SOFT WHEAT QUALITY LABORATORY

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USDA- AGRICULTURAL RESEARCH SERVICE

CORN, SOYBEAN AND WHEAT QUALITY RESEARCH UNIT

SOFT WHEAT QUALITY LABORATORY

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AGRICULTURAL RESEARCH SERVICE VISION AND MISSION

The ARS vision is to lead America towards a better future through agricultural research and information.

ARS conducts research to develop and transfer solutions to agricultural problems of high national priority and provide information access and dissemination to:

- ensure high-quality, safe food, and other agricultural products
- assess the nutritional needs of Americans
- sustain a competitive agricultural economy
- enhance the natural resource base and the environment
- provide economic opportunities for rural citizens, communities and society as a whole

NATIONAL PROGRAM 306: QUALITY AND UTILIZATION OF AGRICULTURAL PRODUCTS

Mission Statement

Enhance the economic viability and competitiveness of U.S. agriculture by maintaining the quality of harvested agricultural commodities or otherwise enhancing their marketability, meeting consumer needs, developing environmentally friendly and efficient processing concepts, and expanding domestic and global market opportunities through the development of value-added food and nonfood technologies and products, except energy and fuels.

Program Vision

Research is focused on developing knowledge and technology for crop and animal product quality measurement and maintenance or enhancement during storage, processing and marketing; commodity and co-product into value-added materials; and new specialty products from crop and animals.

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

MISSION

- Improve END-USE QUALITY and VALUE of soft wheat produced in the Eastern U.S. for the domestic milling and baking industries and for export trade, through contribution to the development of wheat varieties of superior quality. The SWQL has sole responsibility for this within the USDA for the eastern United States (U.S.).
- Lead scientific research on end-use quality traits of soft wheat and their genetic connections, and develop efficient and reliable test methods for estimation of the milling and baking qualities of wheat.
- Contribute to the improvement in HUMAN NUTRITION and HEALTH, in collaboration with wheat foods processors and eastern U.S. wheat breeding programs, through identifying and deploying traits 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 end-use quality evaluation of soft wheat breeding lines and scientific research on wheat quality through long established coordinated research with state land-grant universities and private breeding programs in the eastern U.S., for the purpose of improving the milling and baking quality of soft wheat produced in the regions. 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.

Today, the SWQL evaluates in excess of 6,000 breeding lines and varieties submitted by 19 public and private breeding programs in 15 eastern states annually for end-use quality potentials for the development of wheat varieties possessing desirable quality. The SWQL also plays a pivotal role in the variety evaluation under the uniform Regional Variety testing programs, the Wheat Quality Council project for testing end-use quality potentials of newly released varieties, and the Overseas Varietal Analysis project for popularly grown wheat varieties for overseas users, in cooperation with the eastern soft wheat breeders, the Wheat Quality Council and U.S. Wheat Associates, respectively.

Since its establishment, the SWQL has enjoyed strong, continuous support from the regional milling and baking industries and in return has made significant contributions to the overall improvement in the quality of soft wheat that is produced in the region. No doubt, the solid cooperation from wheat breeding programs and milling and baking industries has been and will continue to be essential for the prosperity of the SWQL.

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, publications in refereed journals and presentations at international conferences. Our website makes SWQL data, protocols, cultivar descriptions and research news publicly available.

CURRENT FUNDING & STAFF

Current base funding ($870,423) supports a lead scientist, a post-doctoral research associate, six full-time and two part-time members of the scientific support staff (five USDA, two Ohio State), and also covers 25% of the research leader's salary and 10% of the salaries of two research support staff members in the corn and soybean programs. Through the sequestration cut and in-unit adjustments, the budget amount available to the SWQL has been reduced from $943,096 in FY 2012 to $825,593 in FY 2014.

Under these reduced budget conditions, the SWQL had to let go Sue Carson (full-time), Anita Kassuba-Middleton (part-time), and Will Ladrach (part-time), who assisted in the quality analysis of breeding lines. Cindy Hampton (part-time) was hired to help with the quality analysis. Dr. Taehyun Ji, post-doctoral research associate, was recently hired to temporarily fill the vacant second scientist position. We have four full-time and two part-time technical support staff members carrying out the quality evaluation of breeding lines and varieties, two full-time research technicians and two post-doctoral research associates working on research projects.

The laboratory continues to improve the efficiency and reliability of the quality evaluations of breeding lines and varieties under declining discretionary funds. Renovations to the flour milling facilities and mills are ongoing and will continue as funding permits. The ARS has purchased a thermogravitational analyzer (TGA), an automated ash content determinator, and a plot combine for timely harvest of wheat in the quality testing plots for the SWQL. In addition, the HVAC in the milling facility is scheduled to be replaced and updated for better control of humidity and temperature conditions.

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 U.S. (2007 production at $16 per 100# of flour). This reduces consumer's food costs. It also contributes to the improved efficiency and competitiveness of the eastern U.S. milling industry. The SWQL is currently conducting research to improve milling, quality testing methods, extended uses of soft wheat, functional properties of soft wheat flour, and human nutrition.

NEW IN 2014

The SWQL Annual Research Review was successfully conducted on March 18-19, 2013, in Wooster, OH with six guest speakers and 85 attendees from wheat breeding programs, universities, state wheat growers associations, foundation seeds programs and milling and baking industries.

Dr. Taehyun Ji recently joined the SWQL as a post-doctoral research associate. Two other post-doctoral research associates funded through the cooperative agreement with the Ohio State University are expected to begin working for the SWQL in March, 2014. One of them is paid from the cooperative research project funding (soft money). We are also hosting Dr. Asif Ahmad, a Fulbright scholar from Pakistan for a year beginning on March 20, 2014.

The SWQL Stakeholders Committee was newly formed. The committee will serve as a liaison between the SWQL and soft wheat industries, and provide suggestions to the lab in quality testing and research activities. The committee is composed of 2-3 representatives each from milling companies, baking companies and breeding programs. Pat Donahue, Carl Griffey, Grace Lai, Sherri Lehman, C.J. Lin, Don Mennel, Perry Ng, Rick Siemer and Clay Sneller have graciously agreed to serve on the SWQL Stakeholder Committee.

The SWQL was successful in obtaining the ARS equipment funding for the purchase of a thermogravitational analyzer for the automated determination of ash content, and a plot combine for the harvest of quality testing plots of eastern soft wheat varieties.

For the quality evaluation of wheat breeding lines, we have introduced two major changes in the protocol for efficient and reliable estimation of quality potentials of breeding lines. The changes include classifying the submitted breeding lines into 'Preliminary', 'Intermediate' or 'Advanced' groups, and subjecting them to appropriate intensities of end-use quality tests to be efficient and, at the same time, to supply the breeders with enough quality evaluation data for screening their lines. End-use quality evaluation of soft wheat varieties for the 2013 crop is in fair progress and is completed for over 60% of the tests. We have received about 6,000 breeding lines and varieties from 19 private and public breeding programs as well as state and regional uniform variety testing programs. Eleven WQC samples and ten OVA samples from the 2013 crop year were collected, cleaned, tested for grain characteristics, milled and sent out for processing and baking quality evaluation. The SWQL also published the 2012 crop OVA and 2013 WQC project reports based on the quality evaluation data obtained by the SWQL and domestic and overseas cooperators.

The SWQL currently works on two research projects. The first one determines the influences of storage time of flour after milling and storage time of grain after harvest on quality evaluation. We intend to generate a more accurate and reliable estimation of flour quality, since freshly milled flour (and also grain after harvest) goes through many biochemical changes during storage which could negatively affect the consistency of the test results. The time frame of flour and grain storage for reliable determination of wheat quality is expected to be identified. For the second project, we intend to develop a cake baking test procedure for non-chlorinated flour. Considering the safety concerns of chlorination and the technical difficulty in laboratory chlorination of a large number of

flour samples, it is important for us to develop a non-chlorinated flour test procedure for cake baking quality determination.

In 2013, the SWQL was recognized as the winner of the best cookie analysis, and was first runner-up in overall quality analysis among the 50 institutions competing throughout the American Association of Cereal Chemists International (AACCI) Cincinnati Section check sample evaluation. We are grateful to be recognized for our accuracy and professionalism in milling and baking evaluations.

We published the '2013 Annual Research Review Report', the 'Overseas Varietal Analysis Report for Crop Year 2012', and the Wheat Quality Council Report, 'Milling and Baking Test Results for Eastern Soft Wheats Harvested in 2013'. Dr. Baik was the corresponding author of two refereed journal articles on sponge cake baking quality of soft wheat and bran characteristics related to whole grain wheat flour functionality published in Cereal Chemistry, and three poster presentations at the American Association of Cereal Chemists International meeting in Albuquerque, NM in 2013.

2013 Soft Wheat Quality Lab Research

Current SWQL Research Projects

The SWQL has initiated several research projects directed toward reliable quality evaluation of wheat breeding lines and improvement of soft wheat milling and baking quality. Below is a list of the current research projects and those in the early stages of progress.

- Influence of post-milling storage time of flour and post-harvest storage time of grain on end-use quality evaluation
- Development of a cake baking test procedure for non-chlorinated flour
- Extended uses of soft red winter wheat in non-conventional food products (noodles, tortillas, steam buns)
- Genetic variation as it relates to the degree of starchy endosperm separation from bran during roller milling
- Effects of the heat drying of grain on functional properties of milled flour

With the first project, we will determine the influences of storage time of flour after milling and storage time of grain after harvest on quality evaluations for the purpose of generating a more accurate and reliable estimation of flour quality. Freshly milled flour and grain after harvest undergo many biochemical changes during storage, which could negatively affect the consistency of the test results. The optimum time frame for reliable determination of wheat quality is expected to be identified.

With the second project, we intend to develop a cake baking test procedure for non-chlorinated flour. Safety concerns of chlorination practices and the technical difficulty in laboratory chlorination of a large number of flour samples make it necessary for us to develop a cake baking test procedure that uses non-chlorinated flour for cake baking quality determination.

Our third project will explore the uses of soft red wheat in non-conventional wheat foods, such as noodles and tortillas, which are commonly consumed and gaining popularity in overseas and domestic markets. Soft red wheat for preparing steam buns, which are popular in China, will also be evaluated. Despite its great potential, soft red wheat is underused for production of these non-conventional products.

For the fourth project, we will determine the genetic variation in endosperm separation from bran during milling as related to flour yield, and also explore biochemical characteristics involved in endosperm separation from bran. We expect that the information obtained will be useful for the development of wheat varieties with improved milling quality, and may be beneficial for commercial milling operations.

For the fifth project, we will determine how heated drying conditions affect the quality of milled flour. Harvested wheat grain is often quite high in moisture content and needs to be dried to about 12% moisture. We are interested in achieving the improvement of flour quality for baking cakes by

the high temperature heat drying of grain, possibly simulating the heat treatment of flour often practiced in the flour milling industry.

WHOLE GRAIN PROCESSING FOR IMPROVED PRODUCT QUALITY

We have conducted a cooperative research project with the National Institute of Crop Science in the Rural Development Administration, Korea, and Washington State University exploring the improvement of whole grain wheat functionality. First, we investigated the influence of bran particle size on the bread-baking quality of whole grain wheat flour (WWF) and found that bran particle size significantly influenced dough properties and bread-baking quality of WWFs and starch retrogradation during storage. WWF prepared with finely ground bran required more water in the preparation of bread dough than WWF of coarsely ground bran. The effects of bran particle size on loaf volume of WWF bread and crumb firmness during storage were, however, not evident. We have concluded that compared with coarse grinding, fine grinding of bran produces a WWF bread of smooth appearance and improved mouthfeel, whereas it negatively affects the shelf life of bread by expediting starch retrogradation during storage. The results were published in the journal Cereal Chemistry (91:65–71, 2013).

The genetic variation of wheat in bran characteristics, and the bran characteristics influencing the functional properties of whole grain wheat flour for baking bread were explored using bran of 18 wheat varieties and bran blends with white flour to prepare whole grain wheat flours. There were large genetic variations in the characteristics of bran. Loaf volume of WWF bread prepared from blends of a wheat flour and bran of eighteen different wheat varieties was negatively correlated with insoluble fiber and phytate content, dough water absorption and mixing time of WWF. Bran of lower insoluble fiber content tended to yield relatively lower water absorption and higher bread loaf volume than that of high insoluble dietary fiber content. The information gained from this study could be used to predict the performance of wheat bran in whole grain wheat flour bread-baking and to screen wheat varieties for producing whole grain foods with enhanced product quality. A research article based on the results obtained was accepted for publication in the journal Cereal Chemistry.

The SWQL lead scientist also worked with two graduate students at Washington State University on research projects concerning 1) the hydrothermal and enzymatic treatments of wheat bran for the improvement of functional properties, 2) the influences of deep-oil frying on phenolics and antioxidant capacity of whole wheat donuts, and 3) bran characteristics and bread-baking quality of whole grain wheat flour. The results of those projects were presented during the 2013 American Association of Cereal Chemists International meeting in Albuquerque. The abstracts are copied below.

Effects of physical and enzymatic treatments of bran on functional and nutritional properties of whole wheat flour

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Consumers' interests in eating whole wheat bread are increasing as they become aware of health benefits of whole grain foods. Bran enhances nutritional attributes of whole wheat flour, but has undesirable effects on dough mixing and handling properties as well as bread

quality. Considering the negative effects of phytate and cell wall polysaccharides we observed in our previous studies, we hypothesized that physical and enzymatic treatments of bran would improve dough mixing properties and eventually baking quality of whole wheat flour. Bran of a hard red spring wheat (cv. Tara 2002) was obtained and treated with phytase, xylanase, cellulase and a combination of xylanase and cellulase for 90 min at the controlled conditions of 55°C, pH 5.3 and moisture contents of 25 and 50%. The enzyme treated bran was evaluated for soluble sugar content, solvent retention capacity and dough mixing properties. Soluble sugar content of bran was increased with xylanase and cellulase treatments, especially at 50% bran moisture content. Bran treated with 50% moisture without enzymes showed higher soluble sugar content than untreated bran, possibly due to the actions of endogenous enzymes. Bran treated with cellulase and a combination of xylanase and cellulase exhibited lower water retention capacity than control at both 25 and 50% moisture contents. Cellulase and a combination of xylanase and cellulase treatment of bran at 50% moisture decreased mixograph water absorption and increased mixing time and stability of bran-flour blends. Results suggest that physical and enzymatic treatment of bran may improve deleterious mixing properties and baking quality of whole wheat flour by changing the physicochemical properties of bran.

Effect of deep-oil frying on antioxidant properties of whole grain wheat donuts

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Deep-oil frying (DOF) consists of cooking foods by immersing them in edible oil at 160 to 190°C. The high temperature may affect the nutritional quality of foods, including antioxidant capacity. Whole grain donuts formulation may be one option to improve the nutritional quality of donuts. The total phenolic content (TPC), phenolic acid composition, and *in vitro* antioxidant capacity of whole wheat donuts deep-oil fried (DOFd) for different lengths of time (1, 2, 3, or 4 min), and at different temperatures (120, 140, 160, or 180°C) were studied. Significant differences ($P<0.05$) between donuts fried for different lengths of time, and temperatures were recorded in TPC of donuts. TPC increased by 112.2% for hard red whole grain wheat meal donuts (HWD), 83.5% for soft wheat flour donuts (SFD), and 72.5% for soft whole grain wheat meal donut (SWD); and decreased with further increase in frying time. TPC increased with frying temperature from 120 to 180°C frying, by 73.7% for HWD, 59.4% for SFD, and 36.1% for SWD. The same trend was confirmed by data from HPLC, and ferulic was the predominant phenolic acid, followed by coumaric, vanillic, p-hydroxybenzoic, chlorogenic, catechuic, and caffeic acids. DPPH radical and iron chelating capacity of DOFd donuts increased with frying time of 1 to 3 min at 190°C, and frying temperature of 120 to 180°C. Lipid peroxidation inhibition capacity of donuts increased with up to 3 min frying at 190°C, and decreased with extended frying time in all donuts. Conversely, DOF at 120°C initially lowered lipid peroxidation inhibition capacity of all three types of donuts, and increased consistently from 120 to 180°C. In conclusion, moderate DOF time and temperature may increase the level and activity of antioxidants of foods. Hard wheat donuts showed lower volume and fat uptake, and future study may be needed to produce acceptable low fat donuts.

Bran characteristics and bread-baking quality of whole grain wheat flour

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Bran provides nutritional advantages to whole wheat flour (WWF) over wheat flour, but negatively affects quality and sensory acceptance of whole wheat bread. Considering the genetic diversity of wheat and significant environmental influences on grain quality, characteristics of wheat bran could vary widely and differentially affect the baking quality of bread, depending on its sources. Bran of 18 wheat varieties of various classes was obtained from roller milling, characterized for composition and mixed with wheat flour for determination of dough properties and bread baking quality. The protein, fat, ash and insoluble dietary fiber (IDF) content were 12.9-18.3%, 3.8-5.4%, 6.3-8.2% and 46.0-51.3% in hard wheat bran, and 11.1-18.9%, 3.8-4.9%, 4.6-8.1% and 40.7-50.6% in soft and club wheat bran. Bran of various wheat varieties was blended with a hard red spring wheat flour at a ratio of 1:4 to prepare WWFs. WWFs with hard wheat bran generally exhibited higher dough water absorption and longer dough mixing time, and produced smaller loaf volume of bread than WWFs of soft and club wheat bran. IDF content and water retention capacity of bran exhibited a significant relationship to loaf volume of WWF bread, whereas no relationship was observed between protein content of bran and loaf volume of bread. Negative correlation between total dietary fiber content and changes in crumb springiness and cohesiveness during storage was found, indicating that fiber has adverse effects on the textural profile of WWF bread during storage. It appears that soft wheat bran, probably owing to relatively low IDF content, has smaller negative effects on mixing properties of WWF dough and loaf volume of bread than hard wheat bran.

END-USE QUALITY EVALUATION OF WHEAT BREEDING LINES AND VARIETIES

Cooperators have submitted around 6,000 samples harvested in the 2013 crop year for end-use quality evaluation. Analyses for more than 55% of these samples were completed by February, 2013. The test results have been summarized and provided to the breeding program by the SWQL. We expect to complete all tests of breeding lines and varieties before the end of May.

For quality evaluation of wheat breeding lines, we introduced two major changes in the protocol for the efficient and reliable estimation of breeding lines' quality potentials. Breeding lines submitted to the SWQL are now placed into 'Preliminary', 'Intermediate' or 'Advanced' groups, based on end-use quality parameters and depending on the breeding stages and screening needs. Grain characteristics (test weight, kernel hardness and protein content) and quadrumat test milling properties are determined for all of the wheat breeding lines submitted to the SWQL. Intermediate and advanced group samples are further tested for flour composition (protein, moisture and ash (optional)) and sodium carbonate and lactic acid SRCs. Only advanced group samples undergo the sugar-snap cookie baking test.

The second modification was made in the quadrumat test milling. Preliminary group samples are milled using only the break roll unit mill to produce bran, break flour and middling, which are used for calculation of flour yield and softness equivalence. Intermediate and advanced group samples are milled using both the break roll unit and reduction roll unit mills to produce bran, break flour,

reduction flour and shorts. Break and reduction flours are combined and blended for flour quality and sugar-snap cookie baking tests.

Flour quality testing of breeding lines routinely includes only sodium carbonate and lactic acid SRC tests, since the 1-g version of the sucrose SRC test was found to give too much variation in test values to be reliable as compared to the 5-g test. The 1-g sucrose test had been adopted previously by the SWQL to handle a large number of breeding lines. The SWQL is not adequately equipped to run the 5-g sucrose SRC test for a large number of breeding lines.

The SWQL continues to collaborate with the Wheat Quality Council and U.S. Wheat Associates to mill and ship flour for the Wheat Quality Council (WQC) and Overseas Varietal Analysis (OVA) projects, respectively. In 2013, a total of 21 wheat varieties were processed and distributed for these two projects.

Development of Quality Targets for Eastern Soft Winter Wheat

The SWQL has exerted continuous efforts in the development of quality targets for eastern soft winter wheat with the eventual purpose of improving the end-use quality of wheat produced in the region. In the previous year, an attempt to establish quality targets for eastern soft wheat was made during the Annual Research Review meeting. Our approach was to 1) reduce the number of quality target parameters; 2) combine the pastry and cracker targets, with the exception of protein content and quality parameters like lactic acid SRC; and 3) prepare targets based on quality parameters the SWQL routinely determines for the breeding lines and varieties. During the quality targets forum, contrasting views and opinions were voiced from the stakeholders. With differences in opinions from the milling and baking industries as well as soft wheat breeders, development of the quality targets was deferred to further discussion.

Considering the importance and benefits of establishing quality targets, especially for breeding programs to screen wheat breeding lines for development of wheat varieties possessing desirable end-use quality, we will again hold a forum on the quality targets during the 2014 SWQL Annual Research Review Meeting. Unlike the efforts in previous years, we will focus only on the quality evaluation parameters that the SWQL determines for breeding lines. We will take a two-step approach, addressing first the minimum number of quality targets required and then extend the list to take on additional quality targets. The minimum quality targets will include SWQL test parameters essential for the selection of breeding lines possessing the required quality potentials, whereas the extended quality targets will expand the number of test parameters to adopt those useful for the identification of the most desirable end uses. With the successful selection of the quality targets parameters, we will have a panel discussion to set target numbers and ranges for each quality target parameter. The established quality targets are expected to be effectively used by the breeders and by milling and baking industries of eastern soft wheat as guidelines in the screening of breeding lines for the former and procurement of grain and flour for the latter.

GENETICS

Anne Sturbaum, SWQL

SOFTNESS

Softness in wheat kernels depends on the expression of the purindoline genes, *Pina-D1* and *Pinb-D1*, located at the hardness locus, *HA*, on chromosome 5D of hexaploid wheat (Bhave and Morris, 2008). A second *HA* locus, derived from *Triticum monococcum* chromosome 5A, was introgressed as $5A^m$-*HA* into the soft cultivar Chinese Spring (Bonafede et al., 2007). The SWQL used the Chinese Spring $5A^m$ germplasm to introduce a second *HA* "softness locus" into the soft red winter wheat lines, USG3555 and OH04.264-58. All parents, USG3555, OH04.264-58 and Chinese Spring 5Am are homozygous for the 'soft alleles' at the *HA* locus on chr. 5D. The recurrent parent USG3555 has good disease resistance and OH04.264-58 is a strong gluten line, but both are harder than typical soft wheats. We selected for the $5A^m$ *HA* locus in USG3555 and OH04.264-58 crosses with Chinese Spring $5A^m$ to produce lines containing two *HA* loci, one locus on each of chromosomes 5A and 5D.

To test whether the presence of the second locus increases softness, we selected BC_3F_7 and BC_4F_7 lines, homozygous and heterozygous for $5A^m$-*HA* to test in the field in 2012 and 2013. Harvested grain was tested for softness using the single kernel characterization system (SKCS). Irrespective of the background (USG3555 or OH04.264-58), introgression lines with $5A^m$-*HA* had significantly lower SKCS values than near-isogenic lines with loci from the recurrent parent on chr. 5A. Although the number of lines evaluated was low, the trend was observed over two years in at least 3 sets of lines.

These results indicate that addition of the $5A^m$-*HA* locus to eastern red soft wheat increases kernel softness. The lines will be evaluated for softness, and milling and baking quality in 2014. In addition to their value as breeding materials, near-isogenic lines producing different amounts of purindolines will be useful for biochemical studies of flour softness.

SUCROSE SYNTHASE

Starch makes up roughly 80% of the wheat endosperm and is composed of amylose and amylopectin in a ratio of approximately 1:3 (Shewry et al., 2013). Sucrose synthase type 2 (*TaSus2*), encoded as an orthologous series on chromosomes 2A, 2B and 2D in wheat (Jiang et al., 2011), functions to catalyze the hydrolysis of sucrose into glucose and fructose and to produce ADP-Glucose, the precursor to starch synthesis. *TaSus2* is a highly regulated, cytosolic enzyme expressed in the endosperm (Emes et al., 2003). A recent study reported that potato sucrose synthase, introduced transgenically into maize, increased starch quantity and altered starch amylose to amylopectin ratios (Li et al., 2013). Genetic mapping of quality traits in Asian and European wheats identified haplotypes of *TaSus2* from chromosome 2B, one of which was associated with increased thousand grain weight (*TaSus2-HapH*) (Jiang et al., 2011). The metabolic function, tissue specificity and natural diversity of *TaSus2* within wheat make it a candidate gene for controlling wheat quality.

VARIABILITY AT TASUS2

The *TaSus2-HapH* allele for high thousand grain weight described above occurs in about 20% of the cultivars genotyped at the SWQL. Unlike the Asian and European hard wheats described (Jiang et al., 2011), we observed that *TaSus2-HapH* in the eastern soft wheats was most frequently linked to the *Sr36* gene for stem rust resistance derived from a large chromosomal translocation from *Triticum timopheevi* (Tsilo et al., 2008). Sequence analysis of the *TaSus2-HapH* allele from an eastern soft wheat (Foster) revealed at least 2 single nucleotide polymorphisms compared to the published sequence (Jiang et al., 2011). Thus, there appears to be a novel allele for *TaSus2* associated with the 2B translocation, designated *TaSus2-HapG*, for its derivation from the G genome of *T. timopheevi* (Tsilo et al., 2008, Nath et al., 1985). Development of germplasm required to test the effects of this allele on traits for milling quality associated with chromosome 2B was impeded by the translocation's effect of repressed recombination in the chromosomal region.

FIELD STUDIES

Highly heritable soft wheat quality traits are flour yield (FY) and softness equivalence (SE) (Souza et al., 2012). These traits are influenced by independent QTL on chromosome 2B located close to an SSR marker (gwm429) and the *TaSus2* gene (Smith et al., 2011, Lehmensiek et al., 2006, Sturbaum et al., 2012, Jiang et al., 2011). The QTL were targeted for fine mapping in a back-crossed, bi-parental mapping population (Foster X Kanqueen) developed by Mark Sorrells (Cornell University). Foster has high FY, high SE and the *TaSus2-HapG*. Kanqueen has low SE and FY and no known translocations. Probably because of the suppressed recombination on chromosome 2B, we identified only a single, recombinant backcrossed inbred line with the QTL marker from Kanqueen (*gwm429*) in the Foster background out of 6000 lines tested.

In BC_1F_6 FxK-13 grain from 2013, SE and SKCS hardness were strongly associated with the Kanqueen allele for the SE QTL marker (*gwm429*). All lines evaluated had the *TaSus2-HapG* allele from the recurrent parent, Foster. Lines with the Kanqueen allele for gwm429 had the highest mean SE (63.4) and lowest SKCS hardness (16.3). FY was not significantly different among the lines. These data suggest that SE may be influenced by the presence of the 2B translocation and that the FY QTL is more closely associated with the *TaSus2* gene than the gwm429 marker. The FxK-13 recombinant line, with increased softness, could provide germplasm useful for breeding improved softness while retaining good flour yield and disease resistance.

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VARIETY DESCRIPTIONS – NEW WHEAT CULTIVARS

Information on new releases is important to breeders in the wheat community. We include a compilation of new releases tested at the SWQL. Descriptions of new wheat cultivars are listed by contributing collaborator. Descriptions of soft wheats grown historically at the SWQL are listed on our website: http://ars.usda.gov/Main/docs.htm?docid=21433.

The SWQL thanks each of the breeders, growers and researchers for his/her contributions providing cultivar descriptions for this report.

