SOFT WHEAT QUALITY LABORATORY

69TH ANNUAL RESEARCH REVIEW
2023 REPORT

Dr. Byung-Kee Baik, Supervisory Plant Molecular Biologist/Director
Dr. Bryan Penning, Plant Geneticist

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USDA - AGRICULTURAL RESEARCH SERVICE

CORN, SOYBEAN AND WHEAT QUALITY RESEARCH UNIT

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1680 Madison Avenue
Wooster, OH 44691
United States Department of Agriculture
Agricultural Research Service
Corn, Soybean and Wheat Quality Research Unit (CSWQRU)

USDA Agricultural Research Service

http://ars.usda.gov/Main/Docs.htm?docid=3032

Dr. Byung-Kee Baik, Research Leader/ Molecular Biologist Byungkee.Baik@usda.gov
Dr. Bryan Penning, Plant Geneticist Bryan.Penning@usda.gov

Soft Wheat Quality Laboratory (SWQL) Staff:

Amy Bugaj	amy.Bugaj@usda.gov
Tom Donelson	thomas.Donelson@usda.gov
Cindy Hampton	cindy.Hampton@usda.gov
Taehyun Ji	taehyun.Ji@usda.gov
Anthony Karcher	anthony.Karcher@usda.gov
Minwoo Lee	minwoo.lee@usda.gov
Fengyun Ma	ma.1036@osu.edu
Dee Marty	dee.marty@usda.gov
Paul Nemes	paul.nemes@usda.edu

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; and
- provide the infrastructure necessary to create and maintain a diversified workplace

National Program 306: Product Quality and New Uses

Vision

Research is focused on developing knowledge and enabling commercially viable technologies to (1) measure and maintain/enhance post-harvest product quality, (2) harvest and process agricultural materials, and (3) create new value-added products.

Mission

Enhance the marketability of agricultural products, increase the availability of healthful foods, develop value-added food and nonfood products, and enable commercially preferred technologies for post-harvest processing.

Current Action Plan 2020-2024

ARS National Program 306 (NP 306), Product Quality and New Uses, including biorefining, has the goal of enhancing economic viability and competitiveness of U.S. agriculture by improving quality and marketability of harvested foods and agricultural feedstocks to meet consumer needs, develop environmentally friendly and efficient processing concepts, and expand domestic and global market opportunities in biorefining in association with the bioeconomy.

Component 1:Foods

Problem Statement 1.A: Define, Measure, and Preserve/Enhance/Reduce Attributes that Impact Quality and Marketability.
Problem Statement 1.B: New Bioactive Ingredients and Health-promoting Foods.
Problem Statement 1.C: New and Improved Food Processing and Packaging Technologies.

SOFT WHEAT QUALITY LABORATORY

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.
- 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. Eastern U.S. soft winter wheat accounts for around 20 percent of total U.S. wheat production and is grown primarily in 23 states in the eastern region served by the USDA-ARS Soft Wheat Quality Laboratory (SWQL), Wooster, Ohio. Since the 1930s, the SWQL has conducted the 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 region. It is one of the few laboratories in the world that develops methods for testing the quality of soft wheat, the major wheat type grown in the eastern U.S.

Today, the SWQL evaluates 3,000 to 5,000 breeding lines and varieties submitted by ten to fourteen public and private breeding programs in fourteen 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 end-use quality evaluation of wheat breeding lines and varieties under the uniform regional variety testing programs, state variety performance testing programs and Wheat Quality Council project in cooperation with eastern soft wheat breeders, the Wheat Quality Council and regional milling and baking companies.

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. Undoubtedly, 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 wheat cultivars marketed from Missouri to the Atlantic seaboard. It also develops and publishes new methods and conducts research in the areas of milling and baking quality and extended uses. Research findings are shared with breeders, millers and food processors through the annual SWQL Research Review, annual Soft Wheat Quality Council Meeting, 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

The SWQL currently operates with $1,289,124 in FY23. We are very grateful to all the stakeholders of the SWQL, including the wheat milling and baking industries, public and private breeding programs, academic institutions, wheat seed companies and wheat growers and growers' associations for their extensive efforts to secure funding and their continuous strong support of the SWQL.

Current base funding supports two scientists, a support scientist, and five full-time and two part-time technicians. In addition, a research scientist, who initially joined the lab as a post-doctoral research associate in 2014, continues to work for the SWQL. Three full-time and one part-time technical support staff members have been responsible for the quality evaluation of breeding lines and varieties. One support scientist, two full-time and one part-time technicians, and a research scientist have worked with two scientists to conduct research projects.

NEW IN 2022-23

With continued concern surrounding the Covid-19 pandemic and the consequent restrictions on travel and in-person meetings, we organized a virtual SWQL Annual Research Review Meeting and Soft Wheat Quality Council Meeting on March 15-16, 2022. Both meetings were attended by 34 stakeholders from wheat breeding programs, universities, state wheat growers' associations, foundation seed programs and milling and baking industries. We had three SWQL presenters sharing the accomplishments and progress on four research projects, and two invited speakers, covering compounds impacting the consumer acceptance of whole wheat and genomics assisted breeding for improving soft red winter wheat at the SWQL Annual Research Review Meeting. Despite many restrictions stemming from the Covid-19 pandemic, the SWQL has been fully open and functional throughout the past year. Our technical staff have successfully completed the quality evaluation of the remaining 2021 crop wheat breeding lines and started working on the 2022 crop samples. We are grateful to the SWQL staff for the extensive efforts put forth to accomplish these tasks, despite the many Covid-19 pandemic-related restrictions.

Dr. Byung-Kee Baik continues to serve as Director of the SWQL and Research Leader of the Corn, Soybean and Wheat Quality Research Unit (of which the SWQL is a part). Dr. Bryan Penning is a Research Geneticist and manages the research program that focuses on the molecular genetics of wheat quality and pre-harvest sprouting resistance. Dr. Fengyun Ma, a Research Scientist, investigates the quality requirements of soft red winter wheat (SRW) for making tortillas and noodles, and works on the development of germplasms carrying waxy and partial waxy, early maturing, and extra soft kernel traits. Dr. Taehyun Ji is a Food Technologist and is responsible primarily for the daily operation of wheat quality evaluation, the maintenance and repair of laboratory equipment, and the research project that focuses on modifications of the experimental cracker baking method to improve efficiency and acceptability. Tom Donelson works on the rapid and reliable pre-harvest sprouting assessment methods and the Wheat Quality Council project. Amy Bugaj, Tony Karcher and Paul Nemes are Physical Science Technicians who primarily work on the milling and quality evaluation of wheat breeding lines and Wheat Quality Council entries. Dee Marty, a Biological Science Technician, assists in conducting the research on SRW wheat quality for making noodles and works with Drs. Baik and Ma. Dr. Minwoo Lee and Cindy Hampton are Biological Science Technicians who work for Dr. Penning on the molecular genetics research projects including isolation of genetic material for testing, developing markers, and evaluation of lines for pre-harvest sprouting resistance and other flour quality traits. Dr. MN Arguello-Blanco works on development of pre-harvest sprouting resistant germplasm.

The USDA-ARS has provided funding for the purchase of a dockage tester routinely used for cleaning wheat grain and a SDmatic Analyzer for determining damaged starch content, which replace the outdated ones that were prone to frequent failure and required repairs. Both have been successfully installed and are in operation.

Thus far, the SWQL has received approximately 3,122 breeding lines and varieties grown in the 2022 crop year from nine private and public breeding programs, two regional Wheat Quality Council projects, one state quality testing program, and two research collaborators, as well as state and regional uniform variety testing programs, for quality evaluation. The end-use quality evaluation for the variety testing program samples from the states of Illinois, Michigan, Ohio and Virginia, and from five uniform regional nurseries, has been completed and the summarized test results were distributed.

For the 2022 crop Soft Wheat Quality Council (SWQC) project, three breeding programs and one seed company participated and contributed a total of 20 entries (including five check varieties). All the entries were grown in three grow-out locations in Wooster, Ohio, Lanexa, Virginia, and Griffin, Georgia. The entries were evaluated for end-use quality potentials by nine cooperators from regional wheat breeding, milling and baking companies, as well as wheat quality testing laboratories. Wheat grain was cleaned, tested for grain characteristics, milled and sent out to collaborators for processing and baking quality evaluation. Based on the quality evaluation data obtained from the SWQL and collaborators, the WQC project report for the 2022 crop was prepared and posted on the WQC website (http://www.wheatqualitycouncil.org/).

Under the five-year project plan, we have conducted research projects including: 1) Development of simple and fast methods for the estimation of wheat grain pre-harvest sprouting (PHS); 2) Improved cracker baking test; 3) Suitability of eastern SW wheat for making tortillas and noodles and the required wheat quality characteristics; 4) Development of partial and full waxy wheat germplasms; and 5) Identification of the genes for pre-harvest sprouting resistance and development of the markers. In addition, the SWQL is working on the development of extra soft wheat germplasms presumed to further improve soft wheat quality for making cakes and cookies, and early maturing wheat germplasms suitable for the wheat-soybean double cropping system. We started developing PHS resistant germplasms in collaboration with Dr. Clay Sneller, a wheat breeder with The Ohio State University (OSU). In collaboration with OSU faculty members, we are also investigating the relationships between protein characteristics and properties of doughs developed under limited water systems, as for making crackers, noodles and tortillas. Dr. Baik and Tom Donelson have organized and carried out a mini-collaborative study in collaboration with the Cereals and Grains Association (CGA) Soft Wheat and Flour Products Technical Committee to identify the optimal levels of aluminum-free baking powder at four locations with different elevations for the experimental cake baking method. We plan to organize a full-scale collaborative study of the method to have it approved as an AACCI Approved Method.

We published the "2022 Annual Research Review Report" and "Milling and Baking Test Results for Eastern Soft Wheats Harvested in 2021." Dr. Baik was the corresponding author of four refereed journal articles and a co-author of two refereed journal articles published in 2022. Drs. Baik and Ma were the authors of two poster presentations at the 2022 Cereals and Grains Association Meeting in Bloomington, Minnesota. The SWQL successfully released ten waxy wheat germplasms possessing unique starch characteristics of considerably reduced starch amylose content ranging from 2.5 to 7.2% in two soft red winter wheat cultivar backgrounds ('Kristy' and 'Wilson'). The SWQL also released twelve partial-waxy germplasms (six single-nulls and six double-nulls) in soft red winter wheat variety 'Kristy' and 'Wilson' backgrounds. Single-null and double-null partial-waxy germplasms exhibited 2.0 to 2.8% and 4.1 to 6.9% lower starch amylose contents, respectively, than the recurrent parents, which makes their starch properties desirable for the production of noodles with improved cooking and textural properties and related food products.

Dr. Penning was the lead and corresponding author of one refereed Journal article published in 2023, co-author of one refereed journal article published in late 2022, and senior and corresponding author of one article currently in review. Dr. Penning made one oral presentation to the Soft Wheat Quality Lab

Research Review in 2022 and one poster presentation in early 2023 at the Plant and Animal Genome meeting in San Diego, CA.

SWQL Research Projects

The SWQL research team, composed of a supervisory research molecular biologist/lead scientist, a molecular geneticist, a research scientist, a support scientist and six technicians, has continued to work on a number of research projects including quality evaluation method development, identification of the biochemical characteristics of wheat grain related to noodles and tortilla making quality, and genetics of pre-harvest sprouting resistance and milling and baking quality. Following the SWQL five-year project plan, we have continued research on 1) Development of simple and fast methods for the estimation of wheat grain PHS; 2) Improved cracker baking test; 3) Suitability of eastern SW wheat for making tortillas and noodles and the required wheat quality characteristics; 4) Development of partial and full waxy wheat germplasms; and 5) Identification of the genes for pre-harvest sprouting resistance and development of the markers.

We have continued our cooperative research with Drs. Osvaldo Campanella and Farnez Maleky in the Department of Food Science and Technology (FST) at The Ohio State University (OSU) to identify the associations of protein characteristics and kernel hardness with the rheological properties of noodle and tortilla dough. In collaboration with Dr. Emmanuel Chatzakis in the FST at OSU, we have investigated the roles of protein content and composition on gluten development during dough mixing and sheeting under limited water conditions. We collaborate with Dr. Clay Sneller in the Department of Horticulture and Crop Science at OSU for the identification of grain traits affecting the food product quality and extended uses of eastern soft wheat, identification of chromosomal locations of PHS resistance genes, and development of PHS resistant germplasms. We have made significant progress in the development of extra-soft kernel soft wheat germplasms and increased the amount of seeds for functional quality evaluation. For the development of early heading and maturing wheat germplasms, five advanced elite eastern soft wheat breeding lines have been crossed with a donor parent exhibiting two weeks earlier heading than the typical eastern U.S. wheat to introduce early heading traits.

