FINAL REPORT

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

BRI58

Grains Industries Centre for Near Infrared (NIR) Spectroscopy: Coordination and support activities

PROJECT DETAILS

PROJECT CODE:	BRI58
PROJECT TITLE:	GRAINS INDUSTRIES CENTRE FOR NEAR INFRARED (NIR) SPECTROSCOPY: COORDINATION AND SUPPORT ACTIVITIES
START DATE:	01.04.1996
END DATE:	30.06.2001
SUPERVISOR:	BRIAN OSBORNE
ORGANISATION:	BRI AUSTRALIA LTD
CONTACT NAME:	G BLUNDELL

Summary

The Near Infrared (NIR) Centre has placed Australia in a position of world leadership in a technology which has become indispensable for assurance of the supply of quality grain. This means that Australian plant breeders are better able than those in competitor countries to select quality lines earlier and more efficiently, growers have more confidence in the NIR testing performed at receival and processors can add more value to grains-based products in Australia.

but this is not, and is not intended to be, an endorsement or recommendation of any product or manufacturer referred to. Other products may perform as well or better than those specifically referred to. Check www.apvma.gov.au and select product registrations listed in PUBCRIS for current information relating to product registration.

Copyright

Old or Archival Reports (Projects that concluded in 2007 or earlier)

The information contained in these older reports is now several years old, and may have been wholly or partially superseded or built upon in subsequent work funded by GRDC or others. Readers should be aware that more recent research may be more useful for their needs. Findings related to agricultural chemical use are also potentially out of date and are not to be taken as a recommendation for their use.

Conclusions

1. An innovative approach to the measurement of wheat protein components has been developed (Component Project CSP222). This approach is currently being extended to starch components (Component Projects CSP301 and BRI104).
2. A patented innovation in the monitoring of dough mixing is close to commercialisation (Component Project NZC1).
3. Since NIR analysis is rapid, applicable to small samples of whole grain and can measure a number of components concurrently, it is especially useful for screening plant breeding material. New calibrations have been developed within Component Project DAW553 for flour yield, water absorption and yellow pigment for use in quality selection in breeding programs. Barley and durum breeding applications are under development with Component Projects DAW582 and DAN393, respectively.
4. An objective test for barley brightness has been developed (Component Project DAQ433) and has been incorporated into grain receival testing in Queensland (QLD) and New South Wales (NSW).

Recommendations

National collaboration has enhanced the outcomes of the NIR Centre and should continue to be encouraged.

The GRDC Major Project model has proved successful in providing an effective yet streamlined approach to research management.

Outcomes

Expected Outcomes

Through the coordination and intellectual contributions made by this project, the NIR Centre has maximised the value of NIR technology to the Australian grains industry and developed Australia's human resource base by raising the levels of NIR expertise in regional laboratories.

The knowledge and innovations developed during this project will have their impact through increased efficiency in plant breeding programs leading to increased product quality and/or generate returns on investments through commercialisation of products such as the dough probe.

Achievements/Benefits

Project Aims

1. Provide support for NIR research across Australia within the GRDC Major Project structure.

2. Provide training to key personnel in the grains industry.

3. Develop a national NIR research strategy for the grains industry.

4. Network NIR monochromator instruments.

5. Establish links with NIR programs in related agro-food industries.

Background

NIR is used by plant breeders to measure key quality specifications, by growers to target fertiliser requirements and blend grain to meet receival standards, by grain handlers to perform load-by-load quality testing and by processors to select and sort raw materials and to control processes. Accordingly, an increasing number of research providers to the Australian grains industry, including nearly all plant breeding institutes, are using NIR to further their research objectives. The Grain Industries Centre for NIR was established to provide leading-edge research across all sectors of the Australian grains industry and to support researchers of different levels of skill in the technology. Recognition of the importance of underpinning research and of the need for rigour in development and validation of calibrations has been an important feature of the Centre.

Project Outputs

Knowledge

- Understanding the spectroscopy of functional wheat proteins.
- Development and application of master curve deconvolution.
- Development and application of dynamic NIR spectroscopy.
- Understanding the spectroscopy of changes in starch structure during processing.
- Estimation of inter-laboratory biases using indicator variables.

Innovations

- A patented invention for monitoring dough mixing.
- Grams 32 Array Basic Program for calculation of glutenin and gliadin contents by curve fitting.
- Novel calibrations for early generation testing of whole wheat breeding material.

