Milling and Baking Test Results for Eastern Soft Wheats

Harvested in 2015

Soft Wheat Quality Council of the Wheat Quality Council

March 1, 2016

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 & flour quality.

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This program was carried out in cooperation with and funded by the Wheat Quality Council.

Collaborators for 2015 Crop Year

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Ardent Mills	Jie Hu, Grace Nelson, Scott Baker
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Siemmer Milling Company	Marianne Tegeler
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Wheat Marketing Center	Bon Lee, Gary Hoe
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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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WQC 2015 Crop Year Entries and Contributing Breeding Programs

Group	Entry	Location	Breeder	Institution/ Company	Class
1	AgriMAXX 462	VA	Carl Griffey	Virginia Tech	SRW
1	Hilliard				SRW
1	VA 258*				SRW
2	E6012	MI	Eric Olson	Michigan State Univ.	SWW
2	MCIA Venus*				SWW

*Check varieties.

Description of Entries

AgriMAXX 462 (VA10W-21)
Soft red winter wheat line VA10W-21 was developed and released by the Virginia Agricultural Experiment Station in May 2015 and will be marketed as variety AgriMAXX 462. It was derived from the cross Z00-5018 / VA01W-158. Wheat line Z00-5018 was developed and derived from the cross U90-1A // ZX90-2C1 / Pioneer Brand '2580' (PI 561198) by Western Plant Breeders and was selected as a parent from the 2002 – 2003 Uniform Eastern SRW Wheat Nursery. Parental line VA01W-158 was developed at Virginia Tech from the cross Pioneer Brand '2643' (PI583739) / VA94-54-331. VA10W-21 was derived as a bulk of an F5:6 headrows selected in 2009 and was evaluated over three years (2012-14) in Virginia's State Variety Trials and throughout most of the soft red winter (SRW) wheat region in the 2012 and 2013 USDA-ARS Uniform Eastern Soft Red Winter Wheat Nurseries.

VA10W-21 is a broadly adapted, high yielding, mid-season, short height, semi-dwarf (gene Rht2). Plant stem and spike color of VA10W-21 are blue green, and spikes are strap shaped with short apical tip awns. In the eastern SRW wheat region, head emergence of VA10W-21 (116 – 136 d) was similar to that of 'Branson', and 2 d earlier than 'Shirley'. Average mature plant height of VA10W-21 has varied from 33 to 35 inches, and is most similar in height to Branson and 1 to 2 inches taller than Shirley. Straw strength (0=erect to 9=completely lodged) of VA10W-21 (0.9 – 3.6) is good and intermediate to that of Shirley (0.6 – 3.2) and 'Bess' (1.2 – 3.9). In the Uniform Eastern Nursery, winter hardiness and spring freeze tolerance (0 = no injury to 9 = severe injury) of VA10W-21 (1.0 – 1.1 and 0.6 – 0.7) were most similar to those of Branson (1.3 – 1.4 and 0.4 – 0.5).

VA10W-21 was evaluated at 25 locations in the 2012 USDA-ARS Uniform Eastern SRW Wheat Nursery, and ranked eighth in grain yield (76 bu/ac) among 35 entries within in the eastern region. Average test weight of VA10W-21 (59.1 lb/bu) was most similar to that of check cultivar Bess (59.7 lb/bu) and significantly ($P < 0.05$) higher than those of Branson (58.4 lb/bu) and Shirley (57.2 lb/bu). In the 2013 Uniform Eastern Nursery, VA10W-21 ranked second in grain yield (81.8 bu/ac) within the eastern region and fourth (79 bu/ac) among the 39 entries over all 20 test sites. The mean test weight of VA10W-21(57.5 lb/bu) was most similar to that of Bess (57.7 lb/bu) and significantly higher than those of Branson (56.6 lb/bu) and Shirley (55.3 lb/bu).

Grain samples of VA10W-21 produced in four crop environments (2011 – 2013) were evaluated for end use quality by the USDA-ARS Soft Wheat Quality Lab. VA10W-21 has exhibited milling qualities that are intermediate between those of Jamestown and USG 3555. Overall Jamestown has superior milling and baking quality to VA10W-21, which in turn has better milling quality but poorer baking quality than USG 3555.

VA10W-21 is a widely adapted wheat variety with good winter hardiness. It has high grain yield potential, high test weight, and has performed well in most of the eastern SRW wheat production areas including the mid-South, mid-Atlantic and Corn-belt regions. With the exception of stem rust, stripe rust, and possibly Hessian fly, VA10W-21 expresses moderate to high levels of resistance to diseases prevalent in the SRW wheat region. These include powdery mildew, leaf

rust, leaf and glume blotch, soil-borne mosaic virus, barley and cereal yellow dwarf viruses, and most notably Fusarium head blight.

Initial Breeder seed of VA10W-21 was planted by Virginia Crop Improvement Association (VCIA) on 0.45 acre at their Foundation Seed farm during fall 2013 and produced 26 units (50 lbs/unit) of Foundation seed. During fall 2014, VCIA planted 8.3 acres of VA10W-21 to produce additional Foundation seed to provide to seedsmen in fall 2015.

Hilliard (VA11W-108)

Soft red winter (SRW) wheat cultivar Hilliard (tested as VA11W-108) was developed and released by the Virginia Agricultural Experiment Station in May 2015. It 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 was evaluated over three years (2013 – 2015) in Virginia's State Variety Trials and throughout the soft red winter (SRW) wheat region in the 2014 USDA-ARS Uniform Southern and Uniform Eastern Soft Red Winter Wheat Nurseries.

Hilliard is a broadly adapted, high yielding, mid-season, medium height, semi-dwarf (gene Rht2) SRW wheat. Plant stem and spike color of Hilliard are green, and its spikes are awned. In the southern SRW wheat region, head emergence of Hilliard (121 d) 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 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.

Initial Breeder seed of Hilliard, derived in 2013 from a 225 ft2 F9 seed increase block from which visible variant plants were removed prior to harvest, was grown on 0.25 ac at the Virginia Crop Improvement Association's (VCIA) Foundation seed farm and produced 10 units (50 lbs / unit) of seed. In fall 2014, this seed was planted on 7.6 ac at the Foundation seed farm and to produce additional Foundation seed. A purer source of Hilliard Breeder seed was developed upon evaluation of plots derived from 89 selected breeder seed headrows having yellow anther and white coleoptile color. Remnant seed (34 lbs) from these headrows was planted on 0.6 acre at VCIA's Foundation Seed Farm during fall 2014 to produce a purer source of Hilliard breeder seed.

VA 258

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

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

similar to those of Branson and USG 3555 and 0.6 Lb/Bu higher than those of Shirley and Pioneer variety '26R15'.

VA258 was evaluated at 29 locations in the 2007-08 USDA-ARS Uniform Southern Soft Red Winter Wheat Nursery, and produced a mean grain yield (73.9 Bu/ac) that was just above the overall test yield average (72.6 Bu/ac) for all 42 entries and 29 locations. VA258 produced yields that were similar to or significantly higher than the test averages at 16 locations. Average test weight of VA258 (55.9 Lb/Bu) was most similar to that of USG 3555 (56.9 Lb/Bu). VA258 also was evaluated at 28 locations in the 2008-09 USDA-ARS Uniform Eastern Soft Red Winter Wheat Nursery, and ranked 13th among 42 entries for grain yield (75.2 Bu/ac) compared to rankings of 3rd for Branson (79.3 Bu/ac), 17th for 'Bess' (74.6 Bu/ac), 26th for Roane (73.0 Bu/ac), and 33rd for 'INW 0411' (69.1 Bu/ac). VA258 produced yields similar to or significantly higher than the test averages at 20 of the 28 test sites. Average test weight of VA258 (55.8 Lb/Bu) was similar to that of Branson. On the basis of winter kill ratings (0 = no injury to 9 = complete kill) reported at 4 of the 29 southern nursery locations and at 5 of the 28 eastern nursery test sites, winter hardiness of VA258 (3.0 and 3.1, respectively) is most similar to that of 'Coker9553' (3.4), better than that of AGS2000 (5.0), and less than that of Branson (2.2).

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

E6012

E6012 (Caledonia/P25W33) is a soft white winter wheat adapted to Michigan growing environments. E6012 is fully awned and short statured with white chaff. The early maturity of E6012 will enable growers to spread their maturities from early to late. Yield potential is stable and comparable to contemporary soft white winter wheat varieties grown in Michigan. The most distinguishing trait E6012 carries is resistance to DON under heavy Fhb pressure. Across four years of evaluation in a misted-inoculated Fhb nursery, E6012 accumulates 6.5 ppm in contrast to DON levels of over 11 ppm in the widely planted varieties AC Mountain, Ambassador and Hopewell (LSD0.05 = 2.3 ppm). The resistance to DON in E6012 is likely conferred in part by a known Fhb resistance QTL carried on chromosome 5A. E6012 Fhb incidence and severity are similar to trial means. E6012 demonstrated a four-year average yield of 84.8 bu/Ac which is not significantly different (LSD0.05 = 3.9 bu/Ac) from contemporary Michigan soft winter wheat varieties AC Mountain, Aubrey, Hopewell, Jupiter, Shirley and Red Ruby. Although yield potential is not the highest of all varieties tested, yields are not different from contemporary varieties. Yield stability of E6012is improved over varieties that perform well in Michigan but were not developed and selected as varieties in Michigan. An example of contrasting yield stability is the soft red winter wheat variety, Shirley, which has a four-year average of 87.1 bu/Ac and yielded 79.4 bu/Ac in 2014, a 7.7 bu/Ac difference. E6012 has consistently yielded between 84 and 86 bu/Ac each year of testing.

MCIA Venus (VA09W-188WS)

The soft white winter wheat cultivar MCIA Venus, formerly designated VA09W-188WS, was developed and released in March 2013 by the Virginia Agricultural Experiment Station. The cultivar was derived from the cross 'Pioneer Brand 25W60 (PI 607579)//Pioneer Brand 25W33 (PI 599197)/VAN98W-170WS'. MCIA Venus is a broadly adapted, high-yielding, early heading, medium-height, semidwarf (gene *Rht2*) wheat. At maturity, the cultivar has yellow-colored straw and spikes with the latter being slightly recurved, tapering in shape, and awned. In the northeastern soft winter wheat regions of the U.S. and Ontario, Canada, average head emergence of MCIA Venus (139–157 days) was 2 to 4 days earlier than that of Caledonia and 4 to 7 days earlier than Superior. Average mature plant height of MCIA Venus has varied from 36 to 41 inches (91–104 cm). MCIA Venus is most similar in height to Featherstone Brand VA258, 2 to 3 inches taller than Branson, and 3 to 5 inches shorter than Superior. Straw strength (0 = erect to 9 = completely lodged) of MCIA Venus (3.2–3.7) is moderate, most similar to those of SS 520 (3.1–4.5) and USG 3555 (2.0–4.0). In the Uniform Eastern Soft White Winter Wheat Nursery, winter hardiness (0–100% survival) of MCIA Venus (93–97%) was similar to those of northern check cultivars. MCIA Venus was evaluated at five locations (Michigan, New York, Virginia, and Ontario, Canada) in the 2012 Uniform Eastern Soft White Winter Wheat Nursery and had a mean grain yield of 77 bu/ac (5,174 kg/ha) over locations. MCIA Venus also was evaluated in this nursery in 2011 at seven locations (Indiana, Ohio, Michigan, New York, Virginia, and Ontario) and ranked second for grain yield (80 bu/ac, 5375 kg/ha). In these two nursery years, average test weights of MCIA Venus were 57.1 and 57.4 lb/bu (73.5–73.9 kg/hl) and similar to or significantly ($P < 0.05$) higher than those of Caledonia. MCIA Venus expresses moderate to high levels of resistance to diseases prevalent in the eastern soft white winter wheat region, including leaf and stripe rusts, powdery mildew, Septoria tritici leaf blotch, Fusarium head blight, barley yellow dwarf virus, wheat soil-borne mosaic virus, and Hessian fly.

SWQL Miag Multomat Mill

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 passes. Each sifting passage contains six separate sieves. The two top sieves for each of the break rolls are intended to be used as scalp screens for the bran.

All SRW varieties are tempered to 14.5% moisture. The tempered wheat is held for 24 hours prior to milling. Wheat is introduced into the first break rolls at a rate of approximately 600g/min. Straight grade flour is a blend of the three break flour streams including the grader flour and the five reduction streams including the 1M re-duster flour. The mean particle size of the straight grade flour will be about 100 microns with flour ash content usually between 0.38 and 0.50%. Bran, break shorts, tail shorts and red dog are by-products which are not included with the flour. Flour yields for soft wheat vary between 70 and 78%. Flour yield is variety dependent, due to heritable milling quality differences, and/or grain quality dependent, as influenced by environmental growing conditions. Sprouted and/or shriveled kernels negatively impact flour production. Recovery of all mill products is usually about 98%.

