

SOFT WHEAT QUALITY LABORATORY 2013 ANNUAL REPORT

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- enhance the natural resource base and the environment
- provide economic opportunities for rural citizens, communities and society as a whole.

SOFT WHEAT QUALITY LABORATORY (SWQL) BRIEFING PAPER

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
Corn, Soybean and Wheat Quality Research Unit
1680 Madison Ave., Wooster, Ohio

MISSION

- Contribute to global FOOD SECURITY by enabling the development of new high-yielding cultivars with end-use quality suitable for commercial food production in the soft wheat milling and baking industries and the export trade. The SWQL has sole responsibility for this within the USDA for the eastern United States (U.S.).
- Address GLOBAL CLIMATE CHANGE by reducing energy used to produce food through 1) selecting cultivars with improved milling efficiency 2) developing test methods to assess grain quality for high-efficiency milling and baking operations, and 3) reducing food loss due to grain shipments that do not meet specifications upon delivery at factories.
- Improve HUMAN NUTRITION, in collaboration with eastern US wheat breeding programs, through identifying and deploying genes for greater food quality and nutrition

BACKGROUND

Wheat is the world's largest crop used for direct human consumption. Approximately half of the wheat in the U.S. is milled in the eastern region served by the USDA-ARS Soft Wheat Quality Laboratory (SWQL), Wooster, OH. Since the 1930's, the SWQL has conducted genetic studies of wheat quality through long established coordinated research with 14 state land-grant universities in the eastern U.S. It is one of the few laboratories in the world that develops methods for testing quality of soft wheat, the major wheat type grown in Ohio and the eastern U.S.

Ohio is historically a large milling state, 4th in the US. It increased its milling production by 20% from 2003 to 2008, much faster than the overall country's rate of increase, through expansion of capacity and increase in operations of newer mills. Older, inefficient mills, located away from major population areas are closing. The flour milling industry is concentrating on newer, higher-yield milling facilities that require cultivars with increased flour yield to match the improved milling equipment's efficiency.

The SWQL critically evaluates nearly all the wheat cultivars marketed from Missouri to the Atlantic seaboard. It also develops and publishes new methods, and conducts research in the area of milling and flour quality. Research findings are shared with breeders, millers and food processors through the annual SWQL Research Review, annual Soft Wheat Quality Council meetings, and publications in refereed journals and presentations in the International conferences.

CURRENT FUNDING & STAFF

Current base funding (\$895,155 NTL) supports a lead scientist and seven full time and one part-time scientific support staff (five USDA, two Ohio State). The laboratory continues to improve the efficiency of sample evaluation; this has allowed for an increase in the total number of wheat samples evaluated per year for researchers in the eastern U.S. to 6,300. This was accomplished despite declining discretionary funds. Renovations to the flour milling facilities and mills are ongoing and will continue as funding permits. The equipment used to measure milling quality at the SWQL is aging; the newest mill used for routine milling research is 50 years old and the oldest still in service is over 100 years old. In addition, the HVAC in the milling facility needs to be replaced and updated.

PROGRAM IMPACTS

The SWQL has supported the development of wheat cultivars that produced \$1.5 B in grain per year (2005-2007 USDA Ag Statistics). Using USDA economic multiplier effects, this grain results annually in \$4.0 B in food and agricultural related business and \$9.9 B in economy-wide economic activity. The genetic improvement in flour yield since 1990, due to breeding programs using the SWQL, resulted in an estimated \$12.7 M annually in increased flour extracted from the wheat milled in the US (2007 production at \$16 per 100# of flour). This reduces consumer's food costs. It also is a component of the improved efficiency and competitiveness of the eastern U.S. milling industry. The SWQL is planning research to improve milling, wheat marketing, and human nutrition.

NEW IN 2013

NEW SWQL DIRECTOR

Dr. Byung-Kee Baik, new Lead Scientist/Director for the Soft Wheat Quality Laboratory, joined the USDA, ARS in February, 2013.

Before joining the USDA-ARS, Dr. Byung-Kee Baik was an Associate Professor in the Department of Crop and Soil Sciences at Washington State University. He led the WSU Wheat Quality Program, where he evaluated the end-use quality of wheat breeding lines and assisted wheat breeders in development of wheat varieties with improved end-use quality for eight years. His research included chemistry and processing of cereal grains and legumes, and processing, functional and nutritional characteristics of whole grains.

Dr. Baik received his B.S. (1988) and M.S (1990) degrees in agronomy from Korea University, Seoul, Korea, and his Ph.D. degree in Food Science from Washington State University (1994). He continued working at Washington State University as a Research Associate (1994-1999). In 1999, he was hired as an Assistant Professor in the Department of Food Science and Human Nutrition. He joined the Department of Crop and Soil Sciences as a Cereal Chemist in 2005. He has published 77 research articles in refereed journals and made numerous presentations at international conventions. He has advised eight M.S. and four Ph.D. students.

USDA, ARS CORN, SOYBEAN AND WHEAT QUALITY RESEARCH UNIT

In June 2012, the SWQL merged with the Corn and Soybean Unit, also in Wooster, to become the USDA-ARS **Corn, Soybean and Wheat Quality Research Unit** (CSWQRU). Dr. Peg Redinbaugh is Research Leader of the combined unit. Peg has been at the helm, as Research Leader for the SWQL, since July, 2011 and with the USDA, ARS since 1989. She was Research Leader for the Corn and Soybean Research Unit in Wooster from 2007 to 2012. Peg's research focuses on virus and insect transmitted diseases in corn and soybean.

In addition to the arrival of Byung-Kee Baik as SWQL Director, there were a few other personnel changes in the SWQL in 2012. William Wade, the group's IT specialist from 2010 to 2012, left the lab in May, 2012 to be a web developer in Tennessee. Anita Kassuba-Middleton joined the lab in late 2011. She assists with quality analysis. Will Ladrach completed his A.S. in 2012, and so has moved from being a Student Assistant to a part-time Physical Science Technician. We are beginning to work on filling the second scientist position in the lab.

ANNUAL RESEARCH REVIEW

The **Annual Research Review** is resuming this year as the 59th meeting. We held a smaller meeting with stakeholders from cooperating academic and industrial institutions and ARS Leadership (Midwest Area Office and Office of National Programs), on March 22, 2012 in Columbus to discuss refilling of scientific positions and the needs of breeders, millers and bakers for soft wheat quality analysis. Collaborators expressed very strong support for continued work at the SWQL, the Annual Research Review meeting and the accompanying Annual Report.

In 2012, the laboratory was recognized as producing the most reliable cookie testing results among the 50 institutions competing throughout the American Association of Cereal Chemists International (AACCI), the laboratory is consistently among the top 5 ranked in overall quality analysis. In 2012, the laboratory ranked fourth out of fifty participants for the AACCI check sample evaluation. We are grateful to be recognized for our accuracy and professionalism in milling and baking evaluations.

2013 SOFT WHEAT QUALITY LAB RESEARCH

SOFT WHEAT QUALITY TARGETS FOR CULTIVARS DEVELOPED FOR THE EASTERN U.S.

Over the years the SWQL has distributed soft wheat quality targets as part of its industry reports. The soft red wheat quality targets (**Table 1** and **Table 2**) were established using the data obtained by the US Wheat Associates Overseas Varietal Analysis and the Soft Wheat Quality Council and have served as guidelines for interpretation of the quality analysis generated by the SWQL. Because end products differ in their flour quality requirements, we produced separate, specific quality guidelines; one for pastry a second for export and cracker products.

Tables 1 and 2 summarize the current quality target parameters and target values for wheat grain and flour, respectively. The main differences in targets for pastry and cracker flours are in mixograph, farinograph and alveograph tests.

While the current SRW wheat quality targets describe comprehensive quality parameters and target values which could satisfy the quality specifications for millers and food processors of diverse wheat foods, there are overwhelmingly too many targets and many describe redundant properties. Many current target quality parameters are not commonly determined for breeding lines and varieties. It is necessary to come up with quality targets, which are more concise, meaningful, relevant and practical for screening wheat breeding lines in the development of wheat varieties of desirable end-use quality.

The milling and flour quality target values presented in Tables 1 and 2 were determined based on data of the OVA and SWQC analyses, where wheat grain was milled using the Miag mill, while the breeding lines and varieties have been exclusively milled using the Quadrumat Jr. mill and subsequently tested for flour quality. This makes the use of the current SRW Wheat Quality Targets by breeding programs difficult for screening breeding lines based on end-use quality. Accordingly, we are proposing a revised version of the SRW wheat quality targets considering the end-use quality parameters the SWQL has determined for breeding lines and varieties between 2008 and 2011.

In the newly proposed SRW Wheat Quality Targets, we are attempting to: 1) reduce the number of quality target parameters. There are too many parameters listed in the current targets. Some are duplicating other quality measurements. Some are rarely determined in the SWQL; 2) combine the pastry and cracker targets, with exception of protein content and quality parameters like lactic SRC. The target values of other quality parameters are the same or quite similar for both pastry and cracker products; 3) prepare targets based on quality parameters we routinely determine for the breeding lines and varieties. Since the prime goal of having the quality targets is to improve the end-use quality of newly developed SRW wheat varieties, the Quad Junior parameters should be used as milling quality target parameters. The target values of flour quality parameters would be selected based on the quality measurements of Quadrumat Jr. milled flour; and 4) reduce the number of dough rheology test parameters (mixograph, farinograph, alveograph). The SWQL seldom determines the dough rheological properties.

Table 1. Grain and milling quality targets for pastry and cracker flour

Category / Method	Pastry Flour	Cracker Flour
TestWeight/GrainCondition		
Test Weight	> 58 lb/bu	> 58 lb/bu
Shriveling Factor	< 15 %	< 15 %
1000 Kernel Weight	> 27 g	> 27 g
Wheat Density (g/cc)	> 1.31	> 1.31
SKCS Diameter (mm)	> 2.1	> 2.1
SKCS Weight (mg)	> 2.7	> 2.7
Field Sprouting		
Viscograph (Amylograph)	> 500 bu	> 500 bu
Alpha-Amylase Activity	< 0.08 abs	< 0.08 abs
Falling Number	> 350 sec	> 350 sec
Kernel Texture-Milling		
Break Flour Yield	30 – 37 %	25 -37 %
Miag-Multomat Break Flour Yield	24 – 35 %	21 -35 %
Quadrumat Sr. Break Flour Yield	32 – 41 %	25 -41 %
Quadrumat Jr. Softness Equivalence	53 – 64 %	45 -64 %
SKCS Hardness Index	< 40.0	10.0 -40.0
MillingQuality		
Quadrumat Jr. Flour Yield	> 67.5 %	> 67.5 %
Quadrumat Sr. Flour Yield	> 62 %	> 62 %
Quadrumat Sr. Flour Ash	< 0.420 %	< 0.420 %
Allis-Chalmers Flour Yield	> 75.7 %	>75.7%
Allis-Chalmers Flour Ash	< 0.430 %	< 0.430 %
Allis-Chalmers E.S.I.	< 11.5 %	< 11.5 %
Allis-Chalmers Milling Score	> 52	> 52
Allis-Chalmers Friability	> 27.2 %	>27.2%
Miag-Multomat Flour Yield	> 71 %	> 71 %
Miag Damaged Starch	< 3.5 %	<3.5%
Miag Flour Ash	< 0.500 %	< 0.500 %
Agtron Color	> 50 Units	> 50 Units

Table 2. Flour quality targets for pastry and cracker flour

Category / Method	Pastry Flour	Cracker Flour
ProteinContent		
Wheat Protein	9 -11.5 %	9 – 12 %
Flour Protein	8 -10 %	8 -11 %
Protein Strength		
Mixograph Absorption	52 -58 %	53 -59 %
Mixograph Peak Time	> 2.0 min	> 2.5 min
Mixograph Peak Height	> 2.8 mu	> 3.0 mu
Alveograph Peak	24 -38 mm	> 30 mm
Alveograph Length	106 -150 mm	> 150 mm
Alveograph Work	70 – 127 Joules (x 10 ⁻⁴)	> 127 Joules (x 10 ⁻⁴)
Farinograph Stability/Tolerance	2 – 4 min	3 -7 min
Farinograph Peak Time	> 0.75 min	> 1.0 min
Farinograph Absorption	51 -55 %	52 -56 %
Acidulated Flour Viscosity	90-173 cps	150-300 cps
Solvent Retention Capacity		
50% Sucrose	<89%	<89%
5% Lactic Acid	>87%	>87%
5% Sodium Carbonate	<64%	<64%
Distilled Water	<51%	<51%
Baking Qualities, Cookie		
Wire-Cut Method 10-53 Width	62.9 -66 cm	62.9-66 cm
Wire-Cut Method 10-53 Height	<8.4 cm	<8.4 cm
Sugar-Snap Method 10-52 Width*	17.2 -18.0 cm	17.2-18.0 cm
Sugar-Snap Method 10-52 Height*	< 1.65 cm	< 1.65 cm
Sugar-Snap Method 10-50D Width	48.6 -52.1 cm	48.6 -52.1 cm
Sugar-Snap Method 10-50D Height	< 5.7 cm	< 5.7 cm
Cookie Instrumental Hardness	< 26.6 kg	< 26.1 kg

Table 3 summarizes the proposed SRW wheat quality targets with the current target values and average values of breeding lines and varieties as determined by the SWQL between 2008 and 2001 for comparison. The end-use quality data summary of SRW we tested between 2008 and 2011 is shown in **Table 4**.

Table 3. Proposed SRW wheat quality targets

Quality Parameter	Current Target	Average value of Lines/Varieties*
Grain		
Test Weight	> 58 lb/bu	60
Hardness Index (NIR)		20
SKCS Hardness Index	< 40.0	35
SKCS Diameter (mm)	> 2.1	
SKCS Weight (mg)	> 2.7	
Falling Number	> 350 sec	350
Grain Protein (%)	9 - 11.5%	10
Milling Quality (Quad. Jr.)		
Flour Yield	> 67.5%	70
Break Flour Yield	30 - 37%	
Softness Equivalent	53 - 64%	59
Milling Quality (Miag)**		
Flour Yield	>71%	74
Break Flour Yield	21 - 35%	32
Flour (Quad Mill)		
Composition		
Flour Protein	8-10% (pastry)	
8-11% (cracker)	8.3	
Flour Ash**	<0.5%	0.4
Solvent Retention Capacity (SRC)		
Water	<51%	53.4
Sodium Carbonate	<64%	68.4
Sucrose	<89%	93.3
Lactic Acid	>87%	106.3
Baking Qualities, Cookie		
Sugar-Snap Width	17.2 - 18.0 cm	18.8

*Average of SRW wheat lines and varieties determined by the SWQL between 2008 and 2011.

**SRW wheat varieties determined for OVA and SWQC.

Table 4. Quality characteristics of SRW wheat breeding lines and varieties tested at the SWQL between 2008 and 2011

Quality Parameter	Mean	Median	STDDEV	Min	Max	N
Test wt (lb/bu)	59.9	60	2.3	35.2	66.7	19612
Hard (NIR)	20.3	19.7	10	-25	61.4	9226
Grain Protein (% , 12% mb)	10.4	10.5	1.4	5.8	14.9	9156
Flour Yield (% , Quad)	69.8	69.9	1.7	61.9	78.5	5155
Softness Eq. (%)	59	59.2	5.5	27.6	75.1	5155
Flour Protein (% , 14% mb)	8.3	8.4	1.1	5.1	12.9	4908
Water SRC (%)	53.4	53.1	2.6	47	72	2460
Carbonate SRC (%)	68.4	68.1	3.9	59.9	98.6	2659
Sucrose SRC (%)	93.3	92.9	7.8	74.5	132	5215
Lactic SRC (%)	106.3	106.2	16.3	61	168.3	5207
Sugar-Snap Cookie (cm)	18.8	18.8	0.7	14.8	20.7	4739

MILLING AND BAKING

Cooperators submitted 6,300 samples harvested in the 2012 crop year for advanced and micro mill evaluations. Analyses for more than 55% of these samples were completed by February, 2013, and advanced analyses of Soft Wheat Quality Plot trials grown in Wooster, Ohio, for 2012 were completed by October, 2012. Results were posted by Tony Karcher in March, 2013, and are available on the SWQL website.

Several upgrades to SWQL milling operation were undertaken in 2011 including acquisition of a new flour blender, refurbishing the Allis mill rolls and painting the mill room. Near Infrared technology (NIR), using the Perten DA7200 is now routinely used to determine whole grain moisture and protein content with a significant increase in testing efficiency over the oven moisture method and combustion nitrogen analyzer, respectively.

The SWQL recycles flour and unused seed through Quasar Energy Group, a bio-energy conversion company that located in Wooster in 2008 to work in collaboration with the Ohio Agricultural Research and Development Center (OARDC). In 2012 the SWQL provided the facility with over two tons of wheat-processing waste for conversion to methane gas. For more on Quasar, see the web site: <http://www.schmackbioenergy.com/pages/oardc.html>

The SWQL continues to collaborate with U.S. Wheat Associates to mill and ship flour for the Wheat Quality Council (WQC) and Overseas Varietal Analysis (OVA) evaluations. In 2012, a total of 24 wheat varieties were processed and distributed for these two projects. Scott Beil, SWQL Physical Science Technician, milled the grain and distributed the flour, communicated with collaborators, assembled collaborator data and prepared the reports in 2012.

REVISED MICRO MILLING METHOD

Contributed by Tom Donelson, SWQL Physical Science Technician

Since the micro evaluation program began in the mid-1980s, the standard procedure has been to mill grain on a Quadrumat Junior mill, and then sift the milled grain on a Great Western sifter box. The sifter has 40 and 94 mesh screens that separate milled product into bran (remains on the 40 mesh screen), midds (sifted product between the 40 and 94 mesh screens) and flour (sifts through the 94 mesh screen). The bran and midds fractions were weighed to determine milling yield and softness equivalence. Due to the limited size of grain samples submitted in the early years of the program, we added the midds fraction to the flour fraction to ensure there was sufficient amount of flour for NIR and SRC analyses. Since the midds fraction contained finely-chopped bran as well as large flour particles, its inclusion into flour had an adverse effect on SRC values.

Samples milled in our advanced nursery evaluation program receive an additional milling step in which the particle size of the midds fraction is reduced and the remaining bran particles are sifted out and discarded. The end result is a flour of finer particle size that is better suited for use in baking and SRC tests. Because larger quantities of grain have been submitted for the micro evaluation program in recent years, we examined the effect of omitting the inclusion of the midds in flour preparation.

A study was performed to compare the SRC results of micro-milled mids plus over 94's (Previous Micro) and the over 94's alone (New Micro), and those of flours milled like the advanced nursery (Table 1). Thirty cultivars representing a wide range in milling quality and softness equivalence were selected for the test. SRC values for New Micro milling method had a comparably broad range, and agreed well with those from advanced-milled flours. Flour yield, softness equivalence and flour protein were not affected by the new procedure. Therefore, beginning with the 2012 crop year, we began discarding the mids fraction and analyzing only the flour fraction of our micro samples.

Table 5. SRC values for flour prepared using previous and new micro and advanced milling

SRC	Previous			
		Micro	New Micro	Advanced
Water	Average	52.7	52.4	54.4
	Values Range	49.1 - 56.6 (7.5)	48.2 - 56.8 (8.6)	50.2 - 59.2 (9.0)
Sodium Carbonate	Average	65.3	68.6	69.4
	Values Range	58.5 - 72.0 (13.5)	62.4 - 78.2 (15.8)	62.4 - 79.0 (16.6)
Lactic Acid	Average	79.8	95.7	100.9
	Values Range	61.5 - 109.9 (48.4)	72.6 - 133.9 (61.3)	77.5 - 134.7 (57.2)
Sucrose	Average	86.4	93	90.1
	Values Range	79.6 - 95.6 (16.0)	84.4 - 105.7 (21.3)	77.1 - 103.6 (26.5)

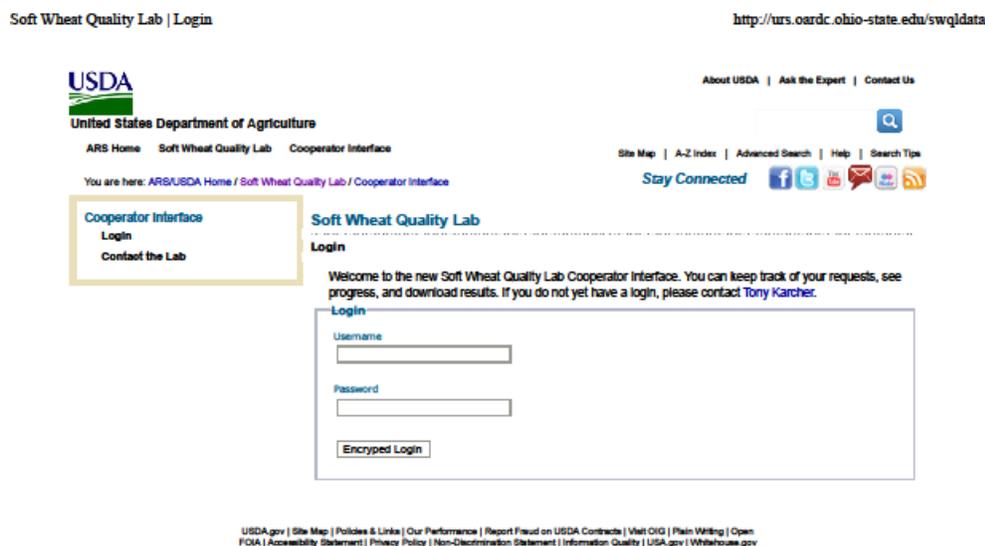
DATA MANAGEMENT

The on-line database for entering milling and baking data established by William Wade continues to be an important tool for the SWQL. The database allows for streamlined data input, storage and access, and has increased productivity and sample processing speed. Field and greenhouse nursery data can now be entered into the database and linked to evaluated cultivars. In addition, all WQC and OVA varieties are genotyped at the SWQL, and these results are linked to the cultivars database as the data become available.

A new web interface providing collaborators with better management of evaluation requests, status updates, and views of new and historical results was implemented in 2012 (Fig. 1). The website includes access to *SWQL Materials and Methods* along with cultivar descriptions that are also accessible through the SWQL home page website. Tony Karcher, SWQL Physical Science Technician, maintains the database and is the contact for accessibility.

The USDA will redesign all websites in 2013. Watch for the new look and the new CSWQRU website.

Figure 1. SWQL collaborator log in



GENETICS

The goal of molecular genetics research at the USDA SWQL is to develop DNA markers to predict end-use qualities and improve resources for soft wheat breeders.

ASSOCIATION MAPPING

A phenotypic analysis of an association mapping (AM) population, "Basis for Selection Soft Wheat for End-Use Quality" was published in 2012 (Souza et al., 2012). Using SSR and DArT marker analysis, two QTL on chromosome 2B, one for flour yield and the other for softness equivalence were identified (Souza et al., 2009). The AM population was genotyped by Shiaoman Chao, USDA-ARS, Fargo, ND, using 9,000 single nucleotide polymorphism (SNP) markers using the Infinium, bead chip platform (Illumina) in 2011-2012. Results from the AM and a multi-population study by Clay Sneller (Ohio State University) and co-workers identified an important and repeatable quantitative trait locus (QTL) for quality on chromosome 2B (publication in preparation). In the multi-population study, the QTL on chromosome 2B was associated with a sucrose synthase type 2 gene, *TaSus2*. In other research, two haplotypes for the sucrose synthase gene were reported to associate with 1000 grain weight (Jiang et al., 2011). The association mapping population is maintained by the SWQL as a valuable genetic resource.

FLOUR QUALITY QTL, CHROMOSOME 2B

The QTL region on chromosome 2B identified in the mapping studies above is affected by a translocation derived from *Triticum timopheevi* that is present in about 20% of current eastern U.S. soft wheat varieties. The translocation provides resistance to stem rust and powdery mildew (Tsilo et al., 2008). In addition, a favorable high-grain weight haplotype for sucrose synthase type 2 was reported to be associated with the same region of chromosome 2B affected by the translocation (Jiang et al., 2011). Because it is derived from a different species, the 2B translocation is preferentially transmitted as a block and is resistant to recombination. Gina Brown-Guedira and co-workers, USDA, ARS, Raleigh, NC, showed that the alien introgression affects approximately 80% of the chromosome (personal communication). Using the association mapping population, Antonio Cabrera, a Postdoctoral Research Associate in Clay Sneller's lab, also identified a large block of linkage disequilibrium on chromosome 2B, covering about 50% of the chromosome. The SWQL identified lines as containing the 2B translocation using the markers for the stem rust resistance gene, *Sr36* (SSR markers *stm773* or *wmc477*) (Tsilo et al., 2008), **Table 6**.

SUCROSE SYNTHASE

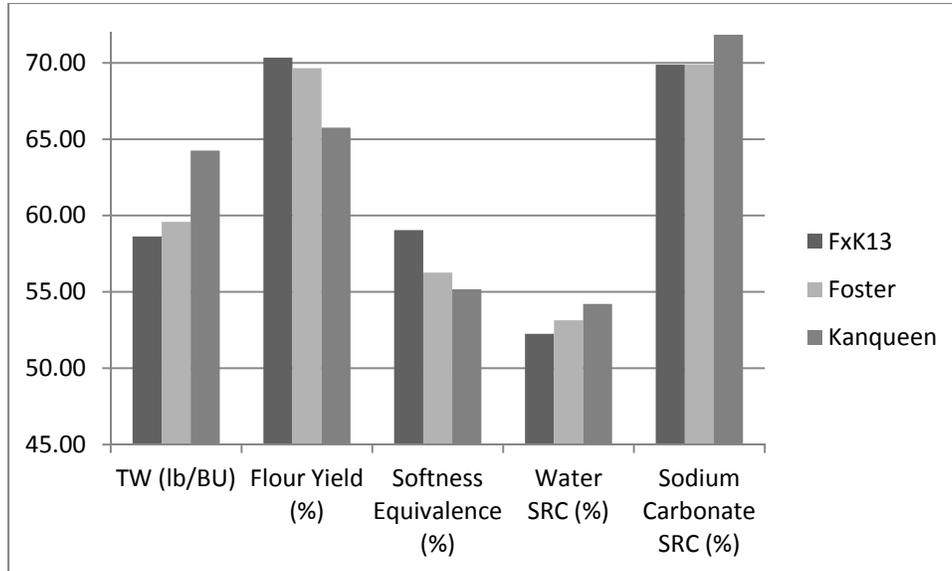
Sucrose synthase type 2 (*TaSus2*) enzymes produce the precursors for starch synthesis in wheat and are present on all three genomes (Emes et al., 2003, Jiang et al., 2011). Fine mapping the quality QTL on the 2B region is being carried out by Anne Sturbaum, Molecular Biologist at the SWQL, using a soft red winter bi-parental population (Foster x Kanqueen) developed by Mark Sorrells, Cornell University. The Foster x Kanqueen population segregates for flour yield with the Foster parent providing the favorable allele and also containing the 2B translocation, which is absent in Kanqueen. The sucrose synthase alleles from Foster and Kanqueen on chromosome 2B correspond to the high and low 1000 grain weight haplotypes, respectively (Jiang et al., 2011). The sucrose synthase gene from chromosome 2B from Foster and Kanqueen were cloned and sequenced, and at least 2 novel SNPs were identified in the Foster gene sequence that are different from that of the high grain weight haplotype. The SNPs do not alter the reading frame or amino acid sequence of the sucrose synthase protein relative to the high grain weight haplotype, but may provide a means to identify the allele in populations. We will continue to evaluate the Foster locus surrounding the sucrose synthase gene during 2013.

