b*</td>
<td>-0.90</td>
<td>-</td>
<td>-6.41</td>
<td>2.71</td>
<td>-1.80</td>
<td>2.24</td>
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<td>Crumb Structure</td>
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<td>Crumb Firmness</td>
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<td>4952</td>
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<td>46277</td>
<td>-</td>
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<td>-</td>
<td>-</td>
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</tbody>
</table>

Effect of Flour on L-b* = (Effect at - level) - (Effect at + level)
= 64.348 - 65.250
= -0.902

This result means that the "weaker" flour gave lower L-b* readings for crumb colour.
<table>
<thead>
<tr>
<th>Run</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Control</td>
</tr>
<tr>
<td>2</td>
<td>Flour Strength + Water +2%</td>
</tr>
<tr>
<td></td>
<td>Yeast + 3%</td>
</tr>
<tr>
<td></td>
<td>Improver + 1%</td>
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<tr>
<td>3</td>
<td>Flour Strength + Water +2%</td>
</tr>
<tr>
<td></td>
<td>Yeast + 3%</td>
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<tr>
<td></td>
<td>Improver + 1%</td>
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<td>4</td>
<td>Flour Strength + Water +2%</td>
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<tr>
<td></td>
<td>Yeast + 3%</td>
</tr>
<tr>
<td></td>
<td>Improver + 1%</td>
</tr>
<tr>
<td>5</td>
<td>Flour Strength + Water +2%</td>
</tr>
<tr>
<td></td>
<td>Yeast + 3%</td>
</tr>
<tr>
<td></td>
<td>Improver + 1%</td>
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<tr>
<td>Control</td>
<td>Run 5</td>
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<tr>
<td>---------</td>
<td>-------</td>
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<tr>
<td>Flour Strength + Water + 3%</td>
<td>Flour Strength + Water + 3%</td>
</tr>
<tr>
<td>Improver + 1%</td>
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</tr>
<tr>
<td>Yeast + 3%</td>
<td>Salt + 1.8%</td>
</tr>
<tr>
<td>Salt + 1.8%</td>
<td>Oil + 1%</td>
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<tr>
<td>Oil + 1%</td>
<td>Gluten 0</td>
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<td>Gluten 0</td>
<td>Soya 0</td>
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<tr>
<td>Soya 0</td>
<td>Softener 0</td>
</tr>
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</table>

Plackett Burman Trials April 1998
Results (cont'd)

- Overall, L-b* was significantly affected by 5 out of the 6 variables tested and seems to be more "responsive" than L or b* readings alone.

- With the results for yeast, loaf volumes went from 69 to 97, as expected, with an increased amount of yeast.
  - This is a large difference
  - The statistical analysis says they aren't significant!
  - Further baking, varying yeast alone, confirmed a significant effect for yeast. Confounding?

- Plackett Burman experiments provide a means of screening many variables so that the possibly important ones can be picked out and experimented further with.
  - Choosing P<0.1 becomes arbitrary and should only be a guide.

- The Oshikiri dough development units were measurably affected by the changes to the flour (strong -> weaker), water (5% change), yeast (6% change) and salt (3.6% change) levels that were used in this experiment.
  - These results to be used as basis for further experiments
  - What changes in the levels of these variables have insignificant effects on dough mixing curves?
    - Bread quality results also need to be considered
  - How do these results translate to an industrial mixer?
  - EVOP design
Project 3.4.1, 1998-02

- Continuation of the major part of C&FR’s in-kind contribution to the CRC
- Funding has been obtained from the New Zealand Foundation for Research Science and Technology (FfRST)
- Original Project 3.4.1 ran from July 1995 through end of June 1998. This coincided with the finish of C&FR’s original contract with FfRST.
- C&FR re-bid the in-kind funding for the project. The renewed contract with FfRST runs 4-6 years, so will see out the CRC’s first 7 year term.