Milling and Baking Results Reported by Collaborators and SWQL

Mill Stream Distribution by SWQL

Table 1. Miag Multomat Mill Stream Yields of the WQC 2015 Crop Year Entries by SWQL

Mill Stream	AgriMAXX 462	Hilliard	VA 258*	E6012	MCIA Venus*
1st Break	6.7	12.0	7.0	8.3	5.9
2nd Break	6.9	13.3	8.5	9.0	4.1
Grader	3.0	4.8	4.8	3.8	2.4
3rd Break	9.6	7.2	6.4	8.5	12.0
Total Brk	26.2	37.3	26.8	29.7	24.3
1st Middlings	11.5	9.8	9.6	10.6	8.8
2nd Middlings	16.0	10.3	14.7	14.5	15.6
3rd Middlings	6.7	2.9	7.6	6.6	11.5
Re-Dust	7.5	5.7	7.3	6.5	5.9
4th Middlings	2.9	1.8	4.4	3.6	6.9
5th Middlings	1.1	1.0	1.8	1.4	1.6
Total Middlings	45.6	31.5	45.5	43.3	50.5
Straight Grade	71.8	68.8	72.2	73.0	74.8
Break Shorts	6.2	6.6	6.1	5.6	6.4
Red Dog	0.7	0.6	0.9	0.7	0.6
Tail Shorts	0.3	0.2	0.4	0.2	0.2
Bran	19.9	22.8	20.0	20.4	17.9
Total Byproduct	27.2	30.2	27.4	27.0	25.2

*Check varieties.

Miag Multomat Flour Milling Ash Curves

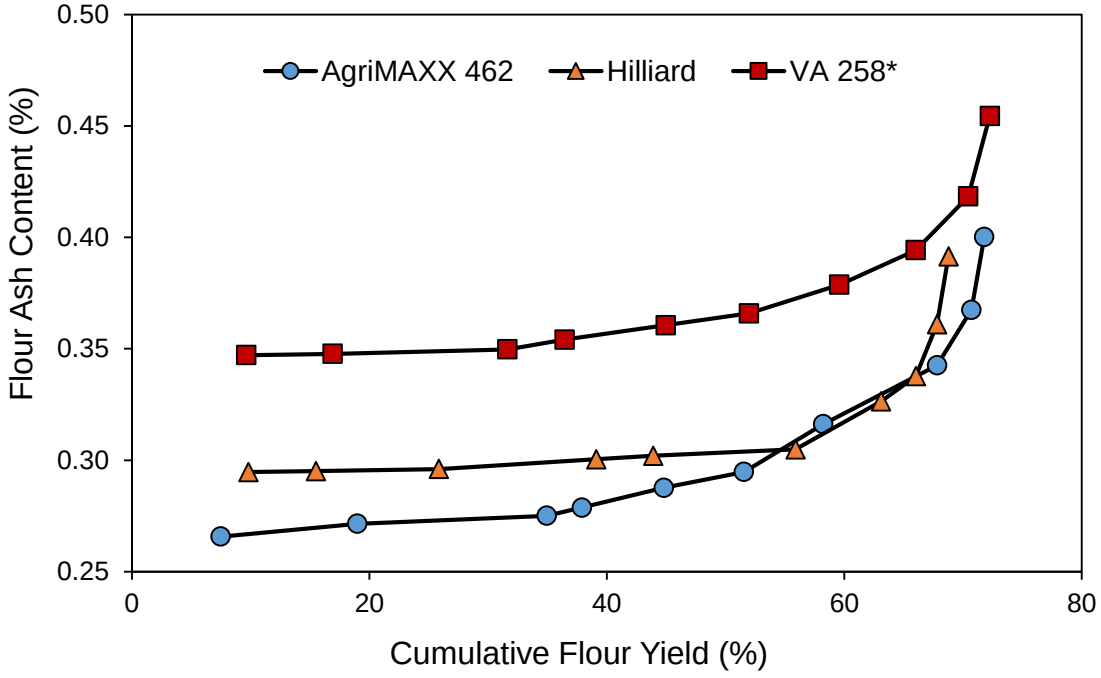

Table 2. Yield and Ash Content of Mill Streams for the WQC 2015 Crop Entries from Virginia Polytechnic Institute and State University

Flour Stream	AgriMAXX 462		Hilliard		VA 258*	
	Yield (%)	Ash (%)	Yield (%)	Ash (%)	Yield (%)	Ash (%)
1 Brk	6.7	0.342	12.0	0.315	7.0	0.400
2 Brk	6.9	0.336	13.3	0.309	8.5	0.388
Grader	3.0	0.322	4.8	0.315	4.8	0.383
3 Brk	9.6	0.503	7.2	0.493	6.4	0.538
1 Mids	11.5	0.275	9.8	0.295	9.6	0.347
2 Mids	16.0	0.279	10.3	0.297	14.7	0.352
3 Mids	6.7	0.481	2.9	0.580	7.6	0.467
Re-Dust	7.5	0.266	5.7	0.296	7.3	0.348
4 Mids	2.9	0.951	1.8	1.230	4.4	0.779
5 Mids	1.1	2.538	1.0	2.520	1.8	1.852

*Check variety.

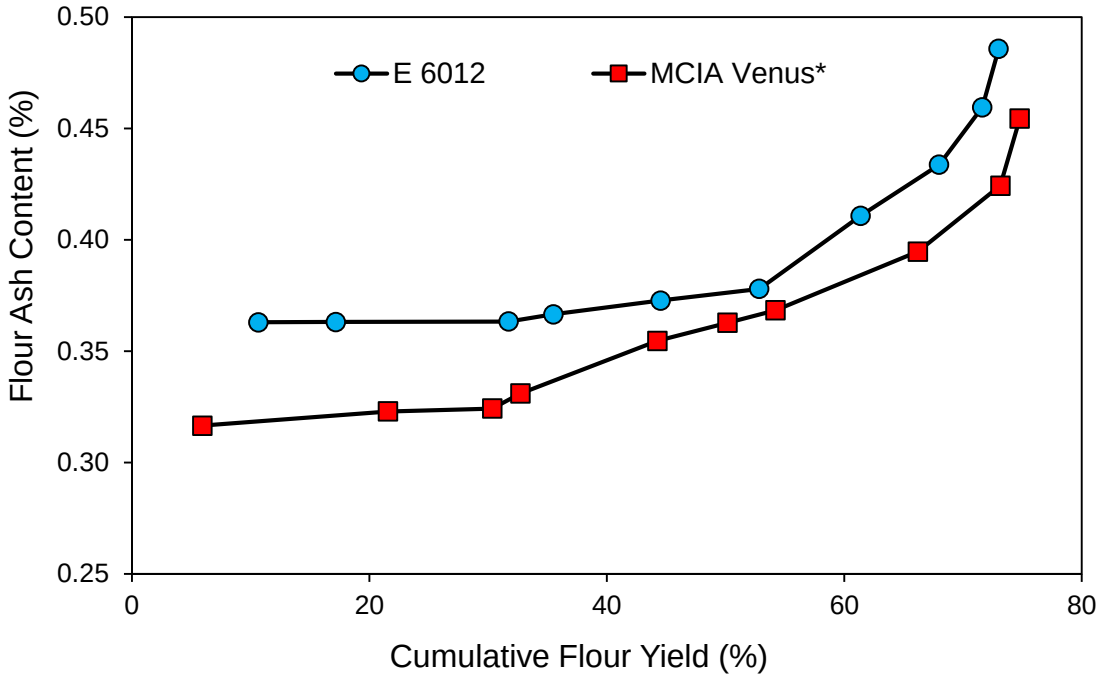

Table 3. Yield and Ash Content of Mill Streams for the WQC 2015 Crop Entries from Michigan State University

Flour Stream	E6012		MCIA Venus*	
	Yield (%)	Ash (%)	Yield (%)	Ash (%)
1 Brk	8.3	0.406	5.9	0.424
2 Brk	9.0	0.397	4.1	0.438
Grader	3.8	0.393	2.4	0.417
3 Brk	8.5	0.614	12.0	0.514
1 Mids	10.6	0.363	8.8	0.327
2 Mids	14.5	0.364	15.6	0.325
3 Mids	6.6	0.646	11.5	0.421
Re-Dust	6.5	0.363	5.9	0.317
4 Mids	3.6	0.942	6.9	0.706
5 Mids	1.4	1.844	1.6	1.812

*Check variety.

Wheat grain and flour quality characteristics

Table 4. Grain characteristics, SKCS test parameters by USDA-ARS Soft Wheat Quality Laboratory

Group	Entry	Test Weight (lb/bu)	Grain Protein (%, 12% mb)	Grain Falling Number	SKCS Parameter		
					Hardness	Kernel Weight (mg)	Kernel Diameter (mm)
1	AgriMAXX 462	57.9	9.9	366	54.3	30.7	2.7
1	Hilliard	58.5	11.0	398	13.4	26.5	2.6
1	VA 258*	60.0	9.4	369	29.4	32.4	2.6
2	E6012	59.8	11.0	355	24.0	31.8	2.6
2	MCIA Venus*	60.8	9.0	384	39.9	39.3	2.8

*Check varieties.

Table 5. Milling quality parameters of the entries by USDA-ARS Soft Wheat Quality Laboratory

Group	Entry	Miag Milling Quality		Qudrumat Milling Quality	
		Break Flour Yield (%)	Straight Grade Flour Yield (%)	Flour Yield (%)	Softness Equivalent (%)
1	AgriMAXX 462	26.2	71.8	68.5	51.5
1	Hilliard	37.3	68.8	68.5	64.8
1	VA 258*	26.8	72.2	67.3	54.5
2	E6012	29.7	73.0	68.6	57.0
2	MCIA Venus*	24.3	74.8	69.4	43.9

*Check varieties.

Table 6. Flour quality test parameters by USDA-ARS Soft Wheat Quality Laboratory

Group	Entry	Moisture (%)	Protein (%, 14% mb)	pH	α-amylase Activity	Starch Damage (%)	Flour Ash (%, 14% mb)
	AgriMAXX 462	12.5	8.3	6.0	0.09	5.8	0.38
1	Hilliard	12.5	9.0	6.1	0.04	2.2	0.41
1	VA 258*	12.3	8.1	6.0	0.04	3.4	0.43
2	E6012	12.2	9.7	6.0	0.05	2.8	0.47
2	MCIA Venus*	12.2	7.4	6.1	0.02	6.8	0.41

*Check varieties.

Summaries and Statistics of Combined Cooperator Test Parameters

Table 7. Mean SRC test parameters and overall flour quality scores by ten cooperators (n=10)[a].

Group	Entry	Solvent Retention Capacity (%)*				Flour Quality Score*
		Water	Sodium Carbonate	Sucrose	Lactic Acid	
1	AgriMAXX 462	61.7 a	80.0 a	106.2 a	129.4 a	4.5 b
1	Hilliard	55.4 b	78.0 a	107.5 a	123.4 a	6.0 a
1	VA 258*	57.8 b	80.6 a	112.8 a	115.9 a	5.8 ab
2	E6012	53.0 b	72.3 a	97.3 a	102.1 a	6.0 a
2	MCIA Venus*	58.7 a	75.3 a	95.0 a	77.3 b	5.3 a

*Check varieties.

