Milling and Baking Test Results for Eastern Soft Wheats
Harvested in 2018

Soft Wheat Quality Council of the Wheat Quality Council

April 23, 2019

Our Mission is to advocate the development of new wheat varieties that improve the value of wheat to all parties in the U.S. supply chain.

Our Goal is to improve the value of all U.S. wheat classes for producers, millers, and processors of wheat.

Membership in the Wheat Quality Council is a wise investment if wheat or flour quality has any influence on your business.

Uniform grow-outs are an extremely important part of the Wheat Quality Council efforts to improve wheat and flour quality.

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Collaborators for 2018 Crop Year

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Soft Wheat Quality Council

Mission, Policy, and Operating Procedure

The Soft Wheat Quality Council (SWQC) will provide an organizational structure to evaluate the quality of soft wheat experimental lines and varieties grown in the Eastern regions of the United States. The SWQC also will establish other activities as requested by the membership. The SWQC operates under the direction and supervision of the Wheat Quality Council (WQC). The mission of the SWQC is to provide a forum for leadership and communication in promoting continuous quality improvement among the various elements of the community of soft wheat.

Objectives

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

Membership

- The membership of the SWQC will consist of members of the WQC.

SWQC Technical Board

- The Technical Board shall be the administrative unit responsible for managing the functions of the council.
- The Technical Board shall consist of three officers elected from the membership.
- Officers of the Technical Board shall consist of a chair, vice-chair, and secretary.
- Each officer serves one year in his/her office.
- Terms start the day after the annual meeting of the SWQC.
- The vice-chair replaces the chair at the conclusion of the chair's term and the secretary replaces the vice-chair at the conclusion of the vice-chair's term.
- Officers (normally only the secretary) shall be elected annually at the annual meeting of the SWQC by nomination and majority vote.

- Any eligible member may be reelected after being out of office for one year.
- Vacancies that occur during the term of office of the members of the Technical Board shall be filled by nomination and majority vote of the remaining members of the board and the WQC Executive Vice President. The appointee will serve the remaining term of the vacancy (up to 3 years).
- Exceptions to the above may be granted if voted on by Technical Board or by majority vote of the SWQC at the annual meeting.

Duties of the Technical Board

- The chair shall be responsible to establish a meeting place and preside at all meetings of the Technical Board and SWQC (selected elements of the General Meeting WQC).
- The vice-chair shall preside at meetings in absence of the chair and assume such duties as may be assigned by the chair of the Technical Board.
- The secretary shall be responsible for taking minutes of the Technical Board and the SWQC meetings.
- The Technical Board will direct the Executive Vice President of the WQC on disbursement of allocated funds.
- The chair shall be responsible for communicating budget needs to the Executive Vice President.
- The Technical Board is responsible for presenting budget updates to the general membership at the annual meeting.

Compensation

- Technical Board members shall serve without compensation.

Expenses

- Certain paid expenses may be authorized for some technical board functions.

Quality Evaluation Committee of the SWQC

Committee Purpose

A technical committee entitled "Quality Evaluation Committee" shall be established consisting of the three Technical Board officers and other key members working on soft wheat. Those other key members should include, but are not limited to:

- The Lead Scientist of the USDA Soft Wheat Quality Laboratory, Wooster, OH.
- A grow-out coordinator who is a soft wheat breeder.

• Technical collaborators from soft wheat milling and baking laboratories.

• Collaborating soft wheat breeders.

Evaluation and Responsibilities

• Establish procedures and requirements for the annual grow-out, handling, evaluation and reporting of the experimental test line quality evaluation program.

• Annual approval of the samples and check varieties submitted by soft wheat breeders.

• Milling of the experimental and check samples.

• Distribution of samples to collaborators (member companies willing to conduct testing and baking evaluations on the samples prepared).

• Preparation of a quality report.

Sample/Locations

• Each breeder entity shall have the privilege of submitting experimental test lines and a check variety each year for evaluation. (maximum 10 samples annually)

Annual Meeting

• The annual meeting of the SWQC shall coincide with the annual meeting of the WQC. If for some reason the WQC annual meeting is not held, it shall be the duty of the Technical Board chair to establish an annual meeting time and place.

• The purpose of the meeting shall be to discuss the results of the test line quality testing program, elect board members and carry on other business as required by the SWQC.

• Other meetings determined to be necessary may be established by the Technical Board.

Finances and Budget

• The finances required to meet the operating expenses of the council shall be designated by the Executive Board of the WQC.

• The budget shall be presented for membership approval at the annual meeting.

Amendments

• Amendments to the policy and operation procedure of the SWQC can be made by majority vote of the council members present.

• The proposed changes must be submitted in writing and must be in the hands of the membership two weeks prior to voting on the change.

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Figures and Tables

WQC 2018 Crop Year Entries and Contributing Breeding Programs

Group	Entry	Location	Breeder	Institution/ Company	Class
1	M12-3312CW	Wooster, OH	Allen Becker	Syngenta	SRW
1	M12-2020#				SRW
1	Branson*				SRW
1	Hilliard*				SRW
2	VA12W-31	Lanexa, VA	Carl Griffey	Virginia Polytech	SRW
2	VA12W-68				SRW
2	VA09MAS2-131-6-2				SRW
2	Branson*				SRW
2	Hilliard*				SRW
3	RS 961	Wauseon, OH	John King	Rupp Seeds	SRW
3	RS 968				SRW
3	RS 902*				SRW
4	GA 07353-14E19	Griffin, GA	Mohamed Mergoum	University of Georgia	SRW
4	GA JT141-14E45				SRW
4	GA 051207-14E53				SRW
4	Branson*				SRW
4	Hilliard*				SRW

*Check varieties.

Description of Entries

M12-3312CW
M12-3312CW is an awnless soft white winter wheat variety bred and developed by Syngenta. M12-3312CW is a medium height, medium-early maturing variety with heading approximately 2 days earlier than W1062. In testing, M12-3312CW has shown above average resistance to current races of leaf rust, stripe rust, and powdery mildew and moderate resistance to Fusarium head blight. It has also shown moderate susceptibility to soilborne mosaic virus, septoria and glume blotch. M12-3312CW has above average test weight and has exhibited acceptable milling flour yields and cookie baking properties.

M12-2020#
M12-2020# is an awnless soft red winter wheat variety bred and developed by Syngenta. M12-2020# is a medium tall semi-dwarf variety with medium maturity heading the same time as SY 483. M12-2020# has tested above average resistance to Fusarium head blight, powdery mildew, stripe rest, septoria and Hessian fly biotypes L & O. It has also tested average tolerance to leaf rust and wheat spindle streak, and is known to be susceptible to soilborne mosaic. M12-2020# has shown average milling flour yields and acceptable cookie baking properties.

Branson
Branson is a soft red winter wheat bred and developed by AgriPro Wheat. Branson is a medium height semi dwarf variety with good straw strength. Branson is moderately resistant to Septoria Leaf Blotch and Stripe rust and Powdery Mildew. Intermediate resistance to Soil borne Mosaic virus and Leaf rust. Primary adaptation is the wheat growing regions of Missouri, Illinois, Indiana, Michigan, and Ohio. Juvenile growth habit is semi erect. Plant color at boot stage is dark green. Flag leaf at boot stage is erect and twisted. Waxy bloom is present on the head, stem and flag leaf sheath. Anther color is yellow. Head shape is strap, mid-dense and awnletted. Glumes are glabrous, narrow in width and long in length with oblique shoulders and obtuse beaks. Seed shape is ovate. Brush hairs are mid-long in length and occupy a large area of the seed tip. Seed crease depth is shallow and width is narrow. Seed cheeks are rounded. Branson has been uniform and stable since 2003. Less than 0.8% of the plants were rouged from the Breeders Seed increase in 2004. Approximately 90% of the rouged variant plants were taller height wheat plants (8 to 15 cm) and 10% were awned plants. AgriPro Wheat maintains seed stock and certified classes of Foundation, Registered and Certified. Certified seed stocks of Branson will be available in the fall of 2005. Certified acreage is not to be published by AOSCA and certifying agencies. Plant Variety Protection is anticipated and Branson may only be sold as a class of certified seed.

Hilliard
Soft red winter (SRW) wheat cultivar Hilliard (VA11W-108) was derived from the cross Pioneer Brand '25R47' (PI 631473) / 'Jamestown' (PI 653731). Hilliard was derived as a bulk of an F5:6 headrow selected in 2010 and has been evaluated over five years (2013 – 2017) in Virginia's State Variety Trials and throughout the soft red winter (SRW) wheat region in the 2014, 2016, and 2017 USDA-ARS Uniform Southern and Uniform Eastern Soft Red Winter Wheat Nurseries.

Hilliard is a broadly adapted, high yielding, mid-season, medium height, awned, semi-dwarf (gene Rht2) SRW wheat. In the southern SRW wheat region, head emergence of Hilliard (121d) has been similar to that of 'USG 3555' and 3 days later than Jamestown. In the eastern SRW wheat region, head emergence of Hilliard (136 d) was 1 day later than 'Branson' and 1.5 d earlier than 'Shirley'. Average mature plant height of Hilliard throughout the SRW wheat region has varied from 34 to 38 inches. In the 2014 Uniform Southern and Uniform Eastern nurseries, plant height of Hilliard (34 inches) was 2 inches shorter than checks 'AGS 2000' and MO_080104 and 2.5 to 3.5 inches taller than Shirley. Straw strength (0=erect to 9=completely lodged) of Hilliard (0.2 – 2.3) is very good and similar to that of Shirley (0.6 – 2.5). In the Uniform Eastern Nursery, winter hardiness (0 = no injury to 9 = severe injury) of Hilliard (2.2) was similar to that of the checks (1.8 – 2.9), while in the Uniform Southern Nursery, its winter injury (4.0) was less than that of the checks (5.4 – 6.5).

Hilliard was evaluated at 21 sites in the 2014 USDA-ARS Uniform Southern SRW Wheat Nursery and ranked second among 33 entries for grain yield (84 bu/ac). Average test weight of Hilliard (55.8 lb/bu) was similar to the overall trial mean and significantly ($P < 0.05$) higher than that of USG 3555 (54.4 lb/bu). Hilliard also was evaluated at 21 locations in the 2014 USDA-ARS Uniform Eastern SRW Wheat Nursery, and ranked first in grain yield within the eastern wheat region (87.6 lb/bu) and second over all test sites (86.9 lb/bu). Average test weight of Hilliard (56.9 lb/bu) was similar to the overall trial mean, and significantly ($P < 0.05$) higher than those of Branson (55.8 lb/bu) and Shirley (54.7 lb/bu).

Grain samples of Hilliard produced in five crop environments (2012 – 2014) were evaluated for end use quality by the USDA-ARS Soft Wheat Quality Lab. Hilliard has exhibited milling and baking qualities that are intermediate between those of Jamestown and USG 3555. Jamestown has better milling quality attributes than Hilliard or USG 3555, while both Jamestown and Hilliard have superior baking quality compared to USG 3555. While flour of Hilliard has the lowest grain protein content, it has slightly stronger gluten strength than Jamestown or USG 3555.

Hilliard is a widely adapted, mid-season wheat variety with good winter hardiness. It has high grain yield potential, good straw strength, and has performed well over most of the eastern SRW wheat production areas. With the exception of stem rust, Hilliard has expressed moderate to high levels of resistance to diseases prevalent in the SRW wheat region. These include powdery mildew, leaf rust, stripe rust, leaf and glume blotch, bacterial leaf streak, Soil Borne Mosaic Virus, Barley and Cereal Yellow Dwarf Viruses, Fusarium head blight, and Hessian fly.

VA12W-31 ('Featherstone 31') SRW Wheat

Soft red winter (SRW) wheat line VA12W-31 was derived from the cross 'MPV 57' (PI639506) / M99*3098 (TX85-264 / VA88-52-69) // Renwood '3434' (PI 656754). VA12W-31 was derived as a bulk of an $F_{5:6}$ headrow selected in 2011 and has been evaluated over four years (2015 – 2018) in Virginia's State Variety Trials. VA12W-31 also was evaluated throughout most of the soft red winter wheat region in the USDA-ARS Uniform Eastern SRW Wheat Nursery in 2016.

VA12W-31 is a high yielding, full-season, short semi-dwarf (gene *Rht1*) SRW wheat. Plant and spike color of VA12W-31 are green, and its awned spikes are tapering in shape. In the 2016

Uniform Eastern SRW wheat nursery, average head emergence of VA12W-31 (127 d) was 2 d later than 'Hilliard' and 1 d earlier than Pioneer '25R46'. Plant height of VA12W-31 (35 inches) was 1 inch taller than 'USG 3118' and 1 inch shorter than 'Branson'. Straw strength of VA12W-31 (1.6) was similar to that of USG 3118. The winter kill ratings (0 = no injury to 9 = severe injury) of VA12W-31 (2.0) were significantly ($P \leq 0.05$) higher than those of Pioneer 25R46 (0.7), but significantly lower than those of USG 3118 (2.9). VA12W-31 was evaluated with 29 other lines at 24 locations and had a mean grain yield (77.5 bu/ac) that was 2% higher than the overall trial average. VA12W-31 ranked among the top 10 entries in tests conducted at one or more locations in GA (1), KY (1), NC (2), VA (2), and WI (1). VA12W-31 had a mean test weight (56.9 lb/bu) that was equal to the overall trial average and significantly ($P \geq 0.05$) higher than that of Pioneer 25R46 (55.2 lb/bu).

Grain samples of VA12W-31 produced in six crop environments (2015 – 2016) were evaluated for end use quality by the USDA-ARS Soft Wheat Quality Lab. VA12W-31 has exhibited milling and baking qualities that are most similar to those of 'Jamestown'. Comparisons of mean milling and baking quality attributes over three crop environments for **VA12W-31** versus Jamestown include: softness equivalent values of **52.9%** versus 53.7%; flour yields of **66.1%** versus 66.5%; flour protein concentrations of **8.8%** versus 9.0%; gluten strength (lactic acid retention capacities) of **126.1%** versus 122.7%; cookie spread diameters of **18.0 cm** versus 17.5 cm; and cookie top grade scores (0-9) of **3.7** versus 2.3. Flour of VA12W-31 has lower Solvent Retention Capacity (SRC) for Sodium Carbonate (69.3%) than that of Jamestown (75.0%) and also produces cookies of larger diameter (18.0 cm) with a higher top grade score (3.7) than those of Jamestown (17.5 cm and 2.3).

VA12W-31 has expressed moderate to high levels of resistance to many diseases prevalent in the SRW wheat region including powdery mildew, leaf rust, leaf and glume blotch, and *Barley Yellow Dwarf Virus*. In comparison to Shirley, VA12W-31 has higher test weight (57.1 versus 54.4 lb/bu) and is more resistant (0 – 9) to stripe rust (3.2 versus 6.3). In the 2016 Uniform Eastern nursery, VA12W-31 had FHB Index (0 – 100), FDK (%), ISK Index (0 – 100), and DON values (22, 44%, 51, and 1.9 ppm) that did not differ significantly from those of Hilliard (20, 37%, 40, and 1.3 ppm), respectively.

VA12W-68 ('SR8483') SRW Wheat

Soft red winter (SRW) wheat line VA12W-68 was derived from the cross **Pioneer '25R47'** (PI 631473) / **'AGS 2010'** (PI 644020) // '**USG 3555'** (PI 654454). VA12W-68 was derived as a bulk of an $F_{5:6}$ headrow selected in 2011 and has been evaluated over four years (2015 – 2018) in Virginia's State Variety Trials. VA12W-68 also was evaluated throughout most of the soft red winter (SRW) wheat region in the USDA-ARS Uniform Southern SRW Wheat Nursery in 2016.

