QUALITY WHEAT
CRC PROJECT REPORT

Tools for Achieving Wheat-Quality Targets

Proceedings of a Wheat CRC Workshop
Held 17th March 1999

Bob Cracknell [1,2] **and Colin Wrigley** [2,3]

1. Australian Wheat Board
2. Quality Wheat CRC Limited
3. CSIRO Plant Industry

Date: March 1999

QWCRC Report No: 27
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Program for a one-day workshop on

"Tools for Achieving Wheat-Quality Targets"

held on Wednesday, 17th March, 1999, at BRI Australia, North Ryde, Sydney, to review aspects of research in Wheat CRC Program 2

Part 1. TOOLS FOR ON-FARM USE

10.0 Quality assurance on-farm
        -Di Miskelly

10.20 On-farm teaching tools: CD-ROMs, farmer groups and literature
        -Clare Johnson

10.40 Diagnostic testing on-farm: experience with the WheatRite kit
        -Russell Heywood

Part 2. "PRIME-HARD IN THE SOUTH" - THE ON-GOING STORY

11.15 The 1998/99 season, extension and up-take of management
    recommendations
        -John Oliver, Kirrily Smith and Bob Cracknell

11.45 Lessons from PH in Sth: Quality X Climate X Management
        -Helen Allen

Part 3. "FLEXIBILITY OF WHEAT USE" - THE GRDC/CRC SET OF PROJECTS

1.00	Bench-marking	-Helen Allen
	Genetic interchangeability	-John Skerritt
	Precision agriculture	-John Skerritt
	Blending - dough	-Frank Bekes
	Blending - colour	- Graham Crosbie

Discussion of integration of the 'Flexibility' projects and
plans for the remaining time of the research.

4.00   Close

**A summary of the day's presentations is provided in this booklet
in the form of the overhead films used by each speaker.**

SUMMARY

The objective of the workshop was to provide interaction between research and extension workers involved in improving grain-quality attributes, thus to maximise returns to growers and to provide better consistency of quality to processors.

The accent on this occasion was to examine recent progress within CRC Program 2 in developing various 'tools' for growers to use within the farm-management system to improve the market value of their harvest. A recent addition to the list of tools is the development of a HACCP-based approach to providing quality assurance on the farm. Di Miskelly's overheads include a list of difficult issues that must be resolved in this project. Her summary indicated that on-farm quality assurance must come inevitably, but that it will take some time for general acceptance by the farming community. During discussions, it was indicated that the cost of the QA program to the grower may be $500-1000 a year, providing accreditation and some advantage when selling grain. There is the anticipation that about 1,000 growers will start the adoption process shortly.

Clare Johnson described some of the tools that will be essential in the improvement of quality on-farm, including the nearly-completed CD-ROM to provide training in on-farm storage management. Her presentation listed a wide range of teaching tools and courses being used to provide improved quality management by growers.

A further significant tool to reduce the risk of rain at harvest is the new WheatRite test kit, described by Russell Heywood. Compared to the standard Falling Number test, the card kit avoids the expense of major equipment, it is quick and cheap, easily distributed as needed, robust, and it does not require running water or electricity. Sampling strategies to identify sound *versus* sprouted sections of a paddock before harvest hold the key to the effective use of the kits at the farm level.

In his introduction to the 'on-going story' of Prime Hard in the South, John Oliver described the anticipated production of higher-protein wheat in the various parts of southern NSW, and the recent failure to achieve these expectations due mainly to the unusual frost conditions of the past season. Specific instances of these problems were described by Kirrily Smith; some of these problems relate to the need for improved varieties better suited to the region with resistance to black point.

Bob Cracknell described commercial receivals of Prime Hard wheat following the 1997 and 1998 seasons. Although the 1998/99 harvest involved ten silos in southern NSW (double that of the previous year), the past year's receivals (20,000 tonnes) were less than those of the previous year. Nevertheless, they were very high in quality, with a better mix of varieties than previously. The Port Kembla shipments were better than those from Newcastle with respect to ash and water absorption, being very acceptable to the Japanese.

A booklet is being produced by Helen Allen and colleagues to provide information on agronomy, quality, economics and risks relevant to the growing of Prime Hard wheat. Helen also described progress in the development of new PH varieties that would be better suited to the southern region.

The workshop included a review of a set of projects, entitled 'Flexibility of Wheat Use', that were undertaken within the Wheat CRC as a result of an initiative of the Grains R&D Corporation. The first of these ('bench-marking'), described by Helen Allen, involves quality testing grain from ten sites around Australia for a range of varieties, including hard, soft and noodle wheats. Some of the recent season's samples have been frost affected. A point made in discussion was that frosted grain may produce flour that tests OK for dough properties, but not when baked.

The section of this set of projects on genetic interchangeability, presented by John Skerritt, is a follow-up to the Prime-Hard in the South work, with the aim of obtaining information about 'north-south' variation for a much wider range of genotypes than could be tested in the main field trials. Quality did not differ systematically between north and south, though there were differences between sites. John Skerritt's other project in this set relates to quality variations within a paddock, such as are relevant to 'precision agriculture'. Most significantly, there was no indication of the expected inverse relationship between grain yield and protein content.

Another potential tool for tailoring quality to market needs involves the blending of wheats (or of flours after milling). Frank Bekes presented progress towards the possibility of predicting the qualities of blends for attributes that are not linearly related, particularly dough properties. Non-linearity was most pronounced for genotypes that differed considerably in their glutenin-subunit composition. In addition, the outcome of blending is affected by the milling process. Current research is directed towards multiple-component mixtures.

Bob Cracknell presented a report about blending studies by Graham Crosbie on noodle quality, particularly relevant to product colour. Noodle colour could be predicted, based on Minolta assessment of slurries of flour samples from small-scale milling. His current research is directed towards the upgrading of low-protein noodle wheats, by blending it with other grades of wheat having higher protein contents.

In general discussions, the title of this group of projects was questioned. In preference to 'Flexibility of Wheat Use', there was support of alternatives such as 'Optimising production and utilisation' or 'Quality optimisation'. There was agreement that the collaborators there should meet (probably mid-1999) to assess the overall direction of the work, and to consider the need for any re-direction of objectives or for new initiatives resulting from current progress.

Tools for Achieving Wheat-Quality Targets

PART 1. TOOLS FOR ON-FARM USE

Quality assurance on-farm

-Di Miskelly
Goodman Fielder

National quality assurance on farm

2.2.5

Collaborators

- Nicole Kerr, AgWest
- Kirrily Smith, NSW Ag
- John Lacey
- Paul Lukins
- Greg Condon
- Peter Matthews
- Helen Allen
- John Dines, Bunge Defiance
- Di Miskelly, Goodman Fielder
- Bob Cracknell, AWB
- Clare Johnson, QWCRC
- Michael Wurst PISA

Anticipated outcomes

- qa systems
- implementation of qa by pilot growers
- qa wheat available
- trained HACCP facilitators
- increased awareness qa
- improved consistency of wheat quality
- increased returns to growers
- satisfy end user requirements
- qa paddock to plate

Activities to date

- **QFA operations and industry consultation - issues papers developed**
- **Wagga workshop Nov**

Workshop outcomes

- **need clear and consistent message for growers**
- **common approach, through QFA**
- **GCA liaison**
- **AWB and domestic support**
- **simple approach**
- **HACCP based**

Current work

- simplified qa approach - Nicole Kerr and Rosemary Richards
- forming collaborative groups

Issues

- **difficult to co-ordinate groups**
- **training**
- **acceptance by growers**
- **domestic industry and AWB need to support proactively**
- **need to get AWB involved through QA Manager**

Tools for Achieving Wheat-Quality Targets

PART 1. TOOLS FOR ON-FARM USE

On-farm teaching tools:
CD-ROMs, farmer groups and literature

-Clare Johnson
Quality Wheat CRC

WHEAT CRC

➤ **On-Farm Quality Awareness:**
Resources, Links and Plans

Clare Johnson

WHEAT CRC

➤ Quality Awareness

➤ Focus Groups

➤ QA development

WHEAT CRC

Resources include:
- video (milling)
- booklets
- slides
- courses
- factsheets
- print articles
- web page
- research extension

WHEAT CRC

- Wheat quality for products; courses
- Protein and quality
- NIR
- Dough strength
- Falling number, rain damage, and kit

WHEAT CRC

- Managing Wheat for Quality
- Nitrogen Management for Wheat and Malting Barley
  (Primary Industries SA / AWB Ltd)
- Wheat Quality check cards (Topcrop)

WHEAT CRC

- Pan (loaf) breads
- Flat breads
- Asian noodles
- Laboratory tests for wheat quality
- Follow up sets from article series

WHEAT CRC

- Pre-harvest test can help boost returns (09/98)
- Which wheat, which product? (01/99)
- Prime Hard - protein pays in the south (02/99)
- Nitrogen for protein, North and South (04/99)
- Specialty wheat breeding focus (05/99)
- Maintain quality - on farm grain storage (06/99)

WHEAT CRC

- Durum
- Soft wheat
- Winter wheats
- Feed wheats

WHEAT CRC

- Prime Hard in the South
  Topdressing leaflet 09/98, Full package 04/99
- Flexibility of wheat use (quality windows)
- Soft wheats for cotton stubble
- WA Hard wheat and Noodle packages

WHEAT CRC

On-farm Grain Storage:
Information for
HACCP-based Quality Assurance

launch Aug /Sept 99 field days

WHEAT CRC

- Standards & inspection
- Storage structures
- Moisture and temperature
- Practical pest control
- Insect pests of storages
- Surface treatments
- Grain hygiene
- Safety on farm
- Commodity information

WHEAT CRC

Phases:
1. Presowing management
2. Preharvest management
3. Harvesting
4. Putting into store
5. Storage period

WHEAT CRC

- ẽ Liaison important
- ẽ Links established
- ẽ Reviewers Identified

WHEAT CRC

- ﹥ Lloyd O'Connell, Australian Grain
  - Quality Wheat Focus
- ﹥ Andrew Marshall, The Land
  - regular stories: kit, storage etc.
- ﹥ Tony McKenzie, Orange Ag. College
  - train best practice facilitators (QA)

WHEAT CRC

- ﹥ SA Premium Quality Wheat (Philip Warren)
- ﹥ Birchip grower groups keen (Tony Fay)
- ﹥ TopCrop grower group network (John Lacy. also irrigation forum)
- ﹥ GRDC Golden Growers
- ﹥ Pinched Grain (Greg Condon)

WHEAT CRC

- ﹥ GRDC Grain Storage Extension working party: CD-ROM promotion?
- ﹥ Milling course - link to QA (Andy Lee, FMC)
- ﹥ Frosted Wheat
- ﹥ Produce National Wheat Quality Evaluation Program Handbook

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WHEAT CRC

- ﹥ Field days, CD launch, Cereal Conference
- ﹥ QWCRC agronomist satellite conference /GRDC Updates
- ﹥ QWFQF courses (Interest from Condobolin, Coonamble, Horsham, Yanco, Narrabri, Wagga, Toowoomba)
- ﹥ CRC Wheat Industry Forum Feb 2000

Tools for Achieving Wheat-Quality Targets

PART 1. TOOLS FOR ON-FARM USE

Diagnostic testing on-farm:
experience with the WheatRite kit

-Russell Heywood
CSIRO Plant Industry

WHEAT
CRC

"WheatRite" test development

Russell Heywood, John Skerritt and
Alan Ellis

CSIRO Plant Industry, Canberra and
Quality Wheat CRC Ltd, Sydney

WHEAT
CRC

Pre-harvest sprouting

- due to significant rain at harvest or just before grain ripens

- whether, and how much sprouting occurs hard to predict
  - degree of sprouting is not just related to total rainfall, but also temperature, humidity, cloud cover
  - on-farm factors also very important in determining sprouting extent

- grain is significantly downgraded before there are any visual signs of sprouting

- sprouting causes problems with bread and noodle colour and texture so grain cannot go to premium export markets

- thus sprouted grain is downgraded and grower payments are reduced, depending on the degree of sprouting

- Detects Alpha-amylases which cause low Falling Numbers
- Quantitative, correlates with the official Falling Number method
- Results independent of wheat variety, growth site

Silo receival - potential use

- Faster, less expensive than Falling Number machine
- Can be made available at all receival sites in wet harvests

On-farm - potential use

- Sprouting can vary significantly within and between paddocks, but the variation can be managed by harvesting separately
- Mild to moderate sprouting cannot be reliably detected by eye
- Thus growers can harvest and bin sound and damaged grain separately

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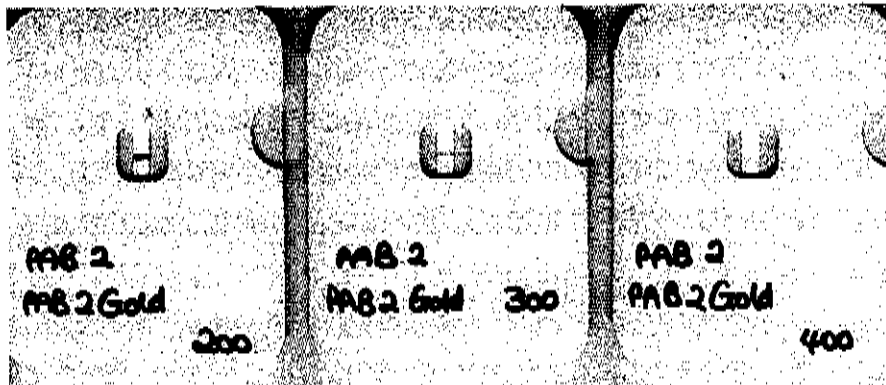
Advantages over the Falling Number test

- No need to invest in expensive equipment
- Portable test kits easily shipped to where rain damaged areas
- Does not require mains electricity
- No need to wash fragile, expensive glass Falling Number tubes
- Accuracy and precision are as good as the Falling Number test
- Results are not as dependent on finely grinding the grain
- Up to 10 samples can be tested at once, not just 1 or 2

The test can be used on farm or at silo receival

- Results can be read by eye and if sprouted, silos can then send the sample for Falling Number testing, OR
- A small reader will soon be available for automated result recording

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WheatRite test method

Grind wheat sample to be tested
Add flat scoop to test tube

▼

Shake ground wheat in salt solution - 15 seconds

▼

Add 2 drops to test card
close card, wait 5 minutes

▼

Read result, compare with colour card or use reader

1. Grain extract applied to lower zone

2. Card closed. Upward movement of sample by capilliary action

3. Complexes of amylase in sample and gold-labelled antibody form and move upwards

4. Complexes trapped by capture antibody on yellow line.
   Pink band appears

   Upper band confirms test is valid.

Sprouted: two bands appear
Unsprouted: one band (control only)
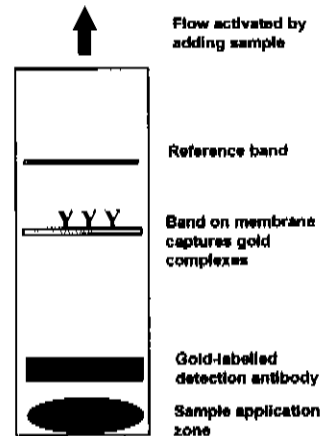
Flow activated by adding sample

Reference band

Y Y Y   Band on membrane captures gold complexes

Gold-labelled detection antibody

Sample application zone

- Performance checked with three large sets of weather-damaged wheat samples from different states

- Good correlation between band colour and Falling Number
  - more colour = more weather damage = lower Falling Number

- Results also correlate with lab tests for alpha-amylase

- Band absent or extremely faint in unsprouted wheat

- Relationship between ELISA absorbance and Falling Number relatively independent of variety
  - variation in wheat starch viscosity sometimes also influences FN
  - the WheatRite test only measures alpha-amylases

Relationship between WheatRite test results and Falling Number.
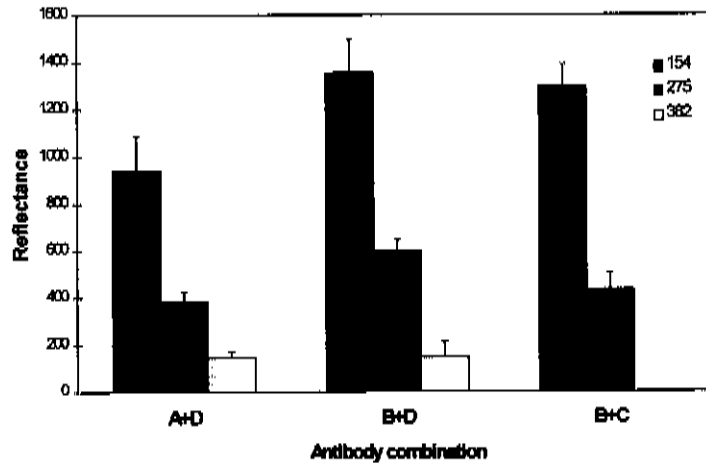Tests run on 6 different days
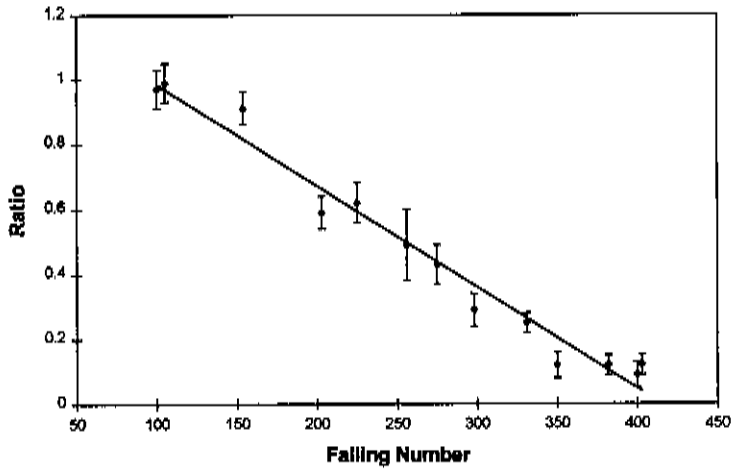
Test performance with five, very different wheat varieties

Antibody precision tests
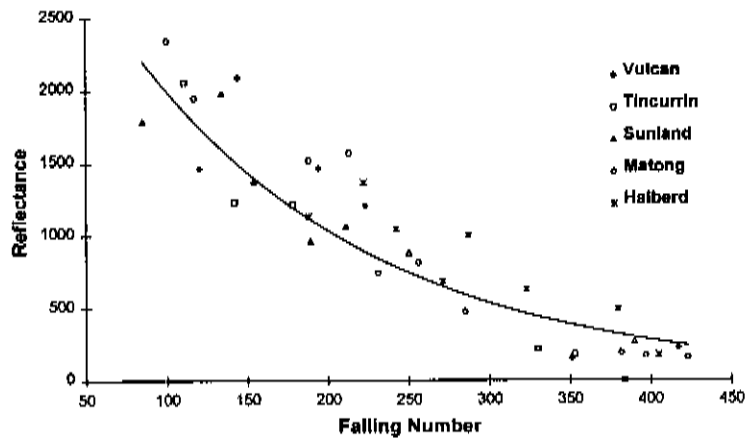
Field studies

- 1996 (Roma, QLD; Liverpool Plains, NSW), 1997 (Tara, QLD)
- 1998 (Southland, NZ; Central QLD; Ravensthorpe, WA)

- Develop suitable sampling methods/ guidelines

- Analyse degree of variation within/ between paddocks
    - measure sprouting at 4-9 places within paddock
    - compare sprouting between paddocks in same farm/ area
    - establish minimum sample size (5, 10, 20, 50 heads)
    - variation in results between repeat samples 2 m apart
    - variation in sample results when returning to similar areas
      of paddock 1-2 hours after initial sample

- sprouting can vary significantly between paddocks
  - factors: variety, sowing date, drainage

- sprouting varies within-paddock (SD > 50 FN units) only 25 % of the time
  - poorly drained or tree-shaded parts have higher damage
  - where paddocks sloped, upper areas had lower damage

- samples taken 2m apart only vary slightly in FN
  - where FN > 150, mean difference = 17 +_8 (22 sites)
  - where FN < 150, neighbouring sample FN < 150 (36/36 sites)

