Proposal to the Agricultural Research Foundation:
Oregon Wheat Commission

TITLE: Oregon State University Cereal Quality Laboratory

PRINCIPAL INVESTIGATOR:
-Dr Andrew S. Ross: Crop & Soil Science, Oregon State University (OSU)

COOPERATORS:
-Dr C. James Peterson, **Dr Michael D. Flowers, Dr Patrick M. Hayes, Mary Verhoeven, Mark Larson.** Crop & Soil Science Department, OSU.
-Dr Craig F. Morris, Douglas Engle USDA Western Wheat Quality Laboratory, Pullman WA.

FUNDING HISTORY:

2007-08	**$36,500**
2008-09	**$35,200**
2009-10	**$41,670**
Requested 2010-11	**$53,122**

ABSTRACT:

Consumers expect wheat or flour-based products to have uniformly high quality. As a result, wheat processors worldwide have become increasingly sophisticated, and increasingly demanding of quality and value. To meet these burgeoning demands new varieties must have specific, class-appropriate, or novel end-use properties, in addition to improved on-farm performance. The OSU Cereal Quality Laboratory's (CQL) primary role is to ensure that the breeders have reliable data on the quality of experimental lines. Selections can then be made based on an experimental line's capacity to meet or surpass market-class expectations. The CQL also supplies quality data or supervises its acquisition for pre- and post-breeding efforts in wheat. A small effort, also supported by the Oregon Grains Commission, helps make possible food barley variety development. This proposal describes our strategies for evaluations of experimental lines and cultivars at the pre-breeding, breeding, post-breeding stages, for the development or evaluation of new analytical techniques, and for the creation of new scientific knowledge of cereals and cereal-based foods. During 2009 the laboratory processed or supervised data collection from 120 whole wheat mixographs, 900 polyphenol oxidase tests, over 1900 kernel hardness tests, 400 NIR protein tests, 195 total polymeric protein analyses, 126 full mill/rheology/bake profiles, 103 mill/bake profiles, and 90 mill/rheology profiles. The laboratory also supervised over 100 barley RVA and over 500 barley beta-glucan analyses. Other laboratory activities included methods validation and development work on the new 100g pin mixer for pup loaf baking, adaptation of a high-throughput beta glucan testing method, and adaptation, commissioning, and validation of a new, more rapid, small-bore chromatographic method for gluten quality analyses. During 2009 CQL personnel attended the PNW Wheat Quality Council and National Food Barley Council meetings. The PI traveled to the Australian Cereal Chemistry Conference, and to Central America and Mexico with US Wheat Associates.

OBJECTIVES:

1- Provide and interpret wheat quality data for the wheat breeding, cereal extension, and cereal genetics programs. Monitor the effects of genotype, growth environment, growing season, and crop management strategies on wheat kernel composition and functionality. Perform standard and non-standard assessments as requested. ***Anticipated outcome:*** *Release of new high quality wheat varieties in collaboration with the wheat breeding program.*

2- Develop or evaluate new analytical techniques. Method development work will focus on investigating the utility of the Perten MicroDoughLab[1]. Additional work will be conducted in collaboration with national peer labs on method upgrades for cakes (zero-trans fat), noodles (hardness, standardization), and pancakes (standardization). ***Anticipated outcome:*** *Test and validate or reject at least one new lab technique (2010-11 Perten MicroDoughLab).*

3- Create new scientific knowledge of cereals and cereal-based foods. The 2010-11 focus for knowledge creation will continue be placed on exhaustive physical and chemical characterization of the genetics and breeding programs' mapping populations. Other work may occur as new knowledge is acquired. ***Anticipated outcomes:*** *Publish at least one new paper on a novel aspect of the functionality of wheat kernel components. Provide breeder with marker options for tracking quality when introducing exotic germplasm with agronomic and/or disease resistance value.*

4- Provide calibration monitoring and support for the near infrared spectroscopy (NIRS) instruments used by the breeding program and other cereal research programs. ***Anticipated outcome:*** *Maintain the validity and reliability of the NIRS instruments.*