Linkage along the 2B chromosome has also been broken in a backcrossed Foster recombinant inbred line (RIL, F₆). A single Foster backcross, Foster by Kanqueen recombinant, line, FxK-13, was produced that has the *Sus2* allele from Foster but the Kanqueen allele for the SSR marker *gwm429*, which mapped close to a softness equivalence QTL (2009 PAG poster). The stem rust resistance locus from *T. timopheevi*, *Sr36*, is present in this RIL. Thus, this line appears to have the sucrose synthase 2 allele from Foster without the rest of the translocation.

Single field plots of 16 Foster x Kanqueen (FxK) RIL and parents were evaluated from the 2012 field for preliminary milling and baking qualities. The RIL FxK-13, with the *Sus2* allele from Foster and the Kanqueen *gwm429* allele, had the highest softness equivalence (SE), 2.98 percentage points above the next highest SE value for Foster 56.06, and flour yield similar to the Foster parent. Results are shown below in **Figure 2**. FxK-13 was crossed to several other soft red varieties that also lack the 2B translocation. Progeny from these crosses will be genotyped for *Sus2* and then

evaluated to determine whether milling quality, flour yield, sucrose SRC and softness equivalence are improved by the addition of the *T. timopheevi Sus2* allele.

Figure 2. Foster, Kanqueen and RIL FxK-13, micro milling field 2012



DOUBLE SOFT EXPERIMENTAL BREEDING

Increased softness in wheat is a desirable trait for millers and bakers. Very soft varieties mill better, require less energy to mill, and produce better quality end-products as indicated by larger cookie spread. Softness in wheat is controlled by a single, dominant allele at the hardness locus (*Ha*) on chromosome 5D (Bhave and Morris, 2008). An alien introgression line in Chinese Spring, CS(5A^m), with the allele for softness at the *Ha* locus on chromosome 5A, was developed by selection for the substitution of chromosome 5A from *Triticum monococcum* (Bonafede et al., 2007). Previous work indicated that in hard wheats, this allele for softness produced softer grains (Hogg et al., 2005). We used this resource, with a softness allele on 5A, by crossing to introduce a second softness allele into soft wheat parents, USG3555 and OH04-264.58. The wild type soft locus is present at the *Ha* locus on chromosome 5D and an additional soft locus from the substituted line is present on chromosome 5A. The goal of this breeding experiment was to attempt to improve softness in established soft red winter wheat varieties.

F₁ plants were back-crossed to OH04.264-58 and USG3555 and advanced to BC₄F₆. Marker assisted selection was used to screen for the second softness allele using chromosome 5A specific primers described in (Bonafede et al., 2007). Selection of lines also included genotyping for high molecular weight glutenins, specifically the Bx7 over-expressing allele and Dx5+10, from the OH04.264-58 parent, and the 2B translocation for stem rust resistance from USG3555. Double soft lines (with two alleles for softness on chromosomes 5A and 5D) were planted in the 2013 field and will be screened for molecular markers and quality traits in 2013.

STEM RUST RESISTANCE AND 2B TRANSLOCATION

A translocation from *Triticum timopheevi* on *Triticum aestivum* chromosome 2B provides disease resistance to stem rust and powdery mildew (Tsilo et al., 2008) as well as the Sucrose Synthase type 2 haplotype associated with favorable quality traits (Jiang et al., 2011). Approximately 20% of the 187 members of the association mapping population carry the *Sr36* gene for stem rust resistance via the 2B translocation, so it is relatively common in commercial cultivars. The *Sr36* gene without the translocation is present in a very limited number of U.S. soft wheat varieties. As mentioned above, QTL for several quality traits were also associated with the 2B region, with the translocation surrounding the *Sr36* locus in the association mapping population and in multiple, bi-parental populations (Sneller, unpublished). We continue to add to the list of cultivars known to carry the *Sr36*, 2B translocation shown below.

Table 6. Soft wheat varieties with 2B translocation for *Sr36*

Abe	Dominion	Pioneer 2643
Adder	Doublecrop	Pioneer 2684
Adena	Dyna-Gro 9911	Pioneer 26R31
AGI 401	Ebberts 501	Progold
AGRA Rubin	Ebberts 590	Purdue 0522
AGRA Silas	FFR 555	Rupp 9xp34
AGRA Trevor*	Foster	Scotty
AGS2060	Freedom	SC 1325
Arcadia	Gries Beuerlein*	SC 1358
Arthur	INW 0411	Severn
Beck 122*	INW0316	Shirley
Beck 137	Jaypee	Shur Grow SG-1567
Branson*	Jordan	Sisson
Buckeye	Kenosha	Steyer
Coker 47-27	Madison	Sullivan
Coker 747	Magnum	SY1526*
Coker 762	Massey	Tecumseh
Coker 797	McNair 1003	USG3209
Coker 916	McNair 1813	USG3295
Coker 9663	Merl	USG3555
Coker 9766	MO 11126*	VA 96W-247
Coker 9803	Neuse NC	VA03W-412*
Coker 9835	Oakes	Wheeler
Compton	OH751	91193D1 Purdue

*heterozygotes

VARIETY DESCRIPTIONS -NEW WHEAT CULTIVARS

Information on new releases is important to breeders in the wheat community. We include a compilation of new releases for the past two years. Descriptions of new wheat cultivars are listed by contributing collaborator. The SWQL thanks each of the breeders, growers and researchers for his/her contributions providing cultivar descriptions for this report.

AGRICULTURAL ALUMNI SEED IMPROVEMENT ASSOCIATION, INC. - JANE LEWIS

INW1131

Soft Red Winter Wheat

INW1131 was performance tested as line 99751RA1-6-3-94 in multi-location tests in Indiana since 2007, and in tests in surrounding regions since 2009. INW1131 typically produces grain yield similar to or statistically not less than leading current cultivars. INW1131 has acceptable pastry wheat milling and baking qualities, matures 2-3 days later than the early maturity cultivar Patterson, depending on latitude of the test location; has awnlets 1/16 to 5/16 inch long in the tip ½ of spikes, has yellow anthers, glumes are yellow at maturity, has strong straw that is typically 33 to 36 inches tall, and is moderately cold tolerant. An important contribution of INW1131 is its effective resistance to Fusarium head blight (FHB) caused by *Fusarium graminearum*, the same fungus that causes ear and stalk rot in corn, and that also produces the vomitoxin deoxynivalenol (DON). INW1131 has effective Type I (reduced percentage of spikes that become infected) resistance, together with moderate Type II (reduced spread of the disease within infected spikes) resistance to FHB; and DON content in the grain is consistently significantly less than in susceptible cultivars. INW1131 has highly effective resistance to Hessian fly, and moderate resistance to *Stagonospora glume blotch*, *Septoria leaf blotch*, barley yellow dwarf virus, wheat spindle streak mosaic virus, and leaf and stem rusts. Given its effective, but not complete, resistances to most of the important diseases, especially FHB, in Indiana and the Eastern US region along with highly variable seasonal weather patterns, some being very favorable to disease organisms, wheat growers are strongly encouraged to monitor their wheat crop for presence and development of diseases, and apply fungicides when appropriate, to maximize crop performance and grain quality, particularly given the very low level of tolerance for DON in the food industry.

INW1021 (02444)

Soft Red Winter Wheat

INW1021 has consistently been in the top group of entries in yield. It has *Fhb1* (moderate FHB resistance), the *Lr37 Yr17 Sr38* rust resistance linkage block, good soft wheat milling and baking qualities and the *Bx70e* strong gluten allele; the *Rht1* dwarfing allele and the *Ppd* day length insensitive allele (one reason for its wide adaptability). Plant height is similar to that of Patterson and Bess, it is awnless, has large spikes, tillers well and has moderately strong straw. It has moderate virus, leaf, stem and stripe rusts, powdery mildew, resistance to Fusarium head blight, barley yellow dwarf virus, soil borne mosaic virus (SBMV), *Stagonospora nodorum blotch*, *Septoria leaf blotch*, and is susceptible to Hessian fly biotype L. Typically heads 1 day earlier than Patterson (1 day later than Clark) in southern Indiana and 1 day later than Patterson (3 day later than Clark)

in northern Indiana (a bit unusual . . . but probably because it has the *Ppd* day length insensitive allele).

AG 1189

Soft Red Winter Wheat

AG 1189 Three years of advanced trials have proven Ag 1189 to be a consistent performer throughout the soft red winter wheat growing area. It is early, moderate in height, averaging 33-36 inches under a wide range of growing conditions, and soils. It is a very leafy variety with a long, awned head. Ag 1189 has proven its ability to stand up to extremely severe weather conditions of too much rain, not enough rain, high heat during grain fill and to produce acceptable yields under low fertility management. It has high test weight, stands well against high winds near harvest and holds tight its grain when many other varieties tend to shatter high percentages of grain. Ag 1189 is a variety that takes advantage of opportunities to produce expected yields.

AG 2581

Soft Red Winter Wheat

AG 2581 is an early, medium height averaging less than 36 inches under good fertility with excellent straw strength. The disease package is quite exceptional which allows it to perform well in all environments. It has shown a unique ability to remain one of the top performers under disease attacks of Fusarium, stripe rust and BYDV. Where conditions are favorable and under high fertility levels it has a proven record of performing with and, in many cases, well above the industry leaders. In a word "it works". INW1021 (02444) has consistently been in the top group of entries in yield. It has Fhb1 (moderate FHB resistance), the Lr37 Yr17 Sr38 rust resistance linkage block, good soft wheat milling and baking qualities and the Bx70e strong gluten allele; the Rht1 dwarfing allele and the *Ppd* day length insensitive allele (one reason for its wide adaptability). Plant height is similar to that of Patterson and Bess, it is awnless, has large spikes, tillers well and has moderately strong straw. It has moderate virus, leaf, stem and stripe rusts, powdery mildew, resistance to Fusarium head blight, yellow dwarf virus, wheat spindle streak mosaic virus, soil borne mosaic virus, Stagonospora nodorum blotch, Septoria leaf blotch, and is susceptible to Hessian fly biotype L. Typically heads 1 day earlier than Patterson (1 day later than Clark) in southern Indiana and 1 day later than Patterson (3 day later than Clark) in northern Indiana (a bit unusual but probably because it has the *Ppd* day length insensitive allele).

INW0412

Soft Red Winter Wheat

INW0412, an awned, soft red wheat has proven to be a real performer in total performance over a wide area. Tall with willowy straw that has proven excellent standability through harvest. Test weight normally runs from 61 to 64 lb. per bushel. Has exceptional winter hardiness, surviving wet, cold, late planted conditions and still producing excellent yields. Tillers profusely and produces long, awned, well filled heads that mature together. INW0412 has a good level of resistance to Fusarium head blight, stripe rust, BYDV, powdery mildew, and soil borne mosaic virus (SBMV). It

responds well to all levels of management and while it is tall it stands well and responds with very high yields of high quality, heavy grain.

INW0731

Soft Red Winter Wheat

INW0731 has consistent high performance, medium height, typically 35-37 inches tall, good straw strength, early - one day later than Patterson, and is awnless. INW0731 has excellent pastry-baking qualities. It provides partial resistance to Fusarium, BYDV, leaf rust, SBMV, and wheat spindle streak mosaic. Due to its large root volume and partial BYDV resistance, its performance has been high and conspicuously consistent in all trials.

AG 1331

Soft Red Winter Wheat

AG 1331 is an early, short to medium height (under 36 inches) variety with a willowy stalk and a long, slightly curved, awnless head with moderately high test weight grain. AG 1331 has excellent eye appeal in the field with its golden husks and plant uniformity at harvest time. It is well adapted from the Central Mid South through the Ohio River Valley and from the Western edge to the Northern and Eastern portions of the Soft Red Winter Wheat growing area. AG 1331 demonstrates good disease tolerance and has very good tolerance to Fusarium head blight as well as most leaf and stem rusts. It is moderately susceptible to Septoria early, but finishes well with healthy flag and upper leaves. It tillers well under good fertility and has the ability to yield well under limited fertility conditions. It has finished in the upper 20 percentile for three years of advanced testing compared to industry leaders.

AG 2581

Soft Red Winter Wheat

AG 2581 is an early, medium height averaging less than 36 inches under good fertility with excellent straw strength. The disease package is quite exceptional which allows it to perform well in all environments. It has shown a unique ability to remain one of the top performers under disease attacks of Fusarium, stripe rust and BYDV. Where conditions are favorable and under high fertility levels it has a proven record of performing with and, in many cases, well above the industry leaders. In a word "it works".

BECK'S WHEAT – BRENT MINETT

BECK 87

Soft Red Winter Wheat

Beck 87 was released in the fall of 2010 as a double-cropping, awned, soft red winter wheat with extremely early maturity, 3 days earlier than Clark, excellent test weight and low straw residue. Beck 87 is medium height with good standability and winter hardiness. It has good resistance to

septoria leaf blotch, leaf rust, powdery mildew, septoria glume blotch, barley yellow dwarf virus, soil-borne wheat mosaic virus and moderate resistance to scab.

BECK 113

Soft Red Winter Wheat

Beck 113 was released in the fall of 2009. Beck 113 is a high yielding, awnless, soft red winter wheat, medium short, medium maturing plant with excellent winter hardiness and standability. Beck 113 has very good resistance to scab, good resistance to septoria leaf blotch, powdery mildew, soil-borne wheat mosaic virus with moderate resistance to septoria glume blotch, barley yellow dwarf virus and leaf rust.

BECK 120

Soft Red Winter Wheat

Beck 120, soft red winter wheat with awns was released in the fall of 2012. Beck 120 is a high yielding, medium-early maturing variety with excellent standability and disease resistance. Beck 120 is a medium height plant with very good test weight and excellent winter hardiness. Beck 120 has very good resistance to septoria glume blotch, barley yellow dwarf virus and leaf rust. It has good resistance to powdery mildew, scab and soil-borne wheat mosaic virus and moderate resistance to septoria leaf blotch.

BECK 129

Soft Red Winter Wheat

Beck 129 is an awnless, soft red winter wheat, released in the fall of 2013. Beck 129 is a medium-tall variety, medium maturity, with excellent straw and grain yields. Beck 129 has very good winter hardiness, standability with good test weight. Beck 129 has very good resistance to septoria glume blotch and scab, good resistance to barley yellow dwarf virus, leaf rust, powdery mildew, soil-borne wheat mosaic virus and septoria leaf blotch.

BECK 135

Soft Red Winter Wheat

Beck 135 is an awned, soft red winter wheat, released in the fall of 2010. Beck 135 is a medium-tall plant with later maturity, excellent yield, very good test weight, standability and winter hardiness. Beck 135 has very good resistance to septoria glume blotch, powdery mildew and leaf rust, with good resistance to barley yellow dwarf virus,, soil-borne wheat mosaic virus and septoria leaf blotch and scab.

CORNELL UNIVERSITY - MARK E. SORRELLS

OTSEGO

Soft Red Winter Wheat

Ostego was tested under the experimental name OH751. Pedigree: 10584-08-01 (IN71761a4-31-5-33 / MO55-286-21) / Coker9663 (IN71761A4-31-5-48 / FL 302).

Grain Yield: Over four years of testing, this line averaged 4 b/a higher grain yield than SW50 and 8 b/a above Truman. The three year summary shows a 1 b/a edge over Pioneer 25R47.

Test Weight: Oh751 averages 0.7 lbs/bu below Truman but 0.6 lbs/b above Pioneer 25R47. Winter Hardiness: Winter survival is similar to current varieties. Lodging Resistance: OH751 is similar to Pioneer 25R47 and Richland and much better than Truman for lodging resistance.

Disease Resistance: Ostego has excellent resistance to powdery mildew, leaf spot, glume blotch, leaf rust and moderate resistance to Fusarium head blight (scab). It is also resistant to Wheat Spindle Streak Mosaic Virus and Wheat Soil Borne Mosaic Virus. Reaction to other diseases is unknown.

Quality Characteristics: Ostego was evaluated for milling and baking quality over four years and it appears to have satisfactory milling and baking properties comparable to current varieties. It is resistant to pre-harvest sprouting.

Morphology: Plant height is about 90 cm compared to 92 cm for Truman and 84 cm for Pioneer 25R47. This line is awnless and has white chaff color. Heading date is one or two days later than Pioneer 25R47 or Truman.

UNIVERSITY OF GEORGIA - JERRY JOHNSON

GA 001138-8E36

Soft Red Winter Wheat

GA 001138-8E36 is a high grain yielding, awned, medium late maturing, good test weight, medium-tall height line with moderate straw strength. It was derived from the cross of GA 961581 / PIO26R61. Its maturity averages about 4 days later than AGS 2000 in Georgia. Juvenile plant growth is semi-erect. At the boot stage, it is blue-green plant color with waxy stems and flag leaves are erect and not twisted. It is resistant to races of leaf rust and stripe rust in Georgia and the Southeast, current biotypes of Hessian fly in Georgia, wheat soil-borne mosaic virus, moderate-resistant to glume blotch, moderate susceptible to Fusarium head blight (scab), good milling and baking quality as a soft red winter wheat.

LIMAGRAIN CEREAL SEEDS – DON OBERT

LCS3311

Soft Red Winter Wheat

LCS3311 is a SRWW owned by Limagrain Cereal Seeds and is scheduled to be released in 2014. It was grown under the experimental name, LCS3211. It is medium-maturing, awnletted line with medium height. Plant LCS33211 from Arkansas to Northern OH, and MO to VA, and it will compete very well with lines such as Shirley and P25R47. This line's yield is supported by a solid disease resistance package. It is moderately resistant to stripe rust, BYDV, WSSMV and head scab, and has exceptionally good resistance to current races of powdery mildew in the Midwest. This line displays good winter hardiness, vigor and spring growth. LCS3311 is medium-early in maturity and finishes with bright golden straw

LCS2214

Soft Red Winter Wheat

LCS2214 is a SRWW owned by Limagrain Cereal Seeds, and is scheduled for release in 2013. This line competes well with USG 3555 and AP1104. It grows to a height between these two lines. This line possesses a very high level of resistance to current races of powdery mildew in the Midwest. It has very good winter-hardiness. The line is moderately resistant to WSSMV, Fusarium head scab, stripe rust, powdery mildew, black chaff and leaf rust. LCS2214 is moderately susceptible to BYDV. The line is of medium maturity and height. It will not stand up to extra high levels of Nitrogen fertilizer.

LCS221

Soft Red Winter Wheat

LCS2212 is a SRWW owned by Limagrain Cereal Seeds and is scheduled to be released in 2013. LCS2212 has very good resistance to BYDV and Fusarium head scab. It has a medium-short height and medium maturity. LCS2212 has moderate resistance to *Septoria tritici*, leaf rust, stripe rust, WSSMV, Fusarium head scab and powdery mildew.

LCS2223

Soft Red Winter Wheat

LCS2223 is a SRWW owned by Limagrain Cereal Seeds, and is scheduled to be released in 2013. It is moderately resistant to stripe rust, WSSMV, powdery mildew and leaf rust. LCS2223 is an early maturing line and medium-short in height. This line and its' sib, LCS2232, tiller well and have good vigor.

LCS2232

Soft Red Winter Wheat

LCS2232 is a SRWW owned by Limagrain Cereal Seeds and is scheduled to be released in 2013. LCS2223 is moderately resistant to stripe rust, BYDV, powdery mildew and leaf rust. It is an early maturing line and medium-short in height. LCS2232 and its' sib, LCS2223, tiller well and have good vigor.

L29220

Soft Red Winter Wheat

L29220 is a SRW experimental line owned by Limagrain Cereal Seeds, scheduled for release in 2014. This line is late maturing and of medium height. It is highly to moderately resistant to races of powdery mildew, leaf rust, stripe rust, *Septoria Tritici* and barley yellow dwarf virus in the Midwest. L29220 has very good winter-hardiness.

L29235

Soft Red Winter Wheat

L29235 is a SRW experimental line owned by Limagrain Cereal Seeds, and is scheduled for release in 2014. This line exhibits dark, lush foliage, vigor, later maturity, and winter hardiness. L29235 is moderately resistant to barley yellow dwarf virus, WSSMV, powdery mildew. It is moderately susceptible to *Septoria tritici* and leaf rust. L29235 medium-tall and should not be grown with abnormally high Nitrogen levels.

L29303

Soft Red Winter Wheat

L29303 is a SRW experimental line owned by Limagrain Cereal Seeds. The line is scheduled for release in 2014. This line is moderately resistant to barley yellow dwarf virus, powdery mildew, leaf rust and WSSMV. It is moderately susceptible to stripe rust and *Septoria tritici*. The line is more adapted to areas of southern KY, as well as TN and AR. It is lush and medium-tall. L29303 exhibits very good tillering capacity and vigor.

L29315

Soft Red Winter Wheat

L29315 is a SRW experimental line owned by Limagrain Cereal Seeds, and is scheduled for release in 2014. This line is very resistant to current races of stripe rust and powdery mildew. It is moderately resistant to leaf rust and barley yellow dwarf virus, and moderately susceptible to *Septoria tritici* and black chaff. This line has a medium height and exhibits vigor. L29315 heads similarly to SR30-530J and is medium early maturing.

L29422

Soft Red Winter Wheat

L29422 is a SRW experimental line owned by Limagrain Cereal Seeds, and is scheduled for release in 2014. This line exhibits vigor and a very erect, dark green flag leaf. It is moderately resistant to stripe rust, barley yellow dwarf virus and powdery mildew, and is MR to MS for leaf rust and black chaff. L29422 is tip awned, medium in height, and medium-late in maturity.

L29423

Soft Red Winter Wheat

L29423 is a SRW experimental line owned by Limagrain Cereal Seeds. The line is segregating awns and needs further reselection. This line has a very erect flag leaf. It is medium-maturing, is taller, and is similar in height to C9663. It is moderately resistant to stripe rust, WSSMV, barley yellow dwarf virus and *Septoria tritici*. L29423 is moderately susceptible to powdery mildew, leaf rust and black chaff.

MICHIGAN STATE UNIVERSITY – NG PERRY, LEE SILER

(Formerly Janet Lewis)

MSU E6012

Soft White Winter Wheat

MSU E6012 is a soft white wheat cultivar developed at Michigan State University from the cross 'Caledonia' / '25W33' made in 2001. MSU E6012 is awned and white chaffed, has an average height and flowering date, matures early in Michigan, and is average for FHB, powdery mildew, leaf blotch and stripe rust. MSU E6012 shows susceptibility to leaf and stem rusts.

JUPITER

Soft White Winter Wheat

Jupiter (MSU research name E5011) is a soft white winter wheat developed at Michigan State University from the cross 'Caledonia' / 'Richland'. Jupiter has exceptional yield in Michigan, good powdery mildew resistance, short stature, bronze chaff and is awnletted (very short awns). Jupiter was released from MSU in 2010. It is susceptible to Fusarium head blight (FHB), though its reaction to FHB is not statistically different (LSD 0.05) from 'Caledonia', the soft white winter wheat that has been predominant in Michigan for the past several years. In the 2010 Wheat Quality Council meeting, Jupiter was reported to have good biscuit and breakfast cereal qualities.

E5024

Soft White Winter Wheat

E5024 is a soft white winter wheat developed at Michigan State University from the cross MSU 'D6234' / Pioneer Brand '25W33'. It has good yield in Michigan, high test weight, is short, has white chaff and is awned. E5024 has resistance to many diseases, including improved resistance to Fusarium head blight, powdery mildew and stem rust. Data also suggest that E5024 has some improved resistance to pre-harvest sprouting (PHS) and it includes the favorable Vp1 allele. In the 2010 Wheat Quality Council meeting, Jupiter was reported to have good biscuit and breakfast cereal qualities.

PIONEER HYBRID – BILL LASKAR, GREG MARSHALL

PIONEER® VARIETY 25R46

Soft Red Winter Wheat

Pioneer® 25R46 was bred and developed by Pioneer Hi-Bred International. It is a very high yielding, awned soft red winter wheat cultivar with short height and has excellent test weight. Spike emergence of 25R46 is about the same time as Pioneer® variety 25R47 and is considered medium late in harvest maturity. It is the same height as 25R47, has excellent straw strength and has winter hardiness similar to 25R47. 25R46 appears moderately susceptible to moderately resistant to fungal leaf blight (*Septoria* spp, *Stagonospora*, and/or *Pyrenophora* spp), is moderately resistant to prevalent isolates of leaf rust (*Puccinia triticina*) and powdery mildew (*Blumeria graminis f.sp. tritici*), and has very good resistance to Fusarium head blight (*Fusarium graminearum*). 25R46 is highly susceptible to isolates of stripe rust (*Puccinia striiformis*) present in 2012. 25R46 does not have specific resistance to Hessian fly (*Mayetiola destructor*). 25R46 has acceptable milling and end use characteristics. 25R46 is very well adapted to the soft wheat production regions north of the Ohio River in the Corn Belt and in Ontario.

