January, 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.

Ben Hancock

Executive Vice President

Wheat Quality Council

P.O. Box 966

Pierre, South Dakota 57501-0966

S. E. Beil and M. G. Redinbaugh

USDA-ARS-CSWQRU Soft Wheat Quality Laboratory

OARDC-OSU

1680 Madison Avenue

Wooster, Ohio 44691

Scott.Beil@ars.usda.gov

Acknowledgments

We thank the Wheat Quality Council for providing this forum to improve the quality of wheat. Thank you to the Soft Wheat Quality Lab 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 among the breeding programs, growers, and the different labs in industry make this project a continued success.

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 variety varieties that may be grown in the traditional growing 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 interests.

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 members 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 U.S.D.A. - A.R.S. 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 Research Leader of the USDA Soft Wheat Quality Laboratory, Wooster, OH.

• A grow out coordinator who is a soft wheat breeder.

• Technical collaborators from soft wheat milling and baking laboratories.

• Collaborating soft wheat breeders.

Evaluation and Responsibilities

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

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

• Milling of the experimental and check samples.

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

• Preparation of a quality report.

Sample/Locations

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

Annual Meeting

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

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

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

Finances and Budget

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

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

Amendments

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

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

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Contributing Soft Wheat Breeding Programs

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2013412

Yorktown

Merl

Greg Marshal, Pioneer Hi-Bred International, Inc.

Pioneer 25R34

Pioneer 25R40

Pioneer 25R47

Clay Sneller, The Ohio State University

Bromfield

Malabar

Barton Fogleman, Syngenta

SY Harrison

Oakes

Herb Ohm, Purdue University

P04606

P05247

P05222

INW 1021

Entry Descriptions

2013412

The soft red winter (SRW) wheat cultivar 2013412 was derived from the cross **'Tribute'** (PI 632689) / '**AGS 2000'** (PI 612956) // **VAN99W-20** (VA90-54-631 / VA90-52-49). Parentage of VA90-54-631 is 'Tyler' / 'Coker 78-23' // 'McNair 1003' /3/ 4* 'Massey' /8/ 'Saluda' /7/ FL737G3-12-2-12 / Tyler /5/ CItr13836 / 9* 'Chancellor' // 'Wheeler' /3/ 'Severn' /4/ 'Feland' /6/ Tyler. Parentage of VA90-52-49 is 'Hunter' / Wheeler. The pedigree of FL737G3-12-2-12 is Vogel 5 / 'Anderson' // Purdue Dwarf / 'Hadden' /3/ Purdue 6562A1-4-2 /4/ 'Blueboy II' / 'Coker 68-8'. Parentage of P6562A1-4-2 is 'Siete Cerros' / 'Arthur'.

Prior to its release, cultivar 2013412 was evaluated as VA06W-412 over three years (2009 – 2011) in Virginia's State Variety Trials, and throughout most of the SRW wheat region in the 2010 USDA-ARS Uniform Southern SRW Wheat Nursery. Cultivar 2013412 is a broadly adapted, high yielding, full-season, short height semi-dwarf (gene *Rht*2) producing grain that is well suited for dual end uses in both pastry and cracker products. It has performed well in diverse regions of the SRW wheat production area from northern Louisiana to Wisconsin. Cultivar 2013412 is resistant to leaf and stem rusts, powdery mildew, and *Barley and Cereal Yellow Dwarf Viruses*, and expresses moderate levels of resistance to other diseases prevalent in the SRW wheat region including stripe rust, leaf and glume blotch, Fusarium Head Blight, *Wheat Soil Borne Mosaic Virus*, *Wheat Spindle Streak Mosaic Virus*, and Hessian fly. During fall 2011, breeder seed of cultivar 2013412 was sown on 8 acres at the VCIA Foundation Seed farm and produced 646 units (50 lbs/unit) of Foundation seed that was distribution to seedsmen in fall 2012. Cultivar 2013412 will be marketed by FFR and Southern States Cooperatives.

In the southern SRW wheat region, average head emergence of cultivar 2013412 (119 d) was 1 d later than 'USG3555'. Average mature plant height of 2013412 has varied from 32 to 36 inches and is about 1.5 inches taller than USG 3555 and two inches shorter than 'Coker 9553'. Straw strength (0=erect to 9=completely lodged) of 2013412 (0 – 1.3) is very good being most similar to that of 'Shirley' (0.7 – 1.0) and better than that of cultivar 5187J (1.9 – 3.8). Winter hardiness and freeze tolerance of cultivar 2013412 are better than those of USG3555. Cultivar 2013412 was evaluated at 26 locations in the 2010 USDA-ARS Uniform Southern SRW Wheat Nursery, and ranked eighth in grain yield (63.9 Bu/ac) among 32 entries over replicated test sites having coefficient of variance values equal to or lower than 10%. It ranked among the top ten highest yielding entries at 11 of the 26 test sites. Average test weight of 2013412 (57.5 Lb/Bu) was most similar to those of check cultivars AGS 2000 (57.2 Lb/Bu) and Pioneer Brand '26R61' (57.9 Lb/Bu) and significantly ($P \leq 0.05$) higher than that of USG 3555 (56.5 Lb/Bu).

Grain samples of cultivar 2013412 produced in five crop environments (2009 – 2011) were evaluated for end use quality by the USDA-ARS Soft Wheat Quality Lab. Cultivar 2013412 has exhibited milling and pastry baking qualities that are most similar to those of the strong gluten cultivars Branson and Pioneer Brand 26R15. While flour protein concentration of 2013412 (7.11% – 9.15%) has been average, gluten strength has been above average based on lactic acid solvent retention capacity (114.1% – 125.7%). Concurrently, cookie diameters of 2013412 (18.8 – 19.0 cm) have been consistently good indicating that flour of 2013412 is well suited for use in production of pastry and cracker products.

YORKTOWN

The soft red winter wheat cultivar Yorktown 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). Wheat line IN71761A4-31-5-48 was developed by Purdue University and has the pedigree 'Benhur' (CItr 14054) /3/ 'Arthur' (CItr 14425) / 'Knox' (CItr 12798) type line /4/ 'Beau' (CItr17420) *2 /3/ Arthur *2 // 'Riley' (CItr 13702) / 'Bulgaria 88' (PI 94407).

Prior to its release Yorktown was evaluated as VA08W-294 in Virginia's State Variety Trials over two years (2010 – 2011) and throughout the soft red winter (SRW) wheat region in the 2011 USDA-ARS Uniform Southern and Uniform Eastern Soft Red Winter Wheat Nurseries. Yorktown is a widely adapted wheat cultivar that has high grain yield potential and high test weight and has performed well over most of the SRW wheat production areas from northern Louisiana to Ontario. With the exception of *Wheat Soil Borne Mosaic Virus* and potentially *Wheat Spindle Streak Mosaic Virus*, Yorktown expresses moderate to high levels of resistance to diseases prevalent in the SRW wheat region. These include leaf, stripe, and stem rusts, powdery mildew, leaf and glume blotch, Fusarium Head Blight, *Barley and Cereal Yellow Dwarf Viruses*, and Hessian fly.

Breeder seed of Yorktown was sown on 13 acres in fall 2011 at the VCIA Foundation Seed farm and produced 1,000 units (50 lbs/unit) of Foundation seed that was distributed to seedsmen. Yorktown will be marketed by Crop Production Services.

Yorktown is a broadly adapted, high yielding, full-season, short height semi-dwarf (gene *Rht*2). In the eastern SRW wheat region, head emergence of Yorktown (133 d) has been similar to that of 'Shirley', while in the southern SRW wheat region, head emergence of Yorktown (117 d) has been 1 d later than 'USG3555'. Average mature plant height of Yorktown has varied from 30 to 35 inches and is about one inch taller than 'Branson' and two inches shorter than 'Bess' and 'AGS 2000'. On average, straw strength (0=erect to 9=completely lodged) of Yorktown (0.8 – 2.0) is good being most similar to that of USG 3555 (0.7 – 2.2) and better than those of 'Bess' (1.2 versus 2.3) and AGS 2000 (1.9 versus 3.2). Winter hardiness and freeze tolerance of Yorktown are better than those of AGS 2000 and USG 3555. Yorktown was evaluated at 26 locations in the 2011 USDA-ARS Uniform Southern SRW Wheat Nursery, and ranked third in grain yield (77.8 Bu/ac) among 28 entries. Average test weight of Yorktown (59.6 Lb/Bu) was most similar to that of AGS 2000 (59.0 Lb/Bu) and significantly ($P \leq 0.05$) higher than that of USG 3555 (58.0 Lb/Bu). In the 2011 USDA-ARS Uniform Eastern SRW Wheat Nursery, Yorktown ranked tenth in grain yield (72.4 Bu/ac) among 38 entries evaluated over 28 environments. Average test weight of Yorktown (58.8 Lb/Bu) was significantly

($P \leq 0.05$) higher than those of the four check cultivars including Shirley and Branson having average test weights of 55.8 and 56.7 Lb/Bu, respectively.
Grain samples of Yorktown produced in five crop environments (2010 and 2011) were evaluated for end use quality by the USDA-ARS Soft Wheat Quality Lab. Yorktown has exhibited milling and baking qualities that are most similar to those of the strong gluten cultivars Coker 9553, USG 3555, and 5187J. Flour protein concentration of Yorktown (7.80% – 8.85%) is lower than average, while its gluten strength is average or above based on lactic acid solvent retention capacity (106.6% – 119.2%).

Pioneer® 25R34

Pioneer® 25R34 was bred and developed by Pioneer H-Bred International. It is a very high yielding, awned soft red winter wheat cultivar with short height and has average test weight. Spike emergence of 25R34 is about one day later than Pioneer® 25R47 and is considered medium late in harvest maturity. It is slightly taller than 25R47 and has exhibited straw strength and winter hardiness similar to 25R47. 25R34 appears moderately susceptible to moderately resistant to fungal leaf blight (*Septoria spp*, *Stagonospora*, and/or *Pyrenophora* spp), is moderately susceptible to prevalent isolates of leaf rust (*Puccinia triticina*) and powdery mildew (*Blumeria graminis* f.sp. *tritici*), and is susceptible to Fusarium head blight (*Fusarium graminearum*). 25R34 is highly resistant to isolates of stripe rust (*Puccinia striiformis*) present in 2012. 25R34 has H13 for resistance to Hessian fly (*Mayetiola destructor*). 25R34 has very good milling and end use characteristics. 25R34 is very well adapted to the soft wheat production regions north of the Ohio River in the Corn Belt and in Ontario.