Products and services

- Technical Report No. 1 'Review of NIR Research in the Australian Grains Industry'.
- Technical Report No. 2 'National NIR Research Strategy'.
- NIR Calibration Workshop Notes (1996).
- NIR Centre Seminar Notes (1998).
- NIR calibration using the NIR Systems 6500 and WINISI v. 1.02B notes.
- Bibliography of Australian NIR research related to grains.
- Royal Australian Chemical Institute (RACI) Cereal Chemistry Division Official Method 11.01.
- Annual Meeting Reports 1995-2000.
- 21 issues of Grain Waves.
- Final Reports BRI65, CSP221, CSP222, DAN 414(324), DAW 553 and NZC1.
- Wheat, barley, durum and pulses NIR spectral databases.
- Ground grain, whole wheat, barley, malt and durum NIRS 6500 standardisation files.
- Whole wheat, barley, malt and durum standardisation samples.
- Microsoft Excel templates for optimisation of maths treatments in NIR calibration.

Project Achievements

Aim 1

Excellent progress has been made towards the development and validation of a range of calibrations for use in the testing of early generation material in wheat, barley and durum breeding programs. In production, the wheat tissue test has been extended to include phosphorus (P) and sulphur (S). Key achievements in relation to grain receival include calibrations for protein in whole wheat which are global with respect to location and season within Australia, verification of the accuracy of NIR for moisture in wheat and sorghum, an objective method for brightness of barley grain and accurate determination of digestible energy in cereals for growing pigs. In processing, novel methods have been developed for the in-process

measurement of flour starch damage, degree of cooking of grains during extrusion processing and mixing of bread doughs. One measure of the quality and quantity of output from a research program is the number of publications, especially those in scientific journals where acceptance is based upon peer review. There have been 12 papers published in peer-reviewed journals and 41 papers presented at 15 national and international conferences. Information flow into, between and out of Component Projects has been managed by:

• Maintaining current awareness of the literature, conferences, activities of key international researchers and instrument companies, then providing a conduit for the latest developments in the technology to flow into projects.

• Ensuring that researchers are kept aware of each other's work to promote synergy and avoid duplication or omission. A key step in avoiding duplication of effort and unnecessary reinvention is awareness of the literature. However, much of the output of Australian NIR research in grains is captured in conference papers not easily accessed by searches. Therefore, a bibliography has been prepared and made available in electronic form.

• Ensuring that key outputs are managed effectively and disseminated according to GRDC policy.

Aim 2

NIR Centre courses were held at North Ryde in 1996 and 1998. In addition, the NIR Centre made a major contribution to two NIR workshops held at Victoria (VIC) University of Technology, Werribee, in 1997 and 1998 and to the Crawford Fund Masterclass in 1998. A NIR Calibration Introductory Training Course was delivered to six staff of NSW Agriculture and Charles Sturt University at Wagga Wagga in 1999. An introduction to NIR was also delivered to a Vineyard Imaging Systems Workshop at The University of Melbourne. Scientists from Agriculture Western Australia and The University of Adelaide have received personal training at North Ryde. Written material from both the Wagga Wagga Course and the 1996 NIR Calibration Workshop is available in the form of training manuals. In 2000, grower seminars were provided as part of NSW Farmers' Regional Council meetings in Spring Ridge and Moree and GrainCorp's Annual General Meeting (AGM) in Dubbo.

Aim 3

The National Coordinator carried out a review of past and present NIR research in the Australian grains industry by means of visits to each NIR grains research laboratory and study of the literature. This review was published as Technical Report No.1. A strategy which addressed the continuation of the NIR research portfolio beyond June 1999 (when the original five Component Projects concluded) was presented in confidence to the GRDC in the form of Technical Report No. 2.

Aim 4

The Australian network of monochromators in 12 grains research laboratories was first established in 1998, maintained in 2000 and extended to 15 instruments in 2001. The optical matching of research instruments has been paramount in promoting the collaboration within the breeding projects in particular. The network already developed needs to be maintained annually and extended when new investments in the relevant equipment are made. The feasibility of transfer of whole wheat and barley protein calibrations has been demonstrated.

Aim 5

Collaborations have been established with NIR researchers in other industries: Bureau of Sugar Experimental Research Stations, Gordonvale, QLD; Meat & Livestock Australia, North Sydney, NSW; The Australian Wine Research Institute, Adelaide, South Australia (SA).

