Project Number: 3607-43440-007-00D **Accession:** 0419817 **FY:** 2011

ModeCode: 3607-20-00 MIDWEST AREA
WOOSTER, OHIO
CORN, SOYBEAN AND WHEAT QUALITY RESEARCH

NPL Leader: ROBERT L FIREOVID **Prin Invs:** VACANT

Start Date: 07/22/2010 **Term Date:** 07/21/2015

National Programs: 306 N Quality and Utilization of Agricultural Products

Title: GENETIC AND BIOCHEMICAL BASIS OF SOFT WINTER WHEAT QUALITY

Period Covered From: 10 / 2010 **To:** 9 / 2011 **Final Report?** No
Terminate in Two Months? No

Progress and Outcomes:

4. Accomplishments

01 Quality standards for soft wheat. In order to simplify interpretation of quality measurement characteristics, researchers at the Soft Wheat Quality Laboratory in Wooster, Ohio analyzed and summarized preferred ranges for forty-nine milling, baking, physical and biochemical parameters based on feedback from industry and cooperators and 10 years of industry and ARS testing. The desired quality parameters for pastry and cracker or export flours were posted on the USDA/ARS Soft Wheat Quality Laboratory website to facilitate cooperating breeder selection of wheats based on preferred flour type and to improve marketing efficiency for the soft wheat class. Results of a cooperator survey at the 2011 Research Review led to revision of ranges for 20 quality traits. The revised ranges for wheat quality allow plant breeders focused on improved yield and disease resistance to maintain high product quality in their selections.

306 1 A 2000

02 Formulation of a cake flour testing method with zero-trans fat. A zero trans-fat method was developed by a USDA/ARS scientist in the Soft Wheat Quality Laboratory in Wooster, Ohio. The method replaces those based on cake recipes containing partially hydrogenated fats that are being phased out in industrial cake baking because of health standards demanding zero trans fat. The zero trans-fat method is being used by flour testing labs and industrial bake labs to test new wheat varieties and flour milling methods for their suitability for cake baking.

306 1 B 2000

03 Whole grain soft wheat flour nutritional profile. Scientists at USDA/ARS Soft Wheat Quality Laboratory completed the first comprehensive survey of the nutritional profile of whole grain soft wheat flour. The analysis resulted in raised estimates of the amount of fiber in whole grain flour, and lowered estimates of B vitamin concentrations, including niacin, thiamin and pyridoxine (vitamin B6). The completed survey brings the nutritional database into compliance with the best methods available for determining fiber and vitamin content. It gives improved nutritional information to dieticians and baking industry product development teams. It also points to a need to investigate the origins in the decline of B vitamins in current non-fortified whole wheat flour. These new results have the potential to change the nutritional labels of every whole wheat product on the market.

306 1 B 2000

Project Number: 3607-43440-006-00D **Accession:** 0418901 **FY:** 2010

ModeCode: 3607-05-00 MIDWEST AREA
WOOSTER, OHIO
SOFT WHEAT QUALITY RESEARCH

NPL Leader: LEWIS FRANKLIN FLORA **Prin Invs:** EDWARD J SOUZA

Start Date: 12/01/2009 **Term Date:** 07/21/2010

National Programs: 306 N Quality and Utilization of Agricultural Products

Title: GENETIC BASES FOR THE BIOCHEMICAL DETERMINANTS OF WHEAT QUALITY

Period Covered **From:** 10 / 2009 **To:** 9 / 2010 **Final Report?** Yes
Terminate in Two Months? Yes

Progress and Outcomes:

4. Accomplishments

01 Milling and baking evaluation of over 7,000 wheat breeding samples. Wheat breeding programs in the eastern US rely on the soft wheat quality laboratory for milling and baking evaluations for selecting new wheat cultivars and genetic studies related to wheat quality. The evaluations supported basic research in genomic selection, crop fertilization, and pre-harvest sprouting by graduate students at Cornell University, Michigan State University, and Purdue University. The evaluation of milling and baking samples allows wheat breeders to select for improved milling and baking quality. A recent study at the University of Illinois on the impact of quality selection on the wheat breeding program demonstrated a gain from selection for quality in a single year selection cycle of more than 500 g per 100 kg of grain milled and more than 4,000 g per 100 kg milled of the most valuable flour fraction, the break flour percentage.