PIONEER® VARIETY 25R77

Soft Red Winter Wheat

Pioneer® 25R77 was bred and developed by Pioneer Hi-Bred International. It is a very high yielding, awned soft red winter wheat cultivar with short height and has excellent test weight. Spike emergence of 25R77 is about one day earlier than Pioneer® variety 25R47 and is considered to be early in harvest maturity. It is the same height as 25R47 and has good straw strength. 25R77 appears moderately susceptible to fungal leaf blight (*Septoria* spp, *Stagonospora*, and/or *Pyrenophora* spp), moderately resistant to powdery mildew (*Blumeria graminis f.sp. tritici*) and is susceptible to prevalent isolates of leaf rust (*Puccinia triticina*). It is susceptible to Fusarium head blight (*Fusarium graminearum*). 25R77 is highly resistant to isolates of stripe rust (*Puccinia striiformis*) present in 2012. 25R77 is resistant prevalent biotypes of Hessian fly (*Mayetiola destructor*) having H13 and/or H22. 25R77 has acceptable milling and end use characteristics. 25R77 is best adapted to the soft wheat production regions north of the Ohio River in the Corn Belt.

PIONEER® VARIETY 26R41

Soft Red Winter Wheat

Pioneer® 26R41 was bred and developed by Pioneer Hi-Bred International. It is a very high yielding, awned soft red winter wheat cultivar with short height and has excellent test weight. Spike emergence of 26R41 is one day earlier than Pioneer® variety 26R15 and is considered medium in harvest maturity. It is shorter than 26R15 has excellent straw strength. 26R41 appears moderately susceptible to moderately resistant to fungal leaf blight (*Septoria spp*, *Stagonospora*, and/or *Pyrenophora spp*), is resistant to prevalent isolates of leaf rust (*Puccinia triticina*) and powdery mildew (*Blumeria graminis f.sp. tritici*), and is susceptible to Fusarium head blight (*Fusarium graminearum*). 26R41 is highly resistant to isolates of stripe rust (*Puccinia striiformis*) present in 2012. 26R41 is resistant to prevalent biotypes of Hessian fly (*Mayetiola destructor*) having H13 and/or H22. 26R41 has good milling and end use characteristics. 26R41 is best adapted to the soft wheat production areas of the south east U.S. from Georgia to Virginia.

PIONEER® VARIETY 26R53

Soft Red Winter Wheat

Pioneer® 26R53 was bred and developed by Pioneer Hi-Bred International. It is a very high yielding, awned soft red winter wheat with short plant height and excellent test weight. Spike emergence of 26R53 is about one day earlier than Pioneer® 26R15 and is considered medium early in harvest maturity. 26R53 is shorter than 26R15 and has excellent straw strength. 26R53 has moderate resistance to fungal leaf blight (*Septoria spp*, *Stagonospora*, and/or *Pyrenophora spp*), is moderately resistant to prevalent isolates of leaf rust (*Puccinia triticina*) and has average resistance to powdery mildew (*Blumeria graminis f.sp. tritici*). 26R53 is highly resistant to isolates of stripe rust (*Puccinia striiformis*) present in 2012. It is susceptible to Fusarium head blight (*Fusarium graminearum*) and to biotype L of Hessian fly (*Mayetiola destructor*). 26R53 has good milling and end use characteristics. 26R53 is best adapted to the soft wheat production areas of the Mid-south and is not recommended for the south east U.S. due to its lack of Hessian fly resistance.

PIONEER® VARIETY 25R34

Soft Red Winter Wheat

Pioneer® variety 25R34 was bred and developed by Pioneer H-Bred International. It is a very high yielding, awned soft red winter wheat cultivar with short height and has average test weight. Spike emergence of 25R34 is about one day later than Pioneer® variety 25R47 and is considered medium late in harvest maturity. It is slightly taller than 25R47 and has exhibited straw strength and winter hardiness similar to 25R47. 25R34 appears moderately susceptible to moderately resistant to fungal leaf blight (*Septoria spp*, *Stagonospora*, and/or *Pyrenophora spp*), is moderately susceptible to prevalent isolates of leaf rust (*Puccinia triticina*) and powdery mildew (*Blumeria graminis f.sp. tritici*), and is susceptible to Fusarium head blight (*Fusarium graminearum*). 25R34 is highly resistant to isolates of stripe rust (*Puccinia striiformis*) present in 2012. 25R34 has H13 for resistance to Hessian fly (*Mayetiola destructor*). 25R34 has very good milling and end use

characteristics. 25R34 is very well adapted to the soft wheat production regions north of the Ohio River in the Corn Belt and in Ontario.

PIONEER® VARIETY 25R40

Soft Red Winter Wheat

Pioneer® 25R40 was bred and developed by Pioneer Hi-Bred International. It is a very high yielding, awned soft red winter wheat with short plant height and strong test weight. Spike emergence of 25R40 is the same time as Pioneer® 25R47 and is considered medium late in harvest maturity. 25R40 is about three inches shorter than 25R47 and has very strong straw. It has average winter hardiness. 25R40 has moderate resistance to fungal leaf blight (*Septoria spp*, *Stagonospora*, and/or *Pyrenophora spp*), is moderately resistant to prevalent isolates of leaf rust (*Puccinia triticina*) and has very good resistance to powdery mildew (*Blumeria graminis f.sp. tritici*). 25R40 is highly resistant to isolates of stripe rust (*Puccinia striiformis*) present in 2012. It is susceptible to Fusarium head blight (*Fusarium graminearum*) and to biotype L to Hessian fly (*Mayetiola destructor*). 25R40 has acceptable milling and end use characteristics. 25R40 is very broadly adapted to the soft wheat production regions north of the Ohio River in the Corn Belt and in Ontario.

PURDUE UNIVERSITY - HERB OHM

P04606

Soft Red Winter Wheat

Test line 04606RA1-1-7-1-6 is good yielding with large seeds and heads. It has excellent Fusarium resistance. It is a little taller, being similar in height to INW0412. It is similar to, or one day later in maturity to INW0412.

P05247

Soft Red Winter Wheat

Test line 05247A1-7-7-3-1 is high yielding with excellent test weight and average height and strong straw. It has good FHB type 1 and type 2 resistance. Its maturity date is very similar to INW0412

P05222

Soft Red Winter Wheat

Test line 05222A1-1-2-7 is good yielding, with good FHB type 1 and type 2 resistance. It is very short and matures similar to Branson.

RUPP SEED – JOHN KING

RS979

Soft Red Winter Wheat

RS979 is an awnless, soft red winter wheat, medium height and maturity, with white chaff at maturity. RS979 has very good winter hardiness, excellent straw strength and standability and very good test weight. RS979 has very good resistance for leaf rust, stripe rust, powdery mildew, septoria leaf blotch and scab.

RS972

Soft Red Winter Wheat

RS972 is an awnless variety with very good winter hardiness, excellent straw strength and standability. RS972 is a medium-late maturing, medium height plant with white chaff at maturity and very good test weight. RS972 has very good resistance for leaf rust, stripe rust, powdery mildew, septoria leaf blotch and scab.

STEYER SEED – JOE STEYER, DEREK HUNKER

PIERSON

Soft Red Winter Wheat

Pierson is an awnless, late maturing, tall variety with excellent winter hardiness and standability, very good resistance to lodging and very good test weight. Pierson has excellent resistance to head scab, leaf rust and soil borne mosaic virus, good resistance to septoria leaf blotch and resistance to stem rust, powdery mildew, septoria glume blotch, barley yellow dwarf virus and Hessian fly. Pierson works well on a wide range of soil types and handles “wet feet” very well.

SYNGENTA SEEDS, INC. – BARTON FOGLEMAN

SY 483

Soft Red Winter Wheat

SY 483 is a soft red winter wheat bred by Syngenta Seeds, Inc. for grain production. SY 483 is a medium-tall semi-dwarf variety and has white chaff at maturity. It has medium maturity and its heads the same time as W1377. It has shown moderate resistance to powdery mildew, moderate susceptibility to Fusarium, leaf rusts in the area, and Septoria. SY 483 tests susceptible to *Rhizoctonia* in laboratory trials. It has tested moderately resistant to soil-borne mosaic virus complex (in Urbana, IL, '09, '11). In 2012, it tested moderately resistant to Barley yellow dwarf.

SY 483 has shown above average milling flour yields and acceptable cookie baking properties.

SY 483 appears to be best adapted for grain production in the states of Illinois, Indiana, Missouri, Kentucky, Michigan, Ohio, Wisconsin, Delaware, Maryland, North Carolina, Pennsylvania, and Virginia.

SY 474

Soft Red Winter Wheat

SY 474 (formerly MH07-7474) is a soft red winter wheat bred by Syngenta Seeds, Inc. for grain production. SY 474 is a medium-tall, semi-dwarf variety and has white chaff at maturity. It has medium maturity and its heading is a day earlier than W1377. SY 474 has shown above average test weight, moderate resistance to Fusarium head blight, moderate resistance to powdery mildew, moderate resistance to the races of leaf rust and stripe rust in this area, and susceptibility to soil borne mosaic virus. It has tested resistant to Hessian fly biotype B. It has above average gluten strength and is an above average broad adaptation end use market variety.

SY 474 appears to be best adapted for grain production in the states of Illinois, Indiana, Missouri, Michigan, Ohio, Wisconsin, Delaware, Maryland, North Carolina, Pennsylvania, and Virginia.

MH07-7474 is being released as SY 474 and will be available thru retail markets in the 2014 sales season. It is in university testing this year (2013).

M09L-9547

Soft Red Winter Wheat

M09L-9547 is a soft red winter wheat bred by Syngenta Seeds, Inc. for grain production. M09L-9547 is a medium tall, semi-dwarf variety and has white chaff at maturity. It has medium early maturity and its heading is similar to Branson. M09L-9547 has shown above average test weight, moderate susceptibility to Fusarium head blight, and powdery mildew, moderate resistance to the races of leaf rust in this area, and susceptibility to soil borne mosaic virus. It has above average flour yield and average milling quality.

M09L-9547 appears to be best adapted for grain production in the states of Illinois, Indiana, Missouri, Michigan, Ohio, Wisconsin, Delaware, Maryland, North Carolina, Pennsylvania, and Virginia

SY HARRISON

Soft Red Winter Wheat

SY Harrison is a soft red winter wheat, bred and developed by Syngenta Seeds, Inc. SY Harrison was selected for height, maturity, appearance, and kernel soundness using a modified bulk breeding method that originated with a single cross made in spring of 1998. SY Harrison is a medium height semi-dwarf variety and has white chaff at maturity. It has medium to medium-full season maturity and its heading date is similar to SY 9978 and about one day earlier than 26R15. SY Harrison has shown best adaptation to the major wheat growing areas of the Midsouth from central Missouri south through Arkansas and western Tennessee to the northern halves of Louisiana and Mississippi; and in the East in the states of Virginia, North Carolina and South Carolina. It has shown moderate resistance to Septoria leaf complex and the races of stripe rust in these areas. It has shown moderate susceptibility to leaf rust and is susceptible to several current races of

powdery mildew. Milling and baking characteristics are very good and this variety is intended for grain production.

Juvenile growth habit is semi-erect. Plant color at boot stage is blue green. Anther color is yellow. Auricle anthocyanin is absent and auricle hairs are present. Flag leaf at boot stage is recurved and twisted. Head shape is tapering and awned. Glumes are midlong in length and narrow in width. Glume shoulder shape is oblique with an acuminate beak. Chaff color is white at maturity. Seed shape is ovate. Brush hairs on the seed are midlong in length and occupy a medium area of the seed tip. Seed depth is shallow and width is narrow. Seed cheeks are rounded.

Sy Harrison has been uniform and stable since 2010. Approximately 0.8% of the plants were rogued from the Breeder's seed increase in 2010. Approximately 95% of the rogued variant plants were taller height wheat plants (8 to 15 cm) and 5% were awnless. Up to 1.0% variant plants may be encountered in subsequent generations.

Syngenta Seeds, Inc. maintains seed stock and certified classes of Foundation, Registered and Certified. Certified seed stocks of SY Harrison will be available in the fall of 2013. Certified acreage is not to be published by AOSCA and certifying agencies. SY Harrison may only be sold as a class of certified seed and all seed sales are royalty bearing.

Its variety name, SY Harrison, was selected to honor the memory of long-time Coker's Pedigreed Seed Company small grains breeder, Howard Harrison.

VIRGINIA TECH – CARL GRIFFEY

2013412

Soft Red Winter Wheat

The soft red winter (SRW) wheat cultivar 2013412 was derived from the cross 'Tribute' (PI 632689) / 'AGS 2000' (PI 612956) // VAN99W-20 (VA90-54-631 / VA90-52-49). Parentage of VA90-54-631 is 'Tyler' / 'Coker 78-23' // 'McNair 1003' /3/ 4* 'Massey' /8/ 'Saluda' /7/ FL737G3-12-2-12 / Tyler /5/ Citr13836 / 9* 'Chancellor' // 'Wheeler' /3/ 'Severn' /4/ 'Feland' /6/ Tyler. Parentage of VA90-52-49 is 'Hunter' / Wheeler. The pedigree of FL737G3-12-2-12 is Vogel 5 / 'Anderson' // Purdue Dwarf / 'Hadden' /3/ Purdue 6562A1-4-2 /4/ 'Blueboy II' / 'Coker 68-8'. Parentage of P6562A1-4-2 is 'Siete Cerros' / 'Arthur'.

Prior to its release, cultivar 2013412 was evaluated as VA06W-412 over three years (2009 – 2011) in Virginia's State Variety Trials, and throughout most of the SRW wheat region in the 2010 USDA-ARS Uniform Southern SRW Wheat Nursery. Cultivar 2013412 is a broadly adapted, high yielding, full-season, short height semi-dwarf (gene Rht2) producing grain that is well suited for dual end uses in both pastry and cracker products. It has performed well in diverse regions of the SRW wheat production area from northern Louisiana to Wisconsin. Cultivar 2013412 is resistant to leaf and stem rusts, powdery mildew, and Barley and Cereal Yellow Dwarf Viruses, and expresses moderate levels of resistance to other diseases prevalent in the SRW wheat region including stripe rust, leaf and glume blotch, Fusarium Head Blight, Wheat Soil Borne Mosaic Virus, Wheat Spindle Streak Mosaic Virus, and Hessian fly. During fall 2011, breeder seed of cultivar 2013412 was sown

on 8 acres at the VCIA Foundation Seed farm and produced 646 units (50 lbs/unit) of Foundation seed that was distributed to seedsmen in fall 2012. Cultivar 2013412 will be marketed by FFR and Southern States Cooperatives.

In the southern SRW wheat region, average head emergence of cultivar 2013412 (119 d) was 1 d later than 'USG3555'. Average mature plant height of 2013412 has varied from 32 to 36 inches and is about 1.5 inches taller than USG 3555 and two inches shorter than 'Coker 9553'. Straw strength (0=erect to 9=completely lodged) of 2013412 (0 – 1.3) is very good being most similar to that of 'Shirley' (0.7 – 1.0) and better than that of cultivar 5187J (1.9 – 3.8). Winter hardiness and freeze tolerance of cultivar 2013412 are better than those of USG3555. Cultivar 2013412 was evaluated at 26 locations in the 2010 USDA-ARS Uniform Southern SRW Wheat Nursery, and ranked eighth in grain yield (63.9 Bu/ac) among 32 entries over replicated test sites having coefficient of variance values equal to or lower than 10%. It ranked among the top ten highest yielding entries at 11 of the 26 test sites. Average test weight of 2013412 (57.5 Lb/Bu) was most similar to those of check cultivars AGS 2000 (57.2 Lb/Bu) and Pioneer Brand '26R61' (57.9 Lb/Bu) and significantly ($P < 0.05$) higher than that of USG 3555 (56.5 Lb/Bu).

Grain samples of cultivar 2013412 produced in five crop environments (2009 – 2011) were evaluated for end use quality by the USDA-ARS Soft Wheat Quality Lab. Cultivar 2013412 has exhibited milling and pastry baking qualities that are most similar to those of the strong gluten cultivars Branson and Pioneer Brand 26R15. While flour protein concentration of 2013412 (7.11% – 9.15%) has been average, gluten strength has been above average based on lactic acid solvent retention capacity (114.1% – 125.7%). Concurrently, cookie diameters of 2013412 (18.8 – 19.0 cm) have been consistently good indicating that flour of 2013412 is well suited for use in production of pastry and cracker products.

2013911

Soft Red Winter Wheat

The soft red winter wheat cultivar 2013911 was derived from the cross Pioneer Brand '26R24' (PI 614110 PVPO) / 'McCormick' (PI 632691). Cultivar 2013911 was evaluated in seven environments over three years (2008 - 2010) in Virginia's State Variety Trials, and was evaluated throughout most of the soft red winter (SRW) wheat region in the USDA-ARS Uniform Southern Soft Red Winter Wheat Nurseries in 2009 and 2010. Cultivar 2013911 is widely adapted, has short plant height, very good straw strength, and high grain yield potential. Cultivar 2013911 has expressed moderate to high levels of resistance to the most prevalent wheat diseases in the eastern U.S. with the exception of stem rust and Hessian fly. Most notably, cultivar 2013911 provides producers in the eastern U.S. with a cultivar having adult plant resistance to stripe rust. In fall 2011, approximately 1,200 Bu of Foundation seed were distributed to seedsmen. Cultivar 2013911 will be marketed by cooperatives affiliated with FFR Cooperative, Battleground, Indiana.

Wheat cultivar 2013911 is a short height semi-dwarf (gene Rht2) that is full-season maturity, resistant to lodging, broadly adapted, and high yielding. In the southern SRW wheat region, average head emergence of cultivar 2013911 (118 - 120 d) has been 4 to 6 days later than 'Coker 9553'. Mature plant height of cultivar 2013911 is 31 to 34 inches and on average is 0.6 inch taller than

'USG 3555' and 2 to 3 inches shorter than Coker 9553. On average, straw strength (0=erect to 9=completely lodged) of cultivar 2013911 (0.2 - 0.9) is better than that of USG 3555 (1.2 - 1.8). Cultivar 2013911 was evaluated at 26 locations in the 2009-10 USDA-ARS Uniform Southern SRW Wheat Nursery (USSRWWN), and ranked seventh among 32 entries for grain yield (64.5 Bu/ac). Cultivar 2013911 had a mean test weight (56.8 Lb/Bu) that was most similar to that of USG 3555. Cultivar 2013911 ranked among the top ten entries for grain yield at 15 of the 26 locations. Cultivar 2013911 also was evaluated at 25 locations in the 2008-09 USSRWWN, and ranked fourth among 40 entries for grain yield (68.7 Bu/ac). Cultivar 2013911 ranked among the top ten entries at 12 of the 25 locations. In comparison to the four check cultivars, cultivar 2013911 produced an average test weight (55.1 Lb/Bu) that was most similar to that of USG 3555. On the basis of winter kill ratings (0 = no injury to 9 = complete kill) reported at 3 of 25 locations in the 2008-09 USSRWWN, winter hardiness of cultivar 2013911 (3.9) was similar to that of Coker 9553 (4.0), and better than 'AGS 2000' (5.2) and Pioneer '26R61' (5.5).

5187J

Soft Red Winter Wheat

The soft red winter wheat cultivar 5187J, tested as VA05W-151, was derived from the cross Pioneer Brand '26R24' (PI 614110 PVPO) / 'McCormick' (PI 632691). Prior to its release, 5187J was evaluated in seven environments over three years (2008-2010) in Virginia's State Variety Trials. It also was evaluated throughout the soft red winter (SRW) wheat region in the USDA-ARS Uniform Eastern SRW Wheat Nurseries (UESRWWN) in 2009 and 2010 and in the Uniform Southern SRW Wheat Nursery (USSRWWN) in 2011. Cultivar 5187J is widely adapted, early heading, and has high grain yield potential and high test weight. It has expressed moderate levels of resistance to the most prevalent wheat diseases in the eastern U.S. with the exception of stripe rust and Hessian fly. An initial seed purification of 5187J was sown on five acres at the VCIA Foundation seed farm during fall 2010 and produced 400 bu of Foundation seed. Breeder seed also was planted on 1 acre during fall 2010 and produced 60 bu of Foundation seed. Most of this seed was provided to seedsmen in fall 2011, and 5187J will be marketed by Growmark-East and Seedway.

Cultivar 5187J is a broadly adapted, high yielding, early maturing, short height semi-dwarf (gene Rht2). In the eastern SRW wheat region, average head emergence of 5187J (129 - 135 d) has been similar to 'Branson' (129 - 134 d) and 2 to 3 d earlier than 'Shirley' and 'Roane'. Mature plant height of 5187J is 33 to 34 inches and on average is similar to Branson, 1 to 2 inches taller than Roane and Shirley, and 2.5 inches shorter than 'Bess'. On average, straw strength (0=erect to 9=completely lodged) of 5187J (2.6 - 3.4) is most similar to that of 'Featherstone 176' (3.1) and Roane (3.2), but weaker than that of Branson (1.3 - 2.0). Cultivar 5187J was evaluated at 27 locations in the 2009-10 UESRWWN, and produced the highest mean grain yield (72.9 Bu/ac) and second highest test weight (59.4 Lb/Bu) among 46 entries. Grain yields of 5187J were significantly ($P < 0.05$) higher than the test averages at 11 of the 27 locations and ranked among the top ten entries at 20 locations. Cultivar 5187J was evaluated at 28 locations in the 2008-09 UESRWWN, and ranked first among 42 entries for grain yield (83.2 Bu/ac) and second for test weight (59.1 Lb/Bu). Grain yields of 5187J were significantly ($P < 0.05$) higher than the test averages at 9 of the 28 locations and ranked among the top ten entries at 20 locations. In the 2010-11 USSRWWN, 5187J ranked first in grain

yield (79.7 Bu/ac) among 28 entries evaluated at 26 locations. On the basis of winter kill ratings (0 = no injury to 9 = complete kill) reported at 5 of 28 locations in the 2008-09 UESRWWN, winter hardiness of 5187J (2.1) was similar to that (2.2 - 2.4) of the check cultivars INW0411, Branson and Bess.

Grain samples of 5187J produced in four crop environments (2008 and 2009) were evaluated for end use quality by the USDA-ARS Soft Wheat Quality Lab. Cultivar 5187J has exhibited milling and baking qualities that are most similar to those of the strong gluten cultivars Pioneer 26R12, USG 3315, and Tribute; although, 5187J has notably higher gluten strength than these cultivars. Mean comparisons of milling and baking quality attributes of 5187J versus Tribute over two years (2008-2009) include: milling quality score (69.3 vs. 69.6), baking quality score (59.0 vs. 54.4), softness equivalence score (70.3 vs. 65.9), flour yield (70.4% vs. 70.2%), flour protein (7.9% vs. 7.4%), gluten strength (lactic acid retention capacity 120.2 vs. 107.3), and cookie spread diameter (18.64 vs. 18.50 cm). On the basis of quality evaluations conducted on entries in the 2010 and 2009 UESRWWN, 5187J had milling quality scores (69.6 and 64.1) that were similar to those of check cultivars Bess, INW0411, and Shirley (60.1 - 65.5) and higher than that of Roane (57.3). Baking quality scores of 5187J (61.3 and 45.7) were similar to Shirley and better than INW0411 in 2010, but were lower than those of the check cultivars (52.6 - 79.8) in 2009. Softness equivalence scores of 5187J (62.6 and 59.0) were most similar to those of Bess (65.5 and 57.3). Flour yields of 5187J (71.0% and 70.4%) were higher than those of Bess (68.9% and 69.5%) and Roane (68.8%). Flour protein concentration of 5187J (8.5% and 8.8%) was most similar to that of INW0411 (8.6% and 8.9%). Protein gluten strength of 5187J estimated by lactic acid solvent retention capacity (112.8% and 114.7%) was consistently higher than that of INW0411, Branson, Bess, and Shirley (85.4% - 109.5%). Cookie spread diameters of 5187J (18.6 and 18.4 cm) were similar to those of INW0411.

Grain samples of cultivar 2013911 produced in six crop environments (2008 - 2010) were evaluated for end use quality by the USDA-ARS Soft Wheat Quality Lab. Cultivar 2013911 has exhibited milling and baking qualities that are most similar to those of the strong gluten cultivar Coker 9553. Mean comparisons of milling and baking quality attributes of cultivar 2013911 versus Coker 9553 include: milling quality scores (60.6 vs. 63.1), baking quality score (37.7 vs. 53.9), softness equivalence score (58.9 vs. 68.0), flour yield (68.0% vs. 68.6%), and flour protein (8.64% vs. 8.92%). Gluten strength of cultivar 2013911 as predicted by lactic acid solvent retention capacity has been consistently higher (mean of 138.8%) than that of Coker 9553 (mean of 121.3%) and other cultivars. Cultivar 2013911 had lower cookie spread diameters (17.8 - 18.1 cm) compared with Coker 9553 (18.3 - 18.7 cm), 'Shirley' (19.59 cm), and AGS 2000 (18.8 - 19.1 cm). While flour solely derived from cultivar 2013911 is not desirable for pastry production, it's very strong gluten flour may be desirable for use in production of leaven products such as crackers and certain breads as well as in blends with flour derived from weak gluten cultivars to improve their functionality.

12V51

Soft Red Winter Wheat

The soft red winter wheat cultivar 12V51, tested as VA05W-251, was derived from the cross VA98W-130 // VA96W-348 / Pioneer Brand '26R61' (PI 612153 PVPO). Parent- age of VA98W-130 is 'Savannah' (PI559929) / VA87-54-558 // VA88-54-328 / 'GA-Gore' (PI 561842). Parentage of VA87-54-558 is 'Massey' (CItr 17953) / 'Holley' (CItr 14579) and parentage of VA88-54-328 is 'Lovrin 29' (PI 519144) / 'Tyler' (CItr 17899) // 'Red- coat' (CItr 13170) *2 / 'Gaines' (CItr 13448). Parentage of VA96W-348 is IN81401A1-32-2 / 'FFR555W' (PI 560318 PVPO), and parentage of IN81401A1-32-2 is 'Arthur 71' (CItr 15282) / 'Caldwell' (CItr 17897) /4/ Arthur 71 /3/ 'Benhur' (CItr 14054) // 'Riley' (CItr 13702) *2 / W62-63-119A.

Prior to its release, 12V51 was evaluated in seven environments over three years (2008 - 2010) in Virginia's State Variety Trials. It also was evaluated throughout the soft red winter (SRW) wheat region in the USDA-ARS Uniform Southern SRW Wheat Nurseries (USSR- WWN) in 2009 and 2010 and in the Uniform Eastern SRW Wheat Nursery (UESRWWN) in 2011. Cultivar 12V51 is widely adapted, has short plant height, high grain yield potential, and good milling and pastry baking quality. It has expressed moderate to high levels of resistance to the most prevalent wheat diseases in the eastern U.S. with the exception of stripe rust and stem rust. Most notably, 12V51 provides producers in the eastern U.S. with a cultivar having resistance to leaf rust and glume blotch. Breeder seed of 12V51 was planted on 8 acres during fall 2010 and produced 480 Bu of Foundation seed in 2011, which was distributed to seedsmen. Cultivar 12V51 will be marketed by seed companies working in collaboration with Maryland Crop Improvement Association.