VA12W-68 is a broadly adapted, high yielding, early heading, semi-dwarf (gene *Rht*2) SRW wheat that is resistant to Hessian fly [*Mayetiola destructor* (Say)]. Plant and spike color of VA12W-68 are green, and its awned spikes are tapering in shape. In the 2016 Uniform Southern SRW wheat nursery, average head emergence of VA12W-68 (109.5 d) was 6 d later than 'Jamestown' and 7 d earlier than Pioneer '26R41'. Plant height of VA12W-68 (35 inches) was 2

inches taller than Jamestown and similar in height to 'AGS 2000'; however, straw strength of VA12W-68 (1.1) was significantly ($P \leq 0.05$) better than that of AGS 2000 (2.7). Winter kill ratings (0 = no injury to 9 = severe injury) of VA12W-68 (3.2) were higher than those of Pioneer 26R41 (1.3), but significantly ($P \leq 0.05$) lower than those of Jamestown (4.8) and AGS 2000 (6.1). VA12W-68 was evaluated with 32 other lines at 23 locations in the 2016 Uniform Southern nursery, and had a mean grain yield (76.5 bu/ac) that was the same as the top yielding cultivar Hilliard. Average test weight of VA12W-68 (56.0 lb/bu) was similar to that of Hilliard (55.7 lb/bu), lower than that of Jamestown (57.6 lb/bu), and significantly ($P \geq 0.05$) higher than those of Pioneer 26R41 (55.0 lb/bu) and AGS 2000 (54.9 lb/bu).

Grain samples of VA12W-68 produced in five crop environments (2015 – 2016) were evaluated for end use quality by the USDA-ARS Soft Wheat Quality Lab. VA12W-68 has exhibited milling and baking qualities that are most similar to those of Jamestown. Comparisons of mean milling and baking quality attributes over four crop environments for **VA12W-68** versus Jamestown include: softness equivalent values of **53.5%** versus 54.6%; flour yields of **66.5%** versus 66.4%; flour protein concentrations of **9.6%** versus 9.0%; gluten strength (lactic acid retention capacities) of **107.6%** versus 122.8%; cookie spread diameters of **18.1 cm** versus 17.5 cm; and cookie top grade scores (0-9) of **2.5** versus 2.0. Flour of VA12W-68 has lower Solvent Retention Capacity (SRC) for Sodium Carbonate (68.5%) than that of Jamestown (74.5%) and also produces cookies of larger diameter (18.1 cm) with a higher top grade score (2.5) than those of Jamestown (17.5 cm and 2.0).

VA12W-68 is resistant to Hessian fly biotypes B, C, D, O, and L, and has expressed moderate to high levels of resistance to most diseases prevalent in the SRW wheat region including powdery mildew, leaf rust, stripe rust, bacterial leaf blight, leaf blotch, *Barley Yellow Dwarf Virus*, and soil-borne viruses. In the 2016 Southern Uniform Winter Wheat Scab Nursery, VA12W-68 had FHB Incidence (39%), Severity (20%), FHB Index (10), FDK (26%), ISK Index (27), and DON (16 ppm) values, that were lower, except for DON, than those of the moderately resistant check cultivar Ernie (49%, 25%, 14, 32%, 31, and 9 ppm).

VA09MAS2-131-6-2 SRW Wheat

Soft red winter (SRW) wheat line VA09MAS2-131-6-2 was derived from the cross **GA991227-6A33** / **'Shirley'** (PI 656753) // **G41730**. The top-cross from which VA09MAS2-131-6-2 is derived was completed in spring 2009. Plants selected for traits of interest via marker assisted selection (MAS), were harvested and threshed separately and advanced each generation in the field using the pedigree breeding method. VA09MAS2-131-6-2 was derived as an $F_{4:5}$ headrow selected and harvested in bulk in 2013. VA09MAS2-131-6-2 was tested in the 2017 and 2018 Virginia State wheat tests. It also was evaluated throughout most of the soft red winter wheat region in the 2018 USDA-ARS Uniform Southern SRW Wheat Nursery in 2016.

VA09MAS2-131-6-2 is a broadly adapted, early heading, semi-dwarf (gene *Rht1*) SRW wheat variety that is very short in plant height with very good straw strength. Plant and spike color of VA09MAS2-131-6-2 are green, and its awnletted spikes are strap in shape.
VA09MAS2-131-6-2 expresses moderate to high levels of resistance to powdery mildew (*Blumeria graminis*), leaf rust (*Puccinia triticina*), stripe rust (*Puccinia striiformis*), stem rust (*Puccinia graminis*), *Barley Yellow Dwarf Virus*, *Wheat Spindle Streak Mosaic Virus*, leaf blotch

(*Septoria tritici*), and leaf and glume blotch (*Stagonospora nodorum*). In the 2018 Uniform Southern nursery, Jamestown (MR), Hilliard (MR), VA09MAS2-131-6-2, and Pioneer '26R41', had Fusarium Head Blight ratings (0 –9) of 1.3, 1.3, 1.9, and 2.4; FDK values of 30, 30, 50, and 50%; and DON levels of 15, 22, 20, and 40 ppm.

Head emergence of VA09MAS2-131-6-2 on average (110 d) is 4 d earlier than 'Shirley' and 3 d later than 'Jamestown', and has varied from 90 to 124 d. Plant height of VA09MAS2-131-6-2 on average (28 inches) is 6 inches shorter than 'Hilliard', and has varied from 26 to 30 inches. Straw strength (0 = erect to 9 = completely lodged) of VA09MAS2-131-6-2 on average (0.8) has been very good, and has varied from 0.2 to 1.6. In the 2018 Uniform Southern nursery, VA09MAS2-131-6-2 ranked 5th among 40 entries over 20 locations with a mean yield (81.4 lb/bu) that was similar to the highest yielding entry Hilliard (85.6 lb/bu), and significantly ($P \leq 0.05$) higher (9.6 bu/ac) than the early heading check variety Jamestown (71.8 bu/ac). VA09MAS2-131-6-2 had a mean test weight (56.1 lb/bu) that was similar to those of all check varieties except for Jamestown (57.8 lb/bu).

Grain samples of VA09MAS2-131-6-2 produced in four crop environments (2017 – 2018) were evaluated for end use quality by the USDA-ARS Soft Wheat Quality Lab. In the 2018 Uniform Southern nursery, VA09MAS2-131-6-2 exhibited milling and baking qualities that were intermediate to those of Hilliard and Jamestown. Comparisons of mean milling and baking quality attributes over four crop environments for **VA09MAS2-131-6-2** versus Hilliard include: softness equivalent values of **52.8%** versus 59.3%; flour yields of **67.6%** versus 68.0%; flour protein concentrations of **8.8%** versus 8.2%; gluten strength (lactic acid retention capacities) of **110.1%** versus 120.2%; sodium carbonate SRC of **73.0%** versus 75.5%; cookie spread diameters of **18.2 cm** versus 18.2 cm; and cookie top grade scores (0-9) of **3.0** versus 4.0. Flour of VA09MAS2-131-6-2 is suitable for pastry and cracker products.

RS 961_Rupp Brand

RS961 is a smooth, scab resistant line that really yields! Very strong agronomic attributes.

Attributes

Maturity	Medium Late
Plant Height:	Medium
Awnedness:	Awnless
Standability:	Excellent
Winter Hardiness:	Excellent
Test Weight:	Excellent
Head Scab:	Resistant
Powdery Mildew:	Tolerant
Septoria Gum Blotch:	Very Good

Chaff Color at Maturity	White
Head Size	Average
Seed Size	Medium
Flag Leaf Orientation	Upright

RS 968_Rupp Brand

RS968 is a very attractive line with excellent fall stooling ability. It has the F1+B1 marker for scab resistance.

Attributes

Maturity	Medium Early
Plant Height:	Medium Tall
Awnedness:	Awned
Standability:	Very Good
Winter Hardiness:	Excellent
Test Weight:	Good
Head Scab:	Resistant
Powdery Mildew:	Good
Septoria Gum Blotch:	Excellent
Chaff Color at Maturity	White
Head Size	Large
Seed Size	Medium
Flag Leaf Orientation	Upright

RS 902*_Rupp Brand

RS902 is an outstanding line with yield, test weight, standability and disease package. This variety is positive for the FHb1 marker gene, bringing a new level of head scab resistance. Strong recommendation for foliar fungicide.

Attributs

Maturity	Medium Late

Plant Height:	Medium
Awnedness:	Awned
Standability:	Very Good
Winter Hardiness:	Excellent
Test Weight:	Good
Head Scab:	Resistant
Powdery Mildew:	Fair
Septoria Gum Blotch:	Excellent
Chaff Color at Maturity	White
Head Size	Average
Seed Size	Medium
Flag Leaf Orientation	Upright

Milling and Baking Results Reported by Collaborators and SWQL

Mill Stream Distribution by SWQL

Table 1. Miag Multomat mill stream yields of the WQC 2018 crop year entries by SWQL

Mill Stream	Group 1				Group 2					Group 3		
	M12-3312CW	M12-2020#	Branson*	Hilliard*	VA12W-31	VA12W-68	VA09MAS2-131-6-2	Branson*	Hilliard*	RS 961	RS 968	RS 902*
1st Break	7.2	7.3	9.7	10.5	6.9	8.5	7.9	10.3	8.7	5.4	5.7	10.5
2nd Break	7.5	7.3	10.2	11.3	6.9	9.7	8.8	11.3	9.6	3.2	2.9	10.0
Grader	3.4	4.1	4.8	5.2	3.5	4.5	3.8	5.2	4.2	2.7	2.7	4.1
3rd Break	8.7	6.8	8.3	7.5	7.5	6.9	7.8	6.3	7.5	12.6	12.3	8.4
Total Break	**26.9**	**25.4**	**33.0**	**34.4**	**24.9**	**29.6**	**28.3**	**33.1**	**30.0**	**24.0**	**23.7**	**33.0**
1st Middlings	10.4	8.9	9.0	8.6	8.7	8.3	8.9	8.4	8.5	7.7	6.6	10.7
2nd Middlings	18.6	17.0	14.7	14.0	17.5	15.8	16.2	16.1	15.7	17.3	16.1	16.0
3rd Middlings	6.2	6.2	4.7	4.0	6.6	5.4	5.9	4.4	5.1	12.3	12.1	5.0
Re-dust	6.7	6.9	6.0	5.4	6.3	6.0	5.8	5.9	5.5	6.1	5.3	6.6
4th Middlings	3.5	4.5	3.5	3.0	4.2	3.6	4.2	2.7	3.3	7.6	9.5	2.7
5th Middlings	1.4	1.6	1.4	1.2	1.5	1.4	1.8	1.0	1.4	1.7	3.0	0.9
Total Middlings	46.9	45.1	39.3	36.2	44.8	40.5	42.9	38.5	39.5	52.7	52.7	41.9
Straight Grade	**73.8**	**70.6**	**72.2**	**70.6**	**69.6**	**70.1**	**71.2**	**71.6**	**69.5**	**76.6**	**76.3**	**74.9**
Break Shorts	7.4	6.6	6.9	6.5	8.5	7.8	7.2	6.5	8.1	6.4	6.8	5.6
Red Dog	1.4	1.3	1.3	1.2	1.5	1.4	1.7	1.1	1.6	0.9	1.4	0.9
Tail Shorts	0.5	0.5	0.4	0.4	0.8	0.7	0.5	0.4	0.6	0.3	0.4	0.4
Bran	16.8	21.0	19.0	21.1	19.5	20.1	19.1	20.4	20.0	15.7	15.0	18.2
Total Byproduct	26.1	29.4	27.7	29.3	30.3	29.9	28.5	28.4	30.4	23.3	23.6	25.1

*Check varieties.

Miag Multomat Flour Milling Ash Curves

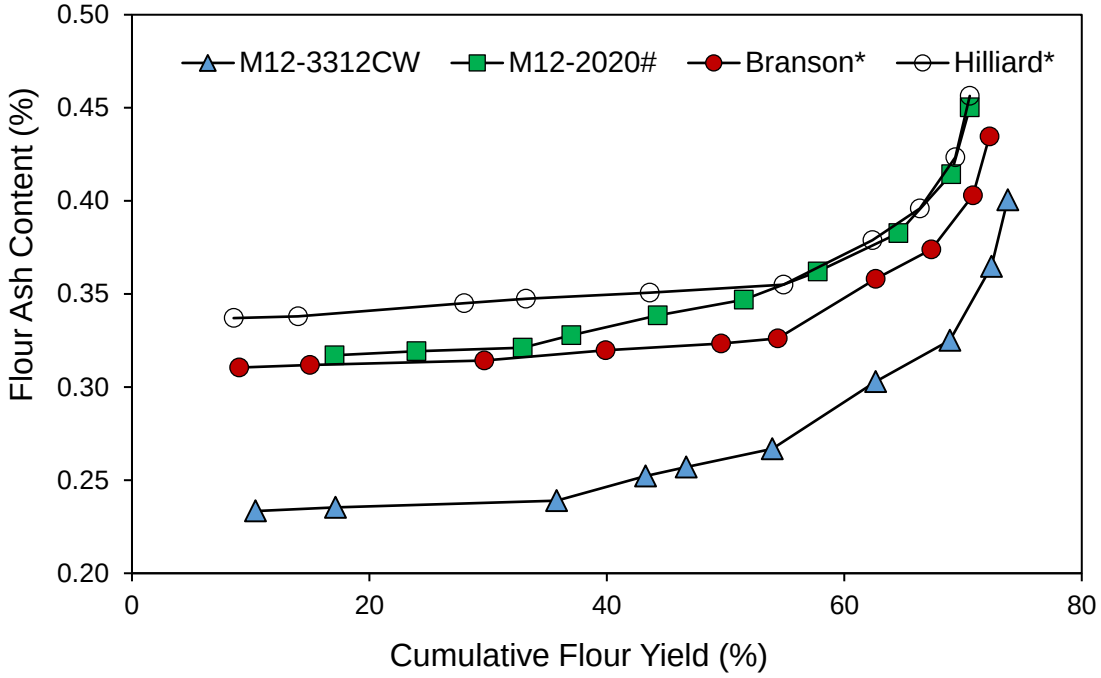

Table 2. Yield and ash content of flour mill streams for the WQC 2018 crop entries from Syngenta

Flour Stream	M12-3312CW		M12-2020#		Branson*		Hilliard*	
	Yield (%)	Ash (%)	Yield (%)	Ash (%)	Yield (%)	Ash (%)	Yield (%)	Ash (%)
1st Break	7.2	0.33	7.3	0.40	9.7	0.34	10.5	0.36
2nd Break	7.5	0.32	7.3	0.39	10.2	0.34	11.3	0.37
Grader	3.4	0.32	4.1	0.38	4.8	0.35	5.2	0.36
3rd Break	8.7	0.53	6.8	0.56	8.3	0.57	7.5	0.55
1st Middlings	10.4	0.23	8.9	0.33	9.0	0.31	8.6	0.34
2nd Middlings	18.6	0.24	17.0	0.32	14.7	0.32	14.0	0.35
3rd Middlings	6.2	0.55	6.2	0.49	4.7	0.59	4.0	0.66
Duster	6.7	0.24	6.9	0.32	6.0	0.31	5.4	0.34
4th Middlings	3.5	1.14	4.5	0.87	3.5	0.96	3.0	1.04
5th Middlings	1.4	2.30	1.6	2.03	1.4	2.06	1.2	2.32

*Check varieties.