- samples taken 1-2h later at approximately same site vary more
  - where FN > 150, mean difference = 22 +- 16   (22 sites)
  - where FN < 150, neighbouring sample usually FN < 150 (23/ 36 sites)

- samples of 20 heads from 3-5 plants give representative results

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Data shown are test imprecision estimates in Falling number units for duplicate samplings of 5, 10 or 20 heads

Mean	Low FN paddocks (7)			High FN paddocks (15)		
	5 heads	10 heads	20 heads	5 heads	10 heads	20 heads
Within-paddock SD	51	26	28	29	29	24
Range of Duplicates	54	28	32	30	28	28

Variation in Falling Number within paddocks
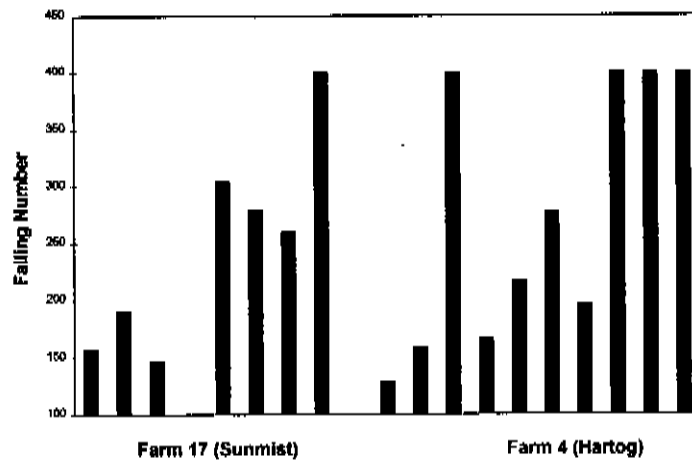
WheatRite demonstrations and trials, 1998

- Gain familiarity of staff at various levels in grain handling companies with new method
- Exposure of new test to key farmer groups

Demonstrations
- National meeting of BHC senior technical staff
  - plus demonstrations at QLD, NSW, SA, WA head/ regional offices
- 3 GrainCo (QLD) pre-harvest silo training courses
- 4 WA CBH silo demonstrations
- 3 Comparative silo trials with Falling Number (QLD, WA)
- 4 QLD Graingrowers association meetings
- 8 NSW GrainCorp pre-harvest growers meetings
- 3 WA CBH pre-harvest growers meetings
- NSW Agriculture field day, Temora
- 15-20 on-farm demonstrations to individual growers

Wheat Preference trial – initial results

- feedback on simplicity of instructions and test methods
- suggestions for any test modifications
- information on preferred place to purchase kit
- assess results with 4 "known" and 6 "unknown" samples
- results assessed visually versus a colour card

Measured Falling Number

	under 150	150	150 – 250	250	250 – 300	300	300 – 350	350
A (202)	0	23	4	37	3	7	0	1
B (430)	0	0	0	0	0	1	7	67
C (202)	0	15	6	34	6	15	0	0
D (110)	26	49	0	0	0	0	0	0
E (310)	1	0	0	4	2	51	14	4
F (310)	0	1	0	6	6	37	16	9

Research and development still needed

- Long-term stability trials of test cards

- Assess performance with barley and durum and red wheats
  - do they require different standard curves ?

- Publish on-farm sampling studies
  - grower guidelines, minimum sample size required

- Grower and Bulk Handling Authority official approval

- Disseminate information on test more widely

- Assess simple colour reader and software for test cards

- Establish international commercial partners / approval

- Evaluate other opportunities for the technology

Tools for Achieving Wheat-Quality Targets

PART 2. "PRIME-HARD IN THE SOUTH"
THE ON-GOING STORY

The 1998/99 season, extension and up-take of management recommendations
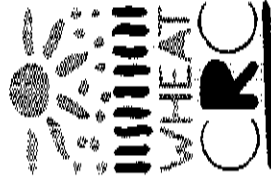
-John Oliver
NSW Agriculture

Tools for Achieving Wheat Quality Targets

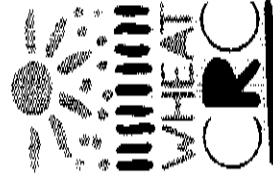## J R Oliver
NSW Agriculture
Wagga Wagga

NSW Agriculture

S NSW - East

- *High, reliable, mainly winter dominant rainfall*
- *Rotations well developed*
- *Achieving high yields*
- *Production stabilised*
- *Interested in markets/ quality*

- **Prime Hard wheats**
- **Durum wheats**

NSW Agriculture

S NSW - East

- ▢ *Ready to listen*
- ▢ *Package needs to suit their current rotations*
  - ▪ Very late N application = an option
- ▢ *Economics will drive uptake*
  - ▪ AH likely to be primary target
  - ▪ APH likely to an opportunity option
  - ▪ APH will compete with canola for best land

NSW Agriculture
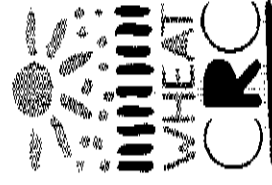
S NSW-West

- *Mallee - Open Woodlands - Grasslands*
- *Low rainfall with large annual fluctuations*
- *Soils have problems:*
  - **Red- brown earths**
  - **Low in organic matter**
  - **Soil structure and fertility problems**
  - **Acidity an increasing problem**

NSW Agriculture
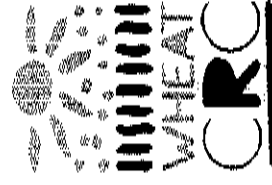
S NSW-West

- □ *Biggest constraint is lack of reliable rainfall!*

- □ *Role of pastures and legumes crucial*

BUT

- □ *Effectiveness limited by soil and rainfall*

- □ *Low returns from wool = more cropping*

  = rotations being de-stabilised

  = sustainability under threat

NSW Agriculture
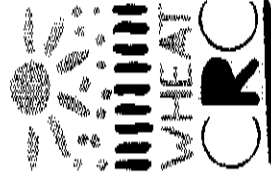
S NSW-West: Issues for APH

☐ Need to define packace in terms of best management practices for low rainfall districts.

= how to manage variable rainfall.

☐ High protein comes easily.

☐ Late N topdressing not a likely option.

☐ Varieties available produce satisfactory quality

= Quality is not being managed.

NSW Agriculture
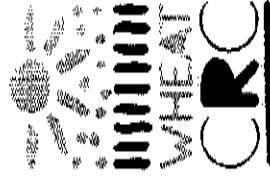
S NSW-West: Issues for APH

Biggest challenge =

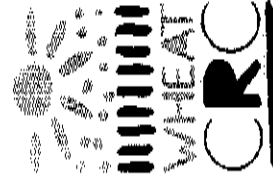□ *Perception that existing research is not relevant!*

Research Gap or Demonstration Gap?

NSW Agriculture
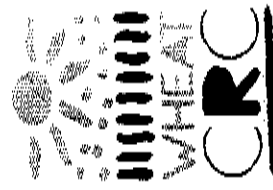
S NSW - Irrigation

- ☐ Rice is the best cereal option
- ☐ APH is an option for winter phase of rotation
- ☐ Will use high inputs
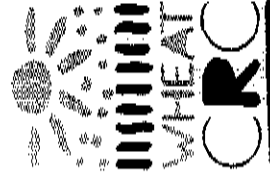- ☐ Package needs to reflect return per ML water

NSW Agriculture

Summary

- □ SNSW - East
  - ■ Ready and willing to manage Quality
- □ SNSW - West
  - ■ Will manage Production; Quality secondary
- □ SNSW - Irrigation
  - ■ Secondary option; Return per ML water

NSW Agriculture

Tools for Achieving Wheat-Quality Targets

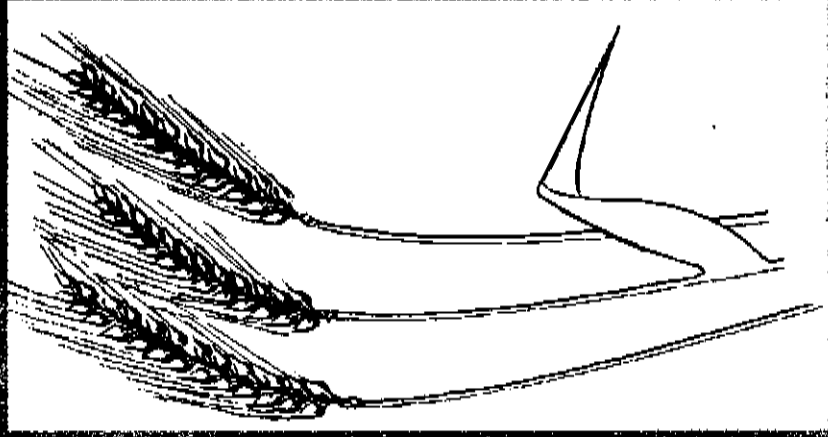## PART 2. "PRIME-HARD IN THE SOUTH" THE ON-GOING STORY

The 1998/99 season, extension and up-take of management recommendations

- Kirrily Smith
NSW Agriculture
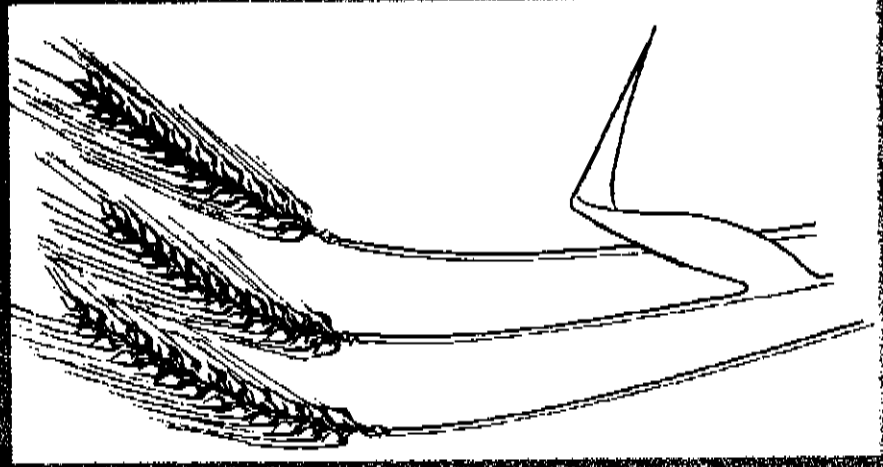
Prime Hard in the South

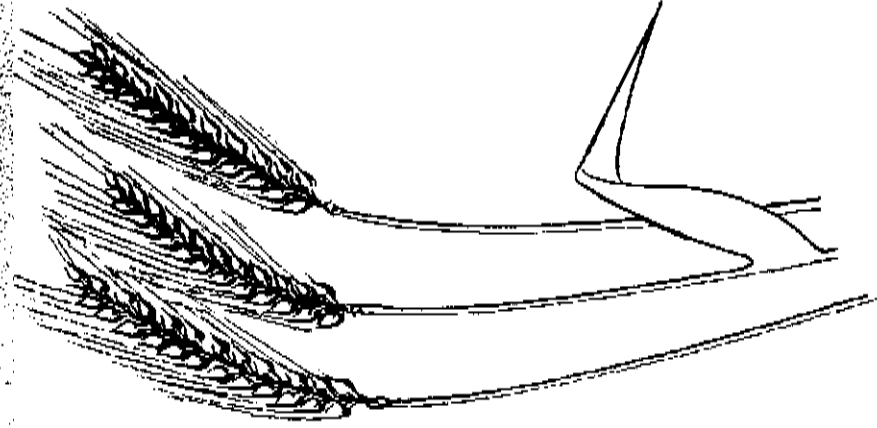# Prime Hard in the South

John Coughlan
"Cudal Park" Cudal

Why?

'accidental high protein wheat grower'

→ growing 12.5% protein Rosella wheat 10 years ago

→ routinely applies 60 units N; grows canola for good disease break

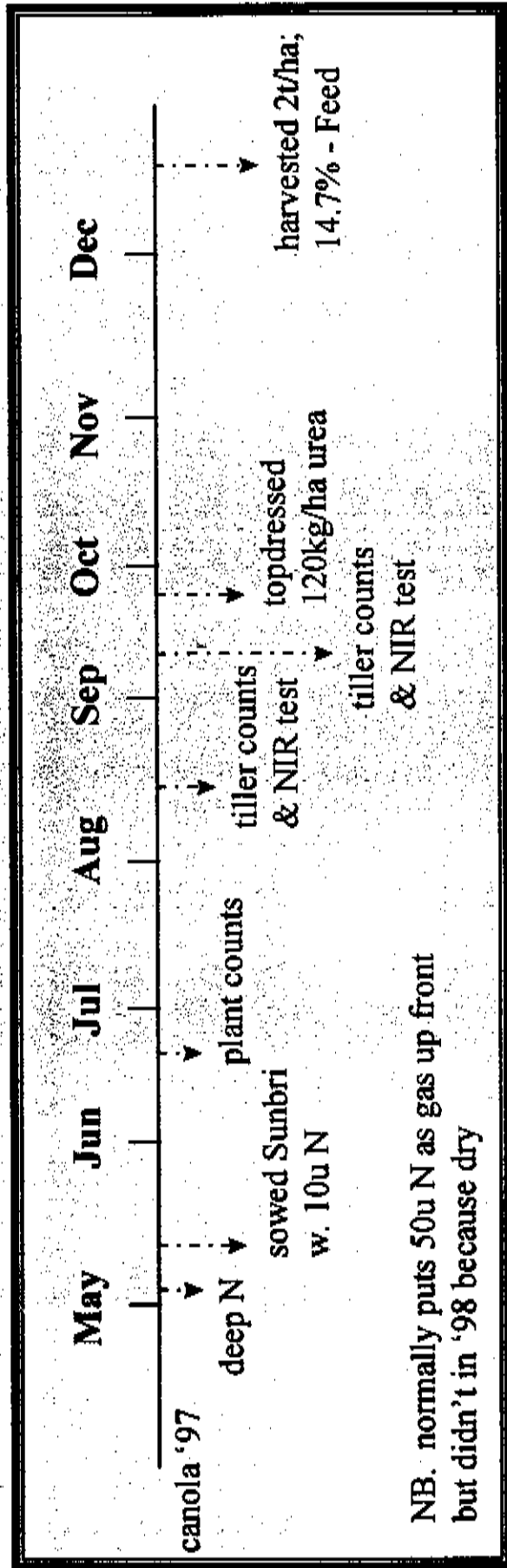## *Information source?*

Tony Good, Incitec

→ deep N soil tests

→ plant/tiller counts

→ NIR tests

Prime Hard in the South

John Coughlan
"Cudal Park" Cudal

canola '97

May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

deep N

sowed Sunbri w. 10u N

plant counts

tiller counts & NIR test

topdressed 120kg/ha urea

tiller counts & NIR test

harvested 2t/ha; 14.7% - Feed

NB. normally puts 50u N as gas up front but didn't in '98 because dry

Will he do it again?

Yes, but main concern is whether premium will be enough to cover additional freight cost to PH receival site (86km away) - can deliver AH13 locally (14km away) and get ~$5/t less?
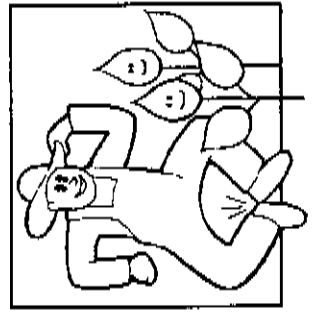
Prime Hard in the South

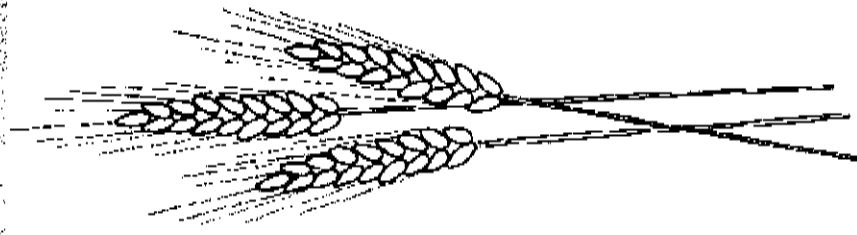Ray Norman
"Glenbrook", Illabo

Why?

Interested in trials done on late topdressing by local Incitec agronomist in early 90's.

→ achieved 7.5t/ha @ 13% protein in 1993 through topdressing twice

→ tries several paddocks each year if conditions and premiums right
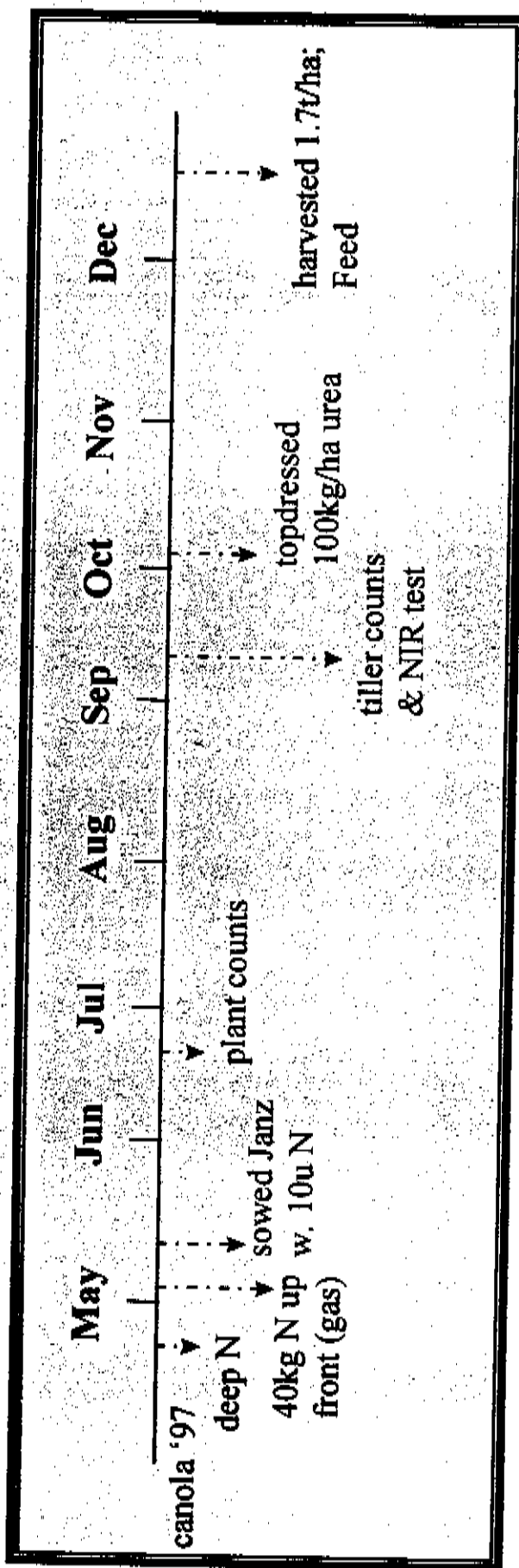
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Scott Boothey, Hanlon Enterprises, Junee (Incitec)

→ deep N soil tests

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Prime Hard in the South

Ray Norman
"□lenbrook", Illabo

May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

canola '97
deep N
40kg N up w. 10u N
front (gas)

sowed Janz
plant counts

tiller counts
& NIR test

topdressed
100kg/ha urea

harvested 1.7t/ha;
Feed

Will he do it again?

