



# QUALITY WHEAT CRC PROJECT REPORT

## Innovations from Research in the Food Sector in Europe:

### Report on a visit to Sweden March 1999

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# **Innovations from Research in the Food Sector in Europe: Report on a Visit to Sweden in March, 1999**

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## **Introduction**

In a one-week absence from Australia, Colin Wrigley made a visit to Sweden to contribute an invited lecture to a European Union Conference on "Innovations from Research in the Food Sector". He also spoke at a meeting of university staff and technical representatives of a farmers' organisation about "On-farm management to improve wheat and barley quality". Copies of the text of these lectures are appended.

The trip was made at the invitation (and expense) of Ideon Agro Food, a non-profit organisation located in the Technology Park of Lund University. This organisation operates with the goal of establishing cooperation between the business sector and the university in the agriculture and food sectors.

The visit also provided the opportunity to discuss market possibilities in Europe for the CSIRO-CRC WheatRite test kit, and to visit the headquarters of the ICC (International Association for Cereal Science and Technology) in Vienna. The itinerary is appended.

## **Ideon Agro Food**

The Ideon Agro Food Foundation was launched in 1986 with the vision of assisting the Swedish agricultural and food sectors to become more dynamic and competitive. Its activities are aimed at establishing better links within the food chain (primary production, food manufacture, packaging and retail trade), and assisting in the contribution of university research at all stages of this chain.

The universities involved are particularly Lund University (Agro Food is located in the Ideon Technology Park, beside the Lund Campus) and the Swedish Agricultural University (with much of its cereal breeding and grains research located at Svalov, about 30 km north of Lund). These organisations serve Sweden in the rich Skane region of southern Sweden, centre of much of the country's grain growing and agriculture, and also a focus for food-related industries, such as a major site of the operations of TetraPak.

Ideon Agro Food Foundation sees itself as a "knowledge broker"...

- identifying problems,
- finding financial and organisational solutions,
- strengthening the contributions of research in the business sector,
- establishing connections between research providers and commercial users of the results,
- assisting researchers to start new companies, and

- ascertaining that projects are conducted to the expectations and goals of both researcher and business collaborator.

A five-page leaflet is available describing the aims and activities of Ideon Agro Food.

Ideon Agro Food has a group of about a dozen consultants, with expertise in relevant sectors of its sphere of work, to carry out these activities. Most of them have university backgrounds, but with strong involvement in industry as well. Our relationships with Ideon Agro Food have been via Dr Lennart Lindahl, their consultant on cereal-grain quality and processing, who spent a sabbatical visit in the CSIRO, North Ryde, a few years ago.

### **Innovations Conference**

Given this overall role for Ideon Agro Food, it was apparently an obvious organisation to oversee a project on innovation, within the framework of the European Union Program "ADAPT". This project aims to make recommendations on how research innovations (especially university-based) should best be translated into commercial realities to benefit Europe's food industry. A part of this project was the conduct of a one-day conference, entitled "Innovations from Research in the Food Sector", bringing together university and business people to recount their experiences in the implementation of innovation. Most of the forty delegates were from European countries, with good representation from Scandinavia. In addition, there were two visitors from USA and one from Australia.

The conference was held in a magnificent setting - the Trolleholm Castle, about 30 km north of Lund. It provided a setting of the formal speaking and discussions, for a dinner in the evening, and overnight accommodation for most of the delegates following the conference. The many castles in the Skane region are now being kept in good repair by having the public contribute to their upkeep in return for the privilege of having access to the facilities for meetings. The contact in this case was the director of Ideon Agro Food, the "host" of the conference, Dr Gert Goransson (said to have a 1% share in Trolleholm).

Prof. Grunert (Denmark) described barriers to innovation for the majority of European food companies, who could be classed as Small-to-Medium Enterprises (SMEs), with inadequate access to research, or even to technological expertise. He claimed that only 12% of European consumers are interested in novelty. This contrasted with an American contribution (Prof. Tillotson, Tufts University) about the thousands of new food products released in the USA, about 95% of which fail within a year. His recommendation was that universities should be selective and focused about where they place their emphasis in research and their associations with agri-food companies.

Prof. Jongen (TNO, Wageningen) spoke of his organisation's direct (and successful) links with food companies, resulting in 60% of their research budget coming directly from the food industry. His specific example of innovation was the development of ingredients for "fabricated foods", particularly plant proteins that can be engineered to substitute for meat ingredients, not for meat-alone foods such as steaks, but as meat ingredients in mixed foods such as pizzas.

Other examples of innovation included ...