Industry Benefits

The NIR Centre has placed Australia in a position of world leadership in a technology which has become indispensable for assurance of the supply of quality grain. This means that Australian plant breeders are better able than those in competitor countries to select quality lines earlier and more efficiently, growers have more confidence in the NIR testing performed at receival and processors can add more value to grains-based products in Australia.

Other Benefits

Component Project NZC1 resulted in a patented invention which is in an advanced stage of commercialisation leading to

stakeholder royalties and export opportunities for Australian manufacturers.

Other research

1. Further development of wheat breeding applications. Component Project DAW553 has resulted in successful calibrations for flour yield, yellow pigment and water absorption. A new project would facilitate the validation and adoption of these applications nationally and extend the successful approach to starch quality and product colour and colour stability.
2. Underpinning research. It has become increasingly clear that successful outcomes in NIR research are facilitated by knowledge of the spectral characteristics of components and their interactions. Much progress has been made in this area within Component Projects CSP222 and CSP301 (BRI104). However, a systematic spectroscopic study of the chemical components of wheat would lead to a sound scientific basis for the recovery of information from spectra and thus increase the chances of achieving successful calibrations.
3. Storage. The sharing of calibrations among breeding programs currently depends on the optical matching of instruments. However, the procedure requires the use of sealed samples which are assumed to remain stable indefinitely. There is no scientific evidence to support this assumption for whole grains. On the other hand, the CSIRO Stored Grain Research Laboratory has invested in a NIR instrument and has an interest in using it to monitor changes which take place during storage.

Intellectual property summary

Intellectual property (IP) is developed, and equity shares allocated, within individual Component Projects but is managed within this project. Project leaders are responsible for reporting IP including calibrations, databases and software to the National Coordinator who maintains a register for referral to the Program Management Committee.

Additional information

Refereed Journals

Batten, G D, Plant analysis using near infrared reflectance spectroscopy: the potential and the limitations. Australian Journal of Experimental Agriculture, 1998, 38, 697-706.

Batten, G D, An appreciation of the contribution of NIR to agriculture. Journal of Near Infrared Spectroscopy, 1998, 6, 105-114.

Evans A J, Huang S, Osborne B G, Kotwal Z and Wesley I J, Near infrared on-line measurement of degree of cook in extrusion processing of wheat flour. Journal of Near Infrared Spectroscopy, 1999, 7, 77-84.

Manley M, Van Zyl L and Osborne B G, Using Fourier transform near infrared spectroscopy in determining kernel hardness, protein and moisture content of whole wheat flour. Journal of Near Infrared Spectroscopy, 2002,Vol. 10, p 71-76.

McGrath V B, Blakeney A B and Batten G D, Fructan to nitrogen ratio as an indicator of nutrient stress in wheat crops. New Phytology, 1997,136, 145-152.

Osborne B G, Near infrared spectroscopic studies of starch and water in some processed cereal foods. Journal of Near Infrared Spectroscopy, 1996, 4, 195-200.

Osborne, B G, Recent developments in NIR analysis of grains and grain products. Cereal Foods World, 2000, 45, 11-15.

Osborne B G, Kotwal Z, Wesley I J, Saunders L, Dardenne P and Shenk J S, Optical matching of near infrared reflectance monochromator instruments for the analysis of ground and whole wheat. Journal of Near Infrared Spectroscopy, 1999, 7, 167-178.

Van Barneveld, R J, Nuttall, J D, Flinn, P C and Osborne, B G, Near infrared reflectance measurement of the digestible energy content of cereals for growing pigs. Journal of Near Infrared Spectroscopy, 1999, 7, 1-7.

Wesley I J, Larroque O, Osborne B G, Azudin N, Allen H and Skerritt J H, Measurement of gliadin and glutenin content of flour by NIR spectroscopy. J. Cereal Science, Vol 34, Issue 2, p 125-133.Wesley I J, Larsen N, Osborne B G and Skerritt J H, Non-invasive monitoring of dough mixing by near infrared spectroscopy. Journal of Cereal Science, 1998, 27, 61-69.

Wesley, I J, Uthayakumaran, S, Anderssen, R S, Cornish, G B, Bekes, F, Osborne, B G and Skerritt, J H, A curve-fitting approach to near infrared reflectance measurement of wheat flour proteins which influence dough quality. Journal of Near Infrared Spectroscopy, 1999, 7, 229-240.