Yes, as long as there is a good premium and the season permits
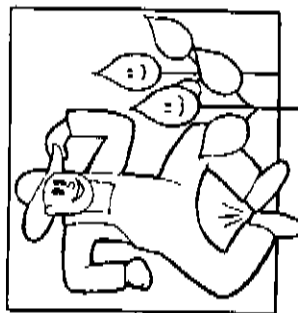
Prime Hard in the South

Tools to achieve Prime Hard:

- deep N test
- plant/tiller counts
- NIR test

Adoption will depend on:

- seasonal outlook
- premiums
- proximity to PH receival centre

DON'T GUESS...LET A SOIL TEST HELP IN YOUR CROP PRODUCTION

Tools for Achieving Wheat-Quality Targets

PART 2. "PRIME-HARD IN THE SOUTH"
THE ON-GOING STORY

The 1998/99 season, extension and up-take of management recommendations

-Bob Cracknell
AWB Ltd

1998/99 Harvest Composite Wheat Quality Report No 25

Grade	**APH13**	APH13	APH13	APH13
Sample Code	**ZPCS**	ZFCS	ZFCS	ZFCS
Season	**98/99**	97/98	96/97	95/96
Zone	**Port Kembla**	Port Kembla	Port Kembla	Port Kembla

Varietal Composition				
Batavia %	32	10	12	7
Cunningham %	3	22	20	31
Hartog %	3	4	7	7
Janz %	41	47	39	31
Miskle %	-	1	5	6
Sunbri %	3	1	3	2
Sunco %	6	5	7	7
Suneca %	3	1	2	2
Sunkota %	3	1	1	3
Sunmist %	-	2	1	2
Sunstate %	-	2	2	1
Sunvale %	7	-	-	-

Australian Prime Hard - New South Wales

Wheat	1998/99	1997/98
	Newcastle	Newcastle
Test Weight (kg/hl)	80.5	84.5
Thousand Kernel Weight (g)	31.3	34.9
Moisture (%)	10.7	10.4
Protein (%)(N x 5.7, 11%mb)	13.4	13.7
Screenings (%, 2.0mm)	4.0	3.0
Falling Number (sec)	476	464
Grain Hardness (PSI)	15	16
Ash % (11% mb)	1.65	1.42

AWB

Australian Prime Hard - New South Wales

Wheat	1998/99	1997/98
	Port Kembla	Port Kembla
Test Weight (kg/hl)	80.5	81.0
Thousand Kernel Weight (g)	32.9	31.2
Moisture (%)	10.6	10.2
Protein (%)(N x 5.7, 11%mb)	13.2	13.6
Screenings (%, 2.0mm)	3.7	3.9
Falling Number (sec)	439	488
Grain Hardness (PSI)	15	16
Ash % (11% mb)	1.44	1.31

AWB

Australian Prime Hard - New South Wales

Flour	1998/99	1997/98
	Newcastle	Newcastle
Extraction	60	60
Protein (%)(N x 5.7, 14%mb)	12.0	12.5
Colour Grade (KJ)	-2.0	-2.2
Diastatic activity (mg)	195	201
Ash (%)(14% mb)	0.39	0.38
Minolta Flour Colour L	93.1	93.0
Minolta FLour Colour b	8.7	8.4

AWB

Australian Prime Hard - New South Wales

Flour	1998/99	1997/98
	Port Kembla	Port Kembla
Extraction	60	60
Protein (%)(N x 5.7, 14%mb)	11.9	12.2
Colour Grade (KJ)	-2.0	-2.3
Diastatic activity (mg)	237	176
Ash (%)(14% mb)	0.39	0.39
Minolta Flour Colour L	92.8	93.0
Minolta Flour Colour b	8.7	9.7

AWB

Australian Prime Hard - New South Wales

Farinogram	1998/99	1997/98
	Newcastle	Newcastle
Water absorption (%)	62.4	63.7
Development time (min)	7.0	8.7
Stability (min)	>15.0	>15.0
Extensogram - 45 Min Pull		
Extensibility (cm)	21.6	21.1
Maximum height (BU)	440	470
Area (sq.cm)	130	136
Viscograph Peak (BU)	560	560

AWB

Australian Prime Hard - New South Wales

Farinogram	1998/99	1997/98
	Port Kembla	Port Kembla
Water absorption (%)	63.8	63.5
Development time (min)	6.0	10.5
Stability (min)	>15	>15
Extensogram - 45 Min Pull		
Extensibility (cm)	21.7	22.0
Maximum height (BU)	455	485
Area (sq.cm)	137	145
Viscograph Peak (BU)	550	540

AWB

RAMEN NOODLE EVALUATION - New South Wales
Australian Prime Hard

60% extraction		1998/999		1997/98	
Newcastle					
		30 mins	24 hrs	30 mins	24 hrs
Noodle sheet - Raw	L	80.7	72.6	80.6	71.8
	b	24.6	24.9	23.7	23.7
Noodle sheet - Cooked	L	71.5		71.5	
	b	26.3		24.7	

AWB

RAMEN NOODLE EVALUATION - New South Wales
Australian Prime Hard

60% extraction		1998/999		1997/98	
Port Kembla					
		30 mins	24 hrs	30 mins	24 hrs
Noodle sheet - Raw	L	80.1	72.7		
	b	25.3	25.6		
Noodle sheet - Cooked	L	72.1			
	b	26.8			

AWB

Tools for Achieving Wheat-Quality Targets

PART 2. "PRIME-HARD IN THE SOUTH"
THE ON-GOING STORY

Lessons from PH in Sth:
Quality X Climate X Management

-Helen Allen
NSW Agriculture

Prime Hard in Southern Australia

Helen Allen, John Angus and Jennifer Apps

GRDC

CSIRO
AUSTRALIA

This work is supported by GRDC
& Quality Wheat CRC

Key Points

- *Research has been a success*
- *Two seasons of Prime Hard Segregation in southern NSW*
- *AH 13 in SA and Vic.*

GRDC

Booklet

❏ *Covering:*

- ■ **Agronomy**
- ■ **Quality**
- ■ **Marketing**
- ■ **Economics and Risks**

NSW Agriculture

CSIRO AUSTRALIA

GRDC

WHEAT CRC

Samples

❏ *600-900 were collected each year*

- ■ **only samples containing > 13% protein were analysed for a range of dough properties**

NSW Agriculture

CSIRO AUSTRALIA

GRDC

WHEAT CRC

Varieties Used

□ *Janz, Sunstar, Hartog, Kite*

■ **Different rates of N were applied to maximise the chance of achieving > 13% wheat protein**

NSW Agriculture   CSIRO AUSTRALIA   GRDC   WHEAT CRC

Protein range achieved at 1997 harvest sites

NSW Agriculture   CSIRO AUSTRALIA   GRDC   WHEAT CRC

Prime Hard in the South

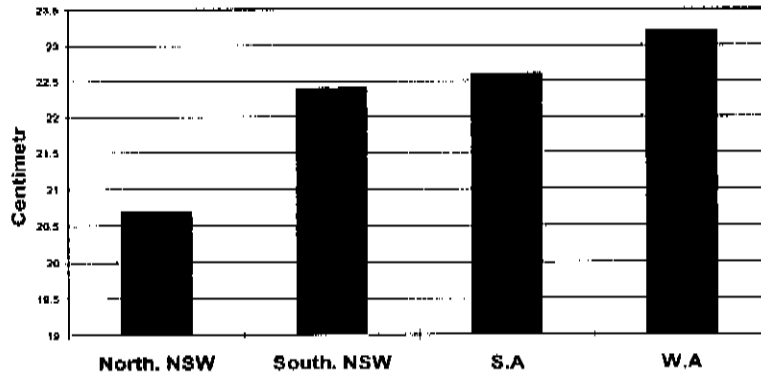**FE% - Combined years**

Legend: ■ Hartog ■ Janz ■ Kite □ sunstar
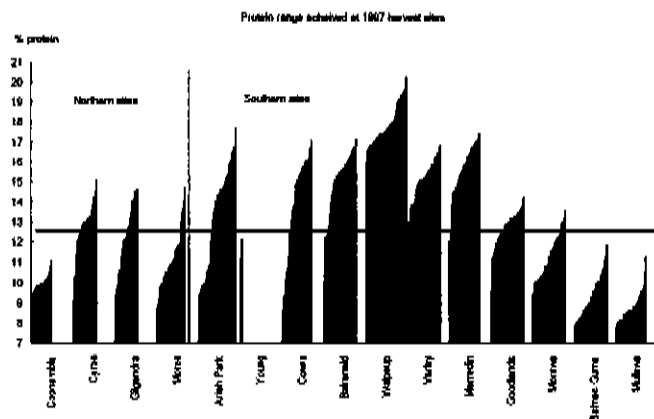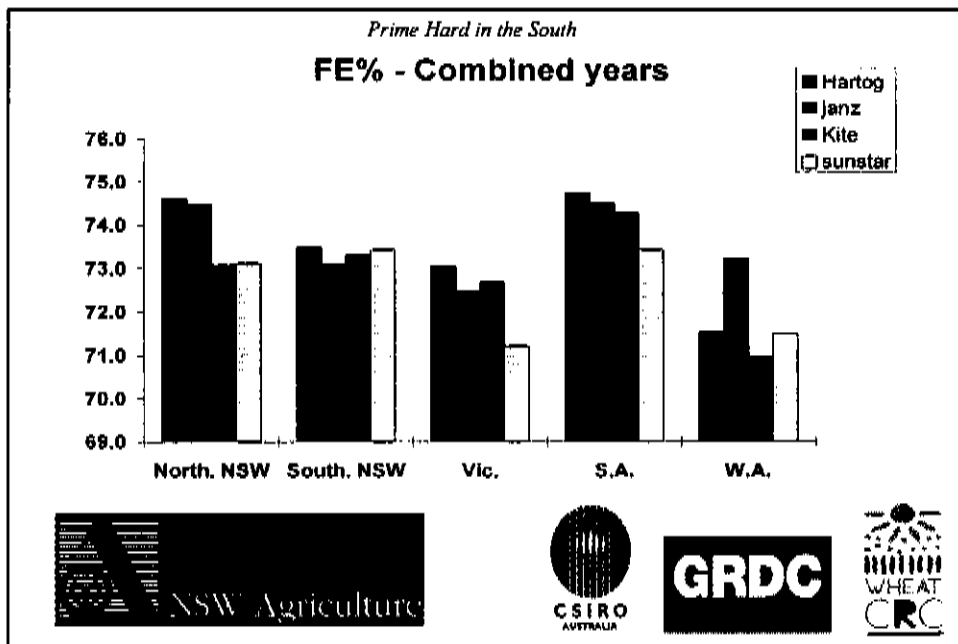
Quality evaluation for Janz 1997

•*Extensibility lowest in the north*
•*Dough Development time higher in the south*
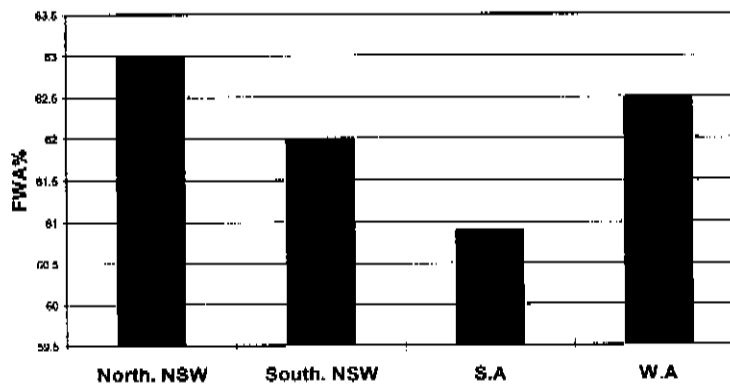•*Low water absorption in the south*

Prime Hard in the South
Janz - Extensibility 1997

Prime Hard in the South
Janz - FWA% 1997

Janz - DDT 1997

A bar chart titled with Minutes on the y-axis (0 to 9). Bar values: North. NSW ≈ 4.2, South. NSW ≈ 8.5, S.A ≈ 5, W.A ≈ 6.

NSW Agriculture   CSIRO AUSTRALIA   GRDC   WHEAT CRC
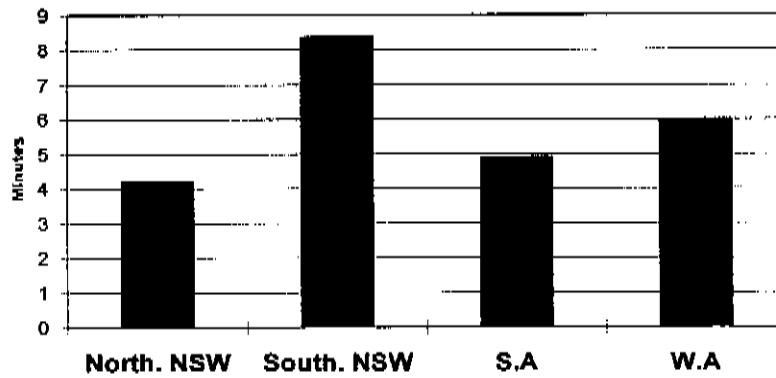
Prime Hard in the South

Results

□ *Research showed*

■ large quality differences between sites

■ but no significant between northern and southern sites

NSW Agriculture   CSIRO AUSTRALIA   GRDC   WHEAT CRC

Tools for Achieving Wheat-Quality Targets

PART 3. "FLEXIBILITY OF WHEAT USE"
- THE GRDC/CRC SET OF PROJECTS

Bench-marking

-Helen Allen
NSW Agriculture

Flexibility of Wheat Use

Bench-Marking

Helen Allen and Jennifer Apps

GRDC

WHEAT CRC

Trials were Grown at:

□ Wagga Wagga
□ Narrabri
□ Moree
□ Roma
□ Dalby

□ Horsham
□ Walpeup
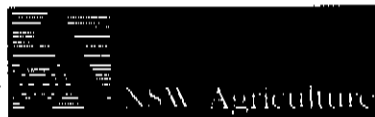□ Roseworthy
□ Wongan Hills
□ Newdegate

GRDC

WHEAT CRC

Collaborators

- NSW Agriculture
- University of Sydney
- DPI -Leslie Research Centre
- Agriculture Victoria
- University of Adeliade
- Agriculture WA

NSW Agriculture

GRDC

WHEAT CRC

Hard Varieties Used

■ Amery	□ Krichauff
■ Dollarbird	□ Meering
■ Frame	□ Ouyen
■ Goldmark	□ Sunco
■ Hartog	□ Wilgoyne
■ Janz	

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Soft Varieties Used

- Rosella
- Cadoux
- Eradu
- M5631

GRDC

Of the Sites Received

- *Wagga Wagga Dryland - frosted*
- *Victorian sites - frosted*
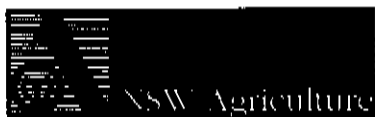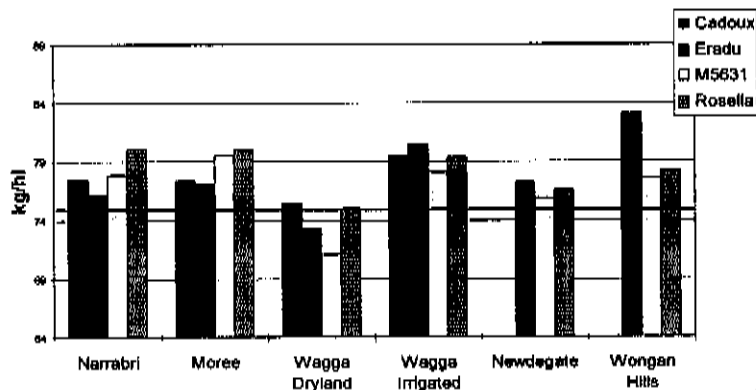- *One SA site - ?*

GRDC

Grain Tests

- Screenings
- Test Weight
- 1000 g Weight
- Wheat Protein
- Hardness
- Falling Number

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WHEAT CRC

Flexibility Test Weights (Noodle varieties)

Legend: Cadoux, Eradu, M5631, Rosella

x-axis: Narrabri, Moree, Wagga Dryland, Wagga Irrigated, Newdegate, Wongan Hills

y-axis: kg/hl

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WHEAT CRC

Flexibility - Test weights (Hard varieties)
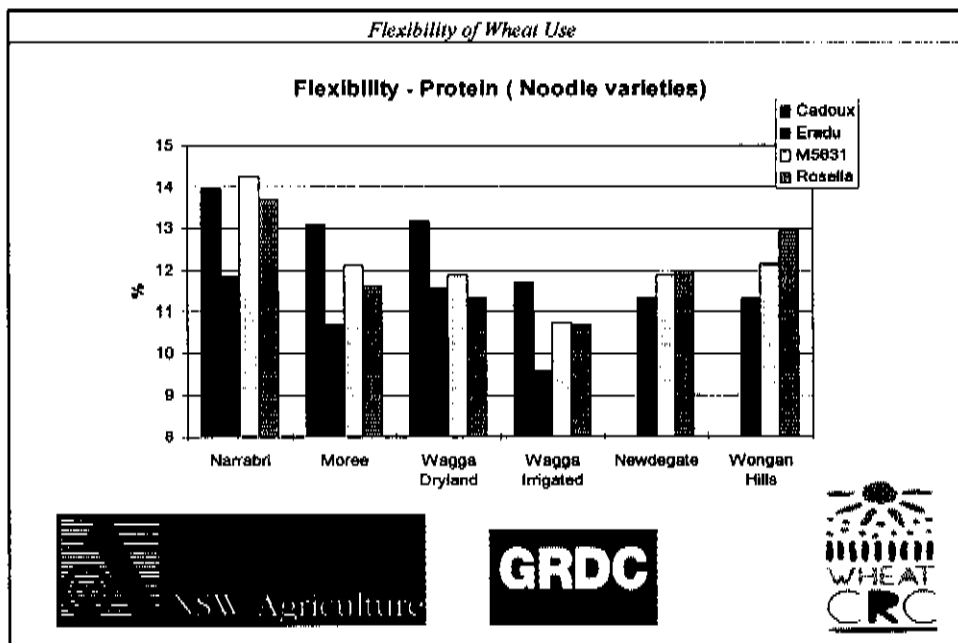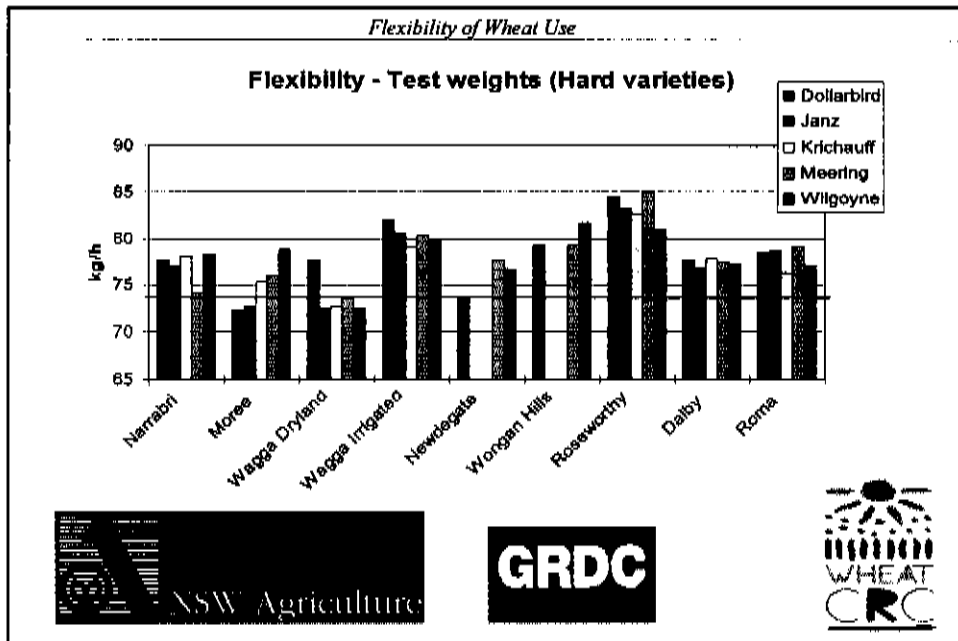
Flexibility - Protein (Noodle varieties)

Flexibility - Protein (Hard varieties)
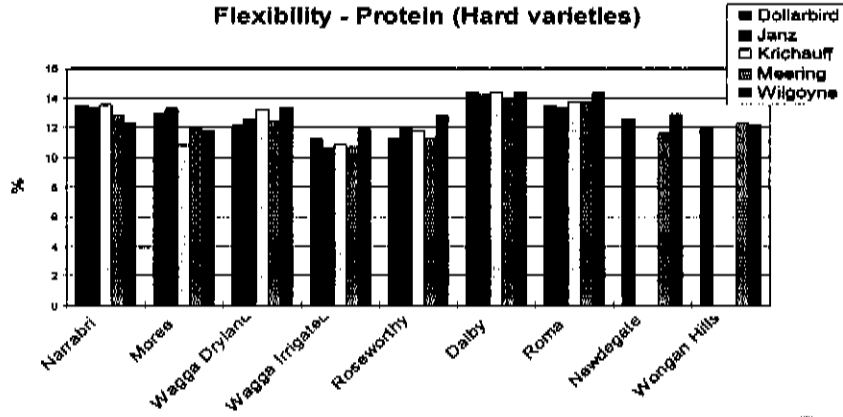
Quality Evaluation

- WWAI
  - Grain Tests, Milling, FC, FP, Probe Test, RVA, Pan Bread, Steam Bread/Bun

- AWA
  - WSN

- SARDI
  - PDT, Flat Bread

- AG Vic
  - YAN, Starch Quality
- TAI
  - HPLC

GRDC

WHEAT CRC

1999 -2000

☐ Select Seed	☐ Complete Milling
☐ Send to collaborators	☐ Send flour to collaborators
☐ Sow Trials	
▪ **Pray for a good year**	

GRDC

NSW Agriculture

WHEAT CRC

Tools for Achieving Wheat-Quality Targets

PART 3. "FLEXIBILITY OF WHEAT USE" - THE GRDC/CRC SET OF PROJECTS

Genetic interchangeability

-John Skerritt
CSIRO Plant Industry

Genetic and biochemical studies: Prime Hard in the South

John Skerritt, Russell Heywood and Greg Naglis
CSIRO Plant Industry and Quality Wheat CRC Ltd, Canberra ACT

Mike Sissons, NSW Agriculture, Tamworth

Frank Ellison, Plant Breeding Institute, Sydney University, Narrabri

Paul Brennan and Stephen Kammholz,
Leslie Research Centre, QDPI, Toowomba

Helen Allen and Jenny Apps, NSW Agriculture, Wagga Wagga

Do Prime Hard wheats maintain Prime Hard quality when grown in the South?