Cultivar 12V51 is a short height semi-dwarf (gene Rht2) that is mid-season maturity, broadly adapted, and high yielding. In the southern SRW wheat region, average head emergence of 12V51 (114 - 118 d) is similar to that of Pioneer Brand 26R61 and one day later than 'AGS 2000'. Mature plant height of 12V51 (31 - 34 inches) is similar to that of 'USG 3555' and 4 to 5 inches shorter than Pioneer Brand 26R61. Straw strength (0=erect to 9=completely lodged) of 12V51 (1.7 - 3.4) is equal to or slightly less than average. In Virginia's State Variety Trials, 12V51 had a three year (2008-2010) average grain yield (84 Bu/ac) similar ($P < 0.05$) to that of the highest yielding cultivar Shirley. Cultivar 12V51 had a three year average test weight (58.0 Lb/Bu) that was significantly ($P < 0.05$) higher than Shirley (57.0 Lb/Bu). Cultivar 12V51 was evaluated at 26 locations in the 2009-2010 USSRWWN, and produced a grain yield (61.8 Bu/ac) that was similar to the nursery average. Cultivar 12V51 ranked among the top ten entries for grain yield at 11 of the 26 locations. In the 2008-09 USSRWWN, 12V51 was evaluated at 25 locations, and ranked seventh among 40 entries for grain yield (67.1 Bu/ac). It ranked among the top ten entries at 13 of the 25 locations. Test weight of 12V51 has been most similar to that of USG 3555. In the 2010-11 UESRWWN, 12V51 was evaluated at 28 locations, and ranked eighth among 38 entries for grain yield (73.3 Bu/ac). On the basis of winter kill ratings (0 = no injury to 9 = complete kill) reported at 3 of 25 locations in the 2008-09 USSRWWN, winter hardiness of 12V51 (4.2) was similar to that of USG 3555 (4.3) and 'Coker 9553' (4.0).

Grain samples of 12V51 produced in six crop environments (2008 - 2010) were evaluated for end use quality by the USDA-ARS Soft Wheat Quality Lab. Cultivar 12V51 has exhibited good milling and pastry baking qualities and overall has superior quality compared to USG 3555. Mean comparisons of milling and baking quality attributes of 12V51 versus USG 3555 include: milling quality score (68.3 vs. 65.7), baking quality score (61.0 vs. 47.4), softness equivalence score (58.3 vs. 62.1), flour yield (69.7% vs. 69.0%), and flour protein (8.2% vs. 8.7%). Gluten strength of 12V51 as predicted by lactic acid solvent retention capacity has been consistently lower (mean of 100.7%) than that of USG 3555 (116.1%). Cultivar 12V51 has consistently produced cookies of larger diameter (mean of 18.76 cm) than USG 3555 (18.30 cm).

VA258

Soft Red Winter Wheat Cultivar

The soft red winter wheat cultivar VA258 was derived from the three-way cross VA98W-130 // 'Coker 9835' / '38158' (PI 619052= SS520). Parentage of VA98W-130 is 'Savannah' / VA87-54-558 // VA88-54-328 / 'GA-Gore'. Parentage of VA87-54-558 is 'Massey' / 'Holley' and parentage of VA88-54-328 is 'Lovrin 29' / 'Tyler' // 'Redcoat' *2 / 'Gaines'. VA258 was evaluated in seven to eight environments over three years (2007-2009) in Virginia's Official State Variety Trials, and was evaluated throughout most of the soft red winter wheat region in the USDA-ARS Uniform Southern and Uniform Eastern Soft Red Winter Wheat Nurseries in 2008 and 2009, respectively. VA258 has expressed moderate resistance to powdery mildew, leaf rust, barley yellow dwarf virus, soilborne mosaic virus, wheat spindle streak mosaic virus, and glume blotch. VA258 expressed seedling resistance to Hessian fly biotypes C and O, but is susceptible to biotypes B, D, and L. Breeder seed comprised of bulked seed from 298 of 320 selected F9 headrows of VA258 that were similar in phenotype and visually homogenous was planted and advanced by Virginia Crop Improvement Association (VCIA). Foundation seed of VA258 produced on 14 acres in 2011 at the VCIA Foundation seed farm was provided to seedsmen. Marketing of the cultivar will be directed by Maryland Crop Improvement Association, Queenstown, MD and Featherstone Seed, Amelia, VA.

The soft red winter wheat line VA258 is broadly adapted, high yielding, full-season maturity, and a standard height semi-dwarf (Rht2). Spikes and straw of VA258 are white to creamy in color at maturity, and the tapering spikes are awnletted. Head emergence of VA258 (123 d, Julian in Virginia) is 1 day later than 'Branson', 2 days later than 'USG 3555', and 2 days earlier than Roane. Mature plant height of VA258 is 37 to 38 inches and on average is 2 inches taller than Branson, 5 inches taller than USG 3555, and 1 inch shorter than 'Magnolia'. Straw strength (0=erect to 9=completely lodged) of VA258 (2.5 - 3.0) is similar to or better than those of 'AGS 2000' (3.1), 'Roane (3.2), and 'MPV 57' (3.0). In Virginia's State Wheat Variety Trials, the three year average (2007-2009) grain yield of VA258 (88 Bu/ac) was similar to that of the highest yielding (89 Bu/ac) cultivar Shirley. Average test weight of VA258 (57.6 Lb/Bu) is most similar to those of Branson and USG 3555 and 0.6 Lb/Bu higher than those of Shirley and Pioneer variety '26R15'.

VA258 was evaluated at 29 locations in the 2007-08 USDA-ARS Uniform Southern Soft Red Winter Wheat Nursery, and produced a mean grain yield (73.9 Bu/ac) that was just above the overall test yield average (72.6 Bu/ac) for all 42 entries and 29 locations. VA258 produced yields that were

similar to or significantly higher than the test averages at 16 locations. Average test weight of VA258 (55.9 Lb/Bu) was most similar to that of USG 3555 (56.9 Lb/Bu). VA258 also was evaluated at 28 locations in the 2008-09 USDA-ARS Uniform Eastern Soft Red Winter Wheat Nursery, and ranked 13th among 42 entries for grain yield (75.2 Bu/ac) compared to rankings of 3rd for Branson (79.3 Bu/ac), 17th for 'Bess' (74.6 Bu/ac), 26th for Roane (73.0 Bu/ac), and 33rd for 'INW 0411' (69.1 Bu/ac). VA258 produced yields similar to or significantly higher than the test averages at 20 of the 28 test sites. Average test weight of VA258 (55.8 Lb/Bu) was similar to that of Branson. On the basis of winter kill ratings (0 = no injury to 9 = complete kill) reported at 4 of the 29 southern nursery locations and at 5 of the 28 eastern nursery test sites, winter hardiness of VA258 (3.0 and 3.1, respectively) is most similar to that of 'Coker9553' (3.4), better than that of AGS2000 (5.0), and less than that of Branson (2.2).

On the basis of four independent quality evaluations over four crop years (2006-2009), VA258 has exhibited milling and baking qualities that are most similar to those of the strong gluten cultivars Featherstone 176, Jamestown, and Tribute. Mean comparisons of milling and baking quality attributes of VA258 versus Tribute over three years (2006-2008) include: milling quality score (61.9 vs. 66.5), baking quality score (36.1 vs. 41.0), softness equivalence score (59.9 vs. 58.5), flour yield (69.9% vs. 70.8%), flour protein (8.0% vs. 7.9%), gluten strength (lactic acid retention capacity 116.4 vs. 116.1), and cookie spread diameter (17.5 vs. 17.9 cm).

YORKTOWN

Soft Red Winter wheat

The soft red winter wheat cultivar Yorktown was derived from the cross '38158' (PI 19052, VA96W-158 = 'FFR555W' / 'GA-Gore') / VA99W-188 [VA91-54-343 (IN71761A4-31-5-48 // VA71-54-147 (Citr 17449) / 'McNair 1813') / 'Roane' (PI 612958) sib (VA91-54-222)] // 'Tribute' (PI 632689). Wheat line IN71761A4-31-5-48 was developed by Purdue University and has the pedigree 'Benhur' (Citr 14054) /3/ 'Arthur' (Citr 14425) / 'Knox' (Citr 12798) type line /4/ 'Beau' (Citr17420) *2 /3/ Arthur *2 // 'Riley' (Citr 13702) / 'Bulgaria 88' (PI 94407).

Prior to its release Yorktown was evaluated as VA08W-294 in Virginia's State Variety Trials over two years (2010 - 2011) and throughout the soft red winter (SRW) wheat region in the 2011 USDA-ARS Uniform Southern and Uniform Eastern Soft Red Winter Wheat Nurseries. Yorktown is a widely adapted wheat cultivar that has high grain yield potential and high test weight and has performed well over most of the SRW wheat production areas from northern Louisiana to Ontario. With the exception of Wheat Soil Borne Mosaic Virus and potentially Wheat Spindle Streak Mosaic Virus, Yorktown expresses moderate to high levels of resistance to diseases prevalent in the SRW wheat region. These include leaf, stripe, and stem rusts, powdery mildew, leaf and glume blotch, Fusarium Head Blight, Barley and Cereal Yellow Dwarf Viruses, and Hessian fly.

Breeder seed of Yorktown was sown on 13 acres in fall 2011 at the VCIA Foundation Seed farm and produced 1,000 units (50 lbs/unit) of Foundation seed that was distributed to seedsmen. Yorktown will be marketed by Crop Production Services.

Yorktown is a broadly adapted, high yielding, full-season, short height semi-dwarf (gene Rht2). In the eastern SRW wheat region, head emergence of Yorktown (133 d) has been similar to that of 'Shirley', while in the southern SRW wheat region, head emergence of Yorktown (117 d) has been 1 d later than 'USG3555'. Average mature plant height of Yorktown has varied from 30 to 35 inches and is about one inch taller than 'Branson' and two inches shorter than 'Bess' and 'AGS 2000'. On average, straw strength (0=erect to 9=completely lodged) of Yorktown (0.8 – 2.0) is good being most similar to that of USG 3555 (0.7 – 2.2) and better than those of 'Bess' (1.2 versus 2.3) and AGS 2000 (1.9 versus 3.2). Winter hardiness and freeze tolerance of Yorktown are better than those of AGS 2000 and USG 3555. Yorktown was evaluated at 26 locations in the 2011 USDA-ARS Uniform Southern SRW Wheat Nursery, and ranked third in grain yield (77.8 Bu/ac) among 28 entries. Average test weight of Yorktown (59.6 Lb/Bu) was most similar to that of AGS 2000 (59.0 Lb/Bu) and significantly ($P < 0.05$) higher than that of USG 3555 (58.0 Lb/Bu). In the 2011 USDA-ARS Uniform Eastern SRW Wheat Nursery, Yorktown ranked tenth in grain yield (72.4 Bu/ac) among 38 entries evaluated over 28 environments. Average test weight of Yorktown (58.8 Lb/Bu) was significantly ($P < 0.05$) higher than those of the four check cultivars including Shirley and Branson having average test weights of 55.8 and 56.7 Lb/Bu, respectively.

Grain samples of Yorktown produced in five crop environments (2010 and 2011) were evaluated for end use quality by the USDA-ARS Soft Wheat Quality Lab. Yorktown has exhibited milling and baking qualities that are most similar to those of the strong gluten cultivars Coker 9553, USG 3555, and 5187J. Flour protein concentration of Yorktown (7.80% – 8.85%) is lower than average, while its gluten strength is average or above based on lactic acid solvent retention capacity (106.6% – 119.2%).

2012 WHEAT QUALITY COUNCIL

ANNUAL EVALUATION OF NEW CULTIVARS

The SWQL participates in the Wheat Quality Council (WQC) annual evaluation of new cultivars by milling grain, distributing flour to collaborators, performing quality trait evaluations on the new varieties and preparing a report that collates quality evaluations among the collaborators for presentation at the annual WQC meeting. Uniform milling and reliable quality trait testing, as performed at the SWQL are critical tasks, allowing collaborators to compare quality evaluations of the new varieties presented each year. Scott Beil coordinates the WQC and prepared the 2012 annual report.

The Quality Evaluation Committee of the Soft Wheat Council

Ben Hancock, Executive Vice President, Wheat Quality Council

USDA-ARS-CSWQRU Soft Wheat Quality Laboratory

M. G. Redinbaugh, Research Leader
Scott Beil

OBJECTIVES OF THE WQC EVALUATION OF NEW SOFT WHEAT CULTIVARS:

- Encourage wide participation by all members of the soft wheat industry.
- Determine, through technical consulting expertise, the parameters which adequately describe the performance characteristics which members seek in new variety.
- Promote the enhancement of soft wheat quality in new varieties.
- Emphasize the importance of communication across all sectors and to provide resources for education on the continuous improvement of soft wheat quality.
- Encourage the organizations vital to soft wheat quality enhancement to continue to make positive contributions through research and communications.
- Offer advice and support for the USDA-ARS Soft Wheat Quality Laboratory in Wooster, Ohio

CONTRIBUTING SOFT WHEAT BREEDING PROGRAMS AND TEST LINES

Variety descriptions are found in the New Wheat Cultivars section of this report.

CARL GRIFFEY, VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

2013412

Yorktown

Merl

GREG MARSHALL, PIONEER HI-BRED INTERNATIONAL, INC.

Pioneer 25R34

Pioneer 25R40

Pioneer 25R47

CLAY SNELLER, THE OHIO STATE UNIVERSITY

Bromfield

Malabar

BARTON FOGLEMAN, SYNGENTA

SY Harrison

Oakes

HERB OHM, PURDUE UNIVERSITY

P04606

P05247

P05222

INW 1021

USDA-ARS SWQL GRAIN AND FLOUR EVALUATIONS

MILLING ANALYSIS

Miag Multomat Mill

The Miag Multomat Mill is a pneumatic conveyance system consisting of eight pair of 254 mm diameter x 102 mm wide rolls, and ten sifting passages. Three pair are corrugated break rolls and five reduction passes. Each sifting passage contains six separate sieves. The two top sieves for each of the break rolls are intended to be used as scalp screens for the bran. The third break sieving unit of the Soft Wheat Quality Laboratory (SWQL) Miag Multomat Mill was modified so that the top four sieves better sift bran.

Milling

All SRW varieties were tempered to 14.5% moisture. The tempered wheat was held for 24 hours prior to milling. Wheat was introduced into the first break rolls at a rate of approximately 600g/hr. First break roll gap was adjusted to allow 46% through a #28 SSBC; 716 μ m. Straight grade flour is a blend of the three Break flour streams including the Grader flour and the five Reduction streams including the 1M Re-Duster flour. The straight grade flour mean volume diameter will be about 100 microns with flour ash content usually between 0.38% and 0.50%. Bran, break shorts, tail shorts and red dog are by-products which are not included with the flour. Flour yield varies between 70% and 78%. Flour yield is variety dependent, due to heritable milling quality differences, and/or grain quality dependent, as influenced by environmental growing conditions. Sprouted and/or shriveled kernels negatively impact flour production. Recovery of all mill products is usually about 98%.

Table 7. USDA-ARS SWQL test for grain and milling characteristics 2012 WQC

2012 WQC Variety	Test Wt Lb/bu	SKCS				Milling	
		Moisture (%)	Diameter	Weight	Hardness	Break	Straight Grade
VA06W-412	64.3	14	2.6	40.1	26.5	26.1	71.5
VA08W-294	63.1	14.2	2.6	41.9	34.9	26.6	72.5
Merl (ck)	63.2	14	2.6	42.4	29.8	26.6	74
Pioneer 25R34	60.8	14.3	2.4	39.8	14.8	28.8	73.5
Pioneer 25R40	60.2	14.1	2.5	42.6	27.5	29.1	74.8
Pioneer 25R47 (ck)	59.6	14.2	2.3	37.1	18.7	30.6	74.1
Bromfield	62.1	14.6	2.2	33	33.8	29.5	74.9
Malabar (ck)	58.2	13.8	2.3	31.6	12.2	36	75.2
SY Harrison	58.4	14	2.3	37.1	10.1	33.7	76.5
Oakes (ck)	61.5	14.3	2.4	34.8	33.8	27.9	75.8
P04606	62	13.7	2.5	36.4	32.6	27	74.1
P05247	62.9	14.5	2.6	38.3	35.7	27.5	74.2
P05222	58.9	14.8	2.4	31.7	38.5	26.1	72.6
INW 1021	55.9	13.5	2.5	34.9	5.5	37.4	74.7

Grain and Flour Evaluation

The SWQL determined the test weight and SKCS of wheat grain. Flour quality analyses conducted by the SWQL included protein, pH, falling number, α -amylase activity, ash, SRC, RVA, mixograph and wire-cut and sugar-snap cookie baking. The flour quality parameters are summarized in tables 8, 9 and 10 below.

Table 8. USDA-ARS SWQL primary flour analysis for 2012 WQC varieties

2012 WQC Variety	Primary Flour Analysis							Solvent Retention Capacity (%)				
	Moisture %	Protein %	pH	Falling No.	α -Amylase	Starch Damage	Ash	Water	NaCarb	Sucrose	Lactic Acid	LA Ratio
2013412	13.3	9	6.2	332	0.06	4.3	0.519	61.2	87.5	110.3	112.8	0.57
Yorktown	13.6	9	6.2	323	0.059	3.6	0.529	61.7	87.5	113.1	106.9	0.53
Merl (ck)	13.4	8	6.2	347	0.05	5.6	0.534	61.3	85.4	103.2	87.9	0.47
Pioneer 25R34	13.1	7.3	6.3	310	0.047	4.4	0.515	57.5	77.4	97.1	93.7	0.54
Pioneer 25R40	13.8	7.4	6.3	315	0.039	4.9	0.532	61.9	83.3	100.2	92	0.5
Pioneer 25R47 (ck)	12.9	7.2	6.3	298	0.044	6.3	0.491	58.9	78.4	96.8	92.8	0.53
Bromfield	13.4	7.6	6.3	324	0.049	5.3	0.573	62.4	86.4	105	93.9	0.49
Malabar (ck)	13.5	7.1	6.3	359	0.054	4.5	0.581	62.1	84.5	98.9	83.6	0.46
SY Harrison	13.7	7.8	6.2	302	0.065	3.4	0.481	57.4	78.3	95.7	87.7	0.5
Oakes (ck)	13.3	9	6.3	344	0.056	4.5	0.497	59	81.5	106.4	94.5	0.5
P04606	13.4	9.2	6.3	349	0.035	3.4	0.572	60.8	83.5	113.2	75.3	0.38
P05247	13.1	10.2	6.2	333	0.033	4.6	0.491	58.8	82.6	107.5	83.3	0.44
P05222	13.5	10.9	6	341	0.056	4.8	0.701	60.8	84.1	107.1	69.1	0.36
INW 1021	13.1	7.5	6.3	346	0.037	2.3	0.562	60.9	82.1	106.2	90.6	0.48

Table 9. USDA-ARS SWQL Rapid Visco-Anlyzer and Mixograph for WQC 2012 varieties

2012 WQC Variety	Rapid Visco-Analyzer							Mixograph					
	Peak cP	Trough cP	Break down Cp	Final Cp	Set- back cP	Peak time (min)	Pasting Temp (°C)	Peak/ Final Ratio	Waster Absorp %	Peak Time (min)	Peak Value %	Peak Width %	Peak Width 7 min
2013412	2452	1309	1143	2472	1163	6.03	87.6	0.99	63	3.68	33.39	12.56	7.86
Yorktown	2551	1396	1156	2616	1221	6.1	87.6	0.98	64	4.54	32.88	10.21	8.26
Merl (ck)	1863	1198	666	2404	1207	6	88.1	0.77	61	4.24	33.42	10.89	6.18
Pioneer 25R34	2323	1374	950	2582	1208	5.97	85.1	0.9	58	5.8	28.07	7.44	7.9
Pioneer 25R40	2224	1327	897	2461	1134	6	85.9	0.9	63	4.41	23.95	9.03	6.8
Pioneer 25R47 (ck)	2318	1367	951	2577	1210	5.93	84.8	0.9	60	5.85	28.5	9.14	7.93
Bromfield	1911	1083	828	2212	1129	5.87	85.1	0.86	63	4.54	30.05	7.72	5.47
Malabar (ck)	2592	1436	1156	2793	1358	6.07	85.2	0.93	63	3.86	21.01	8.48	5.76
SY Harrison	2189	996	1193	2033	1037	5.8	84.9	1.08	59	5.53	28.03	9.52	8.05
Oakes (ck)	2425	1353	1072	2492	1139	6.03	86.4	0.97	60	3.23	34.11	10.77	6.56
P04606	2534	1602	933	2798	1197	6.27	86.8	0.91	62	2.43	34.23	9.93	2.75
P05247	2547	1603	944	2913	1310	6.23	87.2	0.87	61	2.06	40.28	11.26	2.92
P05222	2185	1388	797	2646	1259	6.2	88.9	0.83	61	1.54	39.49	13.12	2.77
INW 1021	2669	1515	1155	2816	1302	6.13	85.9	0.95	63	6.5	25.11	6.55	6.66

Table 10. USDA-ARS SWQL wire-cut AACC 10-54 and sugar-snap AACC 10-52 cookie evaluations for 2012 WQC varieties

WQC 2012 Variety	Cookie Evaluation					
	Wire-cut AACC 10-54				Sugar-snap AACC 10-52	
	Diameter (cm x 2)	Stack Ht (cm x 2)	Force (g)	Spread (mm)	Diameter (cm x 2)	Top Grain Score
2013412	14.74	2.53	1266	1.9	16.76	4
Yorktown	14.56	2.62	1208	2.3	16.43	3
Merl (ck)	14.36	2.55	1255	1.48	16.89	5
Pioneer 25R34	15.22	2.34	1359	1.63	17.62	6
Pioneer 25R40	14.66	2.44	1392	1.98	16.93	5
Pioneer 25R47 (ck)	15.42	2.28	1251	1.91	17.99	7
Bromfield	14.33	2.61	1061	3.34	16.75	3
Malabar (ck)	14.78	2.54	1004	2.31	17.22	5
SY Harrison	15.4	2.26	1074	2.5	17.86	5
Oakes (ck)	14.54	2.42	1216	2.48	16.61	2
P04606	14.38	2.62	1483	2.2	16.33	1
P05247	14.54	2.41	1428	2.03	16.49	1
P05222	14.35	2.62	1371	2.4	16.32	1
INW 1021	14.64	2.54	1058	2.56	16.85	4

SOFT WHEAT QUALITY LABORATORY COLLABORATIVE PROJECTS

QUALITY CHARACTERISTICS OF REGIONAL NURSERY ENTRIES

2012 CROP YEAR EVALUATIONS

Each year, wheat breeders submit elite breeding materials to cooperative yield trials known as regional nurseries, which are then grown by other programs throughout the target production region. Grain samples from some of these nurseries are evaluated each year by the SWQL, and this information is provided to breeders in the regional nursery reports, as well as being posted on the SWQL website.

Narratives describing recent quality evaluation and summary tables for check varieties are provided below. Complete nursery data are attached as Excel spreadsheets. Tony Karcher prepared and submitted the summaries. Evaluations were performed by the SWQL staff, Amy Bugaj, Susan Carson, Sharon Croskey, Tom Donelson and Tony Karcher.

The goal of this project is to provide consistent and complete information on milling and baking performance of new wheat lines and cultivars. Through a generous grant funded by the State of Ohio, the Soft wheat Quality Laboratory has access to a diode array NIR instrument that measures whole grain spectra. As a result, since 2011, we provide whole grain protein and grain hardness with the quality information.

We use multiple checks for adjusting the quality scores in the group. Prior to 2010, a single check was used for the scoring, leading to problems in some of evaluations due to 1) genotype X environment interactions, and 2) interactions between cultivars for cookie diameters. Using the average of multiple checks provides reliable adjustment values. The database of check cultivar performance uses advanced milling and cookie data for the revised AACC sugar-snap cookie method. The scoring system is still indirectly based on Allis mill ratings of cultivars.

The scores given in the following tables under the heading “Historical Advanced Milling” were derived from the average milling and baking scores for five or more millings from trials with sound grain.

Lactic acid Solvent Retention Capacity (SRC) values used to reflect gluten strength, are reported on an “as is” basis. Before 2010, these values were corrected to 9% flour protein, using the formula of 7% SRC increase for every 1% increase in flour protein. After looking at many trials across many regions, we felt that this adjustment was creating more problems than it was solving. In recent years, we have had many low protein trials that resulted in very large adjustments of lactic acid leading to unrealistic expectations of cultivar genetic potential. We found that some genotypes were much more responsive to the model due to the presence of the 5+10 allele at the *GluD1* locus combined with the absence of the rye translocation on the short arm of the chromosome 1B.

New baking sheets

After many years of use and much buildup, SWQL bake sheets were replaced. The new sheets produce a cookie with an average of 0.6 cm smaller than those baked on the old sheets. The cookie diameter was 96.8% (3.2% smaller) than that for a cookie baked on the old sheets. These values are based on cookies made with 22 flour samples at the beginning of the evaluation process and resulted in a standard deviation of 1.36% and standard error of 0.29%. Evaluations for 2012 will report cookie diameters using the new sheets, so adjustment of the baking quality score may be required when comparing to values from previous years.

GENERAL COMMENTS ON EVALUATION PARAMETERS

Flour yield

Of the characteristics of quality we measure at the Soft Wheat Quality Laboratory, flour yield is the most reproducible and perhaps most important because it is genetically and environmentally associated with good soft wheat flour quality.

Softness equivalence

After flour yield, the second trait that we recommend for use in selection is softness equivalence (SE). SE tends to have high heritability and is an important predictor of break flour yield. Larger values are preferred for most soft wheat manufactured goods, particularly cakes and other high sugar baked products.

Solvent Retention Capacity (SRC)

Generally, sucrose SRC is related to the levels of pentosan components. Lactic acid SRC is associated with gluten protein characteristics and sodium carbonate SRC coincides with damaged starch. Water SRC is influenced by all water absorbing components in flour. The combined pattern of these flour SRC results establishes a practical flour quality and functionality profile that is useful in predicting baking performance.