The results from the research projects “Eastern U.S. soft winter wheat characteristics required for making tortillas” and “High molecular weight glutenin subunit (HMW-GS) profiles of eastern U.S. soft winter wheat desirable for making soft-bite white salted noodles” were shared with the international audience at the Cereals and Grains Association (C&G Assoc., Formerly AACCI) Annual Meeting in November 2022. The results from the research project “Uncovering pre-harvest sprouting related genes using whole genome expression analysis” were presented to an international audience at the Plant and Animal Genome Meeting in January 2023.

Our progress on the selected research projects is described below.

High molecular weight glutenin subunit (HMW-GS) profiles of eastern U.S. soft winter wheat desirable for making soft-bite white salted noodles

HMW-GS composition has a significant influence on wheat gluten strength and product quality. The flour protein content and gluten strength required for making soft-bite white salted noodles (WSN) are well established, whereas the HMW-GS composition desirable for making WSN and its association with WSN quality attributes are poorly understood. We evaluated the wheat flours of 25 eastern U.S. soft winter (ESW) wheat varieties carrying diverse HMW-GS profiles and four commercial WSN flours for protein characteristics and WSN quality attributes including cooking loss and textural and tensile properties to determine the influence of HMW-GSs on WSN quality and to identify HMW-GS profiles desirable for making WSN. Ten ESW wheat flours exhibited a protein content of 8.7-10.2% and a lactic acid solvent retention capacity (LA-SRC) of 102.9-142.7%, which were comparable to those of commercial WSN flours. Eight ESW wheat varieties produced WSN of comparable quality to those prepared from commercial WSN flours, with low cooking loss (6.4-7.6%) and desirable tensile force (0.61-0.73 N) and strength (9.0-12.8 N*mm). Allelic variation at the Glu-D1 locus exhibited a significant influence on noodle sheet length and WSN cooking loss, hardness, tensile force and tensile strength. Allelic variation at the Glu-A1 locus exhibited a significant influence only on cooking yield and WSN hardness. Rye translocations exhibited a significant influence only on WSN adhesiveness. The Glu-B1 locus showed no evident influence on WSN quality attributes. Subunit 2* at the Glu-A1 locus was associated with a low cooking yield and high hardness of cooked WSN. ESW wheat varieties carrying subunits $2+12_1$ at the Glu-D1 locus produced WSN with a higher cooking loss and lower hardness, tensile force and tensile strength than those carrying subunits 5+10, 2+12 or 2+10. ESW wheat carrying the 1BL/1RS translocation produced WSN with a higher adhesiveness than those without the 1BL/1RS translocation, indicating that absence of the 1BL/1RS translocation in ESW wheat varieties is desirable for the production of WSN. ESW wheat carrying one of three HMW-GS profiles, (2*, 7*+8, 5+10), (2*, 7+9, 5+10) or (2*, 13+16, 2+12), produced WSN with a relatively low cooking loss and adhesiveness, intermediate hardness and relatively high tensile force and tensile strength, which were most comparable to those prepared from commercial WSN flours. HMW-GS composition appears to be an effective tool for the identification of ESW wheat breeding lines or varieties possessing WSN-making quality potential and genetic improvement of ESW wheat for making WSN.

Eastern U.S. soft winter wheat characteristics required for making tortillas
Tortillas are the staple food in Mexico and Central America and the fastest-growing bakery product in the U.S. market. Hot-press wheat flour tortillas are typically prepared from flour of 8.6-10.3% protein and intermediate gluten strength. Tortillas are expected to have a large diameter, opaque appearance, and good rollability during storage. Eastern U.S. soft winter wheat (ESWW) flours, especially those of relatively high protein content and strength, may carry the protein characteristics needed for yielding good-quality tortillas. The lower damaged starch content of ESWW flours than commercial tortilla wheat flours (CTFs) could have a positive influence on tortilla diameter. To identify ESWW characteristics required for making tortillas, we evaluated twenty-five ESWW varieties for grain and flour characteristics and determined their tortilla-making quality in comparison to five CTFs from the U.S. and Mexico. Protein content (PC) of ESWW flours ranged from 6.6% to 10.2%, while that of CTFs from 10.1% to 11.1%. Thirteen ESWW flours exhibited a lactic acid solvent retention capacity (LA-SRC) of 102.9-142.7%, which was comparable to or higher than that of CTFs, despite their lower PCs. Damaged starch content of ESWW flours ranged from 1.4% to 6.2%, while that of CTFs from 5.7% to 7.0%. To yield a tortilla dough of proper consistency and handling properties, 43.3% to 47.3% water based on flour weight was needed for ESWW flours and 53.9-55.1% for CTFs. Seven ESWW flours produced tortillas of comparable quality to those prepared from CTFs, with a diameter of 172.1-181.1 mm, an opacity score (OS) of 72.0-83.3%, and a rollability score of 4.9-5.0 on day 0 and 2.8-3.1 on day 12. Flour PC exhibited a positive correlation with tortilla OS and rollability score on day 12 ($P<0.01$). Flour LA-SRC and tortilla dough relaxation time (time required for the maximum compression force to decrease by 63.2%) showed significant associations with tortilla diameter, OS and rollability score on day 12 ($P<0.001$). LA-SRC, relaxation time, gluten index and SDSS volume explained 62-86% of the variability in tortilla diameter, OS and rollability scores on days 0 and 12. ESWW flours with a PC greater than 8.7%, LA-SRC higher than 115.6% and dough relaxation time more than 0.51 sec produced tortillas most comparable to those prepared from CTFs. The results provide guidance for selecting ESWW varieties for making tortillas and prove that ESWW flours of high protein content and strong gluten strength can be successfully used for making tortillas.

Uncovering pre-harvest sprouting related genes using whole genome expression analysis
Pre-harvest sprouting could lead to lower quality and prices or rejection of wheat grain by reducing Falling Number. While the changes in physical and chemical characteristics of wheat

grain by pre-harvest sprouting is well understood, few genes controlling it have been identified and less is known about their interaction. To reduce the number of differentially expressed genes unrelated to pre-harvest sprouting, two varieties of soft red winter wheat sharing 82.1% of 1,978 genome-wide markers with significantly different Falling Numbers over multiple years of natural and artificial pre-harvest sprouting tests were chosen. The whole genome expression analysis revealed 48 genes with likely function related to pre-harvest sprouting. One gene, Mother of Flowering Time, was previously associated with pre-harvest sprouting, but the rest have not been. Some of these genes may be a part of the regulatory pathway leading to seed germination while others are downstream germination-related genes. One gene in particular, Flowering Locus C, has great promise as it has been potentially associated with regulation of seed germination under cool temperature and water stress which are hallmarks of pre-harvest spouting conditions. A marker for this gene is currently under development for testing in a larger population. This study increases the number of known pre-harvest sprouting related genes roughly five times.

END-USE QUALITY EVALUATION OF WHEAT BREEDING LINES AND VARIETIES

Nine cooperators, including public and private breeding programs of the eastern soft winter wheat and the state variety testing programs, have thus far submitted over three-thousand samples harvested in the 2022 crop year for end-use quality evaluation. Analyses for approximately 55% of the samples received will be completed by the middle of March 2023. Milling and baking quality evaluations for the samples from four state variety performance test trials and five uniform regional cooperative testing trials in the 2022 crop year have been completed. The samples of replicate trials were tested with Uniform Southern soft red winter wheat nursery. The test results have been summarized and distributed to the breeding programs by the SWQL. We expect to complete all tests of breeding lines and varieties by the end of May 2023.

As implemented beginning with the 2013 crop year, breeding lines submitted to the SWQL for quality evaluation by the breeding programs are classified into ‘Preliminary,’ ‘Intermediate’ or ‘Advanced’ groups, considering breeding stage and screening requests. 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 and moisture) and sodium carbonate and lactic acid SRCs. Only advanced group samples undergo the sugar-snap cookie baking test.

Quality evaluation data have been reported to the breeding programs along with a t-score (which is the number of standard deviations away from the check variety for each quality parameter), and a total t-score is calculated and included in the report. The total t-score is the sum of the t-scores of test weight, kernel hardness, flour yield, softness equivalence and sodium carbonate SRC, with different weights of 0.15, 0.10, 0.40, 0.15 and 0.20, respectively. Each breeding line is assigned a specific grade (A, B, C, D, or F) based on its flour yield compared to the flour yield distribution of wheat breeding lines and varieties tested in the SWQL between 2009 and 2020. The wheat breeding lines that fall in the top 15% receive a grade ‘A,’ in the next 20% a ‘B,’ in the next 30% a ‘C,’ in the next 20% a ‘D,’ and in the bottom 15% an ‘F.’

The SWQL coordinates the Soft Wheat Quality Council (SWQC) in collaboration with the Wheat Quality Council. We obtained wheat grain, milled it and shipped the flour to cooperators in the domestic milling and baking industries for end-users’ evaluations of flour quality and baking performance. In 2022, 20 entries for the SWQC were processed and distributed to cooperators.

Quality Characteristics of the 2022 Eastern Soft Winter Wheat Crop (Compared to the averages of the previous 13 years)

Quality Parameters	2009 - 2021	2022
Test Weight (lb/bu)	59.8	59.9
Grain Protein (%)	10.4	9.7
Kernel Hardness (SKCS)	13.6	15.2
Flour Yield (%)	68.6	68.8
Softness Equivalence (%)	58.1	58.5
Four Protein (%)	8.2	7.7
Solvent Retention Capacity		
Sodium Carbonate (%)	69.6	69.9
Lactic Acid (%)	100.3	104.1
Cookie Diameter (cm)	18.7	19.3

USDA-ARS 2022 SWQL Grain and Flour Evaluations

Long-term relationships established between the SWQL, and cooperative nursery programs and the Wheat Quality Council depend on the reliable milling and baking evaluations performed in the USDA-ARS SWQL in Wooster, Ohio. The SWQL performs quality evaluations for two main collaborative projects: the Soft Wheat Quality Council and Regional Cooperative Nurseries.

2022 Crop Soft Wheat Quality Council

The SWQL coordinates and participates in the Soft Wheat Quality Council (SWQC) annual evaluation of new varieties and advanced breeding lines by milling grain, distributing flour to collaborators, performing quality trait evaluations and preparing a report that collates quality evaluations among the collaborators for presentation at the annual SWQC Meeting. Uniform milling and reliable quality trait testing, as performed in the SWQL, provide data critical for collaborators to compare the quality evaluations of the new varieties presented each year.

For the 2022 SWQC project, three breeding programs and one seed company participated, contributing 20 entries (including the checks). Entries were grown in three grow-out locations including Wooster, Ohio, Lanexa, Virginia, and Griffin, Georgia. The SWQL collected the grain samples of 20 entries, determined the grain characteristics, performed Miag milling as well as Quad experimental milling, and conducted composition analyses. Wheat flour samples were distributed to the 9 cooperators and further tested for flour compositional, biochemical, and dough rheological characteristics, and baking quality, with emphasis on SRC, cookie baking quality and cake baking quality. The test results of the entries by the SWQL and cooperators were pooled, analyzed and used to prepare the report, which is available at the WQC website (http://www.wheatqualitycouncil.org/). The chair of the Soft WQC Technical Board will lead the discussion on the quality potentials of the entries with the cooperators during the virtual Soft WQC Meeting on March 14, 2023.