- Four Prime Hard varieties sown at many sites in several states in 1995, 1996 and 1997 seasons

- Different fertiliser treatments to ensure Prime Hard protein levels achieved

- For wheats exceeding 13 % protein, no overall differences between southern and northern sites, except sometimes in milling quality

- However, significant differences seen between sites

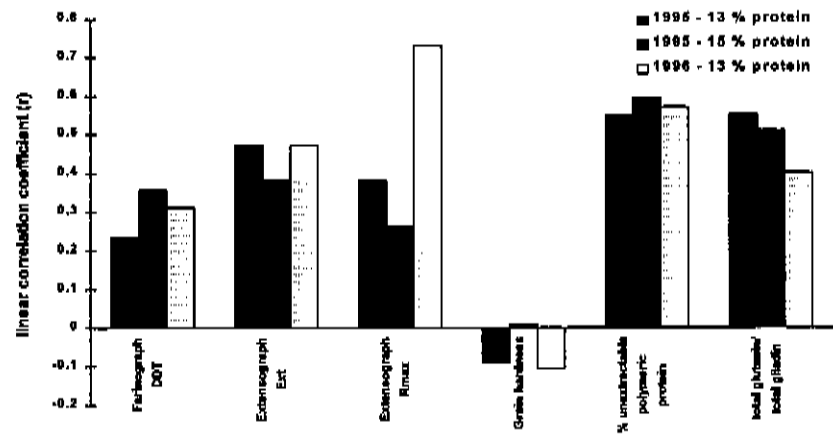- Establish biochemical basis for differences in dough properties between environments using samples from main "Prime Hard in the South" project

- Understand potential genetic basis of any environmental variation between Northern and Southern sites
  - is the finding of a lack of difference in dough properties generally applicable ?
  - We used only four sites and a single fertiliser treatment but many more genotypes

- **Extensibility**
  - in 1995 from 21.5 - 28 cm, and in 1996 from 20.5- 25.5 cm

- **Maximal Resistance**
  - in 1995 from 280 to 425 BU, and in 1996 from 320 to 550 BU

- **Loaf volumes**
  - in 1995 from 610 - 710 mL, and in 1996 from 510 - 720 mL

- differences seen in both individual sample values and site means

- similar trends seen for the other three varieties

- we need to explain basis of this variation
  - relate to flour composition and environmental measurements

---

- glutenin content
- glutenin composition
- glutenin molecular weight distribution
  - are known to have major effects on dough properties

- do these vary even if the set of samples has
  - little genetic variation?
  - no variation in total protein content ?

- analyse data for each season
  - as a full set / by variety / by site
  - compare Northern versus Southern sites

Slide 1

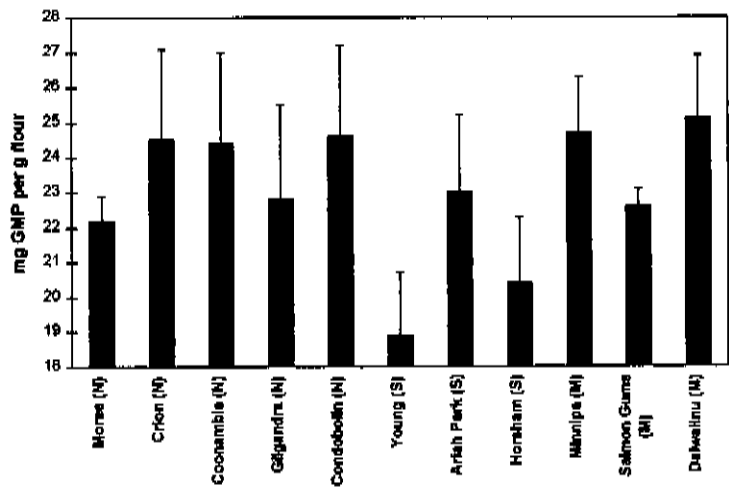**Correlations were significant but not as high as when samples of many different varieties and/or protein levels are studied**

Legend:
- 1996 - 13 % protein
- 1995 - 15 % protein
- 1996 - 13 % protein

Y-axis: linear correlation coefficient (r)

Y-axis scale: 0.8, 0.7, 0.6, 0.5, 0.4, 0.3, 0.2, 0.1, 0, -0.1, -0.2

X-axis categories: Farinograph DDT, Extensograph Ext, Extensograph Rmax, Grain hardness, % unextractable polymeric protein, total glutenin/ total gliadin

Slide 2

Extensograph dough resistance 1998 season; 13% protein

Y-axis: R max (BU)

Y-axis scale: 250, 300, 350, 400, 450, 500, 550, 600

X-axis categories: Moree (N), Orion (N), Coonamble (N), Gilgandra (N), Condobolin (N), Young (S), Ariah Park (S), Horsham (S), Minnipa (M), Salmon Gums (M), Dalwallinu (M)
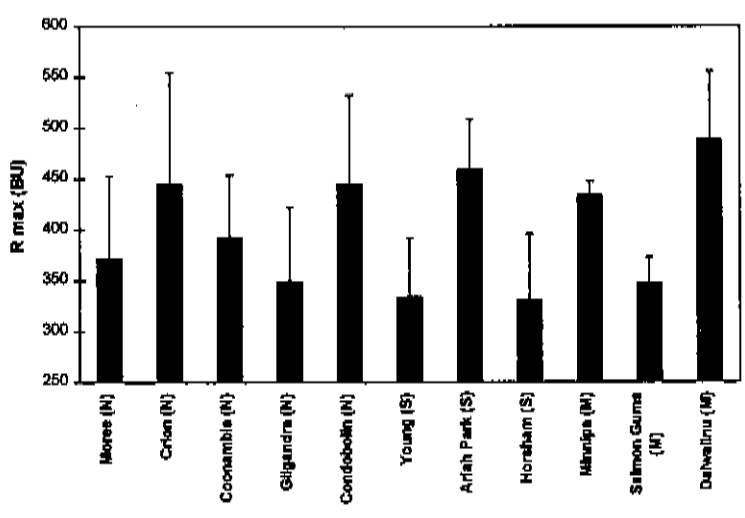
Results:
differences between sites, varieties

- No difference in *average* biochemical parameters between Northern and Southern sites

- Differences in dough resistance and extensibility, Farinograph DDT and loaf volumes *between individual sites* correlated:
  - with differences in glutenin macropolymer content
  - with differences in insoluble glutenin content (SE-HPLC)

- No consistent difference in HMW- / LMW- glutenin subunit ratios

Variation in dough properties between sites due to differences in glutenin content and mol wt distribution

Is this due to differences in environmental conditions during grain development ?

POPULATIONS: Two sets of doubled haploids (grown 1997,1998)

Two sets of cross-breds (grow 1998,1999)

Five key lines (grow 1998,1999)

NORTHERN SITES: Roma (S QLD) and Narrabri (N NSW)

SOUTHERN SITES: Ariah Park (S NSW) and Walpeup (Vic. mallee)

All samples: Protein content, hectolitre and 1000 kernel wt

SDS sedimentation test

Selected samples: Milling yield, Farinograph, Extensograph, baking

---

- **Doubled haploid lines in PH wheats derived from:**
  Hartog x Klasic - differs at only one gli/ glu locus *(Glu-A3)*
  Hartog x CD87 - differs at 5 of 6 loci, but vary in maturity
  Advantages: fixed background of doubled haploid lines
  Disadvantages: variation in maturity and height

- **Advanced lines from crosses between PH varieties:**
  Janz x Hartog; differ at 2 HMW-GS loci and 2 LMW-GS loci
  Janz 1, 7+8, 2+12 b,b,b   Hartog 1, 17+18, 5+10 b, h, e

  Janz*2/ Dollarbird; differ at 2 HMW-GS loci and 1 LMW-GS locus
  Janz 1, 7+8, 2+12 b,b,b   Dollarbird 1, 17+18, 5+10 b, h, b
  Advantages: adapted and uniform, parents current varieties
  Disadvantages: other background genes segregating
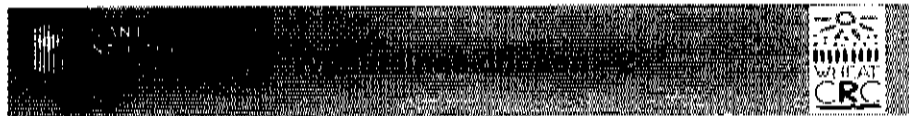
- Recent Australian Hard - type lines from Southern breeding programs that may have potential in Prime Hard segregations:

  Diamondbird (K2011-5)
  VI 341
  RAC 820
  CK*3A (CK*3Ag3Ar) *C8MMC8HMM
  C8M (C8MMMKRK*YK)*MX

  Grown at 3 replications at each site
  Compared performance with Prime Hard control varieties

Protein content
- Over 13 % protein obtained at all sites for almost all lines
  - Roma and Walpeup (15-17 %), Narrabri and Ariah Park (13-14 %)
- high protein achieved in the south by drought or by late N application
- protein contents did not differ in lines with different allelic composition
  - thus allele-dough property interactions can be analysed directly

Physical grain and milling analyses. At Southern sites:
- grain pinched (1000 kernel weights reduced)
- flour colour and extraction rates poorer:
  - Narrabri and Roma 75-76 %, Ariah Park 71 %, Walpeup 67-68 % ER
- Results indicate potential milling problems when high grain protein is achieved in southern sites through drought

- **Effects of glutenin alleles on sedimentation values, Farinograph stability and Extensograph Rmax consistent for all 4 sites:**
  - HMW-GS *Glu-B1b* (7+8) > i (17+18)
  - HMW-GS *Glu-D1d* (5+10) > a (2+12) (smaller effect)

- **At 13-14 % grain protein (Ariah Park and Narrabri):**
  - sedimentation volumes and Extensograph Rmax greater at Ariah Park
  - extensibility and Farinograph parameters similiar
  - loaf volumes / scores slightly greater at Narrabri
  - all values for both sites within acceptable Prime Hard range

- **At 15-17 % grain protein (Walpeup and Roma):**
  - sedimentation volumes and Rmax greater at Walpeup
  - sedimentation volumes higher than that at 13-14 % grain protein
 - high protein caused by drought did not harm protein quality

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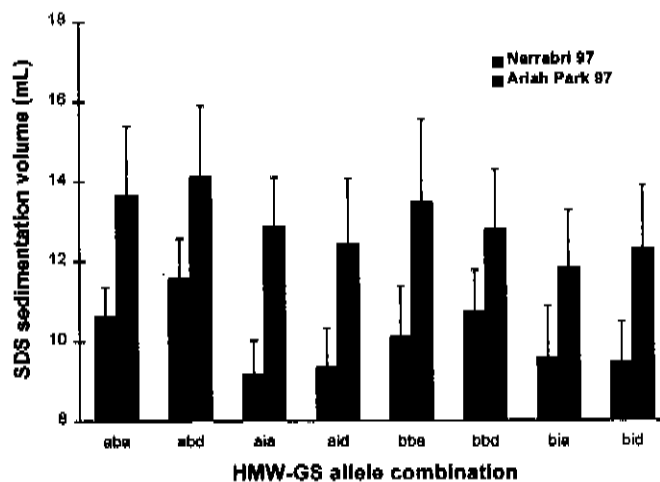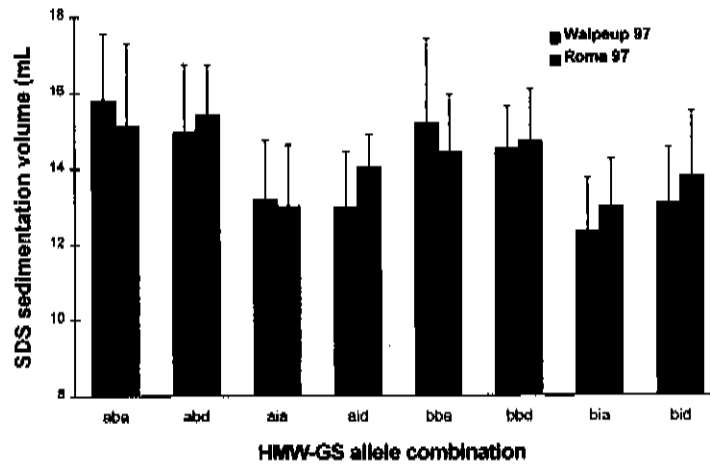
Similar trends and mean values as Hartog x CD 87

- Protein content: Walpeup > Roma > Ariah Park > Narrabri
- SDS-sedimentation volume: Walpeup = Roma > Ariah Park > Narrabri
- Grain weights from southern sites slightly lower and extraction rates poorer at Ariah Park, Walpeup than Narrabri, Roma
- *Glu-A3* allele did not affect protein content, physical characteristics
- *Glu-A3d* (Klasic) allele had higher SDS-SV than *Glu-A3b* (Hartog)

- **Klasic is an important source of flour whiteness**
  - Minolta L values not different between sites
  - But b (yellowness) and - a (greenness) higher at Southern sites
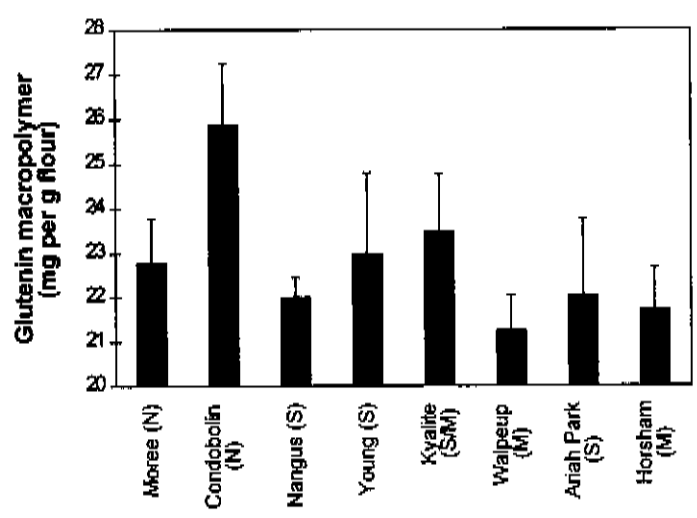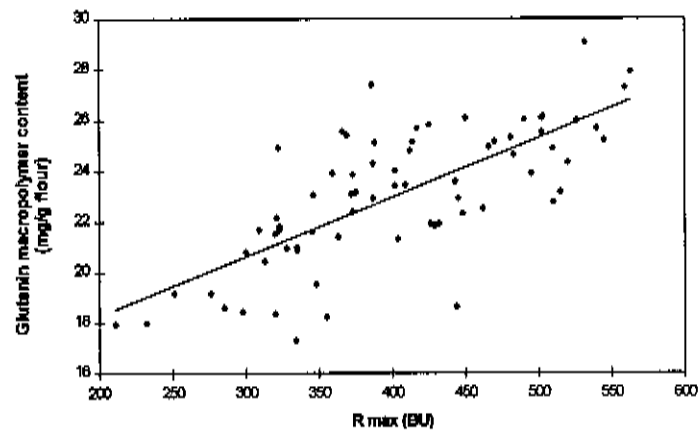   Narrabri < Roma < Walpeup < Ariah Park
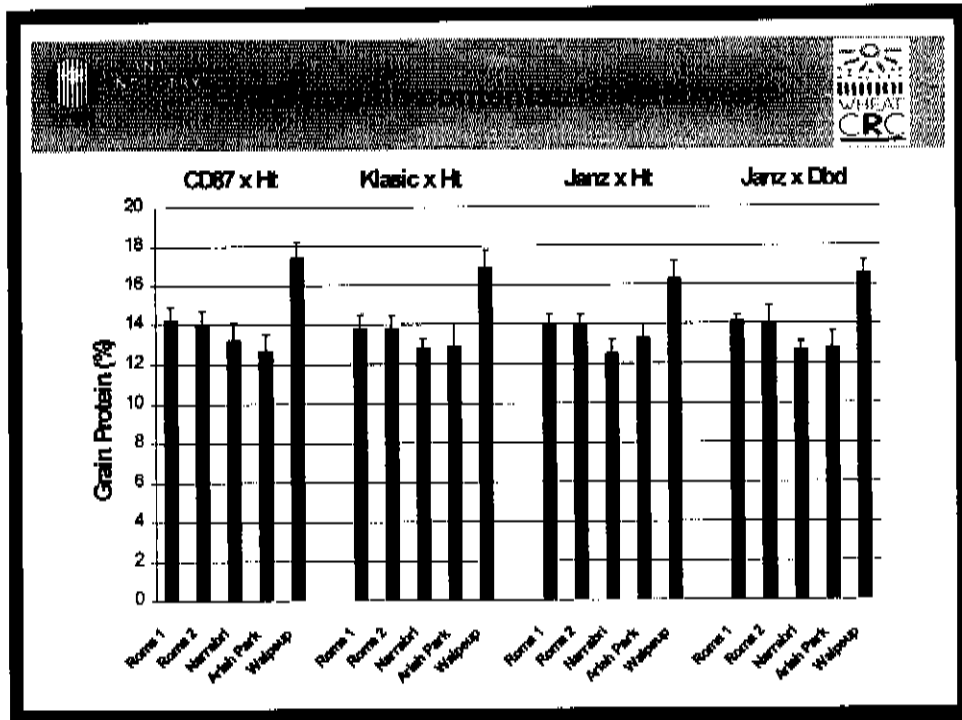
Aim 1: Understand biochemical basis of variation in dough
 properties at constant protein content
- differences appear to be due to glutenin polymerisation
- need to analyse 1995-1997 weather/ soil data for each site to
 establish possible factors affecting endosperm development

Aim 2: Investigate role of glutenin alleles in consistency of
 dough properties
- in 199,7 protein quality of southern sites was as good as, or better
 than the northern sites. Some milling/ flour colour deficits seen.
- differences in glutenin alleic composition did not cause protein
 quality to specifically fall at southern sites

- Need to confirm results with:
 – grain from 1998 season (cooler and wetter)
 – analysis of cross-bred and advanced lines in 1998 and 1999
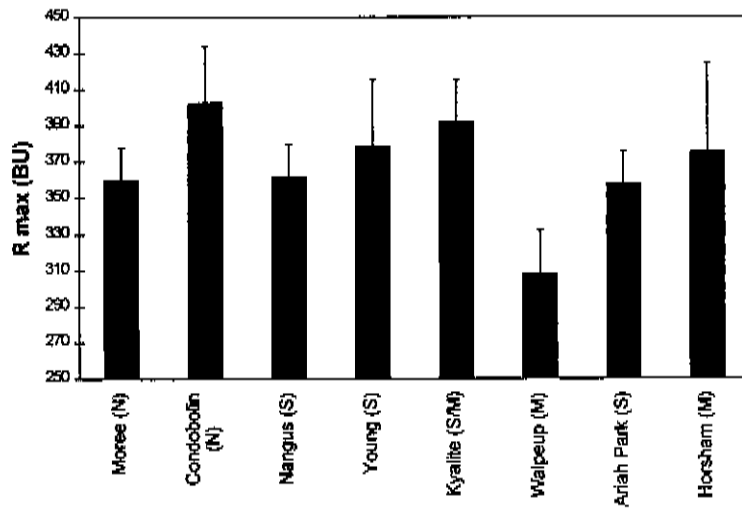
Relationship between Glutenin Macropolymer content and Rmax, 1998 trials

Differences in Glutenin Macropolymer content between sites (1998 trial, 13% protein)

Differences in dough resistance between sites (1996 trial is depicted)

Tools for Achieving Wheat-Quality Targets

PART 3. "FLEXIBILITY OF WHEAT USE"
- THE GRDC/CRC SET OF PROJECTS

Precision agriculture

-John Skerritt
CSIRO Plant Industry

Within paddock variation in wheat quality: measurements and implications for management
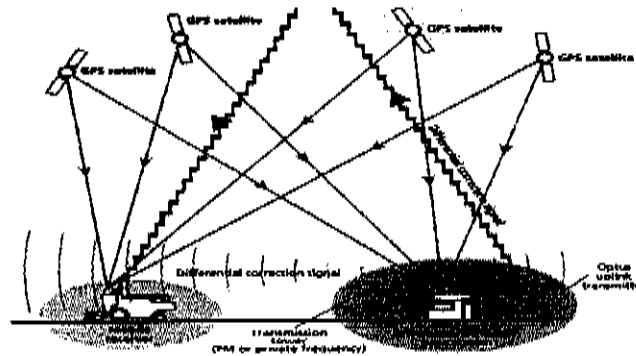
John Skerritt

Simon Cook, Matthew Adams (CSIRO Land & Water, Perth)
Russell Heywood, Greg Naglis (CSIRO Plant Industry)

What is precision agriculture ?