Pioneer® 25R40

Pioneer® 25R40 was bred and developed by Pioneer Hi-Bred International. It is a very high yielding, awned soft red winter wheat with short plant height and strong test weight. Spike emergence of 25R40 is the same time as Pioneer® 25R47 and is considered medium late in harvest maturity. 25R40 is about three inches shorter than 25R47 and has very strong straw. It has average winter hardiness. 25R40 has moderate resistance to fungal leaf blight (*Septoria* spp, *Stagonospora*, and/or *Pyrenophora* spp), is moderately resistant to prevalent isolates of leaf rust (*Puccinia triticina*) and has very good resistance to powdery mildew (*Blumeria graminis* f.sp. *tritici*). 25R40 is highly resistant to isolates of stripe (*Puccinia striiformis*) present in 2012. It is susceptible to Fusarium head blight (*Fusarium graminearum*) and to biotype L to Hessian fly (*Mayetiola destructor*). 25R40 has acceptable milling and end use characteristics. 25R40 is very broadly adapted to the soft wheat production regions north of the Ohio River in the Corn Belt and in Ontario.

Bromfield

Bromfield is a medium height, soft red winter wheat with average lodging resistance and maturity about 1-2 days earlier than Hopewell. Bromfield is tan and awnless and has excellent FHB resistance with index values similar to the moderately resistant check, Freedom, and DON levels similar to the resistant check, Truman. Bromfield has good resistance to most other foliar diseases, average milling quality and below average baking quality primarily due to low softness equivalent score.

SY Harrison

SY Harrison is a soft red winter wheat bred and developed by Syngenta Seeds, Inc. SY Harrison was selected for height, maturity, appearance, and kernel soundness using a modified bulk breeding method that originated with a single cross made in Spring of 1998. SY Harrison is a medium height semidwarf variety and has white chaff at maturity. It has medium to medium-full season maturity and its heading date is similar to SY 9978 and about one day earlier than 26R15. SY Harrison has shown best adaptation to the major wheat growing areas of the Midsouth from central Missouri south through Arkansas and western Tennessee to the northern halves of Louisiana and Mississippi; and in the East in the states of Virginia, North Carolina and South Carolina. It has shown moderate resistance to Septoria leaf complex and the races of stripe rust in these areas. It has shown moderate susceptibility to leaf rust and is susceptible to several current races of powdery mildew. Milling and baking characteristics are very good and this variety is intended for grain production.

Juvenile growth habit is semi-erect. Plant color at boot stage is blue green. Anther color is yellow. Auricle anthocyanin is absent and auricle hairs are present. Flag leaf at boot stage is recurved and twisted. Head shape is tapering and awned. Glumes are midlong in length and narrow in width. Glume shoulder shape is oblique with an acuminate beak. Chaff color is white at maturity. Seed shape is ovate. Brush hairs on the seed are midlong in length and occupy a medium area of the seed tip. Seed depth is shallow and width is narrow. Seed cheeks are rounded.

SY HARRISON has been uniform and stable since 2010. Approximately 0.8% of the plants were rogued from the Breeder's seed increase in 2010. Approximately 95% of the rogued variant plants were taller height wheat plants (8 to 15 cm) and 5% were awnless. Up to 1.0% variant plants may be encountered in subsequent generations.

Syngenta Seeds, Inc. maintains seed stock and certified classes of Foundation, Registered and Certified. Certified seed stocks of SY Harrison will be available in the fall of 2013. Certified acreage is not to be published by AOSCA and certifying agencies. SY Harrison may only be sold as a class of certified seed and all seed sales are royalty bearing.

Its variety name, SY Harrison, was selected to honor the memory of long-time Coker's Pedigreed Seed Company small grains breeder, Howard Harrison.

P05247

P05247 has excellent FHB resistance. This line also exhibited excellent grain yield and test weight.

P05222

Also has good frost resistance and resistance to both leaf and stripe rust.

P04606

P04606 exhibited excellent grain yield and test weight. Line P04606 also has good frost resistance and resistance to both leaf and stripe rust. This line is taller than Branson.

P05222

Shorter than Branson. Line P05222 also has excellent FHB resistance. It also exhibited excellent grain yield and test weight.

Milling Analysis: Ash and Protein Curves

Miag Multomat Mill

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. Three pair are corrugated break rolls and five 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. The third break sieving unit of the Soft Wheat Quality Laboratory (SWQL) Miag Multomat Mill was modified so that the top four sieves better sift 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/hr. First break roll gap is adjusted to allow 46% through a #28 SSBC; 716µm. 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 straight grade flour mean volume diameter 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 will 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 will negatively impact flour production. Recovery of all mill products is usually about 98%.

Table 1. Miag Multomat Mill Stream Percentages for the 2012 Wheat Quality Council Entries

	2013412	Yorktown	Merl	Pioneer 25R34	Pioneer 25R40	Pioneer 25R47	Bromfield	Malabar	SY Harrison	Oakes	P04606	P05247	P05222	INW 1021
1 Brk	11.3	11.1	10.6	12.2	11.5	12.2	11.8	14.5	15.5	11.7	10.8	11.5	9.6	18.4
2 Brk	2.8	3.0	3.0	2.8	3.2	4.5	4.2	4.6	3.3	3.6	3.1	3.1	3.2	4.2
Grader	3.1	3.1	3.2	3.9	3.3	4.1	3.2	5.8	3.3	2.9	2.4	3.1	2.9	4.2
3 Brk	8.8	9.5	9.8	10.0	11.1	9.7	10.4	11.1	11.6	9.7	10.7	9.9	10.5	10.7
Total Brk	26.1	26.6	26.6	28.8	29.1	30.6	29.5	36.0	33.7	27.9	27.0	27.5	26.1	37.4
1 Mids	13.2	14.6	15.1	12.9	15.7	15.2	13.8	11.3	15.4	17.9	16.9	14.8	13.2	11.6
2 Mids	8.5	8.2	8.7	9.5	8.8	8.7	9.4	5.8	7.0	8.9	7.4	9.4	9.3	4.8
3 Mids	6.5	6.6	6.2	6.4	6.5	5.9	5.4	6.9	7.2	5.3	7.3	7.2	7.9	6.5
1M ReDust	6.6	6.7	7.0	6.3	6.4	6.3	7.0	4.4	6.0	7.7	6.2	7.7	6.5	4.3
4 Mids	7.0	6.6	6.9	6.2	5.6	5.3	6.0	7.1	4.9	5.2	6.0	5.3	6.5	6.5
5 Mids	3.6	3.1	3.5	3.4	2.7	2.1	3.7	3.8	2.2	2.9	3.2	2.3	3.2	3.5
Total Mids	45.4	45.9	47.5	44.7	45.7	43.5	45.4	39.3	42.7	47.9	47.0	46.7	46.5	37.3
Straight Grade	71.5	72.5	74.0	73.5	74.8	74.1	74.9	75.2	76.5	75.8	74.1	74.2	72.6	74.7
Brk Shorts	8.3	8.5	8.4	9.3	9.4	9.0	7.6	7.7	8.3	8.0	9.1	7.2	8.8	9.2
Red Dog	3.1	2.8	3.1	3.1	3.0	1.9	3.3	3.7	2.4	2.8	3.1	1.9	3.0	3.0
Tail Shorts	2.3	2.5	2.4	2.7	3.4	2.4	2.7	4.0	2.5	2.4	2.6	1.4	2.8	2.5
Bran	14.4	13.3	11.6	10.5	8.7	12.1	10.9	9.3	9.9	11.1	11.1	15.0	12.5	10.2
Total Byproduct	28.2	27.1	25.5	25.7	24.6	25.4	24.5	24.8	23.1	24.2	25.9	25.5	27.1	24.9

Ash Curves

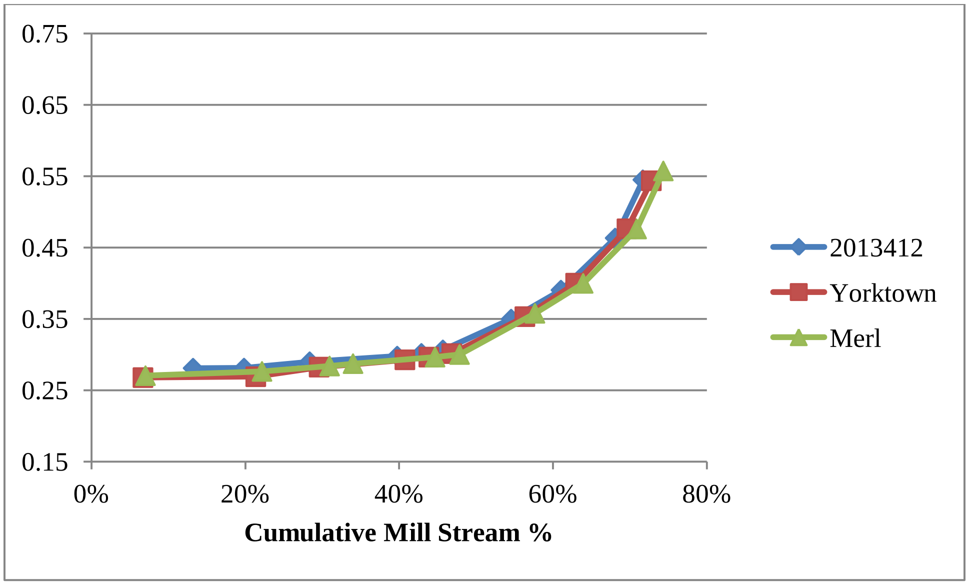


Table 2. Mill Stream Cumulative Ash %, Virginia Polytechnic Institute and State University: 2013412, Yorktown, and Merl