Contributing Soft Wheat Breeding Programs, Test Lines and Checks

Nicholas Santantonio, Virginia Polytechnic Institute and State University

15VDH-FHB-MAS33-13
16VDH-SRW03-018
VA17W-75
Branson*
Hilliard*

Trek Murray, Beck's Hybrids

Beck 705
Beck 720
Beck 722
Beck 724
Beck 727
Beck 732
Beck 721*

Eric Olson, Michigan State University

MI14W0190
MI16R0898

MI16W0133
MI16W0528
Whitetail*

Mohamed Mergoum, University of Georgia

GA19LE12

GA19E38

GA18LE43*

*Check varieties

MILLING AND BAKING RESULTS OF 2022 CROP SWQC ENTRIES REPORTED BY COLLABORATORS AND THE SWQL

Table 1. Miag Multomat mill stream yields (%) of the WQC 2022 crop year entries by SWQL

Mill Stream	Group 1					Group 2						
	15VDH-FHB-MAS33-13	16VDH-SRW03-018	VA17 W-75	Branson*	Hilliard*	Beck 705	Beck 720	Beck 722	Beck 724	Beck 727	Beck 732	Beck 721*
1st Break	9.5	9.1	7.7	9.6	10.1	9.0	11.0	8.8	10.4	10.2	11.0	8.9
2nd Break	9.2	8.6	7.9	8.5	8.4	9.7	10.5	8.6	9.9	9.7	10.9	8.8
Grader	4.0	4.0	3.8	4.2	4.5	4.7	4.9	4.8	5.3	5.5	5.2	4.5
3rd Break	8.9	8.2	8.4	8.5	9.1	9.1	9.7	8.0	10.5	8.8	10.7	8.1
Total Break	**31.7**	**29.9**	**27.8**	**30.9**	**32.2**	**32.4**	**36.0**	**30.2**	**36.1**	**34.2**	**37.8**	**30.4**
1st Reduction	12.0	12.1	10.8	12.1	10.7	9.8	9.2	9.6	8.2	9.0	8.8	10.4
2nd	9.0	9.8	10.2	9.0	8.6	9.3	6.5	10.2	6.4	8.3	6.3	10.2
3rd	5.6	5.2	6.2	5.3	5.4	5.9	5.1	6.5	5.7	5.5	5.2	6.0
Duster	7.9	7.9	7.4	8.4	6.9	7.3	5.8	7.7	5.9	7.1	5.7	7.6
4th	4.4	4.1	5.3	4.0	3.9	4.7	3.5	4.9	4.0	4.0	3.7	4.6
5th	2.7	2.4	2.9	2.2	2.5	2.7	2.2	2.6	2.3	2.3	2.4	2.6
Total Reduction	**41.6**	**41.4**	**42.9**	**41.1**	**38.0**	**39.8**	**32.3**	**41.6**	**32.5**	**36.3**	**32.1**	**41.5**
Straight	**73.3**	**71.3**	**70.7**	**72.0**	**70.2**	**72.2**	**68.3**	**71.7**	**68.6**	**70.4**	**69.9**	**71.8**
Head Shorts	6.6	6.9	6.2	6.8	7.0	6.2	7.5	6.3	6.7	6.0	6.9	5.7
Red Dog	1.8	1.8	2.9	1.7	1.9	1.8	2.3	2.1	2.5	1.5	2.1	2.1
Tail Shorts	0.6	0.5	0.4	0.5	0.5	0.4	0.6	0.4	0.4	0.4	0.5	0.4
Bran	17.6	19.5	19.8	19.0	20.4	19.3	21.3	19.5	21.7	21.7	20.6	19.9
Total Byproduct	26.7	28.7	29.3	28.0	29.8	27.8	31.7	28.3	31.4	29.6	30.1	28.2

*Check varieties.

Table 1-continued

Mill Stream	Group 3					Group 4		
	MI14W0190	MI16R0898	MI16W0133	MI16W0528	Whitetail*	GA19LE12	GA19E38	GA18LE43*
1st Break	8.4	9.0	10.4	11.3	11.2	11.1	10.3	7.9
2nd Break	8.9	10.3	9.7	10.3	10.2	8.1	8.8	10.4
Grader	4.7	4.6	4.9	6.3	6.0	4.8	4.8	3.9
3rd Break	8.1	9.6	9.5	10.0	9.9	7.6	8.9	9.3
Total Break	30.2	33.5	34.5	37.8	37.4	31.6	32.9	31.6
1st	10.6	9.3	10.7	9.0	8.5	14.5	10.6	11.1
2nd	10.1	7.8	7.6	7.0	7.3	9.5	8.8	8.2
3rd	6.1	6.0	5.2	5.5	5.4	3.6	4.9	5.4
Duster	8.4	6.6	7.0	6.2	5.8	10.1	7.5	7.5
4th	4.7	4.6	3.9	3.7	4.0	2.5	3.6	3.9
5th	2.3	3.2	2.3	2.0	2.5	1.3	2.0	2.0
Total Reduction	42.2	37.6	36.6	33.4	33.6	41.5	37.4	38.0
Straight Grade	72.4	71.0	71.1	71.2	71.0	73.1	70.3	69.6
Head	6.2	7.0	6.9	6.4	5.6	5.6	6.7	6.8
Red Dog	2.0	2.2	2.0	2.0	2.0	1.0	1.1	1.4
Tail Shorts	0.4	0.5	0.5	0.4	0.4	0.4	0.5	0.4
Bran	19.0	19.2	19.4	19.9	20.9	19.8	21.5	21.9
Total Byproduct	27.6	29.0	28.9	28.8	29.0	26.9	29.7	30.4

*Check varieties.

Table 2. Grain characteristics, SKCS test parameters of the 2022 entries by USDA-ARS Soft Wheat Quality Laboratory

Group	Entry	Test Weight (lb/bu)	Grain Falling Number	Grain Protein (%, 12% mb)	SKCS Parameter		
					Kernel Hardness	Kernel Diameter (mm)	Kernel Weight (mg)
1	15VDH-FHB-MAS33-13	61.1	368	10.6	12.3	2.6	30.6
1	16VDH-SRW03-018	61.4	429	11.0	20.4	2.7	31.8
1	VA17W-75	61.7	418	11.9	27.1	2.7	32.7
1	Branson*	59.8	376	11.1	7.4	2.7	33.8
1	Hilliard*	60.2	390	10.7	14.1	2.7	34.4
2	Beck 705	56.8	364	10.0	6.6	2.7	31.3
2	Beck 720	54.4	361	10.8	1.0	2.6	31.0
2	Beck 722	58.7	410	11.8	8.0	2.7	32.4
2	Beck 724	56.0	391	10.9	1.2	2.6	31.2
2	Beck 727	57.0	390	11.2	2.8	2.6	29.9
2	Beck 732	53.9	366	10.0	0.5	2.4	28.8
2	Beck 721*	55.8	363	11.4	11.9	2.6	32.2
3	MI14W0190	58.0	380	11.1	9.5	2.6	32.2
3	MI16R0898	59.0	414	11.2	6.4	2.6	31.4
3	MI16W0133	53.7	359	10.5	3.1	2.6	31.3
3	MI16W0528	53.8	346	9.5	-5.4	2.5	28.0
3	Whitetail*	54.8	380	9.2	-5.7	2.7	33.1
4	GA19LE12	56.1	370	9.3	8.7	2.7	31.1
4	GA19E38	60.0	364	9.2	13.9	2.5	30.5
4	GA18LE43*	56.3	497	10.8	7.6	2.4	24.8

*Check varieties.

Table 3. Miag and Quadrumat Milling parameters of the 2022 entries by USDA-ARS Soft Wheat Quality Laboratory.

		Miag Milling		Quadrumat Milling	
Group	Entry	Break Flour Yield (%)	Straight Grade Flour Yield (%)	Flour Yield (%)	Softness Equivalence (%)
1	15VDH-FHB-MAS33-13	31.7	73.3	70.6	60.5
1	16VDH-SRW03-018	29.9	71.3	68.5	58.6
1	VA17W-75	27.8	70.7	68.3	56.5
1	Branson*	30.9	72.0	69.1	61.9
1	Hilliard*	32.2	70.2	68.1	62.0
2	Beck 705	32.4	72.2	69.2	63.2
2	Beck 720	36.0	68.3	66.8	67.4
2	Beck 722	30.2	71.7	69.0	60.0
2	Beck 724	36.1	68.6	66.9	67.0
2	Beck 727	34.2	70.4	68.5	66.4
2	Beck 732	37.8	69.9	67.9	68.8
2	Beck 721*	30.4	71.8	69.6	61.4

3	MI14W0190	30.2	72.4	69.8	59.3
3	MI16R0898	33.5	71.0	68.1	61.7
3	MI16W0133	34.5	71.1	68.4	65.0
3	MI16W0528	37.8	71.2	68.5	68.2
3	Whitetail*	37.4	71.0	69.3	67.9
4	GA19LE12	31.6	73.1	71.0	64.4
4	GA19E38	32.9	70.3	68.4	64.5
4	GA18LE43*	31.6	69.6	67.2	63.9

*Check varieties.

Table 4. Flour quality parameters of the 2022 entries by USDA-ARS Soft Wheat Quality Laboratory

Group	Entry	Moisture (%)	Protein (%, 14% mb)	Flour Ash (%, 14% mb)	α-amylase Activity	Starch Damage (%)
1	15VDH-FHB-MAS33-13	14.3	8.7	0.36	0.04	2.5
1	16VDH-SRW03-018	14.0	9.0	0.38	0.04	3.0
1	VA17W-75	13.8	9.9	0.43	0.05	2.3
1	Branson*	14.1	9.3	0.38	0.04	2.2
1	Hilliard*	13.9	8.8	0.39	0.05	2.0
2	Beck 705	13.8	8.3	0.37	0.04	2.1
2	Beck 720	14.1	8.6	0.36	0.04	1.8
2	Beck 722	14.0	9.9	0.38	0.04	2.1
2	Beck 724	14.0	9.1	0.35	0.04	2.5
2	Beck 727	13.9	9.3	0.35	0.04	1.5
2	Beck 732	14.2	7.9	0.34	0.04	2.5
2	Beck 721*	14.0	9.4	0.37	0.05	3.1
3	MI14W0190	13.9	9.4	0.38	0.06	3.1

3	MI16R0898	14.0	9.2	0.34	0.04	2.3
3	MI16W0133	14.1	8.7	0.37	0.05	1.1
3	MI16W0528	14.0	7.7	0.38	0.07	1.4
3	Whitetail*	13.7	7.3	0.38	0.06	1.8
4	GA19LE12	14.3	7.8	0.31	0.03	n/a
4	GA19E38	14.0	7.4	0.33	0.02	1.2
4	GA18LE43*	14.0	8.8	0.32	0.03	1.6

*Check varieties.

Table 5. Mean SRC test parameters and overall flour quality scores by six cooperators (n=6)[a]

Group	Entry	Solvent Retention Capacity (%)			
		Water	Sodium Carbonate	Sucrose	Lactic Acid
1	15VDH-FHB-MAS33-13	51.6 bc	71.6 a	88.2 b	124.9 b
1	16VDH-SRW03-018	53.2 ab	76.4 a	92.2 ab	122.1 b
1	VA17W-75	55.1 a	79.0 a	103.1 a	137.7 a
1	Branson*	50.2 c	72.9 a	89.0 ab	125.2 b
1	Hilliard*	52.7 b	75.1 a	94.9 ab	125.8 b
2	Beck 705	49.9 a	71.3 a	83.4 b	104.2 c
2	Beck 720	51.9 a	77.3 a	98.0 a	121.1 ab
2	Beck 722	50.3 a	73.3 a	87.6 ab	121.8 ab
2	Beck 724	50.8 a	76.8 a	92.5 ab	128.1 a
2	Beck 727	49.9 a	73.6 a	88.5 ab	124.9 a
2	Beck 732	51.0 a	74.6 a	88.3 ab	116.1 b
2	Beck 721*	51.5 a	73.5 a	88.9 ab	96.0 d
3	MI14W0190	48.3 b	66.5 a	81.7 a	96.9 bc
3	MI16R0898	51.6 a	71.7 a	86.9 a	114.4 a
3	MI16W0133	48.1 b	74.9 a	87.3 a	91.4 c
3	MI16W0528	48.5 b	72.6 a	84.7 a	112.7 a
3	Whitetail*	49.7 ab	74.4 a	86.0 a	99.4 b
4	GA19LE12	50.7 b	77.1 a	97.6 a	133.5 a
4	GA19E38	52.6 a	74.9 a	91.8 a	129.2 a
4	GA18LE43*	50.9 ab	76.0 a	93.3 a	127.3 a

*Check varieties.

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

Table 6. Damaged starch content (n=2), flour falling number (n=2) and amylograph peak viscosity (n=1)[a]

Group	Entry	Damaged Starch Content (%)	Falling Number	Amylograph Peak Viscosity (BU)
1	15VDH-FHB-MAS33-13	3.0 a	356 a	736
1	16VDH-SRW03-018	3.3 a	418 a	758
1	VA17W-75	3.3 a	410 a	711
1	Branson*	3.1 a	342 a	585
1	Hilliard*	2.9 a	340 a	566
2	Beck 705	3.1 a	347 a	623
2	Beck 720	2.8 a	377 a	581
2	Beck 722	2.9 a	371 a	656
2	Beck 724	3.2 a	371 a	670
2	Beck 727	2.6 a	345 a	600
2	Beck 732	3.1 a	355 a	645
2	Beck 721*	3.8 a	335 a	422
3	MI14W0190	3.4 a	378 a	511
3	MI16R0898	3.4 a	377 a	675
3	MI16W0133	2.5 a	349 a	599
3	MI16W0528	2.6 a	321 a	411
3	Whitetail*	2.8 a	365 a	405
4	GA19LE12	1.6 a	303 a	353
4	GA19E38	2.5 a	300 a	388
4	GA18LE43*	2.7 a	396 a	698

*Check varieties.