- ProViva, a Swedish health drink developed by their dairy farmers' company, but containing no dairy products. It is based on oat milk, fortified with a culture of a specific *Lactobacillus* (number 229) with reputed health benefits.
- Fast Foods, of finger-food size, based on hot-dog and hamburger foods, wrapped with inert-gas packaging, giving them a thirty-day shelf life at 4°C.
- Oat milk and oat soup, developed via Ideon Agro Food by Lennart Lindahl and co-workers, and now being manufactured and sold in Britain, Sweden, USA and Australia. However, the Swedish company's oat milk is meeting local competition in these last two countries.
- A 'health' cracker biscuit, made from mill offal (wheat bran and germ), also developed by Lennart Lindahl and co-workers, and now being manufactured by a new company (Brantech AB), specifically started up for this product.

Other speakers described strategies developed in European universities to involve students in industry-based research projects, which in many cases have assured the students of on-going employment.

A lecture of particular interest to the European audience described the conditions for a further round of research grants from the European Commission to encourage innovation in university-industry collaboration, this time to accentuate the involvement of SMEs.

### **Visit to Swedish Farmers' Organisation, Malmo**

My second lecturing appointment was one of two presentations to representatives of the Grains Section of a Swedish Farmers' Organisation, based at Malmo. It is housed in a large, impressive building that is largely occupied by the several branches of the Farmers' Organisation (such as dairy, meat, etc.). The meeting was chaired by Lennart Wikstrom, a technical consultant to the Farmers' Organisation. The meeting was attended by representatives of Ideon Agro Food and of the Swedish Agricultural University, and technical/laboratory staff of the Farmers' Organisation.

The topics I was asked to cover were rapid tests for quality and Australian approaches to growing wheat and barley for defined quality objectives (text attached). Some of the comments on the talk were along the lines of "that's great, but we don't have that problem much here in Sweden", indicating how much of our research is fairly specific to Australia, or at least that our problems are not universal. However, there was certainly interest in the WheatRite test kit for sprouted wheat (see below) and in our methods of variety identification. On the other hand, they have problems that are not severe here, such as high cadmium levels in the grain from some localities.

The other lecturer, Prof. Gunnar Svensson, described recent research at the Swedish Agricultural University, intended to optimise late fertiliser application and to predict grain quality prior to harvest for wheat and barley. He has been pleased with results with "Cropscan", a sensing system attached to a tractor to monitor

nitrogen-fertiliser application in real time. It scans the crop in front of the tractor for crop density and colour (at a few specific wavelengths). Based on the scan results in front, the rate of fertiliser application is adjusted at the back of the tractor. The calibration of the system is dependent on variety as well as on species. It is often used at about one week after flowering.

Gunnar claimed that Cropscan is better for their purposes than precision agriculture methods. In contrast to some results that we have obtained, he assured me that overall, the protein content of grain would be inversely proportional to the grain yield at any part of a field, provided that major factors (such as moisture) are not limiting. The Swedish concern for minimising any excessive fertiliser use is as much due to environmental concerns as to economics. They have considerable pressure to reduce the run-off of fertilisers into waterways.

Gunnar claimed success in the most recent season for their prediction of the protein content of the mature grain, based on the protein content being constant for the last few weeks before maturity, or after the grain moisture content has dropped below 45%. He instanced similar conclusions in the Netherlands, where they were using NIR on whole green heads to predict final protein content. However, he also indicated that he suspected that in other seasons there might be slight increases or decreases in % protein during this period, depending on the climatic conditions.

For the prediction of bread-making quality, he has used the Zeleny sedimentation test, and has found good predictive ability if it is applied to immature grain no earlier than two weeks before harvest. His test for predicting malting quality in barley is to determine the number of kernels over 25 mm, using the Foss-Tecator GrainCheck system of image analysis.

### **WheatRite test kit**

Another purpose of my visit was to explore the market possibilities in Sweden for the CRC-CSIRO WheatRite test kit for sprout damage. Ideon Agro Food has decided to adopt the examination of the kit as one of its innovation projects, involving Lennart Lindahl as the consultant in charge of the project. I delivered a box of kits, plus a few extras for demonstration, and I made sure that Lennart was clear on the performance and functioning of the kit. The potential market in southern Sweden is 11,000 farmers, of which about 5,000 would be classed as 'progressive' and open to such an innovation.

He will initially test a range of Swedish variety samples of wheat and barley, in collaboration with the Swedish Agricultural University at Svalov, using sound and sprouted samples, calibrating back to Falling Number analyses. The next step will be to use the kits during the next grain harvest at mills in parallel with Falling Number tests, as well as trialing it with progressive farmers in their fields. There was the comment at the farmers' meeting that the Falling Number test is performed at all their receival sites. As they are happy with that test system, they did not (at present) see any need for the WheatRite test to replace that arrangement.