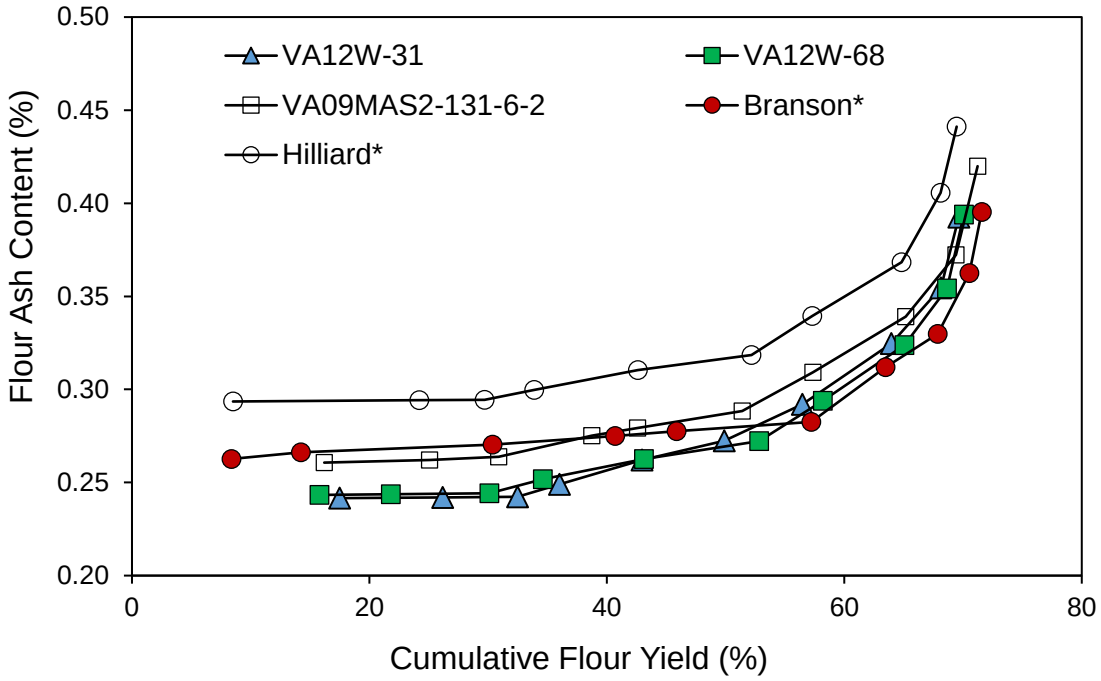

Table 3. Yield and ash content of flour mill streams for the WQC 2018 crop entries from Virginia Polytechnic Institute and State University

Flour Stream	VA12W-31		VA12W-68		VA09MAS2-131-6-2		Branson*		Hilliard*	
	Yield (%)	Ash (%)	Yield (%)	Ash (%)	Yield (%)	Ash (%)	Yield (%)	Ash (%)	Yield (%)	Ash (%)
1st Break	6.9	0.33	8.5	0.31	7.9	0.32	10.3	0.29	8.7	0.35
2nd Break	6.9	0.34	9.7	0.32	8.8	0.33	11.3	0.30	9.6	0.35
Grader	3.5	0.31	4.5	0.30	3.8	0.32	5.2	0.30	4.2	0.34
3rd Break	7.5	0.57	6.9	0.58	7.8	0.56	6.3	0.58	7.5	0.59
1st Middlings	8.7	0.24	8.3	0.25	8.9	0.26	8.4	0.26	8.5	0.29
2nd Middlings	17.5	0.24	15.8	0.24	16.2	0.26	16.1	0.27	15.7	0.29
3rd Middlings	6.6	0.44	5.4	0.51	5.9	0.49	4.4	0.59	5.1	0.55
Duster	6.3	0.24	6.0	0.24	5.8	0.27	5.9	0.27	5.5	0.30
4th Middlings	4.2	0.81	3.6	0.90	4.2	0.88	2.7	1.19	3.3	1.14
5th Middlings	1.5	2.11	1.4	2.32	1.8	2.24	1.0	2.63	1.4	2.22

*Check varieties.

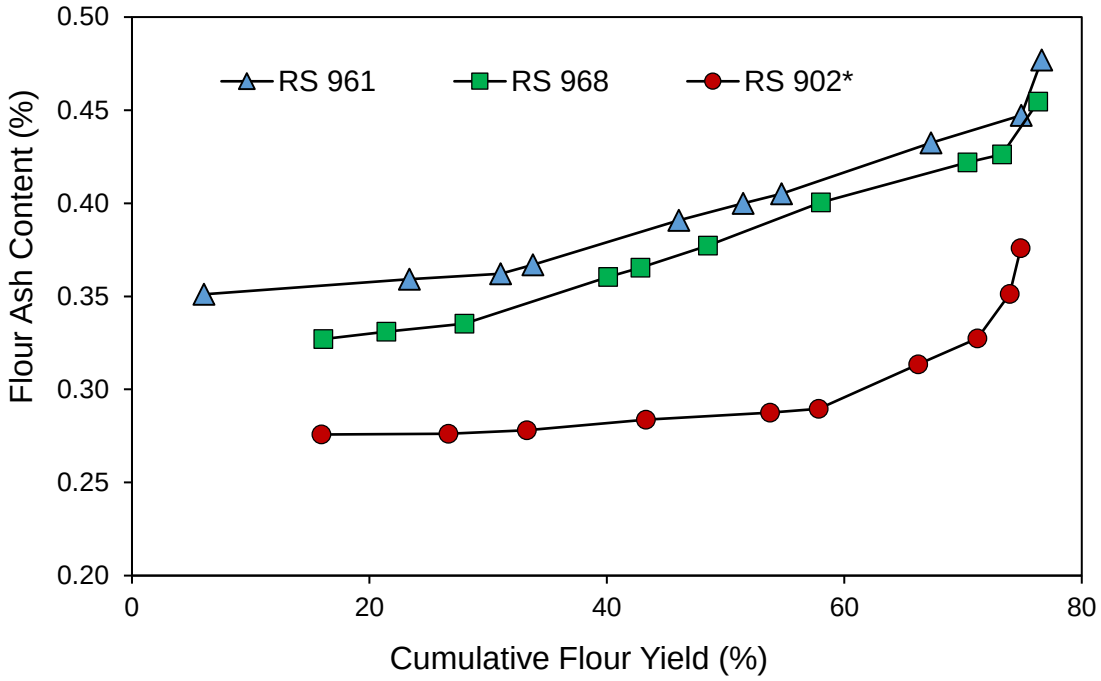

Table 4. Yield and ash content of flour mill streams for the WQC 2018 crop entries from Rupp Seeds

Flour Stream	RS 961		RS 968		RS 902*	
	Yield (%)	Ash (%)	Yield (%)	Ash (%)	Yield (%)	Ash (%)
1st Break	5.4	0.48	5.7	0.47	10.5	0.30
2nd Break	3.2	0.49	2.9	0.53	10.0	0.30
Grader	2.7	0.42	2.7	0.44	4.1	0.32
3rd Break	12.6	0.55	12.3	0.52	8.4	0.48
1st Middlings	7.7	0.37	6.6	0.35	10.7	0.28
2nd Middlings	17.3	0.36	16.1	0.33	16.0	0.28
3rd Middlings	12.3	0.46	12.1	0.42	5.0	0.51
Duster	6.1	0.35	5.3	0.34	6.6	0.29
4th Middlings	7.6	0.58	9.5	0.52	2.7	0.98
5th Middlings	1.7	1.78	3.0	1.14	0.9	2.32

*Check varieties.

Wheat Grain and Flour Quality Characteristics

Table 5. Grain characteristics and SKCS parameters of the 2018 entries by USDA-ARS Soft Wheat Quality Laboratory

Group	Entry	Test Weight (lb/bu)	Grain Protein (%, 12% mb)	Grain Falling Number	SKCS Parameter		
					Kernel Hardness	Kernel Diameter (mm)	Kernel Weight (mg)
1	M12-3312CW	60.0	12.2	385	30.9	2.66	31.8
1	M12-2020#	57.5	11.5	401	19.4	2.69	34.1
1	Branson*	57.3	12.5	388	5.1	2.51	32.0
1	Hilliard*	57.8	12.1	416	8.0	2.57	31.0
2	VA12W-31	60.2	13.3	346	29.7	2.64	31.0
2	VA12W-68	60.6	12.9	377	7.5	2.85	41.1
2	VA09MAS2-131-6-2	58.9	12.3	285	21.0	2.68	37.0
2	Branson*	58.2	12.5	386	7.7	2.56	33.2
2	Hilliard*	58.9	12.7	342	24.2	2.63	34.5
3	RS 961	62.5	10.8	414	64.0	2.59	31.8
3	RS 968	60.9	10.3	453	53.7	2.71	34.7
3	RS 902*	62.5	10.7	346	10.4	2.64	35.2

*Check varieties.

Table 6. Miag and Quadrumat milling parameters of the 2018 entries by USDA-ARS Soft Wheat Quality Laboratory

Group	Entry	Miag Milling Quality		Quadrumat Milling Quality	
		Break Flour Yield (%)	Straight Grade Flour Yield (%)	Flour Yield (%)	Softness Equivalence (%)
1	M12-3312CW	26.9	73.8	67.8	51.2
1	M12-2020#	25.4	70.6	65.8	54.3
1	Branson*	33.0	72.2	67.5	61.5
1	Hilliard*	34.4	70.6	67.0	62.6
2	VA12W-31	24.9	69.6	66.2	51.3
2	VA12W-68	29.6	70.1	66.4	57.1
2	VA09MAS2-131-6-2	28.3	71.2	67.5	52.8
2	Branson*	33.1	71.6	68.5	62.2
2	Hilliard*	30.0	69.5	66.7	57.5
3	RS 961	24.0	76.6	73.2	43.0
3	RS 968	23.7	76.3	72.9	44.2
3	RS 902*	33.0	74.9	72.1	63.2

*Check varieties.

Table 7. Flour quality parameters of the 2018 entries by USDA-ARS Soft Wheat Quality Laboratory

Group	Entry	Moisture (%)	Protein (%, 14% mb)	pH	α-amylase Activity	Starch Damage (%)	Flour Ash (%, 14% mb)
1	M12-3312CW	14.0	10.6	6.11	0.07	4.35	0.393
1	M12-2020#	13.9	9.5	6.14	0.08	4.10	0.437
1	Branson*	13.9	10.0	6.18	0.07	1.66	0.430
1	Hilliard*	13.7	9.7	6.17	0.10	2.31	0.434
2	VA12W-31	14.0	10.6	6.16	0.06	3.51	0.388
2	VA12W-68	13.8	10.8	6.15	0.06	2.25	0.394
2	VA09MAS2-131-6-2	14.0	10.1	6.15	0.17	1.57	0.410
2	Branson*	13.7	10.1	6.07	0.06	1.13	0.389
2	Hilliard*	14.0	10.5	6.15	0.09	2.80	0.438
3	RS 961	13.6	8.8	6.22	0.06	6.62	0.479
3	RS 968	13.7	8.4	6.21	0.04	5.86	0.446
3	RS 902*	13.9	8.3	6.16	0.06	2.30	0.377

*Check varieties.

Summaries and Statistics of Combined Cooperator Test Parameters

Table 8. Mean SRC test parameters and overall flour quality scores by nine cooperators (n=9)[a]

Group	Entry	Solvent Retention Capacity (%)			
		Water	Sodium Carbonate	Sucrose	Lactic Acid
1	M12-3312CW	55.3 a	76.6 b	103.2 bc	101.6 b
1	M12-2020#	52.2 b	78.4 b	100.2 c	78.9 c
1	Branson*	53.7 ab	80.8 ab	108.3 ab	115.2 a
1	Hilliard*	55.4 a	84.3 a	111.4 a	110.9 a
2	VA12W-31	55.3 a	76.0 b	104.1 a	121.6 a
2	VA12W-68	52.1 b	76.3 b	103.1 a	114.7 a
2	VA09MAS2-131-6-2	54.6 a	77.7 b	105.2 a	98.2 b
2	Branson*	52.0 b	77.6 b	102.8 a	116.1 a
2	Hilliard*	55.4 a	81.4 a	108.9 a	116.7 a
3	RS 961	60.3 a	83.0 a	100.4 a	90.8 b
3	RS 968	61.2 a	80.8 a	98.2 a	84.9 c
3	RS 902*	51.4 b	71.3 b	90.3 b	101.4 a

*Check varieties.

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

Table 9. Mean alveograph test parameters by two collaborators (n=2)

Group	Entry	Alveograph			
		P	L	P/L Ratio	W
1	M12-3312CW	36 a	95 bc	0.38 a	73 a
1	M12-2020#	18 c	64 c	0.29 ab	26 a
1	Branson*	29 b	150 a	0.20 b	92 a
1	Hilliard*	32 ab	128 ab	0.26 ab	82 a
2	VA12W-31	42 a	113 a	0.38 ab	107 a
2	VA12W-68	27 b	134 a	0.21 c	66 a
2	VA09MAS2-131-6-2	32 b	99 a	0.34 abc	73 a
2	Branson*	30 b	143 a	0.21 bc	83 a
2	Hilliard*	43 a	100 a	0.43 a	89 a
3	RS 961	39 b	94 a	0.42 b	85 a
3	RS 968	58 a	47 b	1.24 a	89 a
3	RS 902*	22 c	119 a	0.19 c	64 a

*Check varieties.

Table 10. Mean farinograph test parameters by Mennel Milling Company

Group	Entry	Farinograph			
		Water Absorption (%)	Development Time (min)	Stability (min)	Mixing Tolerance Index (BU)
1	M12-3312CW	56.3	1.6	3.5	88
1	M12-2020#	52.1	1.3	2.2	130
1	Branson*	53.3	1.2	5.3	62
1	Hilliard*	53.4	2.0	4.3	69
2	VA12W-31	55.2	1.4	4.5	66
2	VA12W-68	52.8	1.4	2.5	107
2	VA09MAS2-131-6-2	53.9	1.4	3.4	80
2	Branson*	52.9	1.1	2.5	121
2	Hilliard*	55.2	1.3	3.4	81
3	RS 961	49.4	0.5	3.1	98
3	RS 968	54.8	2.2	3.5	72
3	RS 902*	57.1	1.1	1.5	108

*Check varieties.

Table 11. 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	M12-3312CW	6.0 ab	2257 b	1370 b	887 c	1683 a	2332 a	77.5 a
1	M12-2020#	6.0 ab	2216 b	1211 c	1005 b	1552 a	2126 a	81.6
1	Branson*	6.0 a	2866 a	1630 a	1236 a	1910 a	2693 a	79.4 a
1	Hilliard*	5.9 b	2778 a	1547 a	1231 a	1892 a	2649 a	80.1 a
2	VA12W-31	5.9 bc	2229 b	1110 b	1120 b	1382 a	1914 ab	73.9 a
2	VA12W-68	5.9 a	2571 a	1389 a	1182 ab	1622 a	2311 a	80.4 a
2	VA09MAS2-131-6-2	5.5 d	1650 c	522 c	1270 ab	818 a	1068 b	72.6 a
2	Branson*	5.9 ab	2709 a	1339 a	1370 a	1561 a	2206 a	74.1 a
2	Hilliard*	5.8 c	2375 b	1152 b	1223 ab	1448 a	2009 a	78.9 a
3	RS 961	6.0 b	2373 b	1143 a	902 b	1769 a	2467 a	65.9 b
3	RS 968	6.1 a	2899 a	1776 a	1123 a	1870 a	2730 a	65.8 b
3	RS 902*	5.8 c	2577 b	1456 a	1121 a	1845 a	2532 a	77.2 a

*Check varieties.