MICHIGAN STATE UNIVERSITY – ERIC OLSON

MSU LINE F0014

Soft White Winter Wheat

The experimental soft white winter wheat MSU Line F0014 is derived from the cross P2552/E0029. F0014 was entered in the 2013 Michigan State Performance Trials where it yielded 80.6 Bu/ac. This line carries the Rht-D1b dwarfing allele and is photoperiod insensitive. F0014 carries neither the 1RS:1BL nor the 1RS:1AL rye translocation. This line is resistant to soilborne mosaic virus. F0014 does carry the glutenin overexpression allele, $Bx7^{oe}$. F0014 is shorter than D8006 at 31.4 inches and flowers 155.2 days past January 1.

MSU LINE F0039

Soft White Winter Wheat

The experimental soft white winter wheat MSU Line F0039 is derived from the cross D8006/CJ 9306//Caledonia/3/Caledonia/4/Caledonia. F0039 was entered in the 2013 Michigan State Performance Trials where it yielded 81.1 Bu/ac. This line carries the Rht-D1b dwarfing allele and is photoperiod sensitive. F0039 carries neither the 1RS:1BL nor the 1RS:1AL rye translocation. The line is resistant to Soilborne Mosaic Virus. In 2013, F0039 demonstrated a lower than average FHB index at 6.6 ($P<0.05$). F0039 is similar in height to D8006 at 33.6 inches and flowers 155.7 days past January 1.

MSU LINE F0065

Soft White Winter Wheat

The experimental soft white winter wheat MSU Line F0065 is derived from the cross D8006/CJ 9306//Caledonia/3/Caledonia/4/Caledonia. F0065 was entered in the 2013 Michigan State Performance Trials where it yielded 80.6 Bu/ac. This line carries the Rht-D1b dwarfing allele and is photoperiod sensitive. F0065 carries neither the 1RS:1BL nor the 1RS:1AL rye translocation. The line is resistant to soilborne mosaic virus. F0065 is taller than D8006 at 35.5 inches and flowers 156.2 days past January 1.

RUPP SEEDS – JOHN KING

RS907
Soft Red Winter Wheat

RS907 was developed from a unique genetic pool featuring high yields and strong agronomics. It features outstanding test weight and standability. RS907 is an awned, medium to late heading, soft red winter wheat of medium height with very good winter hardiness. RS907 is highly tolerant to scab (FHB) and tolerant to powdery mildew and Septoria glume blotch.

RS935
Soft Red Winter Wheat

RS935 is a medium early heading soft red winter wheat variety that has established a multi-year yield record. It works well on all soil types and exhibits good head scab tolerance. RS935 is medium short, awned with excellent standability, very good winter hardiness and average test weight. It is moderately resistant to head scab (FHB), powdery mildew and Septoria glume blotch.

RS967
Soft Red Winter Wheat

RS967 is a line that has tremendous yield potential. RS967 is a medium maturing variety with good test weight, stiff straw and scab resistance as its defining characteristics. RS967 is a soft red winter wheat of medium height, awned, with excellent standability and very good test weight and winter hardiness. RS967 is Resistant to head scab (FHB), moderately resistant to powdery mildew and Septoria glume blotch.

RS979 - MEDIUM
Soft Red Winter Wheat

RS979 is a medium maturing soft red winter wheat with top notch scab tolerance, leading to high yields. RS979 is an awnless variety of medium height with very good standability and excellent winter hardiness. RS 979 has very good test weight, is highly tolerant to scab and tolerant to powdery mildew and Septoria glume blotch.

RS972
Soft Red Winter Wheat

RS972 is a medium to late maturing soft red winter wheat with superior yields and excellent test weight. RS972 is a medium height, awnless variety with excellent standability and very good winter hardiness. RS972 has excellent test weight and is highly tolerant to scab (FHB) and tolerant to powdery mildew and Septoria glume blotch.

SEED CONSULTANTS – BILL MULLEN

SC 1321
Soft Red Winter Wheat

SC1321 is a bearded, medium maturing soft red winter wheat with high yield potential adapted throughout Ohio, Indiana, Illinois and Kentucky. SC1321 has very good test weight, plant health and standability as well as excellent winter hardiness and a solid disease package.

SC 1342
Soft Red Winter Wheat

SC1342 is a soft red, awnless winter wheat with superior yield potential and excellent test weight. SC1342 is a medium tall, medium-late maturing variety allowing for longer grain fill time. It has very good disease tolerances, including head scab, glume blotch and barley yellow dwarf.

STEYER SEEDS – DEREK AND HEATHER HUNKER

DOWELL
Soft Red Winter Wheat

Dowell is a medium height, medium maturing, awnless, soft red winter wheat with excellent yield potential and scab tolerance. It handles wet conditions well. Dowell has very good test weight, excellent lodging resistance and winter hardiness. Dowell has excellent resistance to scab (FHB), powdery mildew and barley yellow dwarf virus, very good resistance to leaf and stem rusts, Septoria leaf and glume blotch, and good resistance to soil borne mosaic virus and Hessian fly.

SYNGENTA – BARTON FOGLEMAN

SY CYPRESS
Soft Red Winter Wheat

SY Cypress (test name B08*0313) is a soft red winter wheat, bred and developed by Syngenta Seeds, Inc. SY Cypress is a medium-short height, semi-dwarf variety and has white chaff at maturity. It has early maturity and its heading date is about one day earlier than USG 3120 and it averaged about three days earlier than AGS 2035. SY Cypress has shown best adaptation to the wheat growing areas of Louisiana, southern Georgia and eastern South Carolina. It has shown moderate resistance to the races of powdery mildew and leaf rust in these areas. It has shown a moderate resistance/moderate susceptibility reaction to the current race of stripe rust in Louisiana. It is likely also well adapted to south Mississippi and south Alabama. Milling and baking characteristics are good and this variety is intended for grain production.

Juvenile growth habit of SY Cypress is erect. Plant color at boot stage is blue green. Anther color is yellow. Auricle anthocyanin is absent. Flag leaf at boot stage is erect and twisted and wax is present. Head shape is tapering and awned. Glumes are mid-long in length. Glume shoulder shape is elevated with an acuminate beak. Chaff color is white at maturity. Seed shape is ovate. Brush hairs on the seed are mid-long in length and occupy a medium area of the seed tip. Seed cheeks are rounded.

Syngenta Seeds, Inc. maintains seed stock and certified classes of foundation, registered and certified. Limited amounts of certified seed stocks of SY Cypress will be available in the fall of 2014. Certified acreage is not to be published by AOSCA and certifying agencies. SY Cypress may only be sold as a class of certified seed and all seed sales are royalty bearing.

SYNGENTA – JENNIFER VONDERWELL

M10-1100#

Soft Red Winter Wheat

M10-1100# is a soft red winter wheat bred by Syngenta Seeds, Inc. for grain production. M10-1100# is a medium tall semi-dwarf variety and has white chaff at maturity. It has medium maturity and its heading is a day later than W1104. M10-1100# has shown above average test weight, moderate resistance to Fusarium head blight, moderate resistance to all prevalent leaf diseases in the Midwest and mid-Atlantic including current races of powdery mildew, leaf rust and stripe rusts. It has tested moderately susceptible to Septoria leaf blight. It has above average milling and cookie qualities and is an above average broad adaptation end use market variety. M10-1100# 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.

M09-9513

Soft Red Winter Wheat

M09-9513 is a soft red winter wheat bred by Syngenta Seeds, Inc. for grain production. M09-9513 is a medium tall semi-dwarf variety and has white chaff at maturity. It has medium-early maturity and its heading is a similar to Branson. It has tested above average winter survival over the last 4 years. M09-9513 has shown average test weight, moderate resistance to Fusarium head blight, and moderate susceptibility to leaf rust and stripe rusts, and Septoria leaf blight. It has average milling and cookie qualities and is an average broad adaptation end use market variety. M09-9513 has tested well and 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 547 (FORMERLY M09L-9547)

Soft Red Winter Wheat

SY 547 is a soft red winter wheat, bred and developed by Syngenta Seeds, Inc. SY 547 was selected for height, maturity, appearance, and kernel soundness using a modified bulk breeding method that originated with a single cross made in February of 2003. SY 547 is a medium tall semi-dwarf variety and has white chaff at maturity. It has medium maturity and its heading is a half day earlier than SY 474, and about a day later than Branson. SY 547 has shown a wide adaptation with above average check yield performance in the Great Lakes Region, Midwest, Mid-South, North East and Mid-Atlantic. The highest yield advantage has been in the double crop region of Southern IL. SY 547 is moderately resistant to powdery mildew, soilborne virus and fungal leaf blights. It has tested average tolerance to current races of stripe & leaf rust and Fusarium head blight, and is known to be moderately susceptible to barley yellow dwarf virus.

Syngenta Seeds, Inc. maintains seed stock and certified classes of Foundation, Registered and Certified. Certified seed stocks of SY 547 will be available in the fall of 2015. Certified acreage is not to be published by AOSCA and certifying agencies and SY 547 may only be sold as a class of certified seed.

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 483 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).

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.

VIRGINIA TECH – CARL GRIFFEY

VA07W-415

Soft Red Winter Wheat

The soft red winter wheat line VA07W-415 was developed by the Virginia Agricultural Experiment Station in March 2013 and released as variety '072014415'. It was derived from the cross VA98W-895 / GA881130LE5 // VA98W-627. The pedigree of VA98W-895 is 'Roane' sib (VA92-51-38) // KS89WGRC04 (PI 535767) / 'Coker 9835'. The pedigree of GA881130LE5 is KSH8998 / FR 81-10 // 'Gore' (PI 561842). Parentage of VA98W-627 is VA92-52-11 (A55-2 // 'Axminster' / 9* 'Chancellor' /3/ Pioneer Brand '2550') / 'Coker 9803'.

VA07W-415 was derived as a bulk of an $F_{4:5}$ headrow and was evaluated over four years (2009 – 2012) in Virginia's State Variety Trials and throughout the soft red winter (SRW) wheat region in the USDA-ARS Uniform Eastern Soft Red Winter Wheat Nursery in 2010. VA07W-415 is a broadly adapted, high yielding, full-season, short height semi-dwarf (gene *Rht*2). Plant color of VA07W-415 is blue green. At maturity VA07W-415 has creamy white colored, strap shaped, spikes with short tip awns, and yellow colored straw. In the southern SRW wheat region, head emergence of VA07W-415 (106 d) is about 1 day later than 'USG 3555'. In the eastern SRW wheat region, head emergence of VA07W-415 (130.5 d) also is about 1 d later than 'Branson' and 1 d earlier than 'Shirley'. Average mature plant height of VA07W-415 has varied from 35 to 38 inches and is similar to that of Pioneer Brand '25R15' and 1 to 2 inches taller than Branson. On average, straw strength (0=erect to 9=completely lodged) of VA07W-415 (0.5 – 3.6) is good being most similar to that of 'Chesapeake' (0.9 – 3.7) and better than that of '5187J' (1.9 – 4.5). Winter kill (0 = none to 9 = complete) of VA07W-415 (0.9) in the 2010 Uniform Eastern Nursery was most similar to those of check cultivars Bess (0.6) and Shirley (1.2).

In Virginia's State Variety Trials (2010 – 2012), VA07W-415 had a mean grain yield (88 Bu/ac) that was similar to that (89 Bu/ac) of the highest yielding cultivars Shirley and Featherstone Brand 'VA258'. Over the same period, VA07W-415 had a mean test weight (59.5 Lb/Bu) that was significantly higher than those of Shirley (58.1 Lb/Bu) and USG 3555 (58.8 Lb/Bu).

Grain samples of VA07W-415 produced in six crop environments (2009 – 2012) were evaluated for end use quality by the USDA-ARS Soft Wheat Quality Lab. Over four common environments, VA07W-415 had a mean milling quality score (72.8) that was higher than those of Branson (67.0) and Shirley (68.0). Over four other environments, VA07W-415 had a mean baking quality score (58.0) and cookie diameter (18.5 cm) that was similar to those of Pioneer 25R15 (57.6 and 18.4

cm). On average, flour protein concentration of VA07W-415 (8.19%) is higher than those of Branson (7.94%) and Shirley (7.84%), while gluten strength of VA07W-415 (109%) and Branson (110%) are higher than that of Shirley (90%). Like Branson, flour of VA07W-415 is suitable for use in making products requiring stronger gluten strength such as crackers as well as pastry products.

VA07W-415 has performed well in tests from Griffin, Georgia, to Ithaca, New York, and throughout the mid-Atlantic region. VA07W-415 is resistant to Hessian fly [*Mayetiola destructor* (Say)] biotypes B, C, D, O, and L and possesses gene *H13*. It also has the *Lr37/Yr17/Sr38* gene complex that governs resistance to leaf rust (*Puccinia triticina*), stripe rust (*Puccinia striiformis*), and stem rust (*Puccinia graminis*). With the exception of Fusarium head blight, stem rust, and potentially wheat spindle streak mosaic virus, VA07W-415 expresses moderate to high levels of resistance to diseases prevalent in the SRW wheat region. Production of this cultivar likely will require use of fungicides, particularly for Fusarium head blight, in regions where this pathogen and stem rust are prevalent and deemed to be a problem.

Breeder seed of VA07W-415 was planted by Virginia Crop Improvement Association (VCIA) on 0.4 acre at their Foundation Seed farm during fall 2011. Twenty-four units (50 Lb/unit) of seed harvested in summer 2012 were sown in the fall on 8 acres at the VCIA Foundation Seed farm to produce Foundation seed for distribution to seedsmen. VA07W-415 will be marketed by FFR and Southern States Cooperatives.

VA09W-75

Soft Red Winter Wheat

The soft red winter wheat line VA09W-75 was developed by the Virginia Agricultural Experiment Station and released March 2013 as cultivar 'Southern Harvest 3200'. It 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).

VA09W-75 was derived as a bulk of an $F_{5:6}$ headrow selected in 2008 and was evaluated over two years (2011 and 2012) in Virginia's State Variety Trials and throughout most of the soft red winter (SRW) wheat region in the 2012 USDA-ARS Uniform Southern Soft Red Winter Wheat Nursery.

VA09W-75 is a broadly adapted, high yielding, mid-season heading, short height semi-dwarf (gene *Rht*2). At maturity, VA09W-75 has white colored spikes and straw with trace anthocyanin. Its awnletted spikes are semi-erect and strap in shape. In the southern SRW wheat region, head emergence of VA09W-75 (96 d) was most similar to that of Pioneer Brand '26R61', 3 d later than 'Jamestown', and 1 d earlier than 'USG 3555'. Average mature plant height of VA09W-75 has varied from 33 to 36 inches and is similar in height to one inch shorter than 'Branson', 2 to 3 inches shorter than Pioneer Brand '25R15', and 2 to 3 inches taller than USG 3555. Straw strength (0=erect to 9=completely lodged) of VA09W-75 (0.6 – 3.5) is good being most similar to that of 'USG 3555' (0.8 – 4.0) and better than that of Featherstone 'VA258' (2.8 – 4.8). In the Uniform Southern Nursery, VA09W-75 had survival ratings in controlled environment freeze tests conducted by the

USDA-ARS of 57.5% versus ratings of 27.5% for USG 3555, 47.5% for 'AGS 2000', 77.5% for Jamestown, and 87.5% for Pioneer Brand 26R61.

VA09W-75 was evaluated at 21 locations in the 2012 USDA-ARS Uniform Southern SRW Wheat Nursery and ranked third over locations for grain yield (67.8 Bu/ac) among 29 entries. Average test weight of VA09W-75 (57.6 Lb/Bu) was most similar to that of check cultivar AGS 2000 (57.5 Lb/Bu), higher than that of USG 3555 (56.8 Lb/Bu), but lower than that of Jamestown (59.3 Lb/Bu).

Grain samples of VA09W-75 produced in six crop environments (2011 and 2012) were evaluated for end use quality by the USDA-ARS Soft Wheat Quality Lab. VA09W-75 has exhibited milling and baking qualities that are intermediate between those of Branson and USG 3555. Average milling and baking quality attributes over three environments for VA09W-75 versus USG 3555 include: milling quality score (60.4 vs. 56.3), baking quality score (55.3 vs. 42.7), softness equivalence score (72.8 vs. 63.1), flour yield (68.2% vs. 67.3%), flour protein (7.61% vs. 8.60%), gluten strength (lactic acid retention capacity 107.9% vs. 111.9%), and cookie spread diameter (18.2 vs. 18.1 cm). Over all six environments, gluten strength of VA09W-75 (113.0%) has been superior to that of Shirley (89.9%), thus flour of VA09W-75 should be suitable for making crackers and other products requiring gluten strength as well as pastries.

VA09W-75 has performed well in SRW wheat production areas of the Deep South, southern Corn Belt, and mid-Atlantic regions. With the exception of wheat soil borne mosaic virus, *Stagonospora nodorum* blotch, and potentially wheat spindle streak mosaic virus and Hessian fly, VA09W-75 expresses moderate to high levels of resistance to diseases prevalent in the SRW wheat region. These include leaf, stripe and stem rusts, powdery mildew, Fusarium head blight, *Septoria tritici* leaf blotch, and barley yellow dwarf virus.

Breeder seed of VA09W-75 was planted by Virginia Crop Improvement Association (VCIA) on one acre at their Foundation Seed farm during fall 2011 and produced 84 units (50 lb/ unit). Seed produced from this initial increase was grown on 15 acres during the 2012-13 crop season to produce foundation seed for distribution to seedsmen. VA09W-75 will be marketed as 'Southern Harvest 3200' by Meherrin based in Raleigh, NC.

VA09W-73

Soft Red Winter Wheat

The soft red winter wheat line VA09W-73 was developed by the Virginia Agricultural Experimental Station and released in March 2013 as cultivar 'Featherstone 73'. It 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).

VA09W-73 was derived as a bulk of an $F_{5:6}$ headrow selected in 2008 and was evaluated over two years (2011 and 2012) in Virginia's State Variety Trials and throughout most of the soft red winter (SRW) wheat region in the 2012 USDA-ARS Uniform Eastern Soft Red Winter Wheat Nursery. VA09W-73 is a broadly adapted, high yielding, full-season, short height semi-dwarf (gene *Rht*2).

Plant stem and spike color of VA09W-73 is blue, and spikes are strap shaped with short tip awns. In the eastern SRW wheat region, head emergence of VA09W-73 (116 d) was most similar to that of 'Branson', and 2 d earlier than 'Shirley'. Average mature plant height of VA09W-73 has varied from 33 to 36 inches and is similar in height to one inch shorter than Branson and about two inches taller than Shirley. Straw strength (0=erect to 9=completely lodged) of VA09W-73 (0.9 – 3.6) is good being most similar to 'USG 3555' (0.8 – 4.0) and better than Featherstone 'VA258' (2.8 – 4.8). In the Uniform Eastern Nursery, winter hardiness and spring freeze tolerance (0 = no injury to 9 = severe injury) of VA09W-73 (1.2 and 0.4) were similar to those (1.1 – 1.4 and 0.2 – 0.5) of check cultivars 'Bess', Branson and Shirley.

VA09W-73 was evaluated at 25 locations in the 2012 USDA-ARS Uniform Eastern SRW Wheat Nursery, and ranked second over locations for grain yield (77.1 Bu/ac) among 35 entries. Average test weight of VA09W-73 (60.2 Lb/Bu) was most similar to that of check cultivar Bess (59.7 Lb/Bu) and significantly ($P \leq 0.05$) higher than those of Branson (58.4 Lb/Bu) and Shirley (57.2 Lb/Bu).

Grain samples of VA09W-73 produced in six crop environments (2011 and 2012) were evaluated for end use quality by the USDA-ARS Soft Wheat Quality Lab. VA09W-73 has exhibited milling and baking qualities that are intermediate between those of Branson and USG 3555. Comparisons of milling and baking quality attributes over five crop environments for VA09W-73 versus Branson include: milling quality score (61.2 vs. 66.0), baking quality score (67.2 vs. 68.1), softness equivalence score (71.0 vs. 78.2), flour yield (68.4% vs. 69.4%), flour protein (8.29% vs. 8.17%), gluten strength (lactic acid retention capacity 112.7% vs. 114.9%), and cookie spread diameter (18.27 vs. 18.41 cm). Over all six environments, gluten strength of VA09W-73 (112.0%) has been superior to that of Shirley (89.9%), thus flour of VA09W-73 would be suitable for making crackers and other products requiring gluten strength as well as pastries.

VA09W-73 is a widely adapted wheat cultivar that has performed well over most of the SRW wheat production areas from northern Louisiana to Ontario. With the exception of stem rust, wheat soil borne mosaic virus and potentially wheat spindle streak mosaic virus and Hessian fly, VA09W-73 expresses moderate to high levels of resistance to diseases prevalent in the SRW wheat region. These include leaf and stripe rusts, powdery mildew, leaf and glume blotches, Fusarium head blight, and *Barley Yellow Dwarf Virus*.

Initial breeder seed of VA09W-73 was grown on 0.4 ac at the Virginia Crop Improvement Association's (VCIA) Foundation seed farm in 2011-12. The 20 units (50 lb/unit) of seed produced from this initial increase were grown on eight acres during the 2012-13 crop season to produce foundation seed for distribution to seedsmen. VA09W-73 will be marketed as 'Featherstone 73' by Featherstone Farm Seed in Amelia, VA.

VA09W-188WS SOFT

Soft White Winter Wheat

The soft white winter wheat line VA09W-188WS was developed by the Virginia Agricultural Experiment Station and released in March 2013 as cultivar 'MCIA Venus'. It was derived from the cross Pioneer Brand '25W60' (PI 607579) // Pioneer Brand '25W33' (PI 599197) / VAN98W-

170WS. The pedigree of VAN98W-170WS is 'FFR 555W' (PI 560318) / 'GA-Gore' (PI 561842) // 'Coker 9803' (PI 548845) / VA87-54-636. Line VA09W-188WS was derived as a bulk of an $F_{5:6}$ headrow selected in 2008 and was evaluated in the Uniform Eastern Soft White Winter Wheat Nursery and in Virginia's State Wheat Variety Trials in 2011 and 2012.

VA09W-188WS is a broadly adapted, high yielding, early heading, medium height semi-dwarf (gene *Rht*2). At maturity, VA09W-188WS has yellow colored straw and spikes with the latter being slightly recurved, tapering in shape, and awned. In the northeastern soft winter wheat regions of the U.S. and Ontario, Canada, average head emergence of VA09W-188WS (139 – 157 d) was 2 to 4 days earlier than 'Caledonia' and 4 to 7 days earlier than 'Superior'. Average mature plant height of VA09W-188WS has varied from 36 to 41 inches. It is most similar in height to Featherstone Brand 'VA258', 2 to 3 inches taller than Branson, and 3 to 5 inches shorter than Superior. Straw strength (0=erect to 9=completely lodged) of VA09W-188WS (3.2 – 3.7) is moderate being most similar to those of 'SS 520' (3.1 – 4.5) and 'USG 3555' (2.0 – 4.0). In the Uniform Eastern Soft White Winter Wheat Nursery, winter hardiness (0 – 100% survival) of VA09W-188WS (93% – 97%) was very good and similar to those of northern check cultivars.

VA09W-188WS was evaluated at 5 locations (MI, NY, VA, and Ontario Canada) in the 2012 Uniform Eastern Soft White Winter Wheat Nursery and ranked in the third highest yield group over locations for grain yield (77 Bu/ac) among 29 entries. It also was evaluated in this nursery in 2011 at 7 locations (IN, OH, MI, NY, VA, and Ontario) and ranked second for grain yield (80 Bu/ac). In these two nursery years, average test weights of VA09W-188WS (57.1 and 57.4 Lb/Bu) were similar to or significantly ($P \leq 0.05$) higher than those of Caledonia (57.0 and 55.7 Lb/Bu).

Grain samples of VA09W-188WS produced in four crop environments (2011 and 2012) were evaluated for end use quality by the USDA-ARS Soft Wheat Quality Lab. Over all four environments, VA09W-188WS had an average milling quality score (77.5) and flour yield (71.7%) that exceeded those of Shirley (68.5 and 69.9%), Branson (65.0 and 69.2%), and Pioneer Brand '25R15' (69.3 and 70.1%). On average, baking quality score of VA09W-188WS (63.3) was higher than that of Pioneer Brand 25R15 (57.5), but lower than those of Shirley (74.1) and Branson (67.9). Average cookie spread diameter of VA09W-188WS (18.2 cm) was similar to that of Pioneer Brand 25R15, but slightly lower than those of Shirley (18.7 cm) and Branson (18.5 cm). Grain protein content and gluten strength (lactic acid retention capacity) of VA09W-188WS (7.70% and 90%) were slightly higher than those of Shirley (7.58% and 89%), but lower than those of Branson (8.13% and 114%) and Pioneer Brand 25R15 (8.9% and 130%). Like Shirley, flour of VA09W-188WS is most suitable for pastry products, but also may be suitable for manufacturing breakfast cereals and other whole grain products due to its white grain color. In the 2011 and 2012 Uniform Eastern Soft White Winter Wheat Nursery, sprouting scores (0 – 9) for VA09W-188WS (4.1 and 4.4) were lower than those of Caledonia (4.7 and 5.5), but were higher than those of the sprout tolerant check cultivar Cayuga (1.4 and 0.7).

VA09W-188WS has performed well in eastern soft white winter wheat regions of the U.S. and Ontario as well as in the mid-Atlantic region. With the exception of stem rust, glume blotch (*Stagonospora nodorum*), and potentially wheat spindle streak mosaic virus, VA09W-188WS

expresses moderate to high levels of resistance to diseases prevalent in the eastern soft white winter wheat region. These include leaf and stripe rusts, powdery mildew, *Septoria tritici* leaf blotch, Fusarium head blight, barley yellow dwarf virus, wheat soil borne mosaic virus, and Hessian fly.

Breeder seed of VA09W-188WS was planted by Virginia Crop Improvement Association (VCIA) on 3 acres at their Foundation Seed farm during fall 2012 to produce Foundation seed for distribution to seedsmen. VA09W-188WS will be marketed as 'MCIA Venus' by the Michigan Crop Improvement Association based in Lansing, MI.

USDA-ARS SWQL GRAIN AND FLOUR EVALUATIONS

Long-term relationships established between the SWQL and cooperative nursery programs, the Wheat Quality Council and U.S. Wheat Associates depend on the reliable milling and baking evaluations performed in Wooster. The SWQL performs quality evaluations for three main collaborative projects: Wheat Quality Council, Overseas Variety Analysis and Regional Cooperative Nurseries.

2013 WHEAT QUALITY COUNCIL

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, provide data critical for collaborators to compare quality evaluations of the new varieties presented each year.

In the 2013 crop year, a total of nine new wheat varieties and advanced breeding lines, along with two check varieties, were submitted for the WQC project from three wheat breeding programs. The SWQL milled the wheat grain of the submitted entries using a Miag Multomat mill and distributed them to the twelve cooperators for determination of flour solvent retention capacity, dough rheological properties and baking quality. The test results of the entries by the SWQL and cooperators were pooled, analyzed and used for preparation of the report, which is available at the WQC web site (http://www.wheatqualitycouncil.org/). The director of the SWQL led the discussion on quality potentials of the entries with the cooperators during the WQC annual meeting on February 18-20, 2014, in Kansas City, MO.