Dr Glattes (ICC Secretary General in Vienna) said that in Europe, the sensitivity range should be lower than it is for Australia, with the lower range going as low as 60 seconds. He also indicated that European mills would use it for rye, as well as wheat and barley.

Following my talk at the Innovations Conference, there were a few inquiries about the WheatRite test. There was the specific request for further details from Prof. Maury Bredahl (University of Missouri) who offered to contact a company that is involved in the testing of grain quality in the US, to explore their interest in the use of the kits in north America.

### **The Foss-Tecator Grain Check system of image analysis**

Also housed in the Ideon Agro Food building is the company set up to commercialise equipment for the analysis of the physical properties of grain samples based on image analysis. The GrainCheck system examines the image of a grain sample, and computes the range and type of contaminating material, as well as predicting test weight and some other properties. The original AgroVision company has been taken over by Foss-Tecator. They have manufactured and sold about 30 units. A new version is now being developed, targeted at the pharmaceutical industry, for monitoring the dimensions of tablets. They are adding NIR to it, so that ingredient composition can also be monitored. A GrainCheck unit is currently available in Australia for evaluation.

### **Interest in coeliac disease**

Ideon Agro Food has active collaboration on cereal dietary intolerances with Dr Klas Sjoberg at a research hospital in Malmo. Klas is involved in research on coeliac disease, and was planning to develop a test kit for gluten in foods. He was unaware of the CSIRO kit, manufactured and distributed by Medical Innovations in Sydney. I have provided him with details.

### **Visit to the Headquarters of the ICC, Vienna**

A five-hour stop-over in Vienna, en route to Sweden, provided the opportunity for a visit to the headquarters of the ICC (International Association for Cereal Science and Technology). The following topics of mutual interest were discussed:-

- The ICC Web Page (<http://www.icc.or.at/icc/>) is proving to be very successful, with about 5,000 accessions per month. It should therefore be a good source of publicity for the organisation.
- ICC Working Group Number 6 on Variety Identification. ICC has placed several pages of information about variety identification onto its Web Site (<http://www.icc.or.at/icc/>). I had suggested that the dissemination of recent advances in the subject would be more useful than attempting to get international acceptance of standard methods in a changing field of research. This form of dissemination is now happening via the Internet, with this Working Group being the first to adopt this approach. Hopefully, other Working Groups will adopt it.

- I took details from CoResearch of Otto Frankel's death, as a point of interest for the ICC staff, because his origins were in Austria and because some of his research career involved cereal chemistry (especially in New Zealand).
- Dr Glattes was very pleased to hear of my preparation of a glossary of terms used in cereal chemistry and grain processing. The provision of such a reference work has been an unfulfilled ambition of the ICC. He asked if the ICC might be able to provide access to it via a hyper-link from the ICC Web Site to the relevant Australian Web Site.
- Dr Glattes expressed great interest in the WheatRite test kit, requesting that we provide a presentation about it at the coming ICC Conference in Valencia, Spain, in June. This has now been arranged.

### **University of Agricultural Sciences, Vienna**

Helmut Glattes (ICC General Secretary) also arranged a visit to the University of Agricultural Sciences ("BOKU"), Vienna, to inspect their excellent facilities for cereal chemistry and grain-quality testing in the Institute of Food Technology. Staff available for discussion were:

- Dr Gerhard Schleining, who is contracted to ICC for the development of the Web Site. He mentioned that the university runs a course in the application of HACCP principles for grain growers (details available on the Web Site at <http://www.boku.ac.at/ilmt/>).
- Dr Heinrich Grausgruber (Dept. Plant Breeding, Gregor Mendel Str. 33, A-1180, Vienna, Austria. Fax: +43 1 47654 3342. Email: [h330pj@edv1.boku.ac.at](mailto:h330pj@edv1.boku.ac.at)). I have had ongoing interactions with him about the history of cereal chemistry research of the past century, including the origins of wheat varieties of mutual interest. He has access to papers on wheat breeding from the beginning of the twentieth century, collected by Prof. E. Tschermak, one of the re-discoverers of Mendel's laws. He provided photos of the first Alveograph and the graphs produced by it. They come from a summarised reprint of three short communications in ...

Jacques de Vilmorin, Roger de Vilmorin, and Marcel Chopin (1929) La sélection des blés au point de vue de la valeur boulangère. *Journal d'Agriculture Pratique*, nos. des 8, 15 et 22 Juin. (The selection of wheat from the point of view of the baking value. *Journal d'Agriculture Pratique*, numbers from the 8th, 15th and 22nd June).

- Dipl.-Ing. Helmut Reiner, who asked for information about the Australian cereal-growing industry and its grain-quality specifications, in relation to a survey that he has undertaken for the Austrian Chamber of Commerce.