Sucrose SRC typically increases in wheat samples with lower flour yield and lower softness equivalence. The cross hydration of gliadins by sucrose also causes sucrose SRC values to be correlated to flour protein and lactic acid SRC. Soft wheat flours for cookies typically also have a target of 95% or less for sucrose SRC.

Gluten strength is measured by the lactic acid SRC. Lactic acid SRC also correlates to flour protein concentration, but the effect is dependent on genotype and growing conditions.

High sodium carbonate SRC absorption values indicate a tendency for increase in damaged starch. Normal values for good milling soft varieties are 68% or less.

Lower water SRC values are desired for cookies, cakes, and crackers with target values below 51% for flour from small experimental mills, such as the Quadrumat Junior mill.

Reporting Evaluation Results

Soft wheat products such as cookies and crackers require flours with low water absorption. To select the best lines for milling and baking quality, we sequentially sort for flour yield and select all lines with flour yield greater than the nursery average. We then repeat the operation for softness equivalence and solvent retention capacities for sucrose, sodium carbonate, and water selecting the lines that are better than average in each case. Next, we discarded the weakest gluten lines to present a more accurate evaluation of the cookies. The results are reported with high and low entries differentially highlighted. Entries with values greater than standard deviation from the check variety mean are indicated as 1) questionable or undesirable, 2) exceptional, 3) weak gluten or 4) strong gluten varieties.

SOFT WHEAT QUALITY PLOTS, WOOSTER, OHIO

SWQL Staff, USDA-ARS

2012 CROP ADVANCED MILLING AND BAKING EVALUATION



The 2012 SWQL field at Wooster, Ohio, consisted of 119 varieties, including 11 check varieties. Varieties are grown in the SWQL plots for a minimum of three consecutive years. The set was evaluated as an advanced set according to the SWQL milling and baking quality protocols. Varieties were compared to the average for the cultivar checks for this nursery and quality scores for all entries were adjusted to the check averages. A table of historical and observed quality scores for the 11 check samples is given below. Complete results for the set are attached as Excel spread sheets.

Table 11 includes ranking within each parameter, average values for the set and correlations between historical and observed values. Rankings are based on the complete evaluation of the 119 samples of the 2012 SWQL plots and on historical values for the checks.

Table 11. Soft Wheat Quality Lab, Wooster, Ohio, 2012 check varieties and adjustments

2012 SWQL	Historical Advanced Milling						Predicted Milling 2012 Evaluations					
	Milling Quality		Baking Quality		Softness Equivalence		Milling Quality		Banking Quality		Softness Equivalence	
Ambassador	73.72	B	81.94	A	71.84	B	81.98	A	76.98	B	72.81	B
Beck 113	53.22	D	55.89	D	79.15	B	51.38	D	41.46	E	63.02	C
Branson	68.26	C	72.03	B	81.31	A	65.94	C	54.58	D	74.63	B
Caledonia	70.95	B	88.58	A	79.24	B	77.16	B	66.36	C	69.55	C
Jamestown	61.05	C	50.13	D	67.28	C	63.46	C	41.53	E	61.31	C
Jensen	65.3	C	70.2	B	76.24	B	66	C	52.7	D	54.04	D
Jordan	59.84	D	53.95	D	58.01	D	58.91	D	34.57	F	36.01	F
Kenton	62.29	C	55.29	D	60.43	C	68.54	C	55.14	D	54.69	D
Malabar	63.08	C	72.49	B	70.15	B	67.75	C	57.83	D	59.31	D
Merl	68.63	C	68.59	C	73.31	B	65.67	C	55.75	D	57.12	D
Shirley	67.58	C	67.51	C	66.95	C	65.9	C	52.63	D	59.73	D
Average	64.9		66.96		71.27		66.61		53.59		60.2	
Adjustments	-1.71		13.37		11.06							
Correlations	0.9		0.9		0.7							

Adjustments

The adjusted average values of the checks predict increased milling scores, but decreased baking and softness equivalence scores when compared to the historical averages. The observed scores for the checks correlated to the historical scores for milling, baking and softness equivalence at a level of $r > 0.9$, $r > 0.9$ and $r > 0.7$, respectively. The rankings and correlations for the quality measures among the checks were consistent with expectations from previous evaluations. We expect the

outcome of the evaluations to be predictive of future performance of these breeding lines.

Grain Quality

In general, grain condition for this nursery had minimal weathering and black point before cleaning. No evidence of FHB or sprouting was observed. Flour analysis of the nursery shows that the quality trait averages of flour yield, softness equivalence and flour protein, were within the expected target range for soft wheat characteristics. The solvent retention capacities of lactic acid, water and sodium carbonate exceeded the expected target range for soft wheat characteristics. Sucrose SRC was below average for this quality trait.

Milling

This nursery produced an average flour yield of 70.4%, which is on target for flour yield, typically 70% and greater. Ambassador had the highest milling yield at 73.2%, and was the only entry that ranked in the “A” group for milling quality. Other entries with good flour yield included IL 00-8530, Hunker, and GA031238-7E34. INW1131 had the lowest yield at 65.5%.

The average softness equivalence for this sample set was 56.6%, with Geary recording the largest SE value at 64.5%. Eight entries had SE below 50%. These would likely be poor for a wide range of soft wheat products, particularly cakes. Also in this set, Glosa, a variety grown for breeding quality, had softness equivalence below 40%.

SRC

Entry B05*0154 may have had the lowest sucrose SRC absorption (81.2%) and the highest baking score (96.4). Terral TV 8861 produced the largest cookie at 19.3 cm.

Entries MH07-7474, Glosa, IL 07-20743, and G19209 had high lactic acid SRC values and lower than average flour yield and softness equivalence. These could have value as breeding parents for the strong gluten trait. Pioneer 25R56 had the weakest gluten value at 88.1%.

There were 19 samples with sodium carbonate SRC values below 68%. The lowest value was for to Pioneer 25R34 at 65.6%, while Pioneer 25R32 had the highest value at 94.3%.

The average water SRC of the entries was high at 55%, as only Hunker, IL 00-8633, IL 00-8061, and IL 00-8109 had values below 51%. With a value of 67.2%, Pioneer 25R32 had the highest water SRC.

Overall Summary

The entries in this set with the most balanced milling and baking qualities include IL 00-8061, G19227, D8006W and Hunker. Ambassador was the only line to score an “A” for all three quality scores.

REGIONAL AND STATE PERFORMANCE NURSERIES - 2012 CROP

REGIONAL COLLABORATING NURSERIES AND BREEDERS

BROWNSTOWN, ILLINOIS WHEAT VARIETY TRIAL	<i>Fred Kolb, University of Illinois</i>
URBANA, ILLINOIS WHEAT VARIETY TRIAL	<i>Fred Kolb, University of Illinois</i>
NORTHERN UNIFORM WINTER WHEAT SCAB NURSERY	<i>Carl Griffey, Virginia Polytechnic Institute</i>
SOUTHERN UNIFORM WINTER WHEAT SCAB NURSERY	<i>Carl Griffey, Virginia Polytechnic Institute</i>
GULF ATLANTIC WHEAT NURSERY	<i>Stephen Harrison, Louisiana State University</i>
MASON-DIXON REGIONAL NURSERY	<i>Jose Costa, University of Maryland</i>
UNIFORM EASTERN SOFT RED WINTER WHEAT NURSERY	<i>Carl Griffey, Virginia Polytechnic Institute Clay Sneller, Ohio State University Fred Kolb, University of Illinois</i>
UNIFORM SOUTHERN SOFT RED WINTER WHEAT NURSERY	<i>Stephen Harrison, Louisiana State University</i>

BROWNSTOWN, ILLINOIS WHEAT VARIETY TRIAL

Fred Kolb, University of Illinois



A total of 86 samples were grown in Brownstown and submitted by Fred Kolb of the University of Illinois for milling and baking quality evaluations as a micro set. The standard quality data were compared to the average of the cultivar checks for this nursery and quality scores for all entries are adjusted to the check averages. A table of observed and historical quality scores is given below. Complete results for the set are attached as Excel spread sheets.

Table 12. Brownstown, Illinois wheat variety trial 2012 check varieties and adjustments

2012 - Brownstown	Advanced Milling Database Scoring and Rank						Predicted Scores from 2012 Evaluation and Rank					
	Milling Quality		Baking Quality		Softness Equivalence		Milling Quality		Baking Quality		Softness Equivalence	
Pioneer 25R62	66.38	C	78.37	B	71.98	B	55.33	D	38.14	F	32.43	F
Oakes	65.29	C	69.47	C	65.46	C	49.31	E	29.33	F	32.3	F
W1104	59.6	D	68.72	C	55.61	D	44.97	E	38.02	F	39.62	F
Jamestown	54.9	D	38.79	F	59.12	D	45.93	E	32.2	F	52.08	D
Average	61.54		63.84		63.04		48.88		34.43		39.11	
Adjustment Bias	12.66		29.41		23.94							
Diagnostic Correlations	0.8		0.4		-0.6							

Adjustments

The adjusted average values of the checks predict decreased milling, baking and softness equivalence scores when compared to the historical average. The observed scores for the checks correlated to the historical scores for milling, baking and softness equivalence at a level of $r > 0.8$, $r > 0.4$ and $r > -0.6$ respectively. Relative rankings and correlations indicate that the results of the milling quality scores are likely predictive of future results. Correlation for the baking quality score is lower than usual and may not be as predictive of future breeding performance as in previous trials, probably due to the overall compression of scale for the softness equivalence and solvent retention capacity values. Softness equivalence score is uncharacteristically low and may not be as predictive of future breeding performance as in previous trials.

The averages of the soft wheat quality traits demonstrate an increase in lactic acid but a decrease in flour yield and softness equivalence. The attributes of flour protein and sucrose SRC fall within the expected range for soft wheat.

Milling

The goal for sample flour yield is 70% or greater. In this nursery, no samples reached this goal. This is more than likely due to environmental effects such as weathering that often reduces the flour yield. The closest to 70% was IL06-23571 at 69.2%.

Average softness equivalence for this nursery was 50.2%, with the cultivar IL06-23571 exhibiting the best SE at 57.9%. Lines FS 625, Pro Harvest 311, and S-1100 also had higher SE.

SRC

Soft wheat flours for cookies typically have a target of 95% or less for sucrose SRC. This trial displayed an average of 95.3% with Dyna-Gro WX12603 producing the lowest sucrose SRC value as well as the largest estimated cookie diameter for the nursery.

As with flour yield, weathering also affects lactic acid. Weather damaged wheat exhibits elevated lactic acid SRC values. The average for this trial was 112.2% with a range of 105.5% to 140.5%. Strong characteristics for gluten are indicated by lactic acid SRC greater than 105%. Samples LCS-165 and H7W12 have poor soft wheat traits and high lactic acid SRC value. They could have value as a breeding parent for the strong gluten characteristic.

URBANA ILLINOIS WHEAT VARIETY TRIAL



Fred Kolb, University of Illinois

A total of 82 samples were grown and submitted as a micro sample set by Fred Kolb of the University of Illinois for milling and baking quality evaluations. The standard quality data were compared to the average for the cultivar checks for this nursery and quality scores for all entries are adjusted to the check averages. A table of observed and historical quality scores is given below. Complete results for the set are attached as Excel spread sheets.

Table 13. Urbana Illinois wheat variety trial 2012 check varieties and adjustments

2012 Urbana Check Variety	Advanced Milling Database Scoring and Rank						Predicted Scores from 2012 Evaluation and Rank					
	Milling Quality		Baking Quality		Softness Equivalence		Milling Quality		Baking Quality		Softness Equivalence	
Pioneer 25R47	66.79	C	83.06	A	82.57	A	60.63	C	84.21	A	76.2	B
Pioneer 25R62	66.38	C	78.37	B	71.98	B	57.2	D	67.07	C	55.75	D
Pioneer 25R62	66.38	C	78.37	B	71.98	B	56.5	D	74.76	B	63.67	C
Oakes	65.29	C	69.47	C	65.46	C	50.38	D	37.7	F	40.37	E
W1104	59.6	D	68.72	C	55.61	D	40.58	E	54.69	D	44.14	E
Average	64.89		75.6		69.52		53.06		63.69		56.02	
Adjustments	11.83		11.91		13.5							
Diagnostic Correlations	1		0.9		0.9							

Adjustments

The adjusted average values of the checks are predicted to have decreased milling, baking and softness equivalence scores when compared to the historical average. The observed scores for the checks correlated to the historical scores for milling, baking and softness equivalence with significance of $r=1.0$, $r>0.9$ and $r>0.9$, respectively. The relative rankings and correlations indicate that the results of the quality scores are likely predictive of future results.

Milling

Flour analysis shows low flour yield and flour protein for soft wheat. Softness equivalence, lactic acid SRC, and sucrose SRC fall within the expected range for soft wheat.

The nursery's flour yield average was low at 67.1%, below the target of 70% and greater. No samples reached this target, perhaps due to environment such as weathering which can reduce flour yield. Pioneer 25R47 had the greatest yield among the checks at 68.9%. Kidwell, AgriMAXX 413, and Diener 492W flour yield exceeding Pioneer 25R47.

Flour analysis identified 36 cultivars with softness equivalence higher than the cumulative check average (54.7%). Among the high SE varieties were S-1100, Pro Harvest 311, Diener 506, and IL06-23571.

SRC

Soft wheat flours for cookies typically have a target of 95% or less for sucrose SRC. The average sucrose SRC for the nursery was 91.3%. Entry EXCEL 362 had the lowest sucrose SRC value at 84.1%, and entry S-1100 had the highest baking quality score (96.7) and largest estimated cookie diameter (19.7 cm). Good baking quality is predicted by a combination of low sucrose SRC, low flour protein and high SE.

Lactic acid SRC is a good measure of gluten strength. It also correlates to flour protein concentration, but the effect is dependent on genotypes and growing conditions. The average for this trial was 96.3% and PRO 200 was highest among all the samples at 116.7%.

NORTHERN UNIFORM WINTER WHEAT SCAB NURSERY

Carl Griffey, Virginia Polytechnic Institute



A total of 60 samples were grown and submitted for milling and baking quality evaluations as a micro sample set. The standard quality data were compared to the averages for the cultivar checks for this nursery and quality scores for all entries are adjusted to the check averages. A table of observed and historical quality scores is given below. Complete results for the set are attached as Excel spread sheets.

Table 14. Northern Uniform Winter Wheat Nursery 2012 check varieties and adjustments

2012 NUWWSN	Advanced Milling Database Scoring and Rank						Predicted Scores from 2012 Evaluation and Rank					
	Milling Quality		Baking Quality		Softness Equivalence		Milling Quality		Baking Quality		Softness Equivalence	
Ernie	53.03	D	58.62	D	57.83	D	27.51	F	20.64	F	57.17	D
Freedom	54.43	D	72.21	B	63.53	C	39.91	F	30.08	F	52.31	D
Truman	57.1	D	68.09	C	67.52	C	43.42	E	43.93	E	60.18	C
Pioneer 2545	49.86	E	66.52	C	66.33	C	38.73	F	31.14	F	57.99	D
Average	53.61		66.36		63.8		37.39		31.45		56.91	
Adjustments	16.21		34.91		6.89							
Diagnostic Correlations	0.4		0.6		0.3							

The adjusted averages predict lower milling, baking and softness equivalence scores when compared to the historical averages. The observed scores for the checks correlated to the historical scores for milling, baking and softness equivalence at a level of $r > 0.4$, $r > 0.6$ and $r > 0.3$, respectively. The correlation for the baking quality score is lower than usual and baking quality scores may not be as predictive of future breeding performance as in previous trials, probably due to the overall compression of scale for the softness equivalence and solvent retention capacity values. Milling and softness equivalence quality scores are also uncharacteristically low and may not be as predictive of future breeding performance as in previous trials.

Milling

Across this trial, averages for flour protein, lactic acid SRC and sucrose SRC all were higher, while flour yield was lower than expected. Softness equivalence was within the limits for soft wheat characteristics.

The cumulative flour yield average for the checks was 64.3%. There were 45 test lines that had greater flour yield than average with VA10W-21 highest at 70.1%. Other varieties with high flour yield were NE10514, NE10449, and NW03666.

This nursery produced an average softness equivalence of 54.4% with 6 entries scoring an “A”. The top entries for SE were DH1-46, LCS19103, IL06-23571, DH2-45, DH1-62 and LCS19104. Eight entries had poor softness equivalence (below 50%) despite high flour yield, including NW10401, NE10449, NE10514 and VA10W-21.

SRC

Soft wheat flours for cookies typically have a target of 95% or lower for sucrose SRC. The majority of this group (88% of the samples) was above the target range as only 7 samples fell below 95% sucrose SRC. The lowest sucrose SRC score was for DH2-4 at 90.7%, while LCS19103 had the highest baking score at 100.7. Good baking score results from the combination of low sucrose SRC and low flour protein that together predict a larger cookie diameter as evident with this sample.

Typically, as sucrose SRC values increase, so do lactic acid SRC values, implying strong gluten. The sucrose SRC preferentially hydrates arabinoxylans but also swells the gliadins of the flour. Elevated sucrose values with high lactic acid SRC occurring in entries is likely due to gliadins and would be acceptable for most soft wheat products that require strong gluten. A few examples with strong gluten are KWS003, IL06-23571 and M0081320.

Lactic acid SRC also correlates with flour protein concentration depending on genotypes and growing conditions. Weathering often falsely elevates lactic acid SRC values. The average for this trial was 125.8% which indicates “strong” gluten. Lactic acid above 105% is considered indicative of strong gluten flour. There were 7 samples below 105% including the check Pioneer 2545. Pioneer 2545 historically produces low lactic acid SRC values and entries with LA SRC values lower than Pioneer 2545 should be considered for discarding. Some of the genotypes in this trial are strong gluten genotypes that may have extra value in the marketplace for the manufacture of crackers or other products requiring gluten strength.

Soft wheat products such as cookies and crackers require flours with low water absorption. To select the best lines for milling and baking quality, we sequentially sorted for flour yield and selected all lines with greater flour yield than the nursery average. We then repeated the operation for softness equivalence and the solvent retention capacities of sucrose and lactic acid, selecting the lines that were better than average in each case. After the sort, MD08-22-32 and VA09W-73 fit these criteria for best lines.

SOUTHERN UNIFORM WINTER WHEAT SCAB NURSERY



Carl Griffey, Virginia Polytechnic Institute

A total of 51 samples were grown and submitted for milling and baking quality evaluations as a micro sample set. The standard quality data were compared to the average for the cultivar checks for this nursery and quality scores for all entries are adjusted to the check averages. A table of observed and historical quality scores is given below. Complete results for the set are attached as Excel spread sheets.

Table 15. Northern Uniform Winter Wheat Scab Nursery 2012 check varieties and adjustments

2012 Check Variety	Advanced Milling Database Scoring and Rank						Predicted Scores from 2012 Evaluation and Rank					
	Milling Quality		Baking Quality		Softness Equivalence		Milling Quality		Baking Quality		Softness Equivalence	
Ernie	53.03	D	58.62	D	57.83	D	37.2	F	12.92	F	57.6	D
Coker 9835	57.84	D	57.76	D	78.42	B	34.9	F	14.74	F	74.89	B
Bess	56.5	D	60.61	C	66.03	C	46.63	E	34.41	F	51.81	D
Jamestown	54.9	D	38.79	F	59.12	D	38.02	F	16.89	F	59.76	D
Average	55.57		53.94		65.35		39.19		19.74		61.01	
Adjustment s	16.38		34.21		4.34							
Diagnostics Correlations	0.1		0.3		0.7							

Adjustments

The adjusted average values of the checks predict decreased milling, baking and softness equivalence scores when compared to the historical averages. The observed scores for the checks correlated to the historical scores for milling, baking and softness equivalence at a level of $r > 0.1$, $r > 0.3$ and $r > 0.7$, respectively. Relative rankings and correlations indicate that the results of the softness equivalence quality score is likely predictive of future results. The correlation for the baking quality score is lower than usual and may not serve as predictive of future breeding performance as in previous trials. Milling quality score is also uncharacteristically low and may not be as predictive of future breeding performance as in previous trials.

Milling

Possibly due to weather damaged grain, the quality trait averages of flour protein, lactic acid SRC and sucrose SRC all had above average values and flour yield and softness equivalence were below average values.

The nursery's flour yield average was 66.3%, below the target for flour yield of 70% and greater. Two test lines generated flour yield greater than 70%. These lines were ARS09-513 and ARS09-446. Line GA 051173-S25 had the lowest yield of this group with a value of 61.2%.

Average softness equivalence for this nursery was 52.5%, with the check, Coker 9835, recording highest SW at 61.4%. Entry NC06-16-26-988 had similar softness equivalence to Coker 9835. A total of 10 entries scored softness equivalence below 50%. They would likely be poor for a wide

range of soft wheat products and are particularly poor for cakes. Also in this set, three entries have softness equivalence below 40% and are likely to contain true hard wheat traits. They are ARS09-643, ARS09-173 and ARS09-446.

SRC

Soft wheat flours for cookies typically have a target of 95% or less for sucrose SRC. This nursery's average was well above the target range with a value of 105.8% with no experimental lines below 95%. The line VA09W-73 had the lowest sucrose SRC at 95.9%, the largest estimated cookie diameter of 18.3 cm and the top baking score of 80.5.

The average lactic acid SRC for this trial was 139.8% with a range of 115.9% to 168.5% which would be considered as characteristic of strong gluten (above 105%). Because of the differences with historical check values, environmental effects may have resulted in unusually high lactic acid SRC values, as mentioned above. Some of the entries in this trial are strong gluten genotypes that may have extra value in the marketplace for the manufacture of crackers or other products requiring gluten strength. However, the samples should be assessed in another environment to confirm the gluten strength.

Overall

To select the best lines for milling and baking quality, we sequentially sorted for flour yield and selected all lines with greater flour yield than the nursery average. We then repeated the operation for softness equivalence and the solvent retention capacities of sucrose and lactic acid, selecting the lines that were better than average in each case. After the sort, NC8355-4 (Fhb1), GA 051207-S21 and VA10W-140 fit these criteria for best lines.

GULF ATLANTIC WHEAT NURSERY
 Stephen Harrison, Louisiana State University



A total of 76 samples were grown in a composite of nursery locations and submitted to the laboratory for milling and baking quality evaluations. The standard quality data were compared to the average for the cultivar checks for this nursery and quality scores for all entries are adjusted to the check averages. A table of observed and historical quality scores is given below. Complete results for the set are attached as Excel spread sheets.

Table 16. Gulf Atlantic Wheat Nursery 2012 check varieties and adjustments

2012 Check Variety	Advanced Milling Database Scoring and Rank						Predicted Scores from 2012 Evaluation and Rank					
	Milling Quality		Baking Quality		Softness Equivalence		Milling Quality		Baking Quality		Softness Equivalence	
USG 3555	58.3	D	34.04	F	59.28	D	52.47	D	28.21	F	51.96	D
Shirley	67.58	C	67.51	C	66.95	C	60.03	C	65.42	C	52.9	D
AGS 2060	66.11	C	39.49	F	52.16	D	63.41	C	38.34	F	35.95	F
SS 8641	58.25	D	53.27	D	65.37	C	56.49	D	42.1	E	46.34	E
Average	62.56		48.57		60.94		58.1		43.52		46.79	
Adjustments	4.46		5.06		14.15							
Diagnostic Correlations	0.8		1		0.8							

Adjustments

The adjusted averages of the checks predict lower milling, baking and softness equivalence scores when compared to the historical averages. The observed scores for the checks correlated to the historical scores for milling, baking and softness equivalence at a level of $r > 0.8$, $r = 1.0$ and $r > 0.8$, respectively. The rankings and correlations for the quality measures among the checks were consistent with expectations from previous evaluations. Therefore, we expect the outcome of the evaluations to be predictive of future performance of these breeding lines.

Grain

In general, grain condition for this nursery identified evidence of Fusarium, weathering, and black point before cleaning. Sprouting was found in LA06007E-P04, leading to the probability of high alpha-amylase activity as well as increased starch damage. Flour analysis of this nursery produced quality trait averages of flour yield, softness equivalence and flour protein that were within the expected target range for soft wheat characteristics. The solvent retention capacities of sucrose, water and sodium carbonate were also within the limits. Only lactic acid exceeded the expected target range for soft wheat characteristics.

Milling

This nursery produced an average flour yield of 69.1%. Entry SCLA1030J1 had 73.5% flour yield, the highest within the nursery. The next highest flour yield entries were SCLA1084C1 and SCLA1084A1. Only these 3 entries scored a ranking of “A” for milling quality. Entry NC09-21256 had the lowest flour yield at 65%.

The average softness equivalence for the 76 entries was 53.1%. Of the check varieties, Shirley had the highest softness equivalence at 53.6%. There were 35 entries with softness equivalence greater than Shirley. Lines with high SE include SCLA1084A1, SCLA1084C1 and LA04041D-85. The check, AGS 2060, had very low softness equivalence below 40%, similar to hard wheat. It is normally above 50%, but SE score is subject to environment. SE values for this nursery reflect an environmental effect. There were two entries, NC09-22402 and AR00380-3-3, which had SE values lower than AGS 2060.

SRC

Soft wheat flours for cookies typically have a target of 95% or less for sucrose SRC and the majority of samples (55) fit this criterion. A combination of low sucrose SRC and flour protein typically produces a larger cookie diameter and higher baking scores, which is evident in SCLA1084C1 as this sample ranks first in both diameter (19.3 cm) and baking score (79.4).

Gluten strength is measured by the lactic acid SRC which correlates to flour protein concentration depending on genotype and growing conditions. This nursery's average of 109.6% displays "strong" gluten strength (lactic acid above 105%) and these test lines may be of value for the manufacturing of crackers or other products requiring gluten strength. Line NC09-21251 has the highest lactic acid SRC value at 127.3%, but lower than average quality for flour yield and softness equivalence. It could have value as a breeding parent for the strong gluten characteristic.

High sodium carbonate SRC values indicate an increase in damaged starch. Normal sodium carbonate SRC values for good milling soft varieties are 68% or less. Over half of the nursery samples were below 68%. The lowest value belonged to AR00380-3-3 at 63.6%, while AR01168-3-1 had the highest value at 75.2%. High flour yield and low sodium carbonate SRC often indicate low damaged starch. This combination of traits is observed in samples SCLA1030J1 and AR01205-1-1.