306 1 A 2000
306 1 B 2000

02 Development of a standardized, batter-based, pancake evaluation system. Cake and pancake are major batter-based products made with soft wheat flour. A standardized baking method for high-ratio cake has been widely used for evaluating the cake-baking performance of soft wheat flour. Developing a standardized pancake-making method would provide benefits to breeders, millers and bakers for evaluating pancake flour quality and facilitating the development of pancake products formulated with health-promoting ingredients. In a preliminary investigation, the effects of leavening acids and type of fat have been explored, in an effort to identify preferred ingredients and a formula. Flow distance for batter viscosity, and pancake diameter and height were measured. Validation of these preliminary results was performed using various sample flours. As a diagnostic formula to distinguish differences in flour performance for pancake baking, soda (2.25g), MCP (0.38g), and SAPP 28 (2.7g) were selected as the leavening system. Pancake-making performance using liquid canola oil was similar to that using solid shortening, with a minor adjustment in water level. Pancake-making performance for two samples (A and B) of unchlorinated flour or their blends could be predicted from flour solvent retention capacity values (SRC). When the SRC values in all four solvents were lower for flour A than for flour B, the flow distance of the batter and the diameter of the pancake were both greater for flour A, but the pancake height was smaller. Currently, various probes and test modes with a texture analyzer are examining to identify an appropriate setting for measuring pancake texture.

306 1 A 2000
306 1 B 2000

Report of Progress (AD-421)

Project Number: 3607-43440-005-00D **Accession:** 0409215 **FY:** 2010

ModeCode: 3607-05-00 MIDWEST AREA
WOOSTER, OHIO
SOFT WHEAT QUALITY RESEARCH

NPL Leader: LEWIS FRANKLIN FLORA **Prin Invs:** EDWARD J SOUZA

Start Date: 02/02/2005 **Term Date:** 11/30/2009

National Programs: 306 N Quality and Utilization of Agricultural Products

Title: GENETIC BASES FOR THE BIOCHEMICAL DETERMINANTS OF WHEAT QUALITY

Period Covered **From:** 10 / 2009 **To:** 9 / 2010 **Final Report?** Yes
Terminate in Two Months? No

Progress and Outcomes:

4. Accomplishments

01 Linked milling yield to specific protein and arabinoxylan characteristics of the grain and flour. Industry has long noted differences among cultivars in milling yield. The biological causes of those differences are less well understood. We used mill stream analysis of cultivars milled on a 13 stream Miag Multo-mat experimental mill to analyze distribution of cell wall material through the streams. We found that the cultivars with less cross linking structure of arabinoxylan (cell wall material) tend to have a greater percentage of the flour recovered from later break and reduction rolls and overall lower flour yield than those with relatively large amount of cross linked arabinoxylans. This suggests that the arabinoxylans may be involved in rigidity of the endosperm and affecting the degree of friability in the milling. Subsequent work will target the regulation of these genes in the seed with the goal of improving overall flour yield for the milling and baking industry in the eastern U.S.

306 1 B 2000

02 The bench-top cracker method was developed and tested with industry partners. The method predicts well three parts of quality: 1) color due to baking, 2) texture of crackers after baking, and 3) the propensity of doughs to form blisters when baked into crackers. This last point is the most important as blisters lead to breakage in shipping and difficulty for packaging operations. Research with the cracker method identified the ratio of 10% Lactic Acid Solvent Retention Capacity (SRC, AACC method 56-11) to the summed SRC values of 5% sodium carbonate and 50% sucrose as predicting the formation of blisters with lower ratios resulting in undesirable blisters.

306 1 B 2000

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ModeCode: 3607-05-00 MIDWEST AREA
WOOSTER, OHIO
SOFT WHEAT QUALITY RESEARCH

NPL Leader: LEWIS FRANKLIN FLORA **Prin Invs:** EDWARD J SOUZA

Start Date: 02/02/2005 **Term Date:** 11/30/2009

National Programs: 306 N Quality and Utilization of Agricultural Products

Title: GENETIC BASES FOR THE BIOCHEMICAL DETERMINANTS OF WHEAT QUALITY

Period Covered **From:** 10 / 2008 **To:** 9 / 2009 **Final Report?** No
Terminate in Two Months? No

Progress and Outcomes:

4. Accomplishments

01 Sugar Snap Cookie Method Revision: Our laboratory led the method development and, with the USDA-ARS Western Wheat Quality Laboratory, coordinated the approval tests for the American Association of Cereal Chemistry revision of the sugar-snap cookie method. This is internationally and within the US the most widely used bake test for soft wheat quality. The revised test is more uniform and reliable than the previous method for a wider range of soft wheat types in the US, Europe, Latin America and China. This will improve the progress in selecting wheat for the US. It also will allow researchers to better assess germplasm from other countries for its breeding value to improve US wheat.