[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 Methods 10-50D (n=4) & 10-52 (n=4)) parameters[a]

Group	Entry	Sugar-snap Cookie (10-50D)				Sugar-snap Cookie (10-52)	
		Width (mm)	Thickness (mm)	W/T Ratio (mm)	Spread Factor	Width (cm)	Top Grain Score
1	M12-3312CW	471 b	63 a	7.6 a	72 a	17.3 a	3.3 a
1	M12-2020#	489 a	57 a	8.8 a	84 a	17.9 a	4.0 a
1	Branson*	485 ab	59 a	8.4 a	79 a	17.6 a	1.7 a
1	Hilliard*	490 a	58 a	8.7 a	82 a	17.6 a	1.7 a
2	VA12W-31	470 b	61 a	7.9 a	74 b	17.1 a	2.7 a
2	VA12W-68	491 a	56 a	8.9 a	82 ab	17.7 a	4.0 a
2	VA09MAS2-131-6-2	484 ab	57 a	8.7 a	81 ab	17.9 a	3.3 a
2	Branson*	492 a	53 a	9.4 a	88 a	17.7 a	5.0 a
2	Hilliard*	479 ab	58 a	8.4 a	78 b	17.1 a	1.3 a
3	RS 961	457 b	60 a	7.7 b	73 b	16.8 b	2.7 a
3	RS 968	451 b	63 a	7.2 b	68 b	16.4 b	2.3 a
3	RS 902*	505 a	51 b	10.1 a	94 a	18.5 a	5.3 a

*Check varieties.

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

Table 13. Mean (n=2) sponge cake baking test parameters[a]

Group	Entry	Sponge Cake	
		Volume (mL)	Texture Score
1	M12-3312CW	1210 a	22 a
1	M12-2020#	1244 a	20 a
1	Branson*	1269 a	23 a
1	Hilliard*	1269 a	22 a
2	VA12W-31	989 a	8 a
2	VA12W-68	1163 a	10 a
2	VA09MAS2-131-6-2	1145 a	13 a
2	Branson*	1252 a	19 a
2	Hilliard*	1203 a	16 a
3	RS 961	1206 a	18 a
3	RS 968	1211 a	19 a
3	RS 902*	1276 a	24 a

*Check varieties.

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

Table 14. Mean flour quality scores for making cookies (n=10) and sponge cakes (n=2), and product quality scores[a]

Group	Entry	Cookies		Sponge Cake	
		Flour Score	Product Score	Flour Score	Product Score
1	M12-3312CW	5.6 a	4.9 a	5.0 a	5.0 a
1	M12-2020#	4.9 a	6.4 a	5.5 a	5.5 a
1	Branson*	5.7 a	5.7 a	4.5 a	7.0 a
1	Hilliard*	5.3 a	6.3 a	4.5 a	6.5 a
2	VA12W-31	6.1 a	4.3 c	5.0 a	1.5 a
2	VA12W-68	6.4 a	6.3 ab	5.5 a	3.5 a
2	VA09MAS2-131-6-2	5.1 a	6.6 ab	5.0 a	3.0 a
2	Branson*	6.3 a	7.4 a	5.0 a	5.0 a
2	Hilliard*	5.5 a	5.7 bc	4.0 b	4.5 a
3	RS 961	5.2 b	3.7 b	3.5 a	4.0 b
3	RS 968	4.6 b	3.7 b	3.5 a	5.5 ab
3	RS 902*	7.2 a	8.3 a	6.5 a	8.5 a

*Check varieties.

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

Cooperator Data for Each Quality Test Parameter

Table 15. Water SRC (%) of 2018 WQC entries by cooperators

Group	Entry	Ardent	Limagrain	Mennel	Mondelez	Kellogg	Star of West	SWQL	Syngenta	WWQL	**Mean**	**STDEV**
1	M12-3312CW	53	56	55	56	54	55	58	55	56	55.4	1.4
1	M12-2020#	50	52	53	53	49	49	57	53	54	52.1	2.5
1	Branson*	52	55	53	56	53	53	56	52	53	53.5	1.7
1	Hilliard*	53	55	55	59	55	54	58	56	54	55.5	1.7
2	VA12W-31	57	56	54	55	54	53	58	55	56	55.4	1.5
2	VA12W-68	51	51	53	53	49	51	55	54	52	52.2	1.8
2	VA09MAS2-131-6-2	54	55	54	57	53	53	57	53	55	54.4	1.6
2	Branson*	52	52	52	52	49	52	54	52	53	52.1	1.4
2	Hilliard*	53	55	55	58	54	55	57	55	57	55.4	1.7
3	RS 961	57	61	61	66	60	59	61	58	60	60.3	2.6
3	RS 968	58	62	62	66	59	62	64	59	59	61.3	2.7
3	RS 902*	49	51	51	54	49	49	56	52	52	51.5	2.3

*Check varieties.

Table 16. Sodium Carbonate SRC (%) of 2018 WQC entries by cooperators

Group	Entry	Ardent	Limagrain	Mennel	Mondelez	Kellogg	Star of West	SWQL	Syngenta	WWQL	**Mean**	**STDEV**
1	M12-3312CW	75	75	76	90	74	75	78	73	73	76.4	5.1
1	M12-2020#	76	76	75	94	78	77	81	73	76	78.4	6.1
1	Branson*	78	80	78	93	80	79	82	78	79	80.9	4.7
1	Hilliard*	81	83	84	94	84	82	85	83	83	84.4	3.8
2	VA12W-31	75	75	74	87	74	75	79	72	73	75.9	4.6
2	VA12W-68	74	77	76	81	75	76	78	76	74	76.4	2.4
2	VA09MAS2-131-6-2	75	76	77	90	77	76	79	74	75	77.8	4.7
2	Branson*	75	76	76	85	77	76	81	77	75	77.3	3.3
2	Hilliard*	78	81	81	91	79	80	83	80	80	81.4	3.7
3	RS 961	82	83	81	96	82	82	84	78	79	82.7	5.2
3	RS 968	80	81	77	94	78	82	83	75	77	80.9	5.6
3	RS 902*	68	71	70	79	70	71	74	72	67	71.5	3.6

*Check varieties.

Table 17. Sucrose SRC (%) of 2018 WQC entries by cooperators

Group	Entry	Ardent	Limagrain	Mennel	Mondelez	Kellogg	Star of West	SWQL	Syngenta	WWQL	**Mean**	**STDEV**
1	M12-3312CW	107	104	101	119	98	105	100	96	99	103.2	7.0
1	M12-2020#	102	101	87	124	97	101	97	94	99	100.2	10.0
1	Branson*	107	108	106	127	103	109	106	102	107	108.2	7.4
1	Hilliard*	111	114	108	125	107	114	108	106	110	111.5	6.0
2	VA12W-31	103	104	100	121	102	102	103	99	103	104.1	6.5
2	VA12W-68	101	104	102	120	98	103	103	98	99	103.0	6.6
2	VA09MAS2-131-6-2	102	107	104	121	100	105	104	101	103	105.0	6.3
2	Branson*	100	102	100	125	97	101	100	96	104	102.9	8.7
2	Hilliard*	104	109	104	123	103	111	107	102	117	108.7	7.1
3	RS 961	101	98	101	123	95	99	95	94	98	100.4	8.8
3	RS 968	98	97	95	113	96	101	94	93	97	98.2	5.8
3	RS 902*	90	90	88	105	88	88	89	86	89	90.4	5.5

*Check varieties.

Table 18. Lactic acid SRC (%) of 2018 WQC entries by cooperators

Group	Entry	Ardent	Limagrain	Mennel	Mondelez	Kellogg	Star of West	SWQL	Syngenta	WWQL	**Mean**	**STDEV**
1	M12-3312CW	105	95	105	96	108	105	96	97	107	101.6	5.3
1	M12-2020#	81	72	81	77	81	75	83	77	83	79.0	3.7
1	Branson*	121	113	123	99	123	114	111	114	119	115.2	7.6
1	Hilliard*	113	115	114	87	118	106	106	117	122	110.9	10.5
2	VA12W-31	127	117	130	110	133	126	113	116	122	121.4	8.0
2	VA12W-68	120	114	120	100	118	111	110	112	127	114.6	7.9
2	VA09MAS2-131-6-2	75	96	106	97	106	105	98	96	105	98.2	9.6
2	Branson*	75	120	130	109	129	124	115	117	126	116.0	16.7
2	Hilliard*	122	117	123	99	122	116	111	115	125	116.8	7.9
3	RS 961	94	82	96	88	94	92	89	87	95	90.8	4.5
3	RS 968	86	76	88	87	84	94	85	78	86	84.9	5.4
3	RS 902*	105	104	103	90	103	101	100	99	108	101.5	5.3

*Check varieties.

Table 19. Sugar-snap cookie (10-50D) diameter (mm) of 2018 WQC entries by cooperators

Group	Entry	ADM	Ardent	Mennel	Star of West	**Mean**	**STDEV**
1	M12-3312CW	458	473	482	469	471	10.0
1	M12-2020#	472	493	505	486	489	13.8
1	Branson*	472	479	500	487	484	12.1
1	Hilliard*	483	489	504	482	490	10.1
2	VA12W-31	461	464	488	467	470	12.3
2	VA12W-68	483	485	509	485	490	12.5
2	VA09MAS2-131-6-2	475	477	503	482	484	12.9
2	Branson*	483	488	508	489	492	11.0
2	Hilliard*	472	473	495	474	479	11.0
3	RS 961	459	453	462	452	457	4.8
3	RS 968	455	445	456	449	451	5.2
3	RS 902*	497	501	514	507	505	7.4

*Check varieties.

Table 20. Sugar-snap cookie (10-52) diameter (cm) of 2018 WQC entries by cooperators

Group	Entry	Limagrain	SWQL	Syngenta	WWQL	**Mean**	**STDEV**
1	M12-3312CW	17.2	16.9	18.0	16.9	17	0.5
1	M12-2020#	17.8	17.7	18.6	17.6	18	0.5
1	Branson*	17.7	17.0	18.6	17.1	18	0.7
1	Hilliard*	17.5	17.3	18.6	17.1	18	0.7
2	VA12W-31	17.1	16.7	17.8	16.6	17	0.5
2	VA12W-68	17.4	17.6	18.4	17.4	18	0.5
2	VA09MAS2-131-6-2	17.8	17.5	19.2	17.2	18	0.9
2	Branson*	17.5	17.4	18.6	17.4	18	0.6
2	Hilliard*	17.0	16.9	17.8	16.8	17	0.5
3	RS 961	16.5	16.4	17.4	16.7	17	0.5
3	RS 968	16.0	16.2	17.0	16.3	16	0.4
3	RS 902*	18.3	18.4	18.6	18.5	18	0.2

*Check varieties.

Table 21. Sponge cake volume (mL) of 2018 WQC entries by cooperators

Group	Entry	WMC	WWQL	**Mean**	**STDEV**
1	M12-3312CW	1182	1238	1210	39.6
1	M12-2020#	1188	1300	1244	79.2
1	Branson*	1217	1320	1269	72.8
1	Hilliard*	1213	1325	1269	79.2
2	VA12W-31	896	1082	989	131.5
2	VA12W-68	1056	1270	1163	151.3
2	VA09MAS2-131-6-2	1057	1232	1145	123.7
2	Branson*	1189	1315	1252	89.1
2	Hilliard*	1118	1288	1203	120.2
3	RS 961	1173	1238	1206	46.0
3	RS 968	1201	1220	1211	13.4
3	RS 902*	1257	1295	1276	26.9

*Check varieties.

Table 22. Cookie quality scores of 2018 WQC entries by cooperators

Group	Entry	ADM	Ardent	Limagrain	Mennel	Star of West	Syngenta	WWQL	**Mean**	**STDEV**
1	M12-3312CW	4	6	6	5	5	5	3	4.9	1.1
1	M12-2020#	4	8	6	7	8	6	6	6.4	1.4
1	Branson*	4	9	6	6	7	2	6	5.7	2.2
1	Hilliard*	6	9	6	6	8	3	6	6.3	1.9
2	VA12W-31	4	6	4	5	5	4	2	4.3	1.3
2	VA12W-68	7	8	6	7	6	5	5	6.3	1.1
2	VA09MAS2-131-6-2	6	8	6	7	8	7	4	6.6	1.4
2	Branson*	8	9	7	7	8	7	6	7.4	1.0
2	Hilliard*	5	9	6	6	6	2	6	5.7	2.1
3	RS 961	4	5	4	4	3	3	3	3.7	0.8
3	RS 968	4	4	4	4	3	2	5	3.7	1.0
3	RS 902*	8	9	8	9	9	7	8	8.3	0.8

*Check varieties.

Table 23. Sponge cake quality scores of 2018 WQC entries by cooperators

Group	Entry	WMC	WWQL	Mean	STDEV
1	M12-3312CW	7	3	5.0	2.8
1	M12-2020#	5	6	5.5	0.7
1	Branson*	8	6	7.0	1.4
1	Hilliard*	7	6	6.5	0.7
2	VA12W-31	1	2	1.5	0.7
2	VA12W-68	2	5	3.5	2.1
2	VA09MAS2-131-6-2	2	4	3.0	1.4
2	Branson*	4	6	5.0	1.4
2	Hilliard*	3	6	4.5	2.1
3	RS 961	5	3	4.0	1.4
3	RS 968	6	5	5.5	0.7
3	RS 902*	9	8	8.5	0.7

*Check varieties.

Cooperator Data

ADM Milling Quality Evaluations

Table 24. Sugar-snap cookie baking test parameters by ADM Milling

Group	Entry	Cookie (10-50D)				
		Width (mm)	Thickness (mm)	W/T Ratio	Spread Factor	Score
1	M12-3312CW	45.8	6.8	6.7	65.0	4
1	M12-2020#	47.2	6.1	7.7	75.0	5
1	Branson*	47.2	6.2	7.6	74.0	4
1	Hilliard*	48.3	6.0	8.1	78.0	4
2	VA12W-31	46.1	6.4	7.2	69.0	4
2	VA12W-68	48.3	5.8	8.3	80.0	5
2	VA09MAS2-131-6-2	47.5	5.9	8.1	78.0	4
2	Branson*	48.3	5.5	8.8	85.0	5
2	Hilliard*	47.2	6.2	7.6	73.0	4
3	RS 961	45.9	5.9	7.8	75.0	6
3	RS 968	45.5	6.3	7.2	70.0	6
3	RS 902*	49.7	5.3	9.4	91.0	6

*Check varieties.