CONTRIBUTING SOFT WHEAT BREEDING PROGRAMS AND TEST LINES

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

Carl Griffey, Virginia Polytechnic Institute and State University

VA07W-415
VA09W-75
VA09W-73
VA09W-188WS
Shirley (check)

Jennifer Vonderwell, Syngenta

SY 547

Eric Olson, Michigan State University

F0014
F0039
F0065
D8006
Caledonia (check)

MILLING AND BAKING RESULTS OF THE WQC ENTRIES REPORTED BY COLLABORATORS AND THE SWQL

Table 1. Miag Multomat Mill Stream Yields of the WQC 2013 Crop Year Entries by SWQL

Mill Stream	VA07W-415	VA09W-75	VA09W-73	VA09W-188WS	Shirley	SY 547	F0014	F0039	F0065	D8006	Caledonia
1 Brk	8.8	11.6	10.4	8.4	10.2	9.2	9.2	10.1	10.2	10.4	9.6
2 Brk	7.6	10.9	10.4	6.9	9.6	9.2	8.1	9.6	11.0	9.3	8.1
Grader	3.8	4.2	4.2	3.5	4.5	4.0	4.0	4.3	5.3	5.0	4.1
3 Brk	9.5	9.2	7.9	9.8	9.8	8.4	9.8	8.6	8.4	9.5	10.4
Total Brk	29.7	35.9	32.8	28.7	34.1	30.8	31.1	32.6	34.8	34.1	32.2
1 Mids	19.3	15.0	16.5	17.6	15.7	17.4	18.3	17.7	15.7	17.2	17.1
2 Mids	7.5	6.7	7.5	8.2	7.1	8.8	7.8	7.2	7.4	7.8	7.0
3 Mids	5.9	4.6	4.4	6.9	5.1	5.0	5.3	4.6	3.9	4.8	5.6
1M ReDust	7.3	5.1	6.4	7.9	6.8	6.5	7.4	6.9	6.5	7.1	6.4
4 Mids	2.3	2.5	2.2	2.8	2.7	2.4	2.6	2.4	2.3	2.3	3.1
5 Mids	1.3	1.8	1.5	1.6	1.8	1.6	1.5	1.7	1.7	1.3	2.0
Total Mids	43.6	35.7	38.6	45.0	39.4	41.6	42.9	40.5	37.5	40.5	41.2
Straight Grade	73.3	71.6	71.5	73.8	73.4	72.4	73.9	73.1	72.3	74.6	73.4
Brk Shorts	7.7	10.0	7.9	7.6	7.6	8.5	6.9	6.8	6.7	6.4	7.1
Red Dog	0.9	1.5	1.1	1.1	1.3	1.1	1.0	1.1	1.2	0.8	1.3
Tail Shorts	0.4	0.6	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.5
Bran	17.4	16.2	19.1	16.6	17.1	17.5	17.4	18.4	19.2	17.7	17.3
Total Byproduct	26.4	28.2	28.4	25.6	26.4	27.4	25.8	26.7	27.5	25.2	26.3

Table 2. Quadrumat milling test parameters by Mennel Milling

Entry	Adjusted Flour Yield (%)	Milling Quality Score	Milling Rating	Softness Equivalence	Softness Assessment
VA07W-415	72.9	4.6	superior	54.2	normal softness
VA09W-75	69.0	1.7	marginal	59.6	normal softness
VA09W-73	70.1	2.8	below average	57.5	normal softness
VA09W-188WS	72.5	4.4	excellent to superior	51.9	sl. coarser than normal
Shirley (ck)	72.0	4.0	excellent	57.9	normal softness
SY 547					
F0014	72.0	4.0	excellent	56.2	normal softness
F0039	73.0	4.7	superior	57.5	normal softness
F0065	70.1	2.8	below average	61.8	sl. softer than normal
D8006	73.8	5.1	superior	60.2	normal softness
Caledonia (ck)	72.6	4.4	excellent to superior	59.5	normal softness
Mennel Mix 1	71.1	3.5	very good	56.4	avg of all soft wheat
Mennel Mix 2	71.1	3.5	very good	57.5	avg of all soft wheat

MIAG MULTOMAT FLOUR MILLING ASH CURVES OF THE WQC ENTRIES

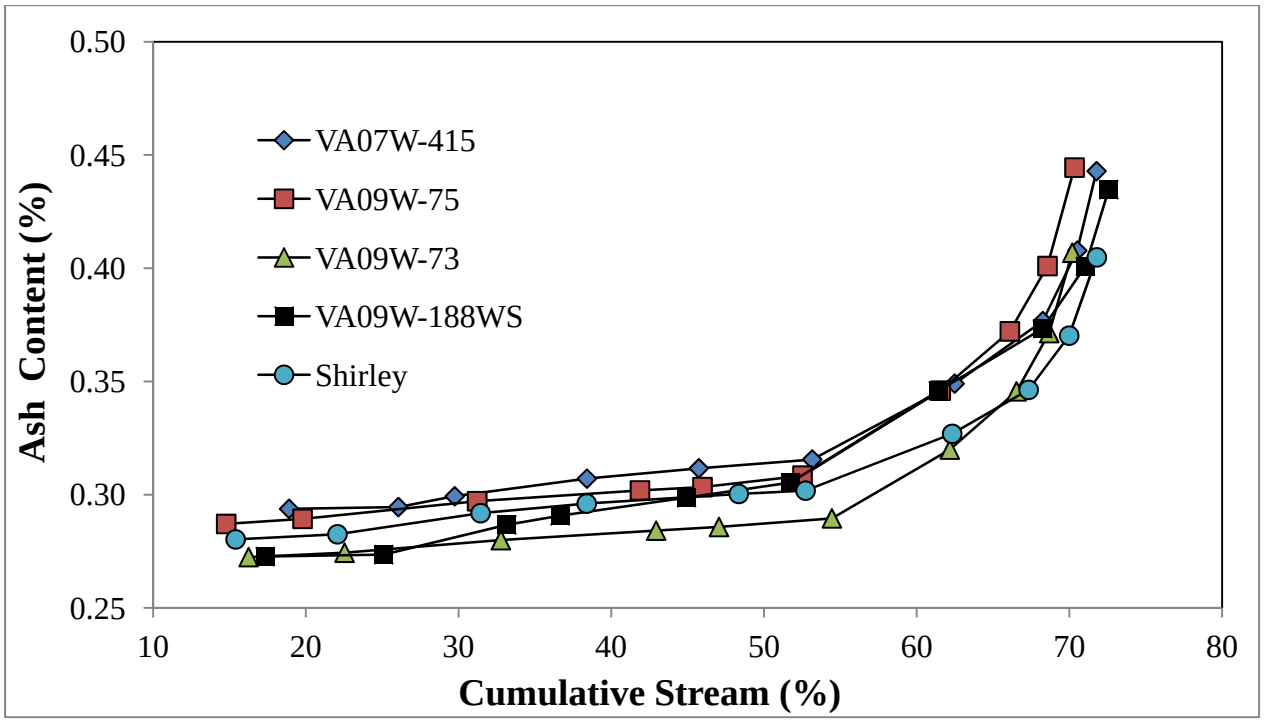

Table 3. Yield and Ash Content of Mill Streams for the WQC 2013 Crop Entries from Virginia Polytechnic Institute and State University

Flour Stream	VA07W-415		VA09W-75		VA09W-73		VA09W-188WS		Shirley	
	Yield (%)	Ash (%)	Yield (%)	Ash (%)	Yield (%)	Ash (%)	Yield (%)	Ash (%)	Yield (%)	Ash (%)
1 Brk	8.7	0.33	11.4	0.31	10.2	0.29	8.3	0.33	10.0	0.32
2 Brk	7.4	0.34	10.7	0.32	10.2	0.30	6.8	0.35	9.4	0.31
Grader	3.7	0.33	4.1	0.32	4.1	0.30	3.5	0.33	4.4	0.32
3 Brk	9.3	0.54	9.0	0.56	7.7	0.53	9.7	0.56	9.6	0.46
1 Mids	18.9	0.29	14.8	0.29	16.2	0.27	17.3	0.27	15.4	0.28
2 Mids	7.3	0.34	6.5	0.34	7.4	0.31	8.0	0.33	6.9	0.32
3 Mids	5.8	0.68	4.5	0.73	4.4	0.71	6.8	0.62	5.0	0.59
Re-Dust	7.2	0.30	5.0	0.30	6.3	0.28	7.8	0.28	6.7	0.29
4 Mids	2.3	1.35	2.5	1.17	2.1	1.17	2.8	1.07	2.7	0.98
5 Mids	1.3	2.40	1.8	2.13	1.5	2.02	1.5	2.00	1.8	1.74
Head Shorts	7.6	4.13	9.8	4.05	7.7	4.03	7.5	4.15	71.8	3.92
Red Dog	0.9	3.16	1.4	3.15	1.1	2.74	1.1	3.09	1.2	2.39
Tail Shorts	0.4	3.25	0.6	3.27	0.4	3.17	0.4	3.39	0.4	2.89
Bran	17.0	5.20	15.9	4.49	18.7	4.88	16.3	5.33	16.7	5.13

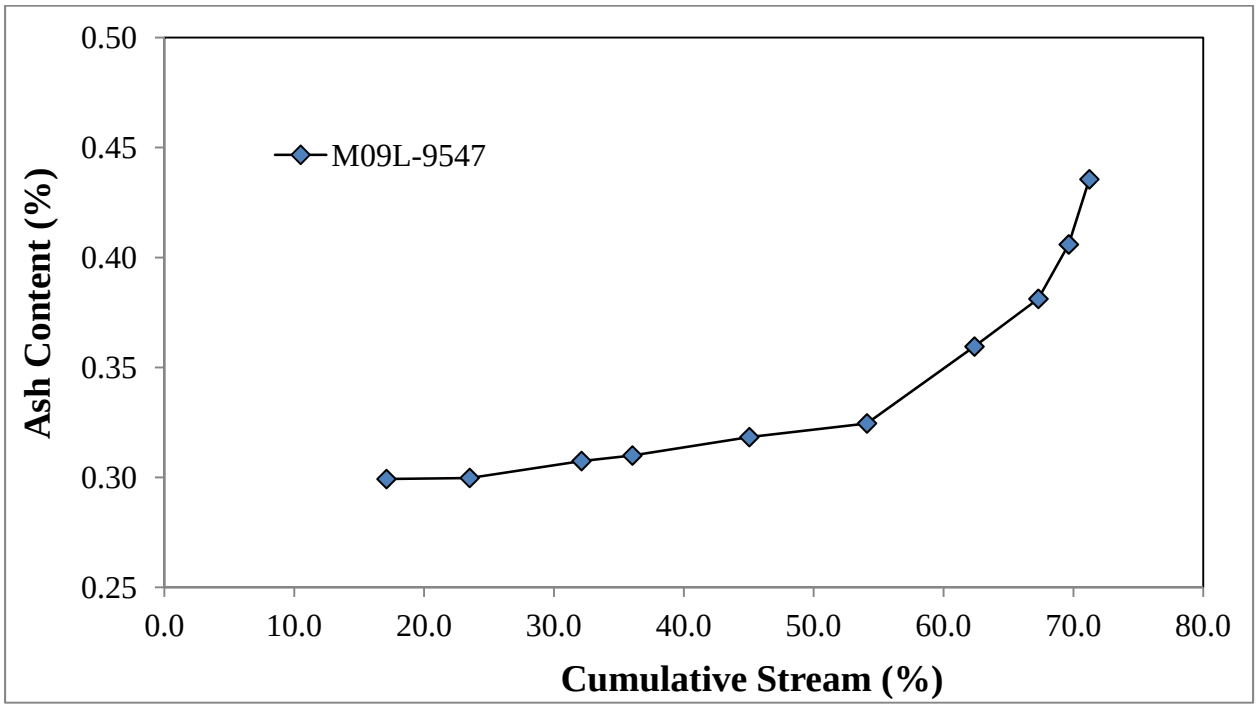

Table 4. Yield and Ash Content of Mill Streams for the WQC 2013 Crop Entries from Syngenta

Flour Stream	SY 547	
	Yield (%)	Ash (%)
1 Brk	9.1	0.36
2 Brk	9.0	0.35
Grader	3.9	0.33
3 Brk	8.3	0.59
1 Mids	17.1	0.30
2 Mids	8.6	0.33
3 Mids	4.9	0.66
Re-Dust	6.4	0.30
4 Mids	2.3	1.12
5 Mids	1.6	1.74
Head Shorts	8.3	4.46
Red Dog	1.0	2.92
Tail Shorts	0.4	3.41
Bran	17.2	5.83

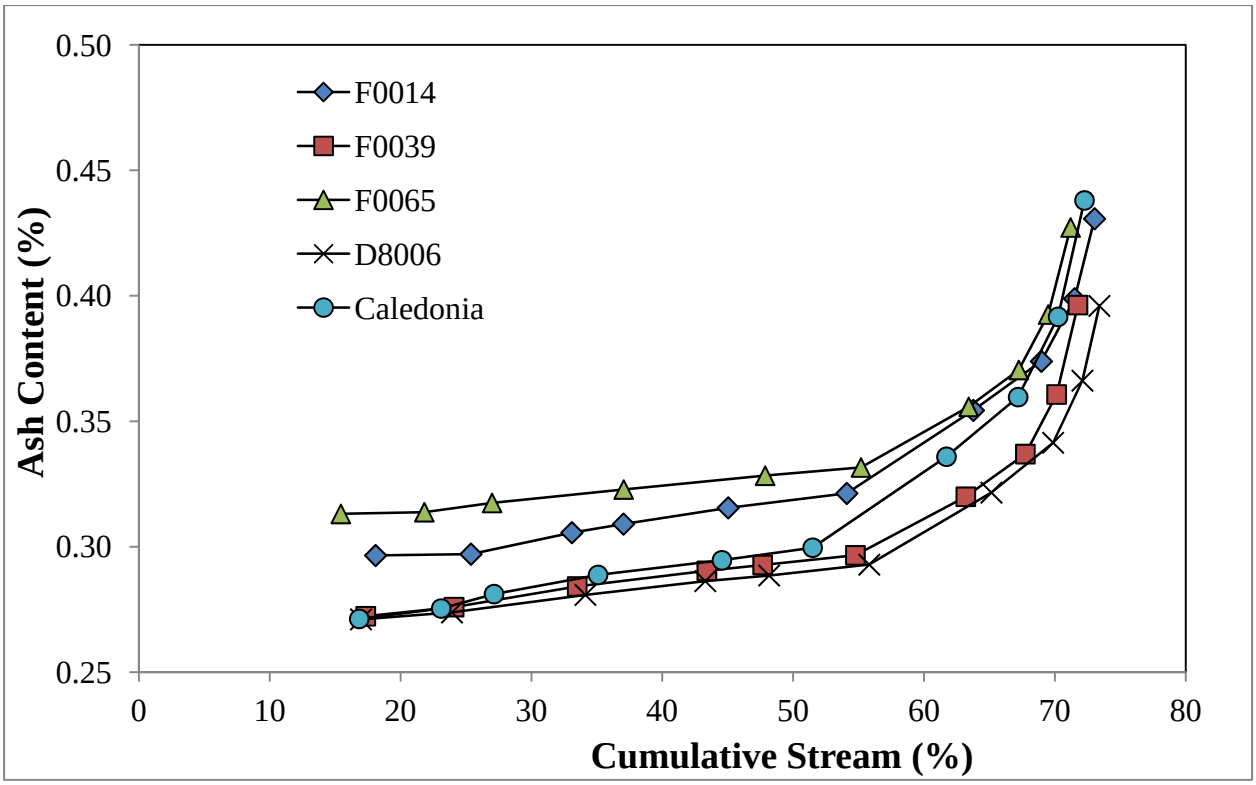

Table 5. Yield and Ash Content of Mill Streams for the WQC 2013 Crop Entries from Michigan State University

Flour Stream	F0014		F0039		F0065		D8006		Caledonia	
	Yield (%)	Ash (%)	Yield (%)	Ash (%)	Yield (%)	Ash (%)	Yield (%)	Ash (%)	Yield (%)	Ash (%)
1 Brk	9.1	0.35	9.9	0.31	10.1	0.34	10.2	0.30	9.5	0.32
2 Brk	8.0	0.35	9.4	0.31	10.8	0.35	9.2	0.31	7.9	0.31
Grader	3.9	0.34	4.3	0.32	5.2	0.33	4.9	0.31	4.0	0.31
3 Brk	9.7	0.54	8.4	0.47	8.2	0.52	9.3	0.49	10.2	0.52
1 Mids	18.1	0.30	17.3	0.27	15.4	0.31	17.0	0.27	16.8	0.27
2 Mids	7.7	0.33	7.1	0.32	7.3	0.35	7.7	0.32	6.9	0.33
3 Mids	5.2	0.61	4.6	0.57	3.8	0.61	4.7	0.62	5.5	0.63
Re-Dust	7.3	0.30	6.7	0.29	6.4	0.32	7.0	0.28	6.3	0.29
4 Mids	2.5	1.08	2.4	1.04	2.2	1.05	2.2	1.14	3.1	1.10
5 Mids	1.5	1.92	1.6	1.93	1.7	1.83	1.3	2.05	2.0	2.05
Head Shorts	6.8	4.15	6.7	3.67	6.6	3.93	6.3	4.30	7.0	3.76
Red Dog	1.0	2.92	1.0	2.71	1.1	2.72	0.8	3.13	1.3	2.76
Tail Shorts	0.4	3.18	0.4	2.99	0.4	3.20	0.3	3.55	0.5	3.13
Bran	17.2	5.68	18.0	5.54	18.9	5.19	17.4	6.03	17.1	5.90

WHEAT GRAIN AND FLOUR CHARACTERISTICS OF THE WQC ENTRIES

Table 6. Test weight, thousand kernel weight and SKCS test parameters by USDA-ARS Soft Wheat Quality Laboratory

Entry	Test Weight (lb/bu)	Thousand Kernel Weight (g)	Grain Protein (%)	Grain Falling Number	SKCS Parameter			Milling Quality	
					Hardness	Weight (mg)	Diameter (mm)	Break Flour Yield (%)	Straight Grade Flour Yield (%)
VA07W-415	57.5	40.6	8.3	290	26	43.8	2.9	29.7	73.3
VA09W-75	59.1	38.6	8.2	358	20	37.9	2.3	35.9	71.6
VA09W-73	60.1	38.9	8.6	366	24	36.5	2.5	32.8	71.5
VA09W-188WS	57.9	37.5	8.7	261	29	36.3	2.4	28.7	73.8
Shirley (ck)	59.2	41.7	8.2	344	6	40.4	2.5	34.1	73.4
SY 547	59.5	36.6	11.2	376	17	35.1	2.2	30.8	72.4
F0014	59.5	38.0	10.0	340	18	34.3	2.3	31.1	73.9
F0039	59.6	43.2	8.8	342	10	37.1	2.5	32.6	73.1
F0065	59.6	35.0	7.8	312	9	34.2	2.1	34.8	72.3
D8006	59.6	39.8	8.6	305	9	36.2	2.4	34.1	74.6
Caledonia (ck)	59.6	37.7	8.7	322	11	33.5	2.3	32.2	73.4

Table 7. Flour quality test parameters by USDA-ARS Soft Wheat Quality Laboratory

Entry	Moisture (%)	Protein (%)	pH	α-amylase Activity	Starch Damage (%)	Flour Ash (%)
VA07W-415	13.4	7.3	6.1	0.09	4.1	0.42
VA09W-75	13.4	7.1	6.2	0.05	4.0	0.44
VA09W-73	13.4	6.9	6.2	0.06	4.1	0.43
VA09W-188WS	13.3	7.7	6.1	0.11	5.2	0.42
Shirley (ck)	13.2	6.7	6.2	0.07	3.9	0.40
SY 547	12.9	10.0	6.2	0.05	3.7	0.43
F0014	13.0	8.2	6.1	0.06	3.4	0.42
F0039	12.8	7.2	6.2	0.06	2.4	0.39
F0065	12.7	7.4	6.0	0.07	2.7	0.42
D8006	12.7	7.9	6.0	0.07	2.3	0.39
Caledonia (ck)	13.0	7.7	6.2	0.08	2.7	0.40

SUMMARIES AND STATISTICS OF COMBINED COOPERATOR TEST PARAMETERS OF THE WQC ENTRIES

Table 8. Mean SRC test parameters and overall flour quality scores

Group	Entry (n=11)	Solvent Retention Capacity (%)*				Flour Quality Score*
		Water	Sodium Carbonate	Sucrose	Lactic Acid	
1	VA07W-415	54.1 c	76.8 bc	97.6 ab	97.0 b	5.0 a
1	VA09W-75	59.0 a	80.5 a	101.7 a	107.9 a	4.0 a
1	VA09W-73	56.8 ab	76.7 bc	95.6 ab	105.7 a	5.3 a
1	VA09W-188WS	57.8 a	79.6 ab	96.0 ab	93.7 b	4.0 a
1	Shirley (ck)	54.6 bc	75.0 c	91.2 b	82.1 c	5.1 a
2	SY 547	52.2	72.9	94.6	92.4	5.1
3	F0014	52.7 ab	75.1 ab	91.5 a	100.3 a	6.3 a
3	F0039	51.4 b	71.5 c	84.4 b	87.3 c	6.3 a
3	F0065	54.1 a	75.6 a	88.4 ab	92.5 b	5.9 a
3	D8006	51.3 b	72.3 c	87.8 ab	104.4 a	7.1 a
3	Caledonia (ck)	52.0 ab	72.7 bc	85.8 ab	91.1 bc	6.8 a

*Means with different letters within the same group are significantly different at $P<0.05$.

Table 9. Mean Alveograph test parameters

Group	Entry	Alveograph (n=3)*			
		P	L	P/L Ratio	W
1	VA07W-415	37.3 d	51.7 a	0.73 c	66.0 b
1	VA09W-75	74.0 a	33.7 b	2.24 a	104.0 a
1	VA09W-73	62.3 b	45.7 a	1.37 b	110.7 a
1	VA09W-188WS	47.0 c	51.3 a	0.92 c	77.3 ab
1	Shirley (ck)	30.3 d	48.7 a	0.63 c	43.3 b
2	SY 547	33.3	84.7	0.40	63.0
3	F0014	30.0 a	116.7 ab	0.27 a	63.0 a
3	F0039	20.0 bc	84.7 c	0.24 ab	37.7 a
3	F0065	22.0 bc	90.3 bc	0.25 ab	40.0 a
3	D8006	24.0 b	129.0 a	0.19 ab	59.3 a
3	Caledonia (ck)	19.3 c	113.0 ab	0.17 b	40.7 a

*Means with different letters within the same group are significantly different at $P<0.05$.

Table 10. Mean Farinograph test parameters

Group	Entry	Farinograph (n=2)*			
		Water Absorption (%)	Development Time (min)	Stability (min)	Mixing Tolerance Index (BU)
1	VA07W-415	53.1 b	1.2 a	1.6 a	116 ab
1	VA09W-75	56.4 a	1.1 a	1.8 a	101 b
1	VA09W-73	55.4 a	1.0 a	1.7 a	124 ab
1	VA09W-188WS	56.2 a	1.3 a	1.9 a	105 ab
1	Shirley (ck)	53.2 b	1.0 a	1.5 a	128 a
2	SY 547	54.8	2.8	4.4	87
3	F0014	54.1 a	1.2 a	2.3 a	120 bc
3	F0039	50.2 c	1.0 a	1.3 ab	138 ab
3	F0065	50.8 ab	1.0 a	1.8 ab	113 c
3	D8006	51.5 b	1.0 a	1.7 ab	134 abc
3	Caledonia (ck)	50.7 c	0.8 a	1.2 b	145 a

*Means with different letters within the same group are significantly different at $P<0.05$.

Table 11. Mean Rapid Visco-Analyzer (RVA) test parameters

Group	Entry	Rapid Visco-Analyzer (n=5)*							
		Peak Time (min)	Peak (cP)	Trough (cP)	Break-down (cP)	Setback (cP)	Final (cP)	Pasting Temperature (°C)	Peak/Final Ratio
1	VA07W-415	5.9 b	2210 c	1086 c	1123 a	1196 d	2282 c	79.6 a	0.97 a
1	VA09W-75	6.1 ab	2653 b	1602 b	1051 a	1443 c	3045 b	73.9 a	0.87 c
1	VA09W-73	6.2 a	2886 a	1849 a	1037 a	1530 b	3379 a	79.1 a	0.86 cd
1	VA09W-188WS	5.3 c	1070 d	472 d	597 b	687 e	1159 d	72.1 a	0.92 b
1	Shirley (ck)	5.9 b	2658 b	1602 b	1056 a	1611 a	3213 ab	73.3 a	0.83 d
2	SY 547	6.0	2679	1624	1056	1394	3017	79.6	0.89
3	F0014	6.0 a	2741 a	1540 a	1202 ab	1358 a	2897 a	79.0 a	0.94 bc
3	F0039	5.9 ab	2515 ab	1372 ab	1142 ab	1293 ab	2665 ab	72.1 a	0.95 bc
3	F0065	5.9 a	2225 b	1278 b	947 b	1255 b	2533 b	81.6 a	0.87 c
3	D8006	5.9 a	2798 a	1457 ab	1341 a	1312 ab	2769 ab	73.4 a	1.01 ab
3	Caledonia (ck)	5.7 b	2020 b	940 c	1080 ab	971 c	1911 c	73.2 a	1.06 a

*Means with different letters within the same group are significantly different at $P<0.05$.

Table 12. Mean sugar-snap cookie test (AACCI Approved method 10-50D & 10-52) parameters

Group	Entry	Sugar-Snap Cookie (10-50D)* (n=5)					Sugar-Snap Cookie (10-52)* (n=4)	
		Width (mm)	Thickness (mm)	W/T Ratio (mm)	Spread Factor	Score	Width (mm)	Score
1	VA07W-415	481 b	57 b	8.4 a	82 a	5.6 b	172 ab	4.0
1	VA09W-75	471 c	63 a	7.5 b	72 b	2.6c	170 b	7.0
1	VA09W-73	483 b	60 ab	8.1 a	79 ab	5.0 b	170 b	4.0
1	VA09W-188WS	461 d	64 a	7.3 b	71 b	2.9 c	167 b	5.0
1	Shirley (ck)	494 a	58 b	8.6 a	84 a	6.7 a	182 a	8.0
2	SY 547	480	58	8.2	79	5.0	171	7.0
3	F0014	500 a	58 a	8.6 c	84 a	5.7 c	173 a	4.0
3	F0039	508 a	53 b	9.6 a	93 a	8.5 a	181 a	7.0
3	F0065	505 a	57 a	8.9 bc	87 a	6.8 bc	181 a	8.0
3	D8006	504 a	56 ab	9.0 bc	88 a	7.4 b	181 a	8.0
3	Caledonia (ck)	504 a	55 ab	9.2 ab	90 a	7.7 ab	182 a	8.0

*Means with different letters within the same group are significantly different at $P<0.05$.

Table 13. Mean sponge cake baking test parameters

Group	Entry	Sponge Cake (n=2)*		
		Volume (mL)	Texture Score	Overall Score
1	VA07W-415	1191 b	14.5 a	3.0 c
1	VA09W-75	1243 a	18.0 a	6.0 ab
1	VA09W-73	1277 a	20.0 a	7.5 a
1	VA09W-188WS	1177 b	16.0 a	4.5 bc
1	Shirley (ck)	1241	14.5 a	5.0 abc
2	SY 547	1209 a	10.0	4.0
3	F0014	1265 a	17.0 a	6.5 a
3	F0039	1298 a	14.5 a	6.0 a
3	F0065	1306 a	19.5 a	8.0 a
3	D8006	1284 a	18.5 a	7.0 a
3	Caledonia (ck)	1287 a	19.0 a	7.5 a

*Means with different letters within the same group are significantly different at $P<0.05$.