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

Table 7. Mean Alveograph test parameters by two collaborators (n=1)[a]

Group	Entry	Alveograph			
		P	L	P/L Ratio	W
1	15VDH-FHB-MAS33-13	53.0	76.0	0.7	87.0
1	16VDH-SRW03-018	56.0	69.0	0.8	87.0
1	VA17W-75	60.0	78.0	0.8	96.0
1	Branson*	37.0	82.0	0.5	58.0
1	Hilliard*	52.0	81.0	0.6	81.0
2	Beck 705	33.0	80.0	0.4	48.0
2	Beck 720	35.0	90.0	0.4	52.0
2	Beck 722	34.0	91.0	0.4	56.0
2	Beck 724	33.0	95.0	0.4	53.0
2	Beck 727	29.0	98.0	0.3	46.0
2	Beck 732	39.0	74.0	0.5	63.0
2	Beck 721*	29.0	73.0	0.4	39.0
3	MI14W0190	26.0	88.0	0.3	37.0
3	MI16R0898	37.0	79.0	0.5	56.0
3	MI16W0133	21.0	96.0	0.2	27.0
3	MI16W0528	23.0	71.0	0.3	38.0
3	Whitetail*	23.0	76.0	0.3	32.0
4	GA19LE12	36.0	72.0	0.5	57.0
4	GA19E38	48.0	63.0	0.8	80.0
4	GA18LE43*	44.0	86.0	0.5	69.0

*Check varieties.

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

Table 8. Mean farinograph test parameters by two collaborators (n=2)[a]

Group	Entry	Farinograph			
		Water Absorption	Development Time	Stability	Mixing Tolerance
1	15VDH-FHB-MAS33-13	53.7 bc	1.1 c	1.9 b	122.5 a
1	16VDH-SRW03-018	54.8 a	1.2 bc	1.8 b	105.5 ab
1	VA17W-75	54.2 ab	1.6 a	4.1 a	80.5 b
1	Branson*	51.9 d	1.1 bc	3.1 ab	100.0 ab
1	Hilliard*	53.2 c	1.3 b	2.4 ab	97.5 ab
2	Beck 705	50.7 bc	0.9 a	1.5 a	138.5 a
2	Beck 720	51.0 abc	1.3 a	2.9 a	92.5 a
2	Beck 722	50.6 bc	1.3 a	3.6 a	93.0 a
2	Beck 724	51.4 ab	0.9 a	1.7 a	126.5 a
2	Beck 727	50.6 bc	0.9 a	1.8 a	103.5 a
2	Beck 732	50.2 c	0.9 a	1.3 a	117.0 a
2	Beck 721*	51.9 a	1.0 a	1.6 a	135.5 a
3	MI14W0190	50.8 b	0.7 c	1.5 ab	127.5 a
3	MI16R0898	52.3 a	1.0 a	1.8 a	125.5 a
3	MI16W0133	50.1 c	0.8 bc	1.2 bc	145.5 a
3	MI16W0528	47.6 e	0.8 bc	1.1 c	127.5 a
3	Whitetail*	48.3 d	0.9 ab	1.2 bc	117.5 a
4	GA19LE12	50.5 b	0.9 a	1.4 b	122.5 a
4	GA19E38	51.6 ab	0.9 a	1.3 b	135.0 a
4	GA18LE43*	52.3 a	0.9 a	2.2 a	90.5 b

*Check varieties.

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

Table 9. Mean (n=4) Rapid Visco-Analyzer (RVA) test parameters[a]

Group	Entry	Rapid Visco-Analyzer						
		Peak Time (min)	Peak (cP)	Trough (cP)	Break-down (cP)	Setback (cP)	Final (cP)	Pasting Temperature (°C)
1	15VDH-FHB-MAS33-13	6.3 a	2927 a	1833 a	1094 a	1369 ab	3202 ab	81.9 a
1	16VDH-SRW03-018	6.4 a	2928 a	1995 a	933 a	1460 a	3455 a	81.4 a
1	VA17W-75	6.4 a	2928 a	1903 a	1015 a	1413 ab	3316 a	80.8 a
1	Branson*	6.2 a	2731 a	1739 a	993 a	1187 b	2926 b	80.9 a
1	Hilliard*	6.2 a	2895 a	1883 a	1012 a	1395 ab	3278 a	81.0 a
2	Beck 705	6.3 a	2699 bc	1770 ab	929 bc	1440 b	3210 a	61.8 a
2	Beck 720	6.3 a	2667 c	1846 a	826 c	1549 ab	3395 a	80.9 a
2	Beck 722	6.3 a	2852 b	1842 a	1010 ab	1485 b	3328 a	81.0 a
2	Beck 724	6.4 a	2729 bc	1907 a	823 c	2022 a	3005 a	81.1 a
2	Beck 727	6.4 a	2722 bc	1846 a	876 bc	1482 b	3328 a	81.4 a
2	Beck 732	6.3 a	3094 a	1975 a	1120 a	1566 ab	3541 a	80.4 a
2	Beck 721*	6.3 a	2456 d	1624 b	832 bc	1317 b	2941 a	81.4 a
3	MI14W0190	6.2 a	2596 bc	1612 ab	984 ab	1283 a	2895 bc	81.1 a
3	MI16R0898	6.3 a	2771 ab	1868 a	902 ab	1502 a	3370 a	80.8 a
3	MI16W0133	6.3 a	2811 a	1712 ab	1099 a	1380 a	3092 ab	81.6 a
3	MI16W0528	6.2 a	2460 cd	1618 ab	842 ab	1310 a	2927 bc	80.8 a
3	Whitetail*	6.2 a	2343 d	1521 b	822 b	1246 a	2767 c	81.3 a
4	GA19LE12	6.3 a	2443 b	1561 ab	907 a	981 b	2542 b	77.1 b
4	GA19E38	6.1 a	2502 b	1419 b	1083 a	1039 b	2458 b	76.6 b
4	GA18LE43*	6.5 a	3106 a	2108 a	998 a	1593 a	3701 a	81.2 b

*Check varieties.

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

Table 10. Mean sugar-snap cookie test (AACCI Approved method 10-50D (n=4) & 10-52 (n=3)) parameters[a]

		Sugar-snap Cookie (10-50D)				Sugar-snap Cookie (10-52)	
Group	Entry	Width (mm)	Thickness (mm)	W/T Ratio (mm)	Spread Factor	Width (cm)	Top Grain Score
1	15VDH-FHB-MAS33-13	484 a	59 a	8.4 a	79 a	9.2 a	6.0 a
1	16VDH-SRW03-018	476 a	61 a	7.8 a	73 a	9.0 ab	5.5 a
1	VA17W-75	466 a	65 a	7.4 a	69 a	8.5 b	3.5 a
1	Branson*	486 a	57 a	8.7 a	81 a	9.0 ab	4.5 a
1	Hilliard*	483 a	61 a	8.1 a	76 a	9.1 a	5.0 a
2	Beck 705	497 a	53 a	9.4 a	89 ab	9.3 a	6.5 a
2	Beck 720	494 a	57 a	8.8 a	83 ab	9.1 a	5.0 a
2	Beck 722	485 a	58 a	8.5 a	80 b	9.2 a	5.0 a
2	Beck 724	498 a	55 a	9.1 a	86 ab	9.2 a	6.5 a
2	Beck 727	504 a	55 a	9.3 a	87 ab	9.3 a	5.0 a
2	Beck 732	505 a	53 a	9.7 a	91 a	9.4 a	6.5 a
2	Beck 721*	494 a	57 a	8.9 a	83 ab	9.4 a	5.5 a
3	MI14W0190	501 a	53 a	9.6 a	89 a	9.4 a	5.5 a
3	MI16R0898	491 a	57 a	8.7 a	82 a	9.3 a	6.0 a
3	MI16W0133	501 a	52 a	9.7 a	91 a	9.4 a	5.0 a
3	MI16W0528	507 a	52 a	9.8 a	92 a	9.5 a	4.5 a
3	Whitetail*	507 a	52 a	9.8 a	92 a	9.5 a	6.0 a
4	GA19LE12	493 a	54 a	9.2 a	86 a	9.2 a	5.0 a
4	GA19E38	480 a	57 a	8.5 a	79 a	9.2 a	5.5 a
4	GA18LE43*	486 a	58 a	8.4 a	79 a	9.0 a	5.0 a

*Check varieties.

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

Table 11. Mean (n=2) sponge cake baking test parameters[a]

Group	Entry	Sponge Cake	
		Volume (mL)	Texture Score
1	15VDH-FHB-MAS33-13	1186 a	25.5 a
1	16VDH-SRW03-018	1254 a	26.0 a
1	VA17W-75	1238 a	26.5 a
1	Branson*	1282 a	27.0 a
1	Hilliard*	1276 a	26.0 a
2	Beck 705	1254 a	26.5 a
2	Beck 720	1301 a	25.5 a
2	Beck 722	1244 a	26.5 a
2	Beck 724	1251 a	26.0 a
2	Beck 727	1284 a	27.5 a
2	Beck 732	1321 a	26.5 a
2	Beck 721*	1233 a	27.0 a
3	MI14W0190	1270 a	24.5 a
3	MI16R0898	1287 a	25.5 a
3	MI16W0133	1303 a	26.5 a
3	MI16W0528	1303 a	26.0 a
3	Whitetail*	1327 a	26.0 a
4	GA19LE12	1281 a	26.5 a
4	GA19E38	1242 a	26.0 a
4	GA18LE43*	1279 a	27.5 a

*Check varieties.

[a]Means with different letters within the same group are significantly different at $P<0$.

REGIONAL AND STATE PERFORMANCE NURSERIES – 2022 CROP

QUALITY CHARACTERISTICS OF REGIONAL NURSERY ENTRIES

2022 Crop Evaluations

Each year, wheat breeders submit elite breeding materials to cooperative yield trials known as regional nurseries, which are then grown throughout the target production region. Grain samples from 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.

Narratives describing recent quality evaluations of these uniform performance testing nurseries and data summary tables 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.

REGIONAL COLLABORATING NURSERIES AND COORDINATORS

GULF ATLANTIC WHEAT NURSERY 2	*Rick Boyles, Clemson University*
UNIFORM EASTERN SOFT RED WINTER WHEAT NURSERY 1	*Eric Olson, Michigan State University*
UNIFORM SOUTHERN SOFT RED WINTER WHEAT NURSERY 1	*Mohamed Mergoum, University of Georgia*
UNIFORM SOUTHERN SOFT RED WINTER WHEAT NURSERY 2	*Rick Boyles, Clemson University*
MASON DIXON	*Nicholas Santantonio, Virginia Polytechnic Institute and State University*

GULF ATLANTIC WHEAT NURSERY 2

Rick Boyles, Clemson University

Sixty-two advanced breeding lines and varieties of SRW wheat were analyzed for test weight, NIR grain protein content, kernel hardness, flour yield, softness equivalence, flour protein content, sodium carbonate SRC, lactic acid SRC and sugar-snap cookie baking quality. Letter grades (A, B, C, D or F) for flour yield were assigned to each entry based on the flour yield range of wheat breeding lines and varieties the SWQL tested in 2009-2021. Those entries that fell in the top 15% range of lines and varieties for flour yield received an 'A,' in the next 20% a 'B,' in the next 30% a 'C,' in the next 20% a 'D,' and in the bottom 15% an 'F.'

Compared to the prior thirteen-year averages of the ESW varieties and lines tested by the SWQL, the entries on average exhibited similar test weights, higher grain protein contents by 0.3%, lower kernel hardness values by 1.8, comparable flour yields, higher flour protein contents by 0.4%, comparable sodium carbonate SRCs, higher lactic acid SRCs by 16.5%, and comparable sugar-snap cookie diameters.

Kernel hardness of the entries ranged from 0.4 to 22.5 in sixty entries. There were, however, two entries exhibiting kernel hardness values greater than 30. Six entries exhibited flour yields of 70.6 to 72.6%, receiving a flour yield grad of 'A.' Flour protein contents of entries ranged from 7.4 to 10.5%, with 52 entries exhibiting protein contents higher than the typical protein content of eastern soft wheat (8.2%). Fifty-seven entries exhibited lactic SRC values greater than 100%. Ten entries exhibited sugar-snap cookie diameters equal to or greater than 19.4 cm, with a cookie diameter grade of 'A.'