5- Maintain communication with PNW-based and national research partners and the Oregon wheat industry through appropriate travel to scientific, laboratory, and grower meetings, and technical workshops. ***Anticipated outcome:*** *Maintain and expand valuable professional contacts and access to current advances in cereal science.*

6- Identify novel and potential economically valuable quality traits that could be incorporated into Oregon wheats or other winter cereals. Focus in 2010-11 continues to be on food barley variety development (waxy and non-waxy, hulled and hull-less). ***Anticipated long-term outcome:*** *Collaborate on the creation of new crop choice options for Oregon winter cereal growing regions.*

PROCEDURES:

Quality support for breeding, extension, and genetics: In the quality support role our allied cereal research programs design the experiments and therefore define the numbers of treatments, field replicates, and locations. Where physical resource limitations in the lab suggest that less samples can be processed than requested, the PI works with the program leaders to find ways to reduce sample numbers with minimum impact on information value. With specific respect to *wheat breeding*, the breeding lines and check varieties to be tested are selected based on the breeder's assessments of overall performance, including yield and agronomic factors, and prior quality

[1] http://www.perten.com/pages/NewsPage 1548.aspx?epslanguage=EN

assessments. Location choices are made based on the grain meeting market-class appropriate specifications for test-weight and protein content. Early generation screening assesses three key quality traits on F4 and F5 headrow samples that have survived field screening for plant type, disease response etc. Mid-generation fast track testing is done on selected replicated and preliminary yield trial samples. CQL resources are completely at the disposal of the wheat breeding program between harvest and planting. Notably the breeding program has set at the disposal of the CQL approximately $10,000 of royalty monies. These are needed for a comprehensive upgrade of the test-mill, repairing the mill from its current state of compromised operation as a result of wear and tear on the sieves. The upgrade will also bring the mill into better compatibility with the equivalent mill at the WWQL in Pullman. (**Note**: we anticipate that the new mill capability will be commissioned prior to the 2010 harvest)

Testing of samples from *extension trials* has been generally confined to routine analyses and generally uses a reduced number of field replicates per location in order to keep numbers manageable. Similarly, testing of samples from the *cereal genetics* group has been generally limited to a small number of relevant standard tests. In both cases more complex analyses are available if requested.

Near infrared spectroscopy (NIRS) analysis support: Provision of the "at harvest" grain protein content is now provided by non-destructive NIRS analysis using 2 instruments located at Hyslop Farm and at CBARC Pendleton. Maintenance of the reliability of the NIRS instrument[s] and their calibrations requires ongoing care. This is achieved by performing the relevant reference tests[2] on a subset of samples analyzed by NIRS. This cycle we will use the OSU Central Analytical Lab for reference protein analyses given the unresolved technical difficulties with our own combustion nitrogen analyzer.

Method development and advancement of scientific understanding: Testing is a combination of routine standard tests, along with the modifications required by idiosyncrasies of our lab equipment, experimental demands, or new knowledge. In 2010-11 we will be continuing to generate standard (mill, mixograph, extensograph, baking) and novel (sheeting springback, dough relaxation time) data to compare with a new rheological instrument developed by Perten instruments. The MicroDoughlab can mimic Farinograph data with only 4 g of flour, but also has the capability of generating novel data on dough stress relaxation that we will be investigating for its usefulness in both breeding and commerce. Perten USA has agreed to let us use their instrument in Springfield IL once the in-house database in compiled.