306 1 A 2000
306 1 B 2000

02 Joint Release of New Soft Winter Wheat Cultivars: The SWQL joined in the release notices of the soft white wheat cultivars Ambassador and Coral from Michigan State University, the soft red winter wheat cultivar Red Amber from Michigan State University, and the soft red winter wheat cultivars Shirley, 3434, 5205, and Jamestown from Virginia Polytechnical Institute. All represent improvements in disease resistance and grain yield over the cultivars they are targeted to replace. All are similar in quality to the existing cultivars they are replacing or, in several cases (Ambassador, Red Amber, and 5205), are significant improvements in quality relative to the best cultivars presently available in the target growing areas. These seven cultivar are the result of cooperative research between breeding programs and the SWQL and will improve the overall quality of the eastern US wheat crop through improved flour yield.

306 1 A 2000
306 1 B 2000

03 Whole Wheat Flour Method: The SWQL developed an experimental milling protocol for producing whole wheat flour from soft wheat that matches industry methods for producing whole wheat flour on an industrial scale. A standard method for producing whole wheat flour is the first step towards developing improved soft cultivars for making whole wheat flour. The method is most applicable to soft white wheat and will speed new cultivar development and other research development for delivering soft wheat products with greater dietary fiber content.

306 1 A 2000
306 1 B 2000

04 Quality of Whole Wheat Flour: The whole wheat flour research has lead to initial

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conclusions about genotypes suitable for improved whole wheat flour. Cultivars with small flour particle size from the first break make better whole wheat wire-cut cookies than cultivars with larger particle size flour. Total flour yield was not an important factor in predicting the quality of cookies made from whole wheat flour as it is for cookies made from white flour. At the biochemical level the improved quality of the small particle size cultivars also is associated with reduced concentrations of water-soluble cell wall material (arabinoxylans). This is the first report of genotypic factors affecting whole wheat flour quality in soft wheats and will contribute to better flour for manufacturing and faster product development of products with dietary fiber from wheat bran.

306 1 A 2000

306 1 B 2000

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WOOSTER, OHIO
SOFT WHEAT QUALITY RESEARCH

NPL Leader: LEWIS FRANKLIN FLORA **Prin Invs:** EDWARD J SOUZA

Start Date: 02/02/2005 **Term Date:** 11/30/2009

National Programs: 306 N Quality and Utilization of Agricultural Products

Title: GENETIC BASES FOR THE BIOCHEMICAL DETERMINANTS OF WHEAT QUALITY

Period Covered From: 10 / 2007 **To:** 9 / 2008 **Final Report?** No
Terminate in Two Months? No

Progress and Outcomes:

4. Accomplishments

01 Millstream Arabioxyan Analysis.
Relative to Objective 1, (Milestone FY2008). Non-starch polysaccharides in wheat flour have significant capacity to affect the processing quality of dough and the finished quality of wheat products. Most research has focused on the effects of arabinoxylans in bread making. We found that water-extractable arabinoxylan and arabinogalactan peptides can predict variation in pastry wheat quality as captured by the wire-cut cookie model system. The sum of water extractable arabinoxylan plus arabinogalactan peptide, as represented by the hydrolyzed monosaccharides, was highly predictive of cookie geometry. The combination of cookie geometry and the ratio of water extractable arabinose to xylose predicted cookie texture. We feel that this is a significant step to developing a predictive model for cookie quality that is based on basic biochemistry of the flour. It is an intermediate step towards identifying the genes that control the ratio of arabinose to xylose and their total quantity. Ultimately these are the necessary tools of rapid genetic manipulation of flour quality in wheat. Addresses NP 306 Action Plan, Component 1b, Methods to Evaluate and Predict Quality.