2013412			Yorktown			Merl		
Mill Stream	Cumulative Mill Stream %	Cumulative Ash %	Mill Stream	Cumulative Mill Stream %	Cumulative Ash %	Mill Stream	Cumulative Mill Stream %	Cumulative Ash %
1 Mids	13	0.281	ReDust	7	0.268	ReDust	7	0.270
ReDust	20	0.281	1 Mids	21	0.269	1 Mids	22	0.276
2 Mids	28	0.290	2 Mids	30	0.282	2 Mids	31	0.284
1 Brk	40	0.298	1 Brk	41	0.293	2 Brk	34	0.287
Grader	43	0.302	Grader	44	0.296	1 Brk	45	0.296
2 Brk	46	0.306	2 Brk	47	0.301	Grader	48	0.300
3 Brk	55	0.350	3 Brk	56	0.353	3 Brk	58	0.358
3 Mids	61	0.390	3 Mids	63	0.400	3 Mids	64	0.400
4 Mids	68	0.463	4 Mids	70	0.476	4 Mids	71	0.476
5 Mids	72	0.545	5 Mids	73	0.543	5 Mids	74	0.557
Red Dog	75	0.648	Red Dog	76	0.639	Red Dog	77	0.670
Tail Shorts	77	0.723	Tail Shorts	78	0.725	Tail Shorts	80	0.755
Brk Shorts	86	1.064	Brk Shorts	87	1.062	Brk Shorts	88	1.091
Bran	100	1.649	Bran	100	1.576	Bran	100	1.568

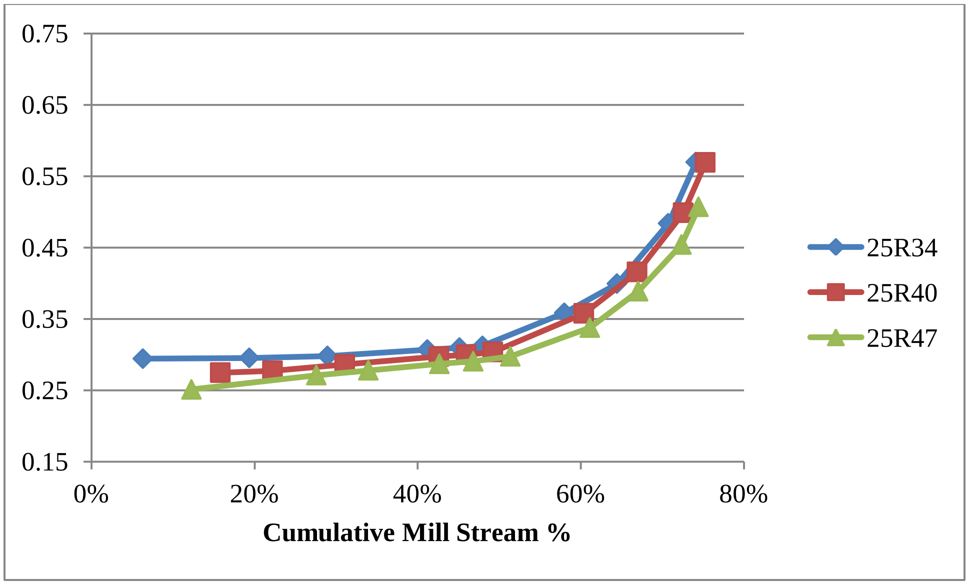


Table 3. Mill Stream Cumulative Ash %, Pioneer Hi-Bred: Pioneer 25R34, Pioneer 25R40, and Pioneer 25R47

25R34			25R40			25R47		
Mill Stream	Cumulative Mill Stream %	Cumulative Ash %	Mill Stream	Cumulative Mill Stream %	Cumulative Ash %	Mill Stream	Cumulative Mill Stream %	Cumulative Ash %
ReDust	6	0.294	1 Mids	16	0.275	1 Brk	12	0.251
1 Mids	19	0.295	ReDust	22	0.277	1 Mids	28	0.271
2 Mids	29	0.298	2 Mids	31	0.286	ReDust	34	0.278
1 Brk	41	0.307	1 Brk	43	0.297	2 Mids	43	0.287
Grader	45	0.310	Grader	46	0.300	Grader	47	0.290
2 Brk	48	0.312	2 Brk	49	0.304	2 Brk	51	0.297
3 Brk	58	0.358	3 Brk	60	0.358	3 Brk	61	0.338
3 Mids	64	0.399	3 Mids	67	0.416	3 Mids	67	0.389
4 Mids	71	0.484	4 Mids	73	0.499	4 Mids	72	0.454
5 Mids	74	0.570	5 Mids	75	0.569	5 Mids	74	0.507
Red Dog	77	0.680	Red Dog	78	0.690	Red Dog	76	0.581
Tail Shorts	80	0.783	Tail Shorts	82	0.830	Tail Shorts	79	0.684
Brk Shorts	89	1.130	Brk Shorts	91	1.204	Brk Shorts	88	1.052
Bran	100	1.525	Bran	100	1.517	Bran	100	1.504

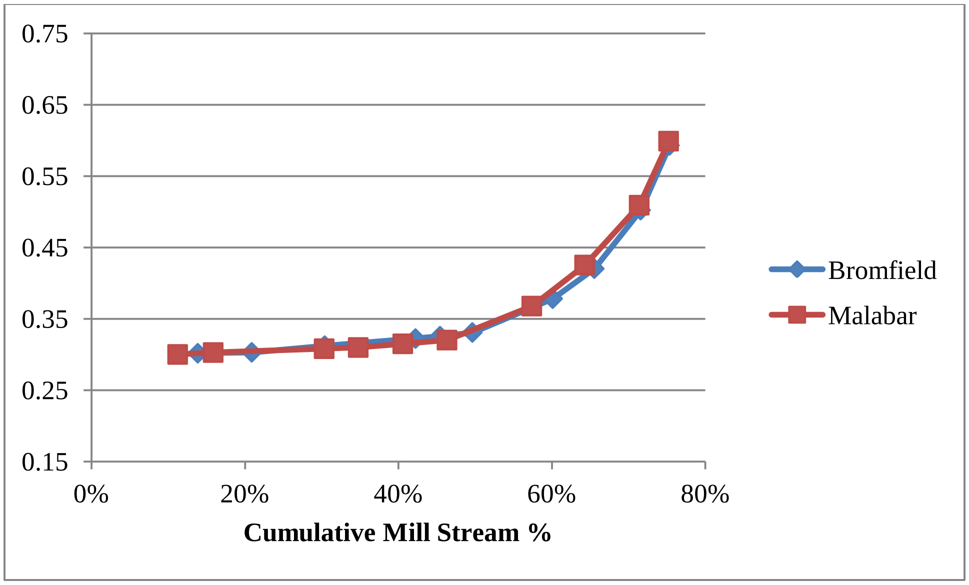


Table 4. Mill Stream Cumulative Ash %, The Ohio State University: Bromfield and Malabar

Bromfield			Malabar		
Mill Stream	Cumulative Mill Stream %	Cumulative Ash %	Mill Stream	Cumulative Mill Stream %	Cumulative Ash %
1 Mids	14	0.302	1 Mids	11	0.300
ReDust	21	0.303	2 Brk	16	0.303
2 Mids	30	0.312	1 Brk	30	0.308
1 Brk	42	0.322	ReDust	35	0.310
Grader	45	0.326	Grader	41	0.315
2 Brk	50	0.331	2 Mids	46	0.320
3 Brk	60	0.378	3 Brk	57	0.368
3 Mids	66	0.420	3 Mids	64	0.425
4 Mids	72	0.502	4 Mids	71	0.509
5 Mids	75	0.593	5 Mids	75	0.599
Red Dog Tail	79	0.710	Red Dog Tail	79	0.741
Shorts Brk	81	0.803	Shorts Brk	83	0.909
Shorts	89	1.095	Shorts	91	1.233
Bran	100	1.509	Bran	100	1.647

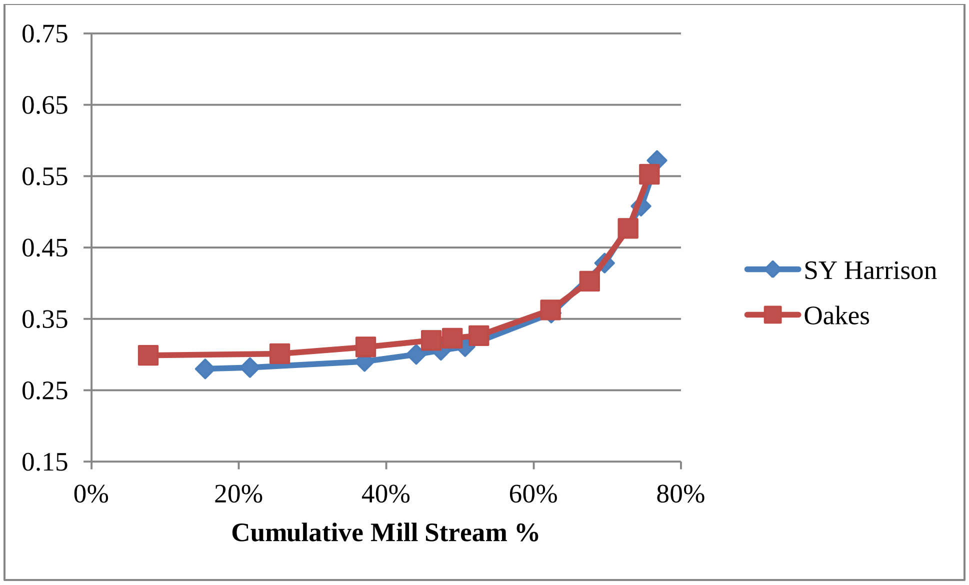


Table 5. Mill Stream Cumulative Ash %, Syngenta: SY Harrison and Oakes

SY Harrison			Oakes		
Mill Stream	Cumulative Mill Stream %	Cumulative Ash %	Mill Stream	Cumulative Mill Stream %	Cumulative Ash %
1 Mids	15	0.280	ReDust	8	0.299
ReDust	22	0.282	1 Mids	26	0.301
1 Brk	37	0.290	1 Brk	37	0.311
2 Mids	44	0.300	2 Mids	46	0.320
Grader	47	0.306	Grader	49	0.323
2 Brk	51	0.311	2 Brk	53	0.326
3 Brk	62	0.358	3 Brk	62	0.362
3 Mids	70	0.428	3 Mids	68	0.403
4 Mids	75	0.508	4 Mids	73	0.477
5 Mids	77	0.572	5 Mids	76	0.553
Red Dog Tail	79	0.655	Red Dog Tail	79	0.632
Shorts Brk	82	0.745	Shorts Brk	81	0.702
Shorts	90	1.057	Shorts	89	0.972
Bran	100	1.403	Bran	100	1.350

