# Milling and Baking Test Results for Eastern Soft Wheats

## Harvested in 2013

## Soft Wheat Quality Council of the Wheat Quality Council


February 19, 2013

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.

**Byung-Kee Baik, Ph.D.**
USDA-ARS-CSWQRU Soft Wheat Quality Laboratory
OARDC-OSU
1680 Madison Avenue
Wooster, Ohio 44691
byungkee.baik@ars.usda.gov

**Ben Hancock**
The Wheat Quality Council
5231 Tall Spruce St
Brighton, CO 80601
Office: (303) 558-0101
Fax: (303) 558-0100
E-mail: BhWQC@aol.com

# Soft Wheat Quality Council

## Acknowledgments

We thank the Wheat Quality Council for providing this forum to improve the quality of wheat. Thank you to the Soft Wheat Quality Laboratory staff and the collaborators in industry for their professional analysis and suggestions and to Anne Sturbaum for editing the report. Also, we are thankful for the cooperation from all the wheat breeding programs involved with this year's project. Great communication and cooperation among the breeding programs, growers, state foundation seeds programs, wheat seed companies and wheat quality laboratories in milling and baking companies make this project a continued success.

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

## Collaborators for 2013 Crop Year

Vickie Correll, ADM Milling, Overland Park, Kansas

Mary Sorensen and Scott Baker, ConAgra Foods, Omaha, Nebraska

Colleen Kuznik, Cargill (Horizon Milling), Minnetonka, Minnesota

Grace Lai and Lori Wilson, Kellogg's, Kalamazoo, Michigan

Hayley butler, LimaGrain Cereal Seeds, Fort Collins, Colorado

Gabriela Rattin, Mondeléz International, East Hanover, New Jersey

Tom Baker, The Mennel Milling Company, Fostoria, Ohio

Marianne Teagler, Siemer Milling Company, Teutopolis, Illinois

James Janson, Star of the West Milling Company, Frankenmuth, MI

Cathy Butti, Syngenta-Agripro, Berthoud, Colorado

Bon Lee and Gary Hoe, Wheat Marketing Center, Portland, Oregon

Doug Engle, USDA-ARS Western Wheat Quality Laboratory, Pullman, Washington

Scott Beil, USDA-ARS Soft Wheat Quality Laboratory, Wooster, Ohio

## 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.

## Table of Contents

## Figures and Tables

## WQC 2013 Crop Year Entries and Contributing Breeding Programs

| Entry Group | Entry Name | Breeder | Institution/Company | Class |
|---|---|---|---|---|
| 1 | VA07W-415 | Carl Griffey | Virginia Polytechnic Institute and State University | SRW |
| 1 | VA09W-75 | | | SRW |
| 1 | VA09W-73 | | | SRW |
| 1 | VA09W-188WS | | | SWW |
| 1 | Shirley (check) | | | SRW |
| 2 | SY 547 (formerly M09L-9547) | Jennifer Vonderwell | Syngenta | SRW |
| 3 | F0014 | Eric Olson | Michigan State University | SWW |
| 3 | F0039 | | | SWW |
| 3 | F0065 | | | SWW |
| 3 | D8006 | | | SWW |
| 3 | Caledonia (check) | | | SWW |

## Description of Entries

**VA07W-415**

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

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

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

Grain samples of VA07W-415 produced in six crop environments (2009 – 2012) were evaluated for end use quality by the USDA-ARS Soft Wheat Quality Lab. Over four common environments, VA07W-415 had a mean milling quality score (72.8) that was higher than those of Branson (67.0) and Shirley (68.0). Over four other environments, VA07W-415 had a mean baking quality score (58.0) and cookie diameter (18.5 cm) that was similar to those of Pioneer 25R15 (57.6 and 18.4 cm). On average, flour protein concentration of VA07W-415 (8.19%) is higher than those of Branson (7.94%) and Shirley (7.84%), while gluten strength of VA07W-415 (109%) and Branson (110%) are higher than that of Shirley (90%). Like Branson, flour of VA07W-415 is suitable for use in making products requiring stronger gluten strength such as crackers as well as pastry products.

VA07W-415 has performed well in tests from Griffin, Georgia to Ithaca, New York and throughout the mid-Atlantic region. VA07W-415 is resistant to Hessian fly [*Mayetiola destructor* (Say)] biotypes B, C, D, O, and L and possesses gene *H13*. It also has the *Lr37/Yr17/Sr38* gene complex that governs resistance to leaf rust (*Puccinia triticina*), stripe rust (*Puccinia striiformis*), and stem rust (*Puccinia graminis*). With the exception of Fusarium Head Blight, stem rust, and potentially *Wheat Spindle Streak Mosaic Virus*, VA07W-415 expresses moderate to high levels of resistance to diseases prevalent in the SRW wheat region. Production

of this cultivar likely will require use of fungicides, particularly for Fusarium Head Blight, in regions where this pathogen and stem rust are prevalent and deemed to be a problem.

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

**VA09W-75**

The soft red winter wheat line VA09W-75 was developed by the Virginia Agricultural Experiment Station and released March 2013 as cultivar 'Southern Harvest 3200'. It was derived from the cross **'38158'** (PI 19052, VA96W-158 = 'FFR555W' / 'GA-Gore') / **VA99W-188** [VA91-54-343 (IN71761A4-31-5-48 // VA71-54-147 (CItr 17449) / 'McNair 1813') / 'Roane' (PI 612958) sib (VA91-54-222)] // **'Tribute'** (PI 632689).

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

VA09W-75 is a broadly adapted, high yielding, mid-season heading, short height semi-dwarf (gene *Rht*2). At maturity, VA09W-75 has white colored spikes and straw with trace anthocyanin. Its awnletted spikes are semi-erect and strap in shape. In the southern SRW wheat region, head emergence of VA09W-75 (96 d) was most similar to that of Pioneer Brand '26R61', 3 d later than 'Jamestown', and 1 d earlier than 'USG 3555'. Average mature plant height of VA09W-75 has varied from 33 to 36 inches and is similar in height to one inch shorter than 'Branson', 2 to 3 inches shorter than Pioneer Brand '25R15', and 2 to 3 inches taller than USG 3555. Straw strength (0=erect to 9=completely lodged) of VA09W-75 (0.6 – 3.5) is good being most similar to that of 'USG 3555' (0.8 – 4.0) and better than that of Featherstone 'VA258' (2.8 – 4.8). In the Uniform Southern Nursery, VA09W-75 had survival ratings in controlled environment freeze tests conducted by the USDA-ARS of 57.5% versus ratings of 27.5% for USG 3555, 47.5% for 'AGS 2000', 77.5% for Jamestown, and 87.5% for Pioneer Brand 26R61.

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

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

VA09W-75 has performed well in SRW wheat production areas of the Deep South, southern Corn Belt, and mid-Atlantic regions. With the exception of *Wheat Soil Borne Mosaic*

*Virus*, *Stagonospora nodorum* blotch, and potentially *Wheat Spindle Streak Mosaic Virus* and Hessian fly, VA09W-75 expresses moderate to high levels of resistance to diseases prevalent in the SRW wheat region. These include leaf, stripe and stem rusts, powdery mildew, Fusarium head blight, *Septoria tritici* leaf blotch, and *Barley Yellow Dwarf Virus*.

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

**VA09W-73**

The soft red winter wheat line VA09W-73 was developed by the Virginia Agricultural Experimental Station and released in March 2013 as cultivar 'Featherstone 73'. It was derived from the cross '38158' (PI 19052, VA96W-158 = 'FFR555W' / 'GA-Gore') / VA99W-188 [VA91-54-343 (IN71761A4-31-5-48 // VA71-54-147 (CItr 17449) / 'McNair 1813') / 'Roane' (PI 612958) sib (VA91-54-222)] // 'Tribute' (PI 632689).

VA09W-73 was derived as a bulk of an $F_{5:6}$ headrow selected in 2008 and was evaluated over two years (2011 and 2012) in Virginia's State Variety Trials and throughout most of the soft red winter (SRW) wheat region in the 2012 USDA-ARS Uniform Eastern Soft Red Winter Wheat Nursery. VA09W-73 is a broadly adapted, high yielding, full-season, short height semi-dwarf (gene *Rht*2). Plant stem and spike color of VA09W-73 is blue, and spikes are strap shaped with short tip awns. In the eastern SRW wheat region, head emergence of VA09W-73 (116 d) was most similar to that of 'Branson', and 2 d earlier than 'Shirley'. Average mature plant height of VA09W-73 has varied from 33 to 36 inches and is similar in height to one inch shorter than Branson and about two inches taller than Shirley. Straw strength (0=erect to 9=completely lodged) of VA09W-73 (0.9 – 3.6) is good being most similar to 'USG 3555' (0.8 – 4.0) and better than Featherstone 'VA258' (2.8 – 4.8). In the Uniform Eastern Nursery, winter hardiness and spring freeze tolerance (0 = no injury to 9 = severe injury) of VA09W-73 (1.2 and 0.4) were similar to those (1.1 – 1.4 and 0.2 – 0.5) of check cultivars 'Bess', Branson and Shirley.

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

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

VA09W-73 is a widely adapted wheat cultivar that has performed well over most of the SRW wheat production areas from northern Louisiana to Ontario. With the exception of stem

rust, *Wheat Soil Borne Mosaic Virus* and potentially *Wheat Spindle Streak Mosaic Virus* and Hessian fly, VA09W-73 expresses moderate to high levels of resistance to diseases prevalent in the SRW wheat region. These include leaf and stripe rusts, powdery mildew, leaf and glume blotches, Fusarium head blight, and *Barley Yellow Dwarf Virus*.

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

**VA09W-188WS SOFT**

The soft white winter wheat line VA09W-188WS was developed by the Virginia Agricultural Experiment Station and released in March 2013 as cultivar 'MCIA Venus'. It was derived from the cross Pioneer Brand '25W60' (PI 607579) // Pioneer Brand '25W33' (PI 599197) / VAN98W-170WS. The pedigree of VAN98W-170WS is 'FFR 555W' (PI 560318) / 'GA-Gore' (PI 561842) // 'Coker 9803' (PI 548845) / VA87-54-636. Line VA09W-188WS was derived as a bulk of an $F_{5:6}$ headrow selected in 2008 and was evaluated in the Uniform Eastern Soft White Winter Wheat Nursery and in Virginia's State Wheat Variety Trials in 2011 and 2012.

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

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

Grain samples of VA09W-188WS produced in four crop environments (2011 and 2012) were evaluated for end use quality by the USDA-ARS Soft Wheat Quality Lab. Over all four environments, VA09W-188WS had an average milling quality score (77.5) and flour yield (71.7%) that exceed those of Shirley (68.5 and 69.9%), Branson (65.0 and 69.2%), and Pioneer Brand '25R15' (69.3 and 70.1%). On average, baking quality score of VA09W-188WS (63.3) was higher than that of Pioneer Brand 25R15 (57.5), but lower than those of Shirley (74.1) and Branson (67.9). Average cookie spread diameter of VA09W-188WS (18.2 cm) was similar to that of Pioneer Brand 25R15, but slightly lower than those of Shirley (18.7 cm) and Branson (18.5 cm). Grain protein content and gluten strength (lactic acid retention capacity) of VA09W-188WS (7.70% and 90%) were slightly higher than those of Shirley (7.58% and 89%), but lower

than those of Branson (8.13% and 114%) and Pioneer Brand 25R15 (8.9% and 130%). Like Shirley, flour of VA09W-188WS is most suitable for pastry products, but also may be suitable for manufacturing breakfast cereals and other whole grain products due to its white grain color. In the 2011 and 2012 Uniform Eastern Soft White Winter Wheat Nursery, sprouting scores (0 – 9) for VA09W-188WS (4.1 and 4.4) were lower than those of Caledonia (4.7 and 5.5), but were higher than those of the sprout tolerant check cultivar Cayuga (1.4 and 0.7).

VA09W-188WS has performed well in eastern soft white winter wheat regions of the U.S. and Ontario as well as in the mid-Atlantic region. With the exception of stem rust, glume blotch (*Stagonospora nodorum*), and potentially *Wheat Spindle Streak Mosaic Virus*, VA09W-188WS expresses moderate to high levels of resistance to diseases prevalent in the eastern soft white winter wheat region. These include leaf and stripe rusts, powdery mildew, *Septoria tritici* leaf blotch, Fusarium head blight, *Barley Yellow Dwarf Virus*, *Wheat Soil Borne Mosaic Virus*, and Hessian fly.

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

**Shirley**

'Shirley' (Reg. No. CV-1039, PI 656753), soft red winter (SRW) wheat (*Triticum aestivum L.*), developed and tested as VA03W-409 by the Virginia Agricultural Experiment Station, was released in March 2008. Shirley was derived from the three-way cross VA94-52-25/'Coker 9835'//VA96-54-234. Shirley is widely adapted and provides producers and end users with a full-season, short-stature, semidwarf (*Rht1*) cultivar that has very high yield potential and good milling and pastry baking qualities. Shirley also is notably resistant to leaf rust (Puccinia triticina Eriks.), stem rust (*Puccinia graminis* Pers.:Pers. f. sp. tritici Eriks. & E. Henn.), and powdery mildew [Blumeria graminis (DC.) E.O. Speer]. In Virginia Shirley had the highest 3-yr (2006–2008) average grain yield (6316 kg ha–1) among cultivars evaluated in the state variety trial. In USDA–ARS Uniform Eastern SRW Wheat Nursery Trials conducted at 29 locations in 2006 and at 22 locations in 2007, Shirley ranked first in grain yield in both years with mean yields of 6155 and 5456 kg ha–1, respectively. Shirley has soft grain texture, low endosperm separation indices (score = 8.9), high break flour (323–328 g kg–1), and high straight grade (777–779 g kg–1) flour yields on an Allis mill. Flour protein concentration (7.62–8.65 g 100 g–1) and gluten strength (84.6–93.6 g 100 g–1) of Shirley are lower than average. These quality attributes combined with low fl our sucrose solvent retention capacity (87.6– 90.8 g 100 g–1) contribute to Shirley's good pastry baking quality (cookie spread diameters of 17.15–18.65 cm).

**SY 547 (formerly M09L-9547)**

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

virus and fungal leaf blights. It has tested average tolerance to current races of stripe & leaf rust and Fusarium head blight, and is known to be moderately susceptible to barley yellow dwarf virus.

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

**MSU Line F0014**

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

**MSU Line F0039**

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

**MSU Line F0065**

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

**D8006**

D8006 is a fully awned white chaffed soft white winter wheat variety. The variety D 8006 has shown very good powdery mildew resistance, resistance to leaf rust, and good winter hardiness. It is very resistant to wheat spindle streak mosaic virus. Sprout and scab resistance are typical of most soft white wheat varieties. MSU D8006 was the highest yield of all white wheat varieties tested in 2007 MSU wheat trials and was the 5th highest yielding white wheat variety in the 2008 MSU wheat trials. Plant height of D8006 is 33 inches. Its lodging resistance is similar to most other commercial varieties. Flowering date is 152.2 days past January 1, similar to most white wheat varieties adapted to Michigan. One distinguishing morphological characteristic of D8006 is purple anthers.

**Caloedonia**

Caledonia is a soft white winter wheat. It has an exceptionally high grain yield, averaging 4% higher than standard cultivars, Harus and Geneva. It is well adapted to cooler climates in the Northeastern US and Southern Ontario, Canada, with a winter survival rate of 93%. Caledonia is resistant to powdery mildew, Soil-borne wheat mosaic virus , and Wheatspindle streak mosaic virus. It is also moderately resistant to loose smut, but susceptible to Fusarium head blight. Evaluation of milling and baking quality has shown Caledonia to have higher flour yields than Harus and Geneva. Flour protein averages, percent alkaline water retention, and mean cookie diameter were similar in all three cultivars.

## 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 Streams SWQL

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

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

## Milling Parameters from Mennel Milling

Table 2. Quadramat Jr. milling test parameters by Mennel Milling

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

## Miag Multomat Flour Milling Ash Curves

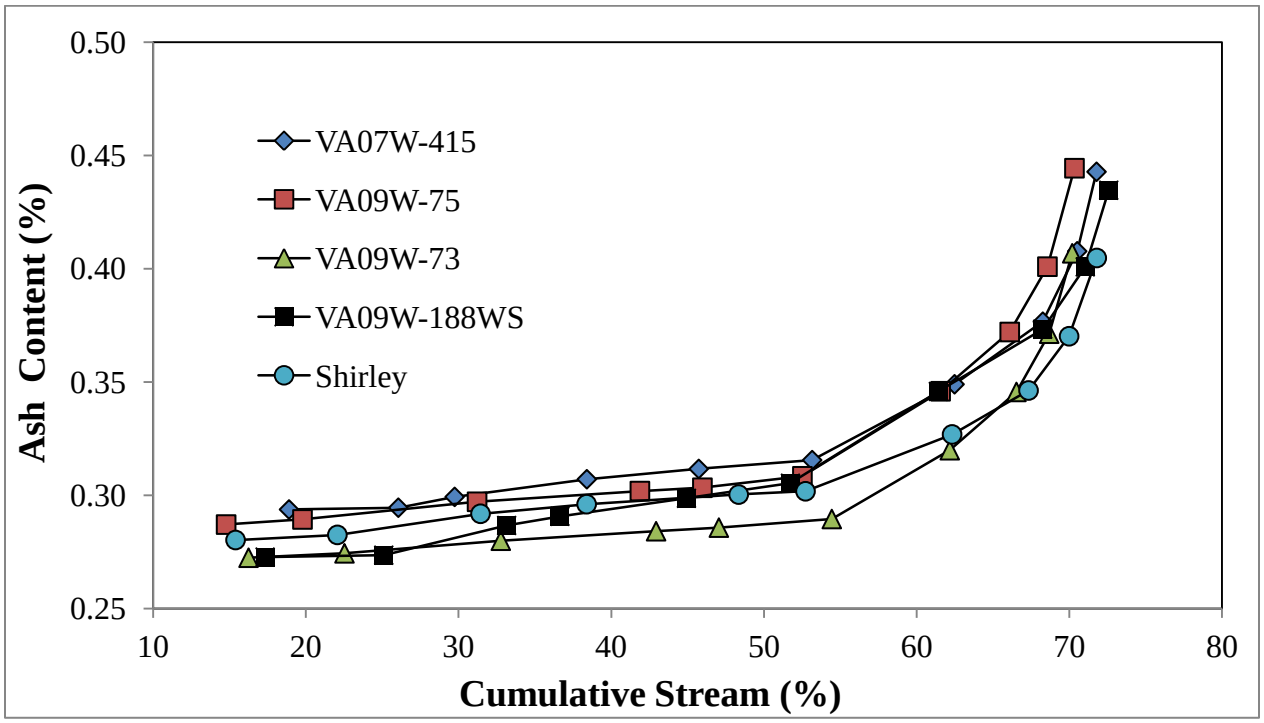


Table 3. Yield and Ash Content of Mill Streams for the WQC 2013 Crop Entries from Virginia Polytechnic Institute and State University