## **Itinerary for Colin Wrigley's visit to Sweden**

### **March, 1999**

Monday 8/3 Depart Sydney at 8.45 pm on Lauda Air NG 2

Tuesday 9/3 Arrive Vienna at 10.55 am

Visit to ICC Offices

Tuesday 9/3 Depart Vienna at 5.25 pm on Austrian Air NG 661

Tuesday 9/3 Arrive Copenhagen at 7.20 pm

Overnight in Copenhagen at SAS Globetrotter Hotel, Engvej 171,  
Copenhagen. Ph 453 287 0202 Fax 453 287 0220

Wednesday 10/3 Travel to Lund by Oresund ferry

Accom. at Sparta Hotel, Lund University, Phone 4646 222 3035

Contact in Lund: Dr Lennart Lindahl, Ideon.

E-mail: <lennart.lindahl@agrofood.ideon.se>

Work phone +4646 286 2953, fax 4646 286 2952

Home phone 4646 138 649

Thursday 11/3 Innovations Meeting at Trolleholm Castle

Lecture "Australian experiences in carrying research innovations to world markets"

Accommodation at Castle of Trolleholm, (30 km from Lund)

Friday 12/3 Farmers' Meeting in Malmo

Lecture: "On-farm management to improve wheat and barley quality"

Accommodation at Sparta Hotel, Lund.

Saturday 13/3 Travel to Copenhagen

Overnight in Copenhagen at SAS Globetrotter Hotel

Sunday 14/3 Depart Copenhagen at 10.50 am on Austrian Air NG 664

Sunday 14/3 Arrive Vienna at 12.45 am

Sunday 14/3 Depart Vienna at 1.30 pm on Lauda Air NG 1

Monday 15/3 Arrive Sydney at 7.15 pm



An invited lecture for a European Union Conference on  
"Innovations from Research in the Food Sector"  
held in Trolleholm, Sweden, on March 11<sup>th</sup>, 1999

## **Australian experiences in carrying research innovations to world markets**

**Colin W. Wrigley**

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Australia

A few years ago, I had the privilege of visiting the laboratory in Svalov, southern Sweden, where the first experiments were carried out in the development of the "Falling Number" test. This method, bearing this strange name, was developed to provide a quantitative estimate of the degree of sprouting of cereal grains that have been at risk of rain damage at harvest. The Falling Number result is now an internationally accepted indicator of incipient sprouting (grain soundness) and of the food-processing quality of grain shipments.

### **The RVA story**

For us in Australia, there is generally a low risk of rain damage, but in some seasons, it is a serious problem. This was so for the 1983/84 harvest, when about one quarter of the wheat crop was rain damaged. Following that disastrous harvest, a forum was called to determine what could be done to provide better testing of rain damage at the grain-receival silo. There had been attempts to use the Falling Number test at the silo, but it is difficult to conduct this laboratory method in the rushed and primitive conditions of grain receival. We were given the task of providing test equipment that would evaluate sprout damage within a few minutes under silo-receival conditions. The Rapid Visco Analyser (RVA) was the result of this assignment. Although it was initially designed to provide a three-minute assessment of grain soundness, it has also found world-wide adoption as a standard test system for characterising starch quality. Its primary design for use in the rough conditions of grain-receival situations has meant that it is also well suited for on-line monitoring in food-production facilities. The story of this development over about a decade (Wrigley *et al.*, 1996) prompts several lessons about how industry innovation might be promoted.

### **Matching industry need to scientific opportunity**

A primary requirement for successful innovation is a knowledge of the needs of the targeted sector of the food industry. The scientist is then in a position to monitor the latest developments in science and technology, and to match a knowledge of these needs to novel scientific opportunities. This was the starting point for my involvement in the development of the RVA. Even before the forum of 1984, we had been aware of the need for on-the-spot testing of rain damage, and ideas had been formulated.

How can industry-scientist interaction be achieved? It is a two-way system, involving both the research academic and the industry partners. The researcher must take an initiative to become aware of the relevant sector of industry, by means such as visiting industry sites, with and without the involvement of students in such activities. Reading, talking, conference attendance and work exchanges are further mechanisms. The research worker will naturally be drawn to certain sectors of industry in this process. This preference may be due to a historic involvement as a student. It will certainly be influenced by the extent to which the approaches are welcomed by industrial colleagues.

This is where the industry's role is important. Commercial concerns need to target the researcher to provide that awareness of its needs. This may involve providing research funds and student scholarships. We have found the provision of vacation student projects to be an excellent way of attracting the top students to be involved in industry research. In our own case, the funds provided by a research levy on Australian grain growers (via the Grains R & D Corporation) have been a valuable incentive for university and government researchers to become familiar with the grain growing and processing industries, thus to be able to apply successfully for research funding. This may amount to "buying scientific loyalty" to a specific industry sector, but it is an effective strategy.