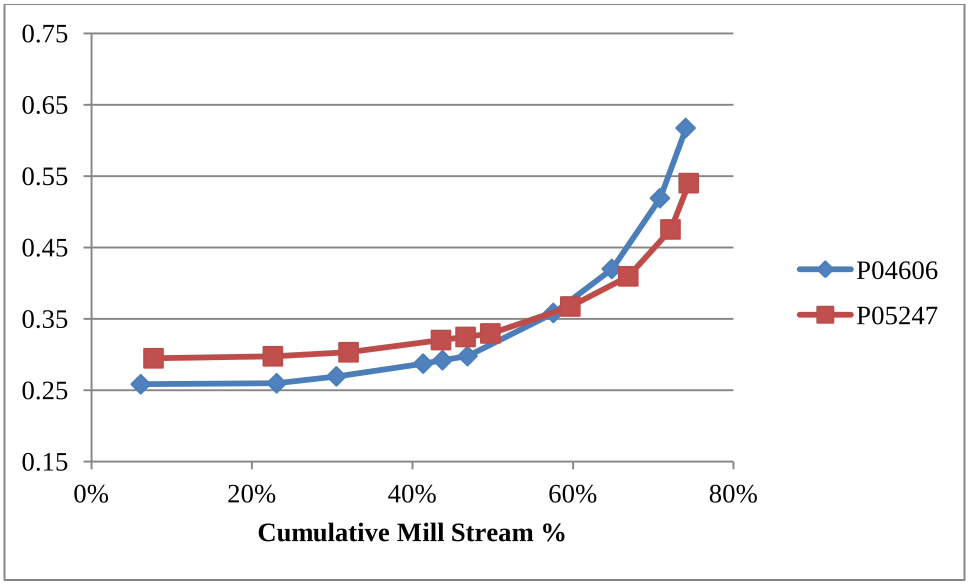


Table 6. Mill Stream Cumulative Ash %, Purdue University: P04606 and P05247

P04606			P05247		
Mill Stream	Cumulative Mill Stream %	Cumulative Ash %	Mill Stream	Cumulative Mill Stream %	Cumulative Ash %
ReDust	6	0.258	ReDust	8	0.295
1 Mids	23	0.260	1 Mids	23	0.297
2 Mids	31	0.269	2 Mids	32	0.303
1 Brk	41	0.287	1 Brk	44	0.320
Grader	44	0.292	Grader	47	0.325
2 Brk	47	0.298	2 Brk	50	0.329
3 Brk	58	0.358	3 Brk	60	0.367
3 Mids	65	0.420	3 Mids	67	0.409
4 Mids	71	0.519	4 Mids	72	0.475
5 Mids	74	0.617	5 Mids	74	0.540
Red Dog Tail	77	0.746	Red Dog Tail	76	0.613
Shorts Brk	80	0.855	Shorts Brk	78	0.670
Shorts	89	1.260	Shorts	85	0.993
Bran	100	1.703	Bran	100	1.626

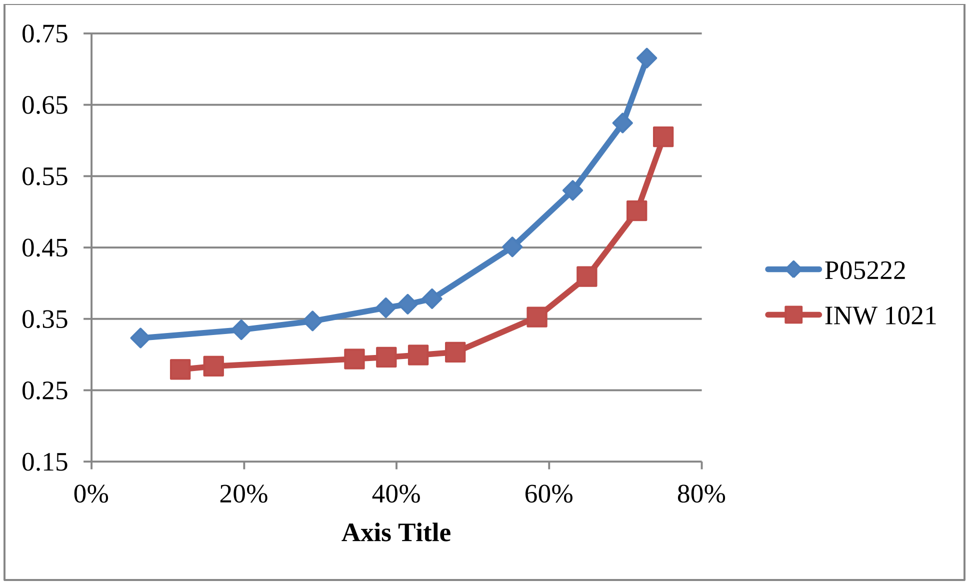


Table 7. Mill Stream Cumulative Ash %, Purdue University: P05222 and INW 1021

P05222			INW 1021		
Mill Stream	Cumulative Mill Stream %	Cumulative Ash %	Mill Stream	Cumulative Mill Stream %	Cumulative Ash %
ReDust	6%	0.323	1 Mids	12%	0.279
1 Mids	20%	0.335	ReDust	16%	0.284
2 Mids	29%	0.347	1 Brk	35%	0.294
1 Brk	39%	0.365	Grader	39%	0.296
Grader	41%	0.370	2 Brk	43%	0.299
2 Brk	45%	0.378	2 Mids	48%	0.303
3 Brk	55%	0.451	3 Brk	58%	0.352
3 Mids	63%	0.530	3 Mids	65%	0.409
4 Mids	70%	0.624	4 Mids	72%	0.501
5 Mids	73%	0.715	5 Mids	75%	0.605
Red Dog Tail	76%	0.851	Red Dog Tail	78%	0.722
Shorts Brk	79%	0.984	Shorts Brk	81%	0.838
Shorts	87%	1.418	Shorts	90%	1.253
Bran	100%	1.974	Bran	100%	1.695

Protein Curves

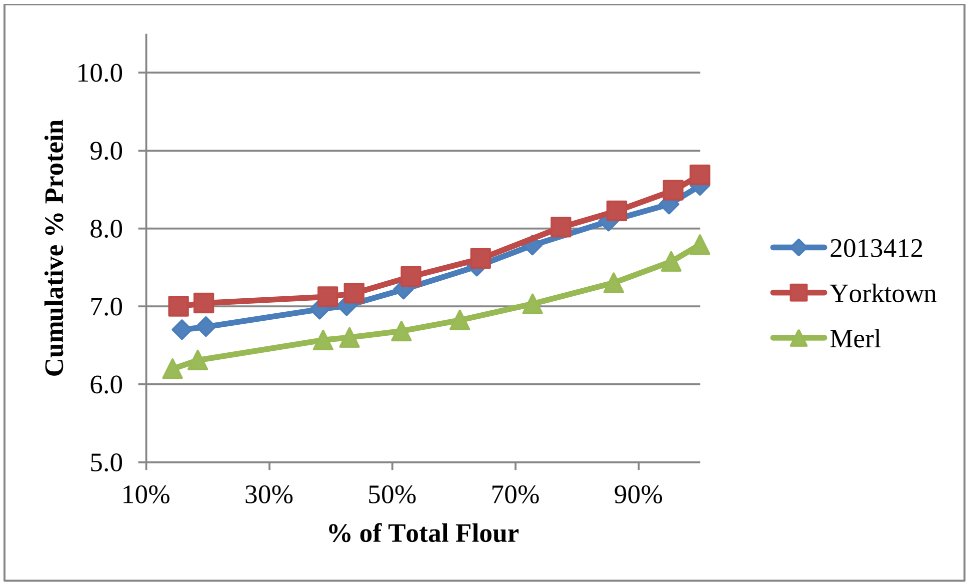


Table 8. Cumulative % Protein, Virginia Polytechnic Institute and State University: 2013412, Yorktown, and Merl

2013412			Yorktown			Merl		
Mill Stream	Cumulative Mill Stream %	Cumulative Protein %	Mill Stream	Cumulative Mill Stream %	Cumulative Protein %	Mill Stream	Cumulative Mill Stream %	Cumulative Protein %
1 Brk	16	6.7	1 Brk	15	7.0	1 Brk	14	6.2
2 Brk	20	6.7	2 Brk	19	7.0	2 Brk	18	6.3
1 Mids	38	7.0	1 Mids	40	7.1	1 Mids	39	6.6
Grader	43	7.0	Grader	44	7.2	Grader	43	6.6
Re-Dust	52	7.2	Re-Dust	53	7.4	3 Mids	52	6.7
2 Mids	64	7.5	2 Mids	64	7.6	Re-Dust	61	6.8
3 Mids	73	7.8	3 Brk	77	8.0	2 Mids	73	7.0
3 Brk	85	8.1	3 Mids	86	8.2	3 Brk	86	7.3
4 Mids	95	8.3	4 Mids	96	8.5	4 Mids	95	7.6
5 Mids	100	8.6	5 Mids	100	8.7	5 Mids	100	7.8

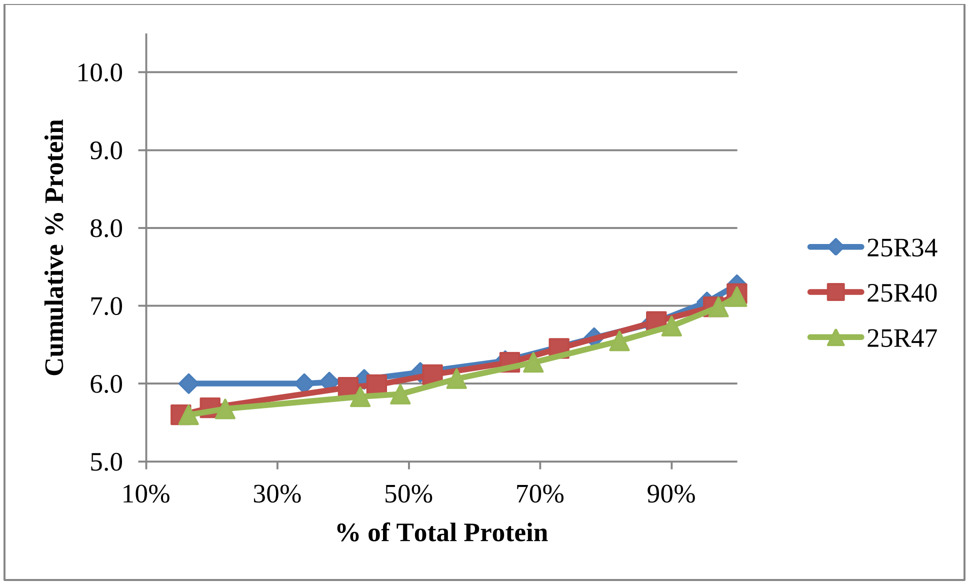


Table 9. Cumulative % Protein, Pioneer Hi-Bred: Pioneer 25R34, Pioneer 25R40, and Pioneer 25R47