The original FfRST contract and CRC aims were to:

To define the relationships between laboratory and industrial scale measurements of dough consistency and development by:

- using monitoring systems such as power consumption and load cells suitable for a range of mixer types.
- measuring changes in dough properties at stages after mixing and relating these to product quality.

The new, modified project will integrate studies of, and comparisons with, sheeting processes in industrial bakeries:

- Linked with Project’s 3.4.4 and 5.1.3 research at the University of Sydney
- Inclusion of sheeting, a component of bakery make-up plant processes.
Project 3.4.1, 1998-02 cont’d

The aims of the new project 3.4.1 will be:

To enhance the ability of the Quality Wheat CRC’s food manufacturing partners to add value to cereal-based food products, by defining, predicting and reducing the industrial processing requirements, and improving the quality, of these foods by:

Mixing

- Defining the relationships between laboratory scale and industrial scale mixing
  - Compare bread quality from four-pieced and single-pieced doughs.
  - Assess the ability of a pilot scale, variable speed horizontal mixer to mimic dough development on a fixed speed industrial horizontal mixer.
  - Define, by microscopy, optimum dough development in a high speed industrial mixer. Compare the microscopic features of these doughs with those from a slow speed industrial mixer and a variable speed laboratory mixer.
  - Define effects of mixer scaling by comparing rheological properties and mixing behaviour of dough from at least two flours mixed on different scale lab mixers (10 g, 50 g, 125 g).
  - Define whether or not, using variable speed mixing, a small-scale laboratory mixer can produce a dough of similar chemical (HPLC profiling of HMW glutenin proteins) properties as a dough produced by a high speed and a slow speed industrial mixer.

Sheeting

- Defining how dough rheological properties affect the outcomes of sheeting processes
  - Record energy use and sheet thickness during the sheeting of at least two simple dough systems.
  - Develop a benchmark for laboratory sheeting studies by defining the rheological properties of sheeted doughs produced from two types of industrial scale mixer (a slow speed mixer and a high speed mixer).
  - For simple doughs, mixed from at least two different flours and sheeted to full dough development by repeated passes, compare energy use and dough microscopic properties with the same dough formulae developed on a variable speed laboratory-scale batch mixer.
Customized Dough Sheeter

Features:

- Adjustable roll gaps (1-30 mm)
- Sheet thickness measurement
- Variable roll speeds (2-200 rpm)
- Interchangeable rolls (range of roll diameters: 40-270 mm)
- Load cells for measuring separation forces between rolls
- Load cells for measuring torque reaction on each roll
- Computer interfacing for control and recording measurements
Oven Technology to Optimise Product Quality and Improve Efficiency

Thomas Adamczak
OVEN TECHNOLOGY TO OPTIMISE PRODUCT QUALITY AND IMPROVE EFFICIENCY

QUALITY WHEAT CRC PROJECT
PROJECT 342

THOMAS ADAMCIK
SIE AUSTRALIA LTD

PROJECT OUTLINE

- The Overview
- On-Line Crust Colour and Height Display System
- On Line Weight Loss Monitoring System
- Colour, Height And Weight Loss Control System
- Humidity Measurement and Control During Baking
- Integrated Control and Optimisation System

PROJECT OUTLINE

- An Overview
  - Introduction
    - Transition of the baking process from being an Art to being an Engineering Process involving technique and science.
    - An Example of one possible application of this project.

PROJECT OUTLINE

- Why Automatic Control and Optimisation ??