#### **Plan for the end from the beginning, and adapt as needed**

In the development of the RVA, we were fortunate to have strong industry backing, prompted by the disaster of the 1983/84 harvest. There was thus an initial, at least, market for the proposed instrument. This is probably the most important factor to establish at the outset, namely, the planning for the outcome from the beginning.

The RVA example also illustrates the need to involve people, throughout the research and development process, that have the capability to carry the process of R & D through into manufacture and distribution. We were fortunate in the development of the RVA to have had Rod Booth and David Edwards (engineers, not chemists) involved from the early stages. Their names appear on the patent documents as co-inventors. They contributed with respect to how the equipment could perform the functions that we required as food chemists. A critical further development was the establishment of the company Newport Scientific, by Rod Booth, to undertake the manufacture and distribution of the instrument. The success of this company has been demonstrated by the production of over 500 RVA instruments, many exported from Australia, and the adoption of Standard Methods for RVA use by the major grain-chemistry organisations around the world.

Despite the initial planning and vision of the eventual outcome, it will be necessary to adapt to changing opportunities. In the case of the RVA, we learnt the lesson of being prepared to adapt development to additional goals. In this case, it was the chance to branch out to use the RVA for the analysis of starch characteristics, and this has become the main use, worldwide, of this instrument.

#### **Retain an awareness of the latest technologies**

The story of the detection of rain-damaged grain has continued in Australia, with the further development of a rapid on-the-spot test kit to perform this function on-farm. The WheatRite kit is designed to provide farmers with the ability to test for

incipient sprouting throughout the standing crop just before harvest, thus to identify those parts of the field that may still be sound, despite recent rain, so that the harvesting may proceed by avoiding the inclusion of damaged grain that would otherwise down-grade the whole crop. The kit has come from the capability to adapt new technologies (in this case adapted from medical diagnostics) and the vision that only this strategy of field testing can permit the harvest of sound grain after moderate rain (Skerritt *et al.*, 1997). Similar technologies have permitted the development of test kits for pesticide residues and gluten in foods, and for aspects of dough-processing quality (Skerritt and Appels, 1995). However, interest in the latest technologies can be enveloping, deflecting the R & D staff from the desired outcomes for industry benefit. Therefore it is important not to be carried away with "technology push".

### **Developing ideas and people in the mentor process**

Obviously, people are the critical ingredient in any enterprise, not least in the exploitation and encouragement of innovation. Important factors in my own development as a scientist have been the twin factors of effective mentoring (supervision) and, within that framework, a degree of freedom to explore novel ideas. An example of the value of the mentor function was the advice "We must use 1990s technologies to analyse flour quality, instead using of the present equipment developed in the 1930s". A series of novel flour-testing systems have since been developed in our laboratories, based on the challenge of those words, plus the degree of flexibility in our duties to permit development of the resulting ideas. As a consequence, we can now take as little as two grams of flour (less than the product of a single wheat plant) and analyse the quality attributes with respect to dough-mixing properties, dough-extension characteristics and baking potential, with automatic analysis of the results (Rath *et al.*, 1990; Gras and Bekes, 1996).

Also memorable in the mentor role, is a former boss who long ago advised me "Make yourself an authority on electrophoretic methods". This led me, in the 1960s, into the development of gel isoelectric focusing and its two-dimensional combination with gel electrophoresis, methods that have impacted analytical protein chemistry generally, as well as facilitating the elucidation of the function of flour proteins in baking. I was fortunate to have been given a degree of freedom to explore these new separation techniques, together with the direction to apply them to provide new insights into the chemistry and genetics of grain-protein function, which was one of our major research objectives (Wrigley and Shepherd, 1973). A later consequence of my following this advice led me to a Directorship with the (then young) Gradipore company, based in Sydney, now successfully exporting electrophoresis products worldwide.

### **Developing innovation in a modest-sized company**

This further step of taking innovation and making it work in the commercial world is unfortunately a distant experience for many academics. It was for me too, but my involvement with Gradipore provided a significant opportunity to learn. What lessons? According to a present senior executive of the company, the innovations being exploited by a company must be very good, but even so, that ingredient contributes only about 20% of the potential for success. Also important is persistence, namely, the ability (and funding) to stay in business for the "long haul",

especially until the time is right for the innovation in question. For smaller countries, such as Australia (and probably also Sweden), a world-wide view of market potential is needed, to ensure adequate market volume. Obvious additional comments relate to good management internally and a good distribution network.