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

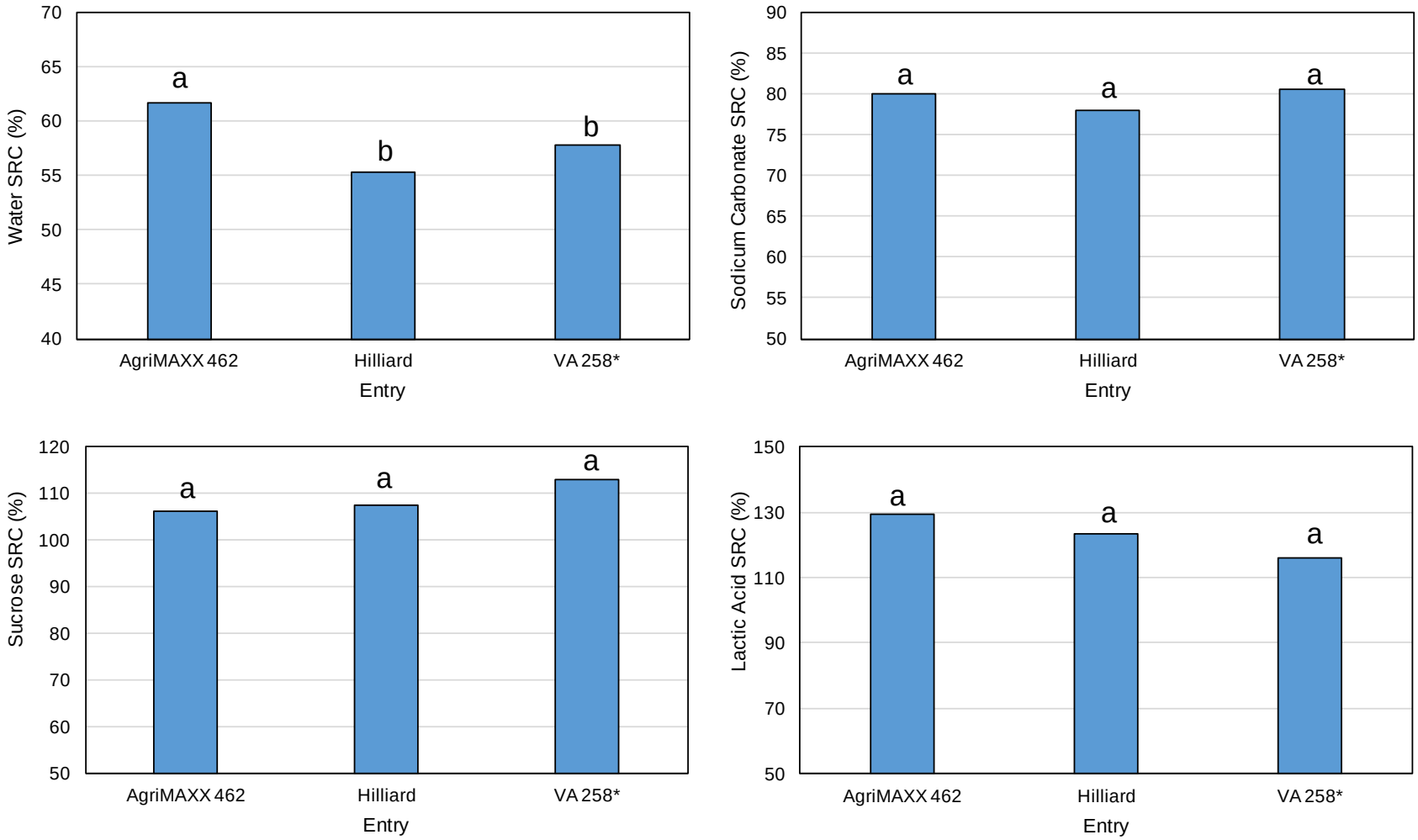

Figure 1. Mean differences in solvent retention capacities of Virginia Polytechnic Institute and State University Entries.

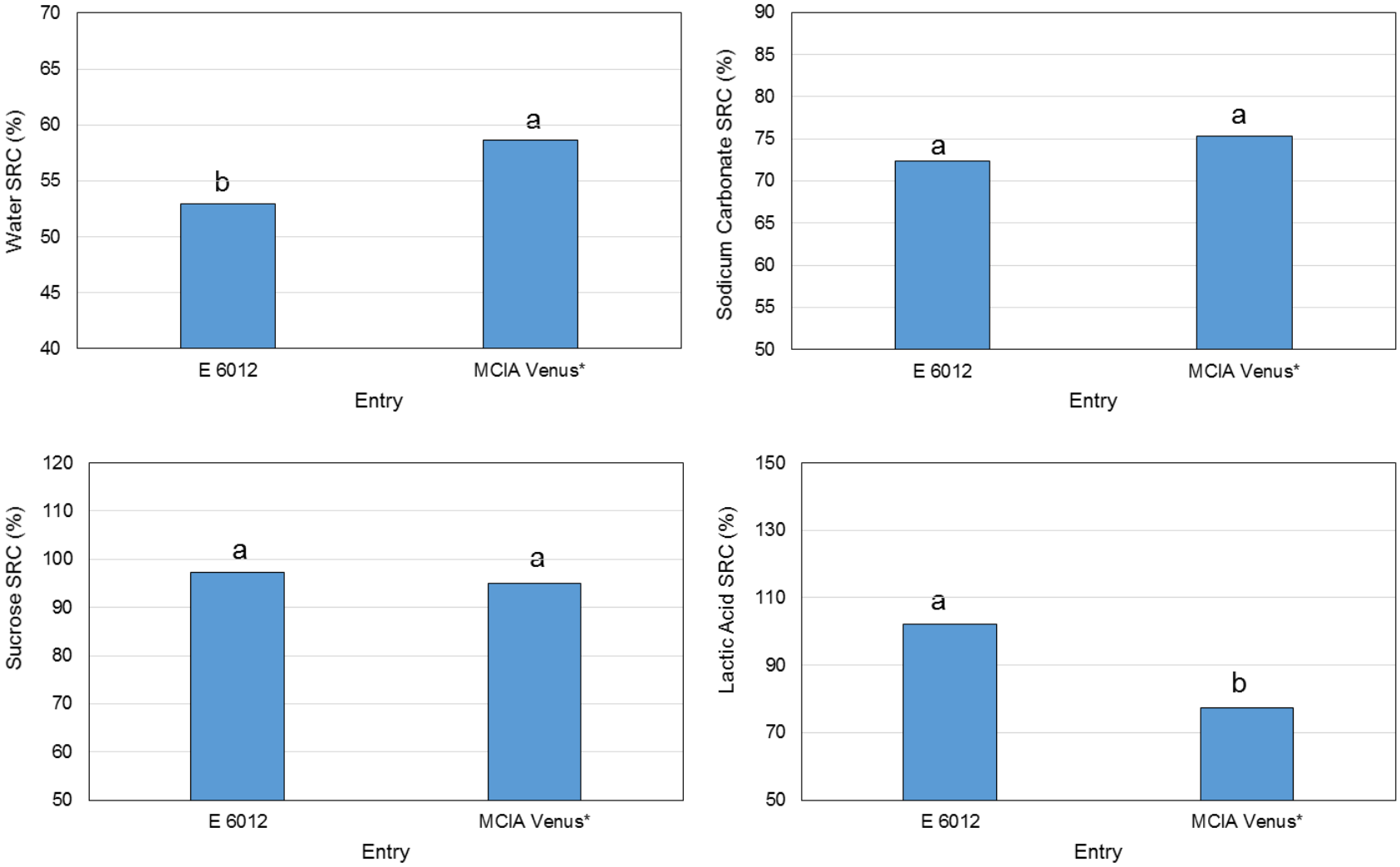

Figure 2. Mean differences in solvent retention capacities of Michigan State University Entries.

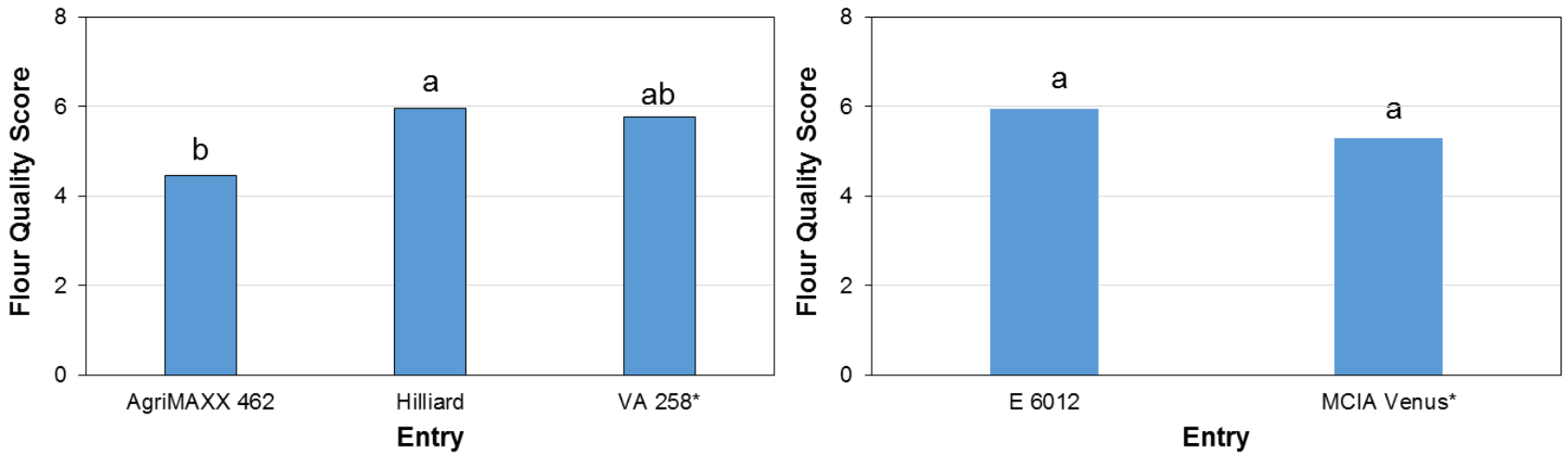

Figure 3. Mean differences in flour quality scores of 2015 crop Soft WQC Entries.

Table 8. Mean Alveograph test parameters by two collaborators (n=1)

Group	Entry	Alveograph			
		P	L	P/L Ratio	W
1	AgriMAXX 462	73.9	48.8	1.5	159.6
1	Hilliard	43.8	95.6	0.5	123.9
1	VA 258*	51.3	101.0	0.5	128.2
2	E6012	35.1	162.6	0.2	137.6
2	MCIA Venus*	58.9	37.0	1.6	86.7

*Check varieties.

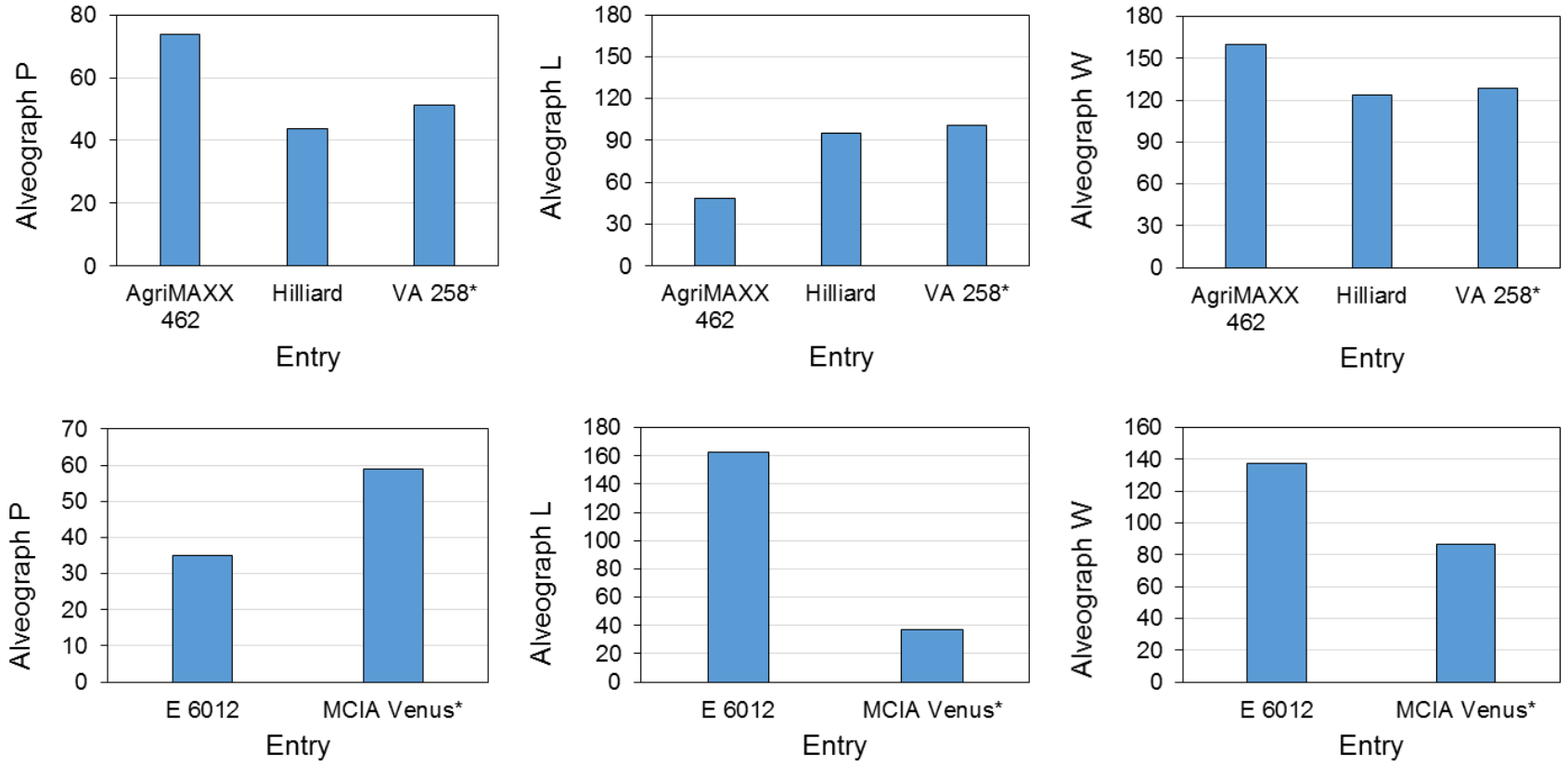

Figure 4. Mean differences in Alveograph parameters of Virginia Polytechnic Institute and State University entries (top) and Michigan State University entries (bottom).