25R34			25R40			25R47		
Mill Stream	Cumulative Mill Stream %	Cumulative Protein %	Mill Stream	Cumulative Mill Stream %	Cumulative Protein %	Mill Stream	Cumulative Mill Stream %	Cumulative Protein %
1 Brk	17	6.0	1 Brk	15	5.6	1 Brk	17	5.6
1 Mids	34	6.0	Grader	20	5.7	Grader	22	5.7
2 Brk	38	6.0	1 Mids	41	6.0	1 Mids	43	5.8
Grader	43	6.1	2 Brk	45	6.0	2 Brk	49	5.9
Re-Dust	52	6.1	Re-Dust	54	6.1	Re-Dust	57	6.1
2 Mids	65	6.3	2 Mids	65	6.3	2 Mids	69	6.3
3 Brk	78	6.6	4 Mids	73	6.5	3 Brk	82	6.5
3 Mids	87	6.8	3 Brk	88	6.8	3 Mids	90	6.7
4 Mids	95	7.0	3 Mids	96	7.0	4 Mids	97	7.0
5 Mids	100	7.3	5 Mids	100	7.2	5 Mids	100	7.1

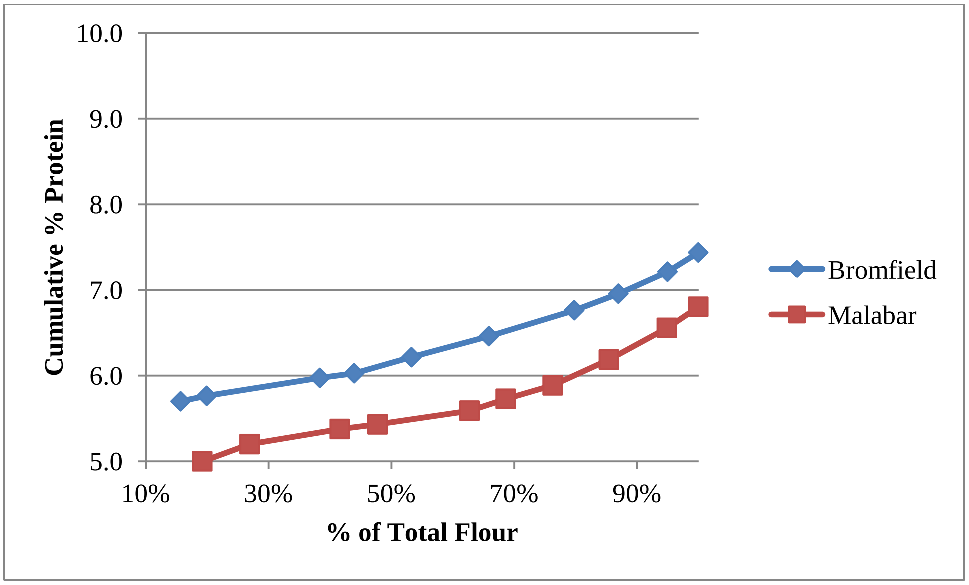


Table 10 Cumulative % Protein, The Ohio State University: Bromfield and Malabar

Bromfield			Malabar		
Mill Stream	Cumulative Mill Stream %	Cumulative Protein %	Mill Stream	Cumulative Mill Stream %	Cumulative Protein %
1 Brk	16	5.7	1 Brk	19	5.0
Grader	20	5.8	Grader	27	5.2
1 Mids	38	6.0	3 Brk	42	5.4
2 Brk	44	6.0	2 Brk	48	5.4
Re-Dust	53	6.2	1 Mids	63	5.6
2 Mids	66	6.5	Re-Dust	69	5.7
3 Brk	80	6.8	2 Mids	76	5.9
3 Mids	87	7.0	3 Mids	85	6.2
4 Mids	95	7.2	4 Mids	95	6.6
5 Mids	100	7.4	5 Mids	100	6.8

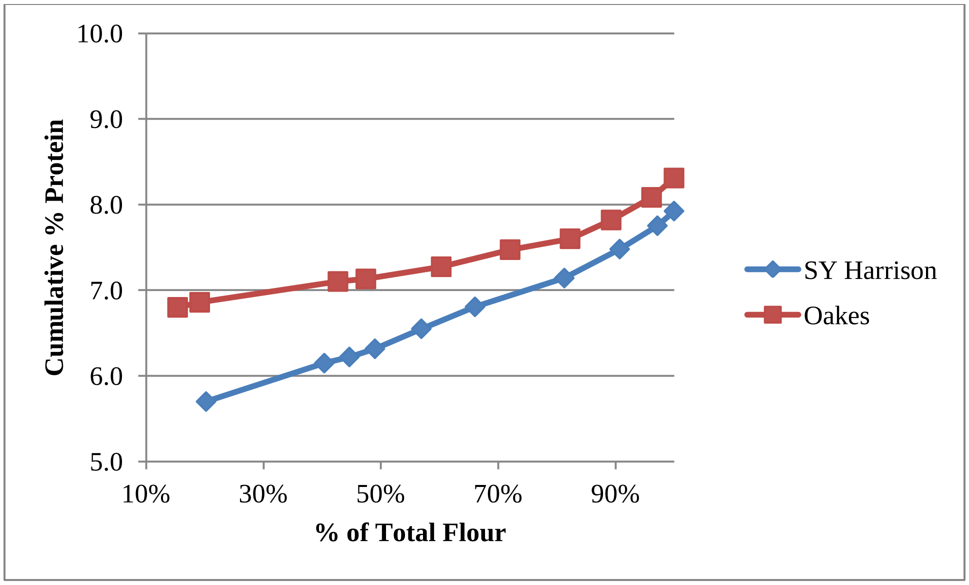


Table 11. Cumulative % Protein, Syngenta: SY Harrison and Oakes

SY Harrison			Oakes		
Mill Stream	Cumulative Mill Stream %	Cumulative Protein %	Mill Stream	Cumulative Mill Stream %	Cumulative Protein %
1 Brk	20	5.7	1 Brk	15	6.8
1 Mids	40	6.1	Grader	19	6.9
2 Brk	45	6.2	1 Mids	43	7.1
Grader	49	6.3	2 Brk	47	7.1
Re-Dust	57	6.6	3 Brk	60	7.3
2 Mids	66	6.8	2 Mids	72	7.5
3 Brk	81	7.1	Re-Dust	82	7.6
3 Mids	91	7.5	3 Mids	89	7.8
4 Mids	97	7.8	4 Mids	96	8.1
5 Mids	100	7.9	5 Mids	100	8.3

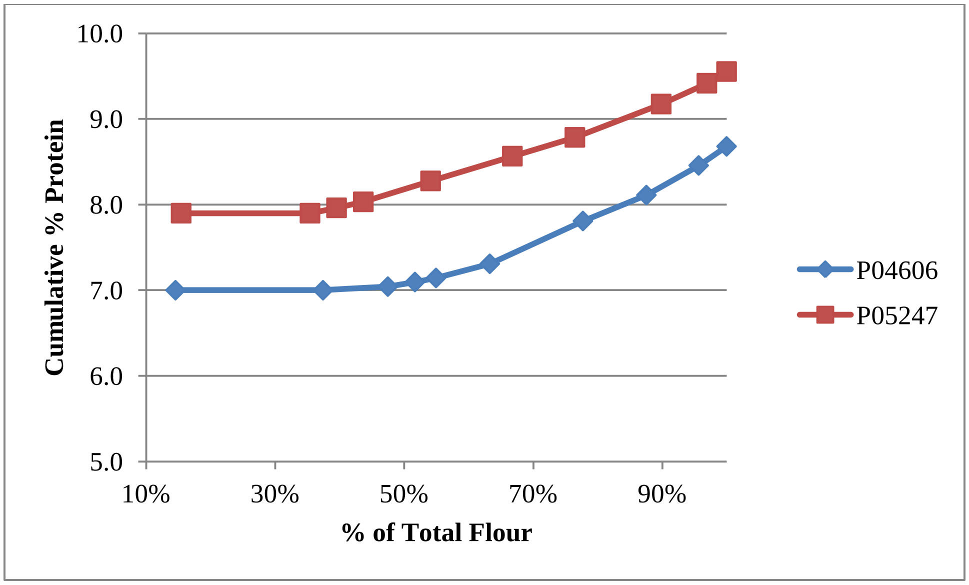


Table 12. Cumulative % Protein, Purdue University: P04606 and P05247

P04606			P05247		
Mill Stream	Cumulative Mill Stream %	Cumulative Protein %	Mill Stream	Cumulative Mill Stream %	Cumulative Protein %
1 Brk	15	7.0	1 Brk	15	7.9
1 Mids	37	7.0	1 Mids	35	7.9
2 Mids	48	7.0	Grader	40	8.0
2 Brk	52	7.1	2 Brk	44	8.0
Grader	55	7.1	Re-Dust	54	8.3
Re-Dust	63	7.3	2 Mids	67	8.6
3 Brk	78	7.8	3 Mids	76	8.8
3 Mids	88	8.1	3 Brk	90	9.2
4 Mids	96	8.5	4 Mids	97	9.4
5 Mids	100	8.7	5 Mids	100	9.6