Table 25. Evaluation comments on flour quality and baked product performance by ADM Milling

		Analytical Flour Qualities					End Product Performance				
		Score: 1 Poor - 9 Excellent					Score: 1 Poor - 9 Excellent				Aditional Comments
Group	Entry	Likes	Dislikes	Basis	Score		Product	Likes	Dislikes	Score	Mitigating Physical/Chemical Properties
1	M12-3312CW	Highest protein in the set		Primary analysis	4		Cookies		Very little checking, slightly dry dough	4	Smallest spread in the set
1	M12-2020#	Protein similar to Hilliard #4		Primary analysis	5		Cookies		Light checking, slightly dry dough	4	Spread similar to #3 Branson check
1	Branson*			Primary analysis	4		Cookies		Very little checking, slightly dry dough	4	
1	Hilliard*			Primary analysis	4		Cookies		Light checking, slightly dry dough	6	Average spread, best in the set
2	VA12W-31			Primary analysis	4		Cookies	Similar to VA09MAS2-131-6-2	Light checking, good dough	4	#5, 6 & 7 all resemble Hilliard #9 check
2	VA12W-68	Highest protein in the set		Primary analysis	5		Cookies	Similar to Hilliard #9	Light checking, good dough	7	Decent spread
2	VA09MAS2-131-6-2	Protein same as Branson ck		Primary analysis	4		Cookies	Similar to VA12W-31	Light checking, good dough	6	
2	Branson*			Primary analysis	5		Cookies	Nice spread, good checking		8	Best spread in the set
2	Hilliard*			Primary analysis	4		Cookies		Light checking, slightly dry dough	5	
3	RS 961	Protein similar to the check		Primary analysis	6		Cookies		Very little checking, good dough	4	Poorer spread than the check
3	RS 968	Protein similar to the check		Primary analysis	6		Cookies		Very little checking, slightly dry dough	4	Poorer spread than the check
3	RS 902*			Primary analysis	6		Cookies	Nice spread, good check., good dough		8	Check was better overall in this set

*Check varieties.

Syngenta Quality Evaluations

Table 26. Solvent retention capacity and cookie baking test parameters by Syngenta

Group	Entry	Solvent Retention Capacity (%)				Cookie (10-52)	
		Water	Sodium Carbonate	Sucrose	Lactic Acid	Width (cm)	Top Grain Score
1	M12-3312CW	55	73	96	97	18.0	5
1	M12-2020#	53	73	94	77	18.6	6
1	Branson*	52	78	102	114	18.6	2
1	Hilliard*	56	83	106	117	18.6	3
2	VA12W-31	55	72	99	116	17.8	5
2	VA12W-68	54	76	98	112	18.4	5
2	VA09MAS2-131-6-2	53	74	101	96	19.2	7
2	Branson*	52	77	96	117	18.6	7
2	Hilliard*	55	80	102	115	17.8	2
3	RS 961	58	78	94	87	17.4	4
3	RS 968	59	75	93	78	17.0	2
3	RS 902*	52	72	86	99	18.6	7

*Check varieties.

Table 27. Evaluation comments on flour quality and baked product performance by Syngenta

		Analytical Flour Qualities					End Product Performance					
		Score: 1 Poor - 9 Excellent					Score: 1 Poor - 9 Excellent					Aditional Comments
Group	Entry	Likes	Dislikes	Basis	Score		Product	Likes	Dislikes	Score		Mitigating Physical/Chemical Properties
1	M12-3312CW	Prot/SRC ok		SRC	7		Cookie 10-52			5		
1	M12-2020#	Vgood SRC values		SRC	7		Cookie 10-52	Good Spread&TG		6		Best cookie of grp
1	Branson*			SRC	7		Cookie 10-52		Poor dough/TG	2		Not typical Branson
1	Hilliard*	Good prot	Hi H2O/SUC	SRC	6		Cookie 10-52			3		
2	VA12W-31	low ash		SRC	8		Cookie 10-52		Performed worse than Chk	4		
2	VA12W-68			SRC	8		Cookie 10-52		Performed worse than Chk	5		
2	VA09MAS2-131-6-2		sl Hi SUC	SRC	7		Cookie 10-52	Exc Cookie Spread +TG		7		Slighty better than CK
2	Branson*	low H2O/Ash		SRC	8		Cookie 10-52			7		
2	Hilliard*		sl Hi SUC	SRC	7		Cookie 10-52		Smaller, Poorer TG	2		Unacceptable for CK
3	RS 961	Vlow prot/LA	Hi H2O, Hi Ash	SRC	4		Cookie 10-52		Smaller, Poorer TG	3		Not as good as Chk
3	RS 968	Vlow prot/LA	Hi H2O	SRC	4		Cookie 10-52		Poorer Cdiam & TG	2		Not as good as Chk
3	RS 902*	Vlow prot/H2O and SUC		SRC	8		Cookie 10-52			7		

*Check varieties.

Ardent Mills Quality Evaluations

Table 28. Solvent retention capacity and cookie baking test parameters by Ardent Mills

Group	Entry	Solvent Retention Capacity (%)				Cookies (10-50D)			
		Water	Sodium Carbonate	Sucrose	Lactic Acid	Width (mm)	Thickness (mm)	W/T Ratio	Spread Factor
1	M12-3312CW	53.2	74.6	107.4	104.8	473.0	50.0	9.5	80.6
1	M12-2020#	49.8	75.6	102.3	80.7	493.5	44.9	11.0	93.6
1	Branson*	51.6	78.2	106.6	120.5	478.6	48.2	9.9	84.6
1	Hilliard*	53.1	81.2	111.0	113.5	489.4	46.6	10.5	89.3
2	VA12W-31	57.2	74.9	103.3	127.0	463.7	48.9	9.5	80.7
2	VA12W-68	51.2	74.3	100.7	120.0	484.8	49.1	9.9	84.1
2	VA09MAS2-131-6-2	53.6	75.4	101.5	75.4	476.8	48.8	9.8	83.1
2	Branson*	52.2	75.2	100.4	75.2	488.0	44.6	11.0	93.2
2	Hilliard*	52.6	78.4	103.7	122.3	473.2	46.9	10.1	85.8
3	RS 961	56.8	81.8	101.1	93.7	453.0	52.3	8.7	73.7
3	RS 968	57.9	79.7	97.7	85.6	445.0	59.0	7.5	64.3
3	RS 902*	49.2	68.4	89.8	104.6	501.2	43.9	11.4	97.2

*Check varieties.

Table 29. Evaluation comments on flour quality and baked product performance by Ardent Mills

		Analytical Flour Qualities					End Product Performance				
		Score: 1 Poor - 9 Excellent					Score: 1 Poor - 9 Excellent				Additional Comments
Group	Entry	Likes	Dislikes	Basis	Score		Product	Likes	Dislikes	Score	Mitigating Physical/Chemical Properties
1	M12-3312CW		Slightly lower lactic acid	SRC	7		Cookie	Spread factor		6	Cookie or cracker. Higher protein leans towards cracker, lower lactic acid and water lean towards cookie.
1	M12-2020#		Significantly lower lactic acid	SRC	5		Cookie	Spread factor		8	Cake or cookie. Medium protein, low water and lactic acid. Could go either way.
1	Branson*	High lactic acid		SRC	9		Cookie	Spread factor		9	Cracker. Medium protein and high lactic acid. Slightly low water for cracker.
1	Hilliard*	High lactic acid and water	Slightly high sucrose	SRC	8		Cookie	Spread factor		9	Cracker. Medium protein, high lactic acid, water, and sucrose.
2	VA12W-31	High lactic acid and water		SRC	9		Cookie	Spread factor		6	Bread or cracker. High protein, high lactic acid, and high water.
2	VA12W-68	High lactic acid	Low water for protein level	SRC	9		Cookie	Spread factor		8	Cracker. Low water absorption for high protein level.
2	VA09MAS2-131-6-2		Significantly low lactic acid	SRC	6		Cookie	Spread factor		8	Cookie. High protein and low lactic acid.
2	Branson*		Significantly low lactic acid	SRC	6		Cookie	Spread factor		9	Cookie. High protein and low lactic acid.
2	Hilliard*	High lactic acid		SRC	9		Cookie	Spread factor		9	Cracker. High protein and high lactic acid.
3	RS 961			SRC	6		Cookie		Low spread factor	5	Cookie. Low protein, lactic acid, high water, low spread factor.
3	RS 968			SRC	6		Cookie		Low spread factor	4	Cookie. Low protein, lactic acid, high water, low spread factor.
3	RS 902*	Low ash and water		SRC	7		Cookie	Spread factor		9	Cake. Low protein, ash and, water.

*Check varieties.

Kellogg Quality Evaluations

Table 30. Solvent retention capacity and alveograph parameters by Kellogg

Group	Entry	Solvent Retention Capacity (%)				Alveograph				
		Water	Sodium Carbonate	Sucrose	Lactic Acid	P	L	P/L	le	W
1	M12-3312CW	54	74	98	108	36	87	0.41	30.6	48
1	M12-2020#	49	78	97	81	19	59	0.32	20.6	21
1	Branson*	53	80	103	123	30	126	0.24	38.6	43
1	Hilliard*	55	84	107	118	33	120	0.28	34.2	45
2	VA12W-31	54	74	102	133	41	97	0.42	44.3	63
2	VA12W-68	49	75	98	118	28	124	0.23	34	38
2	VA09MAS2-131-6-	53	77	100	106	34	81	0.42	35.3	47
2	Branson*	49	77	97	129	29	120	0.24	41.8	43
2	Hilliard*	54	79	103	122	42	97	0.43	37.4	61
3	RS 961	60	82	95	94	37	90	0.41	35.4	52
3	RS 968	59	78	96	84	53	42	1.26	30.7	72
3	RS 902*	49	70	88	103	22	104	0.21	31.1	31

*Check varieties.

Table 31. Farinograph and rapid visco-analyzer parameters by Kellogg

Group	Entry	Farinograph				Rapid Visco-Analyzer							
		Water Absorp-tion (%)	Develop-ment Time (min)	Stab-ility (min)	Degree of Softening	Peak Time (min)	Peak (cP)	Trough (cP)	Break-down (cP)	Setback (cP)	Final (cP)	Pasting Temp (°C)	Peak/ Final Ratio
1	M12-3312CW	55.9	1.9	3	94	6.0	2139	1335	804	1266	2601	66.1	1.216
1	M12-2020#	51.6	1.4	2.3	126	6.0	2128	1215	913	1178	2393	68.6	1.125
1	Branson*	52.6	1.8	4.1	96	6.1	2755	1634	1121	1427	3061	66.0	1.111
1	Hilliard*	53.1	1.7	3.4	96	5.7	2837	1555	1282	1569	3124	66.9	1.101
2	VA12W-31	54.9	1.5	4.5	85	5.9	2130	1096	1034	1038	2134	66.2	1.002
2	VA12W-68	52.6	1.6	2.9	103	6.0	2488	1384	1104	1234	2618	68.6	1.052
2	VA09MAS2-131-6-2	53.6	1.5	3.1	107	5.5	1584	529	1055	656	1185	67.0	0.748
2	Branson*	51.2	1.6	5.5	75	5.9	2607	1320	1287	1179	2499	67.0	0.959
2	Hilliard*	54.9	2	3.3	92	5.9	2292	1152	1140	1114	2266	68.5	0.989
3	RS 961	54.2	1.9	3.8	79	6.1	2264	1448	816	1319	2767	64.4	1.222
3	RS 968	56.2	1.6	3.5	76	6.2	2771	1765	1006	1355	3120	63.6	1.126
3	RS 902*	49.4	0.7	2.3	112	5.8	2493	1446	1047	1411	2857	66.0	1.146

*Check varieties.

Table 32. Evaluation comments on analytical flour quality by Kellogg

			Analytical Flour Qualities					
			Score: 1 Poor - 9 Excellent					Aditional Comments
#	Group	Entry	Likes	Dislikes	Basis	Score		Mitigating Physical/Chemical Properties
1	1	M12-3312CW	High protein, good SRC-LA	Farinograph water absorption is too high		7		
2	1	M12-2020#	Can be a good candidate for cookies and cakes flour	Not suitable for crackers due to low alveo W, lower SRC-LA and dough strength		6		
3	1	Branson*	High protein, high SRC-LA			8		
4	1	Hilliard*	High protein, high SRC-LA			8		
5	2	VA12W-31	Stronger dough strength, very good for cracker applications	Very high SRC-LA for a soft wheat flour, may be a concern for cracker break up during processing; Farino water abs is high too - impact dough making and oven speed		7		
6	2	VA12W-68	low water absroption of Farinograph test,			8		
7	2	VA09MAS2-131-6-2	Flour and dough properties appear to be okay for a soft flour.	slightly lower SRC-LA than other lines, but still okay compared to commercial flour; very low RVA peak and final viscosities - will affect finished food texture. Need to look into the reason - maybe starch composition difference?		4		This flour has very high SRC-LA that is close to a hard wheat flour. Its water absorption is high and hard for cracker application but can be used in batter type products
8	2	Branson*	High SRC-LA, very good dough strength and mixing stability, lower water absorption is possibly a good thing for processing and bake-off moisture, this seem to be a very good cracker flour			9		
9	2	Hilliard*	Strong dough strength and high SRC-LA	Farinograph water absorption is fairly high that may impact dough and baking/line speed		7		
11	3	RS 961	Good dough strength	Water absorption is too high for cracker making		6		This line is very interesting. It can be very different in dough processing. It is worth to look into the processing performance further
12	3	RS 968	Good dough strength; very high water absorption may be suitable for batter / waffle	SRC-LA too low, but not sure why dough strength is still very high; water absorption is too high for a soft flour		5		
10	3	RS 902*	Proper SRC-LA, lower water absorption in Farino dough	Dough might be too soft for cracker making		7		

*Check varieties.

Limagrain Cereal Seeds Quality Evaluations

Table 33. Solvent retention capacity and cookie baking test parameters by Limagrain Cereal Seeds

Group	Entry	Solvent Retention Capacity (%)				Cookies (10-52)		
		Water	Sodium Carb	Sucrose	Lactic Acid	Width (cm)	Thickness (cm)	Top Grain Score
1	M12-3312CW	56	75	104	95	17.2	1.6	1
1	M12-2020#	52	76	101	72	17.8	1.5	1
1	Branson*	55	80	108	113	17.7	1.4	1
1	Hilliard*	55	83	114	115	17.5	1.4	1
2	VA12W-31	56	75	104	117	17.1	1.7	1
2	VA12W-68	51	77	104	114	17.4	1.5	1
2	VA09MAS2-131-6-2	55	76	107	96	17.8	1.3	1
2	Branson*	52	76	102	120	17.5	1.4	2
2	Hilliard*	55	81	109	117	17.0	1.5	1
3	RS 961	61	83	98	82	16.5	1.7	1
3	RS 968	62	81	97	76	16.0	1.7	1
3	RS 902*	51	71	90	104	18.3	1.2	2

*Check varieties.

Table 34. Evaluation comments on analytical flour quality and baked product performance by Limagrain Cereal Seeds

		Analytical Flour Qualities				End Product Performance			
		Score: 1 Poor - 9 Excellent				Score: 1 Poor - 9 Excellent			
Group	Entry	Likes	Dislikes	Basis	Score	Product	Likes	Dislikes	Score
1	M12-3312CW				6	Cookie 10-52			6
1	M12-2020#				7	Cookie 10-52			6
1	Branson*				4	Cookie 10-52			6
1	Hilliard*		high sucrose	SRC	4	Cookie 10-52			6
2	VA12W-31				6	Cookie 10-52		out of target range for width and height of cookie	4
2	VA12W-68				6	Cookie 10-52			6
2	VA09MAS2-131-6-2				6	Cookie 10-52			6
2	Branson*				7	Cookie 10-52	nice top grain		7
2	Hilliard*				5	Cookie 10-52			6
3	RS 961				5	Cookie 10-52		out of target range for width and height of cookie	4
3	RS 968				5	Cookie 10-52		out of target range for width and height of cookie	4
3	RS 902*	best carbonate		SRC	9	Cookie 10-52	nice top grain		8

*Check varieties.