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

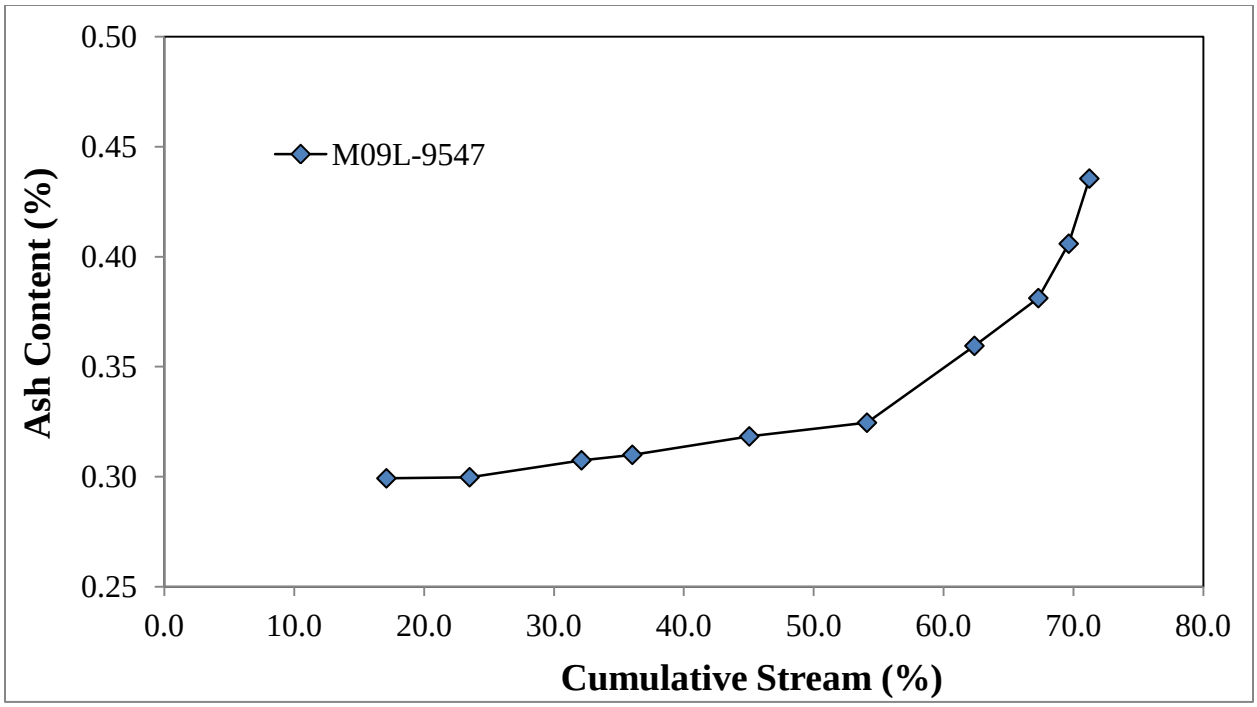


Table 4. Yield and Ash Content of Mill Streams for the WQC 2013 Crop Entries from Syngenta

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

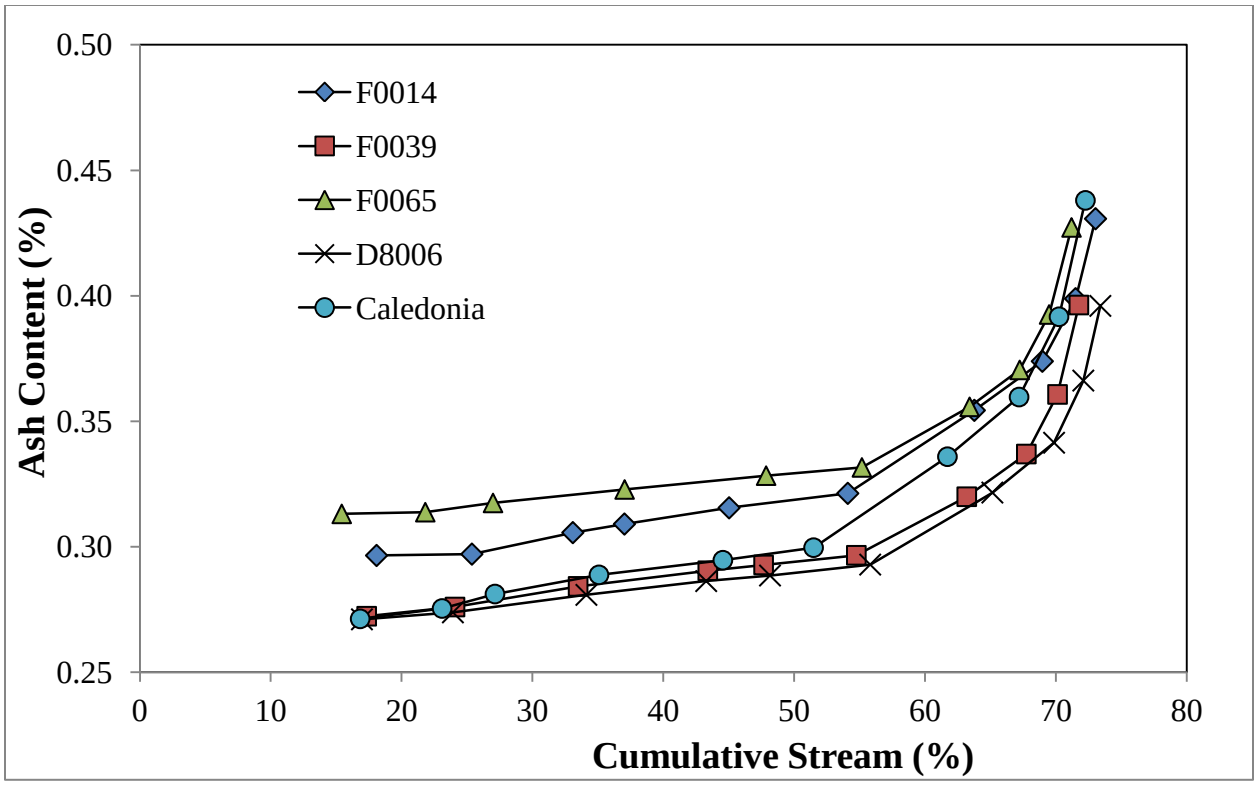


Table 5. Yield and Ash Content of Mill Streams for the WQC 2013 Crop Entries from Michigan State University

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

## Miag Multomat Flour Milling Protein Curves

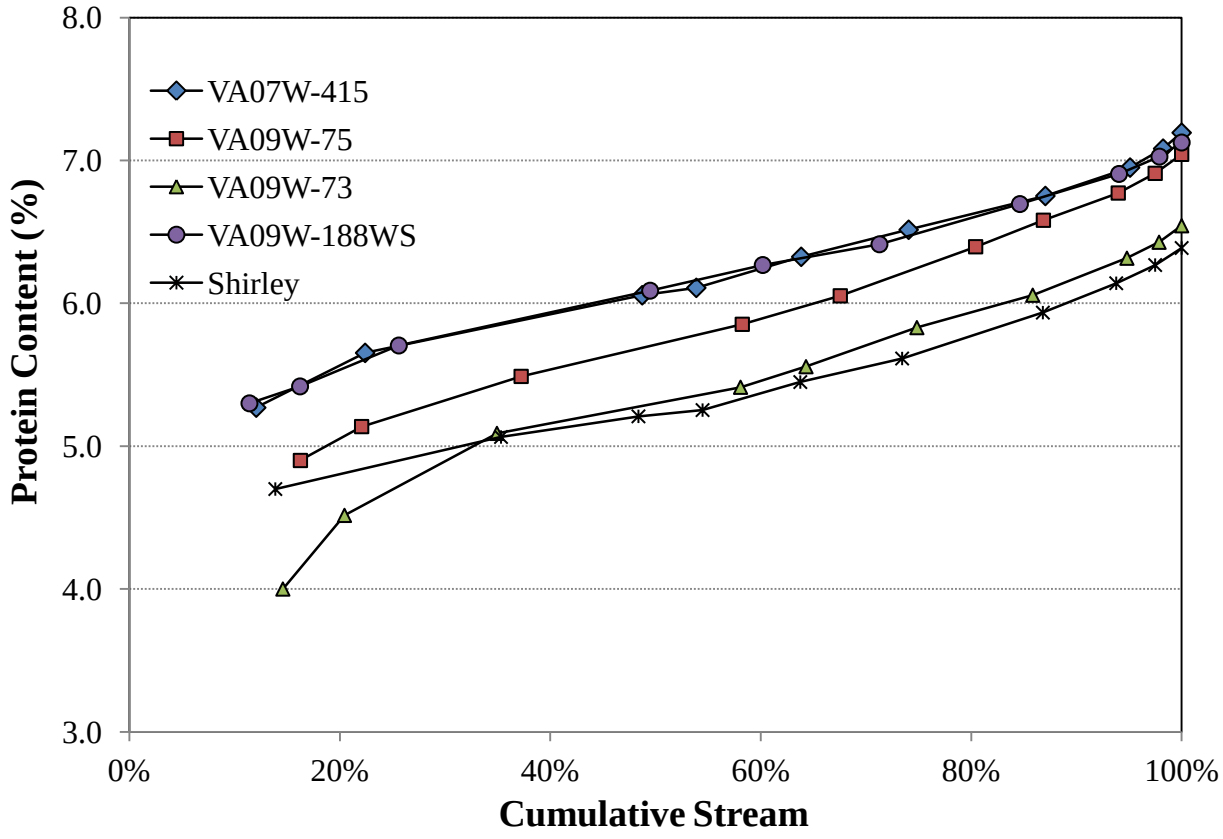


Table 6. Yield and Protein Content of Flour Mill Streams for the WQC 2013 Crop Entries from Virginia Polytechnic Institute and State University

| Flour Stream | VA07W-415 | | VA09W-75 | | VA09W-73 | | VA09W-188WS | | Shirley | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Yield (%) | Protein (%) | Yield (%) | Protein (%) | Yield (%) | Protein (%) | Yield (%) | Protein (%) | Yield (%) | Protein (%) |
| 1 Brk | 8.7 | 5.3 | 11.4 | 4.9 | 10.2 | 4.0 | 8.3 | 5.3 | 10.0 | 4.7 |
| 2 Brk | 7.4 | 6.1 | 10.7 | 6.0 | 10.2 | 5.9 | 6.8 | 6.2 | 9.4 | 5.6 |
| Grader | 3.7 | 6.6 | 4.1 | 5.8 | 4.1 | 5.8 | 3.5 | 5.7 | 4.4 | 5.6 |
| 3 Brk | 9.3 | 8.1 | 9.0 | 8.2 | 7.7 | 7.6 | 9.7 | 8.2 | 9.6 | 7.7 |
| 1 Mids | 18.9 | 6.4 | 14.8 | 6.5 | 16.2 | 5.9 | 17.3 | 6.5 | 15.4 | 5.3 |
| 2 Mids | 7.3 | 7.7 | 6.5 | 7.3 | 7.4 | 7.5 | 8.0 | 7.2 | 6.9 | 6.7 |
| 3 Mids | 5.8 | 9.1 | 4.5 | 8.9 | 4.4 | 6.9 | 6.8 | 8.8 | 5.0 | 8.7 |
| Re-Dust | 7.2 | 7.5 | 5.0 | 9.1 | 6.3 | 8.8 | 7.8 | 7.1 | 6.7 | 6.6 |
| 4 Mids | 2.3 | 11.1 | 2.5 | 10.6 | 2.1 | 9.9 | 2.8 | 10.0 | 2.7 | 9.5 |
| 5 Mids | 1.3 | 13.4 | 1.8 | 12.2 | 1.5 | 11.8 | 1.5 | 11.7 | 1.8 | 11.0 |

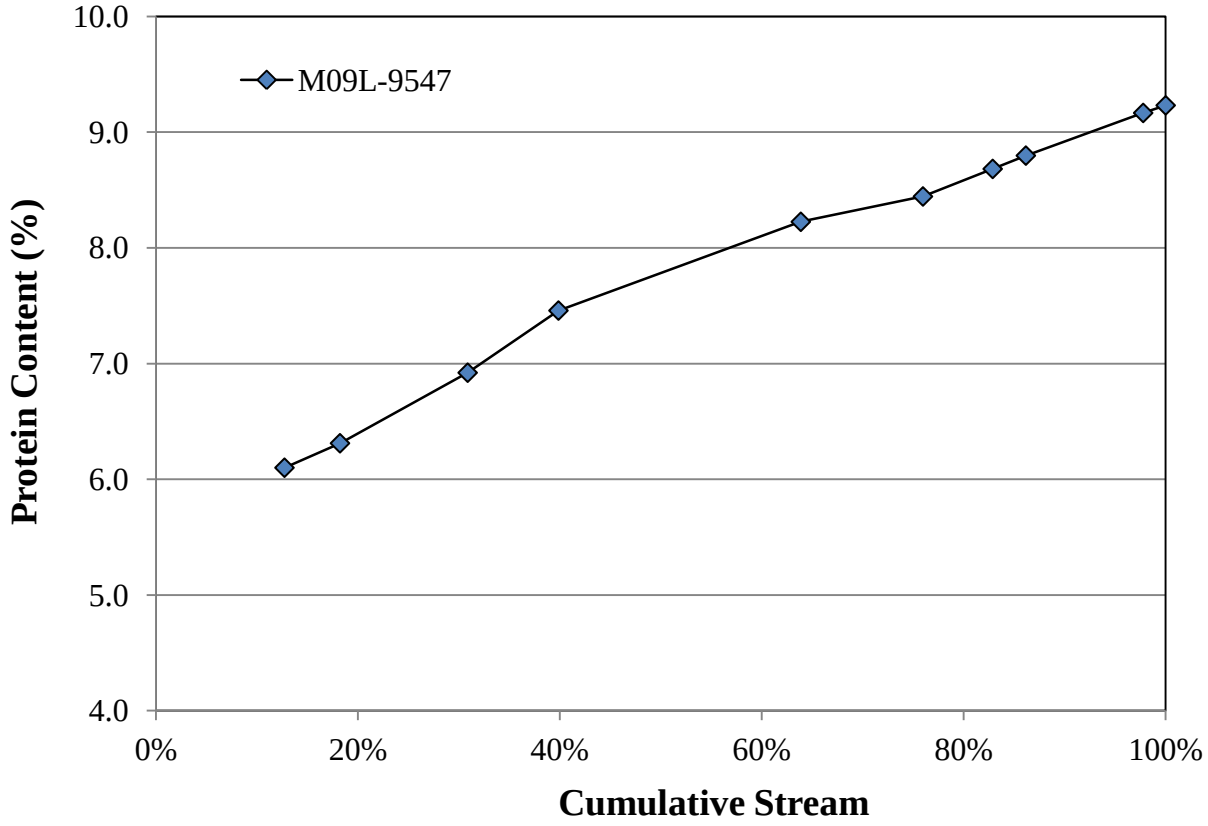


Table 7. Yield and Protein Content of Flour Mill Streams for the WQC 2013 Crop Entries from Suyngenta

| Flour Stream | SY 547 | |
|---|---|---|
| | Yield (%) | Protein (%) |
| 1 Brk | 9.1 | 4.7 |
| 2 Brk | 9.0 | 5.6 |
| Grader | 3.9 | 5.6 |
| 3 Brk | 8.3 | 7.7 |
| 1 Mids | 17.1 | 5.3 |
| 2 Mids | 8.6 | 6.7 |
| 3 Mids | 4.9 | 8.7 |
| Re-Dust | 6.4 | 6.6 |
| 4 Mids | 2.3 | 9.5 |
| 5 Mids | 1.6 | 11.0 |

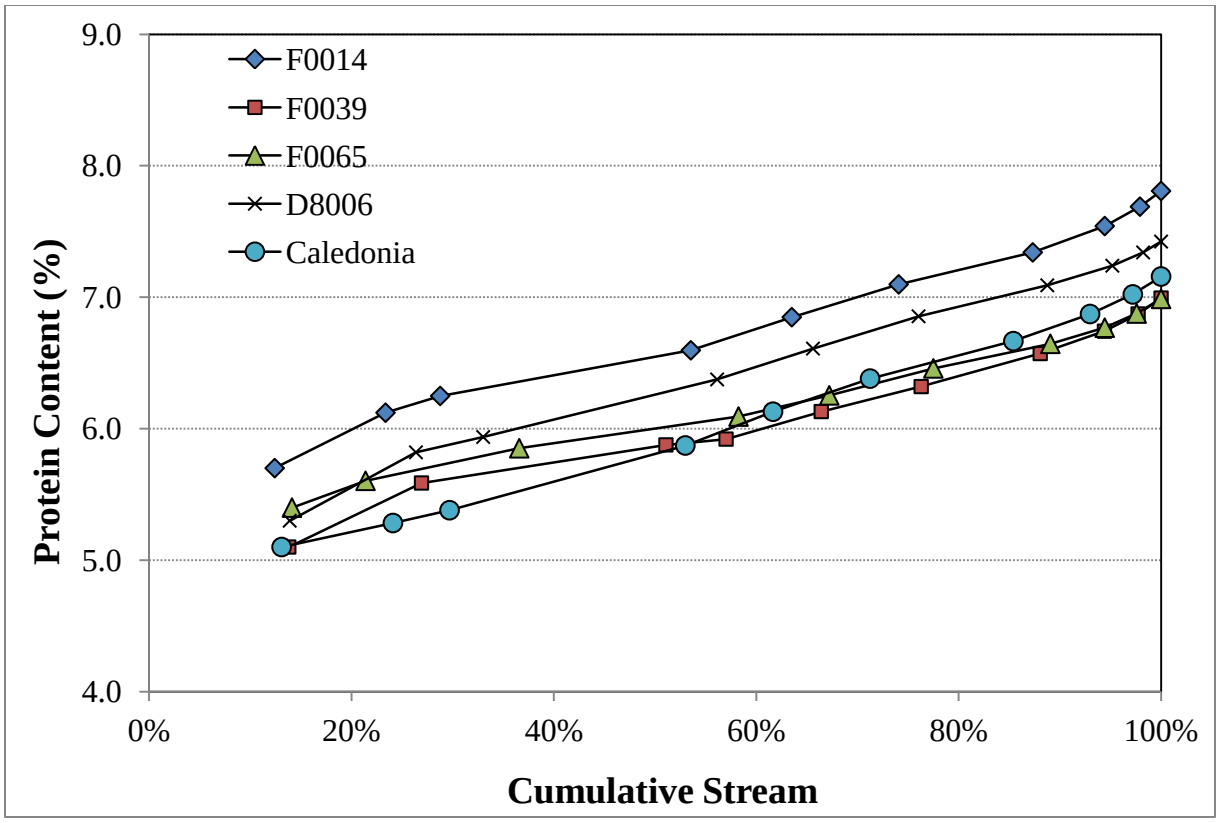


Table 8. Yield and Protein Content of Flour Mill Streams for the WQC 2013 Crop Entries from Michigan State University

| Flour Stream | F0014 | | F0039 | | F0065 | | D8006 | | Caledonia | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Yield (%) | Protein (%) | Yield (%) | Protein (%) | Yield (%) | Protein (%) | Yield (%) | Protein (%) | Yield (%) | Protein (%) |
| 1 Brk | 9.1 | 5.7 | 9.9 | 5.1 | 10.1 | 5.4 | 10.2 | 5.3 | 9.5 | 5.1 |
| 2 Brk | 8.0 | 6.6 | 9.4 | 6.1 | 10.8 | 6.2 | 9.2 | 6.4 | 7.9 | 5.5 |
| Grader | 3.9 | 6.8 | 4.3 | 6.3 | 5.2 | 6.0 | 4.9 | 6.4 | 4.0 | 5.8 |
| 3 Brk | 9.7 | 8.7 | 8.4 | 8.2 | 8.2 | 7.9 | 9.3 | 8.5 | 10.2 | 8.1 |
| 1 Mids | 18.1 | 7.0 | 17.3 | 6.2 | 15.4 | 6.5 | 17.0 | 7.0 | 16.8 | 6.5 |
| 2 Mids | 7.7 | 8.6 | 7.1 | 7.6 | 7.3 | 7.8 | 7.7 | 8.4 | 6.9 | 8.0 |
| 3 Mids | 5.2 | 10.0 | 4.6 | 9.1 | 3.8 | 8.8 | 4.7 | 9.3 | 5.5 | 9.2 |
| Re-Dust | 7.3 | 8.2 | 6.7 | 7.4 | 6.4 | 7.3 | 7.0 | 8.0 | 6.3 | 7.7 |
| 4 Mids | 2.5 | 11.7 | 2.4 | 10.6 | 2.2 | 10.1 | 2.2 | 10.5 | 3.1 | 10.3 |
| 5 Mids | 1.5 | 13.4 | 1.6 | 12.2 | 1.7 | 11.5 | 1.3 | 12.0 | 2.0 | 11.9 |