- The Overview
- On-Line Crust Colour and Height Display System
- On Line Weight Loss Monitoring System
- Colour, Height And Weight Loss Control System
- Humidity Measurement and Control During Baking
- Integrated Control and Optimisation System
Online Operation of Colour Meter

Online Crust Colour And Height Display System

- WORK INVOLVED
- BENEFITS
- CHALLENGES

Online Crust Colour And Height Display System

- WORK INVOLVED
- Development of Software
- Evaluation of Equipment for consistent measurement of colour.
- Evaluation of instrument to work in Industrial Environment
- Evaluate Sensitivity of instrument

Display Panel

Effect of Change in Oven Set Point Over Colour Meter Readings

Online Crust Colour And Height Display System

- WORK INVOLVED
- BENEFITS
- CHALLENGES
Online Crust Colour And Height Display System

- **BENEFITS**
  - Improved quality of baked products
  - Out of Spec Products could be specified

- **CHALLENGES**
  - Synchronization of Instrument for variety of baked products
  - Synchronization of Electrical Signal from the Colour and Height meter with existing Hardware

PROJECT OUTLINE

- The Overview
- On-Line Crust Colour and Height Display System
- On Line Weight Loss Monitoring System
- Colour, Height And Weight Loss Control System
- Humidity Measurement and Control During Baking
- Integrated Control and Optimisation System

Online Weight loss Monitoring System

- **WORK INVOLVED**
- BENEFITS
- CHALLENGES

- Development of Operator friendly software
  - Evaluate instrument's ability to measure consistently weight of raw and Finshed Products
  - Evaluation of instrument's ability to operate in Industrial Environment
Online Weight loss Monitoring System

- Work Involved
- Benefits
- Challenges
Online Weight loss Monitoring System

- BENEFITS
  - Improved Quality and yield of Baked Products.
  - Out of Specification can be identified and redirected.
  - Current Information on final weight and weight loss.

- CHALLENGES
  - Synchronisation of Divider weight with the weight after cooling of Baked products.
  - Synchronisation of Electrical signal from the weighing equipment with Hardware.
  - Identification of New Product Streams.

Online Weight loss Monitoring System

- WORK INVOLVED
  - BENEFITS
  - CHALLENGES

PROJECT OUTLINE

- The Overview
- On-Line Crust Colour and Height Display System
- On Line Weight Loss Monitoring System
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Colour, Height And Weight Loss Control System

- WORK INVOLVED
- BENEFITS
- CHALLENGES

- Development of new Software and Hardware capable of controlling colour, height and Weight Loss.
- Testing of the above software in industrial environment.
Control Panel

The Big Picture

Colour, Height And Weight Loss Control System

- **WORK INVOLVED**
- **BENEFITS**
- **CHALLENGES**

Colour, Height And Weight Loss Control System

- **Benefits**
  - Maximisation of throughput
  - Reduction in weight loss
  - Improvement in Quality
  - Improvement in consistency
  - Reduction in Give-Away quantities

Colour, Height And Weight Loss Control System

- **CHALLENGES**
  - Software should be capable of responding to gaps, stoppages and changes to operating conditions for various products.
PROJECT OUTLINE

- The Overview
- On-Line Crust Colour and Height Display System
- On Line Weight Loss Monitoring System
- Colour, Height And Weight Loss Control System
- Humidity Measurement and Control During Baking
- Integrated Control and Optimisation System

Humidity Measurement And Control During Baking

- WORK INVOLVED
- BENEFITS

Humidity Measurement And Control During Baking

- Work Involved
- Experimental work to determine optimum air humidity for the baking process
- Benefits
- Improvement in quality (Glaze, Stored and Text)

PROJECT OUTLINE

- The Overview
- On-Line Crust Colour and Height Display System
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Integrated Control and Optimisation System

- WORK INVOLVED
- BENEFITS
- CHALLENGES

Integrated Control and Optimisation System

- Work Involved
- Development of the Software
- Testing of the New Software
PROJECT OUTLINE

- The Overview
- On-Line Crust Colour and Height Display System
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- Colour, Height And Weight Loss Control System
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- Integrated Control and Optimisation System

The Case Study

- Underweight Bread was produced in Adelaide Bakery and it seeks assistance identifying the reason and advice to comply with the problem in the future.
- National Production Manager, based in Sydney, is assisting by use of Control and Optimisation Package, using his Computer and a modem.