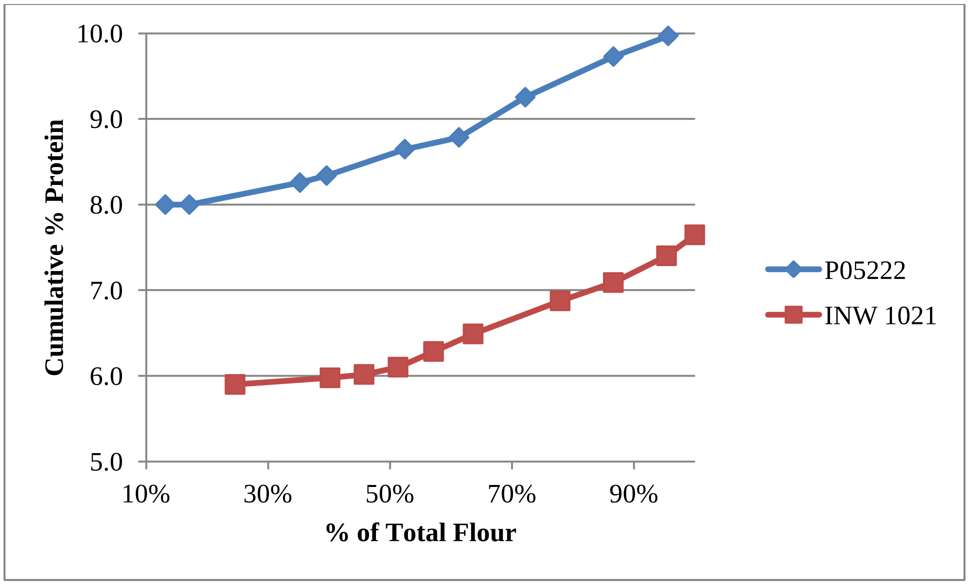


Table 13. Cumulative % Protein, Purdue University: P05222 and INW 1021

P05222			INW 1021		
Mill Stream	Cumulative Mill Stream %	Cumulative Protein %	Mill Stream	Cumulative Mill Stream %	Cumulative Protein %
1 Brk	13	8.0	1 Brk	25	5.9
Grader	17	8.0	1 Mids	40	6.0
1 Mids	35	8.3	Grader	46	6.0
2 Brk	40	8.3	2 Brk	51	6.1
2 Mids	52	8.6	Re-Dust	57	6.3
Re-Dust	61	8.8	2 Mids	64	6.5
3 Mids	72	9.3	3 Brk	78	6.9
3 Brk	87	9.7	3 Mids	87	7.1
4 Mids	96	10.0	4 Mids	95	7.4
5 Mids	100	10.1	5 Mids	100	7.6

Collaborator Evaluations

Dave Green; ADM Milling, Shawnee Mission, Kansas

Scott Baker; ConAgra Foods, Omaha, Nebraska

Colleen Kuznik; Horizon Milling, Minneapolis, Minnesota

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

Diane Gannon; Mondelez International, Toledo, Ohio

Jeanny Zimeri; Mondelez International, East Hanover, New Jersey

Jim Schuh and Tom Baker; The Mennel Milling Company, Fostoria, Ohio

Marianne Teagler; Siemer Milling Company, Teutopolis, Illinois

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

ADM Milling

Table 14. ADM Milling Datasheet: Solvent Retention Capasity and Cookies (10-50D)

Entries	Solvent Retention Capacity				Cookies (10-50D)			
	Water %	Sodium Carb %	Sucrose %	Lactic Acid %	Width (mm)	Thick (mm)	W/T Ratio (mm)	Spread Factor
VA06W-412	56.01	84.70	93.24	109.86	47.80	6.37	7.50	73.23
VA08W-294	56.56	84.52	94.84	108.91	47.00	6.73	6.98	68.16
Merl (ck)	56.81	80.01	88.57	87.35	46.80	6.60	7.09	69.21
Pioneer 25R34	51.82	70.09	84.77	91.49	48.83	5.63	8.67	85.17
Pioneer 25R40	56.18	75.40	90.39	91.59	47.43	6.10	7.77	76.35
Pioneer 25R47 (ck)	52.33	72.24	80.69	92.83	48.83	5.63	8.67	85.17
Bromfield	56.16	83.10	95.68	92.36	47.63	6.37	7.48	72.98
Malabar (ck)	56.22	77.91	86.14	84.54	47.67	6.20	7.69	75.04
SY Harrison	52.38	75.19	81.95	89.81	50.07	5.53	9.05	88.37
Oakes (ck)	54.97	77.67	88.38	95.56	46.90	6.43	7.29	71.19
P04606	53.99	78.99	76.83	95.54	47.50	6.20	7.66	74.77
P05247	54.17	78.25	92.89	84.85	46.70	6.70	6.97	68.03
P05222	55.17	78.52	95.59	67.51	47.10	6.67	7.06	68.92
INW 1021 (ck)	55.78	82.56	94.14	91.29	48.13	6.07	7.93	77.39

Table 15. ADM Milling Evaluation and Comments

	Analytical Flour Qualities		End Product Performance		Aditional Comments
Entry	Likes	Score	Product	Score	Mitigating Physical/Chemical Properties
VA06W-412	highest SD, Sl. high LA	4	low SF, best of set	5	experimental was better than the check
VA08W-294	high SD, Sl.high LA, high pentosans	4	very low SF, below avg.	4	similar to check
Merl (ck)	low LA, Sl high SD	5	very low SF, below avg.	4	
Pioneer 25R34	low LA	6	good SF, good overall	8	similar to the check
Pioneer 25R40	low LA	5	low SF	6	poorer than the check
Pioneer 25R47 (ck)	low LA	6	good SF, good checking	8	
Bromfield	high pentosans	5	low SF, minimal checking	5	similar to the check
Malabar (ck)	low LA	4	low SF	5	
SY Harrison	good overall SRC	5	best SF in group, very good checking	8	much better than the check
Oakes (ck)	good overall SRC	7	low SF, minimal checking	5	
P04606	low pentosans	6	low SF, minimal checking	5	very similar to check
P05247	low LA	5	very low SF, below avg.	4	high protein
P05222	very low LA, high pentosans	4	very low SF, below avg.	4	high protein
INW 1021 (ck)	high pentosans	4	low SF, minimal checking	6	check was better than the experimentals in this set

ConAgra Foods

Table 16. ConAgra Foods Datasheet: Primary Analysis and Solvent Retention Capacity

	Primary Analysis (CAG)			Solvent Retention Capacity				
Entries	Flour Moisture %	Flour Ash %	Flour Protein %	Water %	Sodium Carb %	Sucrose %	Lactic Acid %	Ratio
VA06W-412	13.2	0.513	9.0	57.5	83.5	111.1	118.3	0.61
VA08W-294	13.5	0.555	8.8	59.4	86.1	115.4	119.1	0.59
Merl (ck)	13.2	0.524	7.9	57.6	83.2	105.8	92.6	0.49
Pioneer 25R34	13.0	0.508	7.1	53.8	73.7	96.1	96.0	0.57
Pioneer 25R40	13.8	0.512	7.3	59.5	79.3	100.9	96.6	0.54
Pioneer 25R47 (ck)	12.9	0.475	6.9	55.1	73.8	93.2	93.8	0.56
Bromfield	13.3	0.607	7.4	58.6	84.1	108.9	96.1	0.50
Malabar (ck)	13.4	0.614	7.0	58.7	81.2	98.5	90.2	0.50
SY Harrison	13.6	0.482	7.7	54.3	75.9	95.6	96.7	0.56
Oakes (ck)	13.3	0.523	8.8	56.4	77.5	105.8	102.5	0.56
P04606	13.4	0.569	9.0	57.5	82.9	113.8	77.6	0.39
P05247	13.0	0.510	10.0	54.9	79.5	110.1	87.0	0.46
P05222	13.3	0.728	10.8	55.9	81.3	108.6	66.7	0.35
INW 1021 (ck)	13.0	0.559	7.2	58.8	81.8	111.1	97.1	0.50

Table 17. ConAgra Datasheet Cont.: Cookies (10-50D) and BranScan

	Cookies (10-50D)			BranScan			
Entries	Width (mm)	Thick (mm)	W/T Ratio (mm)	% Bran	% Alurone	Bran Particles	Aluerone Particles
VA06W-412	487	64.5	75.5	0.70	1.16	18.18	20.45
VA08W-294	478	64.5	74.1	0.42	1.14	15.27	21.86
Merl (ck)	480	64.0	75.0	0.34	1.27	12.77	27.32
Pioneer 25R34	494	57.5	85.9	0.21	1.36	7.59	34.00
Pioneer 25R40	476	62.0	76.8	0.27	1.47	8.96	34.96
Pioneer 25R47 (ck)	494	59.0	83.7	0.22	1.35	7.27	36.55
Bromfield	475	64.0	74.2	0.31	1.31	12.96	28.00
Malabar (ck)	488	61.0	80.0	0.33	1.19	12.00	25.09
SY Harrison	499	57.0	87.5	0.89	1.55	24.41	30.27
Oakes (ck)	478	66.5	71.9	0.46	1.09	18.73	21.86
P04606	476	66.0	72.1	0.24	1.42	8.14	31.86
P05247	476	68.0	70.0	0.22	1.15	8.18	27.05
P05222	479	65.5	73.1	0.24	1.39	7.32	27.46
INW 1021 (ck)	484	62.0	78.1	0.38	1.22	13.77	28.14

Table 18. ConAgra Evaluation and Comments

	Analytical Flour Qualities	End Product Performance			Aditional Comments
Entry	Dislikes	Product	Dislikes	Score	Mitigating, Physical/Chemical Properties
VA06W-412	SRC Sucrose High	Cookie	Poor Spread	3	High Bran Content
VA08W-294	SRC Sucrose High	Cookie	Poor Spread	3	
Merl (ck)		Cookie	Poor Spread	3	
Pioneer 25R34		Cookie		6	
Pioneer 25R40		Cookie	Poor Spread	3	
Pioneer 25R47 (ck)		Cookie		5	
Bromfield	SRC Sucrose High	Cookie	Poor Spread	3	High Ash
Malabar (ck)		Cookie	Poor Spread	4	High Ash
SY Harrison		Cookie		6	High Bran Content
Oakes (ck)	SRC Sucrose High	Cookie	Very Poor Spread	2	High Bran Content
P04606	SRC Sucrose High/SRC Lactic Low	Cookie	Very Poor Spread	2	
P05247	SRC Sucrose High/SRC Lactic Low	Cookie	Very Poor Spread	2	
P05222	SRC Sucrose High/SRC Lactic Low	Cookie	Poor Spread	3	Low SRC Lactic Acid; High Ash
INW 1021 (ck)	SRC Sucrose High	Cookie	Poor Spread	4	

Horizon Milling

Table 19. Horizon Milling Datasheet: Cookies (10-50D)