- based on ability to monitor inputs and outputs at individual sites within a paddock due to accurate knowledge of position

- uses global positioning system (GPS) equipment on seeders, spreaders, harvesters

Need for Precision Agriculture research

- Grower interest in precision agriculture has centred around:
  - ability to map variation in grain yield within individual paddocks
  - using this information to remedy site-specific soil fertility problems or weed control so yields can be maximised
  - targetting fertiliser and spray inputs to where they are needed

- However agronomic trials often show an inverse relationship between yield and grain protein content, especially where Nitrogen fertiliser is applied early in crop development

- Could site-specific management to enhance grain yield result in the loss of grade premiums, if the protein content and grain quality from higher yielding parts of the paddock decreases ?

Project background

- Part of GRDC-funded program "Flexibility of varietal use" managed by QWCRC

- Pilot project
  - linked with larger GRDC project at CSIRO Land & Water
  - 9 month's salary spread over 2.5 years
  - finishes July 1999

- Main project aims to
  - understand within paddock yield response to variable inputs/ soil types
  - develop models to enable response to be predicted
  - resourced extensive fieldwork (1996-1998 seasons)

- To what extent does protein content and grain quality vary WITHIN A PADDOCK, especially for similar levels of fertiliser input ?

- Within paddocks, is there a relationship between grain yield, protein content and quality ?

- If extra nirogen or seed is used on responsive parts of the paddock to boost yield, does GRAIN PROTEIN CONTENT DECREASE ?

- How are these parameters affected by soil characteristics, plant nutritional status, crop development, or variation in fertiliser and seed rate inputs ? CAN THE RESPONSE BE PREDICTED ?

In initial work, we have examined 11 paddocks, from two WA and one NSW locations and four quality grades of wheat.

The paddocks also differed significantly in fertility, management inputs and grain yield and protein profiles.

Paddocks used were usually on commercial farms
Treatments could not risk significant loss of returns
thus variation was around mean fertiliser/ seed rates
planned by the grower/s

- Biniguy near Moree, N NSW
  Yallaroi durum wheat
  Uniform applications of urea fertiliser prior to sowing (200 kg/ha)
  plus MAP fertiliser (56 kg/ha) midway through growing season
  Soil and grain analyses performed
  used as an example of a relatively uniform paddock

- Rowland 1, Wyalkatchem, WA
  Blade hard wheat, 3 rd successive wheat crop
  Variable rate N fertiliser checkerboard
  Crop sampling, soil testing done

WA field sites – 1997
(Wyalkatchem (W) and Newdegate (N))

- W Shire 3   Cadoux noodle wheat   3 rd successive wheat crop
  Variable rate N fertiliser (30 - 90 kg/ha, average 50kg/ha)
  Crop samples and anthesis monitoring done

- W Home 6   Trident hard wheat   Pasture to Lupin to wheat rotation
  Variable seed and superphosphate (4 -100 kg/ha)
  Crop sampling done

- W Blackie 8   Blade hard wheat   Pasture to Lupin to wheat rotation
  Variable seed and N applied in strips

- W Blackie 6   Blade hard wheat   Pasture to wheat to wheat
  Variable seed
  Crop checks done

- N 2WD   Perenjori APW wheat   Lupins to barley to wheat
  Variable seed rate and soil types

WA field sites – 1998
(Wyalkatchem (W) and Newdegate (N))

- W Home 6   Spear hard wheat   Lupins to wheat to wheat rotation
  Variable N based on soil tests
  Monitored in 1997
  Crop sampling done

- W Rowlands 1   Blade hard wheat   Wheat to lupins to wheat rotation
  2 rates of N input and lime input

- W Home 8   Machete hard wheat   Wheat to lupins to wheat rotation
  Variable seed
  Crop checks done

- N 3WA   Hard wheat   Pasture to pasture to wheat rotation
 Variable lime and phosphorus

Crop testing   establishment, crop stem and tiller counts, spike counts
weed density, root diseases, anthesis dates (one paddock)

Soil testing   organic carbon, soil nitrate, ammonia
potassium, phosphorus, micronutrients (Mg, Zn, Cu)

Tissue testing   Nitrogen, major elements and micronutrients

Relate paddock fertiliser/ seed inputs and crop/ soil tests to:

Grain testing   yield, physical tests: hectolitre weight, 1000 kernel weight
protein content and grain sulfur content
glutenin content and molecular weight distribution
starch swelling (Cadoux only)

Quality testing   SDS-sedimentation volume
SE-HPLC for glutenin molecular weight distribution
Starch paste viscosity (RVA) on subset (Cadoux only)
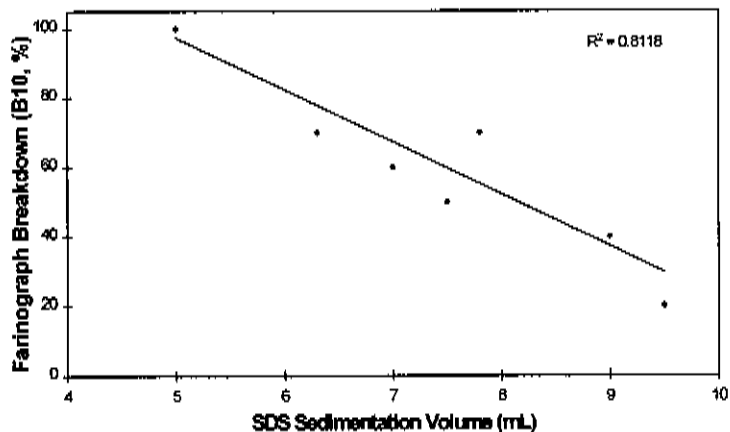
- Predictive tests (measure variation in quality in large sets of samples)
  - SDS-sedimentation tests (predicts baking quality)
  - starch swelling volume (predicts white salted noodle quality)

- Interpretive tests (understand basis of any variation in quality)
  - polymeric flour protein (glutenin) content
  - glutenin molecular weight distribution
  - glutenin composition (proportion of different subunits)

- Results are being related to:
  - effect of within-paddock variation of fertiliser and seed inputs on yield and protein content
  - field measurements of crop development, nutrition and anthesis
  - field measurements of soil type

- Description:
  - central strip contains an uncropped stony ridge
  - N half is weed infested, salt creeks along N and central S boundaries
  - average yield (1.1 T/ha), average protein (11 %)
  - rotation: pasture 95 - wheat 96 - wheat 97

- Variable Inputs:
  - seed rate (40-58 kg/ha) from grower's perception of yield potential

- Soil test results:
  - central N end of N half of paddock rather acid
  - significant paddock variability in soil organic carbon and nitrate status

- Tissue test results:
  - Micronutrient (Cu, Zn, P) deficiency in area with low soil pH
  - K deficiency in upper central part of paddock

- **Yield**
  - poor in N end of paddock (in areas affected by weeds, sandy soil, acid soil)
  - high in areas of high soil organic carbon and nitrate in S end of paddock

- **Grain weight**
  - low in N end of paddock

- **Grain protein content**
  - low in N end of paddock where soils were sandy or very acid
  - low in S central end where soils were sandy or salty
  - correlated with soil organic carbon ($r = + 0.47$) and nitrate ($r = + 0.55$)

- **Grain protein quality**
  - best in areas of high protein content ($r = + 0.52$)
  - but also good in an SE area of high yield (low soil acidity, average soil fertility)

- Aim: maximise yield and keep protein content above 11 %

1. Protein and yield are positively correlated ($r = 0.44$)
   - quality also positively correlated

2. Grain yield responsive to seed rate
   - thus could increase inputs in "good" parts of the paddock

3. Remedy area of soil acidity in N central end of paddock

4. Remedy weed problems in N half of paddock

5. Sandy ridge in N end of paddock shows negative gross margins
   - consider removing from production

- **Description:**
  - seeded and fertilised late in a dry year, yields depressed (average 0.88 T/ha)
  - sand blow-out in SE corner
  - rotation: wheat 95 - wheat 96 - wheat 97

- **Variable inputs:**
  - variable N fertiliser rate (30-90 kg/Ha) applied in sine wave
  - different inputs in four zones according to farmer's perception of yield potential

- **Soil test results:**
  - no areas had significant acidity or micronutrient deficiencies
  - organic carbon and nitrate status adequate, except NE corner central W areas

- **Tissue test results:**
  - tissue nitrogen deficient in N half of paddock
  - mild tissue S deficiency in NE corner, Cu deficiency in sand blow out area

- **Anthesis date:**
  - flowering varied over a 10 day period with clear spatial variation
  - no relationship with fertiliser, soil properties, yield, protein content or quality seen

---

- **Yield**
  - Poor in NE corner (low soil organic carbon and nitrate) and SE edge (sand)
  - High in centre, NW and SW corners

- **Grain weight**
  - Lower in high protein regions, highest in central W (moderate fertiliser input)

- **Grain protein content - Very large variation:**
  Too low in NW corner (high N fertiliser directed to high yields)
        in NE corner (low soil organic carbon and nitrate also produce low yields)
        in SE edge (sand blow out)
  Too high in S central region (soil pH high, high organic carbon/ nitrate, yields average)
  Correlated with soil organic carbon ($r = + 0.44$), nitrate ($r = + 0.36$) and K ($r = + 0.50$)

- **Grain protein quality**
  - Best in areas of high protein content ($r = + 0.92$)
  - Very close correlation because of huge variation in grain protein content

Example 2. Shire of Wyalkatchem WA
Implications for management

- **Aim: maximise yield, maintain protein content in 9.5 - 11.5 % range**

1. **Protein and yield are not correlated**
   - thus no "protein penalty" on high yielding areas

2. **Neither protein nor yield correlated with urea application rate**
   - urea applied too late and 1997 season too dry for incorporation

3. **Much of the grain was outside allowable protein range for noodle wheats**
   - reduce N inputs to SE corner
   - harvest low protein areas separately
   - try increased and better timed N inputs

Example 3. Marinya, Binlgoy, N NSW
Yallaroi durum wheat

- **Description - No variable inputs:**
  - summer rainfall area, thus "stored moisture" important
  - largely grey soil with small area of red soil in NW end
  - high yield (4.1 T/ha), medium to high protein (12.4 %)

- **Soil:** variation in soil texture and water holding capacity, neutral pH

- **Yield:** High in areas of high soil organic carbon ($r = + 0.44$)

- **Grain weight:** Relatively uniform, smaller grains in high protein area

- **Grain protein content:** Moderate variation (10.5 to 14.3 %)
  - highest near NW end (red soil ridge that was also highest in pH)
  - possibly due to late season water stress limiting yield
  - Lowest in SE end. Weak negative correlation with yield ($r = - 0.33$)

- **Grain protein quality**
  - Variation in quality more marked than variation in protein content
  - Total and insoluble glutenin highest at high protein content ($r = + 0.70, + 0.45$)

- Aim: maximise yield and aim for protein content > 13 %

1. Need to slightly increase average protein to achieve No. 1 durum
   grade instead of No. 2 grade

2. Yield is already high and may be limited by soil water
   - thus additional Nitrogenous fertiliser may be directed towards protein

3. Grain from highest protein area of paddock slightly pinched
   - thus do not want to have more high protein, pinched grain
   - reduce N inputs here and redistribute elsewhere on paddock

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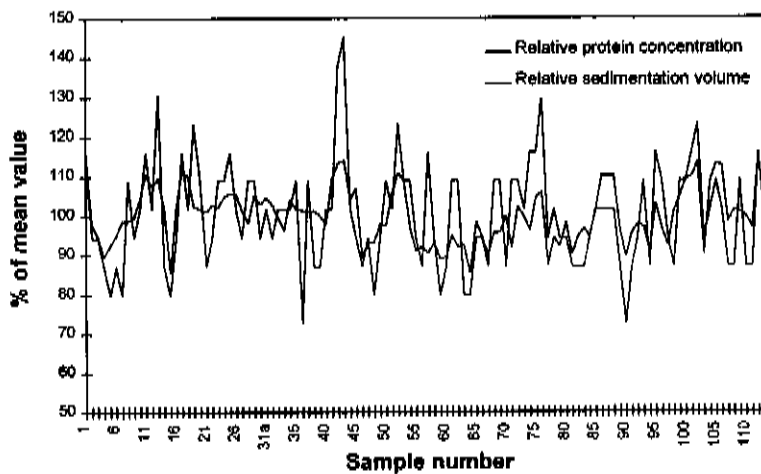
- Within-paddock variation in protein content and protein quality often is very significant and as large as between-paddock variation for the same wheat type/ cropping environment

- Areas of higher yield usually do not provide lower protein content or protein quality. Thus use of precision agricultural methods to increase yield does not result in a protein content/ quality penalty

- Within-paddock variation in wheat quality is often greater than within-paddock variation in protein content

- In 1997, soil characteristics (pH, organic carbon, nitrate) had a more significant effect on grain protein content than variation in fertiliser application or seed rate

- Testing of samples from 1998 season will obtain more data on other paddocks with variable fertiliser inputs, to establish whether the trends noted in 1997 are able to be generalised

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- Examination of results of site-specific monitoring of yield, protein and grain quality for each paddock provides recommendations for the next season:
  - gross margins may be increased by removing a very poorly performing part of the paddock from production
  - uniformity of protein content and quality may be improved by strategic variation in fertiliser application

- In collaboration with local agronomists, future work will be needed to determine whether:
  - the adoption of suggested/ modelled individual paddock management practices based upon site-specific monitoring data from one season
  - does actually lead in the subsequent season, to increased within-paddock uniformity and higher gross margins!
  - whether "certainty maps" can be developed for obtaining N fertiliser responses based on prior response, soil type, pH and organic cabon and nitrate status

- Establish the reliability of on - header NIR protein monitoring equipment and develop guidelines for its use

PART 3. "FLEXIBILITY OF WHEAT USE"
- THE GRDC/CRC SET OF PROJECTS

Blending - dough

-Frank Bekes
CSIRO Plant Industry

Blending of Quality Types
Principles and Predictions

Project 5 of GRDC and Quality Wheat CRC 2.1.5

FLEXIBILITY OF WHEAT USE

Aims:

1) Develop strategies to maximise $ returns by blending wheats

2) Determine relationships between
   - ■ simple measured aspects of composition blending components and
   - ■ processing properties of blends

3) Establish procedures to predict qualities of blends in situations that offer economic advantage

Test methods used

Wheat testing:
- protein and moisture content
- test weight
- Falling Number
- psi
- single kernel analysis for size and hardness

Flour testing:
- protein and moisture content
- starch demage
- color grade
- Farinograph test
- Extensograph test
- Alveograph test

Small-scale tests
- 2g Mixograph
- Micro-Extension Tester

Chemical analysis:
- SE-HPLC for glutenin:gliadin:alb.globulin content
- RP-HPLC for HMW/LMW ratio
- RP-HPLC for HMW glutenin subunit composition
- RP-HPLC for gliadin composition

Contributors:

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AGT-AWB: Peter Hart
Bungi/Defiance: Mark Baczynski
George Westons: Bernie O'Riordan
Goodman Fielder: Di Miskelly

Summary of quality aspects for study

QUALITY ATTRIBUTE

RELEVANT ASPECT OF COMPOSITION

1) Dough properties
- Water Absorption
- Extensibility
- Dough strength
- Dough stability

Protein content
Glu/Gli ratio
HMW/LMW ratio
Size distribution of
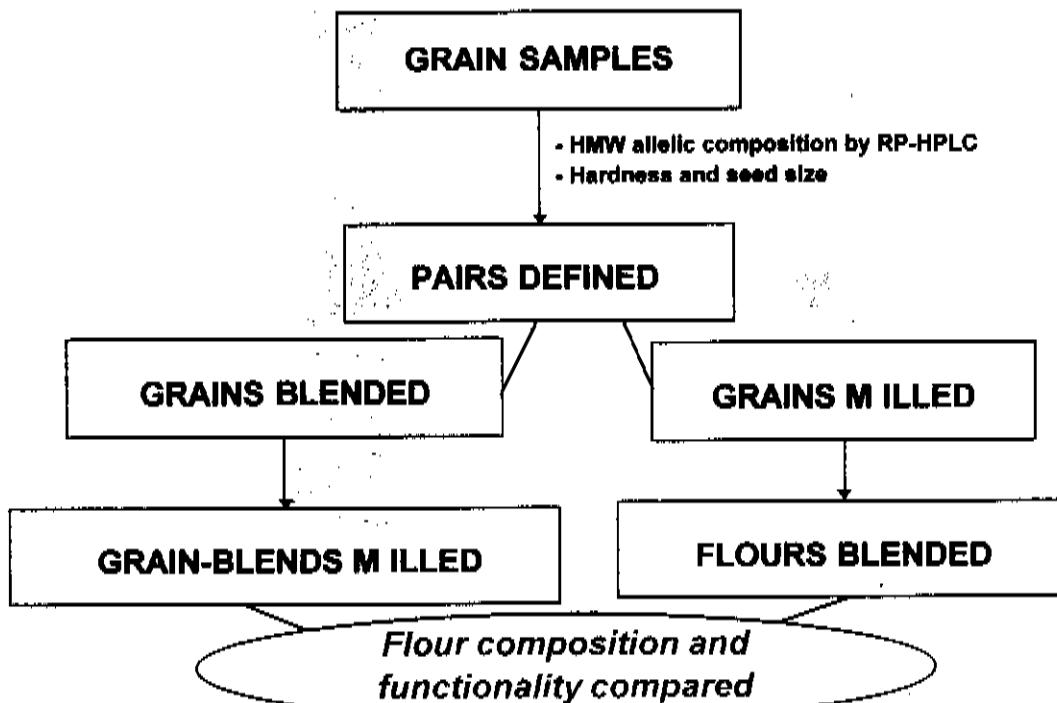   glutenin proteins

2) Milling quality
3) Noodle color
4) Rain damage
5) Starch properties

WHEAT

COMPARING GRAIN AND FLOUR BLENDS

```
                    ┌─────────────────────┐
                    │    GRAIN SAMPLES    │
                    └─────────────────────┘
                              │
                    - HMW allelic composition by RP-HPLC
                    - Hardness and seed size
                              │
                    ┌─────────────────────┐
                    │    PAIRS DEFINED    │
                    └─────────────────────┘
```

