Proposal to the Agricultural Research Foundation: Oregon Wheat Commission

TITLE: Oregon Wheat Quality Program (OWQP)

PRINCIPLE INVESTIGATOR:
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COOPERATORS:
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-Dr Jae B Ohm.
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FUNDING HISTORY:
2005-06 OWC Funds:$31,425
2006-07 OWC Funds:$34,730
2007-08 OWC Funds :$36,500
Requested 2008-09:$35,200

ABSTRACT:
The OWQP works to understand molecular phenomena that control the processing and quality of wheat-based foods. We provide wheat quality data for our companion wheat breeding program, but a growing part of our activities is to provide the same type of data for our other companion programs in cereals extension and genetics. We provide for their basic wheat quality needs either directly by performing the testing, or indirectly by training personnel from the other programs. In the latter case we supervise data collection and aid in data interpretation. Testing is done on wheat from elite variety trials (especially the crucial fast-track quality testing between harvest and sowing) and on samples from early generation headrows, extension trials, and from the cereal genetics program. We also seek to identify new testing methods and to refine current ones. Two methods that were highlighted in the 2007-08 request are still in the pipeline: predicting dough characteristics using the lab-on-a-chip, and predicting dough water absorption from kernel hardness data. These projects are proceeding in collaboration with our colleague Dr Jae Ohm at the SWQL and they remain important in our hard wheat variety development work and our efforts to derive market-applicable methods for estimating dough strength. Another component of the previous request, measuring dough extensibility, also continues, but now in conjunction with new trials aimed at increasing the pace of dough testing methods by testing whole-wheat flours milled our new CleanMill system. Accordingly, quality testing again focuses on developing tests to more rapidly measure or predict dough attributes rather than focusing on finished end-products. Nonetheless, a new high temperature oven will allow us monitor the suitability of wheats for flat-bread production once the baking method has been optimized for our equipment. This is especially applicable to our efforts to ensure a strong market position for lower protein hard wheats. In related

research, the OWQP has pioneered new rheological methods for noodle doughs, and we are embarking on work with WWQL to define the role of soft-wheat soluble fiber in batters.

OBJECTIVES:
1) Provide relevant wheat-quality data to our 3 companion research programs: wheat breeding, cereals extension, and cereal genetics. This encompasses analyses aimed at monitoring effects of genotype, growth environment, growing season, and crop management strategies on wheat composition and functionality.
a) Breeding: Routine assessments including milling performance, mixograph, extensigraph, biaxial extension, and Arabic bread production.
b) Breeding: "Fast-track" assessments (between harvest and replanting) of key milling, dough, and end-product attributes on a small number of lines requiring confirmatory quality-data before investing in seed increases or making release decisions.
c) Breeding: "Fast-track" quality-based selection recommendations on F4 and F5 headrow material: kernel hardness; polyphenol-oxidase; and as appropriate, predictions of dough characteristics. This work has proven invaluable in increasing the effectiveness of the breeding program's quality selections.
d) Cereals extension: Quality testing on trials that emphasize crop management designed to increase the probability of achieving market-class-appropriate grain protein levels.
e) Cereal genetics: Quality testing focused on mapping and exploitation of the extra-soft kernel trait. Protein separations and analyses supporting research into wheats with altered gliadin synthesis.

2) Identify new testing methods and refine current methods. The focus remains primarily on rapid dough testing or prediction of dough properties (partly in collaboration with the SWQL). New components aimed at defining the role of soft-wheat soluble fiber in batters, and development of suitable test methods, are now included (collaborative with WWQL).

3) 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.

4) Provide quality based selection recommendations to the Wheat Breeding program for F6 to F10 material tested at WWQL.

5) Provide preferred variety lists for Oregon wheats, based on the suitability of varieties for existing market classes.

6) Identify potential economically valuable novel quality traits that could be incorporated into wheat or other winter cereals.