	Cookies (10-50D)					
Entries	Width (mm)	Thick (mm)	W/T Ratio (mm)	Spread Factor	Crust	Score
VA06W-412	469	64	7.33	71.96	4.0	5
VA08W-294	454	67	6.78	66.54	4.0	4
Merl (ck)	465	67	6.94	68.15	4.0	4
Pioneer 25R34	490	57	8.60	84.42	3.5	7
Pioneer 25R40	473	61	7.75	76.15	3.5	6
Pioneer 25R47 (ck)	491	56	8.77	86.10	3.5	8
Bromfield	464	64	7.25	70.76	3.5	5
Malabar (ck)	473	63	7.51	73.28	3.5	5
SY Harrison	487	58	8.40	81.95	3.5	7
Oakes (ck)	464	67	6.93	67.59	4.0	4
P04606	466	63	7.40	72.19	4.0	5
P05247	456	65	7.02	68.47	4.0	4
P05222	456	62	7.35	71.78	4.0	5
INW 1021 (ck)	467	61	7.66	74.72	3.0	6

Table 20. Horizon Milling Evaluation and Comments

	End Product Performance			Aditional Comments
Entry	Likes	Dislikes	Score	Mitigating, Physical/Chemical Properties
VA06W-412	Best performance of group	Low SF	5	Dough: slightly yellow, slightly dry, Crust: avg. cracking
VA08W-294		Very Low SF	4	Dough: slightly yellow, slightly dry, Crust: avg. cracking
Merl (ck)		Very Low SF	4	Dough: normal, Crust: avg. cracking
Pioneer 25R34	Good SF		7	Dough: slightly yellow, Crust: moderately high cracking
Pioneer 25R40	Acceptable SF		6	Dough: moderately dry, Crust: moderately high cracking
Pioneer 25R47 (ck)	Good SF, best performance of group		8	Dough: normal, Crust: moderately high cracking
Bromfield		Low SF	5	Dough: very yellow, moderately wet, Crust: moderately high cracking
Malabar (ck)	Best performance of group	Low SF	5	Dough: normal, Crust: moderately high cracking
SY Harrison	Good SF, best performance of group		7	Dough: comparable to check, Crust: moderately high cracking
Oakes (ck)		Very Low SF	4	Dough: normal, Crust: avg. cracking
P04606		Low SF	5	Dough: slightly yellow, slightly dry, Crust: avg. cracking
P05247		Very Low SF	4	Dough: slightly yellow, slightly dry, Crust: avg. cracking
P05222		Low SF	5	Dough: slightly yellow, slightly dry, Crust: avg. cracking
INW 1021 (ck)	Acceptable SF, best performance of group		6	Dough: normal, Crust: very high cracking

Kellogg's

Table 21. Kellogg's Datasheet: Primary Analysis, Solvent Retention Capacity, and Alveograph

	Primary Analysis				Solvent retention capacity				Alveograph				
Entries	Flour Moisture %	Flour Protein %	Ash %	Falling Number	Water %	Sodium Carb %	Sucrose %	Lactic Acid %	P mm	L mm	P/L Ratio	Ie	W (joules)
VA06W-412	13.1	8.92	0.48	366	56.2	78.6	101.6	110.5	51	105	0.49	47.0	82
VA08W-294	13.3	8.88	0.48	389	57.0	79.9	99.2	109.5	58	83	0.70	45.9	93
Merl (ck)	13.1	7.84	0.49	397	54.8	75.6	91.2	85.0	40	73	0.55	33.9	57
Pioneer 25R34	12.8	7.02	0.43	344	52.3	70.1	82.7	90.3	29	81	0.36	42.4	45
Pioneer 25R40	13.6	7.27	0.49	368	56.3	75.5	88.9	91.9	52	59	0.88	42.8	81
Pioneer 25R47 (ck)	12.7	7.02	0.40	335	53.0	68.9	84.3	91.4	33	92	0.36	40.8	50
Bromfield	13.2	7.51	0.53	346	56.8	77.7	95.6	88.3	46	88	0.52	35.0	66
Malabar (ck)	13.4	7.07	0.55	416	56.2	75.9	89.3	82.9	43	63	0.68	45.7	69
SY Harrison	13.4	7.81	0.46	335	52.6	72.1	82.8	91.1	34	88	0.39	43.6	53
Oakes (ck)	13.0	8.96	0.44	420	53.3	73.9	92.2	97.4	38	90	0.42	40.7	58
P04606	13.3	9.16	0.53	404	54.6	77.0	102.0	74.8	44	50	0.88	22.0	56
P05247	12.9	10.13	0.44	410	53.3	74.7	95.8	84.9	43	74	0.58	31.0	60
P05222	13.2	10.90	0.65	390	55.8	76.4	94.2	64.0	37	72	0.51	28.8	51
INW 1021 (ck)	12.8	7.30	0.52	401	55.6	76.7	96.0	90.0	47	68	0.69	38.1	70

Table 22. Kellogg's Datasheet Cont.: Farinograph and Rapid Visco-Analyzer

	Farinograph				Rapid Visco-Analyzer							
Entries	Water Absorp (%)	Develop Time (min)	Stability (min)	Degree of Softening	Peak Time (min)	Peak cP	Trough cP	Break-down cP	Setback cP	Final cP	Pasting Temp °C	Peak/ Final Ratio
VA06W-412	56.9	1.7	4.8	77	6.0	2685	1459	1226	1324	2783	89.9	0.96
VA08W-294	57.9	1.5	3.8	70	6.1	2759	1532	1227	1361	2893	89.0	0.95
Merl (ck)	56.5	1.5	3.8	83	6.0	2207	1391	816	1403	2794	89.8	0.79
Pioneer 25R34	52.2	1.2	1.8	124	5.9	2563	1514	1049	1353	2867	86.6	0.89
Pioneer 25R40	53.9	1.4	2.4	95	6.0	2514	1509	1005	1294	2803	87.5	0.90
Pioneer 25R47 (ck)	53.2	1.2	2.0	115	5.9	2619	1559	1060	1382	2941	86.5	0.89
Bromfield	55.3	1.7	4.7	93	5.9	2218	1258	960	1293	2551	87.5	0.87
Malabar (ck)	52.9	1.0	1.7	130	6.1	2944	1639	1305	1528	3167	87.5	0.93
SY Harrison	53.2	1.4	2.1	105	5.7	2411	1124	1287	1148	2272	86.6	1.06
Oakes (ck)	56.0	1.4	5.9	82	6.1	2630	1495	1135	1264	2759	88.2	0.95
P04606	59.2	1.5	2.6	114	6.3	2812	1788	1024	1332	3120	89.1	0.90
P05247	58.9	1.8	2.5	96	6.1	2728	1679	1049	1416	3095	88.1	0.88
P05222	58.5	1.8	2.5	104	6.2	2422	1522	900	1389	2911	90.6	0.83
INW 1021 (ck)	54.1	1.4	3.4	98	6.1	2949	1681	1268	1448	3129	87.4	0.94

Table 23. Kellogg's Evaluation and Comments

Entry	Comments
VA06W-412 VA08W-294 Merl (ck)	Compares to ck sample both VA06A-412 and VA08W-294 have higher protein content and better protein quality as determined by SRC-Lactic Acid and Farinograph/Alveograph. The characteristics are good for Frozen food and cracker type of products.
Pioneer 25R34 Pioneer 25R40 Pioneer 25R47 (ck)	No significant difference for all aspects measured for these two new varieties Pioneer 25R34 and Pioneer 25R40 compared to the ck sample.
Bromfield Malabar (ck)	Slightly higher water absorption (Farinograph and SRC/water) but not significantly better than the ck sample.
SY Harrison Oakes (ck)	SY Harrison is weaker (protein content and other measurements Farinograph water absorption and SRC-water) than the ck sample.
P04606 P05247 P05222 INW 1021 (ck)	Although higher protein content however weaker protein quality of the tested samples compared to ck material.

Mondelez International

Table 24. Mondelez International Datasheet: Primary Analysis, Solvent Retention Capacity, and Alveograph

	Toledo Primary		Solvent Retention Capacity					Alveograph			
Entries	Flour Moisture	Flour Ash	Water %	Sodium Carb %	Sucrose %	Lactic Acid %	src ratio (lactic/	P mm	L mm	P/L Ratio	W (joules)
VA06W-412	13.0	0.51	57.70	85.28	114.54	116.04	0.58	56	80	0.70	137
VA08W-294	13.4	0.55	60.00	88.78	116.43	115.50	0.56	61	88	0.69	156
Merl (ck)	13.1	0.53	57.43	85.85	99.12	90.16	0.49	42	71	0.59	77
Pioneer 25R34	12.8	0.50	54.25	75.67	96.95	93.33	0.54	28	78	0.36	61
Pioneer 25R40	13.5	0.53	59.29	81.14	102.57	95.77	0.52	52	50	1.04	116
Pioneer 25R47 (ck)	12.7	0.47	54.92	75.42	95.61	89.84	0.53	35	65	0.54	68
Bromfield	13.1	0.57	58.96	85.70	103.69	96.22	0.51	48	64	0.75	86
Malabar (ck)	13.3	0.59	64.80	85.37	109.12	90.34	0.46	50	40	1.25	75
SY Harrison	13.4	0.49	57.87	78.76	106.83	91.26	0.49	33	57	0.58	63
Oakes (ck)	13.1	0.49	55.98	80.58	103.42	92.91	0.50	37	66	0.56	72
P04606	13.2	0.58	60.27	84.77	113.38	76.95	0.39	44	28	1.57	42
P05247	12.9	0.49	50.04	80.88	111.26	81.51	0.42	43	55	0.78	67
P05222	13.2	0.71	54.64	83.49	108.64	66.50	0.35	38	56	0.68	60
INW 1021 (ck)	12.8	0.56	59.93	82.67	114.18	98.34	0.50	50	63	0.79	93
Ideal Parameters	**13**	**< .45**	**<54**	**<68**	**<90**	**<110**	**0.696**	**45+/- 4**	**100**		**125 +/- 15**

Table 25. Mondelez International Evaluation and Comments

	End Product Performance			
Entry	Product	Likes	Dislikes	Score
VA06W-412	cookies/crackers	great gluten	too hard and high pentosans	2
VA08W-294	cookies/crackers	great gluten	too hard and high pentosans	2
Merl (ck)	cookies/crackers			3
Pioneer 25R34	cookies/crackers	softest of the set	marginal gluten	5
Pioneer 25R40	cookies/crackers	improved gluten	too hard and high pentosans	2
Pioneer 25R47 (ck)				5
Bromfield	cookies/crackers	good gluten	high pentosans	4
Malabar (ck)	cookies/crackers			4
SY Harrison	cookies/crackers	lower water absorbtion		3
Oakes (ck)	cookies/crackers			3
P04606	cookies/crackers	too hard,too low gluten, too high water absorbtion		1
P05247	cookies/crackers	too hard,too low gluten, too high water absorbtion		3
P05222	cookies/crackers	too hard,too low gluten, too high water absorbtion		1
INW 1021 (ck)	cookies/crackers	too hard, too high water absorbtion	fair gluten potential	4