Table 12. Gulf Atlantic Wheat Nursery 2 trial 2022 crop quality data

Entry	Test Weight (LB/BU)	NIR Kernel Protein (at 12%)	SKCS Kernel Hardness	SKCS Kernel Diameter (mm)	SKCS Kernel Weight (mg)	Adjusted Flour Yield (%)	Softness Equivalence (%)	Flour Protein (at 14%)	Lactic Acid SRC (%)	Sodium Carbonate SRC (%)	Cookie Diameter (cm)	Top Grade (0-9)	Adjusted Flour Yield % Grade
AGS3015	59.7	10.8	10.9	2.7	31.7	68.5	59.8	8.5	107.9	67.9	19.1	4	C
HILLIARD	59.8	10.6	10.0	2.7	36.2	67.8	62.4	8.6	116.5	71.1	18.4	5	D
PIO 26R41	57.8	10.1	9.6	2.7	36.6	69.4	64.0	8.3	116.4	70.1	19.2	3	C
PIO26R45	58.2	9.2	2.3	2.6	33.6	69.8	60.8	7.7	91.1	63.9	19.8	3	B
SS8641	60.8	11.0	17.9	2.7	33.0	68.3	57.2	9.5	133.4	66.1	18.5	4	C
FL16016LDH-43	59.8	10.9	13.2	3.0	41.2	72.6	55.7	9.2	89.9	67.3	19.4	3	A
FL16009LDH-18	59.9	10.2	1.7	2.8	39.0	71.6	60.1	8.4	107.4	66.5	19.3	3	A
FL16027LDH-42	61.1	11.6	16.4	3.0	41.5	68.7	54.2	9.8	128.4	71.0	17.8	4	C
FL15105-LDH043	60.8	11.5	15.2	2.8	31.1	67.7	55.9	9.4	107.4	69.6	18.4	4	D
FL16016LDH-48	60.7	11.8	16.0	3.0	40.9	67.6	56.3	10.0	118.0	71.6	18.1	3	D
FLLA16124LDH-51	61.2	11.6	31.1	2.8	34.8	69.1	47.4	9.5	117.5	70.2	17.9	3	C
GA151313-LDH-53 -20E18	59.3	10.2	14.1	2.7	35.7	67.3	61.8	8.7	117.7	72.7	18.7	3	D
GA151313-LDH-95 -20E19	60.5	11.1	19.3	2.6	31.2	67.3	55.5	9.5	94.2	66.1	18.7	3	D
GA12230-1 -6-6-3 -20E36	58.0	11.2	22.4	2.7	34.3	65.0	57.6	9.3	105.2	70.4	18.5	3	F
GA131214-8-5-2 -20LE12	60.4	10.3	-2.8	2.8	35.3	68.1	66.0	8.0	127.9	74.3	18.4	6	C
GA131214-8-5-6 -20LE13	60.0	10.9	3.7	2.7	32.3	67.0	64.9	8.8	128.4	74.8	18.1	4	D
GA14235-7-2-6 -20LE31	59.9	10.4	4.0	2.8	38.9	69.3	60.4	8.7	119.8	67.5	19.3	3	C
X12-924-40-7-5	59.5	10.7	17.0	2.9	36.8	67.8	56.4	9.4	114.4	70.1	18.0	3	D
X12-052-1-13-3	59.7	10.4	12.9	2.9	38.6	68.1	59.7	9.0	114.1	73.0	19.3	4	C
X12-3035-50-4-3	59.9	10.8	21.3	2.7	36.3	65.3	60.6	8.3	124.9	74.6	17.8	3	F
X12-3072-55-17-3	59.5	11.2	22.5	2.7	35.2	65.2	60.3	8.4	127.8	74.5	18.1	3	F
X12-3034-49-4-3	60.8	9.5	11.4	2.8	39.2	68.0	64.4	7.4	112.9	73.5	18.6	4	C
X11-0039-1-17-5	61.6	10.7	16.6	2.7	36.3	68.2	57.7	8.7	108.8	70.1	19.2	3	C
LA13202D-82-1	59.7	10.9	16.3	2.7	32.2	67.7	59.5	8.4	114.4	70.7	18.7	4	D
LA13235D-66-3	60.7	11.8	14.0	2.8	34.9	68.4	58.4	9.9	142.8	67.1	18.4	3	C
LA14188CBB-4	62.1	10.8	15.4	2.7	32.2	68.6	58.4	9.2	116.8	67.5	19.5	3	C
LA14261C-45-2	58.2	9.9	7.2	2.7	34.1	67.6	66.2	7.7	111.2	73.5	19.2	3	D
LA14269C-9-3	59.4	10.6	9.7	2.7	35.2	68.2	61.7	8.7	117.2	70.2	18.7	3	C
LA14272C-86-3-1	62.4	11.5	11.0	2.9	37.4	65.7	58.8	9.6	137.7	73.2	18.0	2	F
MD-21-DH116	61.4	12.0	17.2	2.6	33.6	65.4	55.5	10.5	140.3	71.9	17.8	3	F
MD-21-291	58.8	10.4	9.7	2.6	33.0	66.3	59.6	8.6	132.5	73.3	18.2	3	F
MD-21-299	60.2	10.5	7.5	2.7	36.4	67.0	62.0	9.0	117.3	74.8	18.6	3	D
MD-21-58	59.3	10.8	0.4	2.7	37.1	70.6	59.2	9.0	132.6	66.1	18.8	4	B
MD-21-108	58.4	9.9	37.5	2.7	34.6	70.8	55.0	8.9	116.6	75.6	17.4	2	A
MD-21-148	60.8	9.9	11.4	2.8	39.5	65.5	61.0	7.8	97.7	78.9	18.1	4	F
NC18-16900	59.8	10.2	13.4	2.6	31.9	67.4	60.4	8.8	116.8	67.5	19.1	4	D
NC13955-G135	60.6	10.7	11.2	2.6	31.9	66.2	58.9	9.1	126.5	73.0	18.2	4	F

NC13955-G151	59.5	10.7	7.5	2.7	32.2	67.8	62.8	8.6	125.1	70.2	18.8	3	D
NC13955-G200	59.4	11.0	0.4	2.8	37.2	67.4	62.1	9.1	129.5	71.9	18.5	3	D
NC13217-W293	62.2	11.0	6.4	2.8	35.6	68.3	59.4	8.9	128.1	67.6	18.9	3	C
NC15V25-20	59.5	10.1	18.1	2.5	29.8	64.8	62.0	8.0	117.9	73.8	18.7	5	F
SCLA19WF2110	59.7	10.3	14.1	2.8	39.1	67.0	59.3	8.4	122.4	72.9	18.6	5	D
SCGA121098-9-3-7-10	62.1	10.4	5.1	2.9	40.9	68.6	59.3	8.6	106.5	69.3	19.0	3	C
SCGA141072-7	61.5	10.2	6.2	2.8	35.1	71.6	58.3	8.6	113.9	64.3	19.5	3	A
SCGA14120-12-3-4	62.3	10.9	21.9	2.8	35.7	69.7	53.8	8.8	127.9	66.8	19.1	4	B
SCGA141638-8-4	61.0	10.7	8.0	2.8	36.4	71.5	58.8	8.5	100.7	65.5	19.5	3	A
SCGA16085ID-4	60.7	10.8	6.1	2.9	37.5	69.5	61.0	9.3	111.4	68.8	19.2	3	B
TX19D4032	61.7	10.7	6.6	2.9	40.8	68.9	60.5	9.0	113.2	67.2	18.9	4	C
TX19D4035	61.1	10.1	7.8	2.9	40.5	70.3	58.1	8.5	104.0	65.1	18.9	3	B
TX19D4163	61.8	11.1	20.4	2.7	34.0	68.8	54.7	9.0	115.7	66.2	18.9	3	C
TX19D4850	58.3	9.8	3.3	2.6	31.1	70.6	62.1	7.7	89.5	65.9	19.5	4	B
TX2017DDH094	60.5	11.0	8.9	2.8	37.2	69.7	57.2	9.0	103.2	69.5	19.4	3	B
TX2017DDH193	60.5	10.4	3.9	2.9	40.9	70.6	60.5	8.5	117.8	67.6	19.3	4	A
17VDH-SRW05-169	59.5	10.4	0.2	2.8	38.2	70.4	63.1	8.1	106.1	68.1	19.7	3	B
17VDH-SRW01-077	60.2	11.4	15.6	2.8	37.0	68.8	59.1	9.2	139.9	67.6	18.7	4	C
17VTK4-29	60.5	10.7	10.3	2.7	33.7	69.4	60.7	8.5	121.4	66.6	19.1	4	C
18VDH-FHB-MAS07-164-01	59.8	10.0	12.3	2.8	35.9	67.9	60.7	8.3	112.3	69.9	19.7	4	D
VA20W-142	59.7	10.0	11.4	2.8	36.0	67.0	62.9	8.1	128.6	72.5	19.2	3	D
17VTK19-15	60.4	10.7	8.8	2.8	34.8	69.1	61.4	8.5	106.9	66.5	19.9	4	C
AR15V31-26-2285N	61.5	10.6	20.5	2.8	36.5	68.1	55.8	8.8	107.0	70.8	19.2	3	C
ARDH12753-103-1536M	60.9	10.9	11.2	2.8	35.4	68.6	59.8	8.9	133.7	66.4	19.3	4	C
ARDH14002-22-0260N	60.1	10.3	9.4	2.7	31.2	69.0	60.2	8.6	110.7	68.5	18.8	4	C
Average	60.2	10.7	11.8	2.8	35.7	68.3	59.5	8.8	116.8	69.8	18.8	3.5	
Standard Deviation	1.1	0.6	7.4	0.1	3.0	1.7	3.2	0.6	12.3	3.3	0.6	0.7	

UNIFORM EASTERN SOFT RED WINTER WHEAT NURSERY 1

Eric Olson, Michigan State University

Thirty-two advanced breeding lines and varieties were analyzed for test weight, NIR grain protein content, kernel hardness, flour yield, softness equivalence, flour protein content, sodium carbonate SRC, lactic acid SRC and sugar-snap cookie baking quality. Letter grades (A, B, C, D or F) for flour yield were assigned to each entry based on the flour yield range of wheat breeding lines and varieties the SWQL tested in 2009-2021. Those entries that fell in the top 15% range of lines and varieties for flour yield received an ‘A,’ in the next 20% a ‘B,’ in the next 30% a ‘C,’ in the next 20% a ‘D,’ and in the bottom 15% an ‘F.’

Compared to the prior thirteen-year averages of the SRW wheat varieties and lines tested by the SWQL, the entries on average exhibited higher test weights by 2.1 lb/bu, higher grain and flour protein contents, and lower flour yields by 0.5%. The average kernel hardness value was higher by 12.8 compared to the prior thirteen-year average. Eight entries showed kernel hardness values equal to or greater than 31.3. Only one entry, “MI18R0194,” received a flour yield grade of ‘A’ with a flour yield of 71.4%. Twenty-three entries exhibited lactic acid SRCs greater than 100%, indicating the presence of relatively strong protein. Six entries received a cookie diameter grade of ‘A’ with a diameter ranging from 19.4 to 20.1 cm.

Table 13. Uniform Eastern Soft Red Winter Wheat Nursery 1 trial 2022 crop quality data