Table 9. Mean Farinograph test parameters by two collaborators (n=2)[a]

Group	Entry	Farinograph (n=2)*			
		Water Absorption (%)	Development Time (min)	Stability (min)	Mixing Tolerance Index (BU)
1	AgriMAXX 462	57.2 a	1.3 a	2.0 b	97.0
1	Hilliard	54.0 a	1.5 a	4.7 a	68.0
1	VA 258*	54.8 a	1.7 a	4.5 a	82.0
2	E6012	52.7 a	2.1 a	8.2 a	49.0
2	MCIA Venus*	57.7 a	1.1 a	2.4 b	122.0

*Check varieties.

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

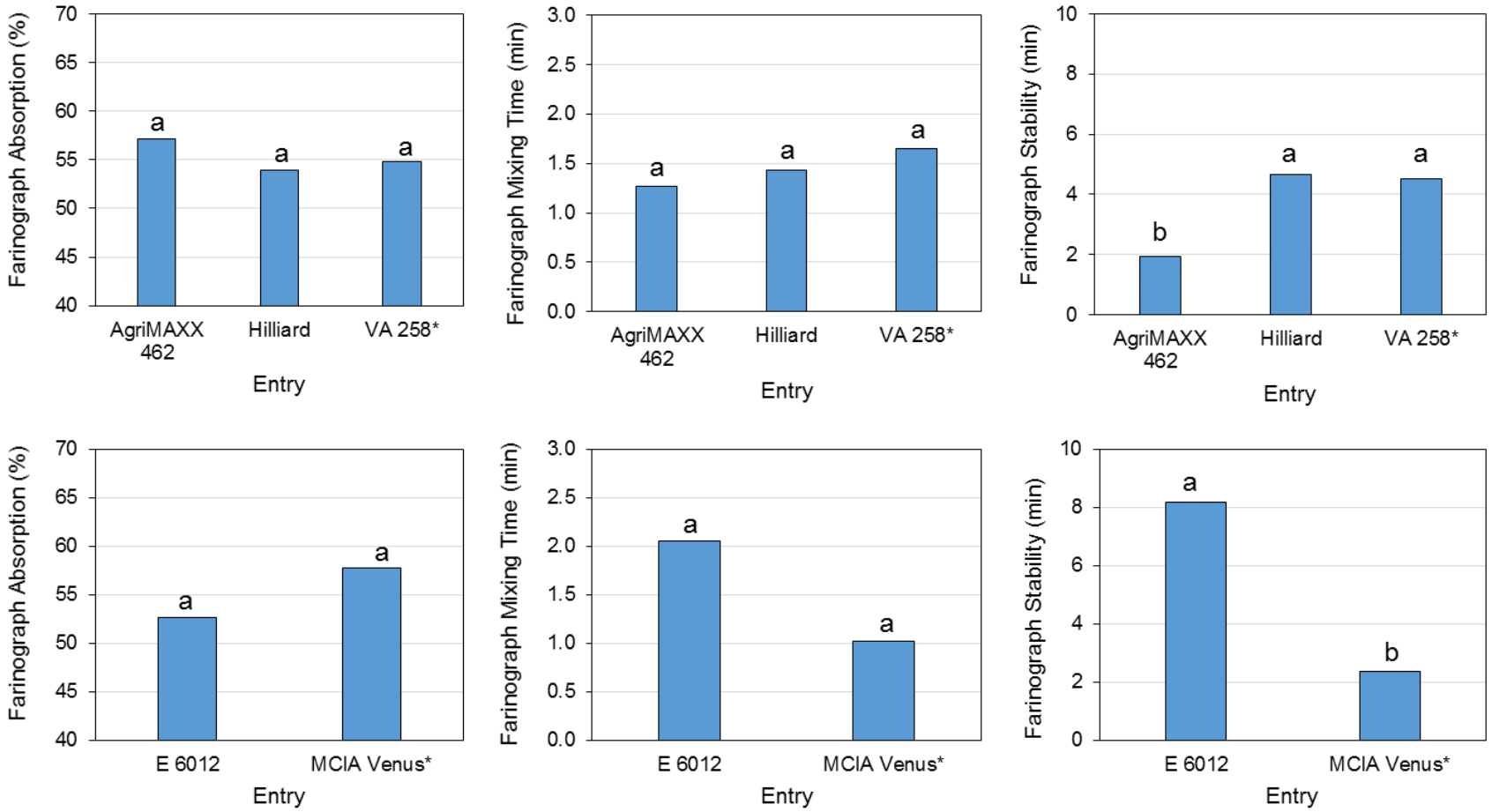

Figure 5. Mean differences in Farinograph parameters of Virginia Polytechnic Institute and State University entries (top) and Michigan State University entries (bottom).

Table 10. 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)	Peak/Final Ratio
1	AgriMAXX 462	5.6 a	1851 c	898 c	952 a	887 a	1998 c	67 a	0.93 a
1	Hilliard	6.0 a	3385 a	2059 a	1326 a	1365 a	3699 a	71 a	0.92 a
1	VA 258*	6.0 a	2551 b	1477 b	1074 a	1113 a	2841 b	68 a	0.90 a
2	E6012	6.1 a	2746 a	1496 a	1250 a	1072 a	2868 a	77 a	0.96 a
2	MCIA Venus*	6.0 a	1774 b	1340 a	434 b	1238 a	2683 a	60 a	0.66 b

*Check varieties.

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

Table 11. Mean sugar-snap cookie test (AACCI Approved method 10-50D (n=4) & 10-52 (n=4)) parameters[a]

		Sugar-Snap Cookie (10-50D)				Sugar-Snap Cookie (10-52)	Overall Product Quality Score
		Width (mm)	Thickness (mm)	W/T Ratio (mm)	Spread Factor	Width (cm)	
1	AgriMAXX 462	449 c	69 a	6.5 c	64 b	16.0 b	3.0 b
1	Hilliard	490 a	60 b	8.1 a	80 a	17.4 a	5.9 a
1	VA 258*	474 b	62 b	7.6 b	75 a	17.0 a	4.6 a
2	E6012	491 a	62 b	7.9 a	78 a	17.7 a	5.9 a
2	MCIA Venus*	456 b	70 a	6.5 b	63 b	16.9 b	4.1 b

*Check varieties.

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

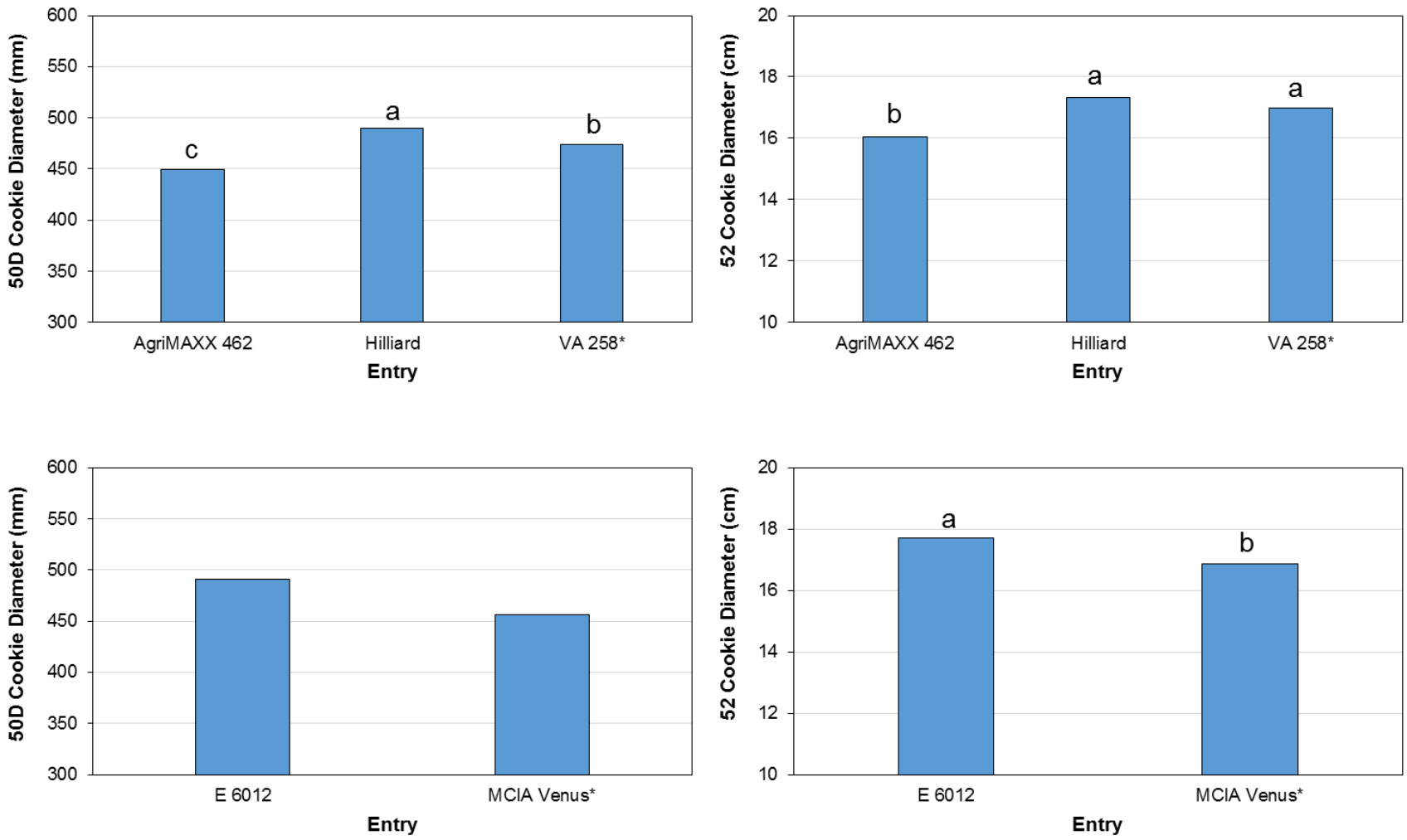

Figure 6. Mean differences in sugar-snap cookie (10-50D & 10-52) diameters of 2015 crop Soft WQC entries.

Table 12. Mean (n=2) sponge cake baking test parameters[a]

Group	Entry	Sponge Cake	
		Volume (mL)	Texture Score
1	AgriMAXX 462	1032 a	26 a
1	Hilliard	1175 a	30 a
1	VA 258*	1170 a	27 a
2	E6012	1116 a	32 a
2	MCIA Venus*	1125 a	33 a

*Check varieties.