Mennel Milling Quality Evaluations

Table 35. Solvent retention capacity and farinograph test parameters by Mennel Milling

Group	Entry	Solvent Retention Capacity (%)				Farinograph			
		Water	Sodium Carb	Sucrose	Lactic Acid	Water Absorp (min)	Develop Time (min)	Stability (min)	Degree of Softening
1	M12-3312CW	54.6	76.2	101.0	104.7	56.3	1.6	3.5	88
1	M12-2020#	52.7	75.4	87.2	81.4	52.1	1.3	2.2	130
1	Branson*	52.6	78.4	105.9	123.5	53.3	1.2	5.3	62
1	Hilliard*	55.3	84.3	108.1	114.3	53.4	2.0	4.3	69
2	VA12W-31	54.4	74.2	99.7	129.7	55.2	1.4	4.5	66
2	VA12W-68	52.9	76.0	102.0	119.7	52.8	1.4	2.5	107
2	VA09MAS2-131-6-2	53.7	77.4	104.1	106.4	53.9	1.4	3.4	80
2	Branson*	52.4	75.5	99.9	129.6	52.9	1.1	2.5	121
2	Hilliard*	55.1	81.0	103.6	122.9	55.2	1.3	3.4	81
3	RS 961	60.9	80.6	101.2	95.9	54.8	2.2	3.5	72
3	RS 968	62.2	77.1	95.1	87.6	57.1	1.1	1.5	108
3	RS 902*	51.5	70.0	88.5	103.0	49.4	0.5	3.1	98

*Check varieties.

Table 36. Sugar-snap cookie baking test (10-50D) and biscuit test parameters by Mennel Milling

		Cookies (10-50D)				Biscuit		
Group	Entry	Width (mm)	Thickness (mm)	W/T Ratio	Spread Factor	Width (mm)	Height (mm)	Weight (g)
1	M12-3312CW	482	68.5	7.0	69.6	258	206	137.3
1	M12-2020#	505	61.2	8.3	81.5	260	204	127.1
1	Branson*	500	62.8	8.0	78.7	255	231	141.8
1	Hilliard*	504	63.0	8.0	79.0	256	236	141.2
2	VA12W-31	488	67.9	7.2	71.0	253	218	140.0
2	VA12W-68	509	61.5	8.3	81.8	268	221	138.6
2	VA09MAS2-	503	60.5	8.3	82.1	254	211	135.2
2	Branson*	508	59.3	8.6	84.7	257	230	136.0
2	Hilliard*	495	64.5	7.7	75.8	258	205	133.8
3	RS 961	462	65.1	7.1	70.1	253	229	139.7
3	RS 968	456	64.5	7.1	69.9	254	192	132.9
3	RS 902*	514	54.8	9.4	92.6	259	210	136.8

*Check varieties.

Table 37. Rapid Visco-Analyzer parameters by Mennel Milling

Group	Entry	Peak Time (min)	Peak (cP)	Trough (cP)	Break-down (cP)	Setback (cP)	Final (cP)	Pasting Temp. (°C)	Peak/Final Ratio
1	M12-3312CW	6.0	2387	1447	940	1409	2856	83.6	0.84
1	M12-2020#	5.9	2330	1240	1091	1320	2559	85.7	0.91
1	Branson*	6.0	2934	1666	1268	1553	3218	84.1	0.91
1	Hilliard*	6.0	2859	1639	1220	1538	3177	84.4	0.90
2	VA12W-31	5.8	2361	1175	1186	1179	2353	76.6	1.00
2	VA12W-68	5.9	2742	1494	1248	1344	2836	84.1	0.97
2	VA09MAS2-131-6-2	5.5	1721	547	1744	739	1285	71.9	1.33
2	Branson*	5.9	2852	1419	1433	1293	2712	75.1	1.05
2	Hilliard*	5.8	2484	1224	1260	1237	2461	82.3	1.01
3	RS 961	5.9	2526	1565	962	1454	3019	65.8	0.84
3	RS 968	6.1	2999	1847	1153	1479	3325	66.2	0.90
3	RS 902*	5.8	2634	1492	1142	1509	3001	80.8	0.88

*Check varieties.

Table 38. Evaluation comments on flour quality and baked product performance by Mennel Milling

			Analytical Flour Qualities					End Product Performance				
			Score: 1 Poor - 9 Excellent					Score: 1 Poor - 9 Excellent				Aditional Comments
#	Group	Entry	Likes	Dislikes	Basis	Score		Product	Likes	Dislikes	Score	Mitigating Physical/Chemical Properties
1	1	M12-3312CW	High LA, Highest Abs			7		Cookies		Lowest SF of group	5	Biscuit- Good height and color
2	1	M12-2020#		Low LA, High degree of softening		4		Cookies	Average SF, good crust		7	Biscuit- Good height and color
3	1	Branson*	High LA, best stability			7		Cookies		Low SF,	6	Biscuit- light crust color, high height, a lot of seperation
4	1	Hilliard*	High LA			7		Cookies		Low SF,	6	Biscuit- High height, a lot of speration
5	2	VA12W-31	High LA, good stability			6		Cookies		Lowest SF of group, Low crust score	5	Biscuit- Light crust, good vol
6	2	VA12W-68	High LA	High degree of softening		6		Cookies	Average SF, average crust		7	Biscuit- Good color
7	2	VA09MAS2-131-6-2	High LA			7		Cookies	Average SF, average crust		7	Biscuit- Good vol
8	2	Branson*	High LA	High degree of softening		6		Cookies	Average SF, average crust		7	Biscuit- High height, a lot of speration
9	2	Hilliard*	High LA			7		Cookies	Average SF, average crust		6	Biscuit- good vol, good color
11	3	RS 961				6		Cookies		Low SF, Low crust score	4	Biscuit- High height, a lot of speration
12	3	RS 968	Highest Abs of group	Lowest LA of group, High degree of softening		5		Cookies		Low SF, Low crust score	4	Biscuit- smallest height, speration,
10	3	RS 902*	High LA	Low Abs,		6		Cookies	Best SF and best crust score		9	Biscuit- best overall, compared to check, good crust and vol

*Check varieties.

Mondelez Quality Evaluations

Table 39. Solvent retention capacity parameters by Mondelez

Group	Entry	Solvent Retention Capacity (%)				
		Water	Sodium Carbonate	Sucrose	Lactic Acid	GPI
1	M12-3312CW	55.9	89.6	119.2	96.0	0.46
1	M12-2020#	53.2	93.6	124.1	77.4	0.36
1	Branson*	56.4	93.0	127.1	98.9	0.45
1	Hilliard*	58.6	94.0	125.5	86.9	0.40
2	VA12W-31	54.9	87.1	121.0	109.6	0.53
2	VA12W-68	52.9	81.5	119.6	99.6	0.50
2	VA09MAS2-131-6-2	57.0	89.6	120.7	96.5	0.46
2	Branson*	52.2	84.7	125.4	109.4	0.52
2	Hilliard*	57.9	90.6	122.8	99.3	0.47
3	RS 961	66.2	95.6	122.8	88.3	0.40
3	RS 968	66.4	94.0	112.5	86.8	0.42
3	RS 902*	53.8	79.2	104.9	89.6	0.49

*Check varieties.

Table 40. Evaluation comments on flour and end product quality characteristics by Mondelez

		Analytical Flour Qualities						
		Score: 1 Poor - 9 Excellent						Aditional Comments
Group	Entry	Likes	Dislikes	Basis	Score			Mitigating Physical/Chemical Properties
1	M12-3312CW	SRC-L, SRC-W	SRC-SC, SRC-S too high	SRC	4			It was observed in general that the damaged starch
1	M12-2020#	Low SRC-W	High SRC-SC, SRC-Suc; low SRC-L	SRC	3			and pentosans were quite high this year compared
1	Branson*	SRC-L	High SRC-SC, SRC-Suc, SRC-W	SRC	3			to checks of 2017. Most of this year lines received
1	Hilliard*	SRC-L	General SRC profile	SRC	2			a low score since are not suitable for biscuit
2	VA12W-31	SRC-L, GPI	SRC-SC, SRC-S too high	SRC	5			manufacturing.
2	VA12W-68	SRC-W, SRC-L, SRC-SC	Low GPI, High Sucrose	SRC	6			
2	VA09MAS2-131-6-2	SRC-L	High SRC-SC, SRC-Suc, SRC-W	SRC	3			
2	Branson*	SRC-L, SRC-W, GPI	SRC-SC, SRC-S too high	SRC	6			
2	Hilliard*	SRC-L	High SRC-SC, SRC-Suc, SRC-W	SRC	3			
3	RS 961	SRC-L	General SRC profile	SRC	2			
3	RS 968	SRC-L, SRC-Sucrose	General SRC profile	SRC	3			
3	RS 902*	SRC profile, OK for cookie	Low GPI	SRC	7			

*Check varieties.

Siemer Milling Quality Evaluations

Table 41. Alveograph test parameters by Siemer Milling

Group	Entry	Alveograph			
		P mm	L mm	P/L Ratio	W joules
1	M12-3312CW	35	103	0.34	98
1	M12-2020#	17	69	0.25	31
1	Branson*	28	174	0.16	140
1	Hilliard*	31	136	0.23	118
2	VA12W-31	42	128	0.33	151
2	VA12W-68	26	144	0.18	94
2	VA09MAS2-131-6-2	29	117	0.25	99
2	Branson*	30	165	0.18	122
2	Hilliard*	44	102	0.43	117
3	RS 961	40	97	0.42	117
3	RS 968	62	51	1.21	107
3	RS 902*	22	134	0.16	97

*Check varieties.

Table 42. Evaluation comments on alveograph dough test by Siemer Milling

		Analytical Flour Qualities					
		Score: 1 Poor - 9 Excellent					Aditional Comments
Group	Entry	Likes	Dislikes	Basis	Score		Mitigating Physical/Chemical Properties
1	M12-3312CW		High Protein		4		Looks like a normal soft wheat graph but protein to high
1	M12-2020#		Extremely Sticky, High protein		1		Thin bubbles, hard to cut and transfer - stuck
1	Branson*		High Protein		3		Extremely long extensibility
1	Hilliard*		High Protein		3		Long extensibility
2	VA12W-31		High Protein		4		Consistant bubbles but protein to high
2	VA12W-68		High Protein		2		Long extensibility, lower peak
2	VA09MAS2-131-6-2		High Protein		3		Dough was very stretchy
2	Branson*		High Protein		3		Long extensibility
2	Hilliard*		High Protein		3		Dough was very sticky
3	RS 961				8		Normal soft wheat graph w/ normal protein level
3	RS 968		Not much extensibility		4		Tight stiff dough / flour to strong Graph more like hard wheat
3	RS 902*		Lower Peak		6		Dough was tacky and very stretchy. Not as strong a flour

*Check varieties.

Star of the West Milling Evaluations

Table 43. Solvent retention capacity, cookie baking test and amyloviscograph test parameters by Star of the West Milling

Group	Entry	Solvent Retention Capacity (%)					Cookies (10-50D)			Flour Falling Number	Amylograph
		Water	Sodium Carbonate	Sucrose	Lactic Acid	LA/SC+S	Width (mm)	Thick-ness (mm)	W/T Ratio		Peak Viscosity (BU)
1	M12-3312CW	54.9	74.8	104.8	105.3	0.59	469	65	7.2	352	246
1	M12-2020#	49.0	77.4	101.3	75.2	0.42	486	61	8.0	356	261
1	Branson*	52.8	79.3	108.6	114.1	0.61	487	61	8.0	419	507
1	Hilliard*	54.4	82.3	114.0	105.6	0.54	482	60	8.0	354	411
2	VA12W-31	53.1	74.7	102.1	126.1	0.71	467	62	7.6	294	316
2	VA12W-68	51.4	75.8	103.0	111.0	0.62	485	55	8.9	317	439
2	VA09MAS2-131-6-2	53.1	76.3	104.7	104.7	0.58	482	58	8.4	242	153
2	Branson*	51.8	75.8	101.3	123.7	0.70	489	54	9.0	314	506
2	Hilliard*	54.9	80.2	110.7	116.3	0.61	474	59	8.0	289	332
3	RS 961	58.9	81.8	98.7	91.9	0.51	452	65	7.0	403	459
3	RS 968	62.2	82.5	100.8	94.5	0.52	449	65	6.9	459	646
3	RS 902*	49.3	70.7	88.3	101.2	0.64	507	51	10.0	327	422

*Check varieties.

Table 44. Rapid Visco-Analyzer parameters by Star of the West Milling

Group	Entry	Peak Time (min)	Peak (cP)	Trough (cP)	Break-down (cP)	Setback (cP)	Final (cP)	Pasting Temp (°C)
1	M12-3312CW	5.9	2109	1254	855	1235	2489	83.9
1	M12-2020#	5.9	2107	1117	990	1158	2275	85.6
1	Branson*	6.0	2785	1527	1258	1431	2958	82.2
1	Hilliard*	5.9	2591	1414	1177	1381	2795	83.8
2	VA12W-31	5.8	2130	1012	1118	1027	2039	67.8
2	VA12W-68	5.9	2429	1279	1150	1197	2476	83.8
2	VA09MAS2-131-6-2	5.5	1607	468	1139	631	1099	70.2
2	Branson*	5.9	2609	1230	1379	1149	2379	71.1
2	Hilliard*	5.7	2297	1049	1248	1085	2134	81.5
3	RS 961	5.9	2199	1325	874	1310	2635	66.2
3	RS 968	6.1	2802	1659	1143	1368	3027	66.1
3	RS 902*	5.8	2460	1348	1112	1413	2761	80.6

*Check varieties.

Table 45. Evaluation comments on flour quality and baked product performance by Star of the West Milling

		Analytical Flour Qualities					End Product Performance					
		Score: 1 Poor - 9 Excellent					Score: 1 Poor - 9 Excellent					Additional Comments
Group	Entry	Likes	Dislikes	Basis	Score		Product	Likes	Dislikes	Score		Mitigating Physical/Chemical Properties
1	M12-3312CW		Lower Amylograph than others in set.	Amylograph	5		Cookies 10-50D		Tightest cookies of set	5		
1	M12-2020#	Low water absorption	Low lactic Acid/high sucrose.	SRC	6		Cookies 10-50D	good top pattern		8		
1	Branson*	High lactic acid-strong SRC profile		SRC	8		Cookies 10-50D			7		
1	Hilliard*		High sodium carb and sucrose	SRC	7		Cookies 10-50D	good top pattern		8		
2	VA12W-31	High lactic acid -good overall SRC profile.			7		Cookies 10-50D		Tightest cookies of set	5		very strong flour. Would probably work better for crackers than cookies.
2	VA12W-68	Low water absorption and good overall SRC			8		Cookies 10-50D			6		
2	VA09MAS2-131-6-2		lower FN and Amylograph-perhaps from partial waxy?	Amylograph	6		Cookies 10-50D	good top pattern		8		
2	Branson*	High lactic acid -good overall SRC profile.			8		Cookies 10-50D	Best cookie spread in set.		8		
2	Hilliard*		relatively high sodium carb and sucrose		6		Cookies 10-50D			6		
3	RS 961	High FN and Amylograph	High water absorption not a very good SRC profile	Amylograph/ SRC	6		Cookies 10-50D		Very tight cookies	3		
3	RS 968	Best FN and Amylograph of set.	Very high water absorption not a good SRC profile	Amylograph/ SRC	5		Cookies 10-50D		Very tight cookies	3		
3	RS 902*	Low water absorption and good overall SRC		SRC	8		Cookies 10-50D	Very good cookie spread-good top pattern		9		Good flour for cookies, should be strong enough for crackers as well

*Check varieties.