02 Effect of Tempering on Flour Quality.
Relative to Objective 1, (Milestone FY2008): Tempering conditions of wheat grain change the quality of the flour; yet most experimental milling systems use a standard tempering without optimization. The effect of tempering condition on milling performance and flour functionality for soft red winter (SRW) wheat grain was tested by measuring flour yield, ash, polyphenol oxidase (PPO), and solvent retention capacity (SRC) in grain samples from three SRW cultivars (‘Roane’, ‘Cyrus’, and ‘Severn’). Tempering was conducted with a full factorial design of initial wheat moisture, tempered wheat moisture, tempering temperature, and tempering time at two levels. Tempered wheat moisture had the largest effect on milling performance and flour functionality. Flour yield was reduced for all samples tempered at 15% moisture than for samples tempered to 12% moisture. Flour quality of the 15% tempered sample was better than the 12% tempered samples due to less bran contamination, as measured by flour ash and PPO. Increasing the tempering moisture increased flour sucrose SRC and lactic acid SRC, but reduced sodium carbonate SRC for samples. Changing tempered wheat moisture changed flour yield and quality much more than did changing the length of time for tempering, the temperature at wheat is tempered, or differences in the initial moisture of the wheat before tempering. The last three effects could be used to improve flour yield in both the 12% and 15% tempered wheat treatment but the detrimental effects of these treatments on flour quality were minimal when combined with the 15% tempered wheat moisture treatment. Addresses NP 306 Action Plan, Component 1a, Definition and Basis of Qualilty.

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WOOSTER, OHIO
SOFT WHEAT QUALITY RESEARCH

NPL Leader: LEWIS FRANKLIN FLORA **Prin Invs:** EDWARD J SOUZA

Start Date: 02/02/2005 **Term Date:** 11/30/2009

National Programs: 306 N Quality and Utilization of Agricultural Products

Title: GENETIC BASES FOR THE BIOCHEMICAL DETERMINANTS OF WHEAT QUALITY

Period Covered From: 10 / 2006 **To:** 9 / 2007 **Final Report?** No
Terminate in Two Months? No

Progress and Outcomes:

4. Accomplishments

Objective 4. Improved Flour Yield
Our largest time commitment as a laboratory is to assist eastern US wheat breeding programs in selecting for improved milling and baking quality. We processed 5,600 samples from wheat breeders and researchers across the eastern US, a 10% increase from FY 2006. The SWQL evaluates wheat quality for all wheat breeding programs in the eastern US. It is the sole quality laboratory for all but one of the eastern US programs. A recent review of cultivar quality found that flour yields increased 3 g/kg of grain due to genetic selection using SWQL data. The estimated value is $200,000 per year in increased income to the milling industry for the Ohio wheat crop alone. Increasing the samples numbers through improved efficiency, as in the past year, will allow the SWQL to increase the rate of improvement. Average flour yield improvement seems due to elimination of the poorest milling cultivars by attrition and replacement with better milling cultivars. (Addresses NP 306 Action Plan Component 1, Problem Area 1d).

Objective 4. Modification of Overseas Varietal Analysis Market Promotion Program
We modified in 2007 the format for the Overseas Varietal Analysis (OVA) Program, a market promotion project for eastern US soft wheat for which the Soft Wheat Quality Laboratory (SWQL) provides technical leadership. We provided additional information to mills and bakeries in foreign countries that participated in this project. The information involved baking quality and sub-classifications of the soft wheat into strong-gluten types and weak gluten types. The goal is to allow customers to better define the wheat quality characteristics that will improve their customer satisfaction and allow them to diversify (and hopefully increase) their use of US grown wheat. The results of the OVA are used to improve methods for cultivar evaluation in the US. Our modification was made in cooperation with US Wheat Associates which coordinates this program and other similar programs for the major US wheat classes. US Wheat Associates is using this as a pilot project for modifying other market promotion projects. US Wheat Associates is an overseas marketing organization with joint funding from US wheat growers and federal funds. The modifications were based on a 5 year retrospective analysis of the SWQL research results in the OVA program. (Addresses NP 306 Action Plan Component 1, Problem Area 1b).

Objective 1. Biochemical Analysis of Flour Mill Streams
Biochemical analysis of flour millstreams from long-flow (10 or more mill streams) flour mills found that cultivars differed for pentosan and damaged starch content, as measured by solvent retention capacity (SRC) testing. Similarly, mill streams of flour differed for pentosan and damaged starch levels. Yet we found no interaction between

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cultivars and mill streams. Therefore, we can compare cultivars for biochemical composition using any stream or extraction rate. Previous work found that low flour extraction due to genetics correlated with elevated pentosan and damaged starch levels in flour. A 5-year study, with Virginia Tech University, concluded that complex milling behavior of cultivars was highly reproducible, having limited cultivar x year interaction. Taken together, this validated using inexpensive low-technology 'short-flow' (2 to 4 mill streams) experimental flour mills with SRC test to select cultivars for release. Flour mills also have adopted this method to select grain lots for purchase and to pay wheat growers premiums for their grain with improved milling quality. (Addresses NP 306 Action Plan Component 1, Problem Area 1b).