## ADM Milling Quality Evaluations

Table 9. Solvent retention capacity and cookie baking test parameters by ADM Milling

| Entry | Solvent Retention Capacity (%) | | | | Cookie (10-50D) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Water | Sodium Carbonate | Sucrose | Lactic Acid | Width (mm) | Thick (mm) | W/T Ratio (mm) | Spread Factor | Dough |
| VA07W-415 | 52.10 | 72.04 | 87.48 | 94.68 | 481 | 55.3 | 8.54 | 85.40 | Slightly Dry |
| VA09W-75 | 55.35 | 80.94 | 92.77 | 105.62 | 467 | 64.3 | 7.13 | 71.30 | Dry |
| VA09W-73 | 53.66 | 72.36 | 85.41 | 103.97 | 475 | 58.3 | 8.00 | 80.00 | Very Dry |
| VA09W-188WS | 56.82 | 73.72 | 88.69 | 92.98 | 456 | 67.0 | 6.68 | 66.80 | Good |
| Shirley (ck) | 52.35 | 74.22 | 84.09 | 79.83 | 489 | 58.0 | 8.28 | 82.80 | Good |
| SY 547 | 51.57 | 71.45 | 86.33 | 90.35 | 477 | 59.0 | 7.89 | 78.90 | Good |
| F0014 | 50.72 | 73.92 | 83.61 | 106.1 | 493 | 55.0 | 8.74 | 87.40 | Good |
| F0039 | 47.47 | 69.79 | 76.27 | 92.48 | 501 | 53.0 | 9.23 | 92.30 | Good |
| F0065 | 50.16 | 75.42 | 80.27 | 90.66 | 500 | 54.7 | 8.93 | 89.30 | Good |
| D8006 | 48.24 | 71.35 | 79.78 | 105.07 | 503 | 54.7 | 8.97 | 89.70 | Good |
| Caledonia (ck) | 48.86 | 70.29 | 76.58 | 95 | 496 | 54.0 | 8.96 | 89.60 | Good |

Table 10. Evaluation comments on flour quality and baked product performance by ADM Milling

| Entry | Analytical Flour Qualities | | End Product Performance | | Mitigating Physical/Chemical Properties |
|---|---|---|---|---|---|
| | Comment | Score | Commen | Score | |
| VA07W-415 | Good SRC | | Best spread factor in the set, minimal checking | 7 | experimental better than the check |
| VA09W-75 | Poor SRC, sl high LA & sucrose | | Poor spread factor, minimal checking | 2 | poorer than the check |
| VA09W-73 | sl high LA | | Average spread factor, very good checking | 6 | |
| VA09W-188WS | sl high sucrose | | Worst spread factor, minimal checking | 3 | poorer than the check |
| Shirley (ck) | Good SRC | | Average spread factor, very good checking | 6 | lowest protein |
| SY 547 | Best SRC | | Average spread factor, minimal checking | 4 | highest protein |
| F0014 | sl high LA | | Nice SF, good checking | 7 | comparable to check |
| F0039 | lower absorp & sl low sucrose | | Best SF in the set, very good checking, comparablet to check | 8 | experimental similar to check, best SF in the group and set |
| F0065 | | | Nice SF, good checking | 7 | comparable to check |
| D8006 | lower absorp & sl high LA | | Nice SF, good checking | 7 | comparable to check |
| Caledonia (ck) | lower absorp & sl low sucrose | | Nice SF, very good checking | 8 | All experimentals and check in this set had nice SF |

## Horizon Quality Evaluations

Table 11. Solvent retention capacity and cookie baking test parameters by Horizon Milling

| Entry | Solvent Retention Capacity (%) | | | | Cookie (10-50D) | | | |
|---|---|---|---|---|---|---|---|---|
| | Water | Sodium Carbonate | Sucrose | Lactic Acid | Width (mm) | Thick (mm) | W/T Ratio (mm) | Spread Factor |
| VA07W-415 | 55.0 | 79.5 | 104.6 | 100.3 | 479 | 56 | 8.6 | 81.4 |
| VA09W-75 | 57.6 | 83.8 | 109.1 | 112.4 | 467 | 61 | 7.7 | 72.9 |
| VA09W-73 | 57.0 | 78.6 | 101.3 | 107.8 | 483 | 56 | 8.6 | 82.1 |
| VA09W-188WS | 59.6 | 80.6 | 98.8 | 98.4 | 456 | 54 | 8.4 | 80.4 |
| Shirley (ck) | 53.9 | 73.2 | 97.5 | 82.7 | 493 | 54 | 9.1 | 86.9 |
| SY 547 | 53.0 | 74.8 | 100.5 | 95.2 | 476 | 56 | 8.5 | 81.9 |
| F0014 | 52.6 | 77.2 | 95.6 | 104.6 | 494 | 54 | 9.2 | 88.2 |
| F0039 | 50.2 | 71.5 | 89.8 | 88.7 | 501 | 48 | 10.4 | 100.6 |
| F0065 | 54.4 | 79.6 | 95.4 | 91.6 | 495 | 54 | 9.2 | 88.4 |
| D8006 | 50.3 | 74.2 | 95.3 | 105.8 | 497 | 53 | 9.4 | 90.4 |
| Caledonia (ck) | 50.5 | 75.7 | 91.8 | 91.7 | 500 | 51 | 9.8 | 94.5 |

Table 12. Evaluation comments on flour quality and baked product performance by Horizon Milling

| Entry | Analytical Flour Qualities | | End Product Performance | | Mitigating Physical/Chemical Properties |
|---|---|---|---|---|---|
| | Comment | Score | Comment | Score | |
| VA07W-415 | Slightly high SRC values (higher than check), lactic acid notably higher than check | 5 | Cookie: average spread and SF | 5 | Cookie dough: moderately yellow and dry |
| VA09W-75 | Slightly high SRC values (higher than check), lactic acid notably higher than check | 5 | Cookie: poor spread and poor SF | 3 | |
| VA09W-73 | Slightly high SRC values (higher than check), lactic acid notably higher than check | 5 | Cookie: average spread and SF | 5 | Cookie dough: slightly yellow |
| VA09W-188WS | Slightly higher protein than check, slightly high SRC values (higher than check), abs notably higher than check | 4 | Cookie: poor spread but average SF | 4 | Cookie dough: moderately yellow and dry |
| Shirley (ck) | Slightly high SRC values, except lactic which is low. Lower starch damage than all test varieties. | 5 | Good spread and SF, nice cracking in the crust | 6 | Best of set |
| SY 547 | Higher protein, slightly high SRC values, lactic OK | 6 | Cookie: average spread and SF | 5 | |
| F0014 | Pretty good SRC values, slightly high on NaCarb. Lactic higher than check | 7 | Cookie: good spread and SF | 7 | Cookie dough: slightly yellow |
| F0039 | Pretty good SRC values, slightly high on NaCarb | 7 | Cookie: great spread, very high SF, nice cracking in the crust | 8 | Best of set |
| F0065 | Pretty good SRC values, slightly high on NaCarb, abs higher than check | 7 | Cookie: good spread and SF | 7 | Cookie dough: moderately yellow and dry |
| D8006 | Pretty good SRC values, slightly high on NaCarb. Lactic higher than check | 7 | Cookie: good spread and SF | 7 | |
| Caledonia (ck) | Pretty good SRC values, slightly high on NaCarb | 7 | Cookie: great spread and SF, nice cracking in the crust | 8 | |

## ConAgra Quality Evaluations

Table 13. Solvent retention capacity and cookie baking test parameters by ConAgra

| Entry | Solvent Retention Capacity (%) | | | | Cookie (10-50D) | | |
|---|---|---|---|---|---|---|---|
| | Water | Sodium Carbonate | Sucrose | Lactic Acid | Width (mm) | Thick (mm) | W/T Ratio (mm) |
| VA07W-415 | 53 | 79 | 99 | 102 | 492 | 59 | 8.3 |
| VA09W-75 | 58 | 82 | 100 | 113 | 474 | 64 | 7.4 |
| VA09W-73 | 57 | 76 | 95 | 108 | 496 | 62 | 8.0 |
| VA09W-188WS | 57 | 79 | 99 | 99 | 472 | 65 | 7.3 |
| Shirley (ck) | 53 | 76 | 95 | 84 | 500 | 57 | 8.8 |
| SY 547 | 51 | 73 | 97 | 94 | 493 | 56 | 8.8 |
| F0014 | 52 | 77 | 93 | 105 | 505 | 61 | 8.3 |
| F0039 | 49 | 71 | 86 | 91 | 515 | 53 | 9.7 |
| F0065 | 53 | 77 | 91 | 94 | 510 | 58 | 8.8 |
| D8006 | 50 | 73 | 87 | 108 | 512 | 56 | 9.2 |
| Caledonia (ck) | 51 | 72 | 85 | 96 | 514 | 56 | 9.3 |

Table 14. BranScan parameters by ConAgra

| Entry | Bran (%) | Aleurone (%) | Bran Particles | Aleurone Particles |
|---|---|---|---|---|
| VA07W-415 | 0.18 | 0.78 | 6.0 | 11.8 |
| VA09W-75 | 0.17 | 0.81 | 5.1 | 18.5 |
| VA09W-73 | 0.21 | 0.76 | 6.9 | 14.4 |
| VA09W-188WS | 0.13 | 0.85 | 4.1 | 19.1 |
| Shirley (ck) | 0.16 | 0.58 | 6.0 | 10.1 |
| SY 547 | 0.22 | 0.59 | 8.2 | 9.9 |
| F0014 | 0.09 | 0.61 | 2.5 | 0.2 |
| F0039 | 0.10 | 0.62 | 1.9 | 10.6 |
| F0065 | 0.13 | 0.60 | 3.7 | 9.9 |
| D8006 | 0.13 | 0.73 | 3.8 | 13.2 |
| Caledonia (ck) | 0.10 | 0.68 | 2.3 | 11.5 |

Table 15. Evaluation comments on flour quality and baked product performance by ConAgra

| Entry | Analytical Flour Qualities | | | End Product Performance | | | Mitigating Physical/Chemical Properties |
|---|---|---|---|---|---|---|---|
| | Likes | Dislikes | Score | Likes | Dislikes | Score | |
| VA07W-415 | | low FN; High SRC Sucrose | 5 | | | 5 | |
| VA09W-75 | | High SRC Sucrose | 5 | Poor W/T Ratio | | 3 | |
| VA09W-73 | good SRC ratio | | 6 | Poor W/T Ratio | | 4 | |
| VA09W-188WS | | low FN; high SRC Sucrose | 4 | Very Poor W/T Ratio | | 2 | |
| Shirley (ck) | | Low SRC Lactic | 3 | | | 6 | |
| SY 547 | | | 4 | | | 6 | High Flour Protein |
| F0014 | | | 5 | | | 5 | |
| F0039 | | Low SRC Lactic | 5 | | Very Good W/T Ratio | 9 | |
| F0065 | | low FN | 4 | | | 6 | |
| D8006 | good SRC profile | low FN | 7 | | Good W/T Ratio | 7 | |
| Caledonia (ck) | | | 6 | | Good W/T Ratio | 7 | |

## Kellogg Quality Evaluations

Table 16. Flour characteristics and solvent retention capacity parameters by Kellogg

| Entry | Flour Characteristics | | | | Solvent Retention Capacity (%) | | | |
|---|---|---|---|---|---|---|---|---|
| | Moisture (%) | Protein (%) | Ash (%) | Falling Number | Water | Sodium Carbonate | Sucrose | Lactic Acid |
| VA07W-415 | 13.2 | 7.0 | 0.37 | 333 | 50.0 | 71.9 | 86.2 | 96.6 |
| VA09W-75 | 12.9 | 6.8 | 0.38 | 358 | 54.8 | 74.3 | 91.6 | 107.2 |
| VA09W-73 | 13.1 | 6.7 | 0.34 | 383 | 51.9 | 69.7 | 83.3 | 103.4 |
| VA09W-188WS | 13.2 | 7.4 | 0.36 | 256 | 53.0 | 71.9 | 86.7 | 94.3 |
| Shirley (ck) | 13.1 | 6.4 | 0.34 | 349 | 50.5 | 70.3 | 80.4 | 80.7 |
| SY 547 | 12.9 | 9.8 | 0.37 | 335 | 47.9 | 67.6 | 85.1 | 93.0 |
| F0014 | 12.9 | 8.0 | 0.36 | 332 | 48.4 | 70.1 | 81.8 | 105.4 |
| F0039 | 12.8 | 7.0 | 0.34 | 334 | 46.1 | 64.5 | 73.8 | 92.7 |
| F0065 | 12.9 | 7.2 | 0.36 | 332 | 50.2 | 73.0 | 77.5 | 89.4 |
| D8006 | 12.7 | 7.7 | 0.33 | 339 | 47.5 | 67.2 | 78.1 | 104.7 |
| Caledonia (ck) | 12.9 | 7.4 | 0.37 | 307 | 46.7 | 67.7 | 76.1 | 94.0 |

Table 17. Alevograph and farinograph parameters by Kellogg

| Entry | Alevograph | | | | | Farinograph | | | |
|---|---|---|---|---|---|---|---|---|---|
| | P mm | L mm | P/L Ratio | le | W (joules) | Water Absorption (%) | Development Time (min) | Stability (min) | Degree of Softening |
| VA07W-415 | 38 | 53 | 0.72 | 43.5 | 59 | 52.6 | 1.4 | 1.9 | 119 |
| VA09W-75 | 67 | 35 | 1.91 | _ | _ | 56.1 | 1.2 | 2.2 | 102 |
| VA09W-73 | 61 | 48 | 1.27 | 46.6 | 97 | 54.9 | 1.0 | 2.0 | 134 |
| VA09W-188WS | 47 | 52 | 0.90 | 34.8 | 66 | 56.2 | 1.2 | 2.0 | 111 |
| Shirley (ck) | 29 | 56 | 0.52 | 31.8 | 39 | 53.2 | 0.9 | 1.8 | 137 |
| SY 547 | 34 | 106 | 0.32 | 37.8 | 49 | 55.1 | 2.8 | 4.9 | 88 |
| F0014 | 30 | 139 | 0.22 | 35.5 | 41 | 54.2 | 1.4 | 2.6 | 121 |
| F0039 | 20 | 80 | 0.25 | 35.8 | 28 | 50.4 | 1.0 | 1.3 | 148 |
| F0065 | 24 | 99 | 0.24 | 33.0 | 32 | 51.1 | 0.7 | 1.3 | 119 |
| D8006 | 25 | 142 | 0.18 | 39.8 | 36 | 51.7 | 0.9 | 1.8 | 142 |
| Caledonia (ck) | 20 | 131 | 0.15 | 34.7 | 27 | 50.7 | 0.7 | 1.3 | 148 |

Table 18. Rapid Visco-Analyzer parameters by Kellogg

| Entry | Peak Time (min) | Peak (cP) | Trough cP | Break-down cP | Setback cP | Final cP | Pasting Temp °C | Peak/ Final Ratio |
|---|---|---|---|---|---|---|---|---|
| VA07W-415 | 6.0 | 2223 | 1110 | 1113 | 1244 | 2354 | 68.5 | 0.94 |
| VA09W-75 | 6.1 | 2604 | 1637 | 967 | 1403 | 3040 | 68.7 | 0.86 |
| VA09W-73 | 6.3 | 2951 | 2004 | 947 | 1508 | 3512 | 68.6 | 0.84 |
| VA09W-188WS | 5.4 | 1089 | 486 | 603 | 710 | 1196 | 68.5 | 0.91 |
| Shirley (ck) | 5.9 | 2647 | 1597 | 1050 | 1615 | 3212 | 68.7 | 0.82 |
| SY 547 | 5.9 | 2668 | 1575 | 1093 | 1369 | 2944 | 68.6 | 0.91 |
| F0014 | 6.0 | 2687 | 1532 | 1155 | 1356 | 2888 | 68.5 | 0.93 |
| F0039 | 5.9 | 2443 | 1383 | 1060 | 1286 | 2669 | 68.7 | 0.92 |
| F0065 | 5.9 | 1907 | 1184 | 723 | 1237 | 2421 | 68.6 | 0.79 |
| D8006 | 5.9 | 2750 | 1441 | 1309 | 1308 | 2749 | 68.7 | 1.00 |
| Caledonia (ck) | 5.7 | 1998 | 958 | 1040 | 979 | 1937 | 68.6 | 1.03 |