### **Lessons from negative experiences**

On the other hand, useful lessons may be learned from some of the projects with which I have been involved, in which sound scientific advances have not been accompanied by successful commercial outcomes. In some instances, with hindsight, we attempted to commercialise innovations for which there was insufficient market volume; in another case, the international price structure changed during the development phase, making it unprofitable to undertake the modification we planned for a specific plant-protein product. Other examples include cases where planned treatments proved to be incompatible with food standards. The broad topic of genetically engineered foods falls into this general area of doubt at present, but there are signs that attitudes may be changing in favour of such innovations. However, much university research may be classed as for the "general good", not necessarily to be exploited for gain by an individual company. This work benefits the public generally, who are often the funding source, after all.

### **Top-down imposition of innovation**

Although many of the ideas for innovation start at the bench level, a conducive environment may be imposed from above. During the past decade, the Australian Government has used the concept of the Cooperative Research Centre (CRC) to promote productive research collaboration between universities, government laboratories and industry. In this way, the combined resources and expertise of several such organisations are focused on a specific area of science or technology. In my own case, this has involved close interactions between wheat growers, grain marketers and food processors, in association with a range of research workers, to the advantage of all partners. The Quality Wheat CRC is one of nearly seventy CRCs throughout Australia, covering a wide range of aspects of science and technology.

During the few years of operation of the Quality Wheat CRC, significant outcomes for industry have been achieved. These include the development of new germplasm with unique quality characteristics, the WheatRite test kit (described above), better agronomic management to increase the production of premium-quality grain, optimised processing methods in milling and baking, and advances in training and education at trade and post-graduate levels. The extension of research outcomes and of market awareness to wheat growers and processors are important educational goals of the CRC.

### **Conclusion**

The basic research of universities and government laboratories should be the underpinning of ongoing innovation in the food-processing industry. Essential to this process is effective interaction between these groups. On the one hand, the academic must be aware of the industry's problems; achieving this primary goal is as much a responsibility of the companies involved as it is of the scientist. In addition, it is essential for the industry partner to have staff trained at such a level of

science and technology for them to interact effectively in assessing the implications of innovations for their own company. Industry involvement throughout the research process helps to ensure that innovations are carried through to practical realities.

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[Summary titles used in the oral presentation]

## **Lessons in carrying research innovations to world markets**

### **1. Know the needs of the targeted sector of the food industry.**

How? It's a two-way system:

- **The researcher must take an initiative to become aware of the industry, by..**
  - **visiting industry sites, also involving students**
  - **reading, talking, conference attendance, work exchanges**
- **The industry must target the researcher to provide that awareness,**  
by ...
  - **providing research funds and student scholarships**
  - **funding vacation student projects**
  - **"Buy scientific loyalty" to your industry sector**

### **2. Plan for the end from the beginning ... and adapt as needed**

- **Ensure that there is a viable market for the proposed product**
- **Involve people with the capability to carry through into manufacture and distribution.**
- **Nevertheless, be prepared to adapt to changing opportunities**

### **3. Retain an awareness of the latest technologies**

- **Plug into the capability to adapt new technologies**
- **Plug into experts with practical knowledge of the technology**
- **Do not be carried away with "technology push"**

### **4. Develop ideas and people in the mentor process**

- **Provide freedom for staff to explore novel ideas**
- **Have senior staff act as "mentors" to encourage innovative ideas**

## **5. How to develop innovation in a modest-sized company**

- **As a scientist, seek experience in the commercial scene**
- **Innovations being exploited must be very good, but ...**
- **The innovation may be only 20% of the potential for success**
- **Also needed are**
  - **persistence, the ability (and funding) to stay in business for the “long haul”**
  - **a world-wide view of market potential**
  - **good management internally**
  - **a good distribution network**

## **6. Lessons from negative experiences**

- **Altered market situations**
  - **modified plant protein products**
- **Insufficient market volume**
  - **micro-scale test equipment**
- **Incompatibility with food standards**
  - **chemical treatments of foods**
- **Genetically engineered foods?**
- **“General-good” research need not be exploited for company gain**

## **7. “Top-down” imposition of innovation**

- **The concept of the Cooperative Research Centre**
- **Formal collaboration between universities, government laboratories and industry**
- **The Quality Wheat Cooperative Research Centre**
  - **Milling and baking companies**
  - **Bread Research Institute (now BRI Australia Ltd)**
  - **Australian Wheat Board (now AWB Ltd)**
  - **Grains R & D Corporation**
  - **Departments of Agriculture in NSW & WA**
  - **University of Sydney**
  - **CSIRO Plant Industry**

## **On-farm management to improve wheat and barley quality**

**Colin W. Wrigley**

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Australia produces a great deal more wheat and barley than is needed for domestic consumption. As a result, about three quarters of these crops are exported. We are therefore very aware of the processing needs of our export customers, as well as needing to satisfy the quality requirements of Australian markets. For barley, a major part of the domestic grain is used for malting, and this is also a significant use overseas. For wheat, customers in the Middle East and Asia use our grain for the manufacture of flat breads, noodles and steamed breads, contrasting with the domestic wheat uses in pan-bread and food production, starch-gluten manufacture and for stockfeed.