Patent Application

Wesley, I.J., Larsen, N., Osborne, B.G. and Skerritt, J.H. Monitoring of dough and grain properties.

International Patent No. AU 98/00267, 18 April 1997.

Articles

Batten G D (1997). Careful selection of NIR instruments. Farming Ahead, 65,49-54.

Batten G D and McGrath V B (1997). Was that fertiliser worthwhile? Australian Grain, 7(3), 38-39.

Osborne B G (1996). National quality testing centre for grains. Australian Grain, December 1996 - January 1997, p. 47.

Osborne B G (1997). Australian Grain Industries Centre for NIR. NIR News, 8(1), 10-12.

Osborne B G (1998). NIR measurements of the development of crystallinity in stored bread crumb. Analysis Magazine, 26(4), M55-M57.

Osborne B G (1998). World beating: Australia's knack for kneading. PIE, 12, 13.

Slee, D (1997). Reflections on grain quality. Ground Cover, Spring Issue, p. 16.

Trainor C (1996). Grain quality goal for new $2m facility. The Land, Thursday July 4, p.21.

Conference Papers

29th Annual Convention Australian Institute of Food Science and Technology, Gold Coast, 5-8 May 1996.

Osborne B G NIR in the cereals and food industry.

Cereals '96: 46th Australian Cereal Chemistry Conference, Sydney, 1-6 September, 1996

Osborne B G, The Grain Industries Centre for NIR.

Australian Near Infrared Spectroscopy Group, NISG Conference 1997, Adelaide, 23-24 April

Osborne B G, The Grain Industries Centre for NIR.

Van Barnevald R and Nuttall J D, The potential for NIR spectroscopy to predict the digestible energy (DE) content of cereals for pigs.

Wesley L J, Larsen N, Osborne B G and Skerritt J H, Monitoring of dough mixing by near infrared spectroscopy.

8th International Conference on Near-Infrared Spectroscopy, Essen, Germany, 15-19 September, 1997

Batten G D, An appreciation of the contribution of NIR to agriculture.

Osborne B G, The Grain Industries Centre for NIR.

Osborne B G, NIR spectroscopy of starch in processed foods.

Wesley I J, Larsen N, Osborne B G and Skerritt J, Non-invasive monitoring of dough mixing by near infrared spectroscopy.

XXX Colloquium Spectroscopicum Internationale, Melbourne, 21-26 September, 1997

Osborne, B.G., Monitoring cereal foods quality on-line using NIR spectroscopy.

82nd Annual Meeting of the American Association of Cereal Chemists, San Diego, CA, 12-16 October 1997

Osborne B G, Burridge P, Palmer G, Hollamby G and Ronalds J, Ultra-rapid grain quality testing using NIR diode array spectrometry.

48th Australian Cereal Chemistry Conference, Cairns, 17-20 August 1998

Burridge P M, Palmer G A and Hollamby G J, Use of whole grain NIR to predict quality in wheat breeding programs.

Evans A J, Huang S, Htoon A, Osborne B G, Kotwal Z and Wesley I J, Monitoring the degree of cook in extrusion processing using NHL

Fearn T and Osborne B G, Prediction of flour water absorption from other flour properties.

Osborne B G, Improved NIR prediction of flour starch damage.

Osborne B G, Jackson R, Burridge P, Palmer G and Hollamby G, Comparison of the prediction of wheat flour yield using the Single-Kernel Characterization System 4100 and the DA-7000 Diode Array NIR Spectrometer.

Osborne B G, Kotwal Z, Wesley I J, Saunders L, Dardenne P, Shenk J and Fearn T, Standardisation of NIR Systems 5000 and 6500 instruments in Australia.

Uthayakumaran S, Wesley I J, Bekes F, Osborne B G and Skerritt J H, Near infrared spectral differences between gliadin and glutenin proteins.

Wesley I J, Gras P W, Larsen N, Osborne B G and Skerritt J H, A preliminary comparison of the 35g Mixograph and dynamic near infrared spectroscopy for studying dough development.

Wesley I J, Skerritt J H, Bekes F, Cornish G B and Osborne B G, Near infrared analysis of a Halberd x Cranbrook doubled haploid sample set.