PROCEDURES:
The proposed project seeks support to conduct relevant wheat quality testing in support of its 3

companion research programs: wheat breeding, cereals extension, and cereal genetics, as well as specific research within the OWQP aimed at improving current test protocols or creating or adapting new techniques. As the OWQP, in its support role for the companion programs, is effectively a derivate program, we rely on the experimental designs used in the companion programs to define the numbers of trials, treatments, replicates, and locations. With respect to the major support given the breeding program we have established and will continue a policy of deciding with the breeder, which elite locations and what lines to test, both for the in-house testing and for testing at the WWQL. Choices of breeding lines and check varieties are based on the breeder's assessments of overall suitability including yield and agronomic factors in addition to prior quality assessments. Locations are chosen based on test-weights and grain protein contents and require grain protein content appropriate for the market class and adequate test-weights. For example, locations with low average grain protein will be selected for soft wheat testing, and vice-versa for hard wheat testing, so in some cases nurseries representing only one market class (e.g. SW) will be tested from a given growing location. Adequate test-weight is important as it is very difficult to assess milling properties with pinched grain. Provision of the "at harvest" protein content has been provided in the recent past by non-destructive near infrared analysis using instruments donated by the Federal Grain Inspection Service. However, these machines have become unserviceable. Continuation of the full scope of this vital data analysis hinges on the successful outcome of an $80,000 internal equipment grant application to OSU that will be decided January 2008. Contingency plans are in place in the event the grant is not funded. Under particular circumstances such as looking at method development and other specific wheat-quality research activities, the OWQP PI may decide that additional locations that are out-of-specification for protein content are required for in-house testing.

Materials:
- Objective 1a- Soft and hard elite nurseries: Soft wheats: 20 lines from 4 locations with 2 field replicates (160 samples total) were tested from the 2006 harvest. 23 lines from 4 candidate locations with 2 field replicates (184 samples total) have been collected from the 2007 harvest. Comparable numbers are anticipated from the 2008 harvest.
Hard wheats: 19 selected lines from 4 locations with 2 field replicates (156 samples) were tested from the 2006 harvest. 23 lines from 4 candidate locations with 2 field replicates (184 samples total) have been collected from the 2007 harvest. Comparable numbers are anticipated from the 2008 harvest.

Objective 1b- Soft and hard elite nurseries - Fast-track: Soft wheats: from the 2007 harvest - 9 lines x 1 location (9 total) were run through a full quality panel at the WWQL. A comparable or larger number of soft wheat samples is expected from the 2008 harvest and it is anticipated that this work will be done in-house for the 2008 harvest (see "Accomplishments").
Hard wheats: 16 lines x 1 location (16 total), and 6 lines x 2 locations (12 total) were run through the single kernel instrument, were milled, and had mixographs performed from the 2006 and 2007 harvests respectively. A comparable number of hard wheat samples is expected from the 2008 harvest.
- Objective 1c - F4 and F5 headrows - Fast-track: Up to 2000 individual headrow samples as selected by breeder after field selections for agronomic traits. Approximately 1350 samples from the 2007 harvest were analyzed for kernel texture and size and 250 for polyphenol oxidase.

- Objective 1d - Extension trials: From the 2007 harvest material from 3 trials of 114 entries with 2 field replicates (342 total). A comparable number of samples is expected from the 2008 harvest.

- Objective 1e - Cereal genetics projects: From the 2007 harvest 165 progeny x 2 field replicates x 1 location and a larger number from the greenhouse samples (~ 900) were tested for kernel texture and size. The same number of samples is expected from the 2008 harvest but more extensive testing on field-grown samples is anticipated. In addition an undefined numberof samples (~100) of wheats with altered gliadin synthesis is anticipated for assessment through the MFCE lab-on-a-chip system.

- Objective 2 - Identify new testing methods and to refine current ones: This objective utilizes grain from the objective 1 testing. - Objectives 3-5: No plant materials

- Objective 6: For example over 200 triticale samples from the 2006 harvest were assessed in April 2007 in order to identify genetic variants for starch characteristics that may be of value for starch utilization in food processing or as a regionally-based starch-ethanol feedstock.