MATERIALS:

Objective 1-

Soft and hard elite winter nurseries: Samples are collected by the breeding program. Up to 45 elite lines and checks (30 soft and 15 hard) from locations that meet grain protein specifications. Samples from each location are provided with 2 field replicates (in the order of 200 to 300 samples in total). ***Fast-track testing:*** We anticipate between 20 and 40 lines and checks for full mill & bake testing (hard- and soft-wheats combined) as well as 100 to 150 mid generation lines for wholewheat mixograph testing. We also anticipate between 500 and 2000 individual early generation (F4 & F5) headrow samples for hardness, PPO, and gluten quality testing. ***Extension***

[2] e.g. for protein, nitrogen determinations combustion; for moisture, oven moisture determinations

trials: Samples are selected by Dr Flowers as required. ***Cereal genetics projects*****:** Sample numbers can vary widely from season to season. From the 2008 harvest around 800 samples were tested for kernel texture and size. We anticipate that further chemical and physical characterization will be needed for other genetic mapping populations (e.g. the super-soft x SW population: and Tubbs x Einstein – SW x English HRW: Tubbs x NSA98-0995 – SW x French HRW populations of around 180 lines each) aimed at driving marker assisted selection (MAS) strategies in the program (Also part of Objective 3).

Objective 2 – This Objective utilizes grain from Objective 1 testing. Samples are gleaned using criteria specific to the experimental requirements even though they may be "out-of-spec" for routine testing.

Objective 3 –Samples of the breeding and genetics groups' mapping populations are provided by the respective PIs. Currently kg quantities from 2 locations x 2 replicates for these populations are available. Additional flour samples (~ 30 of 10 kg (22 lbs) or more) are received from the PNW Wheat Quality Council. These samples are already milled and comprehensively characterized for basic quality attributes at the USDA lab in Pullman WA.

Objective 4 – This will utilize a subset of around 4 – 8% of all samples tested using the NIRS instruments. In 2008, at least 1800 grain samples were put through the NIRS instrument for protein and moisture. To do the calibration maintenance between 50 and 150 samples will need to be analyzed by the reference nitrogen and oven moisture methods.

Objective 5 - No plant materials

Objective 6: Samples come from state-based and regional cereal breeding, extension, and agronomy trials; includes barley and triticale.

METHODS:

Standard procedures of AACC-International (AACCi), the professional society for cereal scientists, established methods from the scientific literature, or in-house standard procedures are used for quality analyses of wheat grain, flour, dough and end-products. Testing encompasses attributes such as kernel texture, grain and flour protein and moisture contents, grain polyphenol-oxidase activity, milling performance, flour protein composition and size distributions, mixograph dough properties, micro-scale dough extensibility, solvent retention capacities, and end-product manufacture and assessment. New methods are trialed and validated or rejected. Research into quality testing methods is primarily targeted at increasing the accuracy, sample capacity, speed of the method under investigation. It is also vital to adapt quality-testing methods to match the contemporary food formulations and manufacturing processes in which the wheat is used

TIMELINES:

-Fast-track high priority testing of soft and hard elite lines and early generation triage (objective 1): Late summer and fall 2010

-Soft and hard elite nurseries (objective 1): Extension trials (objective 1): Cereal genetics projects (objective 1): Fall 2009, Winter and Spring 2010.

-Objective 2 activities are spread throughout he year.

A progress report to the OWC will be available in March 2011 as dictated by the granting/reporting cycle.

JUSTIFICATION:

Oregon produced around 1.4 million metric tons of wheat, valued at around $340 million in 2008 (NASS[3]). Of this wheat about 10% was used domestically. The other 90% contributed directly reducing the US trade deficit and was Oregon's most valuable agricultural export[3]. Deployment of new wheat varieties contributes directly to the prosperity of wheat growers. New varieties bring improved agronomic performance, increased robustness against diseases and environmental stresses, and, ideally, improved end-use quality. These attributes provide increased economic returns to growers through increased yields, decreased risk, and maintenance of market demand through provision of market class appropriate or superior quality attributes. Consumers expect wheat or flour-based products to have uniformly high quality, to be convenient, and to have positive nutritional characteristics. Resulting from consumer expectations, wheat processors worldwide have become increasingly sophisticated, and demanding of quality and value. To meet processors' demands new varieties must have specific end-use properties. To ensure that our new varieties have the end-use properties required for market success, an ongoing commitment to on-site wheat-quality testing is needed as a component of the overall variety development effort.