Table 19. Evaluation comments on analytical flour quality by Kellogg

| | Analytical Flour Qualities | |
|---|---|---|
| Entry | Likes | Dislikes |
| VA07W-415 | Based on higher SRC-water, SRC-lactic acid and higher Farinograph water absorption these varieties are prefered compared to the chek sample Shirley | |
| VA09W-75 | | |
| VA09W-73 | | |
| VA09W-188WS | | low falling # indicate more susceptable to pre-sprout damange |
| Shirley (ck) | | |
| SY 547 | | Although higher protein content this variety has low SRC-water and SRC-Lactic however good Farinograph water absorption and mixing tolerance. |
| F0014 | Compared to ck sample Higher protein content and higher SRC-water; Lactic Acid and higher Farinograph water absorption and better mixing tolerance. | |
| F0039 | | Not an improvement compared to ck sample |
| F0065 | | Although SRC-water is higher than ck sample the SRC-Lactic acid is much lower. |
| D8006 | Based on higher SRC-water, SRC-lactic acid and higher Farinograph water absorption these varieties are prefered compared to the chek sample Shirley | |
| Caledonia (ck) | | |

## Limagrain Cereal Seeds Quality Evalutions

Table 20. Solvent retention capacity and cookie baking test parameters by Limagrain Cereal Seeds

| Entry | Solvent Retention Capacity (%) | | | | Cookie (10-52) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Water | Sodium Carbonate | Sucrose | Lactic Acid | Width (mm) | Thick (mm) | W/T Ratio (mm) | Crust | Score |
| VA07W-415 | 56.7 | 80.4 | 105.7 | 97.9 | 167 | 7.4 | 2.2 | 8 | 6 |
| VA09W-75 | 63.0 | 83.7 | 107.7 | 114.5 | 165 | 8.5 | 1.9 | 5 | 5 |
| VA09W-73 | 59.2 | 79.0 | 101.0 | 108.0 | 164 | 7.5 | 2.2 | 4 | 5 |
| VA09W-188WS | 59.4 | 82.2 | 103.2 | 89.8 | 159 | 9.0 | 1.8 | 4 | 4 |
| Shirley (ck) | 56.4 | 78.3 | 99.1 | 81.9 | 169 | 7.4 | 2.3 | 8 | 7 |
| SY 547 | 54.5 | 74.9 | 104.5 | 91.1 | 162 | 7.3 | 2.2 | 4 | 5 |
| F0014 | 57.0 | 76.7 | 99.9 | 98.3 | 168 | 7.4 | 2.3 | 5 | 6 |
| F0039 | 53.4 | 71.8 | 90.6 | 86.0 | 170 | 7.0 | 2.4 | 6 | 8 |
| F0065 | 57.8 | 78.2 | 96.2 | 94.7 | 170 | 6.8 | 2.5 | 5 | 7 |
| D8006 | 53.6 | 74.2 | 97.6 | 105.6 | 169 | 7.1 | 2.4 | 6 | 8 |
| Caledonia (ck) | 56.5 | 78.9 | 98.1 | 91.9 | 169 | 6.9 | 2.5 | 5 | 7 |

Table 21. Minolta flour color by Limagrain Cereal Seeds

| Entry | L | a | b |
|---|---|---|---|
| VA07W-415 | 92.8 | -2.4 | 10.2 |
| VA09W-75 | 93.0 | -2.2 | 9.0 |
| VA09W-73 | 93.1 | -2.0 | 8.0 |
| VA09W-188WS | 92.8 | -2.2 | 9.4 |
| Shirley (ck) | 92.9 | -2.8 | 11.4 |
| SY 547 | 92.7 | -2.2 | 9.0 |
| F0014 | 93.5 | -2.3 | 9.0 |
| F0039 | 94.4 | -2.4 | 9.5 |
| F0065 | 92.9 | -2.7 | 11.1 |
| D8006 | 93.0 | -2.5 | 10.2 |
| Caledonia (ck) | 92.9 | -2.7 | 11.2 |

Table 22. Evaluation comments on analytical flour quality by Limagrain Cereal Seeds

| | Analytical Flour Qualities | |
|---|---|---|
| Entry | Likes | Dislikes |
| VA07W-415 | | |
| VA09W-75 | | high water SRC |
| VA09W-73 | | high water SRC |
| VA09W-188WS | | high water SRC |
| Shirley (ck) | | |
| SY 547 | low NA2CO3 | |
| F0014 | | |
| F0039 | low Sucrose, low NA2CO3 | |
| F0065 | | |
| D8006 | low NA2CO3 | |
| Caledonia (ck) | | |

## Mennel Milling Quality Evaluations

Table 23. Solvent retention capacity and cookie baking test parameters by Mennel Milling

| Entry | Solvent Retention Capacity (%) | | | | Cookie (10-50D) | | |
|---|---|---|---|---|---|---|---|
| | Water | Sodium Carbonate | Sucrose | Lactic Acid | Width (mm) | Thick (mm) | W/T Ratio (mm) |
| VA07W-415 | 49.4 | 76.1 | 106.8 | 101.5 | 484 | 58.7 | 8.2 |
| VA09W-75 | 58.6 | 79.2 | 115.8 | 114.6 | 475 | 62.6 | 7.6 |
| VA09W-73 | 54.9 | 74.8 | 95.0 | 113.9 | 484 | 62.0 | 7.8 |
| VA09W-188WS | 61.1 | 78.8 | 97.4 | 99.2 | 463 | 67.0 | 6.9 |
| Shirley (ck) | 58.6 | 76.8 | 92.1 | 84.7 | 501 | 58.7 | 8.5 |
| SY 547 | 50.2 | 71.8 | 96.2 | 98.5 | 481 | 60.6 | 7.9 |
| F0014 | 47.3 | 74.5 | 89.7 | 111.8 | 501 | 62.3 | 8.1 |
| F0039 | 54.2 | 69.6 | 82.5 | 96.7 | 514 | 56.1 | 9.2 |
| F0065 | 52.3 | 78.1 | 90.2 | 96.0 | 509 | 58.3 | 8.7 |
| D8006 | 49.5 | 70.8 | 92.4 | 111.0 | 507 | 56.8 | 8.9 |
| Caledonia (ck) | 50.9 | 70.1 | 84.9 | 99.6 | 516 | 56.6 | 9.1 |

Table 24. Farinograph test and biscuit baking test parameters by Mennel Milling

| Entry | Farinograph | | | | Biscuit | | |
|---|---|---|---|---|---|---|---|
| | Water Absorption (min) | Develop Time (min) | Stability (min) | MTI | Width (mm) | Height (mm) | Weight (g) |
| VA07W-415 | 54 | 0.9 | 1.2 | 113 | 410 | 294 | 202 |
| VA09W-75 | 57 | 1 | 1.3 | 99 | 404 | 283 | 201 |
| VA09W-73 | 56 | 1 | 1.3 | 114 | 406 | 298 | 202 |
| VA09W-188WS | 56 | 1.3 | 1.8 | 98 | 407 | 293 | 204 |
| Shirley (ck) | 53 | 1 | 1.1 | 119 | 406 | 291 | 197 |
| SY 547 | 54 | 2.7 | 3.8 | 86 | 414 | 333 | 213 |
| F0014 | 54 | 1 | 1.9 | 118 | 407 | 328 | 212 |
| F0039 | 50 | 1 | 1.3 | 127 | 431 | 338 | 205 |
| F0065 | 51 | 1.2 | 2.2 | 106 | 416 | 349 | 208 |
| D8006 | 51 | 1 | 1.5 | 126 | 407 | 350 | 210 |
| Caledonia (ck) | 51 | 0.9 | 1 | 141 | 415 | 354 | 211 |

Table 25. Rapid Visco-Analyzer parameters by Mennel Milling

| Entry | Peak Time (min) | Peak (cP) | Trough cP | Break-down cP | Setback cP | Final cP | Pasting Temp °C | Peak/ Final Ratio |
|---|---|---|---|---|---|---|---|---|
| VA07W-415 | 6.0 | 172 | 87 | 85 | 94 | 181 | | 0.95 |
| VA09W-75 | 6.1 | 202 | 129 | 73 | 108 | 236 | | 0.86 |
| VA09W-73 | 6.3 | 234 | 163 | 71 | 155 | 278 | | 0.84 |
| VA09W-188WS | 5.3 | 79 | 37 | 41 | 53 | 91 | | 0.87 |
| Shirley (ck) | 6.0 | 201 | 128 | 73 | 119 | 247 | | 0.81 |
| SY 547 | 6.2 | 207 | 138 | 69 | 108 | 245 | | 0.84 |
| F0014 | 6.1 | 215 | 131 | 85 | 104 | 234 | | 0.92 |
| F0039 | 6.1 | 195 | 116 | 79 | 98 | 214 | | 0.91 |
| F0065 | 5.9 | 142 | 93 | 49 | 89 | 182 | | 0.78 |
| D8006 | 6.0 | 228 | 127 | 101 | 105 | 233 | | 0.98 |
| Caledonia (ck) | 5.8 | 161 | 81 | 80 | 76 | 157 | | 1.03 |

Table 26. Evaluation comments on flour quality and baked product performance by Mennel Milling

| | Analytical Flour Qualities | | | End Product Performance | |
|---|---|---|---|---|---|
| Entry | Likes | Dislikes | Score | Comment | Score |
| VA07W-415 | low water abs which give better SF | Low fn and pro- hight suc.value | 5 | | 6 |
| VA09W-75 | Good fn | low pro- high water abs.- high suc. Value | 5 | Poor W/T Ratio | 2.5 |
| VA09W-73 | Good fn | low rpo- water abs | 6 | Poor W/T Ratio | 5 |
| VA09W-188WS | highest pro | low fn- high water | 4 | Very Poor W/T Ratio | 2.5 |
| Shirley (ck) | Good fn | low pro- high water abs. | 3 | | 7 |
| SY 547 | high pro and fn | good water abs and sucrose | 4 | | 5 |
| F0014 | high pro and fn- low water abs | | 5 | lowest sf of group-average crust | 5 |
| F0039 | good water abs- | low pro | 5 | Excellent sf and crust score | 9 |
| F0065 | good water abs- | lower pro | 4 | good crust rating and sf | 7.5 |
| D8006 | good pro- good water abs | lowest fn | 7 | Best crust with a good sf | 8.5 |
| Caledonia (ck) | good proandd water abs | | 6 | Excellent sf and crust score | 9 |

Note: All flour in this years' selection did above average in the biscuit bakes. The Michigan samples seem to do better in volume along with the SY 547.

## Mondelez Quality Evaluations

Table 27. Solvent retention capacity and wire-cut cookie baking test parameters by Mondelez

| Entry | Solvent Retention Capacity (%)* | | | | | Alveograph | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Water | Sodium Carbonate | Sucrose | Lactic Acid | LA Ratio | P mm | L mm | P/L Ratio | W joules |
| VA07W-415 | 55.4 | 81.4 | 103.3 | 93.4 | 0.51 | 35 | 44 | 0.80 | 59 |
| VA09W-75 | 62.3 | 83.6 | 107.3 | 111.2 | 0.58 | 75 | 28 | 2.68 | 87 |
| VA09W-73 | 57.8 | 77.5 | 97.8 | 102.5 | 0.59 | 58 | 40 | 1.45 | 92 |
| VA09W-188WS | 59.3 | 83.3 | 101.5 | 91.3 | 0.49 | 43 | 55 | 0.78 | 74 |
| Shirley (ck) | 56.8 | 78.0 | 95.7 | 80.4 | 0.46 | 31 | 44 | 0.70 | 43 |
| SY 547 | 51.6 | 74.5 | 99.9 | 86.7 | 0.50 | 34 | 72 | 0.47 | 67 |
| F0014 | 55.7 | 77.1 | 96.1 | 90.7 | 0.52 | 27 | 114 | 0.24 | 68 |
| F0039 | 56.0 | 71.5 | 90.6 | 79.3 | 0.49 | 18 | 101 | 0.18 | 41 |
| F0065 | 59.7 | 71.2 | 96.1 | 98.3 | 0.59 | 20 | 99 | 0.20 | 44 |
| D8006 | 52.0 | 76.4 | 92.2 | 100.6 | 0.60 | 21 | 134 | 0.16 | 66 |
| Caledonia (ck) | 53.6 | 73.4 | 89.3 | 83.0 | 0.51 | 17 | 111 | 0.15 | 40 |

*Red, yellow & green highlights indicate poor, marginal and good quality parameters, respectively.

Table 28. Wire-cut cookie test (AACCI 10-53) parameters by Mondelez

| Entry | Wire Cut Cookie Evaluation (10-53)* | | | | | | |
|---|---|---|---|---|---|---|---|
| | Dough Firmness (g) | Dough Stickiness (g) | Cookie Stack Ht (cm x4) | Cookie Width (cm x4) | Cookie Length (cm x4) | Weight Loss % | Calculated Final Moisture % |
| VA07W-415 | 141 | | 4.26 | 30.0 | 30.2 | 13.2 | 4.5 |
| VA09W-75 | 175 | | 4.56 | 29.3 | 29.0 | 12.5 | 5.1 |
| VA09W-73 | 155 | | 4.46 | 30.5 | 30.5 | 13.1 | 4.6 |
| VA09W-188WS | 156 | | 4.65 | 28.7 | 28.7 | 12.2 | 5.4 |
| Shirley (ck) | 143 | | 4.45 | 30.7 | 30.9 | 12.8 | 4.8 |
| SY 547 | 146 | | 4.32 | 30.1 | 29.2 | 12.6 | 5.1 |
| F0014 | 149 | | 4.24 | 31.5 | 30.8 | 12.9 | 4.7 |
| F0039 | 120 | stickier | 4.04 | 32.5 | 32.3 | 13.6 | 4.1 |
| F0065 | 119 | stickier | 4.39 | 31.3 | 31.3 | 12.6 | 5.1 |
| D8006 | 128 | stickier | 4.04 | 32.2 | 32.0 | 13.3 | 4.4 |
| Caledonia (ck) | 112 | stickier | 4.10 | 32.5 | 32.4 | 13.5 | 4.2 |

*Red, yellow & green highlights indicate poor, marginal and good quality parameters, respectively.

D8006

F0039

VA09W-75

| | |
|---|---|
| | poor quality |
| | marginal quality |
| | good quality |

Table 29. Evaluation comments on flour quality characteristics by Mondelez

| Entry | Analytical Flour Qualities | | |
|---|---|---|---|
| | Likes | Dislikes | Score |
| VA07W-415 | Better than the check. Best in set 1. Typical P value for cookies/crackers. | Pentosans and damaged starch were higher than target. Gluten sligghtly under target. | 6 |
| VA09W-75 | High Gluten strengh. P value typical of hard wheat variety, not desired for cookies and crackers, ash was lower than what would typically be expected on this type of flour SRC and cookie baking performance | Worst sample in the set. High level of pentosans, damaged starch and gluten resulted in very high water absorption/ not suitable for cookies and crackers | 1 |
| VA09W-73 | Second best in the set. Good gluten strength | Pentosans and damaged starch were higher than target resulting in high water absorption. Not desired for cookie manufacturing. Could be used in crackers or wheat flour blends | 6 |
| VA09W-188WS | Typical P value for cookies/crackers | Pentosans and damaged starch were higher than target resulting in high water absorption. Gluten strength on the lower end. Not suitable for cookies and crackers. | 3 |
| Shirley (ck) | Typical P value for cookies/crackers | The check had lowest gluten functionality and high levels of pentosans and damaged starch. Not suitable for cookies and crackers. | 3 |
| SY 547 | Typical P value for cookies/crackers | Pentonsans were on high end and gluten strengh on the low end and overall water aborption was surprisingly low but did not perform well on cookie baking. Ash was the highest. Not suitable for cookies or crackers. | 3 |
| F0014 | Typical P value for cookies/crackers | Pentosans and damaged starch were higher than target. Gluten strengh on the lower side. Marginal quality for cookies and crackers. | 7 |
| F0039 | Suitable for cookies. Low P value showing soft wheat flour behavior | Not enough gluten strengh for cracker manufacturing | 6 |
| F0065 | Marginal quality for crackers. | Water absorption was very high. Penstonsans on the high end. Not suitable for cookies. | 6 |
| D8006 | Best sample in set 3 and from all. Low P value showing soft wheat flour behavior. Excellent variety for cookies and crackers. Low water absoprtion and high gluten strength | | 9 |
| Caledonia (ck) | Suitable for cookies. Low P value showing soft wheat flour behavior | Not enough gluten strengh for cracker manufacturing | 7 |

Table 30. Evaluation comments on wire-cut cookie baking performance by Mondelez

| Entry | Analytical Flour Qualities | | |
|---|---|---|---|
| | Likes | Dislikes | Score |
| VA07W-415 | Dough not sticky | Cookie diameter and stack height were slightly under target. Marginal quality | 5 |
| VA09W-75 | Dough not sticky | Low cookie diameter and high cookie height. Typical of hard wheat variety. Not suitable for cookies | 1 |
| VA09W-73 | Dough not sticky | Low cookie diameter and high cookie height. Typical of hard wheat variety. Not suitable for cookies | 3 |
| VA09W-188WS | Dough not sticky | Low cookie diameter and high cookie height. Typical of hard wheat variety. Not suitable for cookies. | 3 |
| Shirley (ck) | Dough not sticky | Low cookie diameter and high cookie height. Typical of hard wheat variety. Not suitable for cookies. | 3 |
| SY 547 | | | |
| F0014 | Dough not sticky | Low cookie diameter and high cookie height. Typical of hard wheat variety. Not suitable for cookies | 3 |
| F0039 | | | |
| F0065 | Dough not sticky | Cookie diameter met requirements and cookie height was on the high end. Marginal quality for cookies. | 5 |
| D8006 | Good quality for cookies. Cookie diameter, stack height and moisture loss during baking met the target requirements. | | 8 |
| Caledonia (ck) | Dough not stick | Cookie height was higher than target. Diameter slightly under target. Marginal quality for cookies. | 5 |

## Siemer Milling Quality Evaluations

Table 31. Alveograph test parameters by Siemer Milling

| Entry | Alveograph | | | |
|---|---|---|---|---|
| | P<br>mm | L<br>mm | P/L<br>Ratio | W<br>joules |
| VA07W-415 | 39 | 58 | 0.7 | 80 |
| VA09W-75 | 80 | 38 | 2.1 | 121 |
| VA09W-73 | 68 | 49 | 1.4 | 143 |
| VA09W-188WS | 51 | 47 | 1.1 | 92 |
| Shirley (ck) | 31 | 46 | 0.7 | 48 |
| SY 547 | 32 | 76 | 0.4 | 73 |
| F0014 | 33 | 97 | 0.3 | 80 |
| F0039 | 22 | 73 | 0.3 | 44 |
| F0065 | 22 | 73 | 0.3 | 44 |
| D8006 | 26 | 111 | 0.2 | 76 |
| Caledonia (ck) | 21 | 97 | 0.2 | 55 |