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

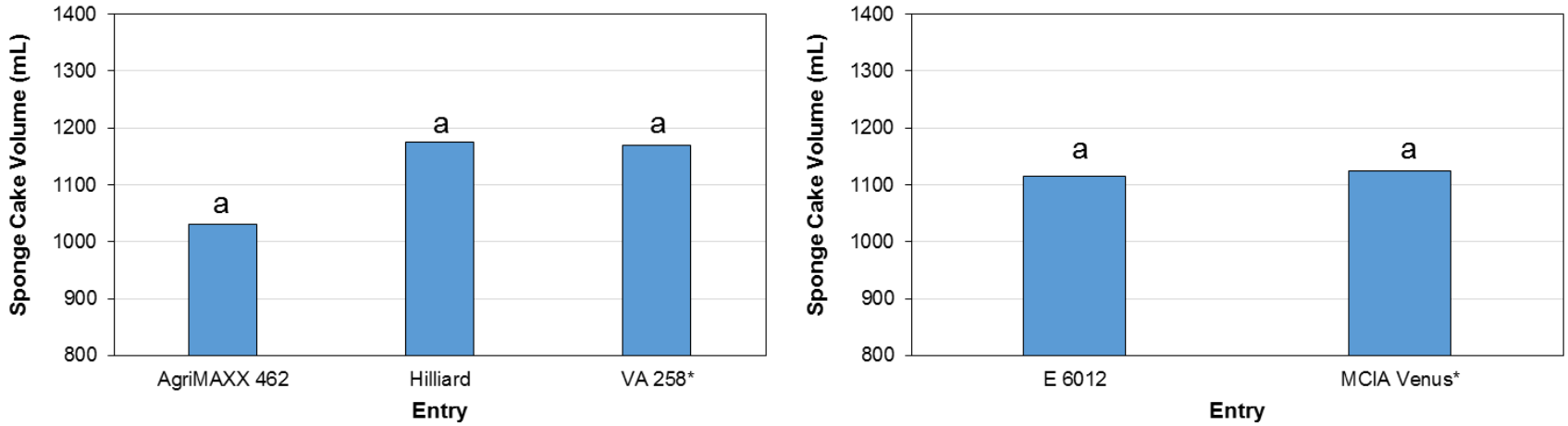

Figure 7. Mean differences in sponge cake volumes of 2015 crop Soft WQC entries.

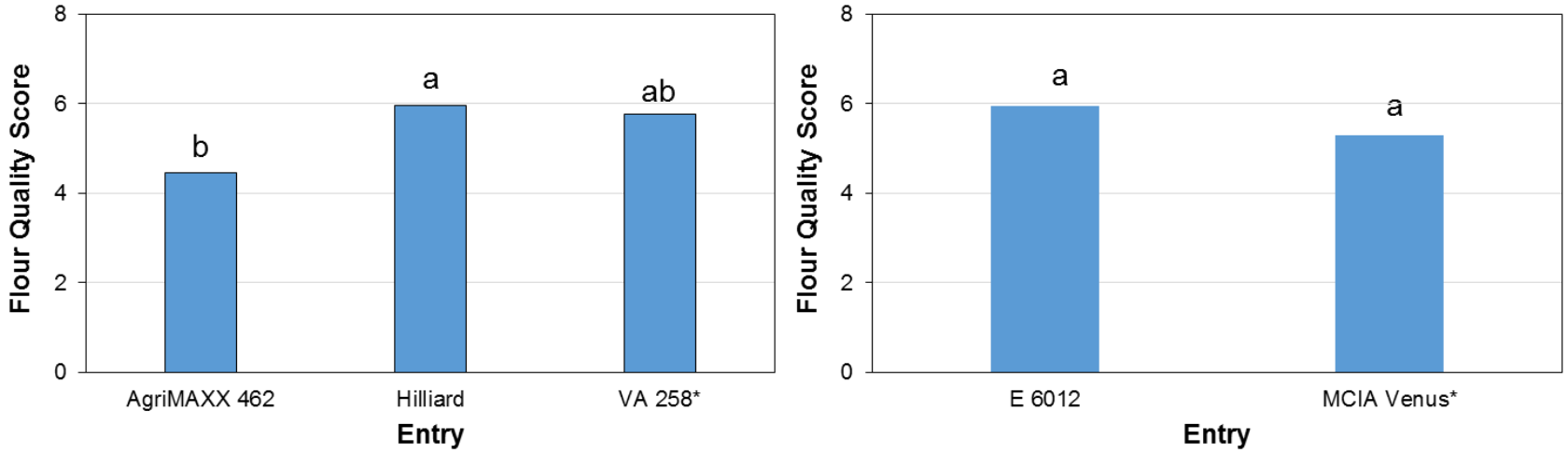

Figure 8. Mean differences in product quality scores of 2015 crop Soft WQC entries.

Cooperator Data for Each Quality Test Parameter

Table 13. Water SRC (%) of 2015 WQC entries by cooperators

Group	Entry	ADM	Ardent	Kellogg's	Limagrain	Mennel	Mondeléz	Star of West	SWQL	Syngenta	WWQL	Mean	STDEV
1	AgriMAXX 462	55.4	59.9	54.6	62.3	62.2	69.3	64.3	65.5	58.0	65.3	61.7	4.71
1	Hilliard	50.6	55.5	49.9	57.1	54.8	61.0	54.4	57.4	55.0	58.0	55.4	3.33
1	VA 258*	55.2	58.2	53.0	59.5	56.9	61.2	57.3	60.9	57.0	58.8	57.8	2.51
2	E6012	49.3	52.9	48.6	55.7	54.5	55.8	51.8	56.0	51.0	54.0	53.0	2.72
2	MCIA Venus*	57.5	60.5	54.7	59.5	59.8	59.0	57.6	62.3	58.0	57.9	58.7	2.05

*Check varieties.

Table 14. Sodium Carbonate SRC (%) of 2015 WQC entries by cooperators

Group	Entry	ADM	Ardent	Kellogg's	Limagrain	Mennel	Mondeléz	Star of West	SWQL	Syngenta	WWQL	Mean	STDEV
1	AgriMAXX 462	71.4	87.4	71.4	86.8	82.3	89.9	84.8	86.2	74.0	65.7	80.0	8.52
1	Hilliard	76.9	82.8	71.8	81.7	79.8	81.9	79.3	80.8	73.0	72.2	78.0	4.26
1	VA 258*	78.1	87.2	71.4	84.9	82.5	88.3	83.7	85.0	74.0	71.0	80.6	6.51
2	E6012	72.3	74.3	65.7	75.9	73.6	76.5	74.4	76.7	68.0	65.8	72.3	4.27
2	MCIA Venus*	72.4	79.1	69.3	79.5	75.0	80.3	76.7	80.5	74.0	65.7	75.3	5.00

*Check varieties.

Table 15. Sucrose SRC (%) of 2015 WQC entries by cooperators

Group	Entry	ADM	Ardent	Kellogg's	Limagrain	Mennel	Mondeléz	Star of West	SWQL	Syngenta	WWQL	Mean	STDEV
1	AgriMAXX 462	73.8	117.0	89.8	119.4	117.1	127.5	112.9	102.3	102.0	100.6	106.2	15.97
1	Hilliard	93.6	111.9	89.0	113.6	112.9	126.1	116.5	107.8	106.0	98.0	107.5	11.27
1	VA 258*	99.9	129.3	93.6	119.1	117.2	124.3	122.7	111.9	109.0	101.0	112.8	11.81
2	E6012	85.4	105.0	84.3	102.9	99.4	111.8	101.8	96.8	94.0	91.2	97.3	8.72
2	MCIA Venus*	88.5	99.6	85.2	98.6	96.8	104.6	97.2	96.2	93.0	90.2	95.0	5.79

*Check varieties.

Table 16. Lactic acid SRC (%) of 2015 WQC entries by cooperators

Group	Entry	ADM	Ardent	Kellogg's	Limagrain	Mennel	Mondeléz	Star of West	SWQL	Syngenta	WWQL	Mean	STDEV
1	AgriMAXX 462	125.3	122.1	121.3	127.1	136.6	142.0	138.4	126.7	114.0	140.9	129.4	9.47
1	Hilliard	130.9	120.1	128.0	135.2	129.6	114.5	124.3	121.3	115.0	115.4	123.4	7.33
1	VA 258*	120.4	123.0	118.2	123.5	123.3	108.2	107.6	113.4	109.0	112.6	115.9	6.51
2	E6012	109.4	104.8	106.7	111.9	108.7	85.7	102.7	96.9	97.0	97.6	102.1	7.93
2	MCIA Venus*	79.9	76.7	77.7	80.0	80.3	76.5	75.9	75.5	72.0	78.7	77.3	2.56

*Check varieties.

Table 17. Farinograph absorption and dough development time of 2015 WQC entries by cooperators

Group	Entry	Absorption (%)				Development Time (min)			
		Kellogg's	Mennel	Mean	STDEV	Kellogg's	Mennel	Mean	STDEV
1	AgriMAXX 462	56.5	57.9	57.2	0.99	1.1	1.4	1.3	0.24
1	Hilliard	53.0	54.9	54.0	1.34	1.4	1.5	1.4	0.04
1	VA 258*	53.9	55.7	54.8	1.27	1.5	1.8	1.7	0.22
2	E6012	51.1	54.2	52.7	2.19	1.7	2.4	2.1	0.49
2	MCIA Venus*	56.6	58.8	57.7	1.56	1.3	0.8	1.0	0.39

*Check varieties.

Table 18. Farinograph dough stability and mixing tolerance index (MTI) of 2015 WQC entries by cooperators

Group	Entry	Dough Stability (min)				MTI (FU)			
		Kellogg's	Mennel	Mean	STDEV	Kellogg's	Mennel	Mean	STDEV
1	AgriMAXX 462	1.5	2.4	1.9	0.61	.	97	.	.
1	Hilliard	5.2	4.1	4.7	0.78	.	68	.	.
1	VA 258*	4.9	4.1	4.5	0.54	.	82	.	.
2	E6012	9.2	7.1	8.2	1.46	.	49	.	.
2	MCIA Venus*	2.9	1.8	2.4	0.78	.	122	.	.

*Check varieties.

Table 19. Sugar-snap cookie (10-50D) diameter (mm) of 2015 WQC entries by cooperators

Group	Entry	ADM	Ardent	Mennel	Star of West	Mean	STDEV
1	AgriMAXX 462	455	445	454	443	449	6.1
1	Hilliard	483	486	494	496	490	6.5
1	VA 258*	464	469	485	479	474	9.3
2	E6012	490	485	501	487	491	7.3
2	MCIA Venus*	456	449	461	458	456	5.1

*Check varieties.

Table 20. Sugar-snap cookie (10-52) diameter (mm) of 2015 WQC entries by cooperators

Group	Entry	Limagrain	SWQL	Syngenta	WWQL	Mean	STDEV
1	AgriMAXX 462	16.3	15.8	16.2	15.8	16	0.3
1	Hilliard	17.8	17.1	17.6	16.9	17	0.4
1	VA 258*	17.2	16.8	17.0	17.0	17	0.1
2	E6012	17.7	17.6	17.8	17.8	18	0.1
2	MCIA Venus*	17.3	16.5	16.8	16.8	17	0.3

*Check varieties.

Table 21. Sponge cake volume of 2015 WQC entries by cooperators

Group	Entry	WMC	WWQL	Mean	STDEV
1	AgriMAXX 462	1075	988	1032	61.5
1	Hilliard	1126	1223	1175	68.6
1	VA 258*	1130	1210	1170	56.6
2	E6012	1123	1108	1116	10.6
2	MCIA Venus*	1110	1140	1125	21.2

*Check varieties.

Table 22. Flour quality scores of 2015 WQC entries by cooperators

Group	Entry	ADM	Ardent	Kellogg's	Limagrain	Mennel	Mondeléz	Siemer	Star of West	Syngenta	WMC	WWQL	**Mean[a]**	**STDEV**
1	AgriMAXX 462	5	6	6	4	3	3	6	4	2	7	3	4.5 b	1.6
1	Hilliard	4	5	7	7	6	4	9	8	4	7.5	4	6.0 a	1.9
1	VA 258*	5	6	8	5	6	4	9	6	4	6.5	4	5.8 ab	1.6
2	E6012	4	8	8	8	.	5	5	7	6	3.5	5	6.0 a	1.7
2	MCIA Venus*	3	7	5	7	.	3	4	6	5	8	5	5.3 a	1.7

*Check varieties.

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

Table 23. Product quality scores of 2015 WQC entries by cooperators

Group	Entry	ADM	Ardent	Limagrain	Mennel	Mondeléz	Star of West	Syngenta	WMC	WWQL	**Mean[a]**	**STDEV**
1	AgriMAXX 462	3	6	4	3	3	3	1	3	1	3.0 b	1.5
1	Hilliard	6	8	8	6	4	8	5	3.5	5	5.9 a	1.7
1	VA 258*	4	6	6	5	4	6	3	2.5	5	4.6 a	1.3
2	E6012	6	8	8	6	5	7	5	5	3	5.9 a	1.6
2	MCIA Venus*	3	4	6	3	3	6	4	5	3	4.1 b	1.3

*Check varieties.

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

Cooperator Data

ADM Milling Quality Evaluations

Table 24. Solvent retention capacity and sugar-snap cookie baking test parameters by ADM Milling
*Check varieties.