GRAINS BLENDED		GRAINS M ILLED
GRAIN-BLENDS M ILLED		FLOURS BLENDED

Flour composition and functionality compared

The effect of protein composition on the non-linearity of **mixing time** in two-component blends

A - 2*, 17+18 , 2+12
B - 2*, 7+ 8 , 2+12

The effect of protein composition on the non-linearity of **mixing time** in two-component blends

A - 2* ,7+8, 2+12
B - 2* ,7+8, 5+10

The effect of protein composition on the non-linearity of **peak resistance** in two-component blends

B - 2*,7+8, 2+12
A - 2*,7+8, 5+10

The effect of protein composition on the non-linearity of **peak resistance** in two-component blends

A - 1,7+8, 2+12
B - 2*,7+8, 5+10
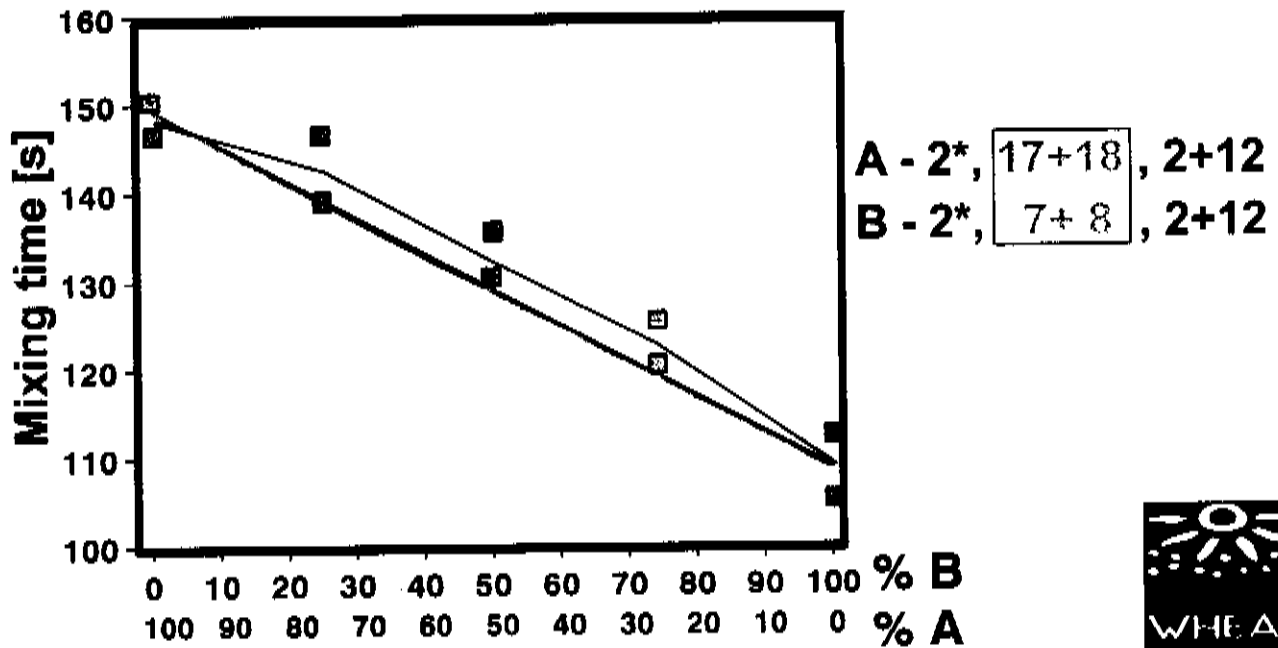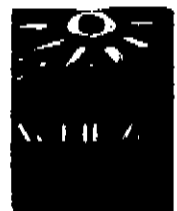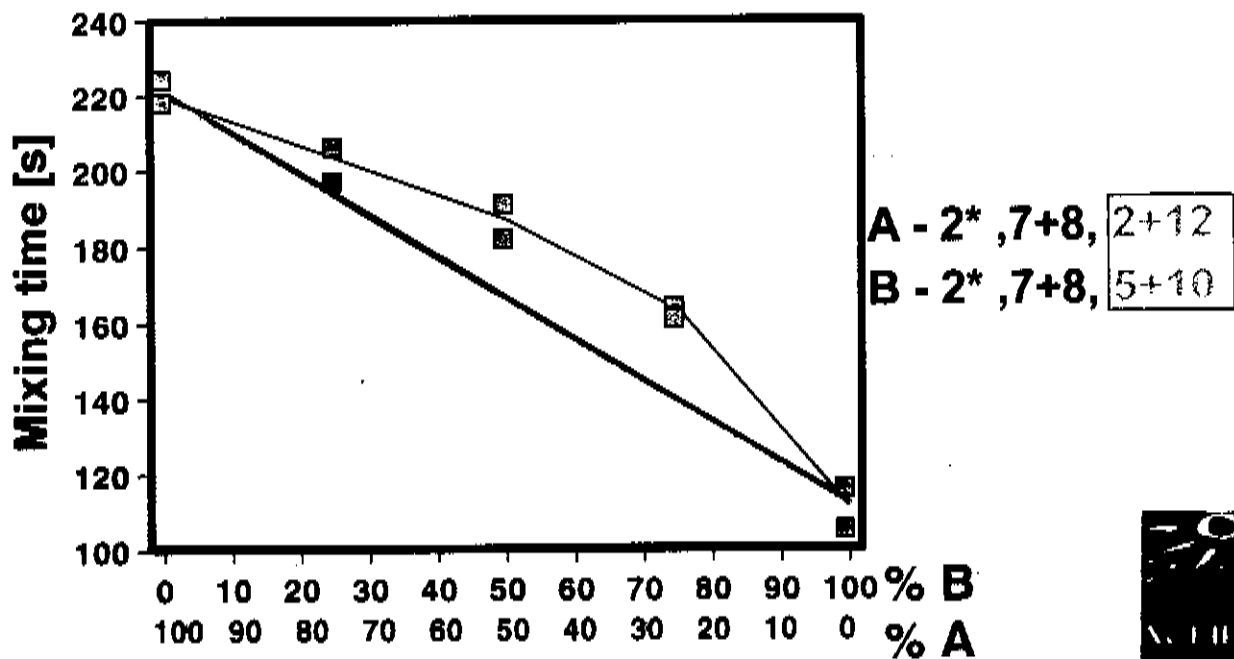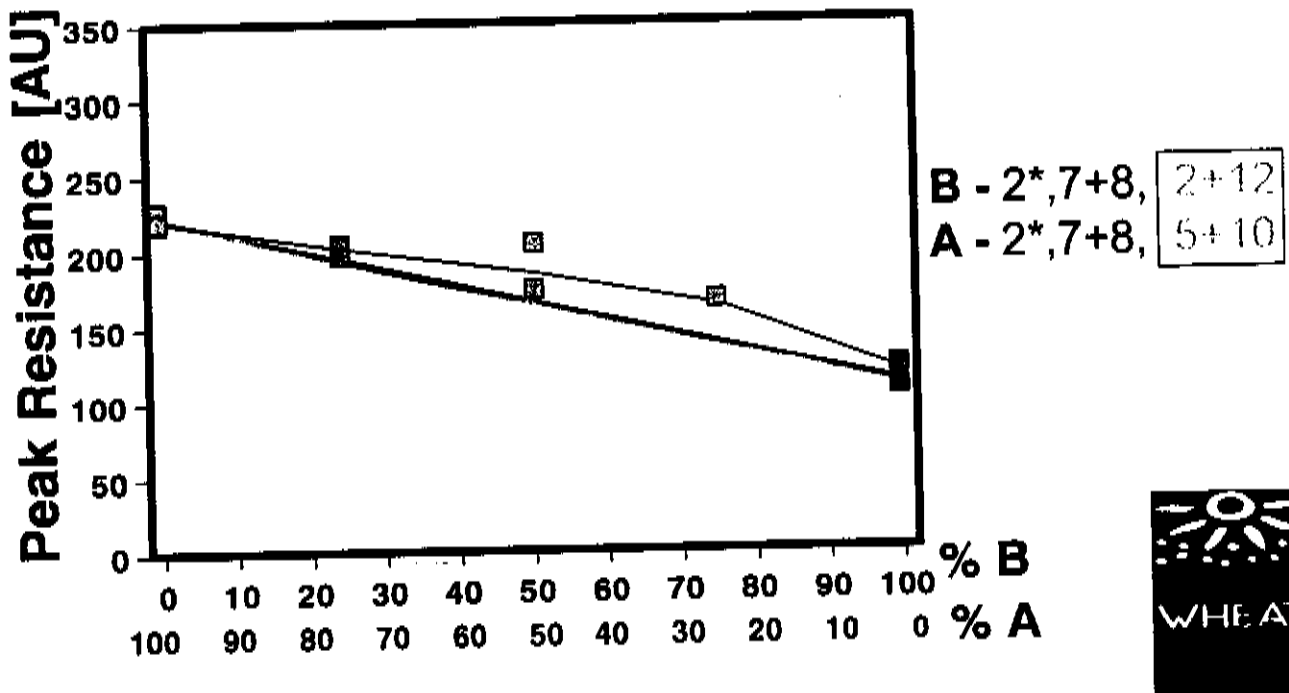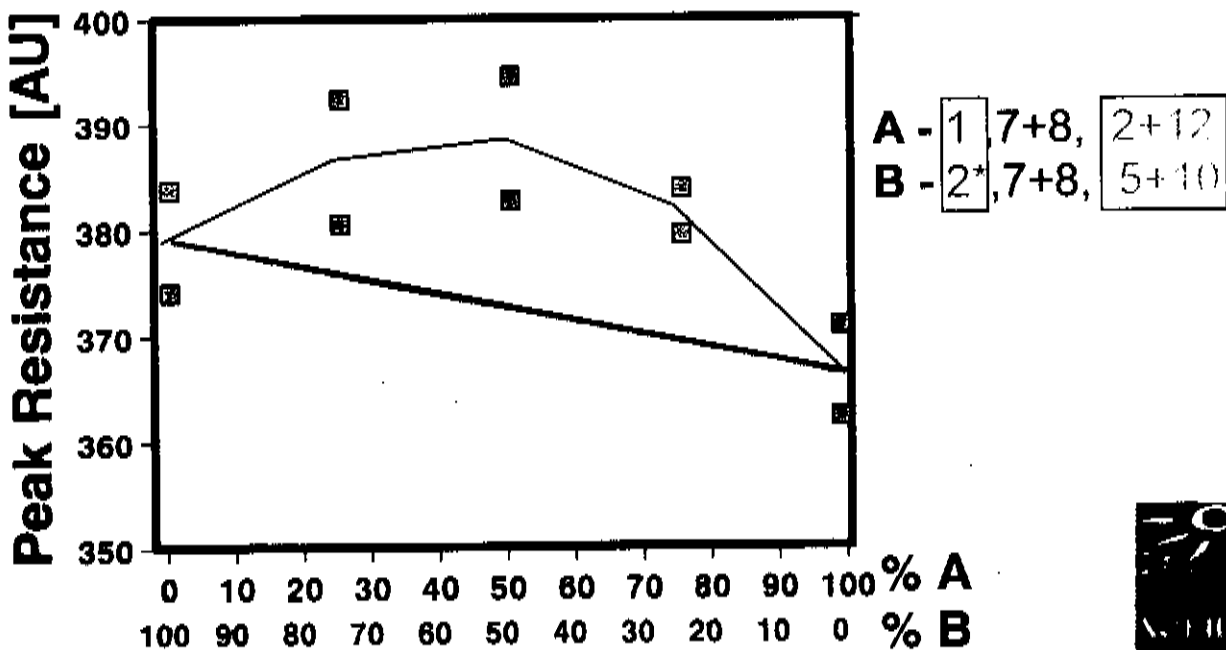
Comparison of the MIXING TIMES of flour and grain blends
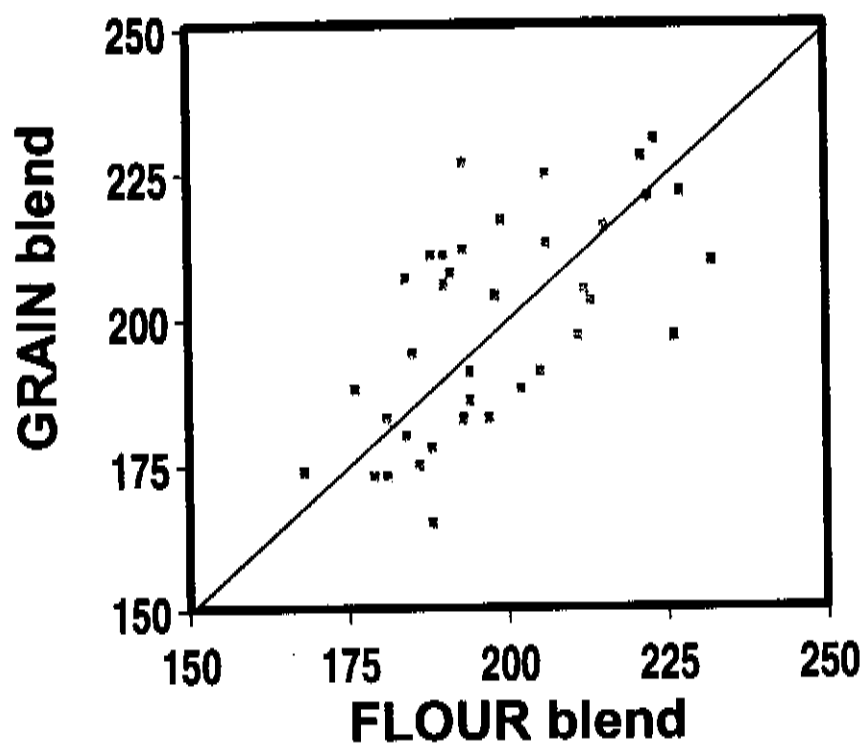
Comparison of the EXTENSIBILITIES of flour and grain blends

Top figure x-axis labels:

Cunningham: 0 10 20 30 40 50 60 70 80 90
Sunstate: 100 90 80 70 60 50 40 30 20 10

Bottom figure x-axis labels:

Sunland: 0 10 20 30 40 50 60 70 80 90
Sunmist: 100 90 80 70 60 50 40 30 20 10
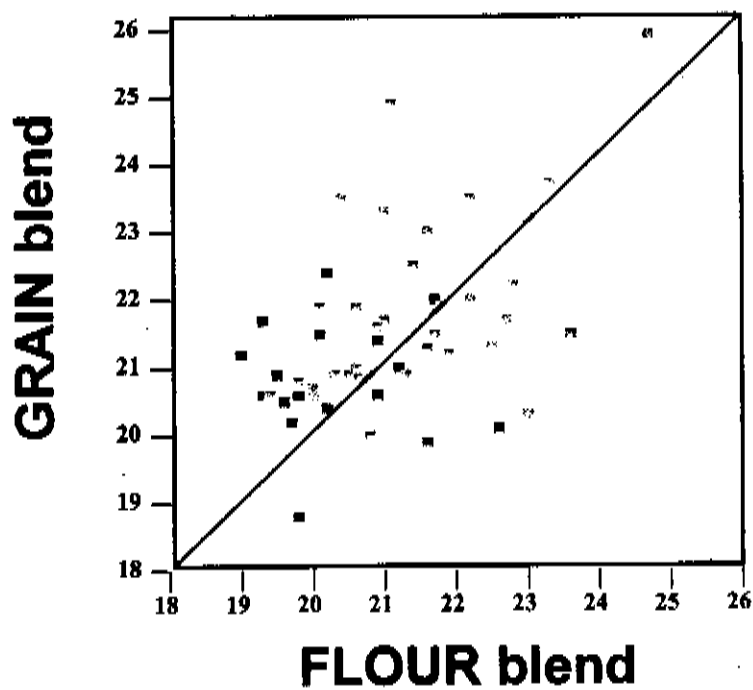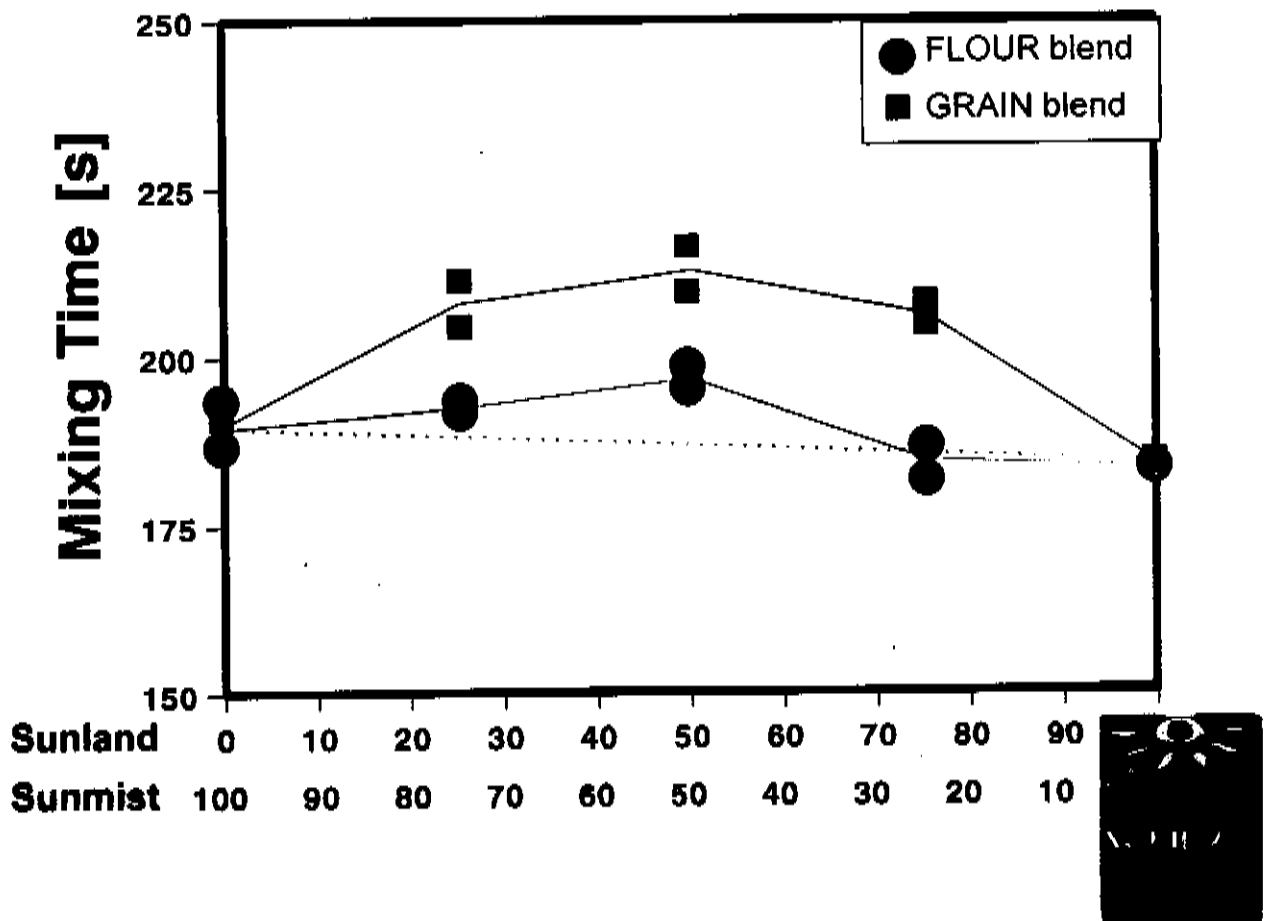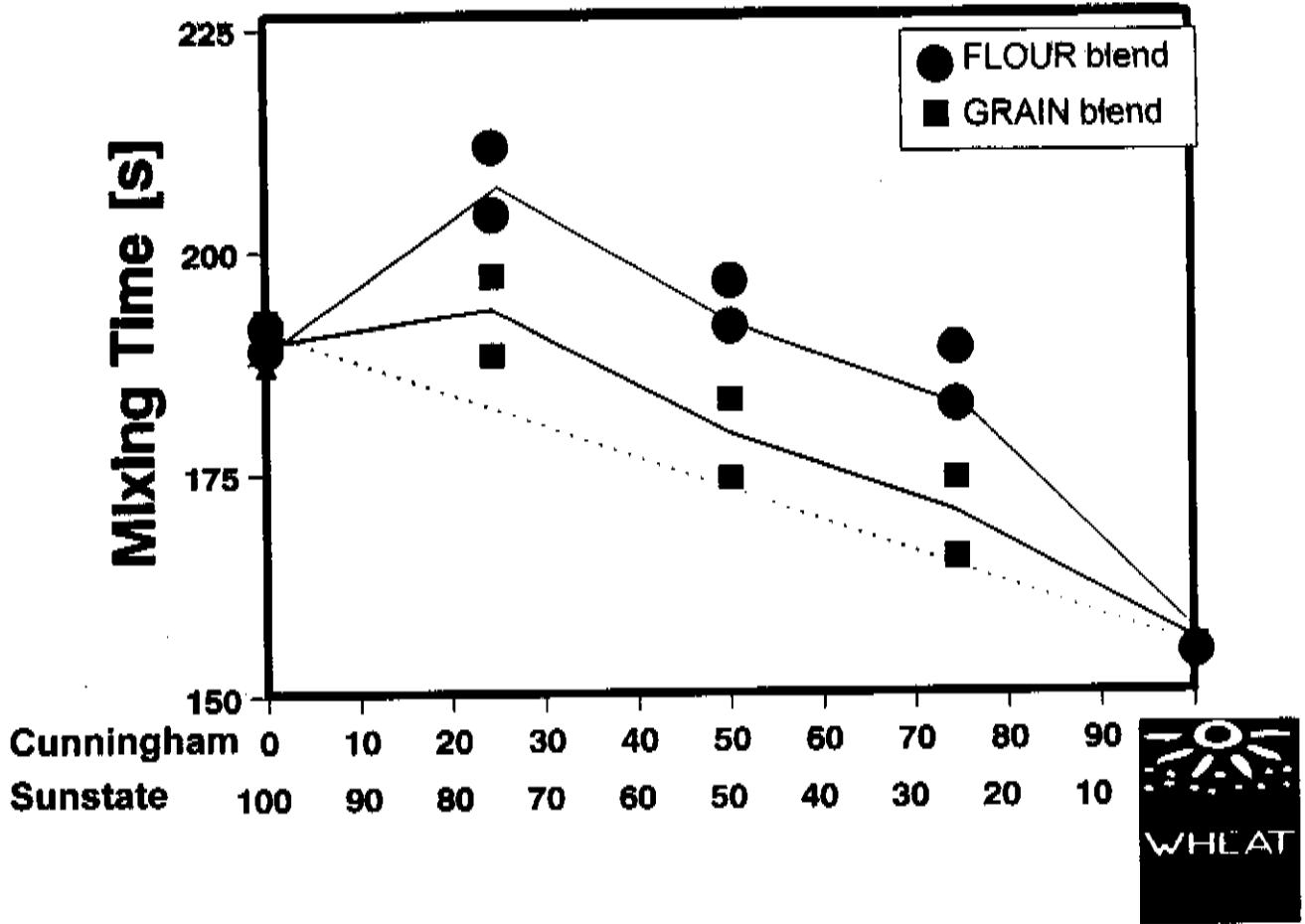
RP-HPLC separation of HMW glutenin subunits isolated from flour and grain blends