Wheat Marketing Center Quality Evaluations

Table 46. Sponge cake baking test parameters by Wheat Marketing Center

Group	Entry	Sponge Cake					
		Volume (ml)	External	Crumb Grain	Texture Score	Total Score	Ranking
1	M12-3312CW	1182	20	24	14	58	3
1	M12-2020#	1188	20	18	14	52	6
1	Branson*	1217	21	24	14	59	2
1	Hilliard*	1213	20	21	14	55	4
2	VA12W-31	896	11	0	7	18	12
2	VA12W-68	1056	15	3	10	28	11
2	VA09MAS2-131-6-2	1057	15	6	10	31	10
2	Branson*	1189	20	15	14	49	7
2	Hilliard*	1118	17	12	12	41	9
3	RS 961	1173	20	15	14	49	8
3	RS 968	1201	21	18	15	54	5
3	RS 902*	1257	20	27	14	61	1

*Check varieties.

Table 47. Evaluation comments on flour quality and sponge cake baking test performance by Wheat Marketing Center

			Analytical Flour Qualities					End Product Performance		
			Score: 1 Poor - 9 Excellent					Score: 1 Poor - 9 Excellent		
#	Group	Entry	Likes	Dislikes	Basis	Score	Product	Likes	Dislikes	Score
1	1	M12-3312CW	Lowest ash	Highest protein	Primary Analysis	5	Sponge Cake	Good Exterior, Interior, Soft texture	Smaller volume than checks	7
2	1	M12-2020#	Lowest protein		Primary Analysis	6	Sponge Cake	Good Exterior, Interior	Slightly hard texture, smaller volume than checks	5
3	1	Branson*			Primary Analysis	5	Sponge Cake	Good Exterior, Interior, Soft texture		8
4	1	Hilliard*			Primary Analysis	5	Sponge Cake	Good Exterior, Interior, Soft texture		7
5	2	VA12W-31	Low ash	High protein	Primary Analysis	5	Sponge Cake		Worst cake	1
6	2	VA12W-68	Low ash	High protein	Primary Analysis	5	Sponge Cake		Bad cake	2
7	2	VA09MAS2-131-6-2	Low protein		Primary Analysis	5	Sponge Cake		Bad cake	2
8	2	Branson*			Primary Analysis	5	Sponge Cake	Good exterior and interior	Hard texture	4
9	2	Hilliard*			Primary Analysis	4	Sponge Cake		Bad cake	3
11	3	RS 961	Low protein	Highest ash	Primary Analysis	4	Sponge Cake	Good exterior, interior	Hard texture, Smaller volume than check	5
12	3	RS 968	Low protein	High ash	Primary Analysis	4	Sponge Cake	Excellent exterior, Good interior	Slightly hard texture, smaller volume than check	6
10	3	RS 902*			Primary Analysis	5	Sponge Cake	Excellent exterior, interior, texture, and volume		9

*Check varieties.

USDA-ARS Western Wheat Quality Laboratory Quality Evaluations

Table 48. Solvent retention capacity and mixograph test parameters by USDA-ARS Western Wheat Quality Laboratory

Group	Entry	Solvent retention capacity (%)				Mixograph					
		Water	Sodium Carbonate	Sucrose	Lactic Acid	Water Absorpion %	Type	Mid-Point Time	Mid-Point Height	Mid-Point Work	Mid-Point With + 2 min
1	M12-3312CW	56.3	72.8	99.1	107.2	60.0	3M	2.3	51.0	102.1	5.6
1	M12-2020#	54.2	75.5	98.6	83.2	58.9	2M	1.8	44.4	68.6	3.0
1	Branson*	52.8	79.2	107.0	118.7	57.9	3M	3.1	51.8	142.4	9.5
1	Hilliard*	54.3	82.9	110.4	122.1	57.2	4M	3.0	50.5	135.4	7.7
2	VA12W-31	55.5	73.2	102.7	122.0	58.0	4M	3.4	51.1	155.0	8.8
2	VA12W-68	51.9	73.7	98.8	127.3	57.3	3M	2.6	49.3	115.3	7.1
2	VA09MAS2-131-6-2	55.1	75.2	102.6	104.5	57.5	4M	2.9	47.2	121.9	6.5
2	Branson*	52.8	74.5	104.2	125.6	57.7	4M	3.9	48.0	171.6	8.9
2	Hilliard*	57.0	80.1	116.7	125.1	57.5	4M	3.2	49.8	144.4	6.8
3	RS 961	59.8	78.5	97.9	95.3	58.0	4M	2.9	50.8	129.4	6.5
3	RS 968	59.4	76.7	97.3	86.4	57.2	2M	3.3	45.4	140.9	8.2
3	RS 902*	51.6	67.2	88.9	108.4	59.9	2M	3.6	43.0	141.0	5.9

*Check varieties.

Table 49. Sugar-snap cookie and sponge cake baking test parameters by USDA-ARS Western Wheat Quality Laboratory

Group	Entry	Cookie (10-52) Width (cm)	Sponge Cake	
			Volume (mL)	Texture Score
1	M12-3312CW	8.4	1238	20
1	M12-2020#	8.8	1300	22
1	Branson*	8.5	1320	21
1	Hilliard*	8.6	1325	22
2	VA12W-31	8.3	1082	16
2	VA12W-68	8.7	1270	17
2	VA09MAS2-131-6-2	8.6	1232	20
2	Branson*	8.7	1315	22
2	Hilliard*	8.4	1288	20
3	RS 961	9.3	1295	21
3	RS 968	8.3	1238	20
3	RS 902*	8.2	1220	19

*Check varieties.

Table 50. Evaluation comments on flour quality and baked product performance by USDA-ARS Western Wheat Quality Laboratory

		Analytical Flour Qualities				End Product Performance				
		Score: 1 Poor - 9 Excellent				Score: 1 Poor - 9 Excellent				Aditional Comments
Group	Entry	Likes	Dislikes	Basis	Score	Product	Likes	Dislikes	Score	Mitigating Physical/Chemical Properties
1	M12-3312CW		high sucrose SRC		5	sugar snap cookie & Sponge Cake			3	
1	M12-2020#		high sucrose SRC		5	sugar snap cookie & Sponge Cake	cake quality		6	
1	Branson*		high sucrose & carbonate SRC		4	sugar snap cookie & Sponge Cake	cake quality		6	big difference between cake & cookie quality
1	Hilliard*		high sucrose & carbonate SRC		4	sugar snap cookie & Sponge Cake	cake quality		6	big difference between cake & cookie quality
2	VA12W-31		high sucrose SRC		5	sugar snap cookie & Sponge Cake		cake and cookie quality	2	
2	VA12W-68	low water SRC	high sucrose SRC		6	sugar snap cookie & Sponge Cake			5	
2	VA09MAS2-131-6-2		high sucrose SRC		5	sugar snap cookie & Sponge Cake			4	
2	Branson*		high sucrose SRC		5	sugar snap cookie & Sponge Cake	cake quality		6	
2	Hilliard*		high sucrose & carbonate SRC		4	sugar snap cookie & Sponge Cake			6	
3	RS 961	low protein	high protein, low water, carbonate sucrose SRC		3	sugar snap cookie & Sponge Cake		poor cookie	3	
3	RS 968	low protein	high protein, low water, carbonate sucrose SRC		3	sugar snap cookie & Sponge Cake		poor cookie	5	
3	RS 902*	low protein, low water,			8	sugar snap cookie & Sponge Cake	cake quality		8	liked both cake and cookie

*Check varieties.

USDA-ARS Soft Wheat Quality Laboratory Soft Wheat Quality Evaluations

Table 51. Solvent retention capacity and cookie baking test parameters by USDA-ARS Soft Wheat Quality Laboratory

Group	Entry	Solvent Retention Capacity (%)				Cookie (10-52)	
		Water	Sodium Carbonate	Sucrose	Lactic Acid	Width (cm)	Top Grain Score
1	M12-3312CW	58.0	77.8	99.5	96.0	16.9	4
1	M12-2020#	56.6	80.9	96.7	83.0	17.7	5
1	Branson*	55.6	82.3	105.6	111.5	17.0	2
1	Hilliard*	57.7	85.2	107.8	106.0	17.3	1
2	VA12W-31	57.9	78.9	102.9	113.0	16.7	2
2	VA12W-68	54.9	78.3	102.8	109.9	17.6	6
2	VA09MAS2-131-6-2	56.6	79.3	103.8	97.9	17.5	2
2	Branson*	54.4	80.8	100.0	114.6	17.4	6
2	Hilliard*	57.4	83.3	107.0	111.3	16.9	1
3	RS 961	61.0	83.8	94.7	89.1	16.4	3
3	RS 968	63.7	83.5	93.9	84.6	16.2	4
3	RS 902*	55.7	74.5	89.1	100.3	18.4	7

*Check varieties.

Table 52. Rapid Visco-Analyzer parameters by USDA-ARS Soft Wheat Quality Laboratory

Group	Entry	Peak Time (min)	Peak (cP)	Trough (cP)	Break-down (cP)	Setback (cP)	Final (cP)	Pasting Temperature (°C)	Peak/Final Ratio
1	M12-3312CW	6.0	2391	1442	949	1381	2823	76.4	0.85
1	M12-2020#	6.0	2297	1272	1025	1278	2550	86.4	0.90
1	Branson*	6.1	2988	1694	1295	1533	3227	85.2	0.93
1	Hilliard*	6.0	2826	1581	1245	1499	3080	85.2	0.92
2	VA12W-31	5.9	2296	1156	1140	1129	2285	84.8	1.01
2	VA12W-68	5.9	2624	1400	1224	1312	2712	85.2	0.97
2	VA09MAS2-131-6-2	5.5	1686	544	1142	701	1244	81.1	1.35
2	Branson*	5.9	2769	1387	1382	1235	2622	83.1	1.06
2	Hilliard*	5.8	2425	1182	1243	1174	2356	83.1	1.03
3	RS 961	6.0	2501	1547	954	1445	2992	67.3	0.84
3	RS 968	6.1	3023	1832	1191	1446	3278	67.4	0.92
3	RS 902*	5.9	2721	1538	1183	1509	3047	81.5	0.89

*Check varieties.

Table 53. Mixograph parameters by USDA-ARS Soft Wheat Quality Laboratory

Group	Entry	Mixing Absorption (%)	Peak Time (min)	Peak Value (%)	Peak Width (%)	Width @7min (%)
1	M12-3312CW	56.0	2.8	51.3	14.6	3.1
1	M12-2020#	51.0	0.8	53.3	26.4	4.0
1	Branson*	57.0	2.0	49.7	18.4	8.1
1	Hilliard*	57.0	2.1	47.8	15.3	6.2
2	VA12W-31	59.0	3.4	47.9	14.9	7.9
2	VA12W-68	57.0	1.0	46.1	19.1	5.0
2	VA09MAS2-131-6-2	56.0	3.4	42.7	9.5	5.5
2	Branson*	57.0	2.9	44.7	14.7	7.5
2	Hilliard*	58.0	2.2	47.1	18.2	5.3
3	RS 961	56.0	3.4	48.4	14.0	5.2
3	RS 968	57.0	0.7	45.0	23.6	5.8
3	RS 902*	54.0	1.9	42.2	14.5	5.6

*Check varieties.

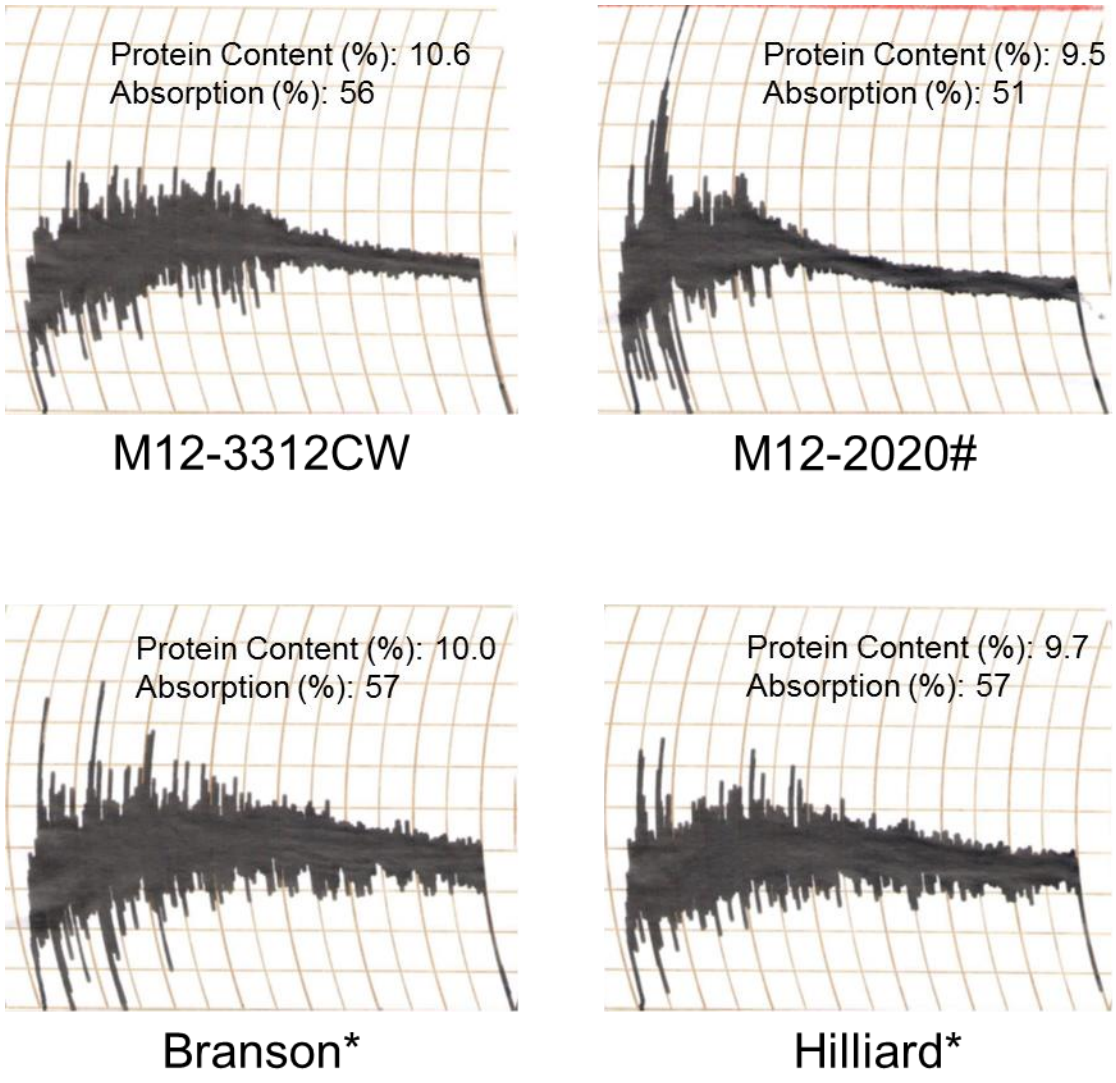

Figure 1. Mixograms of the WQC 2018 crop entries from Syngenta performed by USDA-ARS Soft Wheat Quality Laboratory. *Check varieties.