Group	Entry	Solvent Retention Capacity (%)				Cookie (10-50D)			
		Water	Sodium Carbonate	Sucrose	Lactic Acid	Width (mm)	Thick (mm)	W/T Ratio (mm)	Spread Factor
1	AgriMAXX 462	55.4	71.4	73.8	125.3	45.5	7.1	6.2	62.1
1	Hilliard	50.6	76.9	93.6	130.9	48.3	5.9	7.9	78.8
1	VA 258*	55.2	78.1	99.9	120.4	46.4	6.1	7.3	73.3
2	E6012	49.3	72.3	85.4	109.4	49.0	6.1	7.8	78.1
2	MCIA Venus*	57.5	72.4	88.5	79.9	45.6	7.1	6.2	62.3

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

		Analytical Flour Qualities				End Product Performance				
Group	Entry	Score: 1 Poor - 9 Excellent				Score: 1 Poor - 9 Excellent				Aditional Comments
		Likes	Dislikes	Basis	Score	Product	Likes	Dislikes	Score	Mitigating, Physical/Chemical Properties
1	AgriMAXX 462				5	Very dry dough, Poor Spread			3	Poorer than check
1	Hilliard	Hightest falling number			4	Very dry dough, Light checking, Best spread in this set			6	Better than check
1	VA 258*				5	Good dough			4	
2	E 6012	Highest protein			4	Good dough, Good checking			6	Better than check
2	Venus*	Lowest protein			3	Slightly dry dough, Light checking, Poor Spread			3	

Ardent Mills Quality Evaluations

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

Group	Entry	Solvent Retention Capacity (%)				Cookie (10-50D)			
		Water	Sodium Carbonate	Sucrose	Lactic Acid	Width (mm)	Thick (mm)	W/T Ratio (mm)	Spread Factor
1	AgriMAXX 462	59.9	87.4	117.0	122.1	444.5	70.5	6.3	60.8
1	Hilliard	55.5	82.8	111.9	120.1	485.5	59.0	8.2	79.3
1	VA 258*	58.2	87.2	129.3	123.0	469.0	63.5	7.4	71.2
2	E6012	52.9	74.3	105.0	104.8	484.5	62.5	7.8	74.7
2	MCIA Venus*	60.5	79.1	99.6	76.7	449.0	74.0	6.1	58.5

*Check varieties.

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

		Analytical Flour Qualities				End Product Performance			
Group	Entry	Score: 1 Poor - 9 Excellent				Score: 1 Poor - 9 Excellent			
		Likes	Dislikes	Basis	Score	Product	Likes	Dislikes	Score
1	AgriMAXX 462	High glutenin and water absorption	High starch damage		6	Cookie		low spread factor and diameter	6
1	Hilliard	High glutenin	Low water absorption, high starch damage		5	Cookie	High spread factor and diameter		8
1	VA 258*	High protein and glutenin	High damaged starch, and pentosans		6	Cookie			6
2	E 6012	High protein, low damaged starch, and pentosans	low water absorption		8	Cookie	High spread factor and diameter		8
2	Venus*	High water absorption, low pentosans and starch damage	Low protein and glutenin		7	Cookie		low spread factor and diameter	4

Kellogg's Quality Evaluations

Table 28. Flour characteristics and solvent retention capacity parameters by Kellogg's

Group	Entry	Flour Characteristics					Solvent Retention Capacity (%)			
		Protein (%)	Ash (%)	Falling Number	α-amylase (U/100g)	pH	Water	Sodium Carbonate	Sucrose	Lactic Acid
1	AgriMAXX 462	8.3	0.34	321	16	5.9	54.6	71.4	89.8	121.3
1	Hilliard	8.9	0.34	395	10	5.9	49.9	71.8	89.0	128.0
1	VA 258*	8.2	0.40	364	9	5.9	53.0	71.4	93.6	118.2
2	E6012	9.7	0.43	358	10	5.9	48.6	65.7	84.3	106.7
2	MCIA Venus*	7.6	0.37	420	6	5.9	54.7	69.3	85.2	77.7

*Check varieties.

Table 29. Alevograph and farinograph parameters by Kellogg's

Group	Entry	Farinograph			
		Water Absorption (%)	Development Time (min)	Stability (min)	Degree of Softening
1	AgriMAXX 462	56.5	1.1	1.5	124
1	Hilliard	53.0	1.4	5.2	66
1	VA 258*	53.9	1.5	4.9	69
2	E6012	51.1	1.7	9.2	45
2	MCIA Venus*	56.6	1.3	2.9	87

*Check varieties.

Table 30. Rapid Visco-Analyzer parameters by Kellogg's

Group	Entry	Peak Time (min)	Peak (cP)	Trough cP	Break-down cP	Setback cP	Final cP	Pasting Temp °C	Peak/Final Ratio
1	AgriMAXX 462	5.7	1776	924	852	252	2028	61	0.88
1	Hilliard	6.1	2904	1800	1103	324	3228	64	0.90
1	VA 258*	5.9	2412	1404	1009	348	2760	64	0.87
2	E6012	6.0	2652	1452	1199	168	2820	64	0.94
2	MCIA Venus*	6.0	1704	1284	417	900	2604	62	0.65

*Check varieties.

Table 31. Evaluation comments on analytical flour quality by Kellogg's

		Analytical Flour Qualities				
Group	Entry	Score: 1 Poor - 9 Excellent				Aditional Comments
		Likes	Dislikes	Basis	Score	Mitigating, Physical/Chemical Properties
1	AgriMAXX 462	Fairly good protein content and SRC-LA levels.	Relatively lower falling number, mixing tolerance and dough stability.	FN, SRC, Farino, RVA	6	Its protein content and quality are similar to VA258 the CK. Slightly higher a-amylase activity and marginally lower falling number (but still okay). It might be a bit more susceptable to presprouting. Farinograph dough development was slightly faster and less stable. Its low stability and apparent higher degree of softening (as well as lower RVA peak viscosity) might be related to the lower falling number. This flour should work well for cookies, but may have potential challenges for crackers due to slightly lower falling number.
1	Hilliard	Fairly high protein, FN, dough stability.	Slightly lower SRC-water.	FN, SRC, Farino	7	This line has fair amount of protein and good protein quality indicated by SRC-LA. Desiralbe high FN value. The only low parameter was SRC-Water but based on a single test. This flour would work well for cookies, crackers and pastries. If the low SRC-water was truly the flour's characteristic (need to consider other labs' results), then it may have challenges for batters due to lower water holding capacity.
1	VA 258*	Fairly high protein, FN, water absorption, and		FN, SRC, Farino	8	This flour would be suitable for cookies, crackers, pastries, and batters.
2	E 6012	High protein, FN, and dough mixing tolerance and	Slightly lower waster absorption.	FN, SRC, Farino	8	This flour would work well for crackers and pastries with its higher dough mixing stability. It's SRC-LA was not as high as expected despite it high protein.
2	Venus*	High FN and water absorption.	Low protein and dough stability	FN, SRC, Farino	5	It should be okay for cookies and crackers, and probably better for batters due to slightly higher water holding capacity.

Limagrain Cereal Seeds Quality Evalutions

Table 32. Solvent retention capacity, cookie baking test and flour color parameters by Limagrain Cereal Seeds

Group	Entry	Solvent Retention Capacity (%)				Cookie (10-52)			Flour Color		
		Water	Sodium Carbonate	Sucrose	Lactic Acid	Width (cm)	Thick (mm)	Crust	L	a	b
1	AgriMAXX 462	62.3	86.8	119.4	127.1	16.3	0.8	2.0	93.8	-3.5	10.4
1	Hilliard	57.1	81.7	113.6	135.2	17.8	0.5	3.0	94.6	-3.3	9.1
1	VA 258*	59.5	84.9	119.1	123.5	17.2	0.7	2.0	94.8	-3.5	9.7
2	E6012	55.7	75.9	102.9	111.9	17.7	0.6	3.0	94.6	-2.9	7.6
2	MCIA Venus*	59.5	79.5	98.6	80.0	17.3	0.8	3.0	95.1	-3.1	8.4

*Check varieties.

Table 33. Evaluation comments on analytical flour quality by Limagrain Cereal Seeds

						End Product Performance			
Group	Entry					Score: 1 Poor - 9 Excellent			
		Likes	Dislikes	Basis	Score	Product	Likes	Dislikes	Score
1	AgriMAXX 462		high sucrose/yellow		4				4
1	Hilliard	low ash			7		nice crust/top		8
1	VA 258*		high sucrose		5				6
2	E 6012	low b value			8				8
2	Venus*	white flour			7				6

Mennel Milling Quality Evaluations

Table 34. Solvent retention capacity and Farinograph test parameters by Mennel Milling

Group	Entry	Solvent Retention Capacity (%)				Farinograph			
		Water	Sodium Carbonate	Sucrose	Lactic Acid	Water Abs. (min)	Develop Time (min)	Stability (min)	MTI
1	AgriMAXX 462	62	82	117	137	57.9	1.4	2.4	97
1	Hilliard	55	80	113	130	54.9	1.5	4.1	68
1	VA 258*	57	82	117	123	55.7	1.8	4.1	82
2	E6012	54	74	99	109	54.2	2.4	7.1	49
2	MCIA Venus*	60	75	97	80	58.8	0.8	1.8	122

*Check varieties.

Table 35. Sugar-snap cookie baking test (10-50D) parameters by Mennel Milling

Group	Entry	Cookie (10-50D)					
		Width (mm)	Thick (mm)	W/T Ratio (mm)	Spread Factor	Crust	Score
1	AgriMAXX 462	454	64.6	7.0	69.0	3.5	3
1	Hilliard	494	59.8	8.3	81.2	6	7
1	VA 258*	484	60.0	8.1	79.3	5	6
2	E6012	501	61.1	8.2	80.5	6	6
2	MCIA Venus*	461	67.1	6.9	67.5	3.5	3

*Check varieties.

Table 36. 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	AgriMAXX 462	5.6	1652	837	815	984	1821	74.8	0.91
1	Hilliard	6.2	3126	2064	1062	1467	3531	84.1	0.89
1	VA 258*	6.0	2626	1625	1001	1395	3020	69.8	0.87
2	E6012	6.1	2851	1641	1211	1410	3050	83.7	0.93
2	MCIA Venus*	6.1	1831	1411	420	1309	2720	86.1	0.67

*Check varieties.

Table 37. Evaluation comments on flour quality and baked product performance by Mennel Milling

		Analytical Flour Qualities				End Product Performance				
Group	Entry	Score: 1 Poor - 9 Excellent				Score: 1 Poor - 9 Excellent				Aditional Comments
		Likes	Dislikes	Basis	Score	Product	Likes	Dislikes	Score	Mitigating, Physical/Chemical Properties
1	AgriMAXX 462	high abs-	low vic. Looks like low milling quality.	high suc/SC/SD with low ash and SF	3			low SF and crust score	3	I don't know if the weather was wet when these samples
1	Hilliard	good abs and pro. Good Visc.	high stab	high LA	6		best SF and crust score of set	tough dough- low SF	6	were harvest. The lactic acid and succrose are really high.
1	VA 258*	good abs. Good Visc.	high stab	high LA	6			tough dough- low SF	5	Hillard closest to check sample.
2	E 6012	high pro- good abs.	high stab-	high LA			higher SF ans crust score than ck	tough dough- low SF	6	E 6012 produced a better cookie but was a very strong flour
2	Venus*	good visc.	low pro- but very high abs.- weak flour	low LA			smoother dough	low SF and crust score	3	and dough than the check sample.

Mondeléz Quality Evaluations

Table 38. Solvent retention capacity and wire-cut cookie evaluation parameters by Mondeléz

Group	Entry	Solvent Retention Capacity (%)*					Wire-cut Cookie Evaluation (AACC 10-53)					
		Water	Sodium Carbonate	Sucrose	Lactic Acid	GPI	Dough Firmness (g)	Cookie Stack Ht (cm x4)	Cookie Width (cm x4)	Cookie Length (cm x4)	Weight Loss (%)	Final Moisture %
1	AgriMAXX 462	69.3	89.9	127.5	142.0	0.65	168	4.6	29.1	35.0	14.7	2.9
1	Hilliard	61.0	81.9	126.1	114.5	0.55	189	4.5	30.8	32.1	14.8	2.9
1	VA 258*	61.2	88.3	124.3	108.2	0.51	181	4.5	30.0	31.3	14.4	3.3
2	E6012	55.8	76.5	111.8	85.7	0.46	165	4.3	31.6	32.1	15.0	2.6
2	MCIA Venus*	59.0	80.3	104.6	76.5	0.41	221	4.9	28.8	29.9	14.1	3.6

*Check varieties.