QUALITY TEST VALUES OF THE WQC ENTRIES BY THE COOPERATOR

Table 14. Water SRC of 2013 WQC entries by cooperators

Entry	ADM	ConAgra	Horizon	Kellogg	LimaGrain	Mennel	Mondelez	Star of the West	SWQL	Syngenta	WWQL	**Mean**	**STDEV**
VA07W-415	52	53	55	50	57	49	55	54	56	60	54	**54.1**	**3.0**
VA09W-75	55	58	58	55	63	59	62	61	63	56	59	**59.0**	**2.8**
VA09W-73	54	57	57	52	59	55	58	58	62	58	55	**56.8**	**2.6**
VA09W-188WS	57	57	60	53	59	61	59	58	60	54	58	**57.8**	**2.4**
Shirley (ck)	52	53	54	50	56	59	57	56	58	51	55	**54.6**	**2.8**
SY 547	52	51	53	48	54	50	52	53	56	53	52	**52.2**	**2.0**
F0014	51	52	53	48	57	47	56	54	56	52	54	**52.7**	**3.0**
F0039	47	49	50	46	53	54	56	52	54	53	51	**51.4**	**3.0**
F0065	50	53	54	50	58	52	60	56	55	51	56	**54.1**	**3.1**
D8006	48	50	50	48	54	50	52	52	55	53	52	**51.3**	**2.2**
Caledonia (ck)	49	51	51	47	57	51	54	52	55	55	50	**52.0**	**2.8**

Table 15. Sodium Carbonate SRC of 2013 WQC entries by cooperators

Entry	ADM	ConAgra	Horizon	Kellogg	LimaGrain	Mennel	Mondelez	Star of the West	SWQL	Syngenta	WWQL	**Mean**	**STDEV**
VA07W-415	72	79	80	72	80	76	81	74	78	77	76	**76.8**	**3.0**
VA09W-75	81	82	84	74	84	79	84	83	82	73	79	**80.5**	**3.7**
VA09W-73	72	76	79	70	79	75	77	81	83	78	74	**76.7**	**3.7**
VA09W-188WS	74	79	81	72	82	79	83	93	81	76	76	**79.6**	**5.4**
Shirley (ck)	74	76	73	70	78	77	78	81	77	67	74	**75.0**	**3.8**
SY 547	71	73	75	68	75	72	75	75	75	72	71	**72.9**	**2.2**
F0014	74	77	77	70	77	74	77	75	78	72	75	**75.1**	**2.4**
F0039	70	71	72	65	72	70	72	80	73	71	70	**71.5**	**3.4**
F0065	75	77	80	73	78	78	71	78	76	68	78	**75.6**	**3.4**
D8006	71	73	74	67	74	71	76	74	75	70	70	**72.3**	**2.6**
Caledonia (ck)	70	72	76	68	79	70	73	73	74	75	70	**72.7**	**3.0**

Table 16. Sucrose SRC of 2013 WQC entries by cooperators

Entry	ADM	ConAgra	Horizon	Kellogg	LimaGrain	Mennel	Mondelez	Star of the West	SWQL	Syngenta	WWQL	**Mean**	**STDEV**
VA07W-415	87	99	105	86	106	107	103	104	96	95	86	**97.6**	**7.8**
VA09W-75	93	100	109	92	108	116	107	108	102	92	92	**101.7**	**8.1**
VA09W-73	85	95	101	83	101	95	98	107	101	103	83	**95.6**	**8.0**
VA09W-188WS	89	99	99	87	103	97	101	103	97	94	87	**96.0**	**5.7**
Shirley (ck)	84	95	98	80	99	92	96	104	91	83	81	**91.2**	**7.7**
SY 547	86	97	101	85	105	96	100	103	97	90	81	**94.6**	**7.6**
F0014	84	93	96	82	100	90	96	97	92	95	81	**91.5**	**6.2**
F0039	76	86	90	74	91	83	91	91	84	89	73	**84.4**	**6.7**
F0065	80	91	95	77	96	90	96	97	88	83	79	**88.4**	**7.1**
D8006	80	87	95	78	98	92	92	94	88	85	77	**87.8**	**6.8**
Caledonia (ck)	77	85	92	76	98	85	89	92	86	89	75	**85.8**	**7.0**

Table 17. Lactic acid SRC of 2013 WQC entries by cooperators

Entry	ADM	ConAgra	Horizon	Kellogg	LimaGrain	Mennel	Mondelez	Star of the West	SWQL	Syngenta	WWQL	**Mean**	**STDEV**
VA07W-415	95	102	100	97	98	101	93	101	91	91	98	**97.0**	**3.8**
VA09W-75	106	113	112	107	115	115	111	93	102	100	113	**107.9**	**6.8**
VA09W-73	104	108	108	103	108	114	103	106	102	102	105	**105.7**	**3.4**
VA09W-188WS	93	99	98	94	90	99	91	92	90	89	96	**93.7**	**3.6**
Shirley (ck)	80	84	83	81	82	85	80	81	79	86	82	**82.1**	**2.1**
SY 547	90	94	95	93	91	98	87	90	87	98	93	**92.4**	**3.6**
F0014	106	105	105	105	98	112	91	95	96	87	103	**100.3**	**7.1**
F0039	92	91	89	93	86	97	79	80	87	76	90	**87.3**	**6.2**
F0065	91	94	92	89	95	96	98	88	99	85	90	**92.5**	**4.2**
D8006	105	108	106	105	106	111	101	103	99	100	104	**104.4**	**3.4**
Caledonia (ck)	95	96	92	94	92	100	83	87	87	85	91	**91.1**	**4.9**

Table 18. Sugar-snap cookie (10-50D) diameter (mm) of 2013 WQC entries by cooperators

Entry	ADM	Horizon	ConAgra	Mennel	Star of the West	**Mean**	**STDEV**
VA07W-415	481	479	492	484	470	**481**	**7.1**
VA09W-75	467	467	474	475	470	**471**	**3.4**
VA09W-73	475	483	496	484	479	**483**	**7.1**
VA09W-188WS	456	456	472	463	457	**461**	**6.2**
Shirley (ck)	489	493	500	501	486	**494**	**5.9**
SY 547	477	476	493	481	472	**480**	**7.2**
F0014	493	494	505	501	508	**500**	**5.9**
F0039	501	501	515	514	507	**508**	**6.1**
F0065	500	495	510	509	511	**505**	**6.4**
D8006	503	497	512	507	500	**504**	**5.3**
Caledonia (ck)	496	500	514	516	493	**504**	**9.4**

Table 19. Flour quality scores of 2013 WQC entries by cooperators

Entry	Horizon	Conagra	LimaGrain	Mennel	Mondelez	Star of the West	Syngenta	WMC	WWQL	**Mean**	**STDEV**
VA07W-415	5	5	4	8	6	6	4	4	6	**5.3**	**1.32**
VA09W-75	5	5	4	3	1	4	5	5	3	**3.9**	**1.36**
VA09W-73	5	6	5	6	6	7	2	5	6	**5.3**	**1.41**
VA09W-188WS	4	4	4	6	3	2	6	3	3	**3.9**	**1.36**
Shirley (ck)	5	3	5	5	3	5	8	7	5	**5.1**	**1.62**
SY 547	6	4	6	8	3	6	6	3	7	**5.4**	**1.74**
F0014	7	5	7	8	7	8	6	4	5	**6.3**	**1.41**
F0039	7	5	8	6	6	7	7	6	8	**6.7**	**1.00**
F0065	7	4	7	7	6	4	8	5	5	**5.9**	**1.45**
D8006	7	7	8	8	9	7	8	4	7	**7.2**	**1.39**
Caledonia (ck)	7	6	7	7	7	7	7	5	8	**6.8**	**0.83**

Table 20. Sugar-snap cookie (10-50D) quality scores of 2013 WQC entries by cooperators

Entry	ADM	Horizon	ConAgra	Mennel	**Mean**	**STDEV**
VA07W-415	7	5	5	6	**5.8**	**0.96**
VA09W-75	2	3	3	2.5	**2.6**	**0.48**
VA09W-73	6	5	4	5	**5.0**	**0.82**
VA09W-188WS	3	4	2	2.5	**2.9**	**0.85**
Shirley (ck)	6	6	6	7	**6.3**	**0.50**
SY 547	4	5	6	5	**5.0**	**0.82**
F0014	7	7	5	5	**6.0**	**1.15**
F0039	8	8	9	9	**8.5**	**0.58**
F0065	7	7	6	7.5	**6.9**	**0.63**
D8006	7	7	7	8.5	**7.4**	**0.75**
Caledonia (ck)	8	8	7	9	**8.0**	**0.82**

OVERSEAS VARIETAL ANALYSIS OF 2012 CROP YEAR ENTRIES

EXECUTIVE SUMMARY OF INTERNATIONAL COOPERATORS' RESULTS

Wheat Sources and Characteristics

The U.S. Wheat Associates Overseas Varietal Analysis project for the 2012 crop year evaluated ten soft red winter wheat varieties: AGS 2056, AGS 2035 and AGS 2060 from Arkansas; USG 3251 and USG 3201 from Tennessee; Terral TV 8861 from Louisiana; SY 9978 from North Carolina; Ricochet from Arkansas; and Croplan 9101 from Illinois. RM1201 was an equal blend of four varieties: Kristy, Honey, 25R47 and Branson.

AGS 2056, AGS 2035, USG 3251, USG 3201, Terral TV 8861, Croplan 9101 and RM 1201 graded US #1. SY 9978 and Ricochet graded US #2. AGS 2060 graded US #3 due to contamination of white wheat kernels. SY 9978 was excluded from the cooperative product tests due to scab damage. The summary that follows is primarily based on the sample rankings in Table 24. The relative ranks of SRW wheat varieties for baking cookies, cakes and sweet breads varied widely among cooperators, possibly due to differences in formulas, baking procedures and preferences. The average rankings of the SRW wheat varieties tested were mostly lower than those of the local flours.

Product Preferences

1) Across all cooperators that evaluated cookies, USG 3251 was ranked highest followed by AGS 2035, Ricochet and USG 3201. Terral TV 8861 showed the lowest average ranking for cookie baking. USG 3251, USG 3201 and Ricochet also exhibited greater sugar-snap cookie diameter than others as measured by the SWQL.
2) AGS 2060 was the most preferred variety with an average ranking of 3.5 for sponge cake baking, while AGS 2035 was least preferred, with an average ranking of 7.0. USG 3251, USG 3201, Terral TV 8861 and Ricochet exhibited intermediate average rankings of 5.0-5.7.
3) AGS 2056 performed best for baking chiffon cake, with an average ranking of 2.3, which was the same rank as the local control.
4) The rankings of SRW wheat flours for baking cookies, sponge cakes and chiffon cakes were uncorrelated in this study as in previous years.
5) Terral TV 8861 ranked first and RM 1201 tenth for baking sweet bread.

Summary of Cultivars

USG 3251 had the best average rank of 4.5 (Table 24) across all cooperators and products, followed by USG 3201, Ricochet, AGS 2056 and AGS 2034 with average ranks of 5.3-5.8. The remaining four varieties, including Terral TV 8861, Croplan 9101, RM 1201 and AGS 2050, received relatively lower average rankings of 6.1 to 6.7.

USG 3251 was the most preferred variety for baking cookies and intermediately preferred for baking sponge and chiffon cakes. USG 3251 was highest in break flour yield, second-lowest in protein content, lowest in lactic acid solvent retention capacity (SRC) value and produced the largest diameter cookies baked by the SWQL. AGS 2060 was the highest ranked variety for baking sponge cake, while it ranked lowest for cookies and in overall average ranking, probably due to its

lowest SKCS grain hardness, highest flour protein content, highest sucrose solvent retention capacity (SRC) value of 103 and second highest lactic acid SRC value of 99.3.

USG 3251 and USG 2060 represent the contrasting protein strengths for SRW wheat varieties produced in the eastern United States, the former possessing weak protein and the latter possessing strong protein.

Recommendations for Class

Each internal end-user of SRW wheat has a preferred protein content range. As noted in the summary of SRW wheat varieties above, grain hardness and break flour yield (which are associated with flour particle size), water absorption capacity (sucrose SRC) and protein strength (lactic acid SRC) all showed significant variation among varieties, influences on product quality and overall flour preference rankings. Local preferences for end-use products of SRW wheat should be considered when selecting flours for overseas markets based on quality targets for protein content, flour particle size, flour absorption capacity and protein strength.

The preferred varieties for cake baking are often rated poorly in cookie baking as observed with AGS 2060, and vise versa with AGS 2035. This makes it difficult to set the universal quality profile of SRW wheat for baking both cookies and cakes. AGS 2060, the most preferred for baking sponge cake, failed to produce decent quality cookies, probably due to its high solvent absorption capacity and protein strength. On the other hand, USG 3251, the most preferred for baking cookies, was also rated rather high for baking cake. Low grain hardness, high break flour yield, low protein content and low SRCs would ensure the satisfactory quality rating of SRW wheat for making both cookies and cakes. Appropriate protein strength of SRW wheat for overseas markets still needs to be defined in consideration of the specific end-products requiring relatively strong gluten.

USDA-ARS Soft Wheat Quality Laboratory Evaluation Results

Grain Characteristics and Milling Quality (Tables 21-23)

Test weights of grain were greater than 60 lb/bu in eight SRW wheat varieties and 59.4-59.6 lb/bu in two varieties. All had greater test weights than the minimum requirement (58 lb/bu) for the US grade 2. AGS 2062 exhibited a notably lower SKCS kernel hardness value (7.6) than other varieties, for which hardness ranged from 12.6 to 29.5. AGS 2035 was highest in thousand kernel weight and diameter, while the lowest thousand kernel weight and diameter were observed in RM 1201.

Considerable differences in break flour yield and straight grade flour yield of the SWQL Miag Multomat flour mill were observed in ten SRW wheat varieties. USG 3251 showed the highest break flour yield of 34.2%. Total flour yield was over 76.3% in AGS 2056 and AGS 2035, 75.1-75.6% in USG 3201 and Terral TV 8861 and lower than 74.5% in the rest of the varieties.

Flour Composition, Biochemical and Rheological Properties

Flour protein content of the ten varieties ranged from 6.7% in Croplan 9101 to 9.0% in AGS 2060, falling into the typical protein content range of SRW wheat. Ash content of straight grade flour was lower than 0.46% in AGS 2056, Croplan 9101 and RM 1201. AGS 2035 was the only flour having ash content greater than 0.5%. Flour falling numbers of all ten varieties were greater than 342, indicating little pre-harvest sprouting damage.

Significant variation was present for water, sodium carbonate and sucrose SRC values. All varieties in this set exhibited higher values than the typical range for SRW wheat. Sodium carbonate SRC values were higher than 79.6% in AGS 2035, USG 3251, SY 9978, Croplan 9101 and RM 1201. AGS 2035, AGS 2060 and RM 1201 were also much higher in sucrose SRC value than others. AGS 2060 and RM 1201 had lactic acid SRC values greater than 99.3% and appeared to have much stronger protein than the others. These two wheat varieties also showed relatively high alveograph L scores compared to the rest of this set.

In the Alveograph analyses, all samples had small to moderate P values (< 69 mm) but a wide range in L and W values.

Sugar-Snap Cookie Baking Quality

For the sugar-snap cookie test, the traditional preference is for larger diameters. Cookie diameter of the samples in this OVA set was relatively smaller than that of typical SRW wheat, which corresponds to their relatively higher water, sodium carbonate and sucrose SRC values.

Table 21. Grain Characteristics of SRW Wheat Varieties

Variety	Test Weight (lb/bu)	Thousand Kernel Weight (g)	SKCS Kernel Hardness	Kernel Weight (mg)	Kernel Diameter (mm)
AGS 2056	60.0	30.1	23.4	30.6	2.2
AGS 2035	63.9	42.5	24.8	40.7	2.7
AGS 2060	61.4	35.2	7.6	34.4	2.6
USG 3251	60.7	36.2	19.4	35.2	2.2
USG 3201	62.8	37.8	21.6	37.4	2.4
Terral TV 8861	63.2	38.0	15.7	36.5	2.3
SY 9978	59.4	36.0	15.0	35.2	2.4
Ricochet	59.6	31.0	12.6	31.4	2.3
Croplan 9101	62.1	37.9	28.9	37.0	2.4
RM1201	60.0	28.4	29.5	27.7	2.0

Table 22. Milling Yield, Composition, Falling Number and Solvent Retention Capacities of SRW Wheat Flours

Variety	Miag Milling		Protein (%)	Moisture (%)	Ash (%)	Falling Number (sec)	Alpha-Amylase (CU/g)	Starch Damage (%)	Solvent Retention Capacity (%)			
	Break Flour Yield (%)	Straight Grade Flour Yield (%)							Water (%)	Sodium Carbonate (%)	Sucrose (%)	Lactic Acid (%)
AGS 2056	30.0	76.4	8.8	13.2	0.447	447	0.055	5.45		75.7	91.8	80.5
AGS 2035	29.5	76.3	8.8	13.4	0.531	404	0.073	5.11	62.3	79.7	98.0	81.1
AGS 2060	28.3	73.3	9.0	13.3	0.497	385	0.075	2.74	55.3	73.6	103.0	99.3
USG 3251	34.2	74.4	7.8	13.4	0.493	387	0.042	3.82	59.9	80.9	93.5	80.5
USG 3201	30.3	75.1	8.4	13.4	0.479	385	0.044	4.20	55.8	72.8	89.3	85.5
Terral TV 8861	31.8	75.6	7.9	13.3	0.471	387	0.032	3.84	57.4	74.9	92.8	88.7
SY 9978	29.1	74.5	8.4	13.5	0.488	439	0.047	3.26	56.4	79.7	88.8	87.8
Ricochet	32.5	73.6	7.8	13.3	0.489	373	0.061	5.03	59.5	77.6	89.4	83.4
Croplan 9101	28.6	73.7	6.7	13.5	0.458	343	0.029	4.65	60.7	79.6	92.1	82.2
RM1201	28.0	73.8	8.7	13.5	0.439	359	0.039	4.91	59.1	80.6	96.9	99.8

Table 23. Dough Rheological Characteristics and Sugar-Snap Cookie Diameter of SRW Wheat Flours

Variety	Mixograph:					Farinograph:				Alveograph:				Sugar-Snap Cookie Diameter (cm)
	Abs. (%)	Peak Time (min)	Peak Value (%)	Peak Width (%)	Peak Width @ 7 min (%)	Abs. (%)	Dev. Time (min)	Stability (min)	MTI (FU)	P (mm)	L (mm)	P/L	W (10^{-4} joules)	
AGS 2056	58	2.2	36.1	11.5	6.7	53.0	1.7	2.1	75	42	94	0.45	96	16.9
AGS 2035	60	7.0	37.2	11.3	11.3	53.8	1.9	2.0	45	69	80	0.86	179	16.3
AGS 2060	57	3.8	41.0	15.1	7.4	52.6	1.5	4.1	56	46	160	0.29	177	16.6
USG 3251	58	3.9	32.6	11.1	6.2	50.9	1.2	0.8	98	40	87	0.46	80	17.7
USG 3201	56	3.1	39.2	17.8	6.4	50.2	1.4	1.5	71	33	162	0.20	118	17.7
Terral TV 8861	57	3.0	34.7	11.4	9.7	52.4	1.4	1.3	83	47	98	0.48	128	17.1
SY 9978	56	5.7	33.0	10.1	8.5	52.1	1.4	1.1	94	31	164	0.19	109	17.3
Ricochet	55	5.0	31.2	8.3	5.3	50.8	1.2	0.9	109	33	112	0.29	88	17.8
Croplan 9101	58	6.6	29.3	8.7	8.3	51.9	1.2	0.7	107	48	62	0.77	92	17.4
RM1201	58	3.2	39.3	12.9	9.7	52.5	1.8	3.2	71	37	170	0.22	104	17.0

COOPERATORS' RANKINGS AND SCORES BY PRODUCT

Introduction

Cooperators compared flour samples for suitability to their own standards. Samples are ranked from 1 for most preferred to 9 for least preferred. Cooperators also evaluated the flour samples, assigning scores to the batters or doughs, scores for the baked products and a score for overall suitability of the flour to the customers' needs. The cooperators were asked to respond to four questions concerning the products. Scores were assigned to each sample in response to these questions and the scores are reported on a scale of 1 to 9, with the preferred varieties receiving the higher scores.

Cookies (Tables 24-29)

Quality of the OVA flour samples for baking cookies was evaluated by ten cooperators. The preference ranking of each flour sample fluctuated largely among cooperators, indicating that there are large differences in cookie and consequent flour quality requirements among cooperators. Based on the averaged rankings, USG 3251 was the most preferred flour for baking cookies followed by AGS 2035 and Ricochet. USG 3251 was highest in break flour yield and water SRC, but lowest in lactic acid SRC, indicating that high break flour yield and wheat protein are desirable quality characteristics and preferred by the cooperators for baking cookies. AGS 2060 received the lowest average ranking for cookie baking, probably due to much higher sucrose SRC and lactic acid SRC than others. USG 3251 received a relatively low flour desirability score, but highest scores for dough property, cookie quality and overall desirability, whereas AGS 2060 received relatively low scores in all evaluation categories. The averaged rankings of the OVA flours show a negative correlation with water SRC and a positive correlation with lactic acid SRC, but fail to show any relationship with sugar-snap cookie diameter, indicating the complexity and diversity of flour quality preferred by the cooperators.

Cake (Tables 24-29)

The quality ranking and desirability scores of the OVA flour samples for baking sponge cake were evaluated by six cooperators and those for chiffon cake by three. AGS 2060 was the most preferred variety and received the highest average ranking of 3.5. AGS 2060 was ranked lowest for baking cookies and had the highest sucrose SRC and second highest lactic acid SRC values, indicating that there are big differences in flour quality requirements for baking cookies and cakes, and that high absorption capacity and strong flour protein are not critical for baking sponge cakes. AGS 2060 was lowest in SKCS kernel hardness, which signifies the importance of soft kernel texture and consequent fine flour particle size for baking sponge cake. AGS 2060 also received high desirability scores for batter property, sponge cake quality and overall rating. The least preferred variety for baking sponge cake was AGS 2035, which was highest in flour ash content and also relatively high in kernel hardness and damaged starch content. Both AGS 2060 and AGS 2035, however, ranked second to last for baking chiffon cake, suggesting that chiffon cakes require quite different quality flour from sponge cakes.

Steam Bun and Sweet Bread (Tables 24-29)

The OVA flour samples were evaluated for baking steam buns and sweet bread each by a single cooperator. Terral TV 8861 was the most preferred flour for baking both products. The least preferred flour was USG 3251 for baking steam buns and USG 3201 for sweet bread. Flour characteristics of Terral TV 8861 showed intermediate flour quality characteristics including protein content, absorption capacity and protein strength. The cooperator noted the excellent flour color, good dough extensibility, bright yellow color, upright shape and fine/uniform texture of steam buns prepared from Terral TV 8861. Terral TV 8861 received the highest desirability scores for flour, steam bun and overall quality. Croplan flour, with lowest protein content and relatively low lactic acid SRC (weak protein), was least preferred for baking steam buns followed by USG 3201, which was the most preferred for baking cookies.

Summary

USG 3251 had the highest average rank across all cooperators and all products followed by USG 3201 and Ricochet. The flour receiving the lowest average rank was AGS 2060, which was, interestingly, the highest ranked variety for baking sponge cake. USG 3251, however, was the most preferred for baking cookies and also ranked decently high for baking sponge and chiffon cakes, resulting in the highest average ranking in overall preferences. SRW wheat of high protein content, high absorption capacity (high sucrose SRC) and strong protein (high lactic acid SRC) may perform well for the production of cakes and other products requiring gluten strength, but poorly for the production of cookies, receiving relatively low preference ratings. The OVA samples again show the diversity of the SRW wheat produced in the eastern United States in grain hardness, flour particle size, protein content, absorption capacity and protein strength.

Table 24. Rankings of 10 soft red winter wheat varieties for making cookie, sponge cake, chiffon cake and sweet bread*

Product	Cooperator	Control 1**	Control 2**	AGS 2056	AGS 2035	AGS 2060	USG 3251	USG 3201	Terral TV 8861	SY 9978***	Ricochet	Croplan 9101	RM1201
Cookie	China I	1		2	4	3	7	5	8		9	10	6
Cookie	Indonesia I	4		8	1	10	2	5	9		6	7	3
Cookie	Indonesia II	1		8	3	6	5	4	9		2	7	10
Cookie	Malaysia	4		8	1	6	2	3	5		7	9	10
Cookie	Mexico	1		2	8	9	3	7	6		5	4	10
Cookie	Peru	6		6	10	9	3	3	6		1	5	2
Cookie	Philippines I	3		7	4	10	1	5	8		2	9	6
Cookie	Philippines II	1		8	6	10	2	7	3		5	9	4
Cookie	Philippines III	1		7	3	4	8	6	9		5	2	10
Cookie	Thailand	7		9	4	10	3	6	8		5	1	2
	Average	**2.9**		**6.5**	**4.4**	**7.7**	**3.6**	**5.1**	**7.1**		**4.7**	**6.3**	**6.3**
Sponge Cake	China II			6	5	7	8	4	1		2	9	3
Sponge Cake	China I	1		2	7	6	9	3	8		5	10	4
Sponge Cake	Indonesia I	4		10	9	2	3	8	7		5	1	6
Sponge Cake	Indonesia II	1		4	7	2	5	6	8		9	3	10
Sponge Cake	Malaysia	3		7	6	1	2	4	5		8	9	10
Sponge Cake	Thailand	2		10	8	3	7	9	4		1	5	6
	Average	**2.2**		**6.5**	**7.0**	**3.5**	**5.7**	**5.7**	**5.5**		**5.0**	**6.2**	**6.5**
Chiffon Cake	Philippines I	3	10	2	7	9	5	1	6		11	8	4
Chiffon Cake	Philippines II	2		1	9	6	5	4	8		10	7	3
Chiffon Cake	Philippines III	2	7	4	10	11	5	8	3		6	1	9
	Average	**2.3**	**8.5**	**2.3**	**8.7**	**8.7**	**5.0**	**4.3**	**5.7**		**9.0**	**5.3**	**5.3**
Steam Bun	China II			6	5	7	8	4	1		2	9	3
Sweet Bread	Dominican Republic	3		2	5	6	7	8	1		4	9	10
	Overall Average	**2.6**		**5.6**	**5.8**	**6.7**	**4.5**	**5.3**	**6.1**		**5.4**	**6.3**	**6.4**

*1 = highest/ 11 = lowest; **local flour; ***Eliminated due to scab damage.