Wheat functionality is complex and encompasses a range of characteristics including grain hardness, bran color, milling performance, the size distribution of the flour particles, flour protein composition and concentration, the physical state and molecular composition of the starch, and a recognition of the possible effects of the minor components such as pigments, lipids, fiber, and enzymes. Understanding wheat quality also requires a knowledge of potential interactions between the flour components, between flour components and water, the behavior of doughs during processing, and an understanding of the quality requirements of a wide range of end-products. Doughs in particular have their own profound influence on finished product quality and are a factor in buying decisions in the wheat trade. These factors drive our ongoing focus on dough testing and prediction of dough properties. Milling is also crucial because most wheat-based foods are made from milled flour and thus milling performance (ash, color, yield) of wheat is a key attribute in a variety's commercial acceptance.

Advancing knowledge of the interplay between wheat grain composition, processing, and end-product quality drives our ability to manipulate wheat composition through genetics and breeding in order to make beneficial changes in performance, and hence market competitiveness. Resulting from this, I would then assert that reliable quality support, testing, and research is integral to the success of any wheat breeding program. I would also assert that relevant quality testing is equally integral to success in extension and genetics research where these studies seek to improve the end-use performance of wheat. To achieve these goals these research groups need, at their disposal, a well-functioning cereal quality research lab, with attendant expertise in cereal composition and processing. The OSU-CQL meets this need on an ongoing basis.

[3] http://www.nass.usda.gov/Statistics_by_State/Oregon/Publications/facts_and_figures/facts_and_figures.pdf

ACCOMPLISHMENTS:

2009-10 Objective 1: *Anticipated outcome: Release new high quality wheat varieties in collaboration with the wheat breeding program.* No new varieties were released in CY 2009. This is a decision of the breeder. However, the CQL remained active in assessing the quality of F4, F5, RPN, and ELITE materials in both the hard and soft wheat categories.

2009-10 Objective 2: - *Anticipated outcome: Test and validate or reject at least one new lab technique.* Method validation and development work was done for the new 100g pin mixer, the high-throughput beta glucan testing method, and the new small-bore chromatographic method for gluten quality analyses.

2009-10 Objective 3: *Anticipated outcome: Publish at least one new paper on a novel aspect of the functionality of wheat (cereal) kernel components*.

►Filichkin, T.P., M.A.Vinje, A.D. Budde, A.E. Corey, S.H. Duke, L. Gallagher, J. Helgesson, C.A. Henson, D.E. Obert, J.B. Ohm, S.E. Petrie, A.S. Ross, and P.M. Hayes. Phenotypic variation for diastatic power, beta-amylase activity and thermostability vs. Bmy1 allelic variation in North American barley. Crop Science. In press.

►Y. L. Ong, A. S. Ross, and D. A. Engle. Glutenin Macropolymer in Salted and Alkaline Noodle Doughs. Cereal Chem. In press.

►T. Kongraksawech, A. S. Ross, and Y. L. Ong. Effect of carbonate on co-extraction of arabinoxylans with glutenin macropolymer. Cereal Chemistry. In press.

►Ohm J. B., A. S. Ross, C. J. Peterson, and C. F. Morris. 2009. Relationships of Quality Characteristics with Size-Exclusion HPLC Chromatogram of Protein Extract in Soft White Winter Wheats. Cereal Chem 86: 197-203.

►J. I. Rey, P. M. Hayes, S. E. Petrie, A. Corey, M. Flowers, J. B. Ohm, C. Ong, K. Rhinhart, and A. S. Ross. Production of Dryland Barley for Human Food: Quality and Agronomic Performance Crop Sci. 2009 49: 347-355.

►Ross A.S. and Crosbie G.B. "Effects of flour characteristics on noodle texture" in "Asian Noodles: Science, Technology, and Processing" edited Gary Hou. John Wiley & Sons, Inc. In press.

►Ross A.S. & Bettge A.D. 2009 "Passing the Test on Wheat End-Use Quality" pp 455-493 in "Wheat Science and Trade" B.F. Carver ed. Wiley-Blackwell.