SUNMIST
SUNLAND
50-50% blends
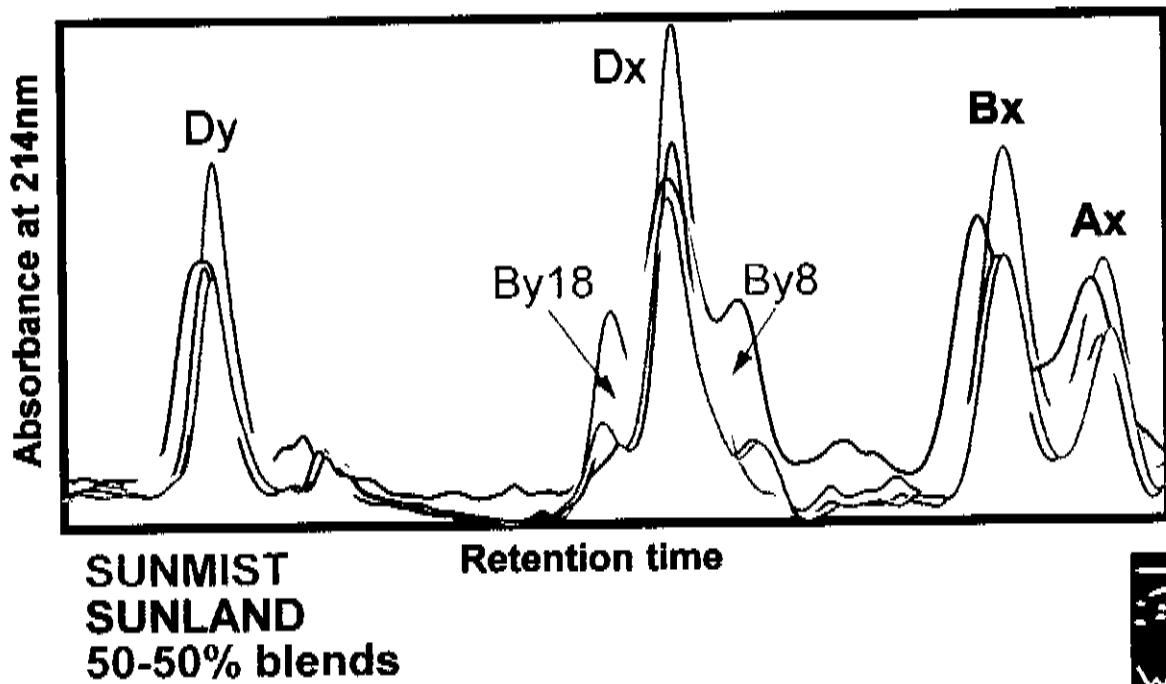
Comparing the chemical composition of flour and grain blends
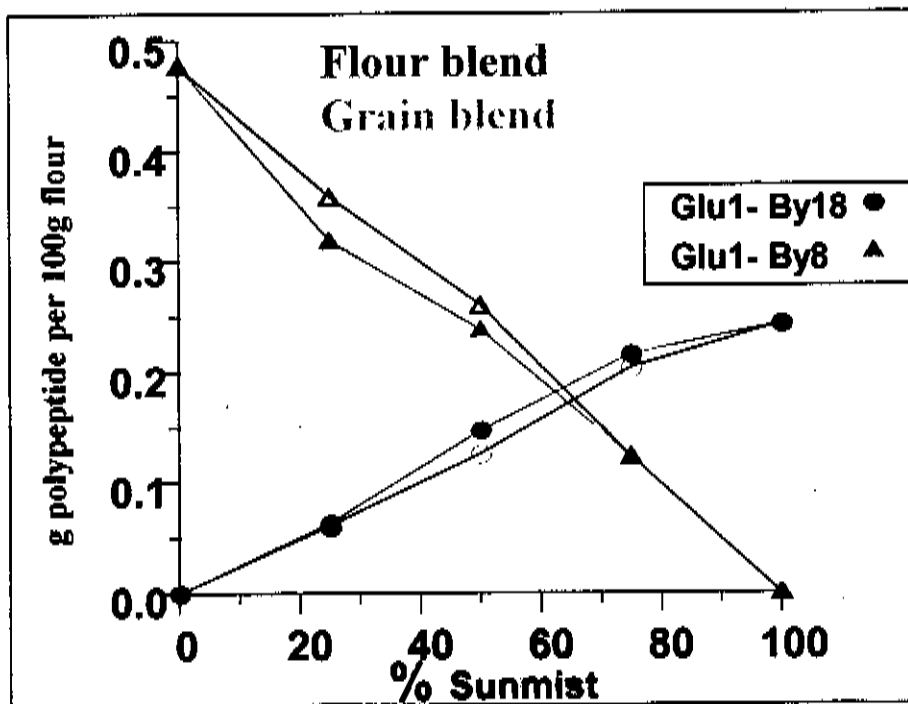
Mixing Time
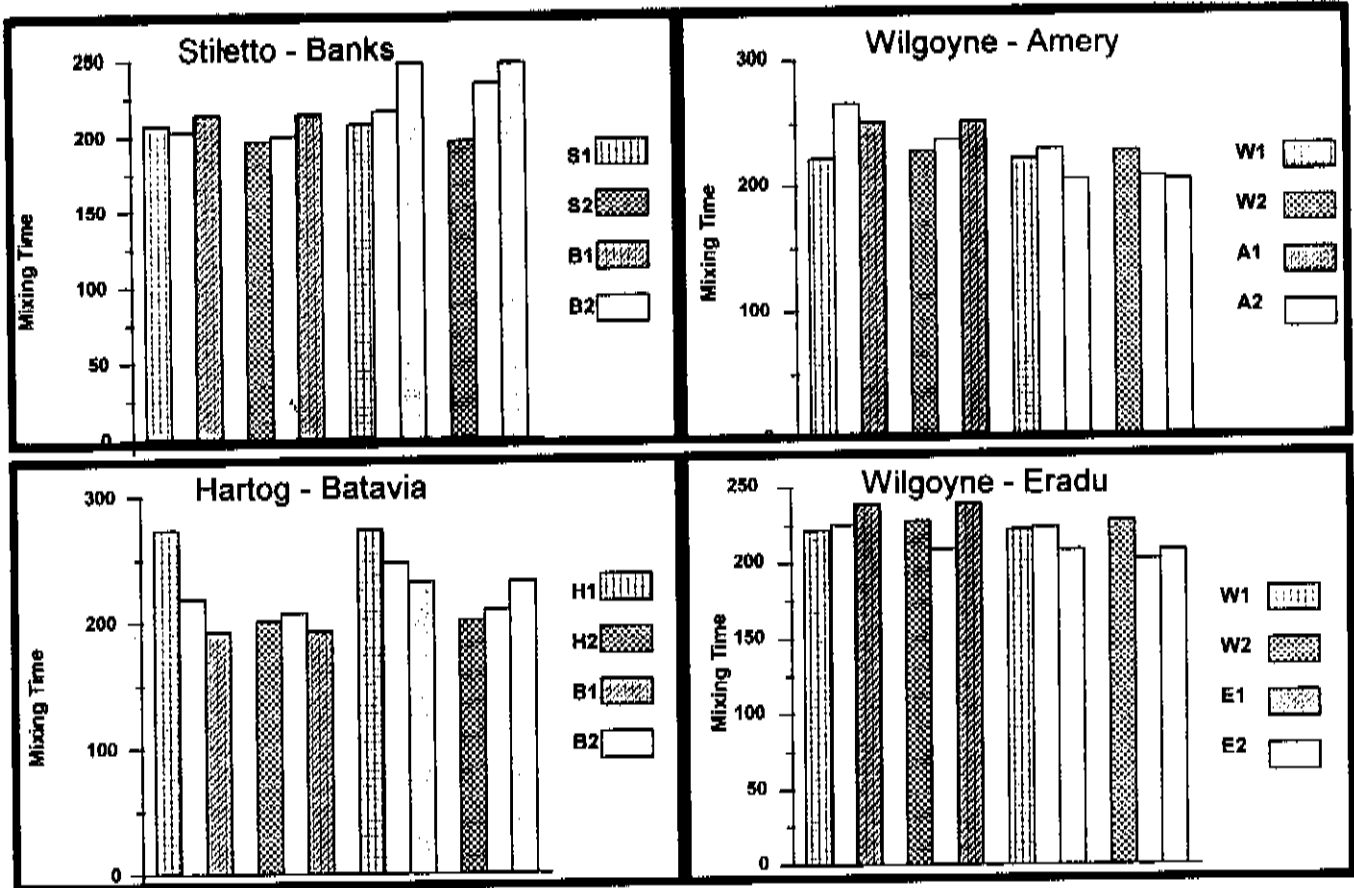
Stiletto - Banks

Legend: S1, S2, B1, B2

Wilgoyne - Amery

Legend: W1, W2, A1, A2

Hartog - Batavia

Legend: H1, H2, B1, B2

Wilgoyne - Eradu

Legend: W1, W2, E1, E2

The effect of protein content of components in Stiletto (50%) - Sunmist (50%) blends

Flour blends   Grain blends

Legend: St1Sn1, St1Sn2

The effect of protein content of components in Stiletto (50%) - Banks (50%) blends

Flour blends   Grain blends

Legend: S1B1, S1B2, S2B1, S1B2

The effect of protein content of components in Stiletto (50%) - Sunmist (50%) blends

Flour blends   Grain blends

Legend: St1Sn1, St1Sn2

The effect of protein content of components in Stiletto (50%) - Banks (50%) blends