Table 25. Desirability scores of 10 soft red winter wheat flours for making cookie, sponge cake, chiffon cake, steam bun and sweet bread*

Product	Cooperator	Control 1**	Control 2**	AGS 2056	AGS 2035	AGS 2060	USG 3251	USG 3201	Terral TV 8861	SY 9978***	Ricochet	Croplan 9101	RM1201
Cookie	China I	8.5		8.0	7.3	7.5	6.0	8.3	6.5		6.8	5.0	7.8
Cookie	Indonesia I	7.0		7.0	7.0	7.0	7.5	8.0	8.0		7.5	7.5	7.0
Cookie	Indonesia II	8.0		8.0	8.5	7.0	6.5	7.5	6.0		7.0	7.0	6.0
Cookie	Malaysia	7.0		7.0	8.5	7.5	7.5	8.0	8.0		7.0	6.0	5.0
Cookie	Mexico	8.7		8.6	7.8	7.7	7.6	7.7	8.4		7.4	7.0	7.3
Cookie	Peru	6.5		6.0	5.5	5.0	4.5	5.5	5.5		6.0	4.5	7.0
Cookie	Philippines I	7.0		7.0	7.0	6.0	5.0	7.0	6.5		5.0	6.0	6.0
Cookie	Philippines II	7.0		6.8	6.5	6.7	6.0	6.3	6.4		5.9	5.0	6.8
Cookie	Philippines III	7.0		6.5	6.5	6.5	6.0	6.0	6.0		6.0	6.0	6.5
Cookie	Thailand	7.0		6.0	7.0	6.5	6.5	7.0	6.0		6.0	5.5	6.5
	Average	**7.4**		**7.1**	**7.2**	**6.7**	**6.3**	**7.1**	**6.7**		**6.5**	**6.0**	**6.6**
Sponge Cake	China II	9.5	9.0	7.0	7.0	6.5	7.0	8.5	8.5		8.0	6.0	9.0
Sponge Cake	Indonesia I	7.0		6.5	7.0	6.0	7.0	7.0	7.0		7.0	7.0	7.0
Sponge Cake	Indonesia II	8.0		7.0	7.5	7.0	6.5	7.5	6.0		7.0	7.0	6.0
Sponge Cake	Malaysia	7.0		7.0	8.5	7.5	7.5	8.5	8.0		7.0	6.0	5.0
Sponge Cake	Thailand	7.0		6.0	7.0	6.5	6.5	7.0	6.0		6.0	5.5	6.5
	Average	**7.7**		**6.7**	**7.4**	**6.7**	**6.9**	**7.7**	**7.1**		**7.0**	**6.3**	**6.7**
Chiffon Cake	Philippines I	7.0	6.0	6.5	6.0	5.0	6.0	6.0	6.5		5.0	5.0	5.5
Chiffon Cake	Philippines II	7.0		6.8	6.5	6.7	6.0	6.3	6.4		5.9	5.0	6.8
Chiffon Cake	Philippines III	7.0	6.5	6.0	5.5	5.5	6.0	5.5	6.8		6.8	7.0	6.0
	Average	**7.0**	**6.3**	**6.4**	**6.0**	**5.7**	**6.0**	**5.9**	**6.6**		**5.9**	**5.7**	**6.1**
Steam Bun	China II	9.5	9.0	7.0	7.0	6.5	7.0	8.5	8.5		8.0	6.0	9.0
Sweet Bread	Dominican Republic			7.5	6.0	5.0	6.0	6.5	8.5		5.0	4.0	6.0
	Overall Average	**7.5**		**6.9**	**7.0**	**6.5**	**6.4**	**7.1**	**7.0**		**6.5**	**5.9**	**6.6**

* 1 = Very poor/ 9 = Excellent; **Local flour; ***Eliminated due to scab damage.

Table 26. Desirability scores of dough of 10 soft red winter wheat flours for making cookie, steam bun and sweet bread*

Product	Cooperator	Control 1**	Control 2**	AGS 2056	AGS 2035	AGS 2060	USG 3251	USG 3201	Terral TV 8861	SY 9978***	Ricochet	Croplan 9101	RM1201
cookie	China I	8.5		7.8	7.5	8.0	7.0	6.5	6.0		5.5	5.0	6.3
Cookie	Indonesia I	7.0		6.0	8.0	5.5	7.0	6.0	5.0		5.5	5.5	7.0
cookie	Indonesia II	7.0		4.0	4.0	5.0	5.5	5.5	5.0		7.0	4.0	4.0
cookie	Malaysia	7.0		6.8	7.7	6.8	8.0	7.5	6.6		7.4	7.2	7.8
cookie	Mexico	8.7		8.4	8.3	8.7	8.4	8.7	8.5		8.2	8.4	8.4
cookie	Peru	6.0		5.0	4.5	4.5	5.5	5.5	6.0		7.5	5.5	7.0
cookie	Philippines I	7.0		5.0	6.0	5.0	9.0	6.0	5.0		9.0	5.0	6.0
cookie	Philippines II	7.0		5.5	5.3	5.0	8.0	6.8	7.3		7.4	6.5	6.7
cookie	Philippines III	7.0		5.0	6.5	6.8	6.8	6.8	6.8		8.0	6.5	7.0
cookie	Thailand	7.0		6.5	8.5	6.0	8.5	7.8	6.5		8.0	7.5	8.5
cookie	China I	9.0		9.0	8.5	8.8	9.0	8.5	8.5		9.0	9.0	8.0
Cookie	Indonesia I	7.0		6.5	7.0	6.5	6.5	6.5	6.5		6.5	6.5	6.5
cookie	Indonesia II	8.0		7.0	7.5	6.5	7.5	7.5	6.0		7.0	7.0	6.0
cookie	Malaysia	7.0		6.5	7.0	6.5	6.0	6.5	6.5		6.0	6.5	7.0
cookie	Mexico	8.5		8.5	7.6	7.4	7.6	7.8	8.3		7.8	7.9	7.4
cookie	Peru	5.5		6.5	4.5	4.5	5.5	6.5	5.5		6.5	5.0	6.0
cookie	Philippines I	7.0		6.0	7.0	6.0	6.0	6.0	6.0		6.0	6.0	6.0
cookie	Philippines II	7.0		6.0	7.0	6.0	6.0	6.2	6.2		6.0	6.2	6.2
cookie	Philippines III	7.0		6.5	7.0	6.5	5.0	6.3	5.0		5.0	5.0	6.5
cookie	Thailand	7.0		5.0	6.0	6.0	3.5	4.0	4.5		4.0	3.5	6.0
	Average	**7.3**		**6.4**	**6.8**	**6.3**	**6.8**	**6.6**	**6.3**		**6.9**	**6.2**	**6.7**
Steam Bun	China II	9.0	8.0	7.0	7.5	7.0	6.0	8.0	8.0		8.0	6.0	9.0
Sweet Bread	Dominmican Republic	6.0		7.0	5.0	4.5	5.0	5.5	8.5		6.0	6.0	6.0
	Overall Average	**6.7**		**5.9**	**6.2**	**5.7**	**6.1**	**6.1**	**5.9**		**6.3**	**5.7**	**6.2**

* 1 = Very poor/ 9 = Excellent; **Local flour; ***Eliminated due to scab damage.

Table 27. Desirability scores of batter of 10 soft red winter wheat flours for making sponge cake and chiffon cake*

Product	Cooperators	Control 1**	Control 2**	AGS 2056	AGS 2035	AGS 2060	USG 3251	USG 3201	Terral TV 8861	SY 9978***	Ricochet	Croplan 9101	RM1201
Sponge Cake	China II	9.0	8.0	7.0	7.5	7.0	6.0	8.0	8.0		8.0	6.0	9.0
Sponge Cake	Indonesia I	7.0		6.5	6.5	7.0	7.0	6.5	7.0		6.5	7.0	7.0
Sponge Cake	Indonesia II	8.0		8.5	8.5	8.0	8.0	8.5	8.0		8.5	8.0	8.0
Sponge Cake	Malaysia	7.0		6.0	6.0	8.0	8.0	6.0	8.0		5.5	8.0	7.0
Sponge Cake	Thailand	7.0		5.0	6.0	6.0	3.5	4.0	4.5		4.0	3.5	6.0
	Average	**7.6**	**8.0**	**6.6**	**6.9**	**7.2**	**6.5**	**6.6**	**7.1**		**6.5**	**6.5**	**7.4**
Chiffon Cake	Philippines I	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0		7.0	7.0	7.0
Chiffon Cake	Philippines II	7.0		7.0	7.0	7.0	7.0	7.0	7.0		7.0	7.0	7.0
Chiffon Cake	Philippines III	7.0	7.0	7.0	6.5	7.0	7.0	7.0	7.0		7.0	7.0	7.0
	Average	**7.0**	**7.0**	**7.0**	**6.8**	**7.0**	**7.0**	**7.0**	**7.0**		**7.0**	**7.0**	**7.0**
	Overall Average	**7.4**	**7.3**	**6.8**	**6.9**	**7.1**	**6.7**	**6.8**	**7.1**		**6.7**	**6.7**	**7.3**
* 1 = Very poor/ 9 = Excellent; **Local flour; ***Eliminated due to scab damage.													

Table 28. Desirability scores for quality of cookie, sponge cake, chiffon cake, steam bun and sweet bread of 10 SRW wheat flours*

Product	Cooperators	Control 1**	Control 2**	AGS 2056	AGS 2035	AGS 2060	USG 3251	USG 3201	Terral TV 8861	SY 9978***	Ricochet	Croplan 9101	RM1201
Cookie	China I	8.5		7.8	7.5	8.0	7.0	6.5	6.0		5.5	5.0	6.3
Cookie	Indonesia I	7.0		6.0	8.0	5.5	7.0	6.0	5.0		5.5	5.5	7.0
Cookie	Indonesia II	7.0		4.0	4.0	5.0	5.5	5.5	5.0		7.0	4.0	4.0
Cookie	Malaysia	7.0		6.8	7.7	6.8	8.0	7.5	6.6		7.4	7.2	7.8
Cookie	Mexico	8.7		8.4	8.3	8.7	8.4	8.7	8.5		8.2	8.4	8.4
Cookie	Peru	6.0		5.0	4.5	4.5	5.5	5.5	6.0		7.5	5.5	7.0
Cookie	Philippines I	7.0		5.0	6.0	5.0	9.0	6.0	5.0		9.0	5.0	6.0
Cookie	Philippines II	7.0		5.5	5.3	5.0	8.0	6.8	7.3		7.4	6.5	6.7
Cookie	Philippines III	7.0		5.0	6.5	6.8	6.8	6.8	6.8		8.0	6.5	7.0
Cookie	Thailand	7.0		6.5	8.5	6.0	8.5	7.8	6.5		8.0	7.5	8.5
	Average	**7.2**		**6.0**	**6.6**	**6.1**	**7.4**	**6.7**	**6.3**		**7.4**	**6.1**	**6.9**
Sponge Cake	China II	8.0		7.2	7.4	7.3	7.2	8.4	8.1		7.1	7.0	8.4
Sponge Cake	Indonesia I	7.0		6.5	6.0	8.0	7.5	6.5	6.5		7.5	7.5	7.0
Sponge Cake	Indonesia II	8.5		6.5	4.5	8.0	7.0	5.5	6.0		4.0	7.5	5.0
Sponge Cake	Malaysia	7.0		6.3	6.0	7.0	7.0	7.0	6.7		6.3	7.0	6.5
Sponge Cake	Thailand	7.0		4.0	5.5	6.8	5.5	5.0	6.5		7.5	6.0	6.0
	Average	**7.5**		**6.1**	**5.9**	**7.4**	**6.8**	**6.5**	**6.8**		**6.5**	**7.0**	**6.6**
Chiffon Cake	Philippines I	7.0	4.0	9.0	5.0	5.5	5.5	10.0	5.0		5.0	6.0	7.0
Chiffon Cake	Philippines II	7.0		7.3	5.0	6.3	7.5	7.5	5.5		5.4	6.5	7.3
Chiffon Cake	Philippines III	7.0	7.0	6.3	6.0	6.0	7.0	6.5	6.2		6.3	6.2	6.2
	Average	**7.0**	**5.5**	**7.5**	**5.3**	**5.9**	**6.7**	**8.0**	**5.6**		**5.6**	**6.2**	**6.8**
Steam Bun	China II	9.0	8.0	7.0	7.0	6.0	7.0	8.0	9.0		9.0	6.0	8.0
Sweet Bread	Dominmican Republic	8.0		8.5	7.5	8.5	8.0	5.5	8.0		8.0	7.0	5.0
	Overall Average	**7.4**	**6.3**	**6.4**	**6.3**	**6.5**	**7.1**	**6.9**	**6.5**		**7.0**	**6.4**	**6.8**

* 1 = Very poor/ 9 = Excellent; **Local flour; ***Eliminated due to scab damage.

Table 29. Overall desirability scores of 10 SRW wheat flours for making cookie, sponge cake, chiffon cake, steam bun and sweet bread*

Product	Cooperators	Control 1**	Control 2**	AGS 2056	AGS 2035	AGS 2060	USG 3251	USG 3201	Terral TV 8861	SY 9978***	Riccochet	Croplan 9101	RM1201
cookie	China I	8.5		8.0	7.5	7.8	6.5	7.0	6.0		5.5	5.0	6.8
Cookie	Indonesia I	7.0		6.5	8.5	6.0	7.5	7.0	6.5		7.0	7.0	7.5
cookie	Indonesia II	7.7		5.9	6.7	6.3	6.5	6.8	5.7		7.0	6.0	5.3
cookie	Malaysia	7.0		6.6	7.8	6.8	7.4	7.2	6.9		6.7	6.5	6.0
cookie	Mexico	8.7											
cookie	Peru	6.0		5.5	4.5	4.5	5.0	6.0	6.0		7.0	5.5	7.0
cookie	Philippines I	7.0		6.0	6.0	5.0	9.0	6.0	6.0		6.5	5.5	6.0
cookie	Philippines II	7.0		6.0	6.8	5.0	7.2	6.0	6.7		6.5	5.5	6.3
cookie	Philippines III	7.0		6.3	6.8	6.7	6.2	6.5	6.1		6.6	6.0	6.9
cookie	Thailand	7.0		6.5	8.5	6.0	8.5	7.8	6.5		8.0	7.5	8.5
	Average	**7.3**		**6.4**	**7.0**	**6.0**	**7.1**	**6.7**	**6.3**		**6.8**	**6.1**	**6.7**
Sponge Cake	China II	8.0		7.2	7.4	7.3	7.2	8.4	8.1		7.1	7.0	8.4
Sponge Cake	Indonesia I	7.0		6.5	6.5	7.5	7.0	6.5	7.0		7.0	8.0	7.0
Sponge Cake	Indonesia II	8.5		7.3	6.8	7.7	7.2	7.2	6.7		6.5	7.5	6.3
Sponge Cake	Malaysia	7.0		6.5	6.6	7.3	7.2	6.9	6.8		6.3	6.0	5.5
Sponge Cake	Thailand	7.0		4.0	5.5	6.8	5.5	5.0	6.5		7.5	6.0	6.0
	Average	**7.5**		**6.3**	**6.6**	**7.3**	**6.8**	**6.8**	**7.0**		**6.9**	**6.9**	**6.6**
Chiffon Cake	Philippines I	7.0	6.0	8.0	6.0	5.0	6.0	8.0	6.0		4.0	5.0	6.0
Chiffon Cake	Philippines II	7.0		7.2	5.0	5.5	5.7	6.3	5.0		5.0	6.0	6.2
Chiffon Cake	Philippines III	7.0	6.5	6.7	6.2	6.0	6.7	6.4	6.9		6.6	7.2	6.3
	Average	**7.0**	**6.3**	**7.3**	**5.7**	**5.5**	**6.1**	**6.9**	**6.0**		**5.2**	**6.1**	**6.2**
Steam Bun	China II	9.0	8.0	7.0	7.0	6.5	6.5	7.5	8.5		8.0	6.0	8.0
Sweet Bread	Dominmican Republic	7.0		5.5	7.5	7.5	6.0	6.0	8.0		7.5	5.5	4.0
	Overall Average	**7.4**	**6.8**	**6.5**	**6.7**	**6.4**	**6.8**	**6.8**	**6.6**		**6.7**	**6.2**	**6.5**

* 1 = Very poor/ 9 = Excellent; **Local flour; ***Eliminated due to scab damage.

GENOTYPING FOR QUALITY TRAITS: WQC AND OVA

Anne Sturbaum, January 2014

Genotyping for traits associated with quality, physiology and disease resistance was done at the Regional Small Grains Genotyping Laboratory (RSGGL) in Raleigh, N.C. for the 9 WQC varieties: VA07W-415, VA09W-75, VA09W-73, VA09W-188WS, SY 547 (formerly M09L-9547), F0014, F0039, F0065 and D8006. Checks for this group were Caledonia and Shirley. 2012 Crop OVA varieties, AGS2056, AGS 2035, AGS 2060, USG 3251, USG 3201, Terral TV 8861, SY9978, Ricochet and Croplan 9101 were also tested.

Quality

High molecular weight glutenins, especially the alleles "5+10" at *GluD1*, the over-expressed *Bx7* at *GluB1* and the *GluA1a (Ax2*)* are useful for selecting varieties with strong gluten protein. These alleles correlate with strong gluten and dough strength (Ma et al., 2003). We report on the *GluA1, GluB1* and *GluD1* loci involved in selecting for varieties with specific dough quality.

Amplification for high molecular weight glutenins at the *GluA1* locus, using the marker *umn19* (Liu et al., 2008a) identified the *Ax2** genotype in 8 WQC entries and the check, Caledonia. D8006 had Ax1 or null alleles and Shirley was heterozygous at this allele. The Ax2* genotype was present for 6 of the OVA entries; Terral TV 8861 and SY9978 had the Ax1 or null alleles and Croplan 9101 was heterozygous at the *GluA1* locus.

Primers detecting a 45 base pair insertion specific to the *Bx7* over-expressing allele (*Bx7OE*) (Guttieri et al., 2008) indicated over-expressing *Bx7* only for F0014 and D8006. For the OVA varieties, over-expressing Bx7 was present in AGS 2035 and SY 9978, while Ricochet and AGS 2060 were heterozygous. All other WQC varieties and checks produced a product indicative of the wild type allele at this locus.

Primers specific for *GluD1*, *Dx5*, generated a PCR product corresponding to the "5+10" genotype in WQC entries F0065, SY 547 and D8006, and for the OVA entries AGS 2035, AGS 2060, Ricochet and Croplan 9101. All other varieties produced amplification products specific for the "2+12" allele (Wan et al., 2005).

A translocation from chromosome 1 of rye, *Secale cereale L* (1RS), onto wheat chromosome 1B or 1A provides multiple resistances to powdery mildew, stem rust, leaf rust and stripe rust. The 1RS:1BR translocation was identified in WQC entries F0065 and SY 547 and Shirley. VA09W-73 and VA09W-75 have the 1R translocation as 1RS:1AL. OVA variety AGS 2035, and possibly Ricochet, had the 1RS:1BL translocation. These varieties produced amplification products with scm9F primers specific for rye ω-secalin using the Scm9 marker pair (Saal and Wricke, 1999).

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

Mutations in the photoperiod genes, *Ppd-D1a, Ppd-B1a* and *Ppd-A1a*, confer photoperiod insensitivity in wheat, allowing early flowering. The mutation in the *Ppd-D1a* allele (Beales et al.,

2007), copy number variations in *Ppd-B1a* (Díaz et al., 2012) and insertions and deletions in *Ppd-A1a* (Nishida et al., 2013) each influence the plant's flowering time.

WQC entries VA07W-415, VA09W-188WS, F0014, F0065 and D8006 have photoperiod insensitivity via the *Ppd-D1a* locus. Varieties VA09W-73 and VA09W-75 are insensitive through the *Ppd-A1a* locus, and SY 547 and Shirley have both the *Ppd-A1a* and *Ppd-D1a* variants for early flowering, with SY 547 testing heterozygous for *Ppd-A1a.1*. F0039 and Caledonia have wild type alleles at the three loci and thus lack photoperiod insensitivity. OVA entries except AGS 2035 and AGS 2060 (*Ppd-B1a*) have the *Ppd-D1a* insensitivity. Ricochet has both *Ppd-D1a* and *Ppd-B1a*.

Dwarfing genes were tested using markers specific for *Rht1 (Rht-B1b), Rht2 (RhtD1b)* and *Rht8* (Zhang et al., 2006). All WQC varieties had at least one dwarfing allele. SY 547 and Shirley amplified the *Rht1* allele, F0065 had both *Rht2* and *Rht8* alleles, OVA entry AGS 2060 had no dwarfing markers, and AGS 2056, SY 9978 and Croplan 9101 all amplified the *Rht1* allele. All other entries have the *Rht2* dwarfing allele.

Disease Resistance

Markers identifying resistance genes to stem and leaf rusts (*Sr2, Sr36, Sr24/Lr24* and *Lr34*) and Fusarium head blight (*Fhb1, Fhb 5A Ernie, Fhb 5A Ning 780*, and *Fhb 2DL*) were not detected among the WQC varieties. The check, Shirley, was positive for the *Sr36* stem rust resistance gene and D8006 had the tan spot resistance gene (*Tsn1*). OVA variety Ricochet amplified markers detecting both FHB-1 and Lr34. AGS 2060 amplified the Sr36 stem rust resistance marker.

Resistance to Fusarium head blight (FHB) was evaluated using markers associated with QTL on chromosomes 3BS (*FHB-1*) (Liu et al., 2008b) and 5A (Ernie and Ning) (McCartney et al., 2007). Leaf and stem rust resistance markers were evaluated using RSGGL KASP markers for diagnostic single nucleotide polymorphisms (SNPs). In soft wheats, the presence of the stem rust resistance gene, *Sr36*, is conferred by a translocation from *Triticum timopheevi* and is tested using the marker *wmc477* (Tsilo et al., 2008).

In soft wheats, the *Sr36* gene is usually linked to an allele for type 2 sucrose synthase, *Sus2*-HapH from the *timopheevi* translocation, and which in hard wheats was reported associated with high test weight (Jiang et al., 2011). The allele is detected by a KASP marker (RSGGL). Although the *Sr36* gene is absent in the variety VA09W-188WS, *Sus2* was heterozygous in this cultivar. Shirley and AGS 2060, both positive for the Sr36 gene, have the expected Sus2B *HapH* allele.

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Table 30. Genotyping 2013 Wheat Quality Council entries

CULTIVAR	Dwarfing	Photoperiod Insensitivity mutation	HMW GluA1	HMW GluB1 (Bx7 OE)	HMW GluD1	1RS RyeTL	Disease Resistance Genes*	Sucrose Synthase 2B - HapH
VA07W-415	Rht2	Ppd-D1a	Ax2*	WT	2+12	no	no	no
VA09W-75	Rht2	Ppd-A1a.1	Ax2*	WT	2+12	1RS:1AL	no	no
VA09W-73	Rht2	Ppd-A1a.1	Ax2*	WT	2+12	1RS:1AL	no	no
VA09W-188WS	Rht2	Ppd-D1a	Ax2*	WT	2+12	no	no	Hap H Het
Shirley (Check)	Rht1	Ppd-A1a.1 Ppd-D1a	Ax2* Het	WT	2+12	1RS:1BL	Sr36	Hap H
SY 547	Rht1	Ppd-A1a.1 Het, Ppd-D1a	Ax2*	WT	5+10	1RS:1BL	no	no
F0014	Rht2	Ppd-D1a	Ax2*	OE	2+12	no	no	no
F0039	Rht2	WT	Ax2*	WT	2+12	no	no	no
F0065	Rht2/ Rht8	Ppd-D1a	Ax2*	WT	5+10	1RS:1BL	no	no
D8006	Rht2	Ppd-D1a	Ax1 or null	OE	5+10	no	Tsn1	no
Caledonia (Check)	Rht2	WT	Ax2*	WT	2+12	no	no	no
AGS 2056	Rht1	Ppd-D1a	Ax2*	WT	2+12	no	no	no
AGS 2035	Rht2	Ppd-B1a	Ax2*	OE	5+10	1RS:1BL	no	no
AGS 2060	no	Ppd-B1a	Ax2*	Het	5+10	no	Sr36	Hap H
USG 3251	Rht2	Ppd-D1a	Ax2*	WT	2+12	no	no	no
USG 3201	Rht2	Ppd-D1a	Ax2*	WT	2+12	no	no	no
Terral TV 8861	Rht2	Ppd-D1a	Ax1 or null	WT	2+12	no	no	no
SY 9978	Rht1	Ppd-D1a	Ax1 or null	OE	2+12	no	no	no
Ricochet	Rht2	Ppd-D1a, Ppd-B1a	Ax2*	Het	5+10	1RS:1BL?	FHB-1, Lr34	no
Croplan 9101	Rht1	Ppd-D1a	het	WT	5+10	no	no	no

* Markers identifying resistance genes to stem and leaf rusts (*Sr2*, *Sr36*, *Sr24/Lr24* and *Lr34*), Fusarium head blight (*Fhb1*, *Fhb 5A Ernie*, *Fhb 5A Ning 780*, and *Fhb 2DL*) and tan spot (*Tsn1*) were tested.

QUALITY CHARACTERISTICS OF REGIONAL NURSERY ENTRIES

2013 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 for end-use quality by the SWQL, and this information is provided to breeders in the regional nursery reports, as well as being posted on the SWQL website: http://www.ars.usda.gov/Main/docs.htm?docid=23253.

Narratives describing recent quality evaluation and summary tables for check varieties are provided below. The goal of this project is to provide consistent and complete information on the milling and baking performances of advanced breeding lines and varieties. Multiple checks in each nursery help to detect quality that has been altered due to growing conditions. Checks are varieties for which a historical record of quality traits has been documented by the SWQL.

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 the trait that gives economic return to the flour millers. To some extent, it is also associated genetically and environmentally with good soft wheat flour quality.

Softness Equivalence

After flour yield, one of the traits that we recommend for use in selection is softness equivalence (SE). SE tends to have high heritability and is an important predictor of flour particle size, grain hardness and damaged starch content. 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 (arabinoxylan) components. Lactic acid SRC is associated with gluten protein characteristics, and sodium carbonate SRC is related to 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 correlate to flour protein and lactic acid SRC values.

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

High sodium carbonate SRC absorption values indicate an increased damaged starch content during milling.

Lower water SRC values are desired for cookies, cakes and crackers.

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.

REGIONAL COLLABORATING NURSERIES AND COORDINATORS

BROWNSTOWN, ILLINOIS WHEAT VARIETY TRIAL	*Fred Kolb, University of Illinois*
URBANA, ILLINOIS WHEAT VARIETY TRIAL	*Fred Kolb, University of Illinois*
NORTHERN UNIFORM WINTER WHEAT SCAB NURSERY	*Carl Griffey, Virginia Polytechnic Institute and State University*
SOUTHERN UNIFORM WINTER WHEAT SCAB NURSERY	*Carl Griffey, Virginia Polytechnic Institute and State University*
GULF ATLANTIC WHEAT NURSERY	*Carl Griffey, Virginia Polytechnic Institute and State University*
MASON-DIXON REGIONAL NURSERY	*Carl Griffey, Virginia Polytechnic Institute and State University*
UNIFORM SOUTHERN SOFT RED WINTER WHEAT NURSERY	*Esten Mason, University of Arkansas*

BROWNSTOWN, ILLINOIS, WHEAT VARIETY TRIAL

Fred Kolb, University of Illinois

A total of 77 samples were grown in Brownstown and submitted by Fred Kolb of the University of Illinois to the USDA-SWQL in 2013 for milling and baking quality evaluations. The samples were tested for grain characteristics (test weight, grain protein, kernel hardness), milling quality (flour yield, softness equivalence), and SRC (sodium carbonate, lactic acid). Cookie baking tests were not performed on this group.

The highest milling yield from this nursery belongs to Hunker at 70.7%. Other high flour yield lines include S-1200, Beck 120, and KSC 412W. Beck 113 had the least yield at 65.1%. Softness equivalence in this group was highest for AgriMAXX Exp 1327 (69%) and lowest for Julie VII (55.5%).