Table 39. Evaluation comments on flour and end product quality characteristics by Mondeléz

		Analytical Flour Qualities				End Product Performance			
Group	Entry	Score: 1 Poor - 9 Excellent				Score: 1 Poor - 9 Excellent			
		Likes	Dislikes	Basis	Score	Product	Likes	Dislikes	Score
1	AgriMAXX 462	Lowest ash in the set	Very strong gluten strength, too high pentosans and damaged starch	SRC/Ash	3	Cookie	Low dough firmness	Performed not better than the check, not suitbale for cookies and crackers	3
1	Hilliard	Low ash	Good gluten potential, too high pentosans and damaged starch	SRC/Ash	4	Cookie		Similar baking performance to the check, not suitbale for cookies and crackers	4
1	VA 258*	Low ash	Good gluten potential, too high pentosans and damaged starch	SRC/Ash	4	Cookie		High dough firmness, small cookie diameter, high stack height, high moisture in cookie, poor quality for cookies, not siutable for cookies and crackers	4
2	E 6012	Ash is in the range of target	Low gluten potential, high pentosans and damaged starch	SRC/Ash	5	Cookie	Low dough firmness	Performed better than the check, marginal quality for cookies, not suitable for crackers	5
2	Venus*	Low ash and proten	Low gluten potential, high pentosans and damaged starch	SRC/Ash	3	Cookie		Too high dough firmness, small cookie diameter, high stack height, high moisture in cookie, poor quality for cookies, not suitable for cookies and crackers	3

Siemer Milling Quality Evaluations

Table 40. Alveograph test parameters by Siemer Milling

Group	Entry	Alveograph			
		P mm	L mm	P/L Ratio	W joules
1	AgriMAXX 462	73.9	48.8	1.51	159.6
1	Hilliard	43.8	95.6	0.46	123.9
1	VA 258*	51.3	101	0.51	128.2
2	E6012	35.1	162.6	0.22	137.6
2	MCIA Venus*	58.9	37	1.59	86.7

*Check varieties.

Table 41. Evaluation comments on alveograph dough test by Siemer Milling

		Analytical Flour Qualities				
Group	Entry	Score: 1 Poor - 9 Excellent				Aditional Comments
		Likes	Dislikes	Basis	Score	Mitigating, Physical/Chemical Properties
1	AgriMAXX 462			Alveo	6	Dough- Stiff-Tight Strong flour in relation to the alveo. Lower Ash
1	Hilliard			Alveo	9	Dough- normal. Higher protein.
1	VA 258*			Alveo	9	Dough normal. Protein similar to the previous years.
2	E 6012			Alveo	5	Dough very soft. High protein. Long extensibility
2	Venus*			Alveo	4	Dough - tight & stiff. High peaks- but no extensibility. Low protein

Star of the West Milling Evaluations

Table 42. Solvent retention capacity, cookie baking test and amyloviscograph test parameters by Star of the West Milling

Group	Entry	Solvent Retention Capacity (%)					Cookie (10-50D)			Amyloviscograph Peak Viscosity (BU)
		Water	Sodium Carbonate	Sucrose	Lactic Acid	LA/ SC+S	Width (mm)	Thick (mm)	W/T Ratio (mm)	
1	AgriMAXX 462	64.3	84.8	112.9	138.4	0.70	443	67	6.61	152
1	Hilliard	54.4	79.3	116.5	124.3	0.63	496	62	8.00	558
1	VA 258*	57.3	83.7	122.7	107.6	0.52	479	64	7.48	398
2	E6012	51.8	74.4	101.8	102.7	0.58	487	62	7.79	506
2	MCIA Venus*	57.6	76.7	97.2	75.9	0.44	458	68	6.74	356

*Check varieties.

Table 43. 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)	Peak/Final Ratio
1	AgriMAXX 462	5.1	2057	823	1234	1190	2013	50.2	1.02
1	Hilliard	5.2	4300	2387	1913	2147	4534	50.0	0.95
1	VA 258*	5.9	2528	1384	1144	1295	2679	67.1	0.94
2	E6012	6.0	2660	1387	1273	1324	2711	83.8	0.98
2	MCIA Venus*	5.9	1727	1264	463	1342	2606	63.0	0.66

*Check varieties.

Table 44. Evaluation comments on flour quality and baked product performance by Star of the West Milling

		Analytical Flour Qualities				End Product Performance				
Group	Entry	Score: 1 Poor - 9 Excellent				Score: 1 Poor - 9 Excellent				Additional Comments
		Likes	Dislikes	Basis	Score	Product	Likes	Dislikes	Score	Mitigating, Physical/Chemical Properties
1	AgriMAXX 462	Good gluten functionality indicated by SRC	low Amylograph	SRC, Amylograph	4	Cookies		tight cookies	3	Gluten functionality indicates this variety may make good crackers
1	Hilliard	Lowest sodium carbonate, good Amylograph,		SRC, Amylograph	8	Cookies	Best top pattern and best spread of group		8	Best flour of group.
1	VA 258*		lowest gluten functionality	SRC	6	Cookies			6	Average flour, no great positives or glaring negatives
2	E 6012	Better Amylograph and SRC profile than check		SRC Amylograph	7	Cookies	More distinct top pattern and larger spread than check		7	Best flour of group.
2	Venus*		Lower RVA viscocity	RVA	6	Cookies		tight cookies	6	

Syngenta Quality Evaluations

Table 45. 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)	Score
1	AgriMAXX 462	58	74	102	114	16.2	1
1	Hilliard	55	73	106	115	17.6	4
1	VA 258*	57	74	109	109	17.0	4
2	E6012	51	68	94	97	17.8	6
2	MCIA Venus*	58	74	93	72	16.8	5

*Check varieties.

Table 46. Evaluation comments on flour quality and baked product performance by Syngenta

		Analytical Flour Qualities				End Product Performance			
Group	Entry	Score: 1 Poor - 9 Excellent				Score: 1 Poor - 9 Excellent			
		Likes	Dislikes	Basis	Score	Product	Likes	Dislikes	Score
1	AgriMAXX 462		H2O,SUC high	SRC	2	Cookie 10-52		Very Small, No TG	1
1	Hilliard		SUC high	SRC	4	Cookie 10-52	Avg TG	Smaller Spread	5
1	VA 258*		SUC high	SRC	4	Cookie 10-52		Small, Poorer TG	3
2	E 6012	H2O, SC good		SRC	6	Cookie 10-52	Avg TG	Smaller Spread	5
2	Venus*	Low LA	H2O high	SRC	5	Cookie 10-52	Avg TG	Small Spread	4

Wheat Marketing Center Quality Evaluations

Table 47. Sponge cake baking test parameters by Wheat Marketing Center

Group	Entry	Sponge Cake				
		Volume (ml)	External	Crum Grain	Texture (g)	Texture Score
1	AgriMAXX 462	1075	13	19	3	35
1	Hilliard	1126	13	17	9	39
1	VA 258*	1130	11	15	9	35
2	E6012	1123	13	19	15	47
2	MCIA Venus*	1110	13	20	15	48

*Check varieties.

Table 48. Evaluation comments on flour quality and sponge cake baking test performance by Wheat Marketing Center

		Analytical Flour Qualities				End Product Performance				
Group	Entry	Score: 1 Poor - 9 Excellent				Score: 1 Poor - 9 Excellent				Aditional Comments
		Likes	Dislikes	Basis	Score	Product	Likes	Dislikes	Score	Mitigating, Physical/Chemical Properties
1	AgriMAXX 462	Lower flour protein	High flour ash		7	Sponge cake	Ok crumb grain	Very hard texture and low volume	3	
1	Hilliard	Lower flour protein and ash			7.5	Sponge cake		Hard texture	3.5	
1	VA 258*		Higher flour protein		6.5	Sponge cake		Poor crumb grain and hard texture	2.5	
2	E 6012		High flour protein and ash		3.5	Sponge cake	Ok crumb grain	Slightly hard texture	5	If protein and ash were equivalent to check, may have produced a better cake than check.
2	Venus*	Low flour protein and ash			8	Sponge cake	Ok crumb grain	Slightly hard texture	5	

USDA-ARS Western Wheat Quality laboratory Quality Evaluations

Table 49. Solvent retention capacity and mixograph test parameters by USDA-ARS Western Wheat Quality laboratory

Group	Entry	Solvent Retention Capacity (%)				Mixograph		Mixograph Mid-point			
		Water	Sodium Carbonate	Sucrose	Lactic Acid	Abs. (%)	Type	Time	Height	Work	Width +2min
1	AgriMAXX 462	65.3	65.7	100.6	140.9	55.0	7M	5.3	39.7	200.9	10.9
1	Hilliard	58.0	72.2	98.0	115.4	55.3	4M	4.4	43.0	175.0	7.7
1	VA 258*	58.8	71.0	101.0	112.6	55.8	4M	3.3	45.7	134.1	7.2
2	E6012	54.0	65.8	91.2	97.6	56.4	4M	4.0	46.5	168.3	8.9
2	MCIA Venus*	57.9	65.7	90.2	78.7	53.9	1M	2.7	43.2	107.3	5.9

*Check varieties.

Table 50. Sugar-snap cookie and sponge cake baking test parameters by USDA-ARS Western Wheat Quality laboratory
*Check varieties.

Group	Entry	Cookie (10-52) Width (cm)	Sponge Cake	
			Volume (mL)	Texture Score
1	AgriMAXX 462	7.91	988	16
1	Hilliard	8.46	1223	20
1	VA 258*	8.49	1210	19
2	E6012	8.9	1108	17
2	MCIA Venus*	8.41	1140	18

Table 51. Alkaline noodle color parameters by USDA-ARS Western Wheat Quality Laboratory

Group	Entry	Alkali noodle color @ 0 Hour			Alkali noodle color @ 24 Hour			Change in L*
		*L**	*a**	*b**	*L**	*a**	*b**	
1	AgriMAXX 462	88.2	-2.6	16.2	85.3	-2.2	18.4	2.9
1	Hilliard	86.0	-2.5	17.6	79.0	-1.6	23.7	7.0
1	VA 258*	87.1	-2.6	18.8	80.5	-1.5	25.4	6.6
2	E6012	86.8	-2.3	15.2	80.2	-1.2	20.4	6.6
2	MCIA Venus*	90.6	-2.5	14.6	85.7	-1.8	17.9	4.9

*Check varieties.

Table 52. Evaluation comments on flour quality and sponge cake baking performance by USDA-ARS Western Wheat Quality Laboratory

		Analytical Flour Qualities				End Product Performance				
Group	Entry	Score: 1 Poor - 9 Excellent				Score: 1 Poor - 9 Excellent				Aditional Comments
		Likes	Dislikes	Basis	Score	Product	Likes	Dislikes	Score	Mitigating, Physical/Chemical Properties
1	AgriMAXX 462		high water & sucrose	SRC	3	sugar snap cookie & sponge cake		both really poor products	1	low flour protein & ash, strong gluten type, good noodle color
1	Hilliard		somewhat higher carbonate, high sucrose	SRC	4	sugar snap cookie & sponge cake	reasonably good cake		5	low flour protein & ash, strong gluten type, good noodle color
1	VA 258*		somewhat higher carbonate, high sucrose	SRC	4	sugar snap cookie & sponge cake	reasonably good cake		5	low flour protein & ash, good noodle color
2	E 6012		best SRC profile	SRC	5	sugar snap cookie & sponge cake	best cookie	very poor cake	3	good noodle color
2	Venus*		best SRC profile	SRC	5	sugar snap cookie & sponge cake			3	low flour protein & ash, good noodle color

USDA-ARS Soft Wheat Quality Laboratory Soft Wheat Quality Evaluations

Table 53. 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	AgriMAXX 462	65.5	86.2	102.3	126.7	15.8	1
1	Hilliard	57.4	80.8	107.8	121.3	17.1	1
1	VA 258*	60.9	85.0	111.9	113.4	16.8	1
2	E6012	56.0	76.7	96.8	96.9	17.6	3
2	MCIA Venus*	62.3	80.5	96.2	75.5	16.5	4

*Check varieties.

Table 54. 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	AgriMAXX 462	5.80	1917	1009	908	1120	2129	82.3	0.90
1	Hilliard	6.27	3210	1984	1227	1520	3504	84.9	0.92
1	VA 258*	6.00	2638	1495	1143	1412	2906	70.2	0.91
2	E6012	6.13	2820	1504	1317	1386	2889	77.9	0.98
2	MCIA Venus*	6.10	1833	1399	434	1402	2801	86.8	0.65

*Check varieties.