Objective 1. Functional Analysis of Flour Mill Streams
We conducted a functional analysis of contrasting flour streams (short patent extraction and straight grade extraction) using rapid visco-analysis (RVA) to measure starch pasting, SRC to measure biochemical traits, particle sizing to measure flour structure, and cake baking to integrate all assays. Decreasing milling extraction rate and increasing chlorination extent improved cake product quality. Additional milling to reduce particle size produced smaller improvements in cake flour quality than additional chlorination. We found that a single cultivar with good flour yield responded to flour treatments (chlorination) to make cake flour than did a cultivar with poor flour yield. The biochemical or physical make-up of the high flour yield wheat improves cake flour quality but also the ability of millers to modify that flour to improve cake flour quality even further. (Addresses NP 306 Action Plan Component 1, Problem Area 1b).

Objective 2. Sugar functionality in soft wheat flour based dough
Use of alternative sugars in soft wheat products may reduce glycemic impact and improve prebiotic nutritional benefits. The functionality of sucrose (Su) and three alternative sugars used in soft wheat products. The three alternative sugars were xylose (X), glucose (G), and fructose (F). We found retardation of flour starch gelatinization in 50% sugar solutions: X<F<G<Su in Differential Scanning Calorimetry (DSC) analysis. In contrast, flour pasting was enhanced by sugars in the following order X>F>G>Su, based on Rapid Visco-Analysis (RVA). Wire-cut cookie baking, a standard laboratory model for low sugar product formulas, 66% sugar and 64 g of total solvent (sugar and water) per 100 g of flour produced cookie diameters that differed with sugar type from largest to smallest in the following order: Su>F>G>X. Wire-cut cookies can be used to measure "snap-back" a change in dough geometry due to gluten effects that is important for crackers. Significant snap-back, that is gluten development, occurred with the sugars G as well as X. The difference in order between starch characteristics in sugar solutions (DSC and RVA rankings) and baked product performance is likely due to gluten effects. This will lead to formulation modifications that can alter cracker quality, and other soft wheat products too, in response to flour characteristics or nutritional goals of the manufacturer. (Addresses NP 306 Action Plan Component 1, Problem Area 1d).

Objective 3. Value-added, Strong Gluten Soft Wheat
We identified, through a specific cooperative agreement with Ohio State University, the presence of a rare glutenin allele (Glu-B1al) in the best soft wheat cultivars used for crackers. Breeding programs and food manufacturers adopted PCR markers for Glu-B1al to select cultivars for crackers. Phenotyping of mapping populations confirmed Glu-B1al the increase in gluten strength for soft wheat cultivars. The PCR primers developed in this work were adopted by the North Carolina Genotyping Center for evaluation of regional nurseries and wheat breeding germplasm. Strong-gluten soft wheat cultivars often command a $0.25 to $0.40 per bushel premium. However premiums often are not paid

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because cultivars are not available or the milling industry cannot identify the cultivars (Addresses NP 306 Action Plan Component 1, Problem Area 1a and NP 301, Component 2, Problem Statement 2C).

Objective 3. Mapping Populations for Milling and Baking Quality
Through collaboration on wheat genetic maps with Ohio State University, Cornell University, Purdue University and Virginia Tech, we identified a range of loci that reduce flour milling yield. Phenotyping and genotyping of the wheat population Foster/KanQueen is substantially completed. We identified one quantitative trait locus (QTL) near the centromere of chromosome 2B that codes for a 15 g/kg improvement in flour yield. The QTL also causes an approximate 40 g/kg improvement in sodium carbonate solvent retention capacity (a measure of damaged starch) and approximately 35 g/kg improvement sucrose solvent retention capacity (a measure of flour pentosans). Through cooperation with the NRI project “Wheat CAP” we are assisting with development of genetic maps in 5 other wheat populations, which will expand this accomplishment. (Addresses NP 306 Action Plan Component 1, Problem Area 1a and NP 301, Component 2, Problem Statement 2C).