Entry	Test Weight (LB/BU)	NIR Kernel Protein (at 12%)	SKCS Kernel Hardness	SKCS Kernel Diameter (mm)	SKCS Kernel Weight (mg)	Adjusted Flour Yield (%)	Softness Equivalence (%)	Flour Protein (at 14%)	Lactic Acid SRC (%)	Sodium Carbonate SRC (%)	Cookie Diameter (cm)	Top Grade (0-9)	Adjusted Flour Yield % Grade
Branson	60.6	11.4	17.4	2.6	33.1	68.8	58.8	9.2	115.8	65.8	19.0	4	C
MO080104	63.4	11.6	28.9	2.7	31.8	67.1	55.5	9.4	129.5	68.9	18.6	3	D
Hilliard	61.1	11.2	26.7	2.6	33.2	67.7	57.9	8.9	113.6	70.5	18.4	3	D
Pioneer Brand 25R46	62.0	10.8	29.5	2.6	33.9	68.4	55.5	8.7	98.1	67.6	19.1	4	C
17NSVX310257	62.3	11.6	28.8	2.7	33.2	68.1	53.2	9.8	96.7	66.0	19.1	3	C
17NSVZ310543	61.0	11.1	25.0	2.6	32.3	67.4	59.5	9.0	116.9	66.8	18.9	4	D
NS18VW311562	62.2	11.7	21.2	2.8	36.4	67.7	52.3	9.5	89.7	69.0	19.2	3	D
IL16-23972	61.5	11.2	18.7	2.7	33.1	69.6	55.3	9.5	109.4	63.9	19.2	4	B
IL17-17739	63.2	11.5	29.5	2.7	32.4	67.7	50.3	9.9	114.1	68.3	19.0	3	D
IL17-23874	61.9	10.2	23.9	2.7	34.8	69.6	54.4	8.6	113.3	65.5	19.3	3	B
KWS398	62.1	10.3	24.0	2.6	32.5	67.1	53.6	8.6	99.2	65.3	20.0	4	D
KWS403	61.8	10.6	21.2	2.8	36.1	66.2	53.8	8.8	120.1	66.4	19.2	4	F
KWS414	59.0	9.9	25.7	2.4	32.3	69.4	55.9	8.2	93.1	68.1	20.1	4	C
TWR 19009	62.8	11.2	21.6	2.6	33.6	68.7	57.1	9.1	106.1	65.0	19.3	4	C
TWR 19016	62.9	11.2	24.2	2.7	34.3	69.1	52.5	9.0	114.6	65.9	19.5	5	C
TWR 09056	62.6	10.9	29.4	2.6	33.5	66.3	54.1	8.8	100.2	70.8	19.0	4	F
X12-3010-4-4-1	62.4	10.6	33.5	2.8	38.1	66.8	48.1	9.0	113.8	71.2	18.6	4	D
X11-0039-1-17-5	62.5	9.8	25.1	2.8	36.5	69.4	55.6	8.0	103.0	67.8	19.0	4	C
X11-0120-12-4-3	60.9	11.0	36.2	2.7	31.2	68.9	51.2	9.1	88.0	66.0	19.1	5	C
VA19W-29	61.6	10.5	23.5	2.7	33.7	68.4	59.0	8.3	117.3	68.2	19.4	4	C
VA19FHB-22	63.0	10.8	25.0	2.8	36.0	69.4	54.0	8.7	95.4	67.6	19.4	3	C
16VDH-SRW03_018	63.1	10.9	32.3	2.7	35.0	67.5	53.2	8.9	110.6	73.7	18.6	4	D
MI18R0194	60.4	11.1	18.9	2.7	38.7	71.4	55.0	9.1	122.5	69.0	19.7	5	A
MI20R0103	62.0	11.1	34.6	2.7	33.4	66.0	54.4	8.9	121.1	71.4	18.7	5	F
MI19R0003	61.3	11.3	13.0	2.6	37.0	69.1	53.4	9.2	99.7	63.6	19.3	4	C
P2104	63.0	11.6	29.0	2.6	31.1	65.9	55.4	9.5	110.1	68.3	18.6	3	F
P2143	64.0	12.4	31.3	3.0	37.6	66.2	45.5	10.0	124.9	71.5	18.3	3	F
P2128	61.1	12.2	32.3	2.7	32.3	69.7	50.2	10.0	81.0	66.6	18.8	4	B
UMD-21-4	61.7	11.4	33.0	2.6	30.6	68.5	53.8	9.3	106.8	70.3	18.7	3	C
UMD-21-5	62.7	11.5	33.6	2.7	31.9	66.5	53.9	9.6	111.9	73.3	18.9	4	F
UMD-21-6	61.6	12.3	33.7	2.7	31.9	66.0	55.4	10.4	119.4	73.4	17.9	3	F
SY 100	60.4	10.4	15.3	2.7	38.3	70.2	57.0	8.5	103.4	66.5	19.9	4	B
Average	61.9	11.1	26.4	2.7	34.1	68.1	54.2	9.1	108.1	68.2	19.1	3.8	
Standard Deviation	1.1	0.6	6.0	0.1	2.3	1.4	3.0	0.6	11.6	2.7	0.5	0.7	

UNIFORM SOUTHERN SOFT RED WINTER WHEAT NURSERY 1

Mohamed Mergoum, University of Georgia

Thirty-eight SRW wheat breeding lines and varieties were analyzed for test weight, NIR grain protein content, kernel hardness, flour yield, softness equivalence, flour protein content, sodium carbonate SRC, lactic acid SRC and sugar-snap cookie baking quality. Letter grades (A, B, C, D or F) for flour yield were assigned to each entry based on the flour yield range of wheat breeding lines and varieties the SWQL tested in 2009-2021. Those entries that fell in the top 15% range of lines and varieties for flour yield received an ‘A,’ in the next 20% a ‘B,’ in the next 30% a ‘C,’ in the next 20% a ‘D,’ and in the bottom 15% an ‘F.’

Compared to the prior thirteen-year averages of the ESW varieties and lines tested by the SWQL, the entries on average exhibited much lower test weights by 2.9 lb/bu, lower grain and flour protein contents, and lower flour yields. The average kernel hardness value of the entries was 3.9, lower by 9.7 than the prior thirteen-year average, which probably led to a higher average softness equivalence by 4.3. Eleven entries exhibited kernel hardness values lower than 0. Four entries exhibited flour yields equal to or greater than 70.9%, receiving a flour yield grade of ‘A.’ The average sodium carbonate SRC was comparable to the prior thirteen-year average. Twenty entries produced cookies with diameters greater than 19.4 cm, receiving a cookie diameter grade of ‘A.’

Table 14. Uniform Southern Soft Red Winter Wheat Nursery 1 trial 2022 crop quality data

Entry	Test Weight (LB/BU)	NIR Kernel Protein (at 12%)	SKCS Kernel Hardness	SKCS Kernel Diameter (mm)	SKCS Kernel Weight (mg)	Adjusted Flour Yield (%)	Softness Equivalence (%)	Flour Protein (at 14%)	Lactic Acid SRC (%)	Sodium Carbonate SRC (%)	Cookie Diameter (cm)	Top Grade (0-9)	Adjusted Flour Yield % Grade
AGS 2000	57.2	9.5	-5.3	3.1	44.1	71.7	62.3	7.5	104.5	70.0	19.7	4	A
Jamestown	58.5	9.9	3.4	2.9	35.2	66.9	60.6	7.5	120.7	74.5	18.7	5	D
Hilliard	56.5	8.7	2.3	2.8	37.4	67.8	65.0	6.9	114.9	74.3	19.4	5	D
Pioneer Brand 26R41	57.3	9.3	6.5	2.7	37.7	69.0	63.1	7.4	120.8	73.8	19.6	4	C
NC15V25-20	58.6	9.3	16.2	2.6	31.8	66.2	62.0	7.2	123.4	75.7	19.2	6	F
NC13955-G125	56.8	10.9	-4.0	2.7	32.9	68.3	63.4	8.8	109.4	72.0	18.9	3	C
NC18-16920	58.0	11.6	10.1	2.8	32.2	66.9	61.5	9.5	149.1	70.2	19.1	3	D
FL15105-LDH039	59.1	11.5	12.1	2.9	31.9	66.1	55.5	9.4	108.4	67.7	19.1	4	F
FL16009LDH-16	54.9	10.5	7.6	2.9	39.3	67.2	60.4	8.5	111.3	67.4	19.4	2	D
FL16045LDH-25	58.3	12.0	4.3	2.9	36.8	68.8	59.2	9.7	111.5	66.8	19.1	3	C
TN 2201	56.1	9.9	-7.3	2.7	34.7	66.9	66.2	7.6	146.3	73.8	19.6	3	D
TN 2202	53.7	10.3	5.3	2.9	37.3	68.3	61.0	8.3	136.1	70.8	19.8	4	C
TN 2203	55.8	10.4	-5.7	2.8	34.4	67.8	64.7	7.8	127.3	74.2	20.2	4	D
GA131218-1-2-7 -20E15	56.2	9.2	20.8	3.0	37.9	65.9	58.6	6.9	103.5	75.5	19.2	7	F
GA151313-LDH-192 -20E48	57.0	10.0	3.4	2.8	34.4	67.3	65.3	7.4	136.8	76.1	18.9	4	D
GA161137LDH-23 -20LE3	56.8	10.3	1.4	2.7	34.4	70.9	63.8	7.8	113.3	68.6	19.8	3	A
GA161240LDH-113 -20LE6	54.9	8.1	-8.2	2.8	38.7	72.1	68.0	6.0	115.2	71.4	20.4	5	A
SS18JL502143N	54.9	8.7	-9.3	2.8	38.7	71.3	66.9	6.2	99.3	67.5	20.9	2	A
SS18JL502282N	57.1	8.9	2.1	2.7	32.9	69.1	64.6	6.8	106.8	67.5	20.5	2	C
TX17D2337	57.5	9.7	-1.4	2.8	35.2	67.5	64.9	7.3	113.2	71.6	20.0	3	D
TX18D3212	57.5	10.2	2.2	2.8	34.2	68.7	63.2	8.0	120.4	70.9	19.4	4	C
TWR 19003	57.5	10.9	-0.6	2.7	34.9	67.2	63.4	8.4	94.3	69.9	19.8	2	D
TWR 19005	57.0	10.8	0.2	2.6	31.5	66.8	62.8	8.7	125.1	75.8	18.4	3	D
TWR 19008	58.3	10.7	26.0	2.6	29.0	65.5	57.3	8.6	100.3	74.0	19.2	6	F
17VDH-SRW03-143	58.4	11.1	5.4	2.7	35.5	69.1	60.4	8.3	129.6	69.1	19.4	5	C
VA19W-31	57.2	11.2	8.5	2.6	31.4	66.1	60.4	8.8	149.5	70.2	18.6	2	F
VA19FHB-05	57.7	9.5	-4.0	2.7	33.6	69.1	63.9	7.6	132.5	67.8	19.1	4	C
15VTK-1-101	57.2	10.3	4.8	2.7	31.8	66.6	61.1	8.0	133.3	72.5	19.5	4	D
KWS347	56.2	8.8	4.7	2.8	38.5	69.6	64.2	6.9	115.1	69.3	19.9	5	B
KWS405	56.8	8.9	-1.2	2.6	30.3	69.8	68.2	7.0	108.2	70.3	19.7	4	B
KWS419	56.7	10.0	8.6	2.9	39.5	69.4	60.5	7.9	127.7	67.8	19.6	3	C
LA13154D-WN1	55.4	10.5	-0.7	2.8	34.9	67.7	61.0	8.3	140.9	65.5	19.9	2	D
LA14152SB-BR52-3	56.9	11.4	14.1	2.8	34.1	68.7	55.7	8.7	108.0	69.8	19.1	4	C
LA14234CBW-31	57.7	10.3	3.5	2.7	34.8	68.6	62.1	8.1	102.5	66.0	19.5	4	C
LA15093SB-30-2	55.0	9.0	-6.2	2.9	38.2	68.1	65.6	7.1	98.7	70.8	19.3	3	C
UMD-21-1	55.2	8.7	2.8	2.8	32.7	67.2	65.6	6.5	102.0	71.8	18.8	5	D
UMD-21-2	57.3	9.9	6.2	2.8	33.3	68.2	60.3	8.0	102.6	69.3	19.6	3	C

UMD-21-3	58.4	11.1	18.4	2.6	27.4	64.7	56.8	8.9	96.3	70.1	19.2	3	F
Average	56.9	10.1	3.9	2.8	34.8	68.1	62.4	7.8	117.3	70.8	19.5	3.7	
Standard Deviation	1.2	1.0	8.1	0.1	3.3	1.7	3.2	0.9	15.3	2.9	0.5	1.2	

UNIFORM SOUTHERN SOFT RED WINTER WHEAT NURSERY 2

Rick Boyles, Clemson University

Thirty-eight advanced breeding lines and varieties were analyzed for test weight, grain protein content, kernel hardness, flour yield, softness equivalence, flour protein content, sodium carbonate SRC, lactic acid SRC and sugar-snap cookie baking quality. Letter grades (A, B, C, D or F) for flour yield were assigned to each entry based on the flour yield range of wheat breeding lines and varieties the SWQL tested in 2009-2021. Those entries that fell in the top 15% range of lines and varieties for flour yield received an 'A,' in the next 20% a 'B,' in the next 30% a 'C,' in the next 20% a 'D,' and in the bottom 15% an 'F.'

Compared to the prior thirteen-year averages of the ESW varieties and lines tested by the SWQL, the entries exhibited lower test weights, kernel hardness values and flour yields, but higher softness equivalence values. The average kernel hardness value of the entries was 4.7, lower by 8.9 than the prior thirteen-year average. The average softness equivalence of the entries was higher by 4% than the prior thirteen-year average. Six entries showed kernel hardness values lower than 0. 'GA161137LDH-23-20LE3' was the only entry receiving the flour yield grade 'A' with a flour yield of 70.9%. Both sodium carbonate and lactic acid SRCs were comparable to the prior thirteen-year averages. Still, 24 entries produced cookies with diameters greater than 19.4 cm, receiving the cookie diameter grade 'A.'