The average lactic acid SRC for this sample set was high (values ranged from 94.8% to 146.5%), indicating "strong" gluten protein. Check samples for this group had higher than historic lactic acid SRC values, indicating an influence due to the growing conditions in 2013.

Sodium carbonate SRC values determined 27 samples were below 68%, with LCS L171, Pro Harvest 288, and Katie 12 having the lowest values.

Table 31. Brownstown, Illinois, wheat variety trial 2013 quality data

Entry	Test Weight (LB/BU)	Whole Grain Protein (at 12%)	Whole Grain Hardness (0-100)	Flour Yield (%)	Softness Equivalence (%)	Flour Protein (at 14%)	Lactic Acid SRC (%)	Sodium Carbonate SRC (%)
AgriMAXX 412	59.6	10.2	7.0	68.0	58.0	7.8	124.6	67.4
AgriMAXX 413	56.4	9.6	7.8	69.6	62.7	7.3	110.4	68.1
AgriMAXX 415	59.3	10.2	3.7	69.7	60.2	7.6	119.0	67.0
AgriMAXX 422	57.8	10.3	12.0	68.2	61.7	7.8	129.6	71.6
AgriMAXX Exp 1335	56.9	9.3	13.2	67.3	63.7	7.2	110.5	73.8
AgriMAXX Exp 1327	58.0	10.2	12.0	69.1	69.0	7.9	114.5	68.7
AgriMAXX Exp 1348	56.3	9.6	11.4	68.5	61.8	7.0	110.0	71.9
Beck 113	**57.6**	**9.9**	**18.0**	**65.1**	**64.0**	**7.7**	**127.0**	**80.0**
Beck 120	55.1	9.5	9.9	70.6	63.6	7.4	111.5	68.1
Beck 129	56.9	9.2	4.3	70.1	65.7	6.5	113.1	67.9
Beck 135	57.4	9.1	14.8	68.9	66.7	6.4	112.9	74.3
BG 2W11	57.2	9.6	8.9	67.4	66.6	6.9	114.0	71.4
Diener 492W	55.1	9.0	8.8	70.3	64.1	7.0	113.6	69.2
Diener 506W	56.8	9.5	10.8	67.7	65.5	7.0	106.0	70.2
Quest	55.8	9.9	1.3	68.7	68.4	7.2	127.0	71.1
Sienna	57.6	10.0	3.5	69.3	63.4	7.4	136.2	68.6
Edge	57.6	10.6	7.2	68.3	64.3	7.5	107.6	72.8
EXP 101	58.3	10.4	10.9	69.1	62.3	8.2	113.6	67.1
Pioneer 25R77	58.0	9.2	6.1	67.8	66.8	6.9	113.5	73.6
Pioneer 25R78	57.4	9.7	15.4	68.7	64.6	7.5	111.7	70.6
Pioneer 25R46	57.5	9.8	12.7	67.9	63.7	6.7	94.8	72.1
Pioneer 25R62	**55.5**	**9.2**	**8.4**	**69.5**	**62.5**	**6.9**	**109.4**	**68.5**
Pioneer 25R40	57.1	9.5	6.8	68.3	65.5	6.8	121.4	73.9
Dyna-Gro 9171	55.0	9.6	8.1	70.1	63.6	7.2	112.3	66.9
Dyna-Gro 9031	59.6	10.0	11.0	69.2	60.5	7.6	129.8	68.3
Dyna-Gro 9223	57.4	8.9	0.0	70.1	66.7	6.3	112.9	67.4
Dyna-Gro WX12803	57.1	10.0	9.5	68.9	62.5	7.4	113.5	70.0
FS 602	55.5	9.3	7.9	70.3	64.0	7.2	109.9	68.0
FS 605	58.5	9.4	8.2	69.8	66.7	6.7	105.2	72.1
FS 622	58.7	9.7	5.5	70.1	62.2	7.1	114.5	66.3
FS 625	56.4	9.4	16.8	68.5	66.7	6.7	102.2	68.0
FS 626	55.3	9.6	12.5	67.4	66.8	7.3	124.9	73.6
WX13A	57.6	9.0	13.0	68.3	67.1	6.9	107.2	71.1
LCS L228	60.8	9.1	16.3	67.2	60.5	7.4	130.0	66.6
H7W14	55.6	9.5	1.4	68.4	65.8	6.7	109.1	69.0
H7W11	58.7	10.4	15.1	67.7	58.7	8.0	132.7	68.9
H-7171	57.9	9.7	12.5	69.2	68.6	7.5	111.2	68.7
H-7180	59.1	9.8	14.7	69.4	60.3	7.7	128.8	68.0
LCS L163	57.6	10.4	8.3	69.6	64.8	7.9	128.0	72.0
KSC 409W	59.2	10.4	16.9	69.2	59.9	8.2	131.2	67.9
KSC 411W	54.9	9.1	9.4	70.2	63.3	6.8	110.3	67.0

Entry	Test Weight (LB/BU)	Whole Grain Protein (at 12%)	Whole Grain Hardness (0-100)	Flour Yield (%)	Softness Equivalence (%)	Flour Protein (at 14%)	Lactic Acid SRC (%)	Sodium Carbonate SRC (%)
KSC 412W	56.9	9.1	8.9	70.5	66.7	6.8	113.9	66.6
Lewis 829	57.9	10.0	8.2	69.7	62.2	7.6	135.4	68.0
Lewis 839	56.1	10.2	16.6	69.1	63.7	7.5	114.5	71.0
Lewis 851	58.3	9.8	11.7	69.2	63.2	7.8	114.4	68.4
LCS 38686	57.8	9.6	10.8	69.9	65.5	7.3	120.8	72.4
LCS 34969	57.1	10.0	13.4	70.3	66.1	7.3	118.3	68.6
Millie 4	58.0	10.7	7.8	69.6	64.3	8.2	129.3	71.0
Bintee 9	58.1	10.0	9.0	69.1	68.3	7.5	111.5	67.9
Katie 12	58.9	10.4	7.5	69.0	59.7	8.2	128.7	66.2
Julie VII	60.5	10.7	15.9	67.7	55.5	8.2	121.6	68.5
Barbie VIII	55.0	9.1	1.4	67.3	66.2	7.0	112.5	71.0
Barbie 9	58.5	10.0	7.4	67.2	62.4	7.4	130.8	70.7
LCS L171	58.5	10.3	10.0	69.5	67.6	7.8	114.7	65.5
Pro Harvest 311	56.9	9.4	17.4	68.2	65.8	6.8	104.1	68.5
Pro Harvest 288	57.6	10.0	6.4	69.9	64.0	7.6	135.5	66.0
Pro Harvest 334	57.4	9.2	2.6	70.3	65.1	6.6	117.6	67.6
Dowell	56.3	9.3	14.9	68.6	65.6	6.8	105.1	68.0
Heilman	57.0	10.0	4.5	69.6	64.3	7.4	135.7	68.2
Hunker	57.1	9.0	5.2	70.7	66.2	6.8	115.6	67.0
S-1200	55.3	9.4	10.7	70.7	63.6	7.4	116.0	66.7
S-1100	56.7	9.2	15.2	68.5	66.4	6.9	105.5	68.8
Syngenta SY 1526 Cruiser	56.9	9.9	12.1	69.4	63.6	7.5	110.0	72.4
Syngenta W1104 Cruiser	55.2	10.0	10.6	67.2	60.3	7.5	99.8	67.2
Syngenta MH07-7474	58.3	9.9	18.2	67.8	59.7	7.8	136.0	67.8
Syngenta SY 483	54.9	9.6	12.2	68.4	64.8	7.4	116.8	75.8
USG 3555	**57.1**	**10.1**	**9.3**	**67.1**	**60.6**	**7.8**	**131.1**	**79.8**
USG 3438	54.8	9.3	12.7	69.5	63.1	7.2	115.8	67.6
USG 3251	57.0	9.6	13.0	68.5	65.9	7.0	116.2	72.4
IL06-7653	57.1	9.6	11.7	68.9	66.5	7.3	121.4	73.3
IL06-23571	**57.8**	**9.9**	**11.3**	**68.9**	**68.9**	**7.3**	**108.5**	**70.2**
IL07-4415	56.5	9.3	11.8	67.9	62.9	6.7	115.1	71.3
IL07-16075	59.9	10.1	15.5	67.3	62.4	7.5	126.6	69.5
IL07-19334	59.1	9.2	14.8	69.5	63.9	7.1	120.0	69.2
IL07-20728	61.4	9.5	15.3	67.2	60.9	7.3	126.2	66.7
Jamestown	**59.2**	**11.4**	**18.3**	**65.7**	**63.3**	**8.3**	**146.5**	**82.8**
VA09W-73	58.6	10.6	12.4	67.5	62.2	7.9	128.4	72.6
Average	57.4	9.7	10.5	68.8	64.0	7.3	118.0	69.9

Check varieties are shaded.

URBANA, ILLINOIS, WHEAT VARIETY TRIAL

Fred Kolb, University of Illinois

A total of 65 samples were grown in Urbana and submitted by Fred Kolb of the University of Illinois to the USDA-SWQL in 2013 for milling and baking quality evaluations. The samples were tested for grain characteristics (test weight, grain protein, kernel hardness), milling quality (flour yield, softness equivalence), and SRC (sodium carbonate, lactic acid). Cookie baking tests were not performed on this group.

An average milling yield of 69.5% was measured for this trial with GV 653 and M13W producing the best milling yields of 72.2% and 72.1%, respectively.

Among the 65 samples, KSC 412W had the highest softness equivalence at 65.2%. KSC 412W was followed very closely by Hunker and Dyna-Gro 9223.

A total of 36 samples exhibited lactic acid SRC values greater than 110%, indicative of "strong" gluten protein. Highest lactic acid SRC values were observed in Syngenta MH07-7474, PRO 260, IL07-20728, and M13W.

All but 15 samples were below 68% in sodium carbonate SRC. Syngenta MA08*8007# had the lowest sodium carbonate SRC at 62.2%. Others lines with low sodium carbonate SRC values include FS 622, Katie 12, and PRO 320A.

Table 32. Urbana, Illinois, wheat variety trial 2013 quality data

Entry	Test Weight (LB/BU)	Whole Grain Protein (at 12%)	Whole Grain Hardness (0-100)	Flour Yield (%)	Softness Equivalence (%)	Flour Protein (at 14%)	Lactic Acid SRC (%)	Sodium Carbonate SRC (%)
AgriMAXX 413	59.2	11.4	29.5	69.0	59.8	9.4	110.8	66.5
AgriMAXX 427	60.4	10.7	33.9	67.3	61.3	8.7	96.4	67.9
AgriMAXX 434	59.2	10.7	21.1	68.6	61.6	8.5	105.5	69.4
AgriMAXX 438	58.7	11.1	24.9	70.6	64.1	8.6	110.7	67.2
AgriMAXX Exp 1348	58.8	12.0	28.3	68.3	58.7	9.5	106.3	70.8
Beck 113	**61.9**	**10.0**	**32.0**	**66.9**	**61.4**	**7.9**	**110.4**	**75.5**
Beck 120	59.0	10.7	26.7	70.0	57.7	8.7	97.0	65.5
Beck 129	57.8	10.8	24.5	70.3	64.1	8.7	115.0	66.2
Beck 135	60.1	11.3	29.3	68.5	62.8	9.1	95.9	71.7
Diener 492W	59.6	11.1	27.5	68.9	57.8	9.1	104.4	66.0
Diener 512W	59.4	9.1	13.0	71.9	64.6	7.4	106.6	65.4
DeRaedt 11	58.6	10.3	25.8	70.7	60.2	7.9	97.7	64.8
DeRaedt 9	58.6	10.8	23.3	70.8	64.4	8.9	113.1	67.9
EXP 101	60.4	11.8	24.8	70.0	60.0	9.5	109.0	64.4
Quest	58.1	10.8	21.1	69.5	64.3	8.5	114.7	69.3
Sienna	60.1	11.0	14.4	70.7	62.2	8.5	119.4	66.6
Pioneer 25R34	60.6	10.0	20.7	70.7	61.9	8.0	113.0	67.1
Pioneer 25R39	58.8	11.3	32.0	68.0	61.1	8.8	109.7	75.5
Pioneer 25R40	60.5	11.8	30.4	68.4	59.4	9.1	118.3	70.6
Pioneer 25R46	61.6	10.8	29.1	69.2	60.1	8.4	95.6	67.4
Pioneer 25R77	61.6	10.5	26.4	68.2	62.7	8.6	109.0	70.9
Dyna-Gro 9171	59.0	10.0	24.0	70.2	58.7	8.5	101.3	65.1
Dyna-Gro 9223	58.8	10.1	24.8	71.6	65.2	8.3	111.7	66.0
GV 653	59.6	9.8	18.0	72.2	63.7	7.7	108.7	67.2
GV 662	63.2	12.1	28.7	69.3	54.5	9.8	111.8	65.2
FS 602	58.6	10.4	26.8	70.1	58.1	8.1	98.8	65.0
FS 622	62.1	10.0	22.1	71.1	60.8	8.2	110.8	63.0
FS 625	60.1	10.9	33.9	68.1	60.7	8.4	101.1	67.3
FS 626	61.2	10.6	30.6	68.9	59.9	8.8	119.0	67.9
WX13A	60.7	9.2	24.8	69.8	63.5	7.5	93.9	67.1
KSC 409W	62.3	11.0	22.1	71.0	57.2	9.4	123.5	65.2
KSC 411W	58.8	10.0	26.3	70.2	59.5	8.1	105.2	65.4
KSC 412W	59.3	9.3	21.1	72.0	65.2	7.4	106.4	66.1
Lewis 829	59.9	11.1	18.9	70.5	61.6	8.8	120.0	67.4
Lewis 839	59.6	12.3	31.2	68.8	58.6	9.1	115.7	67.6
Lewis 851	60.6	11.7	28.8	69.9	60.4	9.4	111.5	65.7
M13W	60.1	10.3	19.4	72.1	61.8	8.4	132.7	69.1
Skysail	59.7	11.2	28.7	68.3	62.0	9.2	126.4	66.8
Barbie 9	62.1	10.6	27.4	68.1	59.0	8.9	121.1	69.0
Barbie VIII	59.7	11.5	27.5	66.7	61.8	9.5	123.0	71.0
Bintee 9	63.6	11.4	17.2	69.8	63.0	9.0	93.3	64.1

Entry	Test Weight (LB/BU)	Whole Grain Protein (at 12%)	Whole Grain Hardness (0-100)	Flour Yield (%)	Softness Equivalence (%)	Flour Protein (at 14%)	Lactic Acid SRC (%)	Sodium Carbonate SRC (%)
Julie VII	63.9	12.6	33.7	68.7	49.7	10.2	126.6	67.8
Katie 12	62.6	11.7	23.2	71.0	55.9	9.8	117.7	63.4
Millie 4	62.1	11.3	22.5	70.6	59.2	9.4	119.1	66.0
Pro Harvest 288	59.6	11.9	21.9	70.3	62.1	9.4	112.2	66.5
Pro Harvest 311	60.1	10.8	31.1	67.8	62.1	8.6	97.9	68.4
Pro Harvest 334	59.2	10.1	23.5	71.3	64.5	8.3	115.2	66.7
PRO 240	61.2	10.9	15.2	70.5	60.0	8.6	114.0	66.6
PRO 260	60.5	11.4	24.5	68.8	56.6	9.0	137.0	71.2
PRO 320A	61.3	12.1	25.4	70.5	54.0	9.6	129.0	63.5
Dowell	59.6	11.6	32.9	67.6	62.0	9.5	97.6	67.5
Heilman	59.9	11.4	19.1	70.6	61.6	9.0	111.5	66.8
Hunker	58.7	9.5	22.8	71.6	65.2	8.0	110.4	66.7
S-1100	60.0	10.5	32.6	68.4	62.0	8.2	98.8	66.5
S-1200	60.1	11.5	28.2	69.4	58.3	9.5	98.9	64.1
Syngenta MA08*8007#	62.2	12.5	28.2	69.4	57.3	10.0	106.5	62.2
Syngenta MH07-7474	61.8	12.0	33.9	68.1	54.9	10.0	145.1	64.9
Syngenta SY 483	58.4	11.1	31.1	68.1	62.4	8.9	108.9	75.9
Syngenta W1104 Cruiser	59.2	11.4	35.9	67.0	53.9	9.1	89.2	65.1
IL06-23571	**62.4**	**11.8**	**20.8**	**69.1**	**64.3**	**9.4**	**89.4**	**66.7**
IL06-7653	60.8	9.6	21.1	70.2	63.7	7.9	106.3	68.8
IL07-16075	63.2	10.9	27.0	68.0	59.8	8.8	124.1	66.9
IL07-19334	61.4	9.6	25.6	70.0	59.8	7.9	115.8	67.1
IL07-20728	63.9	10.3	23.6	68.1	58.1	8.4	133.2	64.3
IL07-4415	61.4	11.9	22.5	67.4	55.4	9.4	128.0	66.3
Average	60.4	10.9	25.7	69.5	60.4	8.8	111.2	67.2

Check varieties are shaded.

NORTHERN UNIFORM WINTER WHEAT SCAB NURSERY

Carl Griffey, Virginia Polytechnic Institute and State University

A total of 60 samples were grown in a composite of nursery locations and submitted by Carl Griffey of Virginia Tech to the USDA-SWQL in 2013 for milling and baking quality evaluations. The standard quality data were compared to the average for the cultivar checks given for this nursery.

Flour analysis indicates that the quality trait averages of milling yield, softness equivalence, and flour protein fall within the expected ranges for soft wheat characteristics. The milling yield average for this nursery was 68.5%, with NE06607 having the highest yield at 72.3%.

An average softness equivalence of 58.1% was measured for this nursery, with OH08-269-58 producing the largest softness equivalence at 65.9%.

The average lactic acid SRC value for the nursery was 116.6%, indicative of "strong" gluten protein. KY05C-1369-13-7-3 had the highest lactic acid SRC value at 158.3%.

Sodium carbonate SRC values for this nursery detected a high value of 91.9% for NW10401. A total of 33 samples were below 68%, with M10-1659 having the lowest sodium carbonate SRC absorption at 62.8%.

Table 33. Northern Uniform Winter Wheat Scab Nursery wheat variety trial 2013 quality data

Entry	Test Weight (LB/BU)	Whole Grain Protein (at 12%)	Whole Grain Hardness (0-100)	Flour Yield (%)	Softness Equivalence (%)	Flour Protein (at 14%)	Lactic Acid SRC (%)	Sodium Carbonate SRC (%)
ERNIE	**58.6**	**10.5**	**25.3**	**68.3**	**57.7**	**7.9**	**120.6**	**66.3**
FREEDOM	**58.5**	**10.6**	**29.3**	**68.2**	**54.6**	**8.0**	**101.3**	**64.9**
PIONEER2545	**57.8**	**11.1**	**36.6**	**66.7**	**56.3**	**9.1**	**109.5**	**67.5**
NY07104-141	60.0	12.0	30.5	66.8	59.3	9.1	86.8	66.3
NY99069-WC	59.9	12.4	35.6	65.8	55.4	9.8	102.2	65.2
NY99045-3110	57.9	10.8	28.1	69.0	61.2	8.2	98.3	65.6
NY99056-161	59.0	10.0	29.0	69.3	59.3	8.2	118.6	68.1
KWS 009	60.8	10.3	33.8	68.8	57.3	8.1	108.0	69.4
KWS 010	61.0	11.9	39.0	68.9	57.3	9.6	106.2	64.7
KWS 013	58.0	10.0	31.1	68.5	57.8	8.2	124.3	66.7
KWS 014	59.0	9.8	27.2	69.8	60.1	7.6	112.2	65.6
LCS10727	58.4	8.9	29.1	71.3	64.2	6.9	111.8	65.9
LCS13531	59.9	10.2	26.5	69.0	55.6	7.5	117.1	67.5
LCS19228	59.2	9.0	30.3	71.7	63.3	7.0	114.9	67.6
LCS19707	58.8	10.7	28.9	69.2	55.6	8.2	106.3	67.1
F0013R	61.7	10.4	35.4	66.7	59.0	8.0	123.2	70.7
F0065	58.0	9.2	27.5	69.3	59.6	7.1	106.5	71.1
F1003R	61.2	11.3	34.8	66.0	55.3	8.5	99.4	72.3
F1029	57.7	9.9	24.5	70.0	61.0	7.7	111.5	68.6
TRUMAN	**59.7**	**9.4**	**30.9**	**68.4**	**58.8**	**7.3**	**108.0**	**68.8**
OH07-263-3	60.1	10.2	32.3	70.4	56.5	8.1	104.0	65.0
OH08-172-42	59.1	9.9	28.2	68.4	58.5	7.5	108.9	67.6
OH08-269-58	57.9	9.9	24.8	68.5	65.9	7.4	121.9	74.2
05247A1-7-7-3-1	59.3	11.2	28.4	69.1	59.0	8.3	97.5	71.2
05287A1-1-13	60.0	11.3	24.5	68.3	53.6	8.8	113.2	64.6
0762A1-2-8	57.0	9.8	28.0	66.8	56.2	7.9	110.8	68.6
05247A1-7-3-120	58.8	10.9	25.8	68.9	57.5	8.4	104.1	69.7
05264A1-1-3-33	59.3	12.0	27.2	68.3	41.2	9.7	100.2	74.4
MH07-7474	60.0	10.8	32.2	68.0	54.3	8.7	137.9	66.8
MA08-8036#	60.8	12.0	31.6	67.9	54.0	9.4	136.4	65.4
M10-1659	60.9	10.7	31.9	69.7	55.4	8.3	116.4	62.8
M10-1615	59.5	9.3	28.6	70.4	55.5	7.4	100.9	66.8
M10*1307#	58.8	9.6	27.5	69.1	57.2	7.5	96.3	64.5
IL06-23571	60.8	10.7	28.2	70.0	62.1	8.2	106.2	64.1
IL07-19334	60.8	10.6	29.0	69.9	57.1	8.3	128.5	66.1
IL07-20728	62.7	10.5	33.3	68.2	57.1	8.3	136.5	65.0
IL07-20743	63.0	11.4	34.8	68.9	53.3	9.3	143.8	63.2
KY05C-1369-13-7-3	61.7	12.5	33.2	66.0	56.3	10.1	158.2	74.2
KY05C-1020-2-19-1	60.0	11.7	27.6	66.3	54.0	9.5	126.3	67.5
KY05C-1600-92-9-5	60.3	11.1	28.4	70.6	53.5	9.0	117.1	66.5
KY05C-1051-37-18-5	62.3	10.9	37.5	67.4	58.4	8.7	129.5	71.0

Entry	Test Weight (LB/BU)	Whole Grain Protein (at 12%)	Whole Grain Hardness (0-100)	Flour Yield (%)	Softness Equivalence (%)	Flour Protein (at 14%)	Lactic Acid SRC (%)	Sodium Carbonate SRC (%)
KY05C-1105-43-10-3	60.6	10.6	30.4	66.5	59.1	8.1	138.8	69.5
MD05W10208-12-16	61.3	11.1	29.4	70.8	55.1	8.7	128.7	65.6
MDC07026-12-42	60.8	10.5	32.9	64.1	44.9	8.1	117.6	78.2
MDC07027-12-12	62.2	11.0	33.7	64.3	43.4	8.9	121.0	76.9
MDC07027-12-24	62.0	11.2	35.0	65.2	46.1	8.9	125.4	78.3
MO111134	60.0	10.6	27.3	68.2	55.1	8.2	122.6	69.4
MO111359	62.0	11.0	33.6	67.0	52.9	8.7	103.6	65.9
MO110719	61.8	11.5	32.2	67.8	53.9	8.8	105.8	64.5
MO100647	61.9	10.8	32.7	68.3	54.3	8.6	128.3	66.0
Bakhsh24	60.4	9.7	37.9	66.9	36.6	8.1	121.8	85.3
Bakhsh33	61.0	9.2	33.7	68.9	43.1	7.6	132.5	82.5
Bakhsh35	61.5	10.0	33.9	67.6	36.7	8.0	126.0	91.4
NW10401	61.2	10.2	25.7	69.1	39.2	8.4	123.7	91.9
NE06607	59.1	10.2	27.3	72.3	46.3	8.2	132.0	82.3
VA09W-188WS	57.1	9.5	22.2	71.5	56.8	7.4	102.5	70.0
VA08MAS-369	61.6	10.8	33.9	69.6	52.3	8.6	128.5	67.2
VA10W-123	59.3	9.4	28.0	70.9	62.8	7.2	120.0	70.2
VA11W-FHB39	56.9	10.2	28.1	69.0	60.1	8.3	120.9	68.3
VA11W-FHB40	57.5	11.1	26.5	68.1	58.0	8.6	114.9	68.7
Average	59.9	10.6	30.3	68.5	55.0	8.3	116.6	69.7

Check varieties are shaded.

SOUTHERN UNIFORM WINTER WHEAT SCAB NURSERY

Carl Griffey, Virginia Polytechnic Institute and State University

A total of 62 samples were grown in a composite of nursery locations and submitted by Carl Griffey of Virginia Tech to the USDA-SWQL in 2013 for milling and baking quality evaluations. The standard quality data were compared to the average for the cultivar checks given for this nursery.

Flour analysis indicates that the quality trait averages of milling yield, softness equivalence, and flour protein fall within the expected ranges for soft wheat characteristics. Lactic acid and sucrose SRCs exhibited higher values than those of the expected ranges.

A total of 34 entries had higher milling yield then that of the check average (68.3%), with LCS19227 having the greatest yield at 72.1%. An average softness equivalence of 54.4% was observed for this nursery, 6 points below the check average (60.4%). In addition to highest flour yield, LCS19227 had the highest softness equivalence amongst all the test lines at 63.5%.

The nursery produced many samples exhibiting higher than 130% lactic acid SRC.

A total of 43 entries displayed sodium carbonate SRC values above 68%. All ARS07- and ARS09- entries exceeded 80% sodium carbonate SRC values. The check average of this sample set (73%) is a bit higher than the check historical average (69.2%).