Lower water SRC values are desired for cookies, cakes and crackers with target values below 51% on small experimental mills, such as our Quadrumat Junior flour mill. The average water SRC of the entries was high at 55.5% and no entry fell below 51%. The range of water SRC values varied from 52% to 61.5%.

Overall

To select the best lines for milling and baking quality, we sequentially sorted for flour yield and selected all lines with greater flour yield than the nursery average. We then repeated the operation for softness equivalence and the solvent retention capacities of sucrose and sodium carbonate, selecting the lines that were better than average in each case. After the sort, 19 samples fit these criteria. Entries with the most balanced milling and baking qualities include AR01044-1-1, SCLA1084C1, VA09W-110, AR00343-5-1 and SCLA1084B1.

MASON-DIXON REGIONAL NURSERY



Jose Costa, University of Maryland

A total of 80 samples were grown in a composite of nursery locations and submitted to the laboratory for milling and baking quality evaluations. The standard quality data were compared to the average for the cultivar checks for this nursery and quality scores for all entries are adjusted to the check averages. A table of observed and historical quality scores is given below. Complete results for the set are attached as Excel spread sheets.

Table 17. Mason-Dixon Regional Nursery 2012 check varieties and adjustments

2012	Advanced Milling Database Scoring and Rank						Predicted Scores from 2012 Evaluation and Rank					
	Milling Quality		Baking Quality		Softness Equivalence		Milling Quality		Baking Quality		Softness Equivalence	
Mason-Dixon												
Check Variety												
Pioneer 26R15	66.02	C	54.19	D	70.71	B	66.43	C	35.4	F	59.28	D
Branson	68.26	C	72.03	B	81.31	A	61.4	C	53.05	D	67.31	C
Shirley	67.58	C	67.51	C	66.95	C	60.84	C	44.24	E	58.93	D
Average	67.29		64.57		72.99		62.89		44.23		61.84	
Adjustments	4.4		20.34		11.15							
Diagnostic Correlations	-0.9		1		1							

Adjustments

The adjusted average values of the check varieties when compared to the historical averages predict decreased milling, baking and softness equivalence scores for the set. The observed scores for the checks correlated to the historical scores for milling, baking, and softness equivalence at a level of $r > -0.9$, $r = 1.0$ and $r = 1.0$, respectively. The rankings and correlations for the baking and softness equivalence quality measures among the checks were consistent with expectations from previous evaluations. Therefore, we expect the outcome of the evaluations to be predictive of future performance of these breeding lines. However, the milling quality score is uncharacteristically low and not as highly correlated as expected with past performance.

Grain

In general, grain condition for this nursery revealed evidence of Fusarium head blight, weathering, black point, and a significant amount of sprouting before cleaning. Due to sprouting, high alpha-amylase activity may be present as well as increased starch damage. Flour analysis of this nursery shows that averages of milling yield, softness equivalence, and flour protein were within the expected target ranges for soft wheat characteristics. Lactic acid and sucrose SRCs both exceeded the expected target range for soft wheat characteristics.

Milling

This nursery produced an average flour yield of 68.4%. Entry VA09W-188WS scored the highest flour yield of 71.6%. Closely following VA09W-188WS were MD05W10208-11-6, ARS07-0542 and KY03C-2314-08. Entry KY04C-2151-41 had the lowest flour yield at 63.8%.

The average softness equivalence for the 80 entries was 54.3%. Of the check varieties, Branson had the highest softness equivalence at 58.7%. Seven entries had greater softness equivalence than Branson including KY03C-2314-08, KY04C-1128-4-13-3 and VA10W-123. Four entries had SE values characteristic for hard wheat at below 50%. These entries were ARS09-572, ARS09-162, KY04C-2151-41 and MD04W249-11-12.

SRC

Soft wheat flours for cookies typically have a target of 95% or less for sucrose SRC. This nursery's average was above the target with a value of 99.7% as nearly 75% of the nursery samples exceeded the target. Sample ARS09-768 had the highest sucrose SRC at 120.9% and sample ARS07-1227 had the lowest at 85.5% as well as the largest cookie diameter at 19 cm.

Lactic acid SRC is correlated to flour protein concentration depending on genotype and growing conditions, as weather damaged wheat may exhibit elevated lactic acid. This nursery's average of 114.4% lactic acid SRC is indicative of "strong" gluten (lactic acid above 110%). Lines ARS09-750, ARS09-572 and VA10W-112 have high lactic acid SRC values and lower than average quality for other soft wheat traits. They could have values as breeding parents for strong gluten characteristic.

Overall

The quality traits evaluated are correlated to each other and the best quality genotypes will have favorable combinations of flour yield, softness equivalence, cookie diameter and sucrose SRC values. Sequentially selecting the genotypes based on those criteria, and in that order, can identify the best overall genotypes in the set. The lines with the best overall quality in the set were KY03C-2314-08, KY03C-2309-25-17-5 and KY04C-1128-4-13-3. These entries are the best quality soft wheat lines in the nursery for general use in the widest range of soft wheat products. They have value both as potential cultivars but also as breeding parents for subsequent improvement of the soft winter wheat germplasm pool.

UNIFORM EASTERN SOFT RED WINTER WHEAT NURSERY 2012

Carl Griffey, Virginia Polytechnic Institute
 Clay Sneller, Ohio State University
 Fred Kolb, University of Illinois

A total of 35 samples were grown in a composite of nursery locations and submitted to the laboratory for milling and baking quality evaluations. The standard quality data were compared to the average for the cultivar checks for this nursery and quality scores for all entries are adjusted to the check averages. A table of observed and historical quality scores is given below. Complete results for the set are attached as Excel spread sheets.

Table 18. Uniform Eastern Soft Red Winter Wheat Nursery 2012 check varieties and adjustments

2012 Check Variety	Advanced Milling Database Scoring and Rank						Predicted Scores from 2012 Evaluation and Rank					
	Milling Quality		Baking Quality		Softness Equivalence		Milling Quality		Baking Quality		Softness Equivalence	
Branson	68.26	C	72.03	B	81.31	A	65.67	C	39.48	F	62.71	C
Bess	58.72	D	62.71	C	66.72	C	54.41	D	24.05	F	41.41	E
Shirley	67.58	C	67.51	C	66.95	C	65.37	C	44.49	E	47.25	E
MO 080104	57.55	D	42.58	E	66.95	C	50.63	D	19.23	F	52.81	D
Average	63.03		61.21		70.48		59.02		31.81		51.05	
Adjustments	4		29.39		19.44							
Diagnostics Correlations	1		0.8		0.9							

Adjustments

The adjusted average values of the check varieties predict decreased milling, baking and softness equivalence scores when compared to historical averages. The observed scores for the checks correlated to the historical scores for milling, baking and softness equivalence at a level of $r=1.0$, $r>0.8$ and $r>0.9$, respectively. The relative rankings and correlations indicate that the results of the quality scores are likely predictive of future results.

Grain

This nursery contained seed that displayed very little Fusarium head blight, weathering, and black point. However, sprouting was observed in KY03C-1237-32. A probability of high alpha-amylase activity as well as increased starch damage may be present within this sample. The quality-trait averages of the samples tested indicate that flour yield and flour protein are within the expected target ranges for soft wheat characteristics. The lactic acid and sucrose SRCs produced higher than normal results for these soft wheat traits and softness equivalence had a reduced nursery average value.

Milling

Target flour yield for the samples is 70% or greater milling yield when milled using the Quadrumat Junior flour mill. This nursery produced an average flour yield of 68.9%. Sample KWS003 had the highest flour yield at 72.1%, followed by KWS002 and IL06-14262, both at 71.1% yield.

An average softness equivalence of 52% was scored for this nursery, with the sample IL06-23571 exhibiting the highest softness equivalence at 57.9%. Good softness equivalence values were also seen in DAS1002 and OH08-180-48. The check, Bess, had softness equivalence similar to hard wheat. It is normally above 50%, but may reflect environmental conditions. A total of seven breeding lines had SE lower than Bess (49.6%) and have poor softness quality.

SRC

Soft wheat flours for cookies typically have a target of 95% or less for sucrose SRC. This trial had average sucrose SRC of 98.9%. IL06-14262 had the lowest sucrose SRC value. This sample also had the best baking quality score (94.6) within the evaluation.

Lactic acid SRC is a good measure of gluten strength. It correlates to flour protein concentration but the effect is dependent on genotypes and growing conditions. The average for this trial was 106.4% with test lines ranging in LA SRC values from strong (above 105%) to weak (below 85%) gluten. The trial has both genetic and internal environmental variability for gluten strength. There were 19 test lines that ranged from 107% to 128.6% considered strong gluten characteristics and may be of value for the manufacturing of crackers or other products requiring gluten strength. Five lines demonstrated weak gluten with values between 84% and 68%. Within these lines, KWS001 and DAS1001 had lower than 70% lactic acid SRC.

UNIFORM SOUTHERN SOFT RED WINTER WHEAT NURSERY 2012



Stephen Harrison, Louisiana State University

A total of 29 samples were grown in a composite of nursery locations and submitted to the laboratory for milling and baking quality evaluations. The standard quality data were compared to the average for the cultivar checks for this nursery and quality scores for all entries are adjusted to the check averages. A table of observed and historical quality scores is given below. Complete results for the set are attached as Excel spread sheets.

Table 19. Uniform Southern Soft Red Winter Wheat Nursery 2012 check varieties and adjustments

2012 Check Variety	Advanced Milling Database Scoring and Rank						Predicted Scores from 2012 Evaluation and Rank					
	Milling Quality		Baking Quality		Softness Equivalence		Milling Quality		Baking Quality		Softness Equivalence	
AGS 2000	74.18	B	59.66	D	74.63	B	72.87	B	51.48	D	62.13	C
Pioneer Brand 26R61	61.64	C	45.08	E	60.33	C	56.68	D	49.84	E	52.14	D
USG 3555	58.3	D	34.04	F	59.28	D	52.69	D	40.45	E	55.21	D
Jamestown	61.05	C	50.13	D	67.28	C	55.71	D	42.72	E	60.47	C
Average	63.79		47.23		65.38		59.49		46.12		57.49	
Adjustments	4.31		1.11		7.89							
Diagnostic Correlations	1		0.7		0.9							

Adjustments

The adjusted average values of the checks predict decreased milling, baking and softness equivalence scores when compared to the historical averages. Observed scores for the checks correlated to the historical scores for milling, baking and softness equivalence at a level of $r=1.0$, $r>0.7$ and $r>0.9$, respectively. The rankings and correlations for the quality measures among the checks were consistent with expectations from previous evaluations. We expect the outcome of the evaluations to be predictive of future performance of these breeding lines.

Grain

The grain condition for this sample set contained minimal Fusarium head blight, weathering, and black point. Sprouting was observed in LA04110D-7, indicating probability of high alpha-amylase activity as well as increased starch damage. Quality trait averages of flour yield, flour protein and sucrose SRC were within the expected target range for soft wheat characteristics. Softness equivalence and the solvent retention capacities of lactic acid, water and sodium carbonate were above normal for these cultivars.

Milling

This nursery produced an average flour yield of 69.8%, achieving the target of 70% and greater. The greatest flour yield was observed for test line G95407 at 72.5%, followed by TN1202 and GA04570-10E46. At 67.3%, test line NC08-23323 had the lowest flour yield.

The average softness equivalence for this sample set was 57% with G95407 recording the highest SE value at 62.2%. Along with G95407, entries GA031086-10E26 and VA08W-176 ranked in the “A” grouping for softness equivalence. All the lines in the set were genetically soft, but NC08-23324 and NC08-23323 had low SE scores and would likely be poorly suited for products like cakes.

SRC

Soft wheat flours for cookies typically have a target of 95% or less. These 29 samples reached the target value with average 92.7% sucrose SRC. The highest baking score belongs to TN1202 at 86. Good baking score is based on the combination of low sucrose SRC and flour protein for TN1202. The cookie diameter of NC08-23323 was one of the smallest at 17.6 cm, reflected by a poor baking quality score of 28.8.

Gluten strength is measured by lactic acid SRC which correlates to flour protein concentration depending on genotype and growing conditions. The average for this trial was 110.2% with 20 entries ranging from 105.5% to 121.1% exhibiting characteristics of strong gluten (above 105%) and may be of value for the manufacturing of crackers or other products requiring gluten strength. The highest lactic acid SRC was for entry LA04110D-7 and TN1202 had the lowest value.

Normal sodium carbonate SRC values for good milling soft varieties are 68% or less, but this nursery had an average of 70.8% with only 4 samples below 68%. These samples were TN1202, GA04570-10E46, VA10W-28 and NC08-23090. Entry NC08-23324 had the highest sodium carbonate SRC absorption at 76.7%.

The average water SRC of the entries was high at 54.2%. Of the checks varieties, AGS 2000 had the lowest value. Three entries had lower water SRC than AGS 2000; TN1202, TN1201 and GA04570-10E46. The sample with the highest value was NC08-23324 at 57.7%.

To select the best lines for milling and baking quality, we sequentially sorted for flour yield and selected all lines with greater flour yield than the nursery average and then repeated the operation for softness equivalence. Knowing that soft wheat products such as cookies and crackers require flours with low water absorption, the sort procedure was continued using the SRC values and selecting the lines that were better than average in each case. Next we discarded the weakest gluten lines to present a more accurate evaluation of the cookies. Six samples, LA04041D-63, LA04041D-117, G95407, GA04570-10E46, TN1202 and MD03W151-10-12 passed the criteria for the set.

GENOTYPING

2012 WHEAT QUALITY COUNCIL AND 2011 OVERSEAS VARIETAL ANALYSIS

Soft Wheat Quality Laboratory, Anne Sturbaum

CULTIVARS AND GENOTYPING

Genotyping for traits associated with quality, physiology and disease resistance was done at the Soft Wheat Quality Lab and the Regional Small Grains Genotyping Laboratory (RSGGL) in Raleigh, N.C. for the 14 varieties tested for the 2012 Wheat Quality Council ; Bromfield, INW 1021, Malabar, Merl, Oakes, Purdue 04606, Purdue 05222, Purdue 05247, Pioneer 25R34, Pioneer 25R40, Pioneer 25R47, SY Harrison, 2013412 and Yorktown. In addition, the 10 varieties from the 2011 Overseas Varietal analysis were included in this genotyping set; AGI 303, AGS 2060, Coker 9804, Malabar, Merl, Shirley, SY 9978, Terral TV 8861, USG 3201 and USG 3251.

Quality

High molecular weight glutenins, especially the “5+10” allele at *GluD1* and the over expressed *Bx7* at *GluB1*, are useful for selecting favorable milling and baking quality. These alleles correlate with stronger gluten. We report on the *GluA1*, *GluB1*, *GluD1* loci and the γ -gliadin loci all involved in selecting for varieties with better dough quality related to gluten.

Amplification for high molecular weight glutenins at the *GluA1* locus, using the marker *umn19*, identified the *Ax2** genotype in Bromfield, INW_1021, Pur05247, Pioneer 25R34, Pioneer 25R40, Pioneer 25R47, SY Harrison, 2013412 and Yorktown in the WQC set. From the OVA set *Ax2** is present for AGS 2035, AGS 2056, AGS 2060, Ricochet, USG 3201 and USG 3251 (Liu et al., 2008), (Ma et al., 2003) All other entries have the *Ax1* or null alleles.

Primers detecting a 45 base pair insertion specific to the *GluB1 Bx7* over-expressing allele (*Bx7OE*) indicated over-expressing *Bx7* for AGS_2035, INW_1021, Purdue 04606, Purdue 05222, Purdue 05247 and SY9978. All other varieties produced a product indicative of the wild type allele at this locus (Guttieri et al., 2008).

Primers specific for *GluD1*, *Dx5* (3), generated a PCR product corresponding to the “5+10” genotype in 2013412, AGS 2035, AGS 2060, Croplan 9101, Pioneer 25R40 and Ricochet. Bromfield and Malabar tested heterozygous for the “5+10” and “2+12” alleles. All other varieties produced amplification products specific for the “2+12” allele (Wan et al., 2005).

Low molecular weight glutenins can be predicted by assaying for γ -gliadins due to linkage on chromosomes 3. Allele-specific primers identified the favorable *GliD1.1* allele for γ -gliadin in all varieties (Zhang et al., 2003).

A rye translocation provides multiple resistances to powdery mildew, stem rust, leaf rust and stripe rust. The 1RS/1BR translocation was identified in AGS_2035, Merl, Purdue 04606, Purdue 05222, Purdue 05247 and Ricochet. Bromfield, 2013412 and Yorktown have the rye translocation as 1RS/1AL which also confers resistance. These varieties produced an amplification product with scm9F primers specific for rye ω -secalin using the Scm9 marker pair (Saal and Wricke, 1999)(De Froidmont).

All genotypes in this set produced the anticipated banding patterns for normal amylose genotypes (non-waxy) at the A, B and D GBSS (Granule Bound Starch Synthase) loci (Nakamura et al., 2002).

Physiology

DNA markers allow early generation selection of preferred physiological traits such as plant height and maturity. The assays described below for dwarfing and photoperiod give breeders justification in choosing breeding parents to donate the preferred traits. Reduced plant height and photoperiod insensitivity can improve spikelet fertility, reduce lodging and promote early flowering (Borojevic and Borojevic, 2005).

Dwarfing genes were tested using markers specific for *Rht1* (*Rht-B1b*), *Rht2* (*RhtD1b*) and *Rht8* (Zhang et al., 2006) All varieties had at least one dwarfing allele except AGS_2060. AGS 2056, Bromfield, INW 1021, Croplan 9101, Malabar, Purdue 04606, Purdue 05222, Purdue 05247 and SY9978 amplified the *Rht1* allele, all others were positive for *Rht2*. Pioneer 25R40 has the *Rht8* allele in combination with *Rht2*.

The semi-dominant Photperiod-D1a (*Ppd-D1a*) allele and copy number variations in Photoperiod-B1a (*Ppd-B1a*) genes confer photoperiod insensitivity in wheat, allowing early flowering (Beales et al., 2007), (Díaz et al., 2012). AGS 2056, Croplan 9101, INW 1021, Merl, Oakes, Pioneer 25R34, Pioneer 25R40, Pioneer 25R47 Ricochet, SY9978, SY Harrison, Terral TV 8861 and USG2101 have the photoperiod insensitive *Ppd-D1a* with Purdue 0527 heterozygous at the locus. AGS 2035, AGS 2060, Purdue 05222, Oakes and Ricochet have the *Ppd-B1a* variants for early flowering. *Ppd-D1a* and *Ppd-B1a* photoperiod insensitivity is absent in Bromfield, Malabar, Purdue 04606, 2013412 and Yorktown.

Disease Resistance

Alleles of the *Vp1B* gene (Viviparous-1) assayed using *Vp1B3* STS marker are associated with tolerance to preharvest sprouting (PHS) (Yang et al., 2007). AGS 2056, Croplan 9101, Malabar, Oakes, Pioneer 25R34, Pioneer 25R40, Pioneer 25R47, SY Harrison and USG 3251 produced the 569 bp product indicating potential tolerance to PHS. USG 3201 was heterozygous at the locus All other WQC and OVA varieties amplified the larger product (652 bp), indicating probable susceptibility to PHS.

Markers identifying resistance genes to stem rust (*Sr2*) and were not detected among the varieties. Ricochet, alone, has the leaf rust resistance (*Lr34*) (McNeil et al., 2008), (Suenaga et al., 2003).

The presence of a stem rust resistance gene, *Sr36*, is conferred by a translocation from *Triticum timopheevi* and was tested using the marker *wmc477* (Tsilos et al., 2008). A 185 base pair

amplification product indicates resistance to the stem rust pathogen. The *Sr36* gene and translocation are present in AGS 2060, Oakes and Purdue 0522 and heterozygous in Merl.

The gene for Sucrose synthase type 2 (*TaSus2*) is located in the same chromosomal region (2B) as the *Sr36* gene. The *Sus2* HapH haplotype was reportedly associated with high test grain weight (Jiang et al., 2011). In U.S. soft wheats, the HapH allele is usually linked to the *Sr36* allele. Mapping studies implicate HapH association with favorable Sucrose SRC values and flour yield (Sneller, unpublished). The HapH allele for *Sus2* is present and linked to the *Sr36* gene in AGS 2060, Oakes and Purdue 05222 as detected by a KASP marker (developed at the ERSGGL). INW 1021 also has HapH, but in this case, the *Sr36* gene is absent.

Resistance to Fusarium head blight (FHB) is evaluated using markers associated with QTL on chromosomes 3BS (*FHB-1*) and 5A (Ernie and Ning), (McCartney et al., 2007), (Liu et al., 2008). Purdue 05247, INW 1021 and Ricochet have favorable resistance alleles for FHB-1. Purdue 05247, Purdue 05222 and Malabar have the 5A Ernie resistance on 3BS. Bromfield has resistance conferred from Fhb 5A Ning.

Table 20. Genotyping 2012 WQC and 2011 OVA varieties

Sample Name	Dwarfing Alleles	Photoperiod Insensitivity	Glu-A1	Glu-B1 Bx7OE	Glu-D1	1RS Trans-location	Sr36	SuSy2 HapH	Disease Resistance	PHS (Vp1)
AGS_2035	Rht-D1b	Ppd-B1 S64	Ax2*	Bx7OE	5+10	1RS:1BL	no	no		
AGS_2056	Rht-B1b	Ppd-D1a	Ax2*	WT	2+12	no	no	no		Tolerant
AGS_2060	no	Ppd-B1 CS	Ax2*	HET	5+10	no	yes	Hap H		
Bromfield	Rht-B1b	no	Ax2*	WT	het	1RS:1AL	no	no	Fhb 5A Ning7840	
Croplan_9101	Rht-B1b	Ppd-D1a	het	WT	5+10	no	no	no		Tolerant
INW_1021	Rht-B1b	Ppd-D1a	Ax2*	Bx7OE	2+12	no	no	Hap H	Fhb1	
Malabar	Rht-B1b	no	Ax1 or null	WT	het	no	no	no	Fhb 5A Ernie	Tolerant
Merl	Rht-D1b	Ppd-D1a	Ax1 or null	WT	2+12	1RS:1BL	het	no		
Oakes	Rht-D1b	Ppd-D1a, Ppd-B1 CS	Ax1 or null	WT	2+12	no	yes	Hap H		Tolerant
Pur04606	Rht-B1b	no	Ax1 or null	Bx7OE	2+12	1RS:1BL	no	no		
Pur05222	Rht-B1b	Ppd-B1 CS	Ax1 or null	Bx7OE	2+12	1RS:1BL	yes	Hap H	Fhb 5A Ernie	
Pur05247	Rht-B1b	Ppd-D1a-het	Ax2*	Bx7OE	2+12	1RS:1BL	no	no	Fhb1, FHB 5A Ernie	
Pioneer_25R34	Rht-D1b	Ppd-D1a	Ax2*	WT	2+12	no	no	no		Tolerant
Pioneer_25R40	Rht-D1b, Rht8	Ppd-D1a	Ax2*	WT	5+10	no	no	no		Tolerant
Pioneer_25R47	Rht-D1b	Ppd-D1a	Ax2*	WT	2+12	no	no	no		Tolerant
Ricochet	Rht-D1b	Ppd-D1a, Ppd-B1 CS	Ax2*	HET	5+10	1RS:1BL?	no	no	Fhb1, Lr34	HET?
SY9978	Rht-B1b	Ppd-D1a	Ax1 or null	Bx7OE	2+12	no	no	no		
SY Harrison	Rht-D1b	Ppd-D1a	Ax2*	WT	2+12	no	no	no		Tolerant
Terral TV 8861	Rht-D1b	Ppd-D1a	Ax1 or null	WT	2+12	no	no	no		
USG3201	Rht-D1b	Ppd-D1a	Ax2*	WT	2+12	no	no	no		HET?
USG3251	Rht-D1b	Ppd-D1a	Ax2*	WT	2+12	no	no	no		Tolerant
Yorktown	Rht-D1b	no	Ax2*	WT	2+12	1RS:1AL	no	no		
2013412	Rht-D1b	no	Ax2*	WT	5+10	1RS:1AL	no	no		

MATERIALS AND METHODS 2013

GRAIN HANDLING

GRAIN PRODUCTION

Historic varieties dating to 1808 (and likely earlier) were acquired through the National Small Grains Collection (located in Aberdeen, Idaho). These are grown with contemporary cultivars. Plant characteristics of the historic varieties and contemporary cultivars are compared with recorded plant descriptions; the identity of the various varieties is confirmed. Yearly, the SWQL grows 100-150 cultivars in forty-square-foot plots.

GRAIN CLEANING AND SIZING

Prior to 1985, most of the shriveled grain was removed mechanically utilizing a modified Carter-Day dockage tester or an air-flow scourer. However, some shriveled grain could have been present in the remaining sample. In 1985, the Carter-Day was further modified to remove shriveled kernels by air aspiration. The ability to remove shrunken grain was greatly enhanced, but the process was time consuming.

In 1989, a large air-aspirator was fabricated by the SWQL that reduced cleaning time significantly and removed shriveled kernels. In 2002, the SWQL began to re-evaluate cultivars that were tested prior to 1989 and to update the milling information if needed. That effort was mostly completed in the summer of 2006.

Every cultivar for milling is mechanically sized into three or four fractions on a SWQL-modified Carter-Day Dockage tester and then aspirated. A maximum of 2500 grams can be aspirated at one time. Air flow is electronically adjustable and the lower density shriveled grain within each sized fraction is removed. Visual inspection through a lighted magnifier is used to ascertain that only sound grain remains. Once aspiration of the wheat has been completed, the cleaned sized fractions are blended. Test weight, 1000-kernel weight and moisture are determined prior to milling.

Weather and Environment

Weather damaged cultivars that produce diminished milling quality can be difficult to identify if known standards are not incorporated within the field trial. In the northern soft wheat region, wet weather at or near harvest time occurred most years from 1990 to 2000 and again in 2003. Some cultivars prominent during that decade produced milling quality data unreflective of their true genetic potential. If a specific cultivar is identified that produced “invalid” milling data, that milling information is replaced with the updated analysis. A cultivar’s revised milling score could increase by as much as two standard deviations.

Off-color flour can appear in wheats which are genetically “white” when there is an excessive quantity of wet weather at harvest time. A yellowish flour color sometimes occurs in cultivars that are normally white when the environment “produces” coarser granulating flour than normal.