8th Australian Near Infrared Spectroscopy Conference, Palm Cove, 21-23 August 1998

Ronalds J A, The prediction of weather damage in whole wheat.

Van Barneveld R J, Kruk J A and Nuttall J D, A comparison of NIR predictions of digestible energy in cereals for pigs with in vivo measurements.

Wesley I J, Osborne B G and Skerritt J H, Alternative approaches to NIR calibration.

9th International Conference on Near-Infrared Spectroscopy, Verona, Italy, 13-18 June 1999

Osborne B G, Kotwal Z, Wesley IJ and Larsen N, A classical spectroscopic approach to food process control.

Osborne B G, Kotwal Z, Wesley I J, Crosbie G B, Tarr A, Harasymow S, Dardenne P and Shenk, J S, Collaborative development of NIR calibrations for quality testing of wheat and barley breeding material: 1. Optical matching of instruments.

Osborne B G and Wesley I J, Collaborative development of NIR calibrations for quality testing of wheat and barley breeding material: 2. The use of indicator variables to correct for interlaboratory biases in reference data.

Osborne B G, Burridge P, Palmer G, Hollamby G, Ronalds J A, Wesley IJ and Laucke A, Collaborative development of NIR calibrations for quality testing of wheat and barley breeding material: 3. Ultra-rapid quality testing of wheat, flour and dough using near infrared diode array spectrometry.

Wesley 1 J, Osborne B G, Anderssen R S and Skerritt J H, Curve fitting applied to NIR deconvolution of wheat functional proteins in flour.

9th Australian Barley Technical Symposium, Melbourne, 12-16 September 1999

Fox G, Osborne B G and Sulman M, Barley colour determination using near infrared spectroscopy.

10th World Congress of Food Science & Technology, Sydney, 3-8 October 1999

Chessari C, Evans A, Huang S, Osborne B, Kotwal Z and Wesley I, The evaluation of NIR spectroscopy for the on line monitoring of starch transformations in the extruder.

83rd Annual Meeting of the American Association of Cereal Chemists, Seattle, WA, 1-3 November 1999

Osborne, B G, Recent developments in NIR analysis of grains and grain products.

9th Australian Near Infrared Spectroscopy Conference, Horsham, 5-6 April

Fox G P, Sulman M, Osborne B G and Inkerman A, Evaluation of barley colour pigment by NIR.

Harasymow S E, Tarr A W, Wesley I J, Osborne B G and Adrianz T D, NIR instrument standardisation for barley and malt products and the potential for nationally derived calibrations for quality testing.

Osborne B G and Wesley I J, Does math treatment matter?

Wesley I J and Anderssen R S, Analysis of reconstructed NIR spectra: Effect of noise on master curve deconvolution.

Wesley I J, Anderssen R S, Osborne B G, Burridge P, Smith P and Hollamby G, Validation of a least squares curve fitting methodology for predicting the gliadin and glutenin composition of whole wheat independent of total protein content

11th World Cereal and Bread Congress, Gold Coast, 8-15 September 2000

Crosbie G B, Wang Y, Osborne B G, Allen H M, Palmer G A, Black C and Mares D J Collaborative development of NIR quality tests for application in wheat breeding.

Osborne B G The Grain Industries Centre for NIR: Key achievements.

Osborne B G, Kotwal Z, Ronalds J A and Allen H M, The effect of degrading factors on NIR measurement of moisture in whole wheat.

Osborne B G, Wesley I J, Sissons M J and Hare R A, Optimisation of NIR calibration for the prediction of semolina yield of whole durum.

Wesley I J, Appels R and Blakeney A B, Applications of dynamic NIR spectroscopy to cereal science. 52nd Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, New Orleans, 4-9 March 2001

Osborne B G, NIR technology for the assessment of grain quality - What the future holds?

Attachments

B.G. Osborne, Recent developments in NIR analysis of cereals and cereal products. Cereal Foods World, 2000, 45, 11-15 (Attachment 1).

B.G. Osborne, The Grain Industries Centre for NIR: Key achievements. Proc. 11th ICC Cereal and Bread Congress and 50th Australian Cereal Chemistry Conference, Eds M Wotton, I L Batey and C W Wrigley, RACI, Melbourne, 2001, 50-54 (Attachment 2).

B.G. Osborne, Bibliography of Australian NIR Research Related to Grains (Attachment 3).