Table 34. Southern Uniform Winter Wheat Scab Nursery wheat variety trial 2013 quality data

Entry	Test Weight (LB/BU)	Whole Grain Protein (at 12%)	Whole Grain Hardness (0-100)	Flour Yield (%)	Softness Equivalence (%)	Flour Protein (at 14%)	Lactic Acid SRC (%)	Sodium Carbonate SRC (%)
ERNIE	**57.5**	**10.3**	**26.5**	**67.3**	**58.3**	**7.5**	**119.6**	**70.5**
COKER 9835	**58.9**	**9.0**	**30.0**	**70.0**	**65.8**	**6.7**	**103.0**	**75.5**
BESS	**58.8**	**9.1**	**27.8**	**67.5**	**57.3**	**7.0**	**103.3**	**70.9**
JAMESTOWN	**59.9**	**10.4**	**35.2**	**68.3**	**60.2**	**7.6**	**127.5**	**75.1**
MD03W61-11-3	60.9	12.9	36.7	65.8	53.0	10.5	134.5	75.4
ARS07-1214	60.7	11.2	32.1	65.8	39.5	9.3	136.9	87.0
ARS09-367	61.3	11.0	32.6	66.8	39.7	9.2	137.6	82.7
ARS09-446	61.2	11.3	34.0	71.2	39.6	10.4	135.6	84.4
ARS09-643	59.0	11.1	23.2	67.9	36.6	9.7	169.2	106.3
LA05102C-1-2	59.5	12.1	28.2	67.2	55.1	9.4	125.3	66.0
LA05102C-8-8	61.1	12.0	30.9	67.4	49.5	10.0	120.6	69.6
NC09-20986 (Fhb1)	60.7	11.7	31.2	67.1	58.3	9.6	155.0	71.4
AR00260-2-2	62.5	11.4	27.6	68.2	54.2	9.4	161.0	71.0
AR01044-1-1	59.5	11.1	28.0	69.6	55.7	8.6	98.0	65.4
AR01110-3-1	58.3	10.4	29.4	69.7	59.3	7.8	109.2	68.9
AR01178-1-1	58.1	10.3	28.7	69.1	55.2	8.3	116.6	69.2
ARGE05-1229-2-1	58.9	12.3	28.0	68.0	50.9	10.0	141.9	70.1
ARGE07-1339-10-5-8	59.6	12.1	29.9	63.9	53.2	9.4	126.1	71.0
ARGE07-1374-17-5-4	62.7	11.7	32.1	65.9	53.6	9.1	135.1	67.8
ARGE07-1374-17-8-5	60.0	11.0	25.0	67.9	59.1	8.6	139.0	71.1
ARS07-1073	55.9	11.3	29.2	66.8	44.1	10.0	165.4	103.3
ARS09-082	59.7	11.0	33.8	68.6	42.2	9.2	142.8	87.2
ARS09-228	59.7	13.4	35.8	70.8	36.4	11.9	118.5	84.6
ARS09-745	60.2	11.0	27.3	70.1	42.0	9.3	136.9	83.1
GA04494-12ES33	60.0	11.2	32.5	68.8	49.1	9.6	123.3	69.2
GA051477-12ES27	60.0	11.1	30.4	69.8	59.7	8.7	141.5	69.7
GA051477-12ES28	61.0	10.8	30.3	69.8	58.5	8.6	134.5	67.8
GA051477-12ES29	59.2	10.8	31.1	69.4	59.7	8.7	135.6	67.8
GA051477-12ES32	60.8	10.5	30.7	69.1	55.9	8.4	124.3	67.2
GANC8170-12DH7	57.8	11.3	24.6	65.4	53.5	9.2	149.2	70.9
GANC8248-12DH1	60.8	11.1	30.9	68.3	55.0	9.1	130.6	64.8
GANCZ4-12DH21	59.9	12.1	27.9	66.2	49.0	9.6	139.7	72.7
LA05079F-P05	58.7	10.0	32.4	68.0	59.6	8.1	125.4	72.6
LA06069E-P01	59.3	10.0	31.9	68.0	61.4	7.9	133.6	75.0
LA06149C-P7	60.7	10.2	34.1	68.6	59.8	8.0	125.6	72.1
LA07085CW-P4	59.3	10.4	26.0	69.1	63.1	8.1	123.5	73.5
LA07178C-44	58.0	9.4	34.2	67.7	60.4	7.3	103.5	72.7
LCS19227	59.4	9.0	29.5	72.1	63.5	6.7	109.6	68.0
LCS15963	58.5	9.3	28.1	68.1	59.4	7.1	117.0	67.6
M10-1615	59.0	9.4	28.4	70.5	56.6	7.5	103.4	66.6
M10-1659	60.7	10.1	33.4	69.4	55.5	8.2	118.2	64.3

Entry	Test Weight (LB/BU)	Whole Grain Protein (at 12%)	Whole Grain Hardness (0-100)	Flour Yield (%)	Softness Equivalence (%)	Flour Protein (at 14%)	Lactic Acid SRC (%)	Sodium Carbonate SRC (%)
MD04W249-11-12	59.5	9.7	32.2	68.2	58.4	7.7	106.1	72.1
MD04W249-11-7	59.8	9.3	35.4	68.4	59.4	7.3	100.3	72.3
MD07W272-11-5	61.0	9.7	34.3	68.9	61.0	7.6	96.6	70.8
MD08-26-H2-7-12-21	61.3	10.8	29.6	68.0	56.3	8.5	123.9	67.5
MD08-26-H2-7-12-9	60.3	10.1	28.4	68.6	57.0	7.9	119.2	68.4
MDNC8248-64	61.2	9.8	37.5	68.1	55.4	8.0	119.2	73.0
MH07-7474	58.6	8.8	34.7	70.1	59.3	7.0	120.6	66.3
NC09-20768	60.4	9.6	36.0	68.3	58.0	7.5	110.0	69.2
NC09-22352	58.1	11.2	38.1	67.8	55.8	9.1	125.2	68.4
NC10-25212	61.4	9.7	36.2	70.0	57.5	7.7	115.7	66.0
NC8170-4-3	60.8	9.3	28.1	70.5	55.8	7.3	126.0	65.4
NC8170-45-2	61.2	10.4	28.1	70.1	56.2	8.1	138.9	65.3
NC8840-19	61.0	9.7	33.3	70.4	43.3	8.0	100.1	78.7
VA10W-112	60.8	10.8	31.9	68.5	57.6	8.4	134.5	72.8
VA10W-118	60.9	10.9	28.6	68.8	59.0	8.8	135.7	73.5
VA10W-119	61.2	11.3	31.2	69.2	52.4	9.1	126.5	66.7
VA11W-FHB110	62.0	11.0	27.9	67.4	54.1	8.7	127.7	66.5
VA11WFHB57	60.2	11.4	24.1	68.0	57.0	8.8	143.5	65.3
VA11W-FHB60	58.9	10.4	26.9	69.5	51.6	8.3	112.0	69.2
VA11W-FHB61	60.7	10.2	32.5	68.9	53.4	8.0	119.5	68.4
VA11W-FHB75	59.7	11.0	30.1	65.5	57.6	8.7	112.7	71.2
Average	60.0	10.7	30.7	68.4	54.4	8.5	126.0	72.4

Check varieties are shaded.

GULF ATLANTIC WHEAT NURSERY

Carl Griffey, Virginia Polytechnic Institute and State University

A total of 64 samples were grown in a composite of nursery locations and submitted by Carl Griffey of Virginia Tech to the USDA-SWQL in 2013 for milling and baking quality evaluations. The standard quality data were compared to the average for the cultivar checks for this nursery.

The averages of the soft wheat quality traits of milling yield, softness equivalence, flour protein, and the solvent retention capacity of sucrose produced values that were within the expected ranges for soft wheat characteristics. The SRCs of lactic acid, sodium carbonate, and water all were higher than the expected values.

Over half of the nursery samples produced a flour yield of 70% or greater, with GA 051754-12LE13 having the highest value at 73.5%. However, 7 entries (including VA11W-108, VA11W-31, and VA11W-106) exhibited flour yield lower than 68%.

The combined average softness equivalence of the checks was 57.8%, and two-thirds of the entries in this group showed softness equivalence values greater than 57.8%. The highest softness equivalence was observed in AR04016-4, followed by AR04032-2 and LA06069E-P01. Entries VA11W-31 and GA 03185-12LE29 were lower than 50% in softness equivalence.

The nursery average of lactic acid SRC was 114.3%, indicating the test lines possess relatively "strong" gluten protein. Thirteen entries, including NC09-21916 (A6), LA06146E-P04, GA 05304-12E35, LA06020E-P16, and AR04016-4, exhibited high lactic acid SRC and favorable flour yield and softness equivalence values, making them suitable for the manufacture of crackers or other products requiring gluten strength.

Twenty entries were below 68% in sodium carbonate SRC, with AR04001-3 having the lowest value at 64%. In contrast, LA03200E-23 had the highest sodium carbonate SRC at 74.9%.

The average sucrose SRC of the entries was 92.1%, with AR04001-3 having the lowest value at 82%. Eighteen entries were higher than 95% in sucrose SRC, with AR04029-4 having the greatest value at 102.1%.

The average water SRC of the entries was on the high end at 55.1%, with only NC09-21916 (A6) scoring a value of 51%. The other 63 samples ranged from 52.1 to 58.7% in water SRC.

Table 35. Gulf Atlantic Wheat Nursery wheat variety trial 2013 quality data

ENTRY	Test Weight (LB/BU)	Whole Grain Protein (at 12%)	Whole Grain Hardness (0-100)	Flour Yield (%)	Softness Equivalence (%)	Flour Protein (at 14%)	Lactic Acid SRC (%)	Sodium Carbonate SRC (%)	Sucrose SRC (%)	Water SRC (%)	Cookie Diameter (cm)	Top Grade (0-9)
NC09-21916 (A6)	61.7	9.8	23.0	70.5	63.3	8.2	141.0	68.7	91.0	51.0	18.3	4
NC09-20036	61.5	9.4	27.1	67.9	59.2	7.7	119.2	71.5	93.5	55.4	18.4	3
NC09-20986 (Fhb1)	61.2	10.1	22.3	68.3	62.0	8.3	144.5	70.6	96.9	55.6	18.3	3
NC10-23407	61.7	9.8	22.7	69.1	55.6	7.6	123.1	67.6	89.6	55.4	18.1	4
NC10-23730	62.9	10.9	26.4	70.5	56.6	8.9	134.6	64.5	86.1	53.4	18.2	5
NC10-23663(Bdv2)	60.6	9.1	20.2	68.5	61.2	7.2	117.4	70.7	91.9	54.0	19.0	4
NC10-23720	61.8	9.7	31.4	66.8	55.2	7.5	111.5	73.9	94.3	56.0	18.3	4
NC10-22592	61.4	10.1	20.2	70.4	59.0	7.9	117.1	73.0	95.8	55.1	17.8	5
NC10-25196	61.9	9.9	27.3	69.4	56.4	8.3	124.8	67.3	89.4	56.6	18.4	4
NC8170-4-3(Fhb1)	62.4	9.9	21.7	70.6	55.2	8.0	129.9	64.5	88.0	57.7	18.3	5
NC10-22614	60.4	9.6	22.5	68.6	60.1	7.8	107.1	67.8	85.9	55.1	18.4	4
NC10-22642	62.3	10.3	31.0	69.4	51.8	8.1	103.7	68.8	88.4	57.0	18.2	5
AGS2060	**62.2**	**10.0**	**25.4**	**70.5**	**55.3**	**8.1**	**122.0**	**65.7**	**92.1**	**54.3**	**18.7**	**5**
SS8641	**60.5**	**9.2**	**22.1**	**69.2**	**57.1**	**7.5**	**119.1**	**67.9**	**91.3**	**54.1**	**18.2**	**4**
GA 03564-12E6	61.2	9.0	27.5	70.2	59.7	7.1	119.4	68.7	89.7	55.4	18.3	5
GA 05304-12E35	60.4	9.0	18.4	72.1	62.2	7.2	112.3	69.7	88.6	56.1	18.3	4
GA 041272-12E42	60.9	10.0	24.3	69.9	58.1	7.9	123.0	68.8	93.4	55.1	17.6	5
GA 04268-12E4	61.8	9.6	27.5	67.5	52.3	7.6	112.3	72.9	97.1	57.8	17.4	4
GA 07270-12E15	61.3	10.1	19.8	71.5	54.7	8.2	116.4	66.3	87.7	55.7	18.5	6
GA 051304-12E28	59.1	9.0	22.5	70.4	57.9	7.1	94.2	72.8	95.6	56.1	18.3	4
GA 04417-12E33	60.4	9.5	21.4	70.2	56.8	7.4	108.7	68.1	91.0	54.9	18.6	5
GA 071630-12LE9	60.7	9.6	26.7	72.0	59.6	7.6	116.7	68.6	89.4	54.3	17.5	4
GA 03185-12LE29	64.0	11.2	34.2	70.2	49.1	8.8	101.1	68.8	90.3	58.7	18.1	4
GA 04434-12LE28	61.4	9.7	24.6	69.7	57.8	7.8	104.0	68.5	89.1	55.4	18.6	5
GA 04244-12LE16	61.6	9.3	27.5	69.0	54.6	7.5	114.2	69.7	90.4	54.7	17.6	3
GA 051754-12LE13	60.4	9.6	26.3	73.5	63.1	7.3	93.8	69.9	86.3	53.2	18.4	5
USG 3555	**59.9**	**9.5**	**23.3**	**70.3**	**59.6**	**7.5**	**113.5**	**73.6**	**98.6**	**55.9**	**18.2**	**4**
SHIRLEY	**59.1**	**9.7**	**23.3**	**70.9**	**58.6**	**7.2**	**92.4**	**68.6**	**88.9**	**53.9**	**17.8**	**4**
VA10W-96	60.7	9.3	21.9	69.3	59.8	7.4	128.9	72.1	93.5	54.2	18.2	4
VA10W-112	61.2	9.6	24.6	68.3	54.2	7.8	119.6	72.9	101.3	56.4	17.8	5
VA10W-118	60.4	9.4	21.6	64.0	53.3	7.2	117.9	72.5	101.2	57.0	18.5	5
VA11W-31	61.5	10.2	23.5	63.2	46.0	7.9	132.4	69.1	95.2	57.0	18.2	4
VA11W-106	59.9	8.4	24.9	63.3	54.9	6.5	106.4	73.0	92.6	55.6	18.8	5
VA11W-108	60.5	9.5	24.5	62.5	52.7	7.4	126.2	70.6	95.0	54.3	18.1	3
VA11W-165	59.4	9.5	19.0	65.2	53.7	7.1	110.5	66.7	89.1	53.7	18.0	4
VA11W-195	59.7	10.4	18.9	69.9	55.7	8.0	114.7	66.3	91.0	56.5	18.8	5
VA11W-196	59.1	10.7	22.3	69.1	57.1	8.3	110.0	70.1	96.7	55.9	18.6	5
VA11W-230	61.4	9.7	24.2	69.2	58.7	7.9	128.1	70.7	97.0	55.9	18.0	4
VA11W-278	60.5	8.8	25.1	69.0	61.3	7.0	115.1	69.5	86.5	56.3	18.9	5
VA11W-301	59.2	9.7	21.0	70.6	58.4	7.4	90.6	69.2	87.7	55.9	18.8	4

ENTRY	Test Weight (LB/BU)	Whole Grain Protein (at 12%)	Whole Grain Hardness (0-100)	Flour Yield (%)	Softness Equivalence (%)	Flour Protein (at 14%)	Lactic Acid SRC (%)	Sodium Carbonate SRC (%)	Sucrose SRC (%)	Water SRC (%)	Cookie Diameter (cm)	Top Grade (0-9)
AR04001-3	60.7	10.3	23.8	69.8	57.9	8.3	91.5	64.0	82.0	52.1	18.9	5
AR04002-3	57.7	8.3	15.8	71.6	62.0	6.4	90.5	66.2	88.5	53.5	18.6	5
AR04006-1	58.1	8.6	21.9	71.0	61.9	6.7	97.0	68.9	88.3	56.2	17.9	4
AR04008-5	59.4	9.1	19.6	69.6	61.0	6.9	106.2	71.1	91.9	55.8	18.5	4
AR04015-5	60.1	9.8	19.1	68.3	61.7	7.7	136.6	72.2	100.0	56.1	18.4	4
AR04016-4	59.8	8.7	13.8	70.7	66.2	6.7	113.8	68.6	88.8	53.8	17.9	5
AR04025-3	58.6	8.9	12.0	71.4	64.1	6.7	106.9	67.9	90.8	54.6	18.5	6
AR04029-4	58.9	10.3	13.4	70.2	60.3	7.8	113.5	67.4	102.1	56.5	18.6	6
AR04029-4-5	59.3	10.4	14.5	70.2	58.5	7.8	106.1	68.5	98.9	58.3	17.7	4
AR04032-2	59.5	9.4	16.8	71.5	65.5	7.4	106.8	67.3	90.4	53.3	18.2	5
AR04084-1-3	62.4	9.9	19.8	71.1	59.1	7.7	115.8	64.8	89.8	52.7	18.8	4
AR04119-3	61.7	8.7	15.2	69.2	55.5	6.7	105.1	65.1	87.9	54.2	18.5	5
FL04363E-P23	58.2	9.7	9.7	70.3	61.5	7.7	116.1	66.3	92.9	53.1	18.5	4
LA03200E-23	60.8	10.0	19.1	68.4	61.9	7.9	110.8	74.9	100.8	56.8	18.3	3
LA05027D-26	61.5	10.9	26.7	70.0	57.5	8.5	118.7	69.6	96.1	54.8	18.5	3
LA05032D-136	61.5	10.8	20.0	69.0	57.8	8.7	125.0	69.3	95.8	55.3	17.6	3
LA05079F-P01	59.3	8.3	16.6	69.6	63.4	6.7	108.6	70.8	94.2	55.1	18.7	6
LA05079F-P05	60.5	9.1	18.9	68.9	62.4	7.2	113.1	69.2	93.0	54.1	18.7	5
LA05120F-P12	59.6	9.6	21.0	71.8	64.7	7.2	114.6	68.3	90.1	53.6	18.6	5
LA06020E-P16	61.0	9.6	29.1	72.2	62.0	7.5	111.4	66.0	87.1	52.4	19.3	6
LA06036E-P04	62.6	9.5	27.4	69.5	54.1	7.8	113.5	68.6	93.4	55.2	18.2	6
LA06069E-P01	59.9	9.0	23.0	68.6	65.2	6.6	113.8	74.1	98.1	57.2	18.1	4
LA06146E-P04	60.7	9.4	24.0	70.0	62.4	7.3	125.6	68.3	91.1	52.3	18.3	5
LA07040D-P01	59.4	9.4	15.4	70.7	60.5	7.6	114.3	66.1	87.6	52.7	18.4	5
Average	60.6	9.6	22.2	69.4	58.5	7.6	114.3	69.1	92.1	55.1	18.3	4.47

Check varieties are shaded.

MASON-DIXON REGIONAL NURSERY

Carl Griffey, Virginia Polytechnic Institute and State University

A total of 79 samples were grown in a composite of nursery locations and submitted to the USDA-SWQL in 2013 by Carl Griffey of Virginia Tech for milling and baking quality evaluations. The standard quality data were compared to the average for the cultivar checks for this nursery.

The overall grain condition for this nursery displayed obvious sprouting. Averages of the soft wheat quality traits demonstrate that milling yield and flour protein were within the expected ranges for soft wheat characteristics. The averages of softness equivalence, lactic acid SRC and sodium carbonate SRC were greater than the expected values.

ARS09-061, KY05C-1713-104-7-3, and KY05C-1519-89-1-3 had higher milling yield than that of the check Pioneer 26R15 (70.7%). The check with the lowest yield was SS 8700 at 65.6%. Lines with flour yield more than a percentage point less than SS 8700 were MDC07026-12-42, ARS10-211, ARS09-692, and MD07W280-12-3.

Out of 79 entries, only ARS10-470 and VA10W-123 exhibited softness equivalence values above 66%. Despite its relatively high milling yield, KY05C-1713-104-7-3 had the lowest softness equivalence of 44.7%.

The average lactic acid SRC of the entries was 119%, indicating relatively "strong" gluten protein. ARS10-096 showed the highest lactic acid SRC value at 149.2%, while VA11W-301 showed the lowest value at 95.8%.

The sodium carbonate SRCs of the entries ranged from 64.3% to 82.3%, with 12 test lines having values below 68%.

Sixty one test lines exhibited sucrose SRC values below 95%, with VA10W-126 having the lowest sucrose SRC at 82.4%.

Table 36. Mason-Dixon Regional Nursery wheat variety trial 2013 quality data

ENTRY	Test Weight (LB/BU)	Whole Grain Protein (at 12%)	Whole Grain Hardness (0-100)	Flour Yield (%)	Softness Equivalence (%)	Flour Protein (at 14%)	Lactic Acid SRC (%)	Sodium Carbonate SRC (%)	Sucrose SRC (%)	Cookie Diameter (cm)	Top Grade (0-9)
Pioneer 26R15	**60.5**	**9.3**	**25.5**	**70.7**	**65.6**	**7.2**	**123.9**	**68.3**	**87.0**	**18.8**	**3**
Branson	**60.7**	**9.4**	**23.5**	**70.4**	**65.4**	**7.0**	**124.3**	**67.5**	**86.0**	**19.0**	**6**
Shirley	**61.5**	**9.6**	**22.8**	**70.0**	**61.2**	**7.1**	**91.8**	**70.6**	**83.2**	**18.9**	**7**
SS 8700	**60.5**	**8.7**	**30.1**	**65.6**	**64.8**	**6.9**	**119.5**	**71.4**	**95.4**	**18.1**	**4**
VA10W-119	62.2	9.2	22.8	70.6	61.3	7.1	112.9	68.9	86.5	17.7	3
VA10W-28	61.4	10.7	22.1	69.6	51.6	8.4	106.0	69.9	88.1	18.3	2
VA10W-123	61.1	8.7	20.6	70.5	66.7	6.6	111.2	71.1	86.0	18.5	3
VA10W-140	63.0	9.5	22.5	70.4	59.9	7.2	118.0	70.0	86.3	18.7	3
VA10W-42	62.5	10.0	20.8	70.5	58.9	7.9	118.7	69.7	85.6	18.6	2
VA10W-96	62.9	9.8	23.1	68.6	58.8	7.8	127.7	72.1	90.3	18.3	2
VA10W-112	63.0	10.3	25.0	68.7	60.8	8.0	129.4	73.8	95.4	17.5	1
VA10W-118	62.5	9.9	21.6	69.2	63.3	7.7	131.5	74.3	98.9	18.0	1
VA10W-126	61.6	9.2	15.7	70.0	61.0	6.6	113.2	67.8	82.4	18.7	2
VA08W-672	62.1	9.5	25.7	69.8	62.5	7.3	134.0	68.7	86.0	18.9	6
VA10W-669	62.4	10.6	27.7	67.1	60.1	8.2	126.2	75.8	101.3	18.1	1
VA11W-31	62.9	10.0	22.9	68.7	57.5	7.7	137.2	69.9	89.7	18.3	2
VA11W-106	62.6	9.1	25.5	68.7	64.2	6.9	113.7	71.8	88.5	18.2	2
VA11W-108	62.6	10.3	25.2	67.9	62.7	7.7	129.8	70.6	89.7	18.3	2
VA11W-165	62.1	9.5	22.2	70.7	64.4	7.0	115.1	67.4	82.8	18.7	7
VA11W-195	61.6	10.3	18.8	68.9	57.3	7.5	116.6	67.1	87.9	18.6	5
VA11W-196	61.4	10.9	23.0	68.0	58.3	7.9	111.1	69.4	91.3	18.4	3
VA11W-230	63.1	9.9	22.6	68.9	59.1	7.9	134.2	71.0	92.6	17.8	1
VA11W-278	63.9	9.8	24.4	68.8	60.7	7.6	128.1	70.0	85.1	19.0	6
VA11W-301	62.9	10.3	22.4	70.0	58.8	7.5	95.8	69.2	83.2	19.3	6
MD05W10208-12-6	63.3	10.4	23.6	69.4	57.0	7.9	126.2	72.1	89.5	18.2	2
MD05W10208-12-7	62.6	9.7	25.4	69.1	58.6	7.6	113.5	68.2	84.2	18.6	6
MD05W10208-12-12	63.2	10.4	26.1	69.5	55.3	8.2	113.4	64.7	85.0	18.1	5
MD05W10208-12-14	64.0	10.2	24.7	69.5	58.0	8.0	104.6	67.4	86.6	18.6	6
MD05W10208-12-16	64.4	10.5	23.3	70.6	58.4	8.2	123.0	64.3	86.1	18.5	7
MD05W56-12-5	62.4	10.6	27.9	68.0	65.0	8.4	131.9	75.4	91.1	18.1	1
MD06W165-12-1	63.2	9.8	23.5	68.2	57.7	7.4	118.5	70.9	93.5	17.6	3
MD06W165-12-3	63.1	10.0	25.9	67.3	56.3	7.7	118.1	72.3	98.3	17.8	3
MDC07026-12-10	64.5	10.7	25.3	69.8	56.5	8.5	116.9	69.3	88.0	17.7	4
MDC07026-12-30	63.6	8.6	23.3	69.6	62.6	6.6	111.3	70.9	87.0	18.7	4
MDC07026-H2-7-12-9	63.5	11.2	24.2	67.3	57.2	8.3	122.9	67.9	86.1	17.5	6
MDC07026-H2-7-12-21	63.4	10.5	23.5	67.6	59.5	8.0	124.7	72.7	85.3	18.3	4
MDC07026-12-42	63.2	10.2	28.5	63.7	47.4	7.6	109.8	79.5	99.2	16.9	4
MD06W146A-12-1	63.2	9.9	21.3	67.7	60.7	7.8	126.6	67.2	86.7	18.5	5
MD06W404A-12-1	61.2	10.8	23.9	67.4	56.8	8.1	119.1	71.6	94.5	18.2	5
MD07W280-12-3	63.7	10.1	27.5	64.5	63.5	7.8	134.0	72.8	89.1	18.3	5

ENTRY	Test Weight (LB/BU)	Whole Grain Protein (at 12%)	Whole Grain Hardness (0-100)	Flour Yield (%)	Softness Equivalence (%)	Flour Protein (at 14%)	Lactic Acid SRC (%)	Sodium Carbonate SRC (%)	Sucrose SRC (%)	Cookie Diameter (cm)	Top Grade (0-9)
MD07W280-12-4	63.0	9.8	19.6	68.4	63.0	7.5	139.9	75.0	91.1	17.9	4
MD04W8-12-1	64.3	11.5	29.6	68.1	55.2	9.3	122.4	66.2	88.5	18.3	3
MD04W8-12-3	63.3	10.0	25.2	68.4	57.0	7.8	116.1	74.0	93.1	18.4	4
MD03W129-12-6	62.6	9.6	27.3	67.4	59.8	7.6	110.6	68.8	88.1	18.4	4
ARS07-0525	63.8	10.4	22.9	70.5	59.9	7.9	100.3	68.7	87.4	18.6	3
ARS08-0047	61.1	9.1	26.4	68.4	62.4	7.1	118.1	68.1	83.7	18.7	4
ARS09-061	62.7	10.3	24.5	72.2	56.1	8.0	98.5	65.6	85.4	18.2	4
ARS09-155	62.6	9.5	14.2	70.1	62.3	6.8	94.8	71.8	90.8	18.6	3
ARS09-162	63.8	11.0	22.0	67.1	53.5	8.1	106.4	72.3	95.2	17.9	3
ARS09-437	61.9	10.1	17.2	67.0	57.6	7.7	131.2	70.4	92.3	17.8	4
ARS09-692	59.4	10.8	22.2	64.2	51.1	7.8	95.7	77.0	91.2	17.8	5
ARS09-744	63.1	9.9	23.8	66.7	53.6	7.4	105.2	75.1	94.5	17.0	3
ARS09-750	63.1	9.7	21.5	66.1	59.7	6.9	133.4	77.6	97.0	16.9	2
ARS10-085	62.7	9.7	26.0	67.1	64.2	7.3	121.6	77.0	97.0	17.6	2
ARS10-094	63.7	11.0	25.4	67.0	61.6	8.1	147.4	77.3	101.3	17.6	3
ARS10-096	62.5	10.5	25.8	66.9	62.8	7.8	149.2	77.6	104.5	17.8	2
ARS10-211	62.0	9.5	28.5	63.8	60.5	7.1	120.1	82.3	101.6	17.2	2
ARS10-235	62.5	11.6	26.1	67.5	56.1	9.0	129.0	73.0	97.6	18.0	2
ARS10-470	62.8	9.6	15.3	69.4	67.3	7.5	132.7	70.0	86.7	18.8	5
KY05C-1140-8-4-1	63.7	10.9	25.0	65.4	55.2	8.7	135.9	68.1	90.8	17.6	2
KY05C-1140-9-8-5	62.7	9.8	30.1	65.6	59.3	7.9	127.7	71.7	89.4	18.3	4
KY05C-1142-10-1-1	62.6	8.9	23.4	67.7	65.2	6.8	121.0	72.6	91.1	18.6	5
KY05C-1369-14-6-3	64.4	11.3	30.7	68.8	56.2	9.0	131.8	69.4	91.1	18.4	3
KY05C-1105-42-20-1	63.7	9.9	24.7	67.5	60.5	7.5	125.4	71.2	89.3	17.7	4
KY05C-1105-43-6-1	64.1	10.2	24.7	67.4	61.0	7.4	127.1	69.8	90.5	18.3	4
KY05C-1118-48-20-1	63.0	10.0	23.8	68.2	58.6	7.6	133.0	73.3	95.5	18.2	3
KY05C-1126-50-12-1	62.7	10.4	27.1	69.5	58.6	8.1	112.9	65.6	86.4	18.2	5
KY05C-1381-77-7-5	61.0	9.0	23.9	67.3	63.9	6.6	97.0	73.1	87.9	18.3	5
KY05C-1381-77-17-1	62.0	10.8	23.9	67.4	60.2	8.1	117.8	73.3	88.9	17.9	5
KY05C-1519-89-1-3	63.7	10.4	22.9	71.2	60.1	8.0	124.1	68.4	87.5	17.8	4
KY05C-1713-104-7-3	63.0	11.4	29.9	71.9	44.7	9.3	112.9	80.3	96.7	16.1	2
KY05C-1713-107-13-1	63.2	10.1	32.5	67.9	58.9	8.0	97.0	73.8	91.8	17.9	4
KY05C-1717-115-3-1	63.1	10.4	29.3	69.3	59.4	8.2	119.7	72.8	92.2	17.8	4
KY05C-1719-119-12-1	64.6	11.1	29.9	68.1	55.8	8.4	123.1	68.3	92.5	17.6	3
KY05C-1719-121-8-3	64.1	11.1	34.0	68.3	49.6	8.6	120.1	74.6	92.0	17.2	3
KY05C-1112-127-18-5	63.8	10.8	20.1	70.6	62.5	8.0	112.6	66.5	85.5	18.4	4
KY05C-1121-130-4-5	64.7	10.9	32.0	66.7	52.4	8.5	109.0	73.2	91.6	18.0	5
KY05C-1121-130-5-1	62.6	10.4	26.4	66.8	53.9	7.9	93.6	69.2	89.5	18.2	3
KY05C-1121-131-3-3	62.9	10.8	34.0	66.5	54.3	9.0	103.2	72.0	90.7	18.2	5
Average	62.8	10.1	24.6	68.3	59.1	7.8	119.0	71.3	90.3	18.1	3.66

Check varieties are shaded.