Wet weather at harvest time will lower test weights and grain density, and can greatly increase the softness of the kernel so that the flour produces larger cookie spread, although milling-yield potential is not affected. Throughput at the 1st-break rolls is diminished with weathered wheat. However, since the wheat is softer, break-flour yield increases and less middling stock is passed to the reduction rolls. That would result in reduced energy required to power the rolls with less wear on the roll surface. More throughput could possibly be realized with softer-weathered wheat versus coarser type wheat if a double 1st-break system were employed.

Excessively wet weather at harvest time can damage wheat for milling quality. Sprouted wheat (after aspiration) can possess higher test weights than unsprouted wheats. After aspiration to remove shriveled grain, a sprouted wheat may have a test weight in excess of 60# / bushel compared to weathered, unsprouted, non-shriveled wheat with 57# / bushel test weight. Alpha-amylase activity may be present despite a lack of visual evidence of sprouting.

Moderate infection from leaf diseases apparently does not affect milling properties once damaged (shriveled) kernels have been removed; however, baking quality of sugar snap cookies may be affected.

MILLING METHODS

MIAG MULTOMAT MILL

The Miag Multomat Mill is a pneumatic conveyance system consisting of eight pair of 254 mm diameter x 102 mm wide rolls, and ten sifting passages. Three pair are corrugated and employed as break rolls and five pair are smooth rolls utilized in the reduction process. Each sifting passage contains six separate sieves. The two top sieves for each of the break rolls are intended to be used as scalp screens for the bran. The third break sieving unit of the Soft Wheat Quality Laboratory (SWQL) Miag Multomat Mill was modified so that the top four sieves are employed to scalp bran. That modification increased the final bran sieving surface by 100% and essentially eliminated any loss of flour. Thus, the mill very closely approximates full scale commercial milling.

Experimental Milling Procedure

All SRW varieties are tempered to 14.5% moisture level. Generally, tempered wheat is held for at least 24 hours in order for the moisture to equilibrate throughout the grain. Wheat is introduced into the first break rolls at a rate of 600g/minute. Straight grade flour is a blend of ten flour streams, the three break flour streams and the five reduction streams, plus the grader flour from the break streams and the duster flour from the reduction streams. The straight grade flour mean volume diameter is about 50 microns with ash content usually between 0.42% and 0.52%.

Flour generated by the SWQL Miag Multomat Mill very nearly represents that of commercially produced straight grade flour. Bran, head shorts, tail shorts and red dog are by-products which are not included with the flour. Flour yields vary between 70% and 78%, which is variety-dependent due to milling quality differences and/or grain condition. Sprouted and/or shriveled kernels negatively impact flour production. Recovery of all mill products is usually about 99%. Least significant differences for straight grade flour yield and break flour yield are 0.75% and 0.82%, respectively.

QUADRUMAT JUNIOR FLOUR MILL

Micro Milling Method

Based on average whole grain moisture determination of the group to be milled, samples are tempered to 14% moisture. Moisture is determined using the Perten Instruments NIR DA7200 for whole grain. Tempered grain samples are milled after 48 hours to allow for equal water distribution throughout the kernel.

Samples are milled in a controlled temperature and humidity room (19–21 °C and RH 55% - 60%). Milling is conducted on a modified Quadrumat Junior flour mill. Prior to sample analysis, the mill is operated to warm and equilibrated (36 °C + /- 1.0). Standard sample size for micro milling is 80 g, although other sample sizes can be used. Tempered grain is milled and the product recovered for sifting on a Great Western sifter box. The sifter has 40 mesh and 94 mesh screens to separate mill product into bran (above 40), mids (between 40 and 94) and flour (through the 94 screen and recovered in the flour pan on the bottom).

To calculate softness equivalence, a modified particle size index, (Finney, P.L and Andrews, L., 1986) the weights of the bran and mids are recorded. The mids are added back to the flour that passed through the 94 mesh screen to produce the final flour product for analysis.

Advanced Milling Method

Mids from micro milling method are further processed as reduction milling on a second Quadrumat Junior mill and sieved as for the micro milling method using an 84 mesh screen to produce baking quality flour. Standard sample size for advanced milling is 200 g, and grain samples are tempered individually to 15% moisture prior to milling. Milled flour is passed through an 84 mesh screen and combined with flour from the micro milling for baking.

Because samples are tempered individually to 15%, the formulas for advanced milling yield are calculated without the adjustment to 15% moisture.

MILLING TESTS

Flour yield

Flour yield “as is” is calculated as the bran weight (over 40 weight) subtracted from the grain weight, divided by grain weight and times 100 to equal “as is” flour yield. Flour yield is calculated to 15% grain moisture basis as follows:

Flour moisture is regressed to predict the grain moisture of the wheat when it went into the Quad Mill using the formula:

$$\text{Initial grain moisture} = 1.3429 \times (\text{flour moisture}) - 4$$

The flour yields are corrected back to 15% grain moisture after estimating the initial grain moisture using the formula:

$$\text{Flour Yield}(15\%) = \text{Flour Yield}(\text{as is}) - 1.61\% \times (15\% - \text{Actual flour moisture})$$

Softness Equivalence

Softness Equivalence "as is" is calculated from the fraction of mill product that is in the mids, with smaller amounts of mids correlating to smaller particle size, greater break flour yield and greater softness equivalence (Finney, P.L and Andrews, L., 1986). The mids weight (over 94) is subtracted from the unadjusted flour yield to calculate the quantity of fine flour that passed through the 94 mesh, which is divided by the unadjusted flour yield and multiplied by 100%. Softness Equivalence at 15% grain moisture is calculated using the estimated grain moisture prior to milling (see milling formulas). The softness equivalence is adjusted to 15% grain moisture with the formula:

$$\text{Softness Equivalence}(15\%) = \text{Softness Equivalence}(\text{as is}) - 1.08\% \times (15\% - \text{Actual flour moisture})$$

Flour yield adjustment, based on flour particle size, at 15% moisture is subtracted from the actual softness equivalence. That difference is multiplied times 0.17% which is the change in flour yield per percentage point change in softness equivalence.

$$\text{Adjusted Flour Yield} = \text{Flour Yield}(15\%) + (\text{Softness Equivalence}(15\%) - 52\%)$$

Mill Score

Mill score represents a standard adjustment based on flour yield by comparing the test cultivar to a check. The check cultivar produces a score that can be used as a handicap against its traditional expected yield, and the test cultivar mill score is adjusted to the same degree as the check. This method relates test cultivars, providing a score that is independent of the environmental influences. The mill score standard deviation will be about 1.43 when evaluating cultivars and test lines that have been grown and harvested together.

KERNEL AND WHOLE WHEAT TESTS

Whole Wheat Flour Moisture (Air-oven method, modified AACC 44-16)

Apparatus

1. Tag-Heppenstall rolls
2. Moisture dish (about 5.5cm diameter x 1.5cm height, with slipover lid)
3. Air oven – a convection oven which maintains temperature $140 \pm 1^\circ$.
4. Aluminum plate

Procedure

1. Scoop out approximately one teaspoon of wheat into a moisture dish. As many as 36 samples may be run at once.
2. Pass the wheat sample through the Tag-Heppenstall rolls with a pan placed below to collect the ground sample. The black knob on the side of the unit may be used to assist the wheat through the rolls if necessary. Transfer the ground sample to the moisture dish and cover the dish with a lid.
3. Record the weight of the dish plus lid containing the ground sample (initial weight). Samples should be weighed soon after grinding and not allowed to sit for more than a few minutes in order to minimize moisture loss prior to weighing.
4. Open the lid, and place the dish and lid in the oven at 140°C . Once all dishes and lids have been placed in the oven, allow the temperature to return to 140°C and set a timer for 90 minutes.

5. At the end of the 90 minute drying time, cover the dishes with the lids and transfer them to an aluminum plate outside oven to cool for 5 minutes. It is recommended that no more than 12 dishes be taken out of the oven at once in order for the cooling time to remain consistent.
6. Record the weight of the dish plus lid containing the dried flour (final weight). Continue weighing all dishes that have been taken out of the oven.
7. Empty the samples from the dishes, brush any residue from the dishes and lids, and record the weights (dish weight).
8. Percent moisture is calculated using the following equation:

$$\% \text{ Moisture} = [(Initial \text{ wt} - Final \text{ wt}) / (Initial \text{ wt} - Dish \text{ wt})] * 100$$

Whole Wheat Flour Moisture

(AACC Method 44-15A) Air-oven method.

Whole Wheat Flour Crude Protein

Nitrogen combustion analysis using Elementar Nitrogen Analyzer. Units are recorded in % protein converted from nitrogen x 5.7 and expressed on 12% moisture basis.

Whole Wheat Flour Falling Numbers

(AACC Method 56-81B) Units are expressed in seconds using the Perten Falling Numbers instrument.

Whole Wheat Flour- Amylase Activity

(AACC Method 22-06) Units are expressed in alpha-amylase activity as SKB units/gram (@ 25°C).

Test Weight

(AACC Method 55-10) Weight per Winchester bushel of cleaned wheat subsequent to the removal of dockage using a Carter-Day dockage tester. Units are recorded as pounds/bushel (lb/bu) and kilograms/hectoliter (kg/hl).

1000-Kernel Weight

Units are recorded as grams/ 1000 kernels of cleaned wheat. There is little difference between 1000-kernel weight and milling quality when considering shriveled-free grain. However, small kernelled cultivars that have 1000-kernel weight below 30 grams likely will have reduced milling yield of about 0.75%.

Single Kernel Characterization System (SKCS)

(AACC Method 55-31) SKCS distribution showing % soft (A), semi-soft (B), semi-hard (C), and hard (D); SKCS hardness index; SKCS moisture content; SKCS kernel size; and SKCS kernel weight; along with standard deviations.

FLOUR TESTS

Flour Moisture

(Air-oven method, modified AACC 44-16):

Apparatus

1. Moisture dish (about 5.5cm diameter x 1.5cm height, with slipover lid)
2. Air oven – a convection oven which maintains temperature $140 \pm 1^{\circ}\text{C}$.
3. Aluminum plate

Procedure

1. Scoop out approximately 1/2 teaspoon of flour into a moisture dish and cover the dish with a lid. As many as 36 samples may be run at once.
2. Record the weight of the dish plus lid containing the flour sample (initial weight).
3. Open the lid and place the dish and lid in the oven at 140°C . Once all dishes and lids have been placed in the oven, allow the temperature to return to 140°C and set a timer for 15 minutes.
4. At the end of the 15 minute drying time, cover the dishes with the lids and transfer them to an aluminum plate outside the oven to cool for 5 minutes. It is recommended that no more than 12 dishes be taken out of the oven at once in order for the cooling time to remain consistent.
5. Record the weight of the dish plus lid containing the dried flour (final weight). Continue weighing all dishes that have been taken out of the oven.
6. Empty the samples from the dishes, brush any residue from the dishes and lids, and record the weights (dish weight).

Percent moisture may be calculated using the following equation:

$$\% \text{ Moisture} = [(Initial \text{ wt} - Final \text{ wt}) / (Initial \text{ wt} - Dish \text{ wt})] * 100$$

Flour Moisture

(AACC Method 44-15A) Units are expressed as % of flour.

Flour Falling Number

(AACC Method 56-81B)

Units are expressed in seconds using the Perten Falling Numbers instrument. Numbers above 400 seconds reflect factors other than alpha-amylase activity (such as particle size). The correlation between alpha-amylase activity and falling number is best for samples with falling number values between 200 and 300 seconds. For cake flours and batters, 350 seconds is a common minimum value. For breakfast cereals or cookies and other high sugar products, values of 250 seconds are more common cut-off values.

Flour Crude Protein

Protein determined by NIR using a Unity NIR instrument calibrated by nitrogen combustion analysis using Elementar Nitrogen Analyzer. Units are recorded in % protein converted from nitrogen x 5.7 and expressed on 14% moisture basis.

Flour protein differences among cultivars can be a reliable indicator of genetic variation provided the varieties are grown together, but can vary from year to year at any given location. Flour protein from a single, non-composite sample may not be representative. Based on the Soft Wheat Quality Laboratory grow-outs, protein can vary as much 1.5 % for a cultivar grown at various locations in the same half-acre field.

Flour protein of 8% to 9% is representative for breeder's samples and SWQL grow-out cultivars. As flour protein increases, the expansive capability of the cookie during the baking process decreases. Flour protein is negatively correlated to cookie diameter ($r=-0.62$, $p<0.0001$) with the cookie shrinking 0.4 cm for every 1 percentage point increase in protein. The effect of flour protein on cookie size is related in part to increased water absorption due to greater protein content, however the amount of cookie shrinkage is greater than that explained by increased water absorption alone.

Protein quality is an evaluation of "elasticity" or gluten strength and is not the same as protein quantity. A cultivar possessing a low quantity of protein could still exhibit strong gluten strength. Gluten strength is thought to be a desirable characteristic for cracker production. Gluten strength is measured using a mixograph and is graded on a scale of 1-8, with 1 as weakest and 8 as strongest gluten. Evaluation of gluten strength using the mixograph or farinograph is difficult for soft wheat flours that are 8.5% protein and lower. Since the representative protein range for breeders' samples is 8-9%, many of these flours are not adequately evaluated using the mixograph or farinograph methods. The Lactic Acid SRC, which does not require mixing action to assess gluten, tends to be a better measurement of protein quality when evaluating soft wheats. Lactic acid hydrates the native matrix of insoluble polymeric protein (IPP) present in the flour.

Flour Ash

(AACC Method 08-01) Basic method, expressed on 14% moisture basis.

Flour Amylase activity

(AACC Method 22-06) Units are expressed in α - amylase activity as SKB units/gram (@ 25°C).

Flour micro Alpha Amylase activity

(Adapted by Mary Guttierrri)

The new method adapts AACC Method 22-02 using the Ceralpha K-CERA (Megazyme) alpha amylase assay procedure for measuring alpha amylase activity at higher throughput in a microwell plate. All reagents, controls and precautions are as described in the Megazyme manual. Units are expressed as described as Ceralpha Units per gram (CU/g). The new assay is described completely at the end of this section as the Micro Assay for Flour Alpha Amylase Activity.

Solvent Retention Capacity Tests (SRC)

(Flour Lactic Acid, Sucrose, Water, and Sodium Carbonate Retention Capacities AACC Method 56-11) Units are expressed as %.

Water SRC

Water SRC is a global measure of the water affinity of the macro-polymers (starch, arabinoxylans, gluten, and gliadins). It is often the best predictor of baked product performance. Water SRC is

correlated to Farinograph water absorption but does not directly measure the absorption of the glutenin macropolymer hydration during mixing as does the Farinograph. Water SRC is negatively correlated to flour yield and softness equivalence among flour samples milled on the Quad advanced flour mill ($r=-0.43$ and $r=-0.45$, respectively). Lower water values are desired for cookies, cakes, and crackers, with target values below 51% on small experimental mills and 54% on commercial or long-flow experimental mills.

Sucrose SRC

Sucrose SRC is a measure of arabinoxylans (also known as pentosans) content, which can strongly affect water absorption in baked products. Water soluble arabinoxylans are thought to be the fraction that most greatly increases sucrose SRC. Sucrose SRC is probably the best predictor of cookie quality, with sugar snap cookie diameters decreasing by 0.07 cm for each percentage point increase in sucrose SRC. The negative correlation between wire-cut cookie and sucrose SRC values is $r=-0.66$ ($p<0.0001$). Sucrose SRC typically increases in wheat samples with lower flour yield ($r=-0.31$) and lower softness equivalence ($r=-0.23$). The cross hydration of gliadins by sucrose also causes sucrose SRC values to be correlated to flour protein ($r=0.52$) and lactic acid SRC ($r=0.62$). Soft wheat flours for cookies typically have a target of 95% or less when used by the US baking industry for biscuits and crackers. Sucrose SRC values increase by 1% for every 5% increase in lactic acid SRC. The 95% target value can be exceeded in flour samples where a higher lactic acid SRC is required for product manufacture since the higher sucrose SRC is due to gluten hydration and not to swelling of the water soluble arabinoxylans.

Sodium carbonate SRC

Sodium carbonate SRC is a very alkaline solution that ionizes the ends of starch polymers increasing the water binding capacity of the molecule. Sodium carbonate SRC increases as starch damage due to milling increases. Sodium carbonate is an effective predictor of milling yield and is negatively correlated to flour yield on the Quad advanced milling system ($r=-0.48$, $p<0.0001$). It also is one of several predictors of cookie diameter ($r=-0.22$, $p<0.0001$). Normal values for good milling soft varieties are 68% or less.

Lactic acid SRC

Lactic acid SRC measures gluten strength. Typical values are below 85% for “weak” soft varieties and above 105% or 110% for “strong” gluten soft varieties. See the above discussion of protein quality in this section for additional details of the lactic acid SRC. Lactic acid SRC results correlate to the SDS-sedimentation test. The lactic acid SRC is also correlated to flour protein concentration, but the effect is dependent on genotypes and growing conditions. The SWQL typically reports a protein-corrected lactic acid SRC value to remove some of the inherent protein fluctuation not due to cultivar genetics. Lactic acid is corrected to 9% protein using the assumption of a 7% increase in lactic acid SRC for every 1% increase in flour protein. On average across 2007 and 2008, the change in lactic acid SRC value was closer to 2% for every 1% protein.

EXPERIMENTAL BAKED PRODUCT TESTS

Wire Cut Cookie

(AACC Method 10-53, Macro Method)

This method determines the texture (hardness) of the cookies. The use of high-fructose corn syrup and lower sucrose concentration allows for a texture more similar to standard commercial cookie formulations. Differences in hardness reflect differences in flour quality, with softer cookie texture produced with better soft wheat quality.

Baking Quality of Cookie Flour

Diameter and stack height of cookies baked according to this method are measured and used to evaluate flour baking quality. All data reported in this report were produced using the new method, accepted in 2008.

Cookie spread determined within a location is a reliable indicator of the source cultivar's genetic characteristics. However, cookie spread, unlike milling quality, is greatly influenced by environmental conditions. An absolute single value for cookie spread could be misleading. Within a location the single value is significantly important in comparison to known standards. The average cookie spread for three different examples of a cultivar is representative of that wheat.

Cultivars with larger cookie spreads tend to release moisture efficiently during the baking process due to lower water absorption while cultivars yielding smaller diameter cookies tend to be higher in water absorption and hold the moisture longer during baking.

The best single predictor of cookie diameter is sucrose SRC. The strong negative correlation of sucrose SRC to cookie diameter ($r=-0.66$, $p<0.0001$) has led to its adoption in lieu of baking cookies for most samples. The best prediction model for cookie diameter among grain samples milled on the Quadrumat advanced system uses a combination of sucrose SRC, softness equivalence, and flour protein ($R^2=0.61$). These three measures are combined into the baking quality score used in Quad Micro milling with the baking quality score favoring lower sucrose SRC and flour protein and greater softness equivalence values.

Cultivars that possess excellent milling properties nearly always produce large diameter cookie spreads. Poor milling cultivars nearly always produce smaller cookie spreads. Cultivars that are very soft in granulation usually produce good cookie spreads.

Baking Quality of Cookie Flour - Micro Method

AACC Method 10-52, Approved December, 2008

Meera Kweon, Research Food Technologist, Campbell Soup Corp

In North America, a "cookie" is a product similar to what is internationally known as a "biscuit". Cookie quality of flour is determined by the interaction among endogenous components of the flour and the ingredients in the mix. This method establishes a carefully controlled competition for water among the various components and ingredients, the results of which are manifest as differing cookie diameters. Larger diameter cookies are preferred and an indicator of good pastry-making

and specifically cookie-baking potential. The method is also useful to evaluate other flour types, various flour treatments and other factors, such as ingredients, that affect cookie geometry.

Apparatus

1. National cookie dough micromixer, with head speed of 172 rpm and special cookie dough bowl.
2. Electric mixer, with timer control (Hobart or Kitchen-Aide), with paddle attachment.
3. Aluminum cookie sheet. See note 1.
4. Rolling pin, 5.7 - 7 cm (2.25 - 2.75 in.) diameter. If wood, check for wear to edges from use and replace if necessary.
5. Cookie cutter, 60 mm inside diameter.
6. Small plastic spatula, ground flat at end, with notch cut to fit cookie dough bowl and mixing head pins.
7. Thermometer and humidity meter / hygrometer. See note 2.
8. Baking oven, reel or rotary, electrically heated and capable of maintaining temperature of $205^{\circ}\text{C} \pm 2^{\circ}$ ($400^{\circ}\text{F} \pm 4^{\circ}$). See note 3.
9. Measuring calipers (large enough to measure 22 cm)

Reagents

1. Solution A. 0.95 M sodium bicarbonate (79.8 g dissolved in water to make 1L).
2. Solution B. 1.9 M ammonium chloride / 1.52 M sodium chloride (101.6 g and 88.8 g respectively, dissolved in water to make 1 L).
3. Sucrose. Any brand of "Baker's Special" sugar: sugar passing through a US No.30 sieve (595 μm openings) only. Particle size affects solubility.
4. Shortening. Non-trans fat, vegetable shortening not containing methyl silicone of medium consistency (e.g. Crisco non-trans fat shortening).
5. Nonfat dry milk. To pass through a US No. 30 sieve (595 μm openings).

Procedure

The total formulation amounts of each cookie pair are listed in Table 18.

1. Sift dry ingredients (sucrose, nonfat dry milk, dry sodium bicarbonate; Table 19 for sufficient creamed mass for different batch sizes, 21-46 cookie pairs; 37.60 g for each pair) together until well-mixed. Cream these ingredients together with shortening using Hobart or Kitchen-Aide mixer, using a paddle attachment, on low speed 1 min, then scrape bowl and paddle; on medium speed 1 min, then scrape; on high speed 30 sec, then scrape; and on high speed 30 sec. Weigh 37.60 g portions of this creamed mass for each cookie-pair to be baked.
2. Scrape measured creamed mass into cookie dough mixing bowl (National cookie dough micro-mixer, using a cookie dough bowl; head speed 172 rpm). Add water as shown in Tables 18 and 20: add 4.0 mL solution A, 2.0 mL solution B, and additional water (use water amount in Table 20 for appropriate flour moisture; 8.7 mL total water per cookie pair). Mix 3 min (stopping mixer and scraping after first few sec if shortening is stuck on side of bowl) and scrape with small spatula.
3. Add 40 g flour (14% mb, weight per Table 20) to mixing bowl. Mix a total of 25 sec. as follows: Mix for the first 10 sec while tapping side of bowl. Scrape dough from mixer and bowl pins; scrape outer edge and bottom of bowl, pushing dough between pins several times. Mix 5 sec and scrape as just described. Mix 5 sec and scrape. Mix 5 sec and scrape mixer pins.

4. Gently scrape dough from bowl, gently form into a single dough mass and cut with spatula into two equal portions. Transfer to a room-temperature cookie sheet with gauge strips. Roll to thickness with one forward and one backward stroke of rolling pin. Cut dough with cookie cutter, discard excess dough, and remove cutter.
5. Immediately place in oven and bake for 10 min. Remove sheet from oven. Cool 5 min and remove cookies from baking sheet.
6. After cookies have cooled to room temperature (at least 30 min), measure cookie diameter using calipers, or image analysis. Lay two cookies edge-to-edge and measure width. Rotate one cookie 90°, the other 45°. Measure again. Rotate both cookies 90° and measure again. Repeat. Average the four readings and divide by two to obtain average diameter of one cookie.

Notes

1. Aluminum cookie sheets made of 3003-H14 aluminum alloy, 2.0 mm (0.08 in) thick, 30.5 X 40.6 cm (12 X 16 in) or 25.4 X 33.0 cm (10 X 13 in), or other sizes required to accommodate oven doors and shelves. Cookie sheets should be manufactured with gauge strips fastened to the long edges of the sheets (gauge strips made of the same alloy as the sheets, 7 mm (0.275 in) thick and the length of the baking sheets). New sheets should be conditioned by lightly greasing and placing in hot oven for 15 min, cooling, and repeating the process two or three times. Cookie sheets should have excess grease wiped off after each cookie pair is baked. Cookie sheets should be washed while warm in water (without use of soap or detergent) and wiped dry after each bake.
2. Dough consistency, stickiness and cookie spread are affected by temperature and humidity. Room and ingredient temperature and humidity should be maintained at constant level among bakes ($21^{\circ}\text{C} \pm 1^{\circ}$ ($70^{\circ}\text{F} \pm 2^{\circ}$) and 30 - 50% are recommended, respectively). Consistent environmental conditions are more important in a lab than adherence to a particular level, within reason.
3. Oven should have a hearth consisting of ceramic-fiber-reinforced structural alumina refractory product (6.4 mm (0.25 in)) thick as shelf liner cut to dimensions of and placed on the steel baking shelf. Oven shelves consisting of wire mesh baking surface are also suitable and may not need shelf liner (to prevent excessive bottom browning).
4. For relatively consistent mixing action, recommended cream mass batch size is 21 - 46 units. Obtain amounts of sugar, nonfat dry milk, sodium bicarbonate and shortening from Table 18.
5. Oven should be heated to temperature with oven shelves turning. Bake “dummy” cookies out of scrap dough or extra flour to condition the oven before beginning a test bake, at the beginning of a baking series, or if the oven has not been used for 15 min or longer.