Table 32. Evaluation comments on alveograph dough test by Siemer Milling

| Entry | Mitigating Physical/Chemical Properties |
|---|---|
| VA07W-415 | performance similar to our SRW flour. |
| VA09W-75 | dough stiff- little to no extensibility |
| VA09W-73 | dough somewhat stiff when compared to SRW - little extensibility- strong SRW- but low protein |
| VA09W-188WS | dough a little stiff- short lengths |
| Shirley (ck) | not a strong flour- short lengths |
| SY 547 | dough somewhat sticky- not a strong flour even though protein is 10.00 |
| F0014 | performance similar to our SRW |
| F0039 | not a strong flour-- dough somewhat soft- short peaks |
| F0065 | dough soft- short peaks |
| D8006 | dough very soft- extensible ( long lengths) |
| Caledonia (ck) | dough too soft- extensible |

## Star of the West Milling Evaluations

Table 33. Solvent retention capacity and cookie baking test parameters by Star of the West Milling

| Entry | Solvent Retention Capacity (%) | | | | | Cookie (10-50D) | | |
|---|---|---|---|---|---|---|---|---|
| | Water | Sodium Carbonate | Sucrose | Lactic Acid | LA/ SC+S | Width (mm) | Thick (mm) | W/T Ratio (mm) |
| VA07W-415 | 54.0 | 73.5 | 103.7 | 100.6 | 0.57 | 470 | 56 | 8.4 |
| VA09W-75 | 61.4 | 82.8 | 108.3 | 92.9 | 0.49 | 470 | 63 | 7.5 |
| VA09W-73 | 58.1 | 81.1 | 107.1 | 106.1 | 0.56 | 479 | 60 | 8.0 |
| VA09W-188WS | 57.8 | 93.2 | 103.4 | 92.3 | 0.47 | 457 | 65 | 7.0 |
| Shirley (ck) | 56.0 | 81.0 | 104.4 | 80.7 | 0.44 | 486 | 60 | 8.1 |
| SY 547 | 52.7 | 75.4 | 103.4 | 90.2 | 0.50 | 472 | 58 | 8.1 |
| F0014 | 54.2 | 75.3 | 96.7 | 95.0 | 0.55 | 508 | 60 | 8.5 |
| F0039 | 51.9 | 79.5 | 91.2 | 79.5 | 0.47 | 507 | 53 | 9.6 |
| F0065 | 55.6 | 78.0 | 97.1 | 87.9 | 0.50 | 511 | 58 | 8.9 |
| D8006 | 52.3 | 73.7 | 93.6 | 102.6 | 0.61 | 500 | 58 | 8.6 |
| Caledonia (ck) | 52.1 | 72.8 | 91.8 | 86.8 | 0.53 | 493 | 58 | 8.6 |

Table 34. Rapid Visco-Analyzer parameters by Star of the West Milling

| Entry | Peak Time (min) | Peak (cP) | Trough cP | Break-down cP | Setback cP | Final cP | Pasting Temp °C | Peak/ Final Ratio |
|---|---|---|---|---|---|---|---|---|
| VA07W-415 | 5.8 | 2175 | 1065 | 1110 | 1155 | 2220 | 83.0 | 0.98 |
| VA09W-75 | 6.0 | 2631 | 1524 | 1107 | 1443 | 2967 | 69.6 | 0.89 |
| VA09W-73 | 6.2 | 2997 | 1903 | 1094 | 1598 | 3501 | 85.5 | 0.86 |
| VA09W-188WS | 5.3 | 1098 | 477 | 621 | 673 | 1150 | 65.4 | 0.95 |
| Shirley (ck) | 5.9 | 2593 | 1532 | 1061 | 1569 | 3101 | 67.9 | 0.84 |
| SY 547 | 6.1 | 2601 | 1574 | 1027 | 1356 | 2930 | 85.5 | 0.89 |
| F0014 | 5.9 | 2695 | 1470 | 1225 | 1324 | 2794 | 83.8 | 0.96 |
| F0039 | 5.7 | 2540 | 1297 | 1243 | 1270 | 2567 | 70.2 | 0.99 |
| F0065 | 5.8 | 1855 | 1122 | 733 | 1171 | 2293 | 93.9 | 0.81 |
| D8006 | 5.9 | 2735 | 1403 | 1332 | 1262 | 2665 | 68.7 | 1.03 |
| Caledonia (ck) | 5.7 | 2022 | 907 | 1115 | 954 | 1861 | 68.6 | 1.09 |

Table 35. Evaluation comments on flour quality and baked product performance by Star of the West Milling

| Entry | Analytical Flour Qualities | | | End Product Performance | | |
|---|---|---|---|---|---|---|
| | Likes | Dislikes | Score | Likes | Dislikes | Score |
| VA07W-415 | Lower water and sodium carb | | 6 | good cookie diameter | | |
| VA09W-75 | | Higher water and sodium carb | 4 | | tight spread on sugar snap cookie | |
| VA09W-73 | High amylograph/RVA | low protein | 7 | good cookie diameter | | |
| VA09W-188WS | | Low Amylograph RVA | 2 | | | |
| Shirley (ck) | | very low protein | 5 | | | |
| SY 547 | High amylograph/RVA | | 6 | | tight spread | |
| F0014 | high protein | | 8 | | tightest spread in set | |
| F0039 | | | 7 | largest spread of set | | |
| F0065 | | relatively low Amylo/RVA | 4 | fairly wide spread | | |
| D8006 | High amylograph/RVA | | 7 | SRC indicate good cracker flour | | |
| Caledonia (ck) | | relatively low Amylo/RVA | 7 | distint top pattern on sugar snap cookies | | |

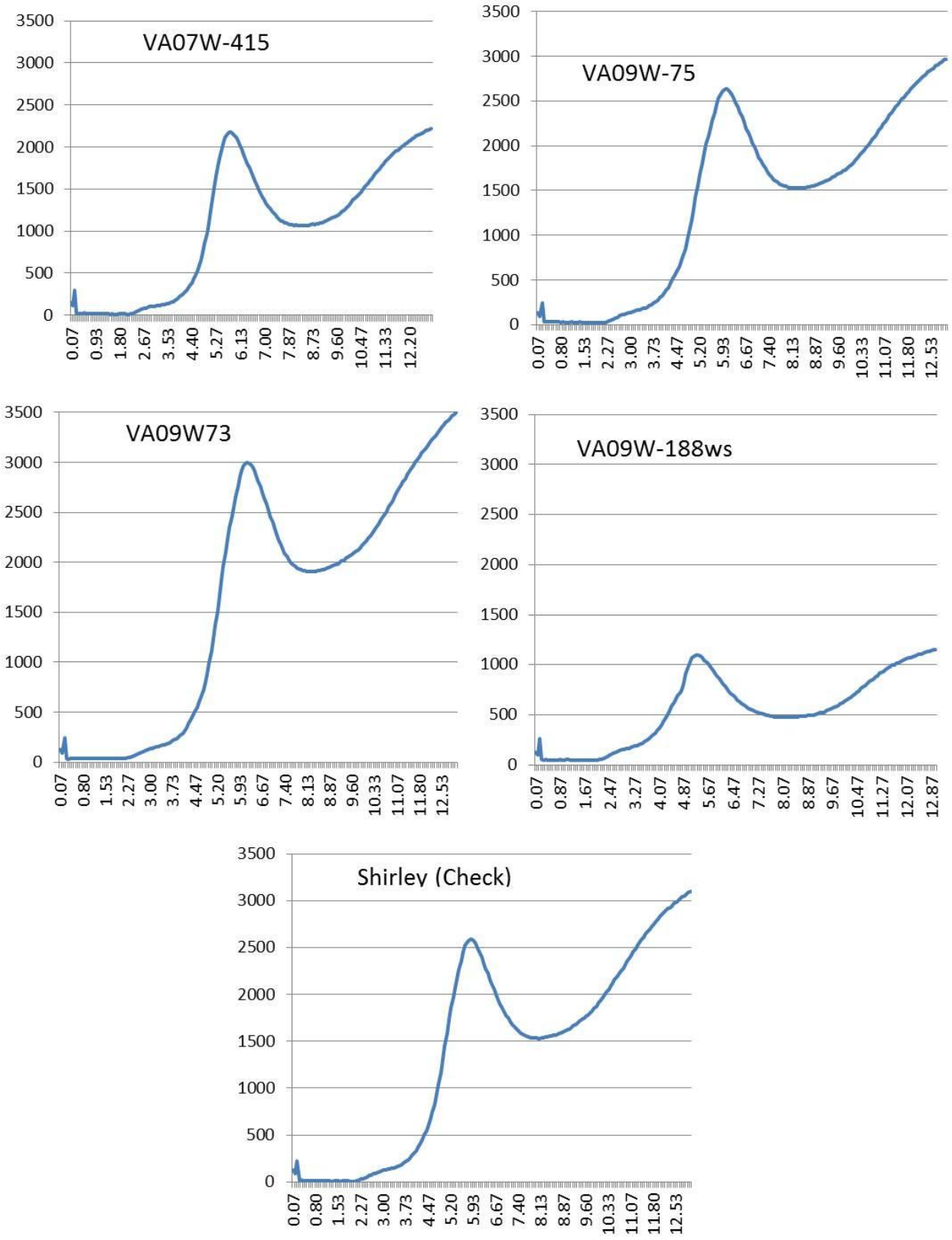


Figure 1. Pasting Curves of Set 1 Flours by Star of the West Milling

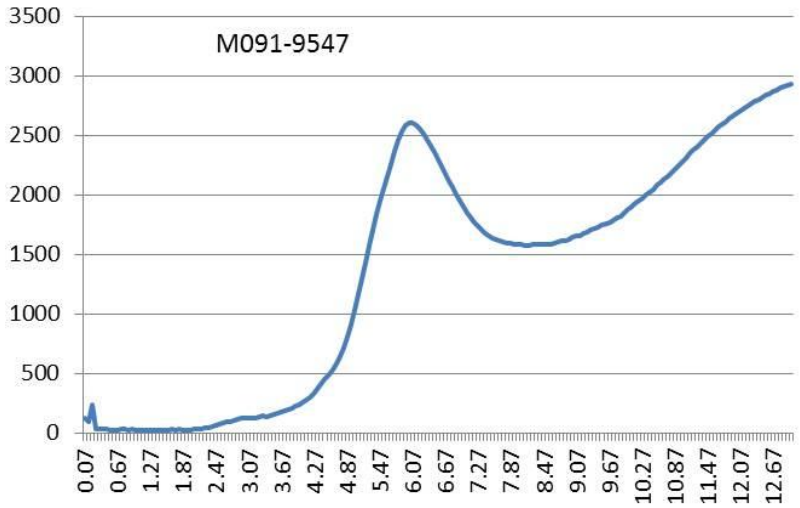


Figure 2. Pasting Curve of Set 2 flour, SY 547 (M091-9547), by Star of the West Milling

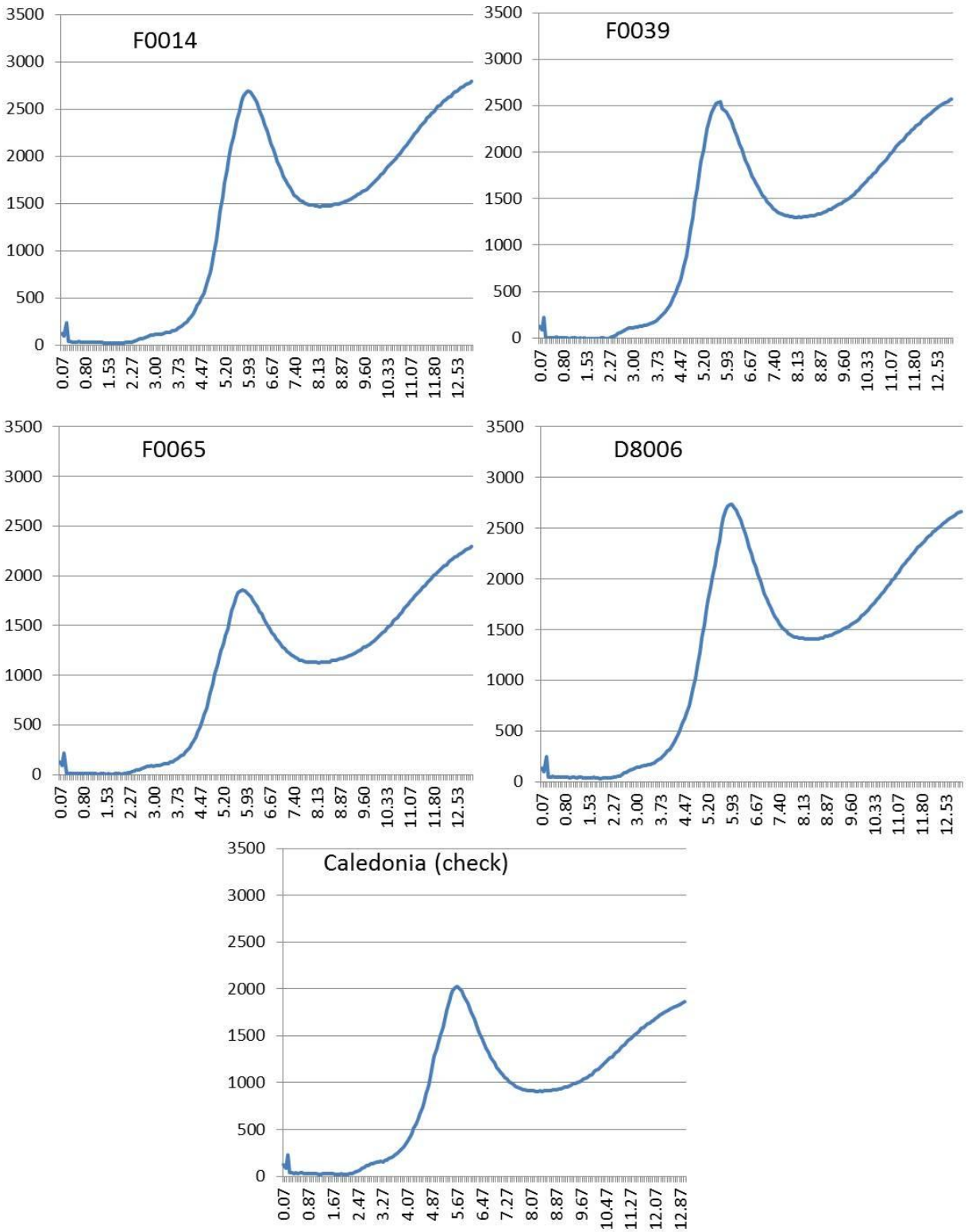


Figure 3. Pasting Curves of Set 3 Flours by Star of the West Milling

## Syngenta Quality Evaluations

Table 36. Solvent retention capacity and cookie baking test parameters by Syngenta

| Entry | Solvent Retention Capacity (%) | | | | Cookie (10-52) | |
|---|---|---|---|---|---|---|
| | Water | Sodium Carbonate | Sucrose | Lactic Acid | Width (cm) | Score |
| VA07W-415 | 60 | 77 | 95 | 91 | 16.8 | 4 |
| VA09W-75 | 56 | 73 | 92 | 100 | 18.0 | 7 |
| VA09W-73 | 58 | 78 | 103 | 102 | 17.0 | 4 |
| VA09W-188WS | 54 | 76 | 94 | 89 | 17.2 | 5 |
| Shirley (ck) | 51 | 67 | 83 | 86 | 18.4 | **8** |
| SY 547 | 53 | 72 | 90 | 98 | 18.0 | 7 |
| F0014 | 52 | 72 | 95 | 87 | 17.2 | 4 |
| F0039 | 53 | 71 | 89 | 76 | 18.0 | 7 |
| F0065 | 51 | 68 | 83 | 85 | 18.6 | 8 |
| D8006 | 53 | 70 | 85 | 100 | 18.4 | 8 |
| Caledonia (ck) | 55 | 75 | 89 | 85 | 18.6 | 8 |

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

| Entry | Analytical Flour Qualities | | | End Product Performance | | | Mitigating Physical/Chemical Properties |
|---|---|---|---|---|---|---|---|
| | Likes | Dislikes | Score | Likes | Dislikes | Score | |
| VA07W-415 | | H2O | 4 | | diameter Small | 4 | Small cookie diameter, lower FN and high water. |
| VA09W-75 | | H2O | 5 | | | 7 | High water SRC, overall nice cookie. |
| VA09W-73 | | H2O,SC,SUC | 2 | | diameter small | 4 | Cookie data reflects poor SRC profile. |
| VA09W-188WS | H2O | | 6 | acceptable diameter | | 5 | Low FN, below avg cookie. |
| Shirley (ck) | H2O,SC,SUC | | 8 | Nice Cookie, good diameter | | 8 | Ck best of group. Good Ash |
| SY 547 | H2O | | 6 | Sl Above Avg Cookie | | 7 | With no ck to compare, cookie has an overall nice profile |
| F0014 | H2O | | 6 | | Poorer Cookie | 4 | Poorest of the group, small cookie diameter. |
| F0039 | H2O,SUC | | 7 | | Sl below Ck | 7 | Above avg cookie. |
| F0065 | H2O,SC,SUC | | 8 | Cookie = to or better then Ck | | 8 | Very good cookie, Better than ck |
| D8006 | H2O,SC,SUC | | 8 | Nice Cookie | | 8 | Very good cookie, equal to ck |
| Caledonia (ck) | H2O,SUC | | 7 | | Sticky dough had to drop the ABS by .2 | 8 | Very good cookie. |

## Wheat Marketing Center Quality Evaluations

Table 38. Sponge cake baking test parameters by Wheat Marketing Center

| Entry | Sponge Cake | | | | | |
|---|---|---|---|---|---|---|
| | Volume (ml) | Total Score | Ranking | External | Crumb Grain | Texture |
| VA07W-415 | 1192 | 42 | 9 | 13 | 17 | 12 |
| VA09W-75 | 1255 | 47 | 5 | 12 | 17 | 18 |
| VA09W-73 | 1284 | 52 | 2 | 13 | 18 | 21 |
| VA09W-188WS | 1198 | 45 | 7 | 12 | 18 | 15 |
| Shirley (ck) | 1236 | 44 | 8 | 14 | 18 | 12 |
| SY 547 | 1187 | 34 | 11 | 13 | 18 | 3 |
| F0014 | 1260 | 46 | 6 | 13 | 18 | 15 |
| F0039 | 1285 | 41 | 10 | 12 | 20 | 9 |
| F0065 | 1331 | 55 | 1 | 14 | 20 | 21 |
| D8006 | 1297 | 49 | 4 | 13 | 18 | 18 |
| Caledonia (ck) | 1269 | 50 | 3 | 12 | 20 | 18 |