UNIFORM SOUTHERN SOFT RED WINTER WHEAT NURSERY

Esten Mason, University of Arkansas

A total of 33 samples were grown in a composite of nursery locations and submitted to the USDA-SWQL in 2013 by Esten Mason of the University of Arkansas for milling and baking quality evaluations. The standard quality data were compared to the average for the cultivar checks for this nursery.

The entries produced an average flour yield of 69%. Out of the 29 test lines, VA07W-415 showed the highest flour yield at 70.7%. NC09-20765 was lowest in flour yield at 66.4%, but produced a sugar-snap cookie with the largest diameter at 18.7 cm.

There were 3 entries with softness equivalence values over 63%: LCS19227, VA09W-110, and VA10W-123. AR01040-4-1 had the lowest softness equivalence value of 55.6%.

Sixteen test lines were higher than 110% in lactic acid SRC and thus could be desirable for making crackers or other products requiring gluten strength. Out of these 16 lines, TN1303, LA05130D-P5, TN1301, VA09W-110, GA041052-11E51, and LCS19227 also showed relatively good flour milling yield.

A total of 18 test lines exhibited sodium carbonate SRC values lower than 68%. The sodium carbonate SRC values of TN1301, TN1302, AR00343-5-1, AR01040-4-1, and GA041293-11LE37 were lower than 64.9%.

Soft wheat flours for cookies typically have a value of 95% or less for sucrose SRC. LCS19227 had the lowest sucrose SRC value at 85.1%, whereas USG 3555 had the highest value at 101.9%.

Table 37. Uniform Southern Soft Red Winter Wheat Nursery wheat variety trial 2013 quality data

ENTRY	Test Weight (LB/BU)	Whole Grain Protein (at 12%)	Whole Grain Hardness (0-100)	Flour Yield (%)	Softness Equivalence (%)	Flour Protein (at 14%)	Lactic Acid SRC (%)	Sodium Carbonate SRC (%)	Sucrose SRC (%)	Cookie Diameter (cm)	Top Grade (0-9)
AGS 2000	**60.8**	**10.5**	**19.7**	**71.3**	**60.6**	**8.3**	**102.7**	**69.2**	**89.7**	**17.6**	**4**
Pioneer Brand 26R61	**61.2**	**11.1**	**27.8**	**68.4**	**56.5**	**8.7**	**112.1**	**67.7**	**94.9**	**17.8**	**3**
USG 3555	**58.9**	**10.4**	**21.2**	**67.7**	**58.0**	**8.2**	**113.4**	**73.5**	**101.8**	**17.6**	**2**
Jamestown	**61.3**	**11.0**	**18.2**	**68.0**	**60.5**	**8.5**	**121.8**	**71.3**	**98.6**	**17.2**	**3**
NC08-23089	60.1	10.0	19.7	68.5	60.2	8.0	112.1	70.6	94.9	17.9	4
NC08-23324	61.0	9.8	24.5	68.1	56.1	7.9	115.9	73.7	96.4	17.8	4
VA10W-119	61.3	10.7	18.0	69.8	57.9	8.1	114.1	67.5	93.6	17.2	3
NC08-21273	59.6	9.5	23.3	67.9	56.4	7.8	103.8	65.5	87.9	18.2	5
NC09-20765	62.3	10.5	18.2	66.4	59.1	8.5	108.1	67.7	93.7	18.7	5
TN1301	60.9	9.8	7.2	70.1	57.6	7.7	114.2	62.7	88.5	18.2	4
TN1302	59.2	9.7	13.5	70.0	60.8	7.6	103.9	64.4	88.9	18.4	4
TN1303	58.2	9.5	17.3	70.0	61.7	7.7	126.0	67.8	91.1	18.4	5
VA07W-415	60.3	9.5	18.7	70.7	58.6	7.5	104.9	66.6	90.3	17.6	5
VA10W-123	60.4	9.6	14.6	69.9	63.1	7.2	111.9	68.7	93.1	17.9	4
VA09W-110	59.0	9.5	13.9	70.0	63.9	7.2	113.6	66.9	87.8	18.3	5
KWS011	59.0	9.9	24.6	69.1	62.0	8.1	97.2	68.9	90.3	18.3	4
KWS012	60.6	10.1	23.2	67.9	58.1	8.0	117.3	69.9	98.0	17.7	3
KWS013	59.2	9.4	25.0	67.7	60.0	7.5	113.8	67.4	89.5	18.4	4
AR00343-5-1	60.8	10.0	13.4	69.3	61.7	8.1	121.4	64.9	92.2	18.3	3
AR01040-4-1	58.8	9.5	13.4	69.1	55.6	7.3	95.6	63.3	87.1	18.2	5
LA03200E-2	61.0	10.4	21.0	67.5	61.7	8.1	104.7	76.3	101.2	17.7	3
LA05038D-105	60.9	10.8	23.0	68.2	57.6	8.4	119.3	67.5	91.9	18.0	3
LA05130D-P5	61.1	9.9	19.4	70.0	56.9	7.9	118.8	69.5	94.4	17.9	4
LCS19701	59.8	9.9	19.6	68.4	61.7	7.6	103.4	71.0	95.8	18.3	3
LCS29817	60.2	10.3	18.2	69.8	60.8	8.0	106.1	65.5	86.1	17.7	4
LCS19227	59.5	9.4	13.0	70.6	66.4	7.2	110.0	66.6	85.1	18.1	4
GA041052-11E51	61.0	9.7	11.5	70.0	60.0	7.8	112.2	67.5	92.8	18.1	4
GA041293-11E54	61.5	10.6	14.3	69.1	58.1	8.0	121.9	66.6	96.5	17.9	4
GA041323-11E63	59.6	9.0	15.6	69.7	60.6	7.5	103.5	65.6	88.3	17.6	3
GA041293-11LE37	61.5	10.4	13.5	69.3	58.9	8.2	127.9	64.4	89.6	18.1	3
MD04W249-11-7	59.8	9.6	15.5	68.1	61.1	7.8	92.6	69.0	98.2	18.3	4
MD04W249-11-12	60.6	10.1	20.6	67.6	58.8	8.0	95.4	69.5	98.7	17.9	3
MD07W272-11-5	62.0	10.2	25.1	68.6	60.2	8.1	89.2	68.8	93.5	18.4	4
Average	60.3	10.0	18.4	69.0	59.7	7.9	110.0	68.1	92.7	18.0	3.79

Check varieties are shaded.

MATERIALS AND METHODS 2014

QUADRUMAT MILLING TESTS – BREEDER SAMPLES

The Soft Wheat Quality Laboratory evaluates thousands of breeder wheat samples yearly. Table 38 summarizes the traits tested and reported to breeders by the SWQL. The SWQL milling methods are described below.

Table 38. Milling and baking measurements and calculations for evaluation of breeder samples

TRAIT	SYMBOL	DESCRIPTION / CALCULATION
Whole Grain Protein	WPRO	Percent protein of whole, untempered grain measured on DA7200 near infrared (NIR) analyzer
Whole Grain Hardness	Hard	Scale of 1-100, soft to hard. Whole, untempered grain measured on DA7200 NIR calibrated to Single Kernel Characterization System
Grain Weight	GW	Weight of tempered, whole grain sample
Bran	Bran	Weight of milled product retained by 40-mesh* screen (over 40)
Mids	Mids	Weight of milled product retained by 94-mesh* screen (over 94)
Break Flour	BkFl	Weight of milled product (excluding bran) passing through 94-mesh* screen
Percent Bran, Mids, Break Flour	%	Expressed as percent of grain weight (Bran Weight/GW) x 100
Total Flour	Flour	Break Flour + Mids
Flour Yield	FY	(Total Flour/GW) x 100
Softness Equivalence	SE	(BkFl/Total Flour) x 100
Flour Moisture	FMOIST	Percent moisture of wheat flour estimated by Unity NIR
Flour Protein	FPRO	% protein of wheat flour by Unity NIR
Cookie Diameter	Cookie Dia	Total diameter of 2 baked cookies (cm)
Cookie Top Grain	Cookie TopG	0-9 visual scale (0 worst, 9 best)
Solvent Retention Capacity Tests	SRC	Percentage of solvent retained by a flour/solvent slurry after centrifugation and draining
Lactic Acid Sodium Carbonate Sucrose Water	LA SC SU WA	((residue wt/ flour wt)-1) x (86/(100 - %FMOIST)) x 100 flour wt = weight of dry flour residue wt = weight of drained, saturated flour

* Mesh size is the number of openings in the SSBC screen per linear inch; smaller particles pass through higher mesh number.

MODIFIED QUADRUMAT MILLING METHOD

Tempering: Prior to milling, wheat grain is estimated for moisture content using a Perten NIR DA7200 whole grain analyzer and tempered to 15% moisture. Grain samples are tempered in glass jars by adding distilled water, sealing with silicon-free, screw-top lids and tumbling on a chain driven roller/conveyor (Lewco) until the water is absorbed, about 30 minutes. Tempered grain samples are kept sealed at room temperature for at least 24 hours prior to milling to allow moisture equilibration throughout the kernel.

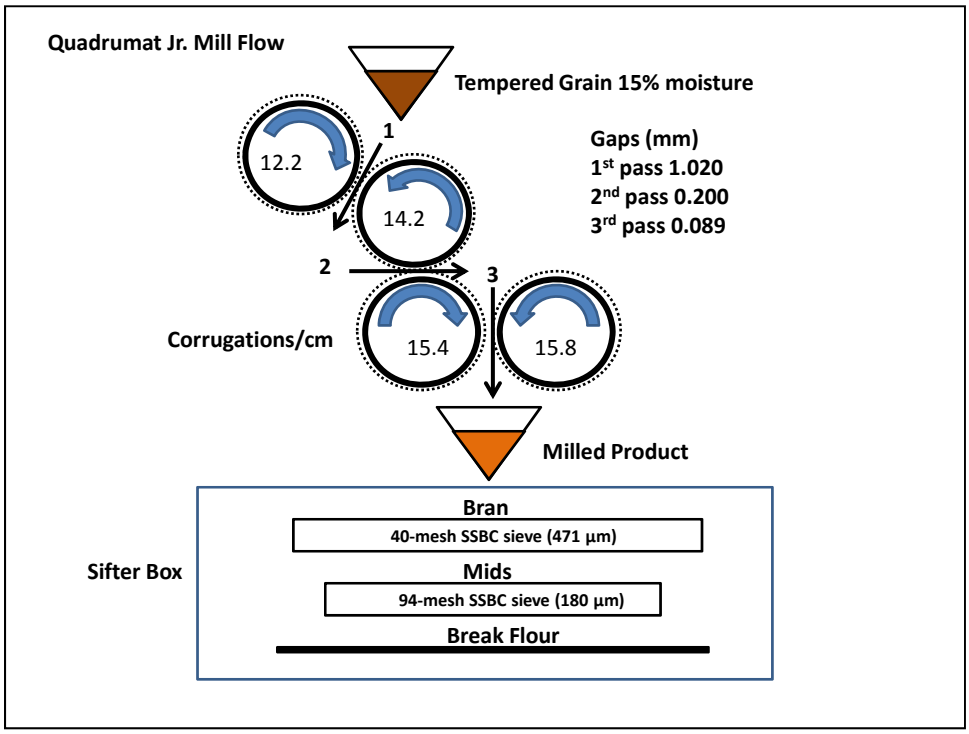
For the ***preliminary*** group samples, *tempered grain* is fed into the Quadrumat break roll unit and passed through three sets of milling rolls, each with increasing corrugations per centimeter and decreasing gaps to decrease particle size sequentially from grain to flour (Figure 1).

Milled product is sifted on a Great Western sifter box through sequential 40- and 94-mesh stainless steel bolting cloth (SSBC) screens, with 471 and 180 micron openings, respectively, to separate the milled product into three fractions: bran, mids and break flour. Bran is recovered above the 40-mesh screen, mids above the 94-mesh screen, and break flour passes through the 94-mesh screen. For ease of handling and accuracy, the bran and mids fractions are weighed as an indirect method for calculating flour yield (grain sample weight less bran as a percent of total grain weight) and softness equivalence (break flour as a percent of total flour).

For the ***intermediate*** group and ***advanced*** group grain samples, middlings are further passed through the Quadrumat reduction roll unit to obtain shorts and reduction flour. The milled fraction is sifted on an 84-mesh screen (213 micron openings) to yield shorts and reduction flour. Break and reduction flours are combined, blended to produce straight grade flour and used for composition, SRCs and cookie baking tests. Bran yield, break flour yield and total flour yield are determined the same ways as described for the preliminary group samples. All samples are milled under controlled temperature and humidity (19-21^{o}C and RH 58-62%). Mill temperature is equilibrated to 33 ± 1.0^{o}C by running the mill empty prior to sample milling.

Bran yield (%) is the percentage of bran retained by a 40-mesh SSBC screen (471 micron opening size) over the grain weight. Break Flour Yield (%) is the percentage by weight of the flour sifted through a 94-mesh SSBC screen (180 micron) over the grain weight. Mids (%) is the percentage middling stock (retained by the 94-mesch screen) over the grain weight. Potential Flour Yield (%) is the percentage by weight of the sum of break flour and middling stock over the grain weight.

Figure 1. Brabender Quadrumat Break Roll Unit Milling – adapted from Gaines, et al, 2000.



BREEDING SAMPLES

The SWQL treats samples as ***preliminary, intermediate*** or ***advanced*** group samples. The difference in treatment for each test type is summarized in Table 39.

Preliminary group testing is used for screening early generation selections, *intermediate* testing is used for intermediate generation samples and *advanced* testing is for advanced breeding lines. Milling scores produced for all three sample treatments are determined in the same way. *Intermediate* and *advanced* group testing add SRC and flour protein determinations, and *advanced* group testing includes sugar-snap cookie baking.

Preliminary group testing involves grain characteristics (TW, Grain NIR for protein and kernel hardness) and milling properties for breeders to screen early generation lines. Grain is milled using the Quadrumat break roll unit to obtain bran, middling and break flour. Flour yield and softness equivalence are calculated based on the equations described in the milling methods, Table 38, above. No further tests are performed using the break flour.

Intermediate and ***advanced*** group samples are milled using both the break and reduction roll units to produce break and reduction flours. The blend of break flour and reduction flour (straight grade flour) is used for flour quality tests. Grain characteristics and milling properties (TW, Grain NIR for protein and kernel hardness, flour yield and softness equivalence) are determined as for the preliminary groups. In addition, straight grade flour is tested for protein content and solvent retention capacity (SRC) of sodium carbonate and lactic acid. For ***advanced*** group samples, the straight grade flour is used for the sugar-snap cookie baking test.

Table 39. Differential processing of ***Preliminary, Intermediate*** and ***Advanced*** testing at SWQL

PROCEDURE	***Preliminary***	***Intermediate***	***Advanced***
Sample Size	80 g		200 g
Test weight	Whole grain		
Milling Method	Break Roll Unit Milling	Break and Reduction Roll Units Milling	
Flour Yield	Mids+Flour/Grain x 100		
Softness Equivalence	(Break Flour/Total Flour) x 100		
Hardness	DA7200 NIR		
Whole Grain Protein	DA7200 NIR		
Flour Test	NO	Straight Grade Flour (blend of break and reduction flours)	
Flour Moisture/Protein Content	NO	YES – Unity NIR	
Solvent Retention Capacity Tests (SRC)	NO	YES	
Sucrose	NO		YES upon request (5-g test)
Lactic Acid	NO	YES (1-g test)	
Water	NO		YES upon request (1-g test)
Sodium Carbonate	NO	YES (1-g test)	
Sugar-snap Cookie Diameter	NO	YES	
Sugar-snap Cookie Top Grain	NO	YES	

SOFT WHEAT QUALITY LABORATORY TESTING METHODS FOR QUALITY TRAITS

Traits included in the SWQL evaluation of breeding samples, the method used, the purpose of the measurement and measurement units are summarized in Table 40. SWQL methods are described in detail below.

Table 40. Traits measured at SWQL: methods, purpose and units

TRAIT	METHOD	INDICATES	UNITS
Test Weight	Modified AACC Method 55-10	Grain size, condition, packing efficiency	Estimated Pounds/bushel
Hardness (SKCS)	Perten Single Kernel Characterization System (SKCS)	Grain hardness <40 is considered soft wheat	1-100
Hardness (NIR)	Near Infra Red (NIR) Perten DA7200	Grain hardness <40 is considered soft wheat Calibrated to SCKS values	1-100
Whole Grain Protein		Whole grain Protein content	Percent
Falling Number	AACC Method 56-81.03 Perten Falling Number Tester	Pre-harvest sprouting damage (α-amylase activity)	seconds
Flour Yield	mids + break flour as % of initial grain weight	Flour recovery	Percent
Softness Equivalence	Break flour weight as % of total flour weight (Finney, 1986)	Estimates grain hardness, flour particle size	Percent
Flour Ash	AACC Method 08-01	Inorganic residue after combustion	Percent
Flour Moisture	NIR Unity Spectra-Star	Flour moisture	Percent
Flour Protein		Flour protein content	Percent
Solvent Retention Capacity Profile (SRC)	AACC Method 56-11.02	Solvent affinity	Percent
	Lactic Acid	Gluten strength	
	Sodium Carbonate	Damaged starch	
	Sucrose	Content of Pentosans (Arabinoxylans)	
	Water	Overall water affinity	
Sugar-snap Cookie Diameter	AACC Method 10-52 Baking Quality of Cookie Flour, Intermediate Method	Cookie spread	Centimeters
Sugar-snap Cookie Top Grain		Visual quality cookie surface	1-10 higher is better

WHOLE GRAIN MOISTURE, HARDNESS AND PROTEIN

Whole grain moisture, hardness and protein are measured using the NIR DA7200 Analyzer (Perten Instruments). Adjustment of calibrations was performed in Wooster, Ohio, for hardness, whole grain moisture and protein using values produced on the Single Kernel Characterization System (Perten Instruments), oven moistures (AACC Method 44-01.01) and nitrogen combustion analysis Rapid NIII Nitrogen Analyzer (Elementar), respectively.

FLOUR YIELD

Flour yield is calculated as the percent total flour weight (break flour + mids) of the sample grain weight from a single pass through the Quadrumat break roll unit. For calculation of flour yield, the difference between the grain weight and the bran weight (over 40) is used.

FY = ((GW-Bran)/GW) x 100

The formula is equivalent to: **(Total Flour/GW) x 100**

SOFTNESS EQUIVALENCE

Softness Equivalence (SE) is the percentage break flour (through 94-mesh screen) of the total flour weight (break flour + mids). SE approximates grain softness and particle size of flour produced from a single pass through the Quadrumat break roll unit (*C.W. Brabender Instruments, Inc.*) and is analogous to break flour in a large-scale mill (Finney, 1986). Total flour weight is calculated by subtracting bran weight (remaining over the 40-mesh screen) from initial grain weight. Subtracting the weight of the mids (remaining over the 94-mesh screen) from the total flour gives the weight for break flour.

SE = (GW - Bran - Mids)/(GW - Bran) x 100

This formula is equivalent to: **(BkFl/Total flour) x 100**

FLOUR MOISTURE AND PROTEIN

Flour moisture and protein are estimated using the SpectraStar NIR analyzer (Unity Scientific), calibrated yearly for protein by nitrogen combustion analysis using the Rapid NIII Nitrogen Analyzer (Elementar) and for moisture by the oven drying method (AACC method 44-01.01). Units are recorded in percent moisture or protein converted from nitrogen x 5.7 and expressed on a 14% moisture basis.

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 tends to decrease. Flour protein is controlled more by climatic conditions and cultural practices, and less by genetic variation.

Protein quality is an evaluation of gluten strength and is not the same as protein quantity. A cultivar low in protein quantity potential of grain could still exhibit strong gluten strength. Soft wheat of relatively strong protein is desirable for cracker production. Gluten strength is estimated using a mixograph and graded on a scale of 1 to 8, weakest to strongest gluten. Evaluation of gluten strength using the mixograph or farinograph is difficult for soft wheat

flours that are 8.5% protein and lower. Lactic acid SRC does not require dough mixing for assessment of gluten strength and tends to be a better measurement of protein quality when evaluating soft wheats.

Solvent Retention Capacity

Solvent Retention Capacity (SRC) assays are performed as described in AACC Method 56-11.02, *Solvent Retention Capacity Profile*. The profile of SRCs in the four solvents (sucrose, lactic acid, sodium carbonate and water) is used to predict milling and baking quality. In general, lower SRCs are preferred for water, sodium carbonate and sucrose solvents (Kweon, Slade, & Levine, 2011).

Breeder samples processed by intermediate and advanced group testing use straight grade flour (blend of break and reduction flours) for SRC tests.

With the exception of sucrose, SRCs are performed using 1 gram of flour in glass test tubes with rubber stoppers. Sucrose SRCs are performed with 5 grams of flour in 50 mL disposable screw top centrifuge tubes, because the highly viscous sucrose solution impedes even distribution of solution in 1 gram flour tests, reducing the reliability of the small scale test.

SRC Biochemistry and Correlations to Traits

The following descriptions of the biochemistry and correlations of SRCs with milling and baking traits were published in the Soft Wheat Quality Laboratory Annual Report 2011 (Souza, Kweon, & Sturbaum, 2011).

Water SRC is a global measure of the water affinity of the macro-polymers (starch, arabinoxylans, gluten, and gliadins). 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 values are related to the content of arabinoxylans (also known as pentosans), which can strongly affect water absorption in baked products. Sucrose SRC is a good predictor of cookie quality and shows a negative correlation with wire-cut cookie diameter ($r = -0.66$, $p<0.0001$). 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 ($r = 0.62$). The 95% target value can be exceeded in flour of high lactic acid SRC.

Sodium carbonate SRC takes advantage of the very alkaline solution to ionize the ends of starch polymers increasing the water binding capacity of the molecule. Sodium carbonate SRC increases as starch damage due to milling increases.

Lactic acid SRC predicts gluten strength of flour. Typical values are below 85% for "weak" protein soft wheat varieties and above 110% for "strong" protein soft wheat varieties. Lactic acid SRC results correlate to the SDS-sedimentation test. The lactic acid SRC is also correlated to flour protein concentration and dependent on genotypes and growing conditions.

COOKIE BAKES (SUGAR-SNAP COOKIES)

Two sugar-snap cookies are baked in the SWQL bake laboratory for each sample as described in AACC Method 10-52, *Baking Quality of Cookie Flour*. Cookies are baked exclusively for advanced group samples using straight grade flour (blend of break and reduction flours). Diameter of the two cookies is measured and recorded electronically using a Mitutoyo Absolute Digimatic Caliper. Cookies are graded visually for surface appearance and color, from worst to best on a scale of 1 to 10.

FALLING NUMBER

The falling number test (AACC Method 56-81B) measures the travel time of the plunger in seconds (falling number) from the top to the bottom position in a glass tube filled with a suspension of whole grain meal or milled flour, immediately after being cooked in a boiling water jacket to produce gelatinized starch. The higher the viscosity of whole grain meal or flour paste in the glass tube, the longer the travel time of the plunger. The enzyme α-amylase, produced when grain sprouts, hydrolyzes starch molecules and lowers viscosity of gelatinized starch, resulting in a decreased travel time of the plunger (falling number). The test is performed using the Perten Falling Number Instrument. Alpha-amylase can be measured directly using a kit from Megazyme, International (AACC Method 22-02-01, *Measurement of alpha-Amylase in Plant and Microbial Materials Using the Ceralpha Method*). The SWQL uses a modified micro method of the Megazyme assay.

FLOUR ASH

Flour Ash is measured according to the AACC method 08-01 and detects residual inorganic materials after combustion. Since inorganic materials are higher in bran than in endosperm, flour ash is an indirect indicator of residual bran in the flour.

Materials and Methods References

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Souza, E., Kweon, M., & Sturbaum, A. (2011). *Research Review.* USDA-ARS Soft Wheat Quality Laboratory.

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

Molecular markers and protocols are available at the University of California Davis website:

http://maswheat.ucdavis.edu/

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. Primer sequences are given 5' to 3'.

High Molecular Weight Glutenins and γ-gliadin

GluA1

AxFwd	ATGACTAAGCGGTTGGTTCTT
Ax1 R	ACCTTGCTCCCCTTGTCCTG
Ax2* R	ACCTTGCTCCCCTTGTCTTT

Amplifies at 58°C, 1,200 bp product, present or absent using single forward primer, alternate reverse primers.
(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, touchdown 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 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	CACGACGTTGTAAAACGACTGACAACCCCCTTTCCCTCGT
SCM9_R	TCATCGACGCTAAGGAGGACCC

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

2B translocation - Sr 36 stem rust resistance

Stm773-F5	AAACGCCCCAACCACCTCTCTC
Stm773-R5	ATGGTTTGTTGTGTTGTGTGTAGG

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)