Table 15. Uniform Southern Soft Red Winter Wheat Nursery 2 trial 2022 crop quality data

Entry	Test Weight (LB/BU)	NIR Kernel Protein (at 12%)	SKCS Kernel Hardness	SKCS Kernel Diameter (mm)	SKCS Kernel Weight (mg)	Adjusted Flour Yield (%)	Softness Equivalence (%)	Flour Protein (at 14%)	Lactic Acid SRC (%)	Sodium Carbonate SRC (%)	Cookie Diameter (cm)	Top Grade (0-9)	Adjusted Flour Yield Grade
AGS 2000	58.2	9.7	-0.2	2.9	39.9	69.9	60.9	8.2	105.2	70.2	19.5	5	B
Jamestown	58.8	9.9	8.5	2.8	32.0	65.4	60.7	7.5	110.7	72.5	18.7	4	F
Hilliard	57.4	9.3	5.0	2.7	34.6	66.0	63.5	7.2	108.7	71.4	19.8	4	F
Pioneer Brand 26R41	57.4	9.7	7.0	2.8	37.7	68.4	63.0	7.7	109.9	67.1	19.8	5	C
NC15V25-20	58.6	9.0	12.6	2.7	32.3	65.0	62.4	6.9	109.5	72.6	19.5	5	F
NC13955-G125	58.1	9.9	-1.6	2.7	33.6	68.0	62.4	8.1	96.3	68.9	19.5	5	C
NC18-16920	57.8	9.5	6.7	2.8	33.1	68.3	63.5	7.6	111.3	66.1	19.4	6	C
FL15105-LDH039	58.6	10.9	12.3	3.0	32.6	64.8	55.6	8.5	100.2	68.1	19.1	5	F
FL16009LDH-16	55.8	10.2	4.8	3.0	40.4	67.9	61.8	7.7	104.4	66.8	19.5	4	D
FL16045LDH-25	58.8	10.1	4.2	2.9	36.9	68.5	59.3	8.0	94.7	66.8	19.7	5	C
TN 2201	56.2	8.8	-6.9	2.9	38.3	66.6	65.7	6.5	118.9	70.9	19.3	4	D
TN 2202	55.5	9.4	0.5	2.9	38.4	66.8	60.9	7.5	112.5	69.3	19.3	4	D
TN 2203	57.3	10.3	-4.0	2.9	37.4	67.8	62.2	7.7	105.8	70.6	19.9	5	D
GA131218-1-2-7 - 20E15	56.7	9.7	21.4	2.9	34.0	65.3	59.5	7.1	93.9	70.4	18.6	4	F
GA151313-LDH-192 - 20E48	58.2	9.6	5.5	2.7	34.0	66.2	65.1	7.1	122.2	74.4	19.3	4	F
GA161137LDH-23 - 20LE3	57.7	9.3	4.7	2.7	34.1	70.9	64.7	7.0	104.3	67.5	19.6	5	A
GA161240LDH-113 - 20LE6	56.2	8.7	-3.2	2.8	35.9	70.0	65.9	6.5	110.4	69.8	19.8	6	B
SS18JL502143N	54.7	9.2	-5.0	2.7	35.3	69.2	67.7	6.5	95.2	66.9	20.3	4	C
SS18JL502282N	57.1	9.1	1.1	2.7	33.6	68.1	64.0	7.0	102.4	65.1	20.1	5	C
TX17D2337	58.3	9.7	0.2	2.8	34.8	66.2	64.3	7.4	102.2	69.8	19.7	5	F
TX18D3212	57.8	9.1	4.9	2.9	36.2	68.3	62.8	7.2	99.6	69.0	19.7	5	C
TWR 19003	58.2	10.0	1.4	2.7	32.8	67.8	64.8	7.6	79.1	67.0	20.2	5	D
TWR 19005	57.8	9.9	7.5	2.7	31.7	67.3	61.9	7.7	98.0	72.2	19.1	4	D
TWR 19008	57.7	9.1	13.5	2.6	30.8	68.0	61.8	7.5	89.6	67.4	19.8	5	C
17VDH-SRW03-143	58.9	9.5	8.1	2.9	38.7	68.9	59.4	7.7	114.2	68.4	19.5	5	C
VA19W-31	57.6	9.9	10.4	2.7	31.7	66.1	60.8	7.6	123.5	69.8	19.3	4	F
VA19FHB-05	57.9	8.9	0.5	2.8	34.3	68.8	62.9	6.6	112.6	68.2	19.3	5	C
15VTK-1-101	57.4	9.8	5.8	2.8	33.2	66.4	61.8	7.6	108.3	68.2	19.5	5	F
KWS347	56.8	9.8	5.1	2.8	37.4	68.0	62.8	7.8	109.5	66.5	20.0	6	C
KWS405	57.4	9.7	-4.8	2.7	30.7	67.6	66.1	7.4	102.0	67.1	19.6	5	D
KWS419	56.3	10.0	4.7	2.8	36.1	68.8	62.4	7.6	112.5	66.4	19.6	5	C
LA13154D-WN1	56.4	9.6	0.7	2.8	34.6	67.7	61.0	7.6	119.4	65.5	19.6	4	D

LA14152SB-BR52-3	58.4	9.9	11.6	2.8	34.3	69.4	57.3	7.6	105.9	69.6	19.0	7	C
LA14234CBW-31	58.6	10.4	7.4	2.8	34.2	68.1	61.3	8.0	94.0	65.3	19.7	4	C
LA15093SB-30-2	57.2	10.0	0.5	3.0	38.8	64.9	60.6	7.7	96.8	72.9	18.8	4	F
UMD-21-1	57.7	10.4	9.5	2.7	30.8	66.9	60.8	7.7	107.4	70.7	18.9	4	D
UMD-21-2	59.2	10.4	7.3	2.8	32.9	67.6	58.3	8.4	100.0	68.8	18.9	4	D
UMD-21-3	58.1	10.7	12.1	2.6	28.6	64.9	59.5	8.5	87.9	68.4	19.4	5	F
Average	57.6	9.7	4.7	2.8	34.7	67.5	62.1	7.5	104.7	68.9	19.5	4.7	
Standard Deviation	1.0	0.5	6.0	0.1	2.8	1.5	2.5	0.5	9.6	2.3	0.4	0.7	

MASON-DIXON REGIONAL NURSERY

Nicholas Santantonio, Virginia Polytechnic Institute and State University

Eighty-two advanced breeding lines and varieties were analyzed for test weight, grain protein content, kernel hardness, flour yield, softness equivalence, flour protein content, sodium carbonate SRC, lactic acid SRC and sugar-snap cookie baking quality. Letter grades (A, B, C, D or F) for flour yield were assigned to each entry based on the flour yield range of wheat breeding lines and varieties the SWQL tested in 2009-2021. Those entries that fell in the top 15% range of lines and varieties for flour yield received an ‘A,’ in the next 20% a ‘B,’ in the next 30% a ‘C,’ in the next 20% a ‘D,’ and in the bottom 15% an ‘F.’

The averages for test weight, grain and flour protein contents, sodium carbonate SRC and sugar-snap cookie diameter of the 82 entries were not evidently different from the prior thirteen-year averages of the ESW varieties and lines tested by the SWQL. The average kernel hardness of the entries was higher by 3.0 than the prior thirteen-year average, which led to a lower average softness equivalence by 2.2%. Only four entries received a flour yield grade of ‘A,’ with flour yields equal to or higher than 70.7%. The entries exhibited a higher average lactic acid SRC value than the prior thirteen-year average by 13.5%. Still, fourteen entries produced sugar-snap cookies with diameters greater than 19.4 cm, receiving a cookie diameter grade of ‘A.’

Table 16. Mason-Dixon Regional Nursery trial 2022 crop quality data

Entry	Test Weight (LB/BU)	NIR Kernel Protein (at 12%)	SKCS Kernel Hardness	SKCS Kernel Diameter (mm)	SKCS Kernel Weight (mg)	Adjusted Flour Yield (%)	Softness Equivalence (%)	Flour Protein (at 14%)	Lactic Acid SRC (%)	Sodium Carbonate SRC (%)	Cookie Diameter (cm)	Top Grade (0-9)	Adjusted Flour Yield % Grade
X14-1147-158-14-5	56.7	10.1	15.7	2.8	36.3	68.5	56.3	8.1	123.6	69.6	18.9	3	C
UMD-MsDx-16	59.4	11.2	27.9	2.5	28.2	66.4	55.5	9.0	87.1	70.8	19.2	4	F
DH17SRW136-043	59.3	10.0	11.7	2.8	35.2	68.0	56.2	7.7	90.4	66.6	20.1	4	C
18VDH-FHB-MAS15-367-20	60.6	10.8	21.6	2.8	39.5	68.5	54.1	9.1	90.5	73.2	18.9	5	C
UMD-MsDx-9	60.8	11.6	25.1	2.6	32.5	65.8	53.4	9.3	121.2	73.3	19.0	5	F
X12-974-18-1-3	59.1	10.8	14.4	2.9	34.0	67.9	55.9	8.7	127.6	66.3	19.1	6	D
UMD-MsDx-20	58.6	10.7	11.2	2.6	30.7	64.0	58.3	8.7	119.5	78.6	18.4	2	F
ARS19W326	60.5	10.8	20.0	3.0	42.6	67.3	52.6	9.2	108.3	74.5	19.0	5	D
Pioneer 26R59	58.8	9.7	11.6	2.7	36.2	69.5	60.5	7.7	95.7	70.2	19.3	4	B
VA20W-52	56.6	10.6	9.9	2.7	36.8	69.6	57.9	8.5	106.2	71.5	19.5	3	B
UMD-MsDx-12	61.0	12.6	29.4	2.6	31.9	66.5	51.5	10.8	131.5	72.3	18.5	3	F
VA20W-42	59.0	10.3	19.9	2.6	34.1	68.3	58.1	8.3	104.3	68.8	18.9	5	C
UMD-MsDx-6	60.6	11.4	19.8	2.6	31.0	68.8	57.9	9.5	115.3	69.0	19.2	3	C
UMD-MsDx-14	62.1	11.1	15.6	2.8	36.8	69.2	54.5	9.3	107.3	70.2	19.5	4	C
ARS19W345	59.9	10.0	25.1	2.8	35.7	68.3	54.8	8.3	102.6	72.3	19.2	6	C
UMD-MsDx-19	58.9	10.3	11.7	2.5	31.4	63.9	59.9	8.5	119.8	83.4	18.6	4	F
X14-1118-59-4-1	59.4	10.5	19.4	2.9	40.1	68.4	52.8	8.8	117.1	69.2	19.2	5	C
X12-3014-46-8-5	59.3	10.4	22.9	2.7	35.5	66.1	57.1	8.3	134.1	77.6	18.2	4	F
X14-1008-92-13-3	59.2	10.8	10.0	2.8	35.8	69.0	57.8	8.4	107.8	67.6	18.8	7	C
17VDH-SRW05-169	58.1	10.1	4.3	2.8	36.5	70.1	61.3	8.5	110.7	70.5	19.7	5	B
UMD-MsDx-10	60.9	12.1	36.4	2.7	32.4	66.8	49.5	9.7	126.3	77.3	17.4	2	D
ARS19W318	58.3	11.6	9.1	2.9	40.1	68.1	53.1	9.8	133.5	69.6	19.0	5	C
UMD-MsDx-22	58.9	11.5	14.3	2.7	33.9	66.2	59.6	9.6	110.4	75.4	18.6	4	F
UMD-MsDx-17	61.2	11.2	18.5	2.9	34.8	69.4	52.8	9.5	100.9	69.3	18.4	5	C
UMD-MsDx-18	60.6	11.0	20.8	2.8	34.4	67.9	55.6	9.2	107.2	75.4	18.9	5	D
ARS19W177	59.5	11.8	24.6	2.6	29.2	70.7	52.1	10.5	101.3	65.7	18.8	5	A
VA20W-136	59.5	10.8	23.1	2.8	35.4	68.3	56.9	8.7	128.2	71.3	18.9	4	C
Hilliard	59.3	10.9	16.9	2.7	37.3	67.6	57.5	8.8	118.9	71.9	19.3	3	D
17VDH-SRW05-052	59.7	10.4	5.8	2.7	36.9	70.8	59.2	8.4	107.0	68.9	19.4	7	A
VA20FHB-20	61.5	10.8	11.1	2.9	41.7	69.0	54.0	8.7	116.5	69.5	19.6	3	C
VA19W-43	60.1	10.6	25.7	2.7	35.8	67.4	53.9	8.6	103.9	76.1	18.8	6	D
ARS18W0336	59.4	10.9	46.1	3.0	42.2	68.8	44.6	9.1	144.7	88.6	17.3	1	C
X12-3072-55-3-3	59.0	10.5	20.9	2.6	35.9	65.9	57.2	8.2	130.7	78.4	18.1	3	F
UMD-MsDx-8	59.6	11.3	31.5	2.7	32.2	67.6	53.6	9.3	113.4	69.6	18.9	4	D
ARS19W324	59.4	11.4	17.0	2.8	36.6	69.1	53.1	9.5	123.2	67.6	19.2	5	C
VA20FHB-22	59.4	10.5	9.0	2.8	40.3	67.8	55.5	8.2	114.0	67.7	19.4	6	D
X14-1008-96-2-1	58.7	10.5	12.3	2.6	32.9	68.4	57.5	8.6	122.8	65.0	19.2	6	C