Flour blends   Grain blends

Legend: S1B1, S1B2, S2B1, S1B2

Multi-component blending

Batavia
Cunningham
Hartog
Banks

25-25-25-25	
50-15-15-20	
15-50-15-20	
15-15-50-20	
calculated	

Multi-component blending

Batavia
Cunningham
Hartog
Banks

25-25-25-25	
50-15-15-20	
15-50-15-20	
15-15-50-20	
calculated	

Multi-component blending

Batavia
Cunningham
Hartog
Banks

- 25-25-25-25
- 50-15-15-20
- 15-50-15-20
- 15-15-50-20
- calculated

Multi-component blending

Batavia
Cunningham
Hartog
Banks

- 25-25-25-25
- 50-15-15-20
- 15-50-15-20
- 15-15-50-20
- calculated

Predicting the biological value of food protein blends

BV

Legend:
- — Morup-Olesen index
- + BV
- * FAO-WHO

$$BV \neq x_A^* \, BV_A + x_B^* \, BV_B$$

% egg protein
% potato protein

| % egg protein | 0 | 20 | 40 | 60 | 80 | 100 |
| % potato protein | 100 | 80 | 60 | 40 | 20 | 0 |
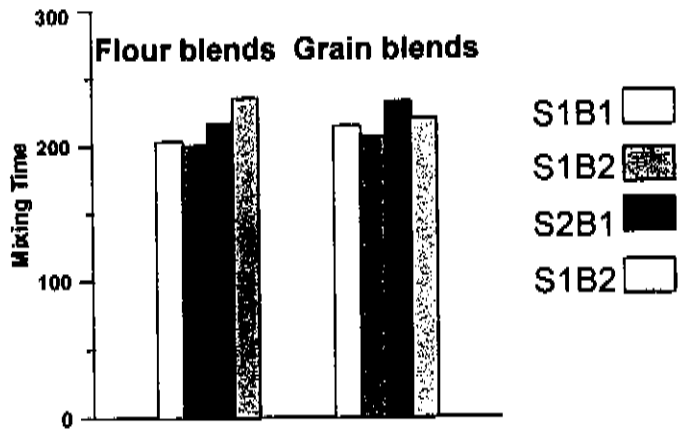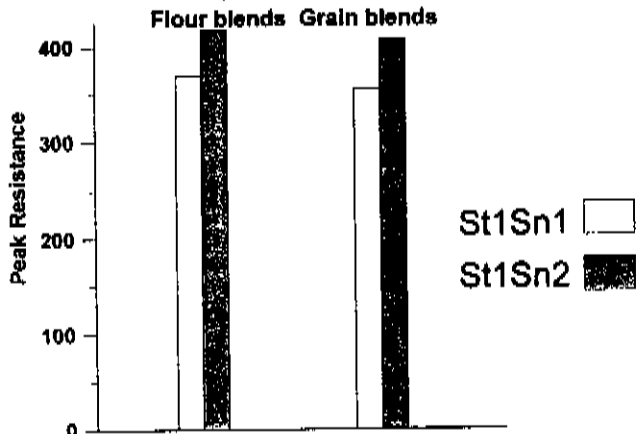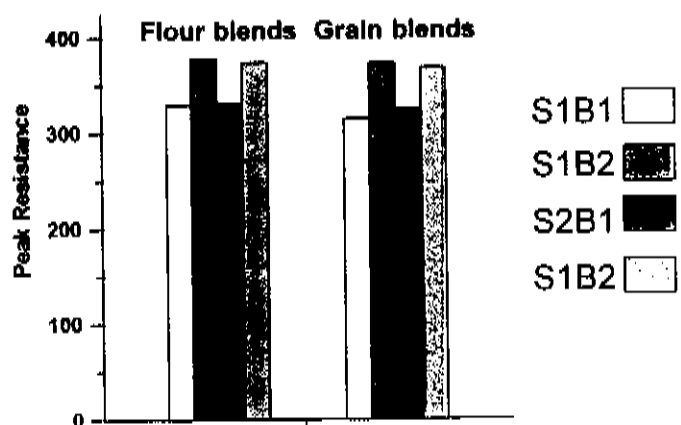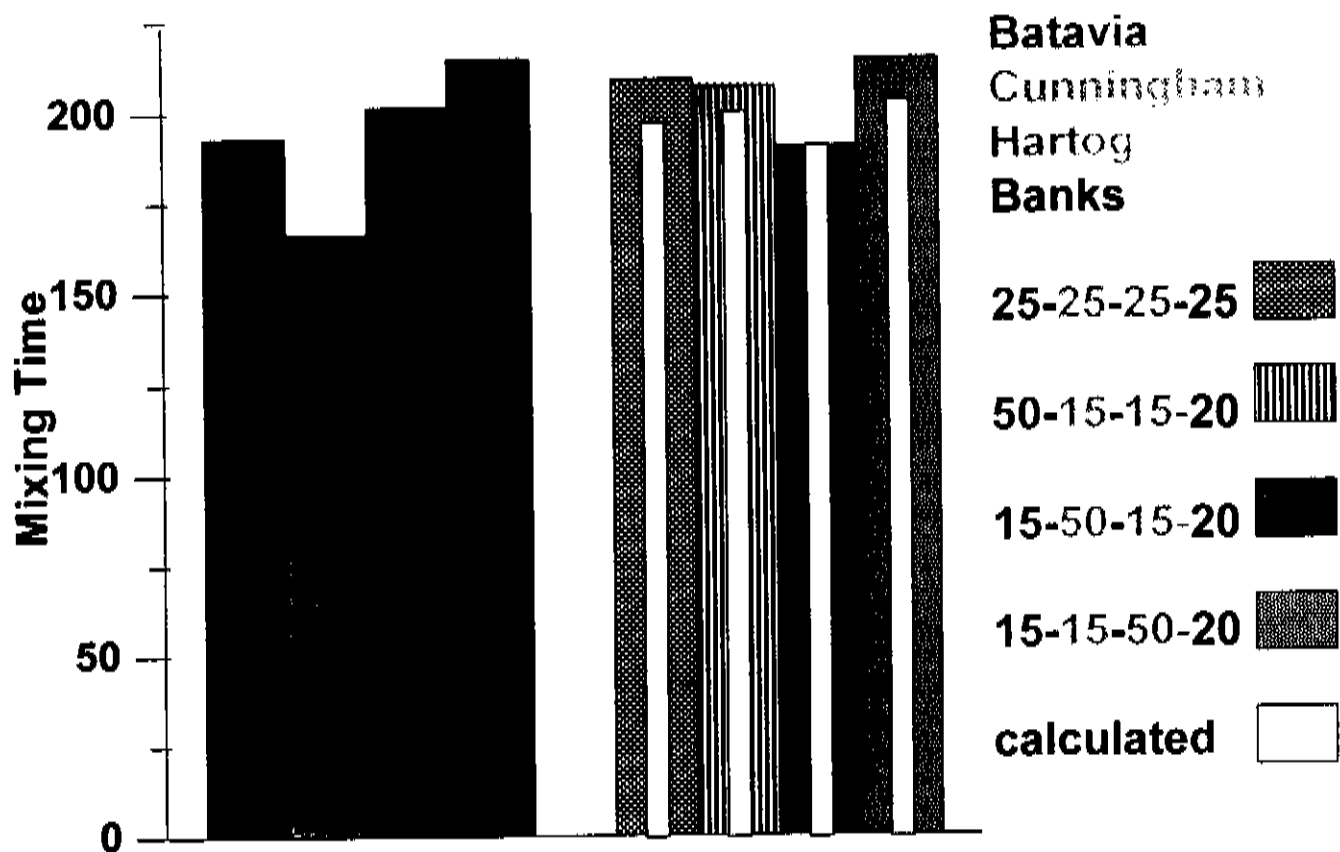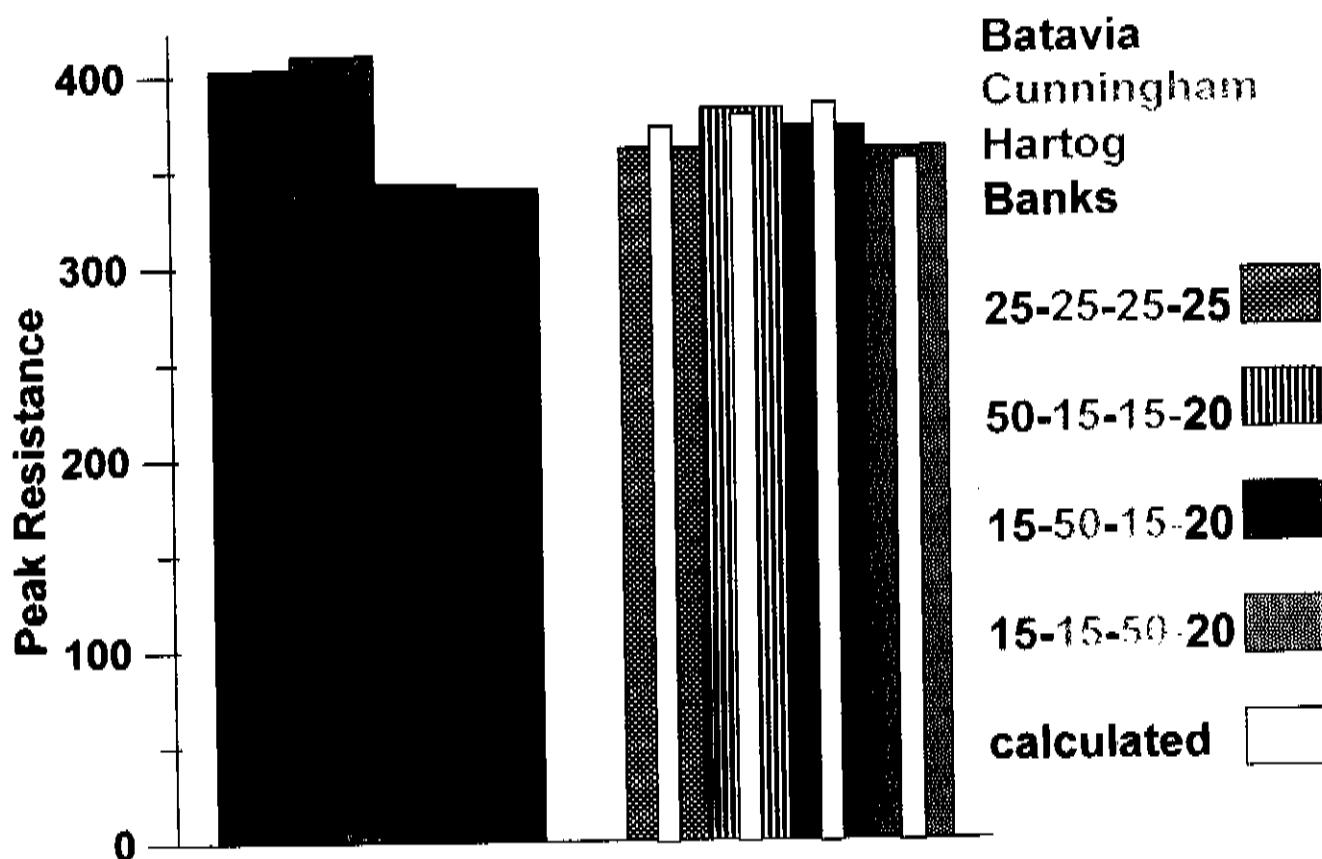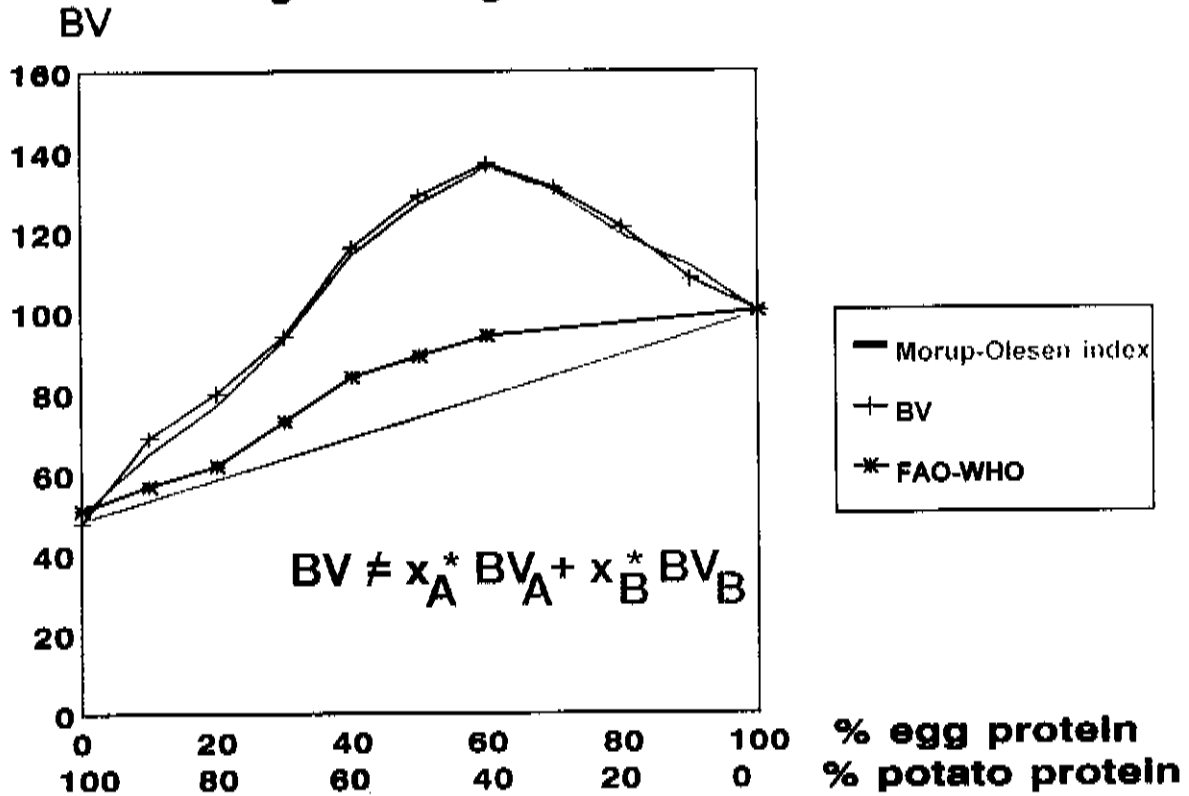
Predicting the biological value of food protein blends

$$a_i = \sum_{j=1}^{m} x_i^* a_{i,j}$$

$$BV \approx PV = q_o \sqrt[n]{\prod_{i=1}^{n} q_i^{e_i}} = q_o * \sqrt[n]{\prod_{i=1}^{n} \left[\frac{\left(\dfrac{(a_i)}{\sum_{i=1}^{n}(a_i)} \right)_{sample}}{\left(\dfrac{(a_i)}{\sum_{i=1}^{n}(a_i)} \right)_{reference}} \right]^{e_i}}$$

$$= q_o * \sqrt[n]{\prod_{i=1}^{n} \left[\frac{\left(\dfrac{\sum_{j=1}^{m} x_i^* a_{i,j}}{\sum_{i=1}^{n} \sum_{j=1}^{m} x_i^* a_{i,j}} \right)_{sample}}{\left(\dfrac{(a_i)}{\sum_{i=1}^{n}(a_i)} \right)_{reference}} \right]^{e_i}} = \boxed{f(x_i, a_{i,j})}$$

Anomalies in quality parameters of blended flours

In 10-15% of the cases of industrial blending:

$$Q \neq \sum_{i=1}^{n} x_i^* Q_i \qquad \sum_{i=1}^{n} x_i = 1$$

Q - quality parameter of the blend

Q_i - quality parameter of the i-th component

x_i - mass fraction of the i-th component

n - number of components in the blend

$$Q \neq x^* Q_A + (1-x)^* Q_B$$

Sample A 0 10 20 30 40 50 60 70 80
Sample B 100 90 80 70 60 50 40 30 20 1

WHEAT
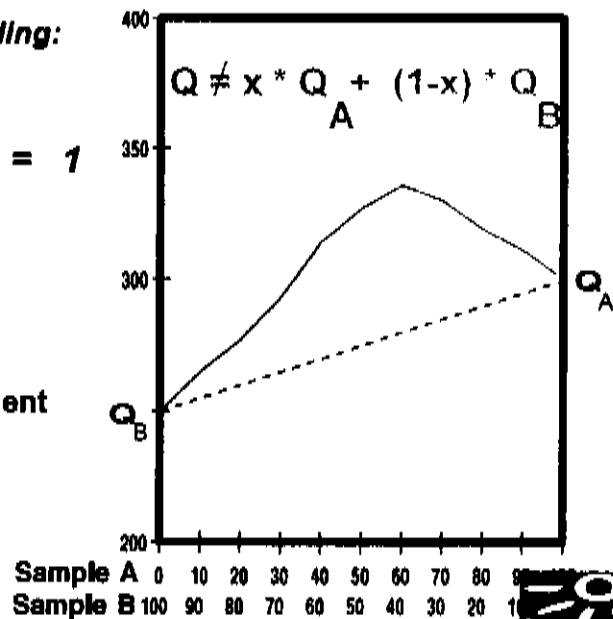
PV = f(x_{flour} - formulation of the blend
    PR   - protein content of the components
    Glu/Gli ratio of the components
    size distribution of polymeric proteins in the components
    HMW/LMW ratio of the components
    quantitative HMW-GS allelic composition of the components
    quantitative HMW-GS allelic composition of the components
    quantitative HMW-GS allelic composition of the components)

x_{flour} = f(x_{grain} , milling properties of the components)

Tools for Achieving Wheat-Quality Targets

PART 3. "FLEXIBILITY OF WHEAT USE" - THE GRDC/CRC SET OF PROJECTS

Blending - colour

-Bob Cracknell and Graham Crosbie
AWB Ltd and WA Agriculture

Report on blending studies associated with "Flexibility of wheat use" project.

G.B. Crosbie, Agriculture WA, March 1999

Aspects considered

Prediction of raw and boiled noodle colour from flour

Linearity of colour measurement in blends of soft and hard wheat flour

Current study – upgrading of low protein noodle wheat

Report on blending studies associated with "Flexibility of wheat use" project.

G.B. Crosbie, Agriculture Western Australia, March 1999

Prediction of raw and boiled noodle colour from flour

This study built on earlier work by Oliver et. al. (1993) who showed an apparent effect of particle size on the relationship between Minolta b* and yellow pigment levels of Buhler flour - the correlation coefficient was improved by testing flour-water slurries rather than dry flour.

In the present study, 8 samples of hard wheat and 9 of soft wheat, with varying combinations of Minolta L*, a* and b*, were selected from trials grown in Western Australia in 1994.

The wheats were milled at 60% extraction on a Buhler mill and also on a Quadrumat Junior mill.

Udon noodles were prepared from 60% extraction flours.

Flour colours were measured as dry flour and as flour-water slurries.

Results

Table 1 shows that correlations between flour and noodle colour (both raw and boiled noodles) were generally improved if colour measurements were carried out on flour water slurries rather than dry flour.

Table 1. Correlation coefficients between flour and noodle colour measurements.

Noodle type	Quadrumat flour		Buhler, 60% extn flour	
	Dry	Slurry	Dry	Slurry
L*				
Raw noodle sheet	0.70**	0.60*	0.85**	0.85**
Boiled noodle	0.44	0.73**	0.49*	0.60*
a*				
Raw noodle sheet	0.94**	0.94**	0.87**	0.96**
Boiled noodle	0.87**	0.85**	0.87**	0.94**
b*				
Raw noodle sheet	0.77**	0.93**	0.84**	0.98**
Boiled noodle	0.62**	0.85**	0.71**	0.94**

$* P < 0.05; ** P < 0.01$

The improved correlations were largely due to a minimisation of the effects of particle size differences between flours from hard and soft wheats.
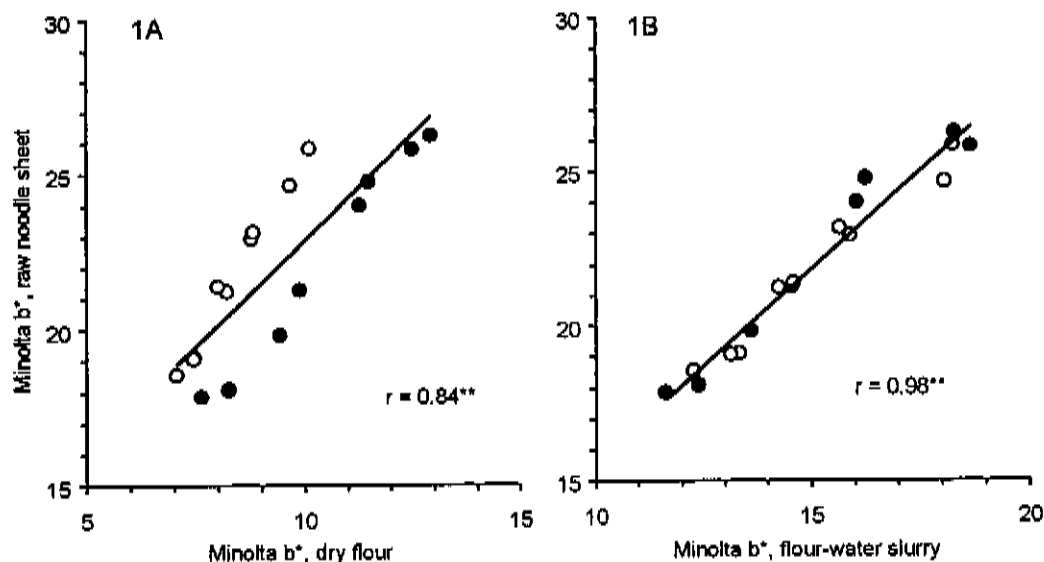

Figure 1. The relationships between Minolta b* values from dry flour and flour-water slurries and corresponding values from raw noodle sheets (at 0 hr).

Flours from soft and hard wheats showed clearly different relationships when Minolta colour tests were carried out on dry flours, but the differences were largely eliminated when the tests were done on flour-water slurries.

Conclusions

Predictions of raw and boiled noodle colour from flour colour measurements are greatly improved if the tests are carried out on flour-water slurries rather than dry flour.

The results have application in the following areas:

1. In wheat breeding, selection for improved noodle colour can be achieved by tests carried out on Quadrumat flour-water slurries.

2. In WA, in the management of the blending of segregated soft-grained noodle wheat and hard-grained APW wheat. The two components vary in varietal composition and yellow pigment level at the various receival points, and a testing program based on Quadrumat-milled flour would assist in minimising variation in yellow pigment levels and noodle colour between shipments. The results from this study and associated recommendations have been sent to the AWB.

3. In flour milling and noodle manufacturing plants, in relation to raw material quality control.

Linearity of colour measurement in blends of soft and hard wheat flour

This study was done to check out the linearity of Minolta b* measurements in blends of flour of hard and soft wheat that varied in yellow pigment level.

Four samples of Buhler-milled flour were selected:

- Flour from soft wheat of low yellow pigment (S1) and high yellow pigment (S2).

- Flour from hard wheat of low yellow pigment (H1) and high yellow pigment (H2).

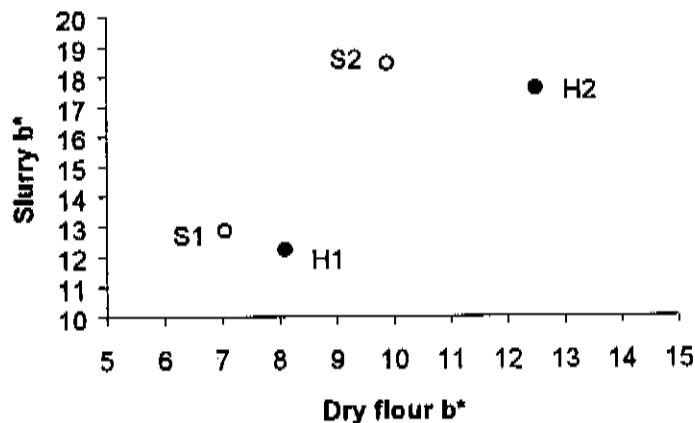Dry flour and flour-water slurry Minolta b* values of the four samples are shown in Figure 2.

Figure 2. Dry flour and flour-water Minolta b* values for the four samples used in the blending study.

Note from Figure 2 that for dry flour, Minolta b* on H1>S1 and H2>S2. However, for slurry measurements (and expected noodle colour from previous study) S1>H1 and S2>H2. This highlights the substantial effect that particle size has on dry flour measurements, and that particle size effects can alter rankings of varieties in terms of predicted noodle colour.

The linearity of Minolta b* measurements in various flour blends was assessed. Here all combinations of S1, S2, H1 and H2 flours were tested as blends, mixed in the following ratios: 0:100, 20:80, 40:60, 60:40, 80:20, and 100:0.

For each combination of flours there was a strong linear correlation between Minolta b* and the ratio of the two components in the blend – this was the case with both dry flour and flour-water slurry measurements (Table 2).

Table 2. Correlation coefficient between Minolta b* and relative proportions of the two main components.

Blends 0:100, 20:80, 40:60, 60:40, 80:20, 100:0	Dry flour	Flour-water slurry
	Correlation coefficient, r	
S1:H2	0.999**	0.999**
H1:H2	1.000**	0.998**
S1:H2	0.999**	0.999**
H1:S2	0.994**	1.000**
S1:H1	0.995**	0.967**
S2:H1	0.995**	0.984**

**P<0.01

The above study showed that the Minolta b* of various flour blends could be accurately predicted from the b* values of the two basic components and their relative proportions in the blend. However, an earlier study had clearly pointed to the better prediction of noodle colour if the tests were done on flour-water slurries.

Current study – upgrading of low protein noodle wheat

Since the inception of the noodle wheat segregation in WA in 1989/90, production of noodle wheat has failed to meet the market demand. To meet the tonnage required, segregated noodle wheat (ASWN) continues to be blended with specially selected APW.

Despite this shortfall, each year considerable quantities of noodle wheat (>100,000 t) fail to meet the ASWN minimum of 9.5% protein (or 9.0% with active stack management), suffering a large financial penalty (currently $37.50/t).

This study explores the possibility of upgrading low protein noodle wheat (with the right protein quality and an abundance of high-swelling starch) by blending with higher protein wheat. The aim will be to produce a blend that is at least comparable in quality to the current ASWN:APW blend.

The AWB has supported the study by providing samples of wheat representing shipments to Japan this year, together with various samples of AH. The AH samples will be adjusted to a varietal composition similar to that in APW (by blending in small quantities of APW specific varieties such as Spear and Stiletto from AWA trials).

If this study shows that upgrading of low protein noodle wheat is feasible, it should be noted that the upgrading would involve additional costs. Here we are proposing the blending together of wheat that varies considerably in protein content (and varietal composition). The current blending of ASWN and APW involves wheat that varies less in protein content but also varies in varietal composition. We would have to be certain that the blending capability is in place. Facilities may be adequate in the Fremantle Zone with a special blending facility at Kewdale – this would allow the adequacy of the blending to be checked prior to loading on the ship. Such facilities are lacking at Geraldton.

G.B. Crosbie
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Table 1. Correlation coefficients between flour and noodle colour measurements.

Noodle type	Quadrumat flour		Buhler, 60% extn flour	
	Dry	Slurry	Dry	Slurry
L^*				
Raw noodle sheet	0.70**	0.60*	0.85**	0.85**
Boiled noodle	0.44	0.73**	0.49*	0.60*
a^*				
Raw noodle sheet	0.94**	0.94**	0.87**	0.96**
Boiled noodle	0.87**	0.85**	0.87**	0.94**
b^*				
Raw noodle sheet	0.77**	0.93**	0.84**	0.98**
Boiled noodle	0.62**	0.85**	0.71**	0.94**

*$P < 0.05$; **$P < 0.01$