2009-10 Objective 4: *Anticipated outcome: Maintain the validity and reliability of the NIRS instrument[s]*. Technical and reliability issues with our primary protein tester (shared with brewing and dairy in the Food Science Dept.) have not been resolved at December 2009.

2009-10 Objective 5:- *Anticipated outcome: Maintain and expand valuable professional contacts and access to current advances in cereal science.* During 2009 CQL personnel attended the PNW Wheat Quality Council and National Food Barley Council meetings. The PI traveled with US Wheat Associates to Central America and Mexico, and to the 59th Australian Cereal Chemistry Conference.

2009-10 Objective 6: *Anticipated outcome: Help the breeder identify the best quality lines to advance, minimize his time input, and maximize the value of the WWQL data.* There was less activity in this area in CY 2009. The breeder developed a new approach to sorting and summarizing the WWQL data that we are investigating as a more effective method of data handling.

2009-10 Objective 7: *Anticipated long-term outcome: Collaborate on the creation of new crop choice options for Oregon winter cereal growing regions.* The CQL worked with the barley breeding program on the development of winter habit food barley with options for including both the waxy and/or hull-less traits in release candidates.

BUDGET

Salary:	
-Faculty Research Assistant	
25% of salary - covering state shortfall	**8250**
-Graduate Student - 3 terms 0.49 FTE @ GRA IV	
*(oral prelim complete) -- $1,842/month***	**16578**
*-Other students approx 25 days * 8 h @ $10 / hour*	**2000**
-Other Labor (specify type)	**NA**
-OPE & health for all categories	**7044**
Equipment:	
Instrument and equipment upkeep, maintenance, and calibration (Perten SKCS, Foss Infratec NIRS, Texture Meter, ovens, balances, pipettes, spectrometers, cold room, mixers, Mixograph, RVA etc)	**5000**
Travel:	
Domestic (in state) - *OWC research review, Wheat Marketing Center etc*	**750**
Domestic (out of state) - *AACC annual meeting, WWQL, Springfield IL for Perten MicroDoughLab work, PNW WQC (2 attendees)*	**4000**
Foreign (conferences, etc)	NA
Supplies and Materials:	
Routine renewal of HPLC column and guard column	**3000**
150 samples OSU Central Analytical Lab Grain protein @ $10 each	**1500**
Chemical supplies *(lactic acid, SDS, sucrose, sodium carbonate, sodium chloride, sodium and potassium hydroxides, L-DOPA, mercaptoethanol, petroleum ether, pH meter standards etc)*	**2000**
HPLC grade reagents (acetonitrile, ethanol, methanol, etc)	**1500**
Lab-on-a-chip - 2 chip kits	**1500**
TOTAL	**53,122**

**The PI considers that this will be the most effective way of staffing the labs half time, providing needed additional hands for the Faculty Research Assistant

SIGNATURE PAGE

PROPOSAL TITLE:

SUBMITTED TO: AGRICULTURAL RESEARCH FOUNDATION FOR THE OREGON WHEAT COMMISSION

SUBMITTED BY:

_____ Date: _____
Principal Investigator(s)
Use separate line for each additional P.I.

APPROVED BY:

_____ Date: _____
Principal Investigator's Unit Supervisor(s)
(Department Head, Superintendent, or County Chair)

_____ Date: _____
Principal Investigator's Academic College

_____ Date: _____
Agricultural Research Foundation

CURRENT AND PENDING SUPPORT

NAME	SUPPORTING AGENCY	TOTAL $ AMOUNT	EFFECTIVE AND EXPIRATION DATES	% OF TIME COMMITTED	TITLE OF PROJECT
Current:					
Andrew Ross	OWC	40,570	July 2009 to June 2010	25	Oregon State University – Cereal Quality laboratory
Pending:					
Andrew Ross	OWC	53,122	July 2009 to June 2010	25	Oregon State University – Cereal Quality laboratory [Subject of this proposal]
Patrick Hayes Andrew Ross - cooperator	Agricultural Research Foundation	12,500	July 1 2010 – June 30 2012	5	Seed production and pilot processing of potential barley varieties