X12-052-1-13-3	59.3	11.0	19.2	3.0	40.7	68.4	55.1	9.0	114.4	74.0	19.0	3	C
ARS19W036	61.4	10.5	21.7	3.0	44.3	70.3	55.1	8.5	97.5	73.8	18.8	4	B
VA20W-69	58.9	10.6	24.9	2.7	30.9	67.0	59.8	8.6	117.7	74.7	19.2	4	D
DH17SRW136-066	58.7	9.8	25.4	2.7	32.5	68.9	56.8	7.8	100.2	67.9	19.5	5	C
UMD-MsDx-15	59.9	10.7	30.2	2.6	29.8	66.3	56.2	9.0	116.2	73.5	19.0	4	F
DH17SRW136-038	57.1	9.6	14.1	2.8	35.2	70.9	55.1	8.0	89.2	64.2	20.1	6	A
17VTK6-17	61.7	10.1	27.6	2.7	34.0	70.0	55.6	8.3	124.6	74.2	19.1	5	B
VA20W-135	59.4	9.4	17.3	2.8	36.3	67.2	62.5	7.3	128.5	74.7	18.8	5	D
X12-3035-50-4-3	59.4	10.2	21.0	2.7	35.5	66.2	58.1	7.8	128.5	76.7	18.3	4	F
UMD-MsDx-11	60.7	11.2	24.4	2.6	30.9	67.0	52.8	8.5	124.7	72.4	18.9	5	D
UMD-MsDx-4	61.4	10.3	20.8	2.7	31.6	69.1	54.5	8.5	116.0	70.2	18.8	5	C
17VTK8-7	59.9	9.8	18.8	2.6	34.0	67.8	55.6	7.8	117.7	72.3	19.0	6	D
Shirley	57.3	10.2	9.9	2.7	37.8	69.5	55.6	8.1	89.7	71.5	19.2	4	B
18VDH-FHB-MAS07-173-03	58.5	11.0	20.1	2.9	39.5	69.6	49.3	8.9	114.7	70.0	19.1	5	B
UMD-MsDx-3	59.9	10.9	29.0	2.6	27.5	68.3	61.0	8.9	115.9	68.6	19.5	5	C
X12-3005-20-18-1	59.1	10.3	16.8	2.6	30.9	68.9	59.6	8.2	110.8	67.3	19.8	6	C
VA19FHB-36	59.6	10.2	21.8	2.7	34.7	65.7	57.3	8.2	129.3	75.7	18.8	5	F
ARS19W375	56.5	9.8	27.9	2.7	36.3	67.7	53.0	8.7	95.1	73.7	18.4	4	D
UMD-MsDx-1	60.2	12.0	40.5	2.6	29.7	64.9	50.6	10.2	121.7	76.9	17.5	3	F
18VDH-FHB-MAS06-152-03	60.1	10.4	20.5	2.7	33.9	68.7	56.0	8.2	103.6	73.9	18.7	5	C
X12-3072-55-13-3	59.8	10.1	20.9	2.6	34.2	66.2	57.8	7.9	127.2	76.4	18.3	4	F
ARS19W020	58.7	9.6	20.2	2.7	33.5	65.4	59.4	7.7	113.0	72.0	18.9	5	F
ARS18W0542	58.9	9.9	20.5	2.6	29.4	66.6	57.6	8.1	113.8	71.8	19.0	6	D
UMD-MsDx-21	58.8	10.6	20.5	2.7	30.6	69.1	56.8	8.2	105.5	71.5	18.8	4	C
X14-1107-182-13-3	58.4	10.0	25.2	2.8	35.4	67.7	54.3	8.1	103.0	71.1	18.7	4	D
X12-3034-49-4-3	59.7	9.7	17.7	2.7	35.8	68.5	61.3	7.5	113.6	75.9	18.8	5	C
L11541	59.4	9.9	27.7	2.7	31.5	69.9	55.9	8.1	118.3	71.5	19.3	5	B
ARS18W0583	58.2	10.6	10.6	2.8	36.2	69.0	54.0	8.6	85.1	69.1	18.7	4	C
X12-3072-55-17-3	59.5	10.5	23.1	2.6	34.8	66.3	56.5	8.4	126.2	76.5	18.3	3	F
UMD-MsDx-13	60.0	10.9	18.7	2.6	27.7	68.8	57.7	9.1	111.5	69.2	18.8	5	C
UMD-MsDx-7	59.4	12.2	22.6	2.5	29.9	66.6	54.6	10.0	123.6	73.8	18.0	4	D
UMD-MsDx-5	60.5	11.9	18.1	2.7	31.2	68.2	58.5	9.5	117.0	70.6	18.9	5	C
ARS19W508	59.3	11.1	23.8	2.9	37.5	69.0	51.2	9.2	118.9	71.5	18.5	5	C
X14-1107-186-8-3	58.3	10.2	22.9	2.8	32.3	69.0	54.5	8.2	120.3	72.2	19.0	6	C
ARS18W0147	58.4	9.7	22.9	2.8	34.3	67.8	57.3	7.9	108.6	71.8	19.3	5	D
X14-1353-139-9-1	59.2	9.7	13.6	2.7	33.2	68.3	57.5	8.1	116.4	71.6	19.4	6	C
X12-3005-20-11-1	59.6	10.0	14.9	2.7	33.5	69.9	58.7	8.0	110.9	67.7	19.2	6	B
X12-156-9-19-3	59.0	10.1	23.1	2.7	35.5	66.5	51.4	8.4	116.0	74.5	18.7	5	F
UMD-MsDx-2	60.9	11.0	29.9	2.5	30.5	67.3	54.7	9.4	122.2	73.9	18.4	4	D
18VDH-FHB-MAS07-164-08	59.5	9.8	15.2	2.8	35.4	67.8	57.8	8.1	107.4	72.4	19.4	6	D

VA20W-171	56.8	9.7	11.8	2.7	34.1	69.6	57.5	7.7	110.0	69.5	19.6	6	B
X13-1115-25-3-3	57.6	9.9	14.4	2.7	33.4	69.4	54.7	8.3	112.1	69.1	19.4	6	C
X14-1049-27-10-1	57.5	9.5	12.4	2.8	35.9	69.9	60.7	7.7	116.6	66.9	19.0	6	B
ARS19W235	60.0	11.6	32.0	2.7	33.5	65.4	46.0	9.9	119.1	70.5	18.6	5	F
17VTK6-61	60.4	10.2	31.7	2.6	29.6	73.8	61.4	8.6	114.8	69.4	19.4	5	A
Average	59.4	10.6	20.2	2.7	34.5	68.1	55.9	8.6	113.8	71.9	18.9	4.6	
Standard Deviation	1.2	0.7	7.6	0.1	3.5	1.7	3.3	0.7	11.8	3.9	0.5	1.2	

MATERIALS AND METHODS

QUADRUMAT MILLING TESTS – BREEDER SAMPLES

The Soft Wheat Quality Laboratory evaluates thousands of breeder wheat samples yearly. Table 17 summarizes the traits tested and reported to breeders by the SWQL. The SWQL milling methods are described below.

Table 17. 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 1-120, soft to hard. Whole, untempered grain measured using 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)
Midds	Midds	Weight of milled product retained by 94-mesh* screen (over 94)
Break Flour	BkFl	Weight of milled product passing through 94-mesh* screen (Grain weight – (bran + midds))
Percent Bran, MIdds, Break Flour	%	Expressed as percent of grain weight (Bran Weight/GW) x 100
Total Flour	Flour	Break Flour + Midds
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 Lactic Acid Sodium Carbonate Sucrose Water	SRC LA SC SU WA	Percentage of solvent retained by a flour/solvent slurry after centrifugation and draining ((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

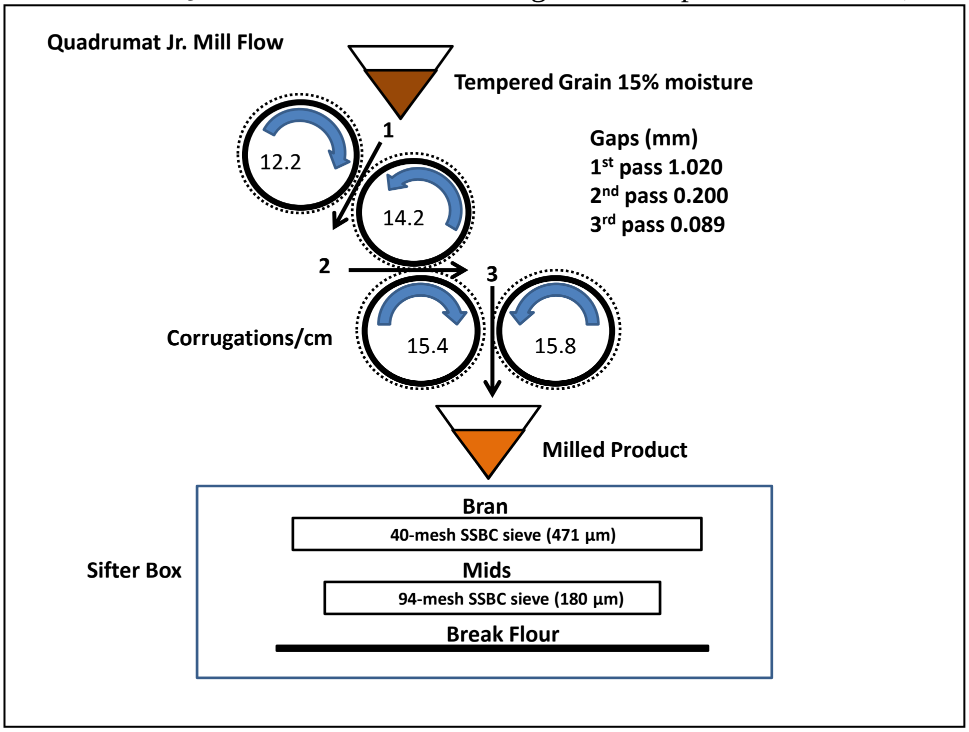
Tempering: Prior to milling, wheat grain is estimated for moisture content using a Perten NIR DA7200 whole grain analyzer and tempered to 15% moisture. Grain samples are tempered in glass jars by adding distilled water, sealing with silicon-free, screw-top lids and tumbling on a chain driven roller/conveyor (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.

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, midds and break flour. Bran is recovered above the 40-mesh screen, midds above the 94-mesh screen, and break flour passes through the 94-mesh screen. For ease of handling and accuracy, the bran and midds 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. Midds (%) 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 milling unit – 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 18.

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 below in **Soft Wheat Quality Laboratory Testing Methods for Quality Traits** and summarized in Table 19. 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 18. 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	Midds+Flour/Grain x 100		
Softness Equivalence	(Break Flour/Total Flour) x 100		
Kernel Hardness	Single Kernel Characterization System (SKCS)		
Whole Grain Protein & Moisture	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 31, below. Complete descriptions of the individual SWQL methods follow below.

Table 19. 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) AACC Method 55-31.01	Grain hardness <40 is considered soft wheat	0-120
Whole Grain Protein & Moisture	Near Infra Red (NIR) Perten DA7200	Whole grain Protein & Moisture content	0-100 Percent
Falling Number	Perten Falling Number Tester AACC Method 56-81.03	Pre-harvest sprout damage	seconds
Flour Yield	midds + 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	Pentosan Content (Arabinoxylans)	
	Water	Overall water affinity	
Sugar-snap Cookie Diameter	Baking Quality of Cookie Flour, Intermediate Method AACC Method 10-52	Cookie spread	Centimeters
Sugar-snap Cookie Top Grain		Visual quality cookie surface	1-10 higher is better

Grain Moisture, Hardness and Protein

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

Definitions:

Grain is the cleaned whole grain.

Break flour (BkFl) is the flour passing through the 94 mesh screen after a single pass through the Quadrumat break roll unit. Break flour has the finest particle size. Break flour weight is approximated by subtracting the weight of bran and midds from the tempered grain weight.

Midds (middlings) is the particles/grits passing through the 40 mesh screen but retained by the 94 mesh screen after a single pass through the Quadrumat break roll unit.
Bran is the pieces of wheat grain outer layers retained by the 40 mesh screen after a single pass through the Quadrumat break roll unit.

Reduction flour is the flour passing through an 84 mesh screen after a second, reduction milling of the midds (from break roll unit) through the Quadrumat reduction roll unit.

Straight Grade Flour is a blend of break flour and reduction flour.

Flour Yield

Flour yield (FY) is calculated as the percent total flour weight (break flour + midds) of the tempered grain weight (GW) from a single pass through the Quadrumat break roll unit. For calculation of flour yield, the difference between the grain weight (GW) and the bran weight (Bran) is used to estimate total flour (midds + break flour).

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 (BkFl) passing through 94-mesh screen, of the total flour weight (break flour + midds). 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 midds (remaining over the 94-mesh screen) from the total flour gives the weight for break flour.

SE = {(GW – (Bran + Midds))/(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 a combustion nitrogen analyzer (Leco) 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.

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.

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) is performed using the Perten Falling Number instrument. A glass tube filled with a suspension of whole grain meal or milled flour is heated in a boiling water jacket to produce gelatinized starch. Immediately after heating, a weighted plunger is released into the suspension, and the travel time of the plunger is measured in seconds (falling number) as it falls from the top to bottom of the glass tube. 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 the viscosity of gelatinized starch, resulting in decreased travel time of the plunger (falling number). 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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