Table 39. Evaluation comments on flour quality and sponge cake baking test performance by Wheat Marketing Center

| Entry | Analytical Flour Qualities | | | End Product Performance | | |
|---|---|---|---|---|---|---|
| | Likes | Dislikes | Score | Likes | Dislikes | Score |
| VA07W-415 | low protein | low FN | 4 | | hard texture | 3 |
| VA09W-75 | low protein | | 5 | good volume | | 5 |
| VA09W-73 | low protein | | 5 | good volume, soft texture | | 7 |
| VA09W-188WS | | high protein, low FN | 3 | | hard texture | 4 |
| Shirley (ck) | low protein, low ash | | 7 | good volume | hard texture | 4 |
| SY 547 | | high protein | 3 | | low volume, very hard texture | 2 |
| F0014 | | | 4 | good volume | hard texture | 5 |
| F0039 | low protein, low ash | | 6 | good volume | hard texture | 3 |
| F0065 | low protein | | 5 | very good volume, soft texture | | 8 |
| D8006 | low ash | | 4 | good volume | | 6 |
| Caledonia (ck) | low ash | | 5 | good volume | | 6 |

## USDA-ARS Western Wheat Quality laboratory Quality Evaluations

Table 40. Solvent retention capacity, RVA test, sugar-snap cookie and sponge cake baking test parameters by USDA-ARS Western Wheat Quality laboratory

| Entry | Solvent Retention Capacity (%) | | | | RVA Peak cP | Cookie (10-52) | | Sponge Cake | |
|---|---|---|---|---|---|---|---|---|---|
| | Water | Sodium Carbonate | Sucrose | Lactic Acid | | Width (mm) | Score | Volume (mL) | Texture Score |
| VA07W-415 | 53.8 | 75.7 | 85.5 | 97.6 | 110 | 18.0 | | 1190 | 17 |
| VA09W-75 | 59.2 | 79.3 | 92.3 | 113.0 | 142 | 16.9 | | 1230 | 18 |
| VA09W-73 | 55.3 | 74.4 | 82.8 | 105.2 | 172 | 18.2 | | 1270 | 19 |
| VA09W-188WS | 57.5 | 75.5 | 86.7 | 96.0 | 34 | 17.0 | | 1155 | 17 |
| Shirley (ck) | 54.5 | 74.3 | 81.2 | 81.5 | 132 | 19.0 | | 1245 | 17 |
| SY 547 | 51.9 | 71.2 | 80.9 | 92.9 | 157 | 17.0 | | 1230 | 17 |
| F0014 | 54.0 | 75.3 | 81.2 | 103.2 | 141 | 17.6 | | 1270 | 19 |
| F0039 | 51.0 | 69.6 | 73.0 | 90.2 | 134 | 19.1 | | 1310 | 20 |
| F0065 | 56.2 | 77.8 | 78.5 | 89.9 | 92 | 18.6 | | 1280 | 18 |
| D8006 | 52.3 | 70.3 | 77.2 | 104.4 | 163 | 18.8 | | 1270 | 19 |
| Caledonia (ck) | 50.3 | 69.8 | 75.1 | 91.3 | 101 | 18.8 | | 1305 | 20 |

Table 41. Alkaline noodle color parameters by USDA-ARS Western Wheat Quality Laboratory

| Entry | Alkali noodle color @ 0 Hour | | | Alkali noodle color @ 24 Hour | | | Change in L* |
|---|---|---|---|---|---|---|---|
| | *L** | *a** | *b** | *L** | *a** | *b** | |
| VA07W-415 | 83.6 | -1.8 | 20.2 | 67.8 | 0.2 | 24.6 | 15.8 |
| VA09W-75 | 85.5 | -2.8 | 19.8 | 77.6 | -1.7 | 24.2 | 7.9 |
| VA09W-73 | 86.4 | -2.1 | 15.1 | 79.7 | -1.6 | 19.6 | 6.7 |
| VA09W-188WS | 85.9 | -2.2 | 17.3 | 77.7 | -1.0 | 20.2 | 8.2 |
| Shirley (ck) | 85.1 | -2.4 | 20.2 | 75.9 | -1.3 | 24.7 | 9.2 |
| SY 547 | 84.2 | -1.6 | 17.6 | 73.9 | -0.8 | 19.6 | 10.3 |
| F0014 | 86.9 | -2.8 | 19.2 | 78.7 | -2.0 | 23.4 | 8.2 |
| F0039 | 86.7 | -2.7 | 21.0 | 77.2 | -1.8 | 25.5 | 9.5 |
| F0065 | 84.5 | -2.9 | 26.4 | 75.3 | -1.3 | 29.8 | 9.2 |
| D8006 | 85.9 | -2.6 | 21.9 | 75.7 | -1.0 | 25.3 | 10.2 |
| Caledonia (ck) | 85.9 | -2.6 | 21.7 | 75.3 | -1.3 | 25.8 | 10.6 |

Table 42. Evaluation comments on flour quality and sponge cake baking performance by USDA-ARS Western Wheat Quality Laboratory

| Entry | Analytical Flour Qualities | | | End Product Performance | | | Mitigating Physical/Chemical Properties |
|---|---|---|---|---|---|---|---|
| | Likes | Dislikes | Score | Likes | Dislikes | Score | |
| VA07W-415 | | | | | poor coarse grain | 3 | runny, flat, streaky batter |
| VA09W-75 | | | | | | 7 | barely retains batter shape |
| VA09W-73 | | | | | | 8 | retains batter shape, moderatly stiff |
| VA09W-188WS | | very low RVA but cake did not display classic symptoms of sprout | | | poor coarse grain | 5 | slightly runny batter |
| Shirley (ck) | | | | good volume | poor coarse grain | 6 | loose batter |
| SY 547 | | | | good volume | poor coarse grain | 6 | |
| F0014 | | | | | | 8 | |
| F0039 | | | | great volume | nice grain | 9 | great cake |
| F0065 | | | | | | 8 | stiffer batter |
| D8006 | | | | | | 8 | nice batter properties |
| Caledonia (ck) | | | | great volume | nice grain | 9 | stiffer batter/ great cake |

Table 43. Evaluation comments on flour quality and sugar-snap cookie baking performance by USDA-ARS Western Wheat Quality Laboratory

| Entry | Analytical Flour Qualities | | | End Product Performance | | | Mitigating Physical/Chemical Properties |
|---|---|---|---|---|---|---|---|
| | Likes | Dislikes | Score | Likes | Dislikes | Score | |
| VA07W-415 | | | 6 | | | 5 | VERY dark alkaline noodle color |
| VA09W-75 | | high on all src | 3 | | | 3 | strong gluten |
| VA09W-73 | | | 6 | | | 5 | good alkaline noodle color / strong gluten |
| VA09W-188WS | | low RVA sprouted? | 3 | | | 3 | |
| Shirley (ck) | | | 5 | good cookie spread | | 8 | |
| SY 547 | low water abs | highest protein | 7 | | | 4 | |
| F0014 | | | 5 | | | 4 | good alkaline noodle color/ strong gluten |
| F0039 | good src profile | | 8 | best spread | | 8 | |
| F0065 | | high water | 5 | | | 6 | |
| D8006 | low water abs | | 7 | good cookie spread | | 7 | strong gluten |
| Caledonia (ck) | good src profile | | 8 | good cookie spread | | 7 | |

## USDA-ARS Soft Wheat Quality Laboratory Soft Wheat Quality Evaluations

Table 44. Test weight, thousand kernel weight and SKCS test parameters by USDA-ARS Soft Wheat Quality Laboratory

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

Table 45. Flour quality test parameters by USDA-ARS Soft Wheat Quality Laboratory

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

Table 46. Solvent retention capacity and cookie baking test parameters by USDA-ARS Soft Wheat Quality Laboratory

| Entry | Solvent Retention Capacity (%) | | | | Cookie (10-52) | |
|---|---|---|---|---|---|---|
| | Water | Sodium Carbonate | Sucrose | Lactic Acid | Width (cm) | Top Grain Score |
| VA07W-415 | 56.1 | 77.8 | 95.7 | 91.1 | 17.4 | 4 |
| VA09W-75 | 62.5 | 81.6 | 101.8 | 101.6 | 16.7 | 3 |
| VA09W-73 | 62.4 | 83.1 | 101.2 | 102.2 | 16.3 | 2 |
| VA09W-188WS | 60.0 | 80.7 | 97.3 | 89.8 | 16.7 | 3 |
| Shirley (ck) | 58.2 | 77.2 | 91.2 | 79.1 | 18.3 | 5 |
| SY 547 | 56.3 | 75.2 | 96.7 | 86.6 | 17.3 | 3 |
| F0014 | 56.4 | 77.7 | 92.2 | 96.2 | 17.6 | 3 |
| F0039 | 54.2 | 72.9 | 84.0 | 86.9 | 18.2 | 4 |
| F0065 | 55.5 | 75.9 | 87.9 | 99.3 | 18.2 | 5 |
| D8006 | 55.0 | 75.3 | 88.5 | 98.8 | 18.1 | 5 |
| Caledonia (ck) | 55.1 | 74.3 | 85.5 | 87.4 | 18.4 | 5 |

Table 47. Rapid Visco-Analyzer parameters by USDA-ARS Soft Wheat Quality Laboratory

| Entry | Peak Time (min) | Peak (cP) | Trough cP | Break-down cP | Setback cP | Final cP | Pasting Temperature °C | Peak/Final Ratio |
|---|---|---|---|---|---|---|---|---|
| VA07W-415 | 6.0 | 2231 | 1084 | 1147 | 1189 | 2273 | 87.2 | 0.98 |
| VA09W-75 | 6.1 | 2724 | 1645 | 1080 | 1484 | 3129 | 83.5 | 0.87 |
| VA09W-73 | 6.1 | 2711 | 1641 | 1070 | 1483 | 3123 | 83.1 | 0.87 |
| VA09W-188WS | 5.3 | 1022 | 454 | 568 | 677 | 1131 | 82.3 | 0.90 |
| Shirley (ck) | 6.0 | 2735 | 1678 | 1057 | 1650 | 3327 | 83.2 | 0.82 |
| SY 547 | 6.1 | 2768 | 1722 | 1047 | 1456 | 3178 | 84.8 | 0.87 |
| F0014 | 6.0 | 2842 | 1618 | 1225 | 1393 | 3010 | 84.8 | 0.94 |
| F0039 | 6.0 | 2561 | 1437 | 1124 | 1323 | 2760 | 77.5 | 0.93 |
| F0065 | 6.0 | 2914 | 1529 | 1385 | 1357 | 2886 | 82.3 | 1.01 |
| D8006 | 5.9 | 2909 | 1528 | 1381 | 1365 | 2893 | 82.8 | 1.01 |
| Caledonia (ck) | 5.8 | 2039 | 955 | 1084 | 981 | 1935 | 82.3 | 1.05 |

## Summaries and statistics of combined cooperator test parameters

Table 48. Mean SRC test parameters and overall flour quality scores

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

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

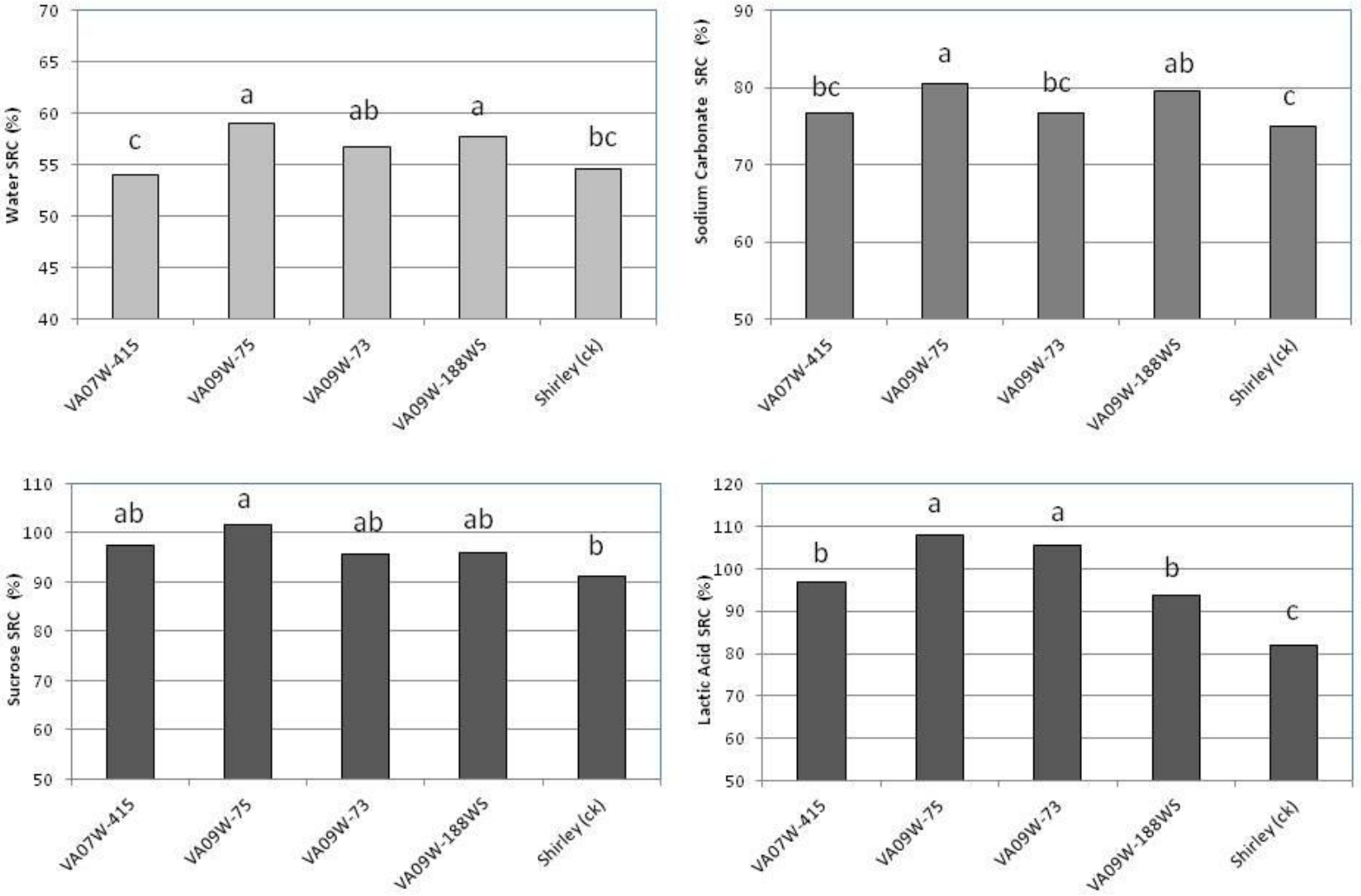


Figure 4. Mean differences in solvent retention capacities of Virginia Polytechnic Institute and State University Entries.

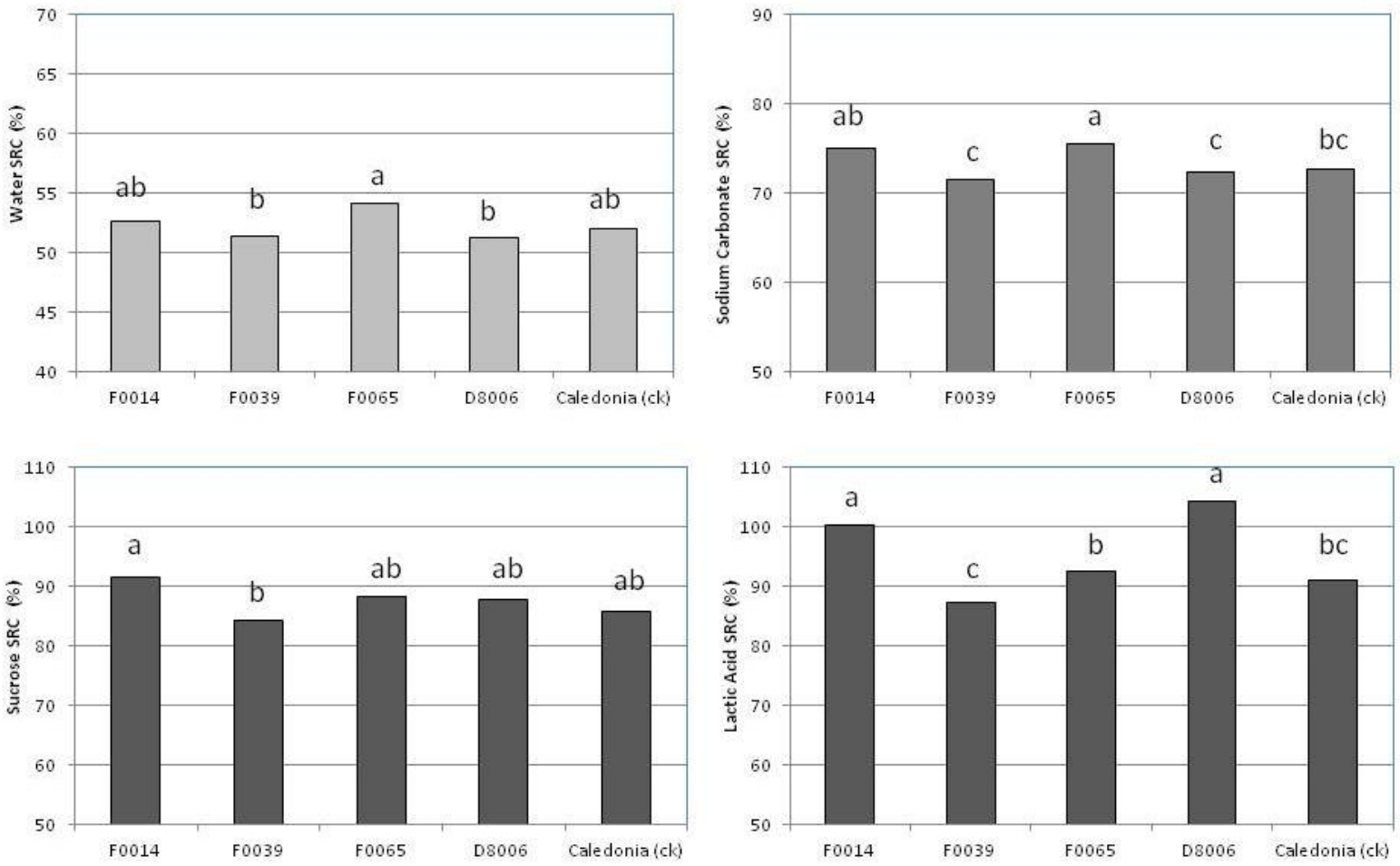


Figure 5. Mean differences in solvent retention capacities of Michigan State University Entries.