### **The right quality targets - Rätt kvalitetsmål**

Australia's dependence on world markets in wheat and barley means that there has been increasing pressure for Australian grain growers to achieve grain-quality targets suited to this diversity of customers (Wrigley, 1994). The 'right' quality targets involve achieving premium payments for superior grades such as Prime Hard, Australian Hard, Australian Premium White and Australian Noodle qualities. The premiums may be as great as Aust\$50 per tonne, compared to normal grades of milling wheat or the feed category. Currently, we are developing a Quality Assurance system, based on HACCP principles at all stages of the growing and delivery cycle. In this way, grain growers will increase their chances of achieving the quality targets that will best suit their economic strategies.

### **Grow it right - Rätt odling**

The strategy of aiming for premium grades starts with the adoption of improved farm-management systems designed to increase returns per hectare through the combination of grain yield and quality (especially protein content). These systems include decisions on variety selection, the timing of planting, and appropriate use of fertilisers, with due consideration of soil moisture (probably our most limiting factor) (Wurst, 1999a and b). Decision-support systems have been developed for computer use to predict the risks of frost and heat to the developing grain, based on estimations of the timings of flowering and maturity, taking into account the characteristics of the specific variety. One of the systems being used to estimate the potential of late-application nitrogen fertiliser is tissue testing (McGrath *et al.*, 1995). By this method, the farmer takes leaf material from plants after the five-leaf stage, and dries the leaves in a microwave oven. This material is mailed to a regional laboratory for analysis by near infrared spectroscopy (NIR) to determine the levels of nitrogen and fructan, from which recommendations are made about fertiliser application.



### **Harvest it right - Rätt skördeteknik**

To minimise the risks of delivery of grain that may be down-graded on the basis of sprouting, CSIRO scientists have developed a rapid (ten-minute) on-farm test kit to predict the Falling Number value for field samples of grain. The test involves the coarse grinding of a small grain sample, and shaking the ground grain with buffer solution. Two drops of this extract are placed onto the upper pink pad of a test card. A drop of another solution (supplied in the kit) is added to the lower porous pad. Closing the card brings the two pads into contact, allowing the test sample to flow up to contact two antibody-impregnated reaction lines, which develop colour in proportion to the concentration of alpha-amylase in the extract. The colour intensity can be related to Falling Number by visual comparison between test and reference lines or by using a portable reader device. The whole test takes only a few minutes, permitting decisions to be taken about how to proceed with harvesting the sound grain and avoiding those parts of the crop that are shown to have sustained a significant degree of rain damage (Skerritt *et al.*, 1997).

Other important grain-quality considerations at harvest are grain moisture and protein content. It is common for growers to use a moisture meter at harvest to ensure that the grain they deliver is below the maximum moisture permitted, namely 12.5%. Some of the larger grain farms have NIR equipment for the determination of protein content, thus to test and blend on the farm to achieve quality targets for premium payments. In other cases, a grower may take a range of pre-harvest grain samples to the nearest delivery station for protein analyses to be performed there.

The concept of 'precision agriculture' is undergoing trial in many parts of the Australian wheat belt. This system involves the continuous monitoring of grain yield (also protein content in some cases) so that a map of the area harvested can be constructed in 'real time' providing information about those parts of the field that may need attention to increase their productivity.

### **Test it right - Rätt analys**

Traditionally, Australian wheat and barley growers deliver their crop to rail-based storage terminals immediately after harvest. At these 'silos', the grain is sampled and tested, initially for the obvious physical characteristics, such as test weight, cleanness, and the presence of defects and contaminants (listed in Table 1). Manuals illustrating the range of contaminating grain species (and tolerance levels) are valuable for both growers and receival agents to become familiar with the many weed seeds and grain defects (Wurst, 1999b). Image analysis provides a new approach to the automated and objective analysis of many of these aspects of quality, with the potential to make testing at receival more efficient (Peterson, 1998).

Near infrared spectroscopy (NIR) equipment is used routinely at the silo to determine moisture and protein content, and the method is being examined for analysis of a wider range of quality attributes, including malting quality and aspects of feed value (Table 1) (Wrigley, 1999). Further antibody-based test kits have been developed to determine other aspects of grain quality, such as identifying wheat varieties with the rye translocations (1A/1R and 1B/1R) that produce dough stickiness, and also to determine whether pesticide levels are with the minimum residue limits, in cases where such protectants are used (Skerritt and Appels, 1995).