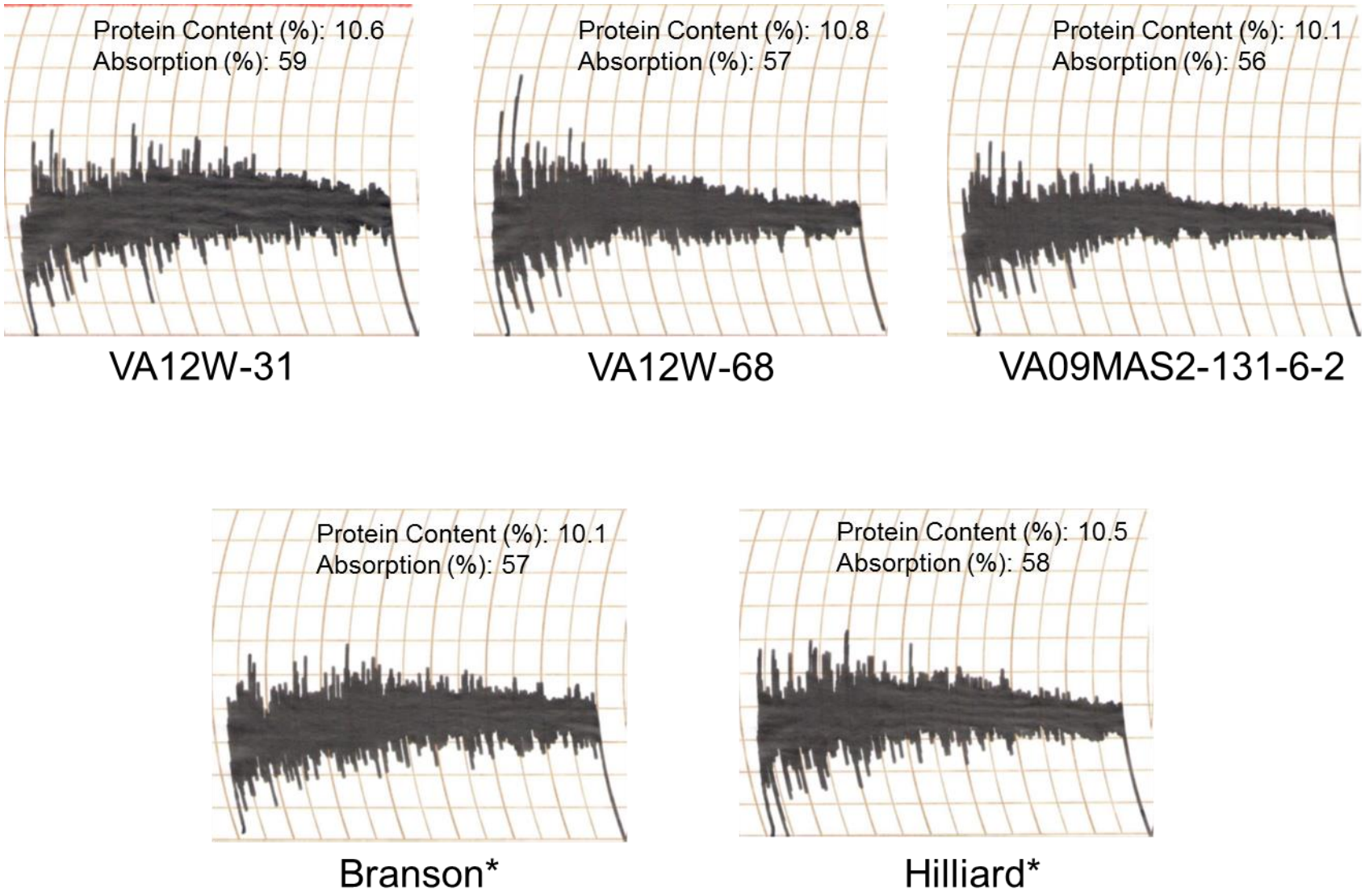

Figure 2. Mixograms of the WQC 2018 crop entries from Virginia Polytechnic Institute and State University performed by USDA-ARS Soft Wheat Quality Laboratory. *Check varieties.

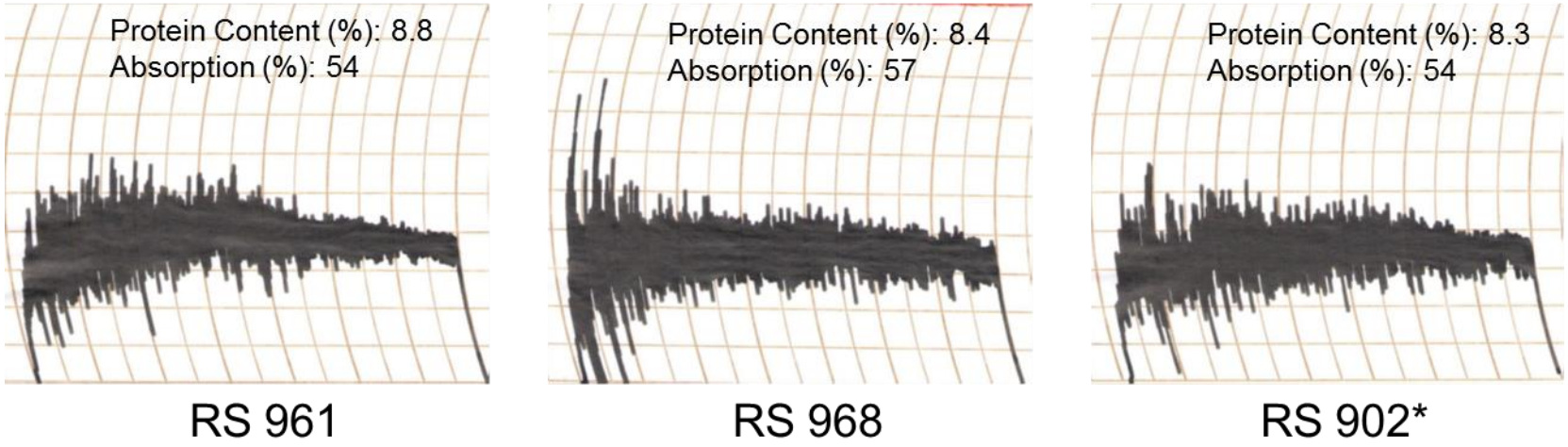

Figure 3. Mixograms of the WQC 2018 crop entries from Rupp Seeds performed by USDA-ARS Soft Wheat Quality Laboratory. *Check varieties.

Table 54. Wheat grain and flour quality characteristics of the 2018 crop Soft Wheat Quality Council entries between 2009 and 2018 crop years

Group	Entry	N	Test Weight (LB/BU)	Grain Protein (%)	Kernel Hardness	Flour Yield (%)	Softness Equivalence (%)	Flour Protein (%)	Lactic Acid SRC (%)	Water SRC (%)	Sodium Carbonate SRC (%)	Sucrose SRC (%)	Cookie Diameter (cm)
1	M12-3312CW	1~2	60	11.7	29	67	52	10.0	104	58	72	100	.
1	M12-2020#	2~6	60	11.0	20	67	53	9.0	79	56	73	95	18.8
1	Branson*	105~408	57	10.6	6	69	62	8.3	106	52	66	90	18.9
1	Hilliard*	8~106	60	10.8	16	67	59	8.4	120	56	74	98	17.9
2	VA12W-31	3~15	61	10.9	25	66	53	8.7	117	56	69	96	18.2
2	VA12W-68	2~13	60	11.3	12	67	56	9.4	105	54	69	97	18.3
2	VA09MAS2-131-6-2	2~8	61	11.5	19	67	52	9.0	108	55	75	101	18.0
2	Branson*	105~408	57	10.6	6	69	62	8.3	106	52	66	90	18.9
2	Hilliard*	8~106	60	10.8	16	67	59	8.4	120	56	74	98	17.9
3	RS 961	1~2	63	10.5	58	73	44	8.4	93	61	82	93	17.2
3	RS 968	1	61	10.3	54	73	44	8.4	85	64	84	94	
3	RS 902*	4~8	61	10.4	3	72	64	7.9	102	54	67	85	19.3

*Check varieties.

Appendix I. Materials and Methods of the USDA-ARS SWQL

Whole Kernel Moisture, Air-oven Method, AACC Method 44-15.02

What grain is coarsely ground to minimize moisture loss and dried in a convention oven set at 140°C for 90 min. The moisture content is express as the percent loss of weight during drying.

Whole Wheat Protein

Whole wheat protein is determined by Nitrogen combustion analysis using the Elementar Nitrogen Analyzer. Units are recorded in % protein converted from nitrogen x 5.7 and expressed on a 12% moisture basis.

Falling Number, AACC Method 56-81B

The falling number test 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.

Amylase Activity, AACC Method 22-02-01

Alpha-amylase can be measured directly using a kit from Megazyme, International, Measurement of alpha-Amylase in Plant and Microbial Materials Using the Ceralpha Method. The SWQL uses a modified micro method of the Megazyme assay. Units are expressed in alpha-amylase activity as SKB units/gram (@ 25°C).

Test Weight, AACC Method 55-10

Test weight is measured per Winchester bushel of cleaned wheat subsequent to the removal of dockage using a Carter-Day dockage tester. Units are recorded as pounds/bushel (lb/bu) and kilograms/hectoliter (kg/hl).

1000-Kernel Weight

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

Single Kernel Characterization System (SKCS), AACC Method 55-31

SKCS distribution shows percent soft (A), semi-soft (B), semi-hard (C), and hard (D) SKCS hardness index; moisture content; kernel size; and kernel weight; along with standard deviations.

Miag Multomat Experimental Flour Mill Unit

The Miag Multomat Mill is a pneumatic conveyance system consisting of eight pair of 254 mm diameter x 102 mm wide rolls, and ten sifting passages. Break rolls operate at 340 rpm for the fast rolls and 145 rpm for the slow rolls; 2.34:1 and reduction at 340 rpm fast and 250 rpm slow; 1.36:1. The first three rolls are break rolls; 1st break: 14 corrugations/inch, α 40, β 70, land 0.004”, 8% spiral; 2nd break: 20 corrugations/inch, α 40, β 75, land 0.002”, 10% spiral; 3rd break: 24 corrugations/inch, α 35, β 75, land 0.002”, 10% spiral. The five reduction rolls are

smooth, not frosted. Following the second break is the grader and duster following the first reduction; allowing for more sifting surface area respectfully. Each mill run including the grader and duster precedes six sieves. Residue for this system includes head shorts, bran, red dog, and tail shorts.

Experimental Milling Procedure

The Miag Multomat Mill is a pneumatic conveyance system consisting of eight pairs of 254 mm diameter x 102 mm wide rolls, and ten sifting passages. Three of the pairs are corrugated break rolls and five are reduction rolls. Each sifting passage contains six separate sieves. The two top sieves for each of the break rolls are intended to be used as scalp screens for the bran.

Soft red and soft white winter wheat grain is tempered to 14.5% moisture. The tempered grain is held for 24 hours prior to milling and then introduced into the first break rolls at a rate of approximately 600g/min. Straight grade flour is a blend of three break flour streams, grader flour, five reduction streams and 1M re-duster flour. The straight grade flour is then re-bolted to remove any remaining residual by-products not removed by the mill using a stainless steel screen of 165 micron openings. The ash content of the straight grade flour usually range from 0.38 and 0.50%. Bran, head shorts, tail shorts and red dog are by-products, which are not included with the flour. Flour yield of eastern soft wheat varies from 70 to 78%. Flour yield depends on wheat variety and is influenced by environmental growing conditions. Sprouted and/or shriveled kernels negatively impact the flour yield. Recovery of all mill products is usually about 98%.

Flour Moisture, Air-oven Method, AACC Method 44-16.01

Wheat flour (~2 g) is dried on hot aluminum plate in an air oven set at 140°C for 15 min. The moisture content is express as the percent loss of weight during drying.

Flour Protein

Protein determined by near infra-red (NIR), using a Unity NIR instrument calibrated by a nitrogen combustion analysis on the Elementar Nitrogen Analyzer. Units are recorded in percent protein converted from nitrogen x 5.7 and expressed on 14% moisture basis.

Flour protein differences among cultivars can be a reliable indicator of genetic variation provided the varieties are grown together, but can vary from year to year at any given location. Flour protein from a single, non-composite sample may not be representative. Based on the Soft Wheat Quality Laboratory grow-outs, protein can vary as much 1.5 % for a cultivar grown at various locations in the same half-acre field. Flour protein of 8% to 9% is representative for breeder's samples and SWQL grow-out cultivars.

Flour Ash, AACC Method 08-01

Flour ash is determined following the basic AACC method, expressed on 14% moisture basis.

Solvent Retention Capacity Test (SRC), AACC Method 56-11

Flour Lactic Acid, Sucrose, Water, and Sodium Carbonate Retention Capacities (SRC) results are expressed as percent solvent retained by weight.

Water SRC is a global measure of the water affinity of the macro-polymers (starch, arabinoxylans, gluten, and gliadins). It is often the best predictor of baked product performance. 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 is a measure of arabinoxylan (also known as pentosans) content, which can strongly affect water absorption in baked products. Water soluble arabinoxylans are thought to be the fraction that most greatly increases sucrose SRC. Sucrose SRC probably is the best predictor of cookie quality, with sugar snap cookie diameters decreasing by 0.07 cm for each percentage point increase in sucrose SRC. Soft wheat flours for cookies typically have a target of 95% or less when used by the US baking industry for biscuits and crackers. The 95% target value can be exceeded in flour samples where a higher lactic acid SRC is required for product manufacture since the higher sucrose SRC is due to gluten hydration and not to swelling of the water soluble arabinoxylans.

Sodium carbonate SRC employs the very alkaline solution that ionizes the ends of starch polymers increasing the water binding capacity of the molecule. Sodium carbonate SRC increases as starch damage due to milling increases. Normal values for good milling soft varieties are 68% or less.

Lactic acid SRC measures gluten strength. Typical values are below 85% for "weak" soft varieties and above 105% or 110% for "strong" gluten soft varieties. Lactic acid SRC results correlate to the SDS-sedimentation test. The lactic acid SRC is also correlated to flour protein concentration, but the effect is dependent on genotypes and growing conditions.

Flour Damaged Starch

As measured by the Chopin SDMatic starch damage instrument using the supplied AACC calibration. Starch damage is a measure of the damage to the starch granule occurring during the milling process.

Rapid Visco-Analyzer (RVA) Method

Viscosity units are in centipoise units, peak time in minutes, pasting temperature in degrees centigrade. The hot pasting viscosity/time analysis of starch and flour was accomplished using a Rapid Visco-Analyzer (RVA), Model RVA-4 (Foss North America, Inc., Eden Prairie, MN). The "standard 1" heating profile of that instrument's software (Thermocline for Windows, version 2.0, Newport Scientific Pty. Ltd., Warriewood, NSW, Australia) was employed to produce pasting curves based on 3.5 g (14% moisture basis) flour and 25 ml deionized water. Maximum heating temperature was 95°C and minimum cooled temperature was 50 °C. Peak pasting viscosity, peak time, minimum (trough) viscosity during cooling, breakdown viscosity (difference between peak and minimum viscosities), final viscosity at the conclusion of cooling, and setback (difference between final and minimum viscosities) were determined for each sample.

Sugar Snap Cookie, Micro Method, AACC Method 10-52

Diameter of Two-cookie expressed in cm, cookie top grain expressed in arbitrary units from unacceptable to outstanding from 1 to 9, respectively, are determined. Diameter and stack height

of cookies baked according to this method are measured and used to evaluate flour baking quality.

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

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