Table 55. Mixograph parameters by USDA-ARS Soft Wheat Quality Laboratory

Group	Entry	Mixing Absorption (%)	Peak Time (min)	Peak Value (%)	Peak Width (%)	Width @7min (%)
1	AgriMAXX 462	57.0	4.0	41.3	15.1	11.1
1	Hilliard	55.0	0.9	43.2	17.9	8.2
1	VA 258*	54.5	2.0	50.1	22.1	6.8
2	E6012	56.0	2.5	49.6	23.3	7.7
2	MCIA Venus*	55.0	0.9	46.0	23.4	6.3

*Check varieties.

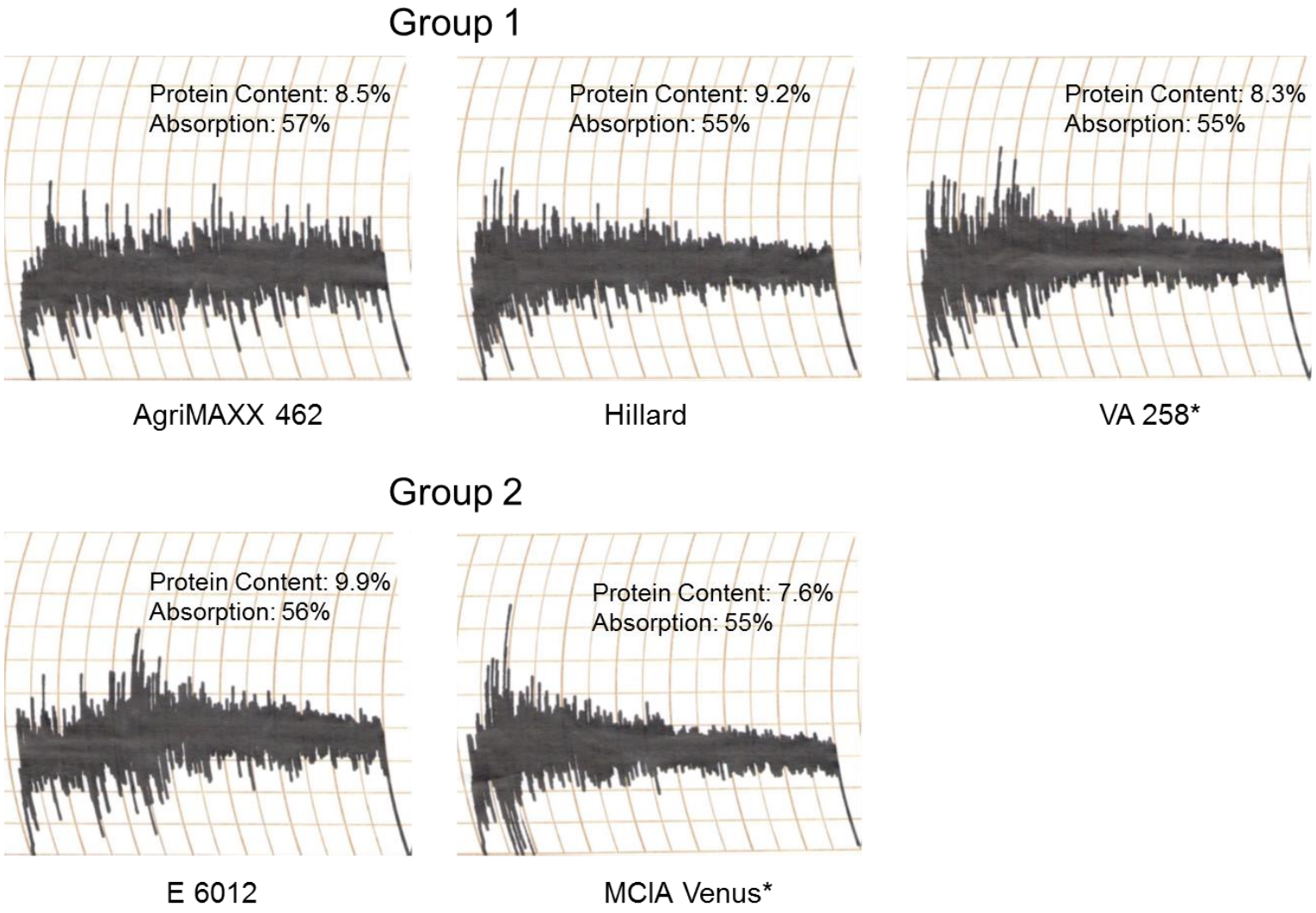

Figure 9. Mixograms of 2015 crop Soft WQC Entries by USDA-ARS Soft Wheat Quality Laboratory.
*Check varieties.

Average Quality Characteristics over Multiple Crop Years

Table 56. Wheat grain and flour quality characteristics of the 2015 crop Soft Wheat Quality Council entries between 2009 and 2015 crop years

Group	Entry	N	Test Weight (lb/bu)	Grain Protein (%)	Kenel Hardness	Kernel Diameter (mm)	Kernel Weight (mg)	Flour Yield (%)	Softness Equivalent (%)	Flour Protein (%)	Water SRC (%)	Sodium Carbonate SRC (%)	Sucrose SRC (%)	Lactic Acid SRC (%)	Cookie Diameter (cm)	Cookie Top Grade
1	AgriMAXX 462	2 ~ 15	61.6	9.6	52.8	2.7	33.6	70.1	48.0	7.8	63.5	81.4	97.6	115.7	16.7	2.3
1	Hilliard	2 ~ 22	60.0	10.2	11.4	2.6	34.3	67.5	61.0	8.1	54.8	71.1	94.5	120.5	18.2	3.4
1	VA 258*	6 ~ 12	59.3	9.6	24.6	2.6	35.9	70.3	55.9	7.8	54.9	66.6	91.7	104.7	18.4	5.0
2	E 6012	4 ~ 37	58.1	9.9	9.9	2.7	34.7	69.1	57.6	7.8	54.4	69.8	84.4	87.6	18.5	4.3
2	Venus*	4 ~ 21	59.4	9.2	23.7	2.7	35.8	71.6	57.1	7.2	57.3	71.9	88.7	87.0	18.4	4.1

*Check varieties.

Genotyping for Quality Traits: Soft Wheat Quality Council

Anne Sturbaum, January, 2016

Genotyping for traits associated with quality, physiology and disease resistance was done at the Regional Small Grains Genotyping Laboratory (RSGGL) in Raleigh, N.C. for the three WQC entries, AgriMAXX 462, Hilliard and E6012 with check varieties VA 258 and MCIA Venus.

Quality

High molecular weight glutenins, especially the alleles for *Dx5 (*"*5+10*") at *GluD1*, the over expressed *Bx7* subunit at *GluB1* and *Ax2** at the *GluA1* loci are useful for selecting preferential milling and baking quality. These alleles correlate with strong gluten and dough strength (Ma et al., 2003). We report on the *GluA1*, *GluB1* and *GluD1* loci involved in selecting for varieties with specific dough quality.

Amplification for high molecular weight glutenins at the *GluA1* locus, adapted from the marker *umn19* (Liu et al., 2008a) identified the *Ax2** genotype in the WQC entries Hilliard, VA 258 and MCIA Venus. AgriMAXX 462 and E6012 have the *Ax1* or null alleles at the *GluA* locus.

None of the cultivars has the overexpressing the *GluB1* allele, *Bx7OE*, as tested by primers diagnostic for a 45 base pair insertion specific to the *Bx7* over-expressing *GluB1* allele (Guttieri et al., 2008).

Primers specific for *GluD1* alleles *Dx5* and *Dx2* generated a PCR product corresponding to the "5+10" strong gluten allele for AgriMAXX 462 and "2+12" for Hilliard, E6012 and MCIA Venus. VA 258 was heterozygous at the *GluD1* locus. (Wan et al., 2005).

A translocation from chromosome 1 of rye, *Secale cereale L* (1RS), onto wheat chromosome 1B or 1A provides multiple resistances to powdery mildew, stem rust, leaf rust and stripe rust. Amplification products with scm9F primers are specific for rye ω-secalin using the Scm9 marker pair (Saal and Wricke, 1999). None of the five cultivars tested has the 1RS/1BR translocation.

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

Physiology

Mutations in the homeologous photoperiod genes *Ppd-A1*, *Ppd-B1* and *Ppd-D1* of chromosome 2, confer photoperiod insensitivity, or day neutral growth in wheat permitting early flowering. Mutations in the *Ppd-D1* allele (Beales et al., 2007), copy number variations in *Ppd-B1* (Díaz et al., 2012) and insertions and deletions in *Ppd-A1* (Nishida et al., 2013) each influence the plant's flowering time allowing early maturation thus lowering the risk of high temperature exposure during grain fill and allowing for early harvest.

All five WQC varieties lack photoperiod sensitivity through one or more of the mutant photoperiod alleles described above. All WQC varieties are homozygous for the mutant form of the *Ppd-D1* gene (*Ppd-D1a*). In addition, Hilliard is heterozygous at the *Ppd-A1* locus.

Dwarfing genes were tested using markers specific for reduced height genes *Rht-B1* and *RhtD1* (formerly *Rht1 and Rht2).* The mutant alleles, *Rht-B1b* and *Rht-D1b* confer dwarfing traits to reduce plant height, increase yield and improve resistance to lodging (Zhang et al., 2006). All five WQC varieties were homozygous for the single dwarfing allele, *Rht-D1b*.

Disease Resistance

Markers identifying resistance genes to stem (*Sr*), leaf (*Lr*) and stripe (*Yr*) rusts, fusarium head blight (*Fhb*) and tan spot (*Tsn1*) were assayed at the RSGGL for WQC varieties. Resistance to fusarium head blight (FHB) was evaluated using markers associated with QTL on chromosomes 3BS (*Fhb-1*) (Liu et al., 2008b), 2DL (*Fhb2DL)* (Somers et al., 2003), and 5A (*Fhb 5A Ernie* and *Fhb 5A Ning*) (McCartney et al., 2007). Varieties were evaluated for the rust resistance genes (*Sr2, Sr36, Sr38, L9) and* multiple stem, leaf and stripe rust resistance loci (*Sr24/Lr24, Lr34/Yr18* and *Yr17/Lr37/Sr38*). Markers, protocols and references for the disease resistance loci can be found on the MASWheat website: http://maswheat.ucdavis.edu/protocols/index.htm.

The only resistance gene detected in the set was the fusarium head blight resistance gene, *Fhb5A-Ernie*, present in E6012.

The preferred haplotype for sucrose synthase (HapH for high grain weight) was absent in all cultivars of this WQC set.

Table 57. Genotypes 2015 WQC cultivars[a]

Cultivar	Dwarfing	Photoperiod Insensitivity	High Molecular Weight Glutenins*			1RS RyeTL	Sucrose Synthase HapH	Disease Resistance
			*GluA1 Ax2**	*GluB1 Bx7OE*	*GluD1 Dx5+10*			
AgriMAXX 462	***Rht-D1b***	***D1a***	Ax1 or null	no	**5+10**	no	no	none detected
Hilliard	***Rht-D1b***	***D1a, A1a Het***	**Ax2***	no	2+12	no	no	none detected
VA 258	***Rht-D1b***	***D1a***	**Ax2***	no	Het	no	no	none detected
E6012	***Rht-D1b***	***D1a***	Ax1 or null	no	2+12	no	no	**Fhb 5A Ernie**
MCIA Venus	***Rht-D1b***	***D1a***	**Ax2***	no	2+12	no	no	none detected

[a]Preferred allele is presented in bold type.
*Assays for high molecular weight glutenins test for the specific allele indicated.

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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

All soft wheat varieties are tempered to 14.5% moisture level. Tempered wheat is held for at least 24 hours in order for the moisture to equilibrate throughout the grain. The mill operates at a rate of approximately 600 grams/minute. Up to 12 kg of grain is milled per run. Each of the fourteen streams is weighed and an aliquot is sampled for ash analysis. The straight grade flour, each of the three breaks, reduction and duster, are then re-bolted to remove any remaining residual by-product not removed by the mill; 165 micron SSBC (stainless steel) sieve. Finished flour is a blend of the straight grade, breaks, reductions and duster following re-bolting.

The straight grade flour mean volume diameter is about 130 microns with flour ash content between 0.38% and 0.49%. Flour yields vary between 70% and 78% and are variety-dependent due to milling quality differences and/or grain condition. Expected recovery of all mill products is about 98.5%. Least significant differences for straight grade flour yield and break flour yield are 0.75% and 0.82%, respectively.

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 4 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.