Methods:
Standard procedures cereal scientists, established methods from the scientific literature, or in-house standard procedures will be used for quality analyses of wheat grain and flour attributes such as kernel texture, grain and flour protein and moisture contents, polyphenol-oxidase activity, milling performance, mixograph dough properties, micro-scale dough extensibility, solvent retention capacities, and end-product manufacture and assessments. Additionally, new methods are to be trialed or validated. The new method for predicting optimum water absorption for mixograph testing from kernel hardness testing is still to be validated. We are confident that this new method for predicting optimum water absorption will increase the “information value” of kernel hardness testing, which is done routinely on all samples we test, and therefore increase our efficiency in dough testing. The additions to our equipment roster of a stone-mill and a state-of-the-art impact mill (CleanMill) will allow us to attend to whole-grain assessments both from 2 viewpoints; adaptation of standard methods to whole-wheat flours with the aim of faster turn-around of breeding samples; and assessment of breeding lines for their utility in whole-wheat products. The new “lab-on-a-chip” MFCE technique for analyzing wheat proteins is to be optimized for both gliadin and glutenin analyses. The gliadin analyses are to support the cereal genetics program (see materials for objective 1e) and the glutenin analyses to continue method development of potential market-applicable prediction methods for dough strength. The MFCE lab-on-a-chip technology enables rapid automated identification and quantification of proteins (around 3 min per analysis) by integrating multiple procedures (sample handling, separation, staining, detection, computerized interpretation) in a single process. One anticipated direct benefit to OSU wheat breeding is an increase in the number of early generation breeding lines that can be reliably screened for dough characteristics.
TIMELINES:
- Fast-track high priority soft and hard elite lines (objectives 1b and 1c): Late summer and early fall 2008
- Soft and hard elite nurseries (objective 1a): Extension trials (objective 1d): Cereal genetics projects

(objective 1e): Winter/spring 2009.
A progress report to the OWC will be available in December 2009 or February 2010 depending on the granting/reporting cycle.

JUSTIFICATION:
Quality testing is an integral component of the OSU wheat breeding program and is increasingly important to the cereal extension and genetics groups. The cereal extension work on crop management designed to increase the probability of achieving market acceptable grain protein levels requires consistent quality back-up. The cereal genetics projects targeting genetic mapping and genetic manipulation of kernel composition, and therefore quality traits, also requires consistent quality back-up. As the quality program serves the 3 companion programs its aims are conistent with theirs, for example, supporting the breeding program's aims to increase economic returns to growers through development of varieties with superior end-use qualities. Of course the market will be the final test of which varieties have acceptable or better quality. However, it saves considerable time and money if the wheat breeding and quality programs work closely together to maximize the probability that released lines are desired in the marketplace. Maximizing this probability leads to better returns on the substantial economic investments made in wheat variety development by OWC and the State of Oregon. In order to maximize the probability that released lines possess superior end-use qualities we need systematic quality assessments at three levels: fundamental, functional, and end-use. Testing at these three levels is needed as intrinsic wheat quality is determined in the first instance by the fundamental physical and chemical attributes of the kernel's molecular components and then by interactions between the components. Component interactions are best addressed in a practical manner by the functional testing of attributes like milling quality and end-product performance. Additionally for wheat the functional characteristics of a key process intermediate, the dough, can be as important as end-product quality in purchase decisions by buyers, hence the great emphasis on dough testing and prediction of dough properties in all iterations of this project to date. The objectives for 2008-09 are again designed to improve synergy with the results of WWQL testing, specifically by testing functional properties that are not covered by WWQL testing. This project fits into regional and national research efforts aimed at wheat quality improvement and improved testing methodologies.

REPORT OF ACCOMPLISHMENTS TO DEC 31 2007:
As selected by the wheat breeder 12 critical hard-wheat samples (6 lines x 2 locations) from the 2006 harvest were milled and analyzed for kernel texture, milling performance, and mixograph dough properties in the period prior to replanting. This testing also provided us with our first opportunity to observe the potential of "whole-wheat" mixographs using in this instance an 80% extraction flour milled on our new stone-mill. Preliminary results suggest a strong possibility of success. Additionally, we have since acquired a new CleanMill impact mill to replace the obsolete and unreliable Udy impact mills. There are 3 tremendous advantages of the CleanMill system with respect helping us increase dough testing throughput; one is the ability of the mill to automatically take sub-samples when grinding larger samples, the second is the mill's self-cleaning attribute, and the third and arguably most beneficial is the claimed capability of the mill to grind the samples with no moisture loss. Other mills lose large and unspecified amounts of moisture during grinding necessitating additional time-consuming oven

moisture determinations on the ground meal. The retention of the measured grain moisture in material milled on the CleanMill will allow us to use the grain moisture content for further analyses, such as whole-grain mixographs and extensigraphs where accurate performance of these analyses is predicated on accurate knowledge of the initial moisture content of the flour or meal. The leverage we gain from use of the CleanMill accrues because we determine grain moisture automatically when running the samples through the single kernel tester and single kernel analyses are done on all samples we test regardless of their provenance or the type of testing to be done.