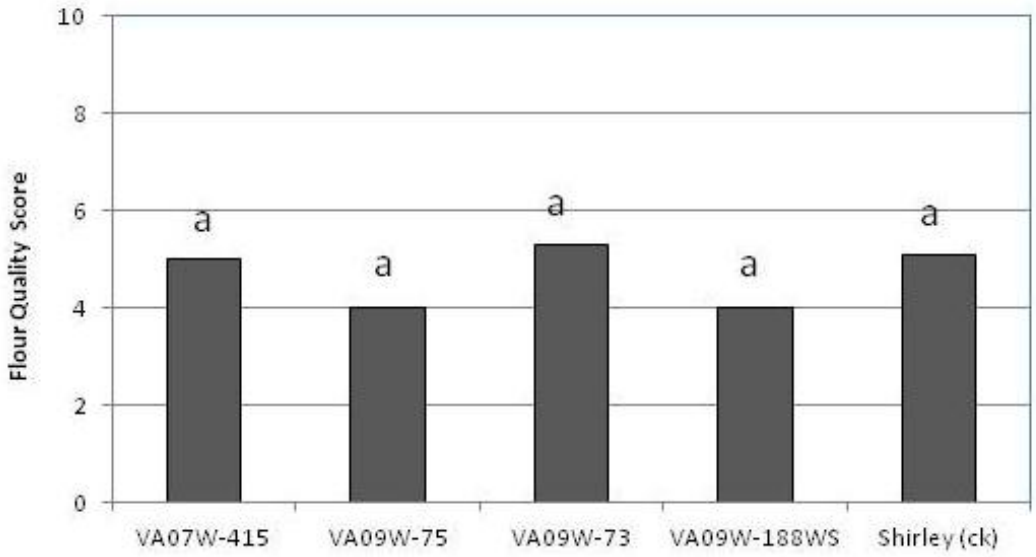


Figure 6. Mean differences in flour quality scores of Virginia Polytechnic Institute and State University Entries.

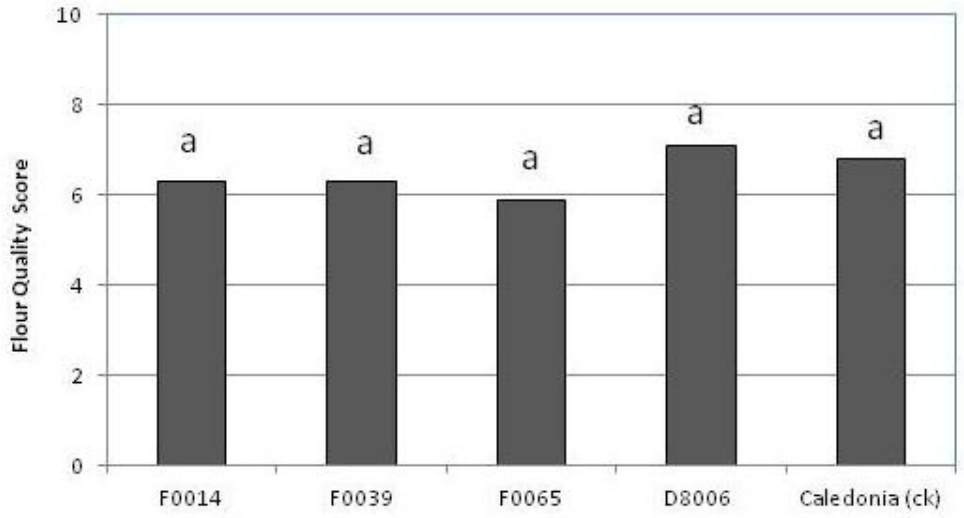


Figure 7. Mean differences in flour quality scores of Michigan State University Entries.

Table 49. Mean Alveograph test parameters

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

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

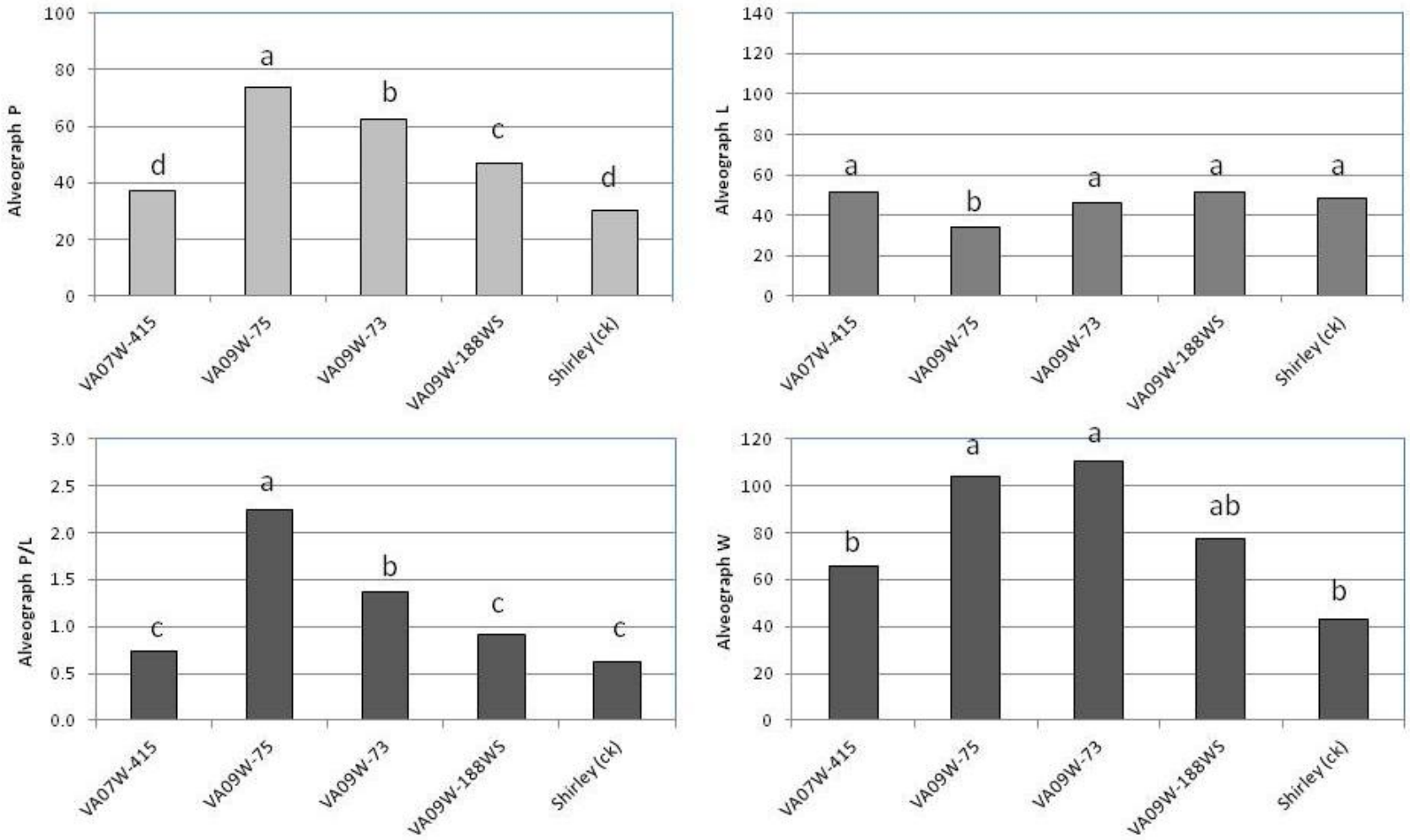


Figure 8. Mean differences in Alveograph parameters of Virginia Polytechnic Institute and State University Entries.

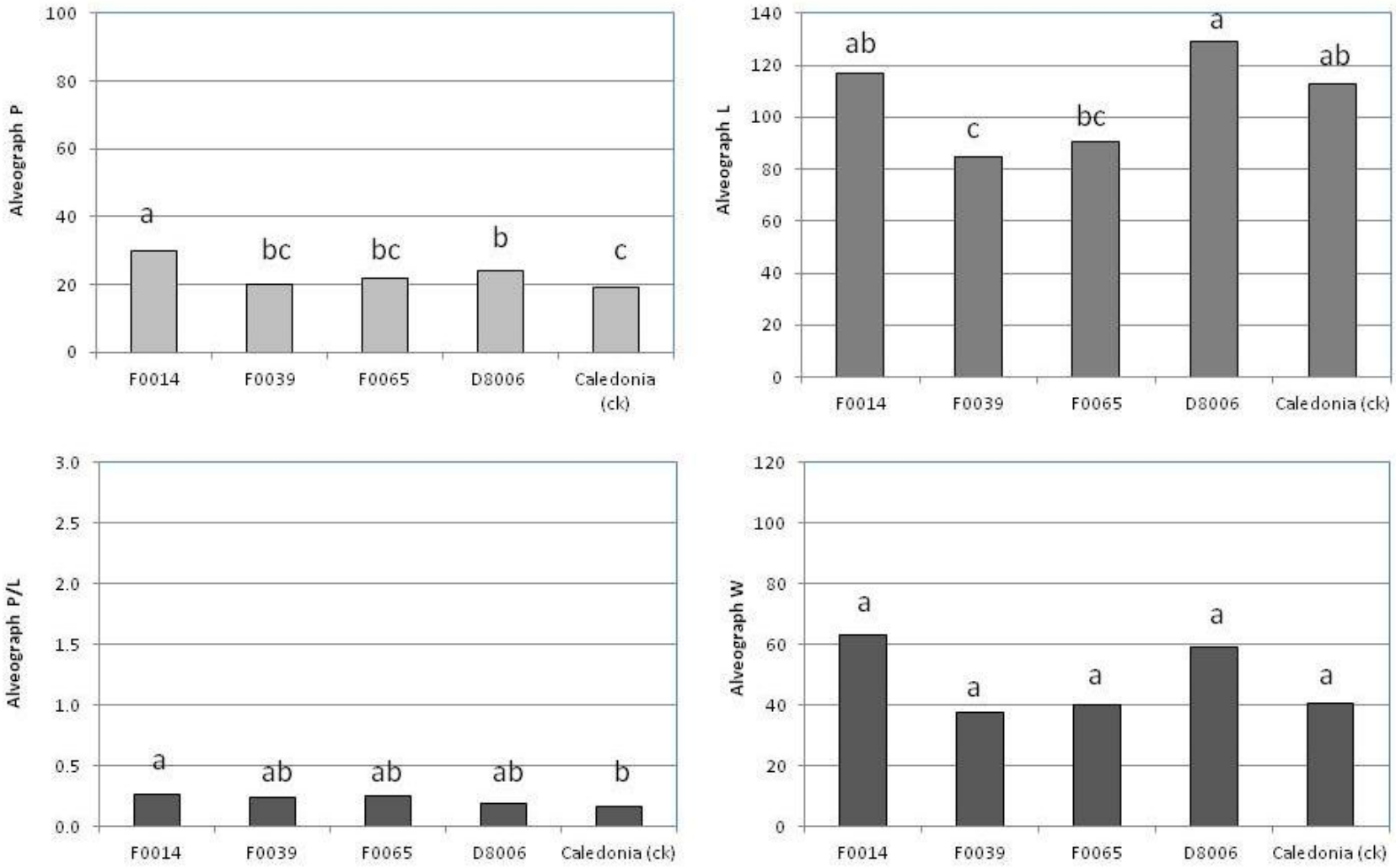


Figure 9. Mean differences in Alveograph parameters of Michigan State University entries.

Table 50. Mean Farinograph test parameters

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

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

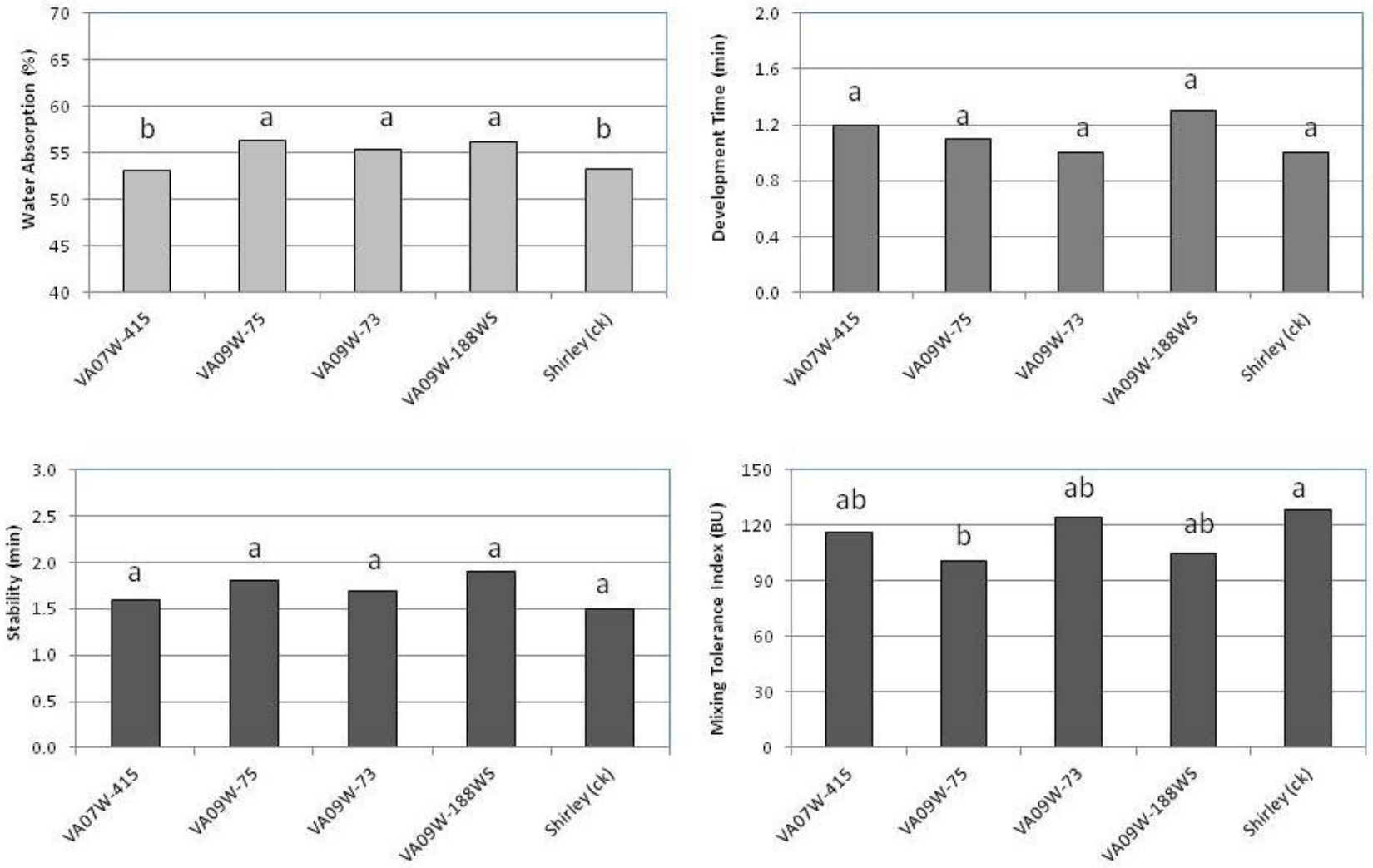


Figure 10. Mean differences in Farinograph parameters of Virginia Polytechnic Institute and State University Entries.

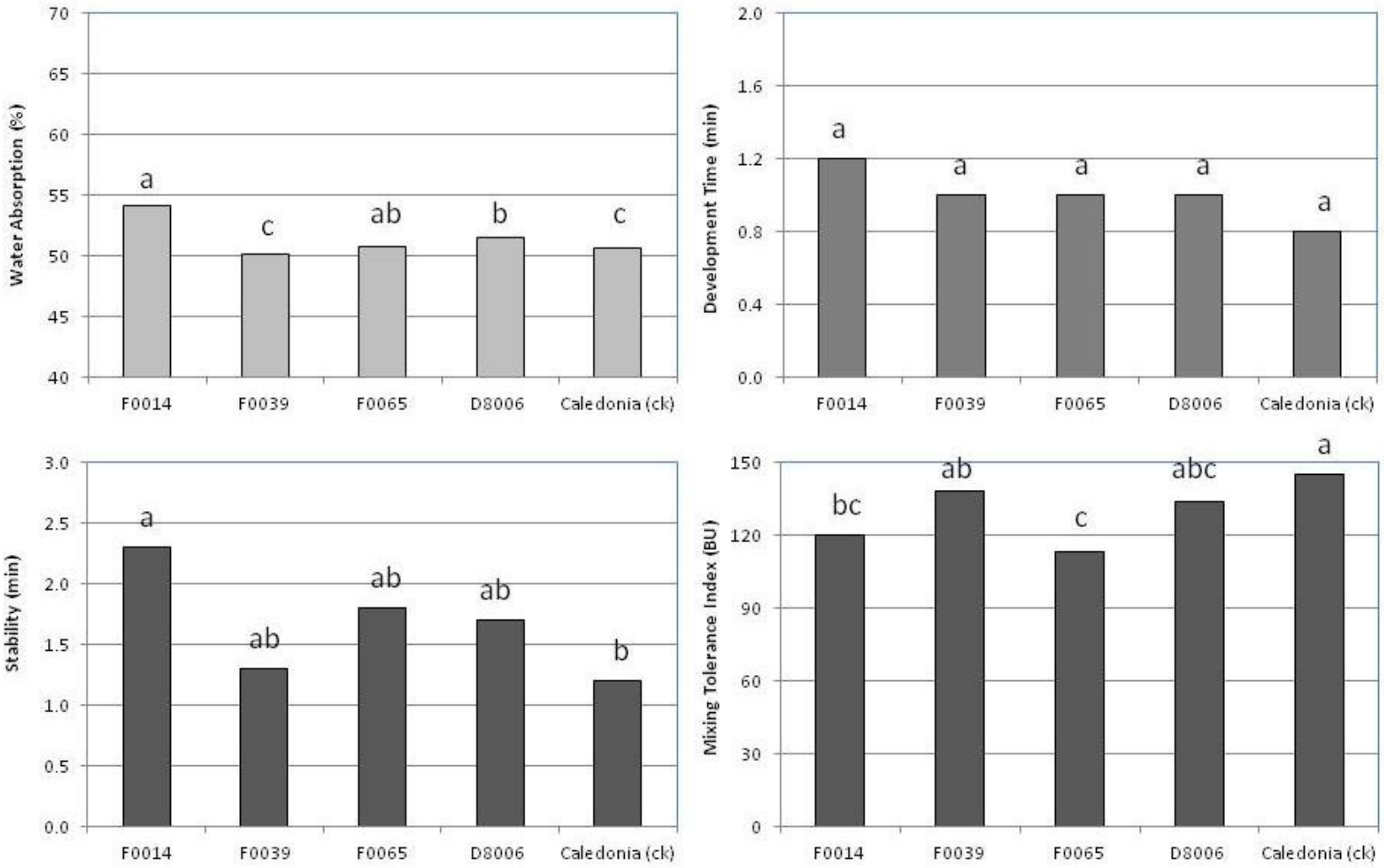


Figure 11. Mean differences in Farinograph parameters of Michigan State University entries.