In addition to all these tests, many grain-quality attributes are determined in practice for Australian grain deliveries on the basis of variety, a narrow range of

varieties being specified for each premium class, either for wheat or barley. This requirement introduces the technical difficulty of varietal identification. For this purpose, small grain samples are retained for subsequent analysis, usually by a simplified method of gel electrophoresis to determine protein composition using the standard method of the Royal Australian Chemical Institute (Westcott and Ross, 1995).

Nevertheless, even the combination of protein content and variety does not necessarily establish that dough properties, for example, are right, due to the added influences of growth environment. Sulfur deficiency is one of these factors that may alter protein quality from what is expected for wheat. We have developed a test for sulfur deficiency (Moss *et al.*, 1982) that can detect cases where the N:S ratio of the grain is too high, indicating the need for sulfur fertiliser, in balance with nitrogen, in the next crop. Temperature variation is another aspect of growth conditions that alters protein quality, and we are working to select varieties that show minimal quality variation with respect to this factor, especially heat stress (a few days when the day maximum exceeds 35°C).

### **Store it right - Rätt lagring**

Safe storage of grain has also been a priority of Australian farmers, as there is a growing use of on-farm storage. A CD-ROM has been produced as a training aid to help growers to avoid quality deterioration, and thus loss of market value. The rate of loss of malting quality for barley has been modelled as a means of predicting the 'safe' storage period and conditions during which malting quality will be retained. This model forms the basis of a computer program which can be used to predict the time period that will elapse before stored barley will lose malting quality (>95% germination), based on its initial soundness, and the temperature and moisture conditions of storage (Bason *et al.*, 1993). In Australia, the use of this model has saved large amounts of money by ensuring that the barley grain with the shortest 'safe' storage life is used first, thus avoiding the possibility of it from being down-graded to feed quality.

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**Table 1. Grain-quality attributes relevant to wheat (including feed uses) and rapid test methods likely to be applicable. (Adapted from Wrigley, 1999.)**

<b>Quality attribute</b>	<b>Conventional test method</b>	<b>Rapid method</b>
Genotype of grain & contaminants (genus, species, cultivar)	Visual examination, gel electro-phoresis, HPLC (Wrigley, 1995)	Visual examination, image analysis (Wrigley, 1995)
Broken and defective grains, contaminants	Visual examination (Wurst, 1999)	Visual examination, image analysis (Peterson, 1998)
Bulk density, size distribution	Chromometer	Perten SKCS
Sprouting / rain damage	Visual examination, Falling Number test	Visual examination, Rapid Visco Analyser, ELISA
Moisture content	Gravimetric, after oven drying	NIR, Perten SKCS
Protein content	Kjeldahl or Dumas total nitrogen	NIR
Starch content	Hydrolysis, glucose determination	Enzymic test kit, NIR
Non-starch polysaccharides (including beta-glucans)	Assay for individual components	Enzymic test kits, NIR (McCleary & Glennie-Holmes, 1985)
Essential amino acids	Hydrolysis, HPLC analysis	ELISA
Amylase and protease inhibitors	Enzymic assay	ELISA
Mycotoxins, other toxic compounds	GC, HPLC	ELISA (Morgan, 1995)
Pesticide residues, other agrochemicals	GC, HPLC	ELISA (Skerritt & Appels, 1995)

[Summary titles used in the oral presentation]

## **On-farm management to improve wheat and barley quality**

### **The right quality targets - Rätt kvalitetsmål**

- Achieving premium payments for superior grades
- Premiums of up to Aust\$50 / tonne = SKK250 / tonne
- A Quality Assurance system, based on HACCP principles

### **Grow it right - Rätt odling**

- Adopt improved farm-management systems
- Increase returns per hectare by yield and quality (especially protein content)
  - variety selection
  - timing of planting
  - appropriate use of fertilisers
  - tissue testing, to decide on late-application nitrogen fertiliser

### **Harvest it right - Rätt skördeteknik**

- Rapid test kit to predict the Falling Number
  - grind grain and shake with solution
  - place 2 drops of extract onto test card
  - close card and see reaction line
- Grain moisture and protein content
  - moisture meter at harvest (> 12.5% in Australia)
  - NIR equipment for protein content
- Precision agriculture

### **Test it right - Rätt analys**

- Physical characteristics
  - test weight, cleanness, defects and contaminants
- NIR equipment for moisture and protein content
  - also malting quality and feed value
- Test kits for dough stickiness, pesticide levels
- Varietal identification
- Environmental factors:- sulfur deficiency, heat stress

### **Store it right - Rätt lagring**

- CD-ROM for training
- Loss of malting quality for barley
  - predict 'safe' storage period and conditions