References:

- (Bettge, A.D., Kweon, M., 2009)
- (Finney et al., 1950)
- (Kissell et al., 1973)

Table 21. AACC Method 10-52 - Ingredient amounts per cookie pair

Ingredient	Amount
Flour (14% mb)	40 g
Sucrose	24 g
Nonfat dry milk	1.2 g
NaHCO ₃	0.40 g
NaHCO ₃ (in Soln A)	0.32 g (in 4 mL)
NH ₄ Cl (in Soln A)	0.20 g (in 2 mL)
NaCl (in Soln B)	0.18 g
Shortening	12.0 g
Added Water ¹	2.7 mL

¹Based on moisture of flour, adjusted water was added (see table 20)

Table 22. AACC Method 10-52 - Ingredient weights for batch preparation

Ingredient	Ingredient weights (g) for preparing creamed mass for different batch sizes					
	20	25	30	35	40	45
Sucrose ¹	504.0	624.0	744.0	864.0	984.0	1104.0
Nonfat dry milk	25.2	31.2	37.2	43.2	49.2	55.2
Na bicarbonate	8.4	10.4	12.4	14.4	16.4	18.4
Shortening	252.0	312.0	372.0	432.0	492.0	552.0

Table 23. AACC Method 10-52 - Calculated amounts of flour and added water for cookie test formula

Flour moisture (%)	Added Water (g or mL)	Flour (g)	Flour moisture (%)	Added Water (g or mL)	Flour (g)
9.1	4.9	37.8	12.1	3.6	39.1
9.2	4.9	37.8	12.2	3.5	39.2
9.3	4.8	37.9	12.3	3.5	39.2
9.4	4.7	38.0	12.4	3.4	39.3
9.5	4.7	38.0	12.5	3.4	39.3
9.6	4.6	38.1	12.6	3.3	39.4
9.7	4.6	38.1	12.7	3.3	39.4
9.8	4.6	38.1	12.8	3.3	39.4
9.9	4.5	38.2	12.9	3.2	39.5
10.0	4.5	38.2	13.0	3.2	39.5
10.1	4.4	38.3	13.1	3.1	39.6
10.2	4.4	38.3	13.2	3.1	39.6
10.3	4.3	38.4	13.3	3.0	39.7
10.4	4.3	38.4	13.4	3.0	39.7
10.5	4.3	38.4	13.5	2.9	39.8
10.6	4.2	38.5	13.6	2.9	39.8
10.7	4.2	38.5	13.7	2.8	39.9
10.8	4.1	38.6	13.8	2.8	39.9
10.9	4.1	38.6	13.9	2.7	40.0
11.0	4.0	38.7	14.0	2.7	40.0
11.1	4.0	38.7	14.1	2.7	40.0
11.2	4.0	38.7	14.2	2.6	40.1
11.3	3.9	38.8	14.3	2.6	40.1
11.4	3.9	38.8	14.4	2.5	40.2
11.5	3.8	38.9	14.5	2.5	40.2
11.6	3.8	38.9	14.6	2.4	40.3
11.7	3.7	39.0	14.7	2.4	40.3
11.8	3.7	39.0	14.8	2.3	40.4
11.9	3.7	39.0	14.9	2.3	40.4
12.0	3.6	39.1	15.0	2.2	40.5

NEW METHOD – CHEMICALLY-LEAVENED CRACKER BAKING PROCEDURE

Developed by Meera Kweon, Research Food Technologist, Campbell Soup Corp

Background

Traditionally, the baking performance of soft wheat flours has been evaluated by well-established, bench top, cookie-baking methods (e.g. AACC Approved Methods 10-52 and 10-53 (AACC International 2000)). In contrast, a bench top cracker-baking method has not been widely explored or implemented as an official method, due to hurdles including the difficulty in finding ideal diagnostic flours and the absence of suitable bench top equipment (e.g. powerful dough mixer, dough sheeter, multi-zone oven).

There are generally three major types of crackers: saltine, chemically-leavened, and savory. The typical processes for preparing saltine and savory crackers usually require about 24 hours, due to a prolonged fermentation time. In comparison, chemically-leavened crackers ordinarily do not require a fermentation step, and their processing is relatively easy and simple to manage. Development of a bench top method for chemically-leavened crackers would enable one to use such a method as a predictive tool for evaluating gluten functionality in flour for crackers.

Soft wheat flours with greater gluten strength are typically preferred for commercial cracker production. The purpose of developing a bench top baking method is to predict the contribution of gluten functionality to overall flour performance for chemically-leavened crackers.

Apparatus

1. Pin mixer (National Manufacturing Co.), with head speed of 102 rpm and a 100g flour batch dough bowl
2. Dough sheeter (Model SFB 528, width of sheeting rolls, 19 5/8", Univex Corp., Salem, NH)
3. Hand cutter (2.25 x 1.65 in, 7 docker pins, Weidenmiller Co., Itasca, IL)
4. Baking mesh (cord-weave, 13L x 10W in, 0.26 in thickness, Hi Carbon Steel, spec. C-100-3F, Audubon, Feasterville, PA)
5. Baking (cooling) rack
6. Aluminum cookie baking sheet
7. Baking oven, reel or rotary, electrically heated and capable of maintaining temperature of 500°F ± 5°)
8. Measuring calipers

Table 24. Basic ingredients and formula, chemically leavened cracker baking

Ingredient	Formula (g)
Flour	100.0 (14% moist.)
Fine granulated sucrose	9
Salt	0.75
Sodium bicarbonate	1.25
Ammonium bicarbonate	1.25
Monocalcium phosphate (MCP monohydrate)	1.25
Shortening	12.0
Water	29.0

Mixing procedure

Stage 1:

1. Dissolve fine granulated sucrose in water to prepare a pre-dissolved sugar solution.
2. Weigh 38g of pre-dissolved sugar solution into a 100g pin mixer mixing bowl at room temperature and add ammonium bicarbonate to dissolve.
3. Add room temperature shortening.
4. Mix 1 min.

Stage 2:

5. Add pre-weighed flour, salt, sodium bicarbonate, and monocalcium phosphate.
6. Mix 10 min continuously.
7. Use dough to make a dough ball.

Sheeting procedure

1. Make a dough ball with hands, and flatten it for sheeting.
2. The sheeted dough is sheeted at dial setting “5” (5.59mm) of the Univex sheeter.
3. Change the sheeting direction knob to the opposite direction and sheet the dough at dial setting “3” (3.78mm).
4. Repeat step 3 three times with dial settings “2” (2.71mm), “1” (1.77mm), and 2nd smallest (0.54mm), sequentially.
5. The sheeted dough is rested for 1 min on the sheeter belt, and dough pieces are cut with a hand cutter (4 pieces of cracker dough) twice to prepare 8 pieces of cracker dough.
6. The 8 pieces of cracker dough are transferred to a cookie baking sheet, and total dough weight is measured before transferring the dough pieces to pre-heated baking mesh.

Baking procedure

Oven temperature: set 500°F (260°C)

Baking time: about 5-6 min (Target moisture: 2.75% (2.0-3.5%))

1. A cracker baking mesh is placed on the top of a baking (cooling) rack, and pre-heated in an oven for 5 min before sheeting dough.
2. Cut cracker dough pieces are placed on pre-heated baking mesh, and placed in an oven for baking.
3. Baked crackers are removed from the oven, and transferred to the cookie baking sheet to measure the cracker weight.

Evaluation

Moisture loss during baking is calculated.

Length, width and height are measured for 8 crackers, and the average length, width and height are reported.

MICRO ASSAY FOR FLOUR ALPHA AMYLASE ACTIVITY

Adapted by Mary Guttieri for the Soft Wheat Quality Laboratory

The method adapts the AACC Method 22-02 using the Ceralpha K-CERA (Megazyme) alpha-amylase assay procedure for higher throughput to determine flour alpha-amylase activity in a microwell plate. All reagents, controls and precautions are as described in the Megazyme manual.

Required Materials

1. Ceralpha Alpha-Amylase Kit (AACC Method 22-02)
2. 50 mL conical centrifuge tubes
3. Centrifuge with rotor to spin 50 mL conical tubes at 1000 xg
4. Analytical balance
5. Microplate reader and plate (510 nm)
6. Vortex mixer
7. Water bath at 40°C
8. Multichannel repeating pipette

Method Preparation

Ceralpha Substrate and Stopping Reagent

Ceralpha substrate is prepared as described and stored frozen (-20°C) in 1 mL aliquots in microcentrifuge tubes. Additional Stopping Reagent is prepared using 1% w/v sodium phosphate tribasic dodecahydrate in distilled water adjusted to pH11.

Enzyme Extraction

1. Accurately weigh 3.0 g of ground grain or flour into a 50 mL conical centrifuge tube.
2. Add 20.0 mL of 1X Extraction Buffer solution (pH 5.4) to each tube and mix vigorously.
3. Allow enzyme to extract over 20 minutes in a 40°C water bath, with occasional mixing.
4. Centrifuge 1,000 x g for ten minutes.
5. Assay enzyme activity within two hours.

Reaction Blank

A single set of triplicate Reaction Blanks (non-enzymatic control) is prepared as follows for each batch of samples being analyzed.

1. 0.3 mL of stopping reagent
2. 20 µL of substrate solution at the start of the reaction time
3. 20 µL of any enzyme preparation in the sample set

Evaluation

The mean absorbance of the non-enzymatic control is subtracted from all assays conducted during that day to establish the background or blank absorbance.

Assay Procedure

1. Dispense 20 µL aliquots of Ceralpha Reagent Solution into a microtiter plate and pre-incubate the tubes and contents at 40°C for 5 min. Dispense 3 aliquots for each enzyme extract (assay each extract in triplicate).
2. To each well containing Ceralpha Reagent solution (20 µL), add 20 µL of wheat α-amylase extract directly to the bottom of the well at 30 second intervals.
3. Incubate at 40°C for exactly twenty min from time of addition.
4. Following the 20 min incubation period, add exactly 0.3 mL of Stopping Reagent.
5. Read the absorbance of the solutions and the reaction blank at 400 nm against 340 µL distilled water.

SOFT WHEAT WHOLE GRAIN NIR (PERTEN INSTRUMENTS DA 7200)

Prepared by William Wade

Method

1. Turn on DA7200 – Start SIMPLICITY FOR DA7200 and allow to warm up for 30 minutes.
2. Assemble equipment: sample cups and level bar.
3. Select the Product “Soft Wheat Grain”.
4. Prepare first sample in sample cup; slightly overfill sample to ensure that after leveling off, sample is flush with the top of the sample cup. (If there is not enough sample to fill the cup, place the black riser inside the cup first. If there is still not enough to have the sample flush with the top of the cup, the sample is unable to be analyzed on this machine.)

5. Level off the sample cup and place inside the machine. (Note: there are two size cups; with the small cup the platter will need to be pushed in, with the large cup it will need to be pulled out.)
6. Start analysis:
 - Barcode: Scan the barcode of the first sample. This will start the analysis.
 - No Barcodes: Enter a unique identifier (sample name) in the Sample text area and press ENTER.
 - When requested, repack the cup by pouring out the current cup and refilling. Always re-level sample.
 - Repeat steps 4-6 as needed.
7. Exit the program and shutdown the machine if done for the day.

ADVANCED MILL DATABASE CREATION

Edward Souza, SWQL, February 22, 2011

Purpose

To summarize cultivar milling and baking data into a reference for use in adjusting other data sets of experimental lines.

Background

Each group of germplasm from breeders that is evaluated by the laboratory should have check cultivars included in the group. As part of the validation process of the data, those checks should be compared to prior performance of the check in quality evaluations. Environmentally adjusted scores are created for each line evaluated in the laboratory. This is calculated based on the difference between an historical average of the cultivar's performance and the observed value within the trial. The Advanced Mill Database is the tabular form of historical averages for cultivars evaluated at the laboratory using the modified Quadrumat flour mill.

Compilation of Data

Databases of previous year's performance are compiled and stored on the SWQL server in the folder marked 'Quality Scores'. Begin with the most recent and add to it all new advanced groups evaluated in the laboratory since the last compilation. The dataset as of 2/22/2011 bridges evaluations with the current and earlier sugar-snap cookie method. Samples evaluated with the earlier method are noted in a method column with 'Old'. All current data should be marked as 'New' for the method column as we are using the revised sugar-snap cookie method exclusively since 2009. Edit previous entries of new cultivar releases in the past year for consistent naming. Review all naming for consistency as company names can and do change each year.

Analysis of Data

Due to the unbalanced nature of the data, we can only generate approximate means. The current model used includes 'year' of testing and 'cult' or cultivar name as the independent variables to generate a least squares mean.

Any entries that appear fewer than seven times in the database should not be analyzed. Mean values for each cultivar as well as the number of observations contributing to the mean are tabled for use in adjustments. Milling, baking, and softness equivalence scores are included in the table and graded.

Cookie data has a more complex model; it includes a third variable of 'method' to specify the different baking methods. The new method produces cookies approximately 0.6 cm greater in diameter than the earlier method.

When cookie means are entered into the database table, the average value should be increased by half the difference between the two methods so that the value appearing in the table is close to the values produced under the current baking method.

Regression models for generating scores are created by modeling the mean scores against the mean milling and baking data for the cultivars in the Advanced Mill Database. Using the means in the table, SAS should solve the regression models:

$$\text{Milling score} = \text{Intercept} + b * \text{Milling yield}$$

$$\text{Baking score} = \text{Intercept} + b1 * \text{Cookie diameter} + b2 * \text{Sucrose SRC} + b3 * \text{Softness equivalence}$$

$$\text{Softness equivalence score} = \text{Intercept} + b * \text{Softness equivalence}$$

Milling and baking data analysis uses the models in the templates sheets marked 'Adjustment Factor' sheet to calculate the observed scores for the checks. The observed scores are compared to the historical averages for the checks in the Advanced Mill Database, and the difference is used to calculate the bias for adjusting the score of all the experimental lines to accommodate the environmental influences on the trial.

Annotation of the Set

The data sheets should note averages of all entries and standard errors for a specified number of observations. The raw data used to generate the means should be annotated for date of last entry and any missing or unusual information in the group. Backups should be made on the local computer and server. All technicians should be informed of the conversion to the new database. In the database and in files a date should be noted for conversion to the new database. Each group processed should be marked at the bottom with the version of the database used for analysis.

MILLING FORMULAS USED FOR SWQL REPORTS

MICRO MILLING

GRAIN MOISTURE ESTIMATE

$$\text{Grain moisture} = 1.3429 \times (\text{flour moisture}) - 4$$

ESTIMATED FLOUR YIELD CORRECTED TO 15% MOISTURE

$$\text{Flour Yield}(15\%) = \text{Flour Yield}(\text{as is}) - 1.61\% \times (15\% - \text{Actual flour moisture})$$

SOFTNESS EQUIVALENCE (SE)

$$SE(\text{as is}) = ((\text{GW} - \text{Bran}) - \text{Mids}) / (\text{GW} - \text{Bran})$$

Where:

SE = Softness Equivalence

GW = Weight of grain milled

Bran = Weight of milled product that remains above a 40 mesh screen

Mids = Weight of mill product through a 40 mesh and remaining above a 94 mesh screen

SOFTNESS EQUIVALENCE AT 15% GRAIN MOISTURE (SE15%)

$$SE(15\%) = SE(\text{as is}) - 1.08\% \times (15\% - \text{Actual flour moisture})$$

FLOUR YIELD ADJUSTMENT

$$\text{Adjusted Flour Yield} = \text{Flour Yield}(15\%) + 0.17 \times (\text{Softness Equivalence}(15\%) - 52\%)$$

MILLING QUALITY SCORE (MQS)

$$MQS = MF + (5.0144 \times \text{Adjusted Flour Yield}) - 292.6425$$

Where:

MF = Allis Milling Score - $(5.0144 \times \text{SAFY}) - 292.6425$

Allis Milling Score = Mill score from Allis database for the quality standard designated for the group

SAFY = Adjusted Flour Yield for the quality standard designated for the trial as measured in the trial being evaluated

BAKING QUALITY SCORE (BQS)

$$BQS = BF + (33.3333 \times CS) - 526.667$$

Where:

BF = Allis Baking Score - *SCS*

CS = Cookie Score = $(-0.145 \times \text{Flour Protein}) + (-0.07 \times \text{Sucrose SRC}) + (0.049 \times SE) + 21.9$

SCS = Standard Cookie Score - cookie score for the quality standard designated for the trial as measured in the trial being evaluated

ALLIS BAKING SCORE

Allis Baking Score = Allis baking score for the quality standard as determined in the Allis Milling Database

ADVANCED FLOUR MILLING

All formulas for Advanced milling are the same as Micro milling with the exception of Baking Quality Score.

BAKING QUALITY SCORE (BQS)

$$BQS = (33.33333 \times \text{Cookie Diameter}) - 526.667 + BF$$

Where:

BF = Baking Factor = Allis Bake Score - (33.33333 x SCD) - 526.667

Allis Baking Score = Allis baking score for the quality standard as determined in the Allis Milling Database

SCD = Standard Cookie Diameter – cookie diameter for the quality standard designated for the trial as measured in the trial being evaluated

GENOTYPING

DNA markers applied in marker assisted selection and genotyping are included below. The SWQL sends samples to the Eastern Regional Small Grains Genotyping Laboratory for SNP genotyping.

<http://www.ars.usda.gov/Main/docs.htm?docid=19522><http://www.ars.usda.gov/Main/docs.htm?docid=19522>

For assays referenced but excluded from the list below. Molecular markers and protocols are available at the University of California Davis website:

MASWheat

<http://maswheat.ucdavis.edu/protocols/index.htm><http://maswheat.ucdavis.edu/protocols/index.htm>

QUALITY GENOTYPING - PRIMER SEQUENCES, AMPLIFICATION CONDITIONS AND REFERENCES.

The molecular markers described below are the most commonly used markers at the SWQL. These are reliable and robust reactions that have been useful in assessing wheat quality. All primer sequences are given 5' to 3'.

High Molecular Weight Glutenins and γ -gliadin

GluA1

AxFwd	ATGACTAAGCGGTTGGTTCTT
Ax1 R	ACCTTGCTCCCTTGTCTCTG
Ax2* R	ACCTTGCTCCCTTGTCTTT

Amplifies at 58°C, 1,200 bp product, present or absent using single forward primer, alternate (Ma et al., 2003), (Liu et al., 2008)

GluD1

DxL_151	AGGATTACGCCGATTACGTG
Dx2R ``2+12"	AGTATGAAACCTGCTGCGGAG
Dx5R ``5+10"	AGTATGAAACCTGCTGCGGAC

Amplifies 664 bp product, present or absent using single forward primer, alternate reverse primers, touch down amplification.
(Wan et al., 2005)

GluB1

Bx7oe_L1	GCGCGCTCAACTCTTCTAGT
Bx7oe_R1	CCTCCATAGACGACGCACTT

Amplifies at 64°C a 404 bp for wild-type or 447 bp product for over-expressing Bx7.
(Lei et al., 2006)

γ-gliadin

GligDF1 AAGCGATTGCCAAGTGATGCG
GligDR1 GTTTGCAACACCAATGACGTA
GligDR2 GCAAGAGTTTGCAACAGCG

Amplifies at 56°C, a 264 bp product for gliadin 1.1 or or 270 bp product for gliadin 1.2, using single forward primer, alternate reverse primers.

(Zhang et al., 2003)

Translocations and Disease Resistance

1B/1R and 1A/1R – Chromosome 1B or 1A substituted with rye secalin

Tailed Reaction

SCM9_L_M13 CACGACGTTGTAAAACGACTGACAACCCCTTTCCCTCGT
SCM9_R TCATCGACGCTAAGGAGGACCC

Amplifies using a tailed reaction, 207 bp for 1B/1R or or 203 bp for 1A/1R.

(De Froidmont)

2B translocation - Sr 36 stem rust resistance

Stm773-F5 AAACGCCCAACCACCTCTCTC
Stm773-R5 ATGGTTTGTGTGTGTGTAGG

Amplifies with 62/55°C touchdown program producing a 162 fragment indicative of the 2B translocation carrying Sr36 or 192 bp for wild type 2B.

(Tsilo et al., 2008)

Sucrose Synthase type 2 Sus2

HapH higher grain weight (Sus2-SNP-185/592H2)
Sus2-SNP-185 TAAGCGATGAATTATGGC
Sus2-SNP-589H2 GGTGTCCTTGAGCTTCTgG
Hap L associated with low grain weight
Sus2-SNP-227 ctataGTATGAGCTGGATCAATGGC
Sus2-SNP-589L2 GGTGTCCTTGAGCTTCTgA

Amplifies each of the primer pairs independently at 52°C to produce a 423 or 381 bp fragment, haplotypes indicative of high or low grain weight, respectively.

(Jiang et al., 2011)

Pre-harvest sprouting

Vp1BF TGCTCCTTTCCCAATTGG
Vp1BR ACCCTCCTGCAGCTCATTG

Amplifies at 62°C a 569 or 845 bp fragment for reported tolerance to preharvest sprouting.

(Yang et al., 2007)

BIBLIOGRAPHY

- Beales, J., Turner, A., Griffiths, S., Snape, J.W., and Laurie, D.A. (2007). A pseudo-response regulator is misexpressed in the photoperiod insensitive Ppd-D1a mutant of wheat (*Triticum aestivum* L.). *Theor. Appl. Genet.* *115*, 721–733.
- Bettge, A.D., Kweon, M. (2009). Collaborative Study on updated Method 10-52: Baking Quality of Cookie Flour - Micro Method (Sugar-Snap Cookie). *Cereal Foods World* *54*, 70–73.
- Bhave, M., and Morris, C.F. (2008). Molecular genetics of puroindolines and related genes: regulation of expression, membrane binding properties and applications. *Plant Mol Biol* *66*, 221–231.
- Bonafede, M., Kong, L., Tranquilli, G., Ohm, H., and Dubcovsky, J. (2007). Reduction of a Chromosome Segment Carrying the Softness Genes and Translocated to Bread Wheat. *Crop Science* *47*, 821.
- Borojevic, K., and Borojevic, K. (2005). The Transfer and History of “Reduced Height Genes” (Rht) in Wheat from Japan to Europe. *J Hered* *96*, 455–459.
- Emes, M.J., Bowsher, C.G., Hedley, C., Burrell, M.M., Scrase-Field, E.S.F., and Tetlow, I.J. (2003). Starch synthesis and carbon partitioning in developing endosperm. *J. Exp. Bot.* *54*, 569–575.
- Finney, K., Yamazaki, W.T., and Morris, V.H. (1950). Effects of varying quantities of sugar, shortening and ammonium bicarbonate on the spreading and top grain of sugar-snap cookies. *Cereal Chem* *27*.
- Finney, P.L and Andrews, L. (1986). Revised Microtesting for Soft Wheat Quality Evaluation. *Cereal Chem* *63*, 177–182.
- De Froidmont, D. A Co-dominant Marker for the 1BL/1RS Wheat-rye Translocation via Multiplex PCR. *Journal of Cereal Science* *27*, 229–232.
- Guttieri, M., A. Sturbaum, Smith, N., and Sneller, C. (2008). Optimized PCR Primer Set for Determining Gluten Strength Quality in soft whet germplasm (Plant and Animal Genome 2008).
- Hogg, A.C., Beecher, B., Martin, J.M., Meyer, F., Talbert, L., Lanning, S., and Giroux, M.J. (2005). Hard Wheat Milling and Bread Baking Traits Affected by the Seed-Specific Overexpression of Puroindolines. *Crop Science* *45*, 871.
- Jiang, Q., Hou, J., Hao, C., Wang, L., Ge, H., Dong, Y., and Zhang, X. (2011). The wheat (*T. aestivum*) sucrose synthase 2 gene (TaSus2) active in endosperm development is associated with yield traits. *Funct. Integr. Genomics* *11*, 49–61.
- Kissell, L.T., Marshall, B.D., and Yamazaki, W.. (1973). Effect of Variability in Sugar Granulation on the Evaluation of Four Cookie Quality. *Cereal Chemistry* *50*, 255–263.
- Lei, Z.S., Gale, K.R., He, Z.H., Gianibelli, C., Larroque, O., Xia, X.C., Butow, B.J., and Ma, W. (2006). Y-type gene specific markers for enhanced discrimination of high-molecular weight glutenin alleles at the Glu-B1 locus in hexaploid wheat. *Journal of Cereal Science* *43*, 94–101.

- Liu, S., Pumphrey, M.O., Gill, B.S., Trick, H.N., Zhang, J.X., Dolezel, J., Chalhoub, B., and Anderson, J.A. (2008). Toward positional cloning of *Fhb1*, a major QTL for Fusarium head blight resistance in wheat. *Cereal Research Communications* 36, 195–201.
- Ma, W., Zhang, W., and Gale, K.R. (2003). Multiplex-PCR typing of high molecular weight glutenin alleles in wheat. *Euphytica* 134, 51–60.
- McCartney, C.A., Somers, D.J., Fedak, G., DePauw, R.M., Thomas, J., Fox, S.L., Humphreys, D.G., Lukow, O., Savard, M.E., McCallum, B.D., et al. (2007). The evaluation of FHB resistance QTLs introgressed into elite Canadian spring wheat germplasm. *Mol Breeding* 20, 209–221.
- McNeil, M.D., Kota, R., Paux, E., Dunn, D., McLean, R., Feuillet, C., Li, D., Kong, X., Lagudah, E., Zhang, J.C., et al. (2008). BAC-derived markers for assaying the stem rust resistance gene, *Sr2*, in wheat breeding programs. *Mol Breeding* 22, 15–24.
- Nakamura, T., Vrinten, P., Saito, M., and Konda, M. (2002). Rapid classification of partial waxy wheats using PCR-based markers. *Genome* 45, 1150–1156.
- Saal, B., and Wricke, G. (1999). Development of simple sequence repeat markers in rye (*Secale cereale* L.). *Genome* 42, 964–972.
- Souza, E.J., Sneller, C., Guttieri, M.J., Sturbaum, A., Griffey, C., Sorrells, M., Ohm, H., and Van Sanford, D. (2012). Basis for Selecting Soft Wheat for End-Use Quality. *Crop Science* 52, 21.
- Suenaga, K., Singh, R.P., Huerta-Espino, J., and William, H.M. (2003). Microsatellite Markers for Genes *Lr34/Yr18* and Other Quantitative Trait Loci for Leaf Rust and Stripe Rust Resistance in Bread Wheat. *Phytopathology* 93, 881–890.
- Tsilo, T.J., Jin, Y., and Anderson, J.A. (2008). Diagnostic Microsatellite Markers for the Detection of Stem Rust Resistance Gene in Diverse Genetic Backgrounds of Wheat. *Crop Science* 48, 253.
- Wan, Y., Yan, Z., Liu, K., Zheng, Y., D'Ovidio, R., Shewry, P.R., Halford, N.G., and Wang, D. (2005). Comparative analysis of the D genome-encoded high-molecular weight subunits of glutenin. *Theor Appl Genet* 111, 1183–1190.
- Yang, Y., Zhao, X.L., Xia, L.Q., Chen, X.M., Xia, X.C., Yu, Z., He, Z.H., and Röder, M. (2007). Development and validation of a *Viviparous-1* STS marker for pre-harvest sprouting tolerance in Chinese wheats. *Theor Appl Genet* 115, 971–980.
- Zhang, W., Gianibelli, M.C., Ma, W., Rampling, L., and Gale, K.R. (2003). Identification of SNPs and development of allele-specific PCR markers for γ -gliadin alleles in *Triticum aestivum*. *Theor Appl Genet* 107, 130–138.
- Zhang, X., Yang, S., Zhou, Y., He, Z., and Xia, X. (2006). Distribution of the *Rht-B1b*, *Rht-D1b* and *Rht8* reduced height genes in autumn-sown Chinese wheats detected by molecular markers. *Euphytica* 152, 109–116.