In a departure from previous protocols, 9 soft wheat samples were assessed for full kernel, milling, and cookie and baking attributes at the WWQL labs. This departure from previous protocols accrued from 2 circumstances; the first was that this was the first time in my incumbency that elite soft wheats had been fast-tracked. The second was that testing was done at WWQL because of the lack of experienced personnel at OSU after the loss of both the OWC and the State of Oregon funded research assistants in mid-2007. As an additional outcome of this circumstance is the carryover of some 2006 harvest testing to the 2007-08 season. This is primarily the extensibility and MFCE testing for the breeding program. Thankfully an experienced research assistant, Caryn Ong, who is familiar with our labs and testing protocols was appointed December 1 2007.

As in previous years a large number (> 1350) early generation samples was put through primary quality screening on the single kernel tester with a further 250 tested for the enzyme associated with undesirable dough darkening. At each stage approximately 1/3 of the lines were deleted, saving much time and money by not testing lines that will eventually be rejected in subsequent yield trials and quality testing. An additional accomplishment was the detection of potential genetic variants for starch amongst approximately 200 triticale lines that may provide advantages for winter cereal growers into the future. This work will be followed up in 2008-09 after a hiatus related to the late 2007 triticale harvest, which at this point appears to be rain-affected.

Work has continued on the commissioning of the OSU funded MFCE lab-on-a-chip system and at the time of writing a number of crucial technical issues have been resolved. Subsequently, the graduate student working on the project has begun to collaborate with the cereal genetics program on optimizing gliadin analyses for the gliadin synthesis project. The potential long-term benefits of this work are justified in the cereal genetics program's overall aims and it is not appropriate for me to amplify them here. We also supported additional work of the cereal genetics program, training a graduate student in the use of the single kernel tester and supervising the collection of single kernel data from over 1200 samples. Full crush profiles were also collected and data analysis is ongoing. Further single kernel analyses has been supported on over 400 samples from a graduate student project within the breeding program.

RELATION TO OTHER RESEARCH:

The project is wholly integrated with the OSU Wheat Breeding Program, and is associated with projects related to quality traits in the cereal genetics program, and the crop management research of the cereals extension program. The work meets the requirements of the breeding program for data that is specific to end-use quality. The project has also intersected with an Oregon Agricultural Research

Foundation funded project on fundamental testing of reduced water doughs such as those used in noodle processing, and with a successful graduate student project looking at the fundamental interactions between flour protein content and composition and the processing of noodle doughs. This OWC funded work has also contributed to the book chapter “Passing the test on wheat quality” in the new book in preparation “Wheat science and trade” edited by Dr Brett Carver, wheat breeder at Oklahoma State University.

BUDGET:
Overall
Servicing of Single Kernel Analysis System- 4000
Instrument upkeep, maintenance, replacement, and calibration- 4000

Objectives 1 and 2
1250 samples; Grain protein and flour protein = 2500 tests @ 0.60 cents plus estimated cost increases and unanticipated additional samples- 2500
Travel to Hyslop farm for flour milling (motor pool vehicle rental) 60 days @ $21/day plus 0.20 cents per mile (20 miles) $4/day- 1500
Chemical supplies (lactic acid, SDS, sucrose, sodium carbonate, sodium chloride)- 2500
Lab-on-a-chip “chips” for up to 1000 samples in duplicate - 8 kits @ $607 each plus ancillaries (Objectives 1a, 1d, 1e, 2) - 6000
Student hourly wages (approx 125 days * 8 h @ $10 / hour)- 10000

Objective 3
Western Wheat Quality Lab Pullman WA (PI only)- 500
PNW Wheat Quality Council meeting (PI plus technician)- 2000
Eastern Soft Wheat Technical meeting Wooster OH (airfare ~ $500, accomodation ~ $450 (3 nights @ $150, registration $200) (PI only)- 1200
Contribution to PI travel to annual cereal chemistry meeting- 1000

Objectives 4-6
No cost or covered by services and supplies from Objective 1 (Objective 6)
Total 35200

Project Title: The Oregon Wheat Quality Program

Funding Agency: Agricultural Research Foundation Oregon Wheat Commission

Principal Andrew S. Ross
Investigator: Assoc. Professor, Cereal Science

Organization:
Dept. of Crop and Soil Science

Oregon State University
Corvallis, OR 97331-3002

Requested Funding: $35,200

AES Project Number Associated with this Research: # ORE00141 - "Development of wheat varieties with enhanced end-product suitability "

Approved:

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