Table 51. Mean Rapid Visco-Analyzer (RVA) test parameters

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

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

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

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

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

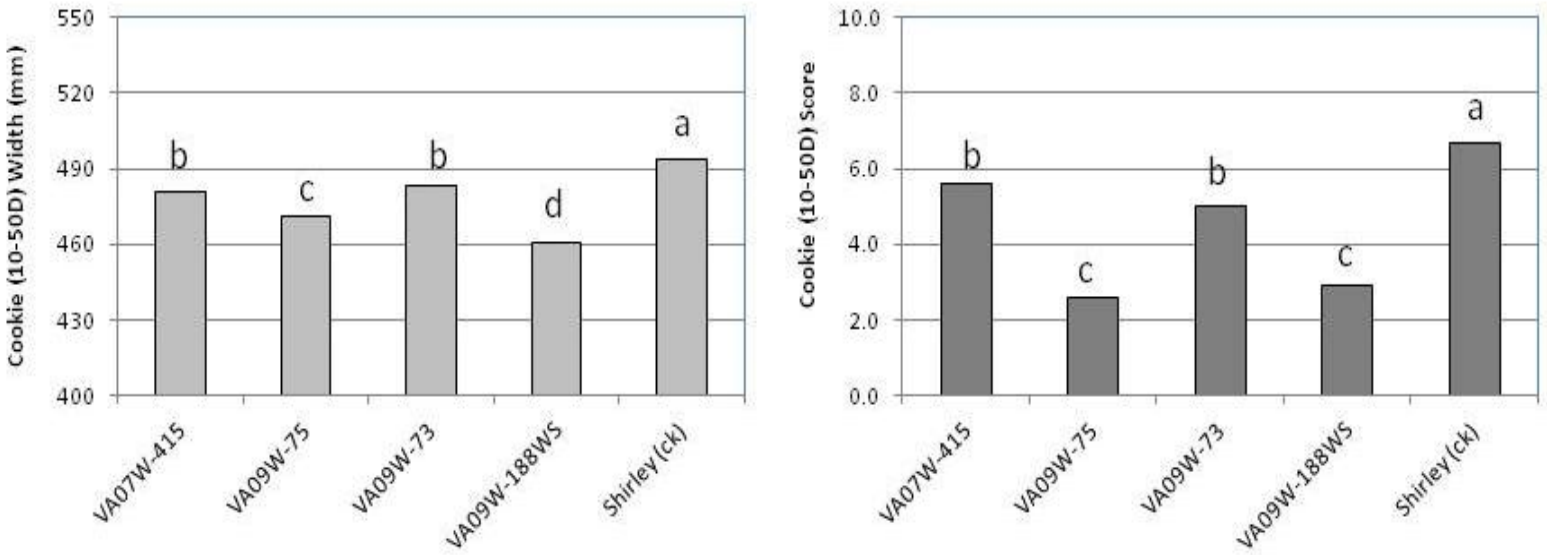


Figure 12. Mean differences in cookie (10-50D) diameters of Virginia Polytechnic Institute and State University Entries.

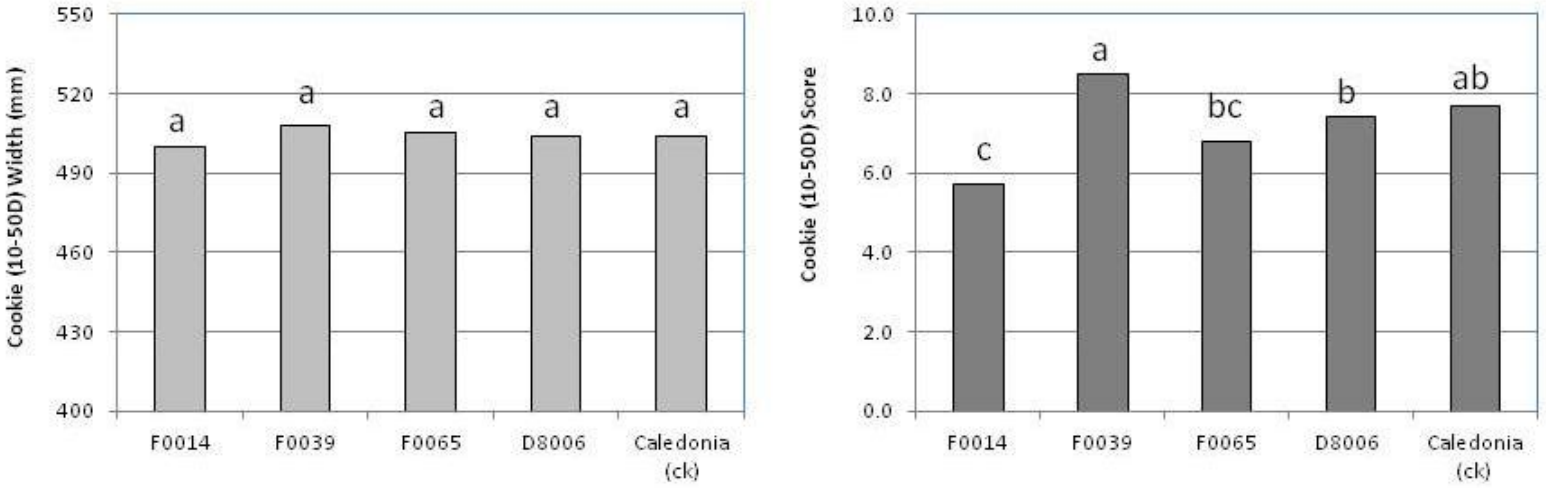


Figure 13. Mean differences in cookie (10-50D) diameters of Michigan State University Entries.

Table 53. Mean sponge cake baking test parameters

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

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

Table 54. Water SRC of 2013 WQC entries by cooperators

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

Table 55. Sodium Carbonate SRC of 2013 WQC entries by cooperators

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

Table 56. Sucrose SRC of 2013 WQC entries by cooperators

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

Table 57. Lactic acid SRC of 2013 WQC entries by cooperators

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

Table 58. Sugar-snap cookie (10-50D) diameter (mm) of 2013 WQC entries by cooperators

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

Table 59. Flour quality scores of 2013 WQC entries by cooperators

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

Table 60. Sugar-snap cookie (10-50D) quality scores of 2013 WQC entries by cooperators

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

## Genotyping for Quality Traits: WQC

Anne Sturbaum, January, 2014

Genotyping for traits associated with quality, physiology and disease resistance was done at the the Regional Small Grains Genotyping Laboratory (RSGGL) in Raleigh, N.C. for the 9 varieties: VA07W-415, VA09W-75, VA09W-73, VA09W-188WS, SY 547 (formerly M09L-9547), F0014, F0039, F0065 and D8006. Checks for this group were Caledonia and Shirley.

Quality

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

Amplification for high molecular weight glutenins at the *GluA1* locus, using the marker *umn19* (Liu et al., 2008a) identified the *Ax2** genotype in 8 WQC entries and the check, Caledonia. D8006 had Ax1 or null alleles and Shirley was heterozygous at this allele.

Primers detecting a 45 base pair insertion specific to the *Bx7* over-expressing allele (*Bx7OE*) (Guttieri et al., 2008) indicated over-expressing *Bx7* only for F0014 and D8006. All other varieties and checks produced a product indicative of the wild type allele at this locus.

Primers specific for *GluD1*, *Dx5*, generated a PCR product corresponding to the "5+10" genotype F0065, M09L-9547 and D8006. All other varieties produced amplification products specific for the "2+12" allele (Wan et al., 2005).

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

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

Physiology

Mutations in the photoperiod genes, *Ppd-D1a, Ppd-B1a* and *Ppd-A1a,* confer photoperiod insensitivity in wheat, allowing early flowering. The mutation in the *Ppd-D1a* allele (Beales et al., 2007), copy number variations in *Ppd-B1a* (Díaz et al., 2012) and insertions and deletions in *Ppd-A1a* (Nishida et al., 2013) each influence the plant's flowering time.

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

Dwarfing genes were tested using markers specific for *Rht1 (Rht-B1b), Rht2 (RhtD1b)* and *Rht8* (Zhang et al., 2006). All varieties had at least one dwarfing allele. SY 547 and Shirley amplified the *Rht1* allele, F0065 had both *Rht2* and *Rht8* alleles, all others entries have the *Rht2* dwarfing allele.

Disease Resistance

Markers identifying resistance genes to stem and leaf rusts (*Sr2, Sr36, Sr24/Lr24* and *Lr34*), fusarium head blight (*Fhb1, Fhb 5A Ernie, Fhb 5A Ning 780,* and *Fhb 2DL*) were not detected among the varieties. The check, Shirley, was positive for the *Sr36,* stem rust resistance gene and D8006 had the tan spot resistance gene (*Tsn1*).

Resistance to fusarium head blight (FHB) was evaluated using markers associated with QTL on chromosomes 3BS (*FHB-1*) (Liu et al., 2008b)and 5A (Ernie and Ning) (McCartney et al., 2007). Leaf and stem rust resistance markers were evaluated using RSGGL KASP markers for diagnostic single nucleotide polymorphisms (SNPs).

In soft wheats, the presence of the stem rust resistance gene, *Sr36,* is conferred by a translocation from *Triticum timopheevi* and is tested using the marker *wmc477* (Tsilo et al., 2008). In soft wheats, the *Sr36* gene is usually linked to an allele for type 2 sucrose synthase, *Sus2*-HapH from the *timopheevi* translocation, and which in hard wheats was reported associated with high test weight (Jiang et al., 2011). The allele is detected by a KASP marker (RSGGL). Although the *Sr36* gene is absent in the variety, VA09W-188WS, *Sus2* was heterozygous in this cultivar. Shirley, positive for the Sr36 gene, has the expected Sus2B HapH allele.

**References**


Beales, J., Turner, A., Griffiths, S., Snape, J.W., and Laurie, D.A. (2007). A pseudo-response regulator is misexpressed in the photoperiod insensitive Ppd-D1a mutant of wheat (Triticum aestivum L.). TAG Theor. Appl. Genet. Theor. Angew. Genet. *115*, 721–733.

Díaz, A., Zikhali, M., Turner, A.S., Isaac, P., and Laurie, D.A. (2012). Copy Number Variation Affecting the Photoperiod-B1 and Vernalization-A1 Genes Is Associated with Altered Flowering Time in Wheat (Triticum aestivum). PLoS ONE *7*, e33234.

Guttieri, M., A. Sturbaum, Smith, N., and Sneller, C. (2008). Optimized PCR Primer Set for Determining Gluten Strength Quality in soft whet germplasm (Plant and Animal Genome 2008).

Jiang, Q., Hou, J., Hao, C., Wang, L., Ge, H., Dong, Y., and Zhang, X. (2011). The wheat (T. aestivum) sucrose synthase 2 gene (TaSus2) active in endosperm development is associated with yield traits. Funct. Integr. Genomics *11*, 49–61.

Liu, S., Chao, S., and Anderson, J.A. (2008a). New DNA markers for high molecular weight glutenin subunits in wheat. Theor. Appl. Genet. *118*, 177–183.

Liu, S., Pumphrey, M.O., Gill, B.S., Trick, H.N., Zhang, J.X., Dolezel, J., Chalhoub, B., and Anderson, J.A. (2008b). Toward positional cloning of *Fhb1* , a major QTL for Fusarium head blight resistance in wheat. Cereal Res. Commun. *36*, 195–201.

Ma, W., Zhang, W., and Gale, K.R. (2003). Multiplex-PCR typing of high molecular weight glutenin alleles in wheat. Euphytica *134*, 51–60.

McCartney, C.A., Somers, D.J., Fedak, G., DePauw, R.M., Thomas, J., Fox, S.L., Humphreys, D.G., Lukow, O., Savard, M.E., McCallum, B.D., et al. (2007). The evaluation of FHB resistance QTLs introgressed into elite Canadian spring wheat germplasm. Mol. Breed. *20*, 209–221.

Nakamura, T., Vrinten, P., Saito, M., and Konda, M. (2002). Rapid classification of partial waxy wheats using PCR-based markers. Genome Natl. Res. Counc. Can. Génome Cons. Natl. Rech. Can. *45*, 1150–1156.

Nishida, H., Yoshida, T., Kawakami, K., Fujita, M., Long, B., Akashi, Y., Laurie, D.A., and Kato, K. (2013). Structural variation in the 5′ upstream region of photoperiod-insensitive alleles Ppd-A1a and Ppd-B1a identified in hexaploid wheat (Triticum aestivum L.), and their effect on heading time. Mol. Breed. *31*, 27–37.

Saal, B., and Wricke, G. (1999). Development of simple sequence repeat markers in rye (Secale cereale L.). Genome *42*, 964–972.

Tsilo, T.J., Jin, Y., and Anderson, J.A. (2008). Diagnostic Microsatellite Markers for the Detection of Stem Rust Resistance Gene in Diverse Genetic Backgrounds of Wheat. Crop Sci. *48*, 253.

Wan, Y., Yan, Z., Liu, K., Zheng, Y., D'Ovidio, R., Shewry, P.R., Halford, N.G., and Wang, D. (2005). Comparative analysis of the D genome-encoded high-molecular weight subunits of glutenin. Theor. Appl. Genet. *111*, 1183–1190.

Zhang, X., Yang, S., Zhou, Y., He, Z., and Xia, X. (2006). Distribution of the Rht-B1b, Rht-D1b and Rht8 reduced height genes in autumn-sown Chinese wheats detected by molecular markers. Euphytica *152*, 109–116.

Table 61. Genotyping 2013 Wheat Quality council entries

| CULTIVAR | Dwarfing | Photoperiod Insensitivity mutation | HMW GluA1 | HMW GluB1 (Bx7 OE) | HMW GluD1 | 1RS RyeTL | Disease Resistance Genes* | Sucrose Synthase 2B - HapH |
|---|---|---|---|---|---|---|---|---|
| VA07W-415 | Rht2 | Ppd-D1a | Ax2* | WT | 2+12 | no | no | no |
| VA09W-75 | Rht2 | Ppd-A1a.1 | Ax2* | WT | 2+12 | 1RS:1AL | no | no |
| VA09W-73 | Rht2 | Ppd-A1a.1 | Ax2* | WT | 2+12 | 1RS:1AL | no | no |
| VA09W-188WS | Rht2 | Ppd-D1a | Ax2* | WT | 2+12 | no | no | Hap H Het |
| Shirley (Check) | Rht1 | Ppd-A1a.1 Ppd-D1a | Ax2* Het | WT | 2+12 | 1RS:1BL | Sr36 | Hap H |
| SY 547 | Rht1 | Ppd-A1a.1 Het Ppd-D1a | Ax2* | WT | 5+10 | 1RS:1BL | no | no |
| F0014 | Rht2 | Ppd-D1a | Ax2* | OE | 2+12 | no | no | no |
| F0039 | Rht2 | WT | Ax2* | WT | 2+12 | no | no | no |
| F0065 | Rht2/ Rht8 | Ppd-D1a | Ax2* | WT | 5+10 | 1RS:1BL | no | no |
| D8006 | Rht2 | Ppd-D1a | Ax1 or null | OE | 5+10 | no | Tsn1 | no |
| Caledonia (Check) | Rht2 | WT | Ax2* | WT | 2+12 | no | no | no |

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

# Appendix I.

## Materials and Methods of the USDA-ARS SWQL

### Whole Kernel Moisture, Air-oven Method, AACC Method 44-16 – modified

***Apparatus***

1. Tag-Heppenstall rolls
2. Moisture dish: aluminum (5.5cm diameter x 1.5cm height, with slipcover lid)
3. Air oven – a convection oven which maintains a temperature of 140 ± 1oC.
4. Aluminum plate to aid in maintaining oven temperature

***Procedure***

1. Scoop out approximately five grams of grain into a moisture dish. No more than 12 samples should be run at once to maintain accuracy.
2. Run the grain sample through the Tag-Heppenstall rolls with a pan placed below to collect the ground sample. Transfer the ground sample to the moisture dish and cover with the lid.
3. Record the weight of the dish with lid containing the ground sample (initial weight). Samples should be weighed soon after grinding and not allowed to sit for more than a few minutes in order to minimize moisture loss prior to weighing.
4. Open the lid, and place the dish and lid in the oven at 140°C. Set a timer for 90 minutes. Start the timer when the oven reaches 140°C.
5. At the end of the 90 minute drying time, cover the dishes with the lids and transfer them to an aluminum plate outside oven to cool for 4 four minutes. It is recommended that no more than 12 dishes be taken out of the oven at once in order for the cooling time to remain consistent with weigh back.
6. Record the weight of the dish plus lid containing the dried grain (final weight). Continue weighing all dishes that have been taken out of the oven.
7. Empty the samples from the dishes, brush any residue from the dishes and lids, and record the weights (dish weight).
8. Percent moisture may be calculated using the following equation:
   \%\, Moisture=\frac{Initial\, Weight-Final\, Weight}{Initial\, Weight-Dish\, Weight}100

### Kernel Moisture, air-oven method, AACC Method 44-15A

### 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.

### Amylase Activity, AACC Method 56-81B

Units are expressed in seconds using the Perten Falling Numbers instrument.

### Amylase Activity, AACC Method 22-06

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

**Test Weight, AACC Method 55-10**

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 – modified**

***Apparatus***

1. Moisture dish; : Aluminum (5.5cm diameter x 1.5cm height, with lid)
2. Air oven – a convection oven which maintains a temperature of 140 ± 1oC.
3. Aluminum plate inside oven to aid in maintaining oven temperature.

***Procedure***

1. Scoop out approximately one1 teaspoon of flour into a moisture dish and cover the dish with the lid. As many as 12 samples may be run at once.
2. Record the weight of the dish plus lid containing the flour sample (initial weight).
3. Open the lid and place the dish and lid in the oven at 140°C. Once all dishes and lids have been placed in the oven, allow the temperature to return to 140°C before setting the timer; set timer for 15 minutes.
4. At the end of the 15 minute drying time, cover the dishes with the lids and transfer them to an aluminum plate outside the oven to cool for 4 four minutes. It is recommended that no more than 12 dishes be taken out of the oven at once in order for the cooling time to remain consistent.
5. Record the weight of the dish plus lid containing the dried flour (final weight). Continue weighing all dishes that have been taken out of the oven.
6. Empty the samples from the dishes, brush any residue from the dishes and lids, and record the weights (dish weight).
7. Percent moisture may be calculated using the following equation: \%\, Moisture=\frac{Initial\, Weight-Final\, Weight}{Initial\, Weight-Dish\, Weight}100. Units are expressed as % of flour.

**Flour Falling Number, AACC Method 56-81B**

Units are expressed in seconds using a Perten Falling Number 1800 Instrument. Numbers above 400 seconds reflect factors other than alpha-amylase activity (such as particle size). The correlation between alpha-amylase activity and falling number is best for samples with falling number values between 200 and 300 seconds. For cake flours and batters, 350 seconds is a common minimum value. For breakfast cereals or cookies and other high sugar products, values of 250 seconds are more common cut-off values.

**Flour 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.

**Wire Cut Cookie, Macro Method, AACC Method 10-53**

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

**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.