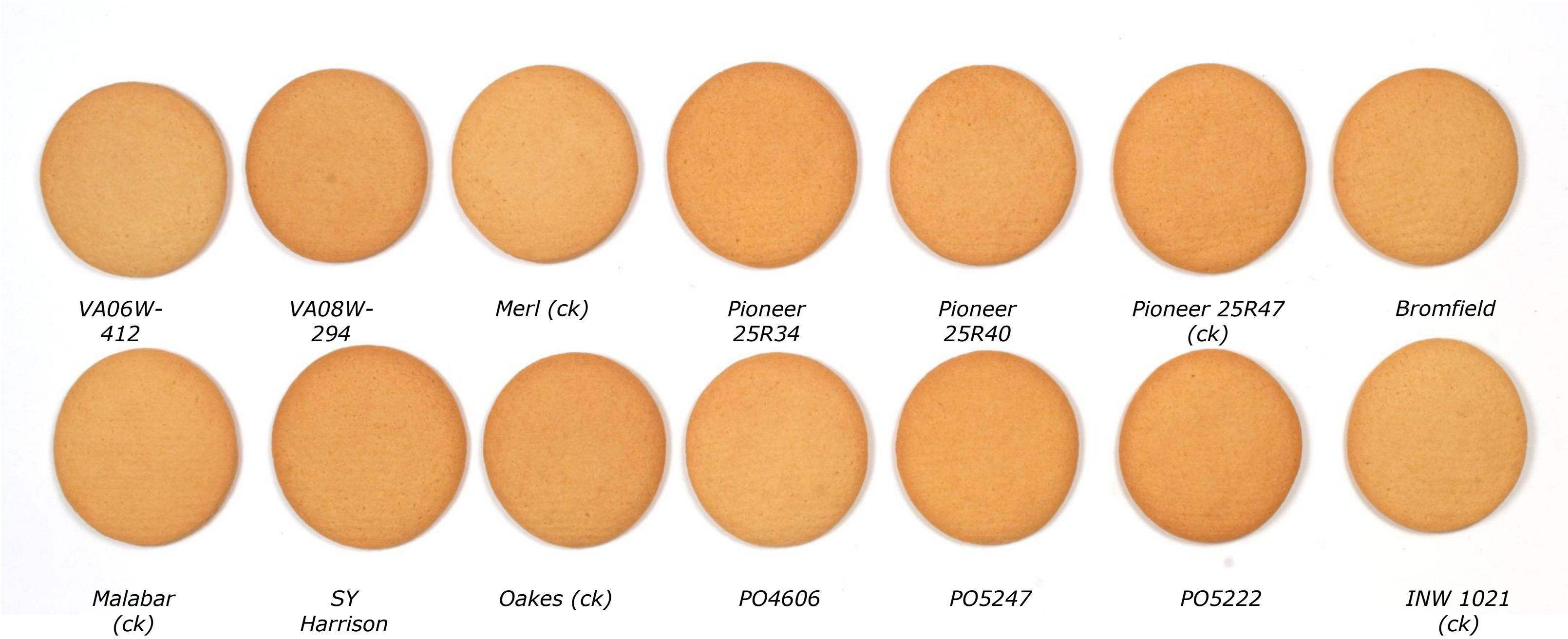
Table 26. Mondelez International Evaluation and Comments Cont.

	Aditional Comments	Analytical Flour Qualities*
	Mitigating, Physical/Chemical Properties	
VA06W-412	worse than check	* Due to the high ash content, the analytical properties of the flours appear highly absorptive and most are unacceptable for cookies/crackers. The properties analytically may not truly reflect the baking potential of the varieties.
VA08W-294	worse than check	
Merl (ck)		
Pioneer 25R34	slightly better than check	
Pioneer 25R40	worse than check	
Pioneer 25R47 (ck)		
Bromfield	better than check	
Malabar (ck)		
SY Harrison	slightly better than check	
Oakes (ck)		
P04606	low gluten	
P05247		
P05222	low gluten	
INW 1021 (ck)		

Table 27. Mondelez International Cookie Pictures

AACC 10-53

Table 28. Mondelez International Cookie Pictures Cont.



The Mennel Milling Company

Table 29. The Mennel Milling Company Datasheet: Primary Analysis and Solvent Retention Capacity

	Primary Analysis					Solvent retention capacity (AACC56-11)			
Entries	Flour Moisture %	Flour Protein %	Ash % (AACC)	Falling Number	α-Amylase	Water %	Sodium Carb %	Sucrose %	Lactic Acid %
VA06W-412	13.3	9.0	0.526	332	0.060	62.04	86.43	115.57	117.82
VA08W-294	13.6	9.0	0.555	323	0.059	60.97	87.7	116.99	117.16
Merl (ck)	13.4	8.0	0.52	347	0.050	59.58	84.15	105.04	92.11
Pioneer 25R34	13.1	7.3	0.487	310	0.047	55.75	79.25	96.99	100.52
Pioneer 25R40	13.8	7.4	0.557	315	0.039	60.08	82.07	101.63	99.56
Pioneer 25R47 (ck)	12.9	7.2	0.481	298	0.044	56.54	77.01	95.33	98.38
Bromfield	13.4	7.6	0.561	324	0.049	56.87	84.76	109.03	94.07
Malabar (ck)	13.5	7.1	0.588	359	0.054	61.8	83.98	99.12	88.38
SY Harrison	13.7	7.8	0.490	302	0.065	59.37	74.84	96.09	97.74
Oakes (ck)	13.3	9.0	0.469	344	0.056	58.46	68.77	104.71	104.61
P04606	13.4	9.2	0.564	349	0.035	62.56	83.77	112.13	81.48
P05247	13.1	10.2	0.476	333	0.033	58.26	81.13	111.19	93.84
P05222	13.5	10.9	0.686	341	0.056	59.24	85.1	111.09	71.27
INW 1021 (ck)	13.1	7.5	0.570	346	0.037	61.14	85.1	110.37	99.6

Table 30. The Mennel Milling Company Datasheet Cont.: Farinograph and Rapid Visco-Analyzer

	Farinograph (AACC54-21)				Rapid Visco-Analyzer						
	Water Absorp (min)	Develop Time (min)	Stability (min)	MTI	Peak Time (min)	Peak cP	Trough cP	Break-down cP	Setback cP	Final cP	Peak/ Final Ratio
VA06W-412	57.3	1.5	3.4	55	6.27	239.92	152.58	87.33	106.17	258.75	0.93
VA08W-294	58.5	1.7	3.9	54	6.27	243.50	154.92	88.58	106.75	261.67	0.93
Merl (ck)	56.7	1.7	3.3	68	6.13	199.83	134.92	64.92	115.42	250.33	0.80
Pioneer 25R34	53.5	1.2	2.8	59	6.07	225.75	144.92	80.83	109.08	254.00	0.89
Pioneer 25R40	54.4	1.2	1.4	98	6.07	225.25	149.17	76.08	105.58	254.75	0.88
Pioneer 25R47 (ck)	52.7	1.1	1.5	105	6.07	236.67	155.33	81.33	113.58	268.92	0.88
Bromfield	55.8	1.3	3.2	78	6.00	195.75	121.5	74.25	103.17	224.67	0.87
Malabar (ck)	53.5	1.0	1.1	118	6.20	254.58	154.25	100.33	126.17	280.42	0.91
SY Harrison	53.9	1.0	1.4	100	5.87	214.75	109.25	105.5	95.17	204.42	1.05
Oakes (ck)	56.0	1.7	3	86	6.13	239.00	148.33	90.67	105.33	253.67	0.94
P04606	58.9	1.5	2.3	137	6.47	246.92	172.92	74.00	106.33	279.25	0.88
P05247	58.8	2.2	2.3	112	6.40	240.42	174.67	65.75	117.00	291.67	0.82
P05222	58.9	2.3	2.1	116	6.47	221.33	157.42	63.92	116.67	274.08	0.81
INW 1021 (ck)	54.4	1.2	1.5	101	6.27	263.67	166.67	97.00	119.67	286.33	0.92

Table 31. The Mennel Milling Company Datasheet Cont.: Cookies 10-50 and Biscuit 10-31

	Cookies (AACC 10-50)				Biscuit (AACC 10-31)		
	Width (mm)	Thick (mm)	W/T Ratio (mm)	Spread Factor	Width (mm)	Height (mm)	Weight (g)
VA06W-412	467.5	67.3	6.9	68.2	400.0	335.0	212.7
VA08W-294	470.0	70.0	6.7	65.9	405.0	325.3	212.2
Merl (ck)	476.0	69.7	6.8	67.1	405.0	311.7	201.0
Pioneer 25R34	494.0	59.4	8.3	81.7	410.0	280.7	191.6
Pioneer 25R40	480.5	66.2	7.3	71.3	409.0	268.0	192.3
Pioneer 25R47 (ck)	501.0	58.9	8.5	83.5	419.3	294.7	206.2
Bromfield	475.0	64.4	7.4	72.4	406.0	281.0	186.7
Malabar (ck)	483.0	63.5	7.6	74.7	406.0	276.0	193.5
SY Harrison	503.5	58.3	8.6	84.9	413.3	289.7	196.2
Oakes (ck)	473.0	69.6	6.8	66.7	402.3	325.0	205.4
P04606	479.5	67.4	7.1	69.0	411.7	327.0	207.6
P05247	476.0	66.1	7.2	69.8	413.7	376.7	220.7
P05222	472.0	67.2	7.0	68.2	410.0	324.3	203.2
INW 1021 (ck)	478.0	64.5	7.4	71.9	410.3	289.7	195.4

Table 32. The Mennel Milling Company Evaluation and Comments

	Analytical Flour Qualities			End Product Performance	
Entry	Likes	Dislikes	Score	Comments	Score
VA06W-412	Good Stab + abs		7.0	Highest SF of set- Good cracking- Highest height in Biscuit	6.0
VA08W-294	Higher Stab + abs		7.5	Lowest SF of set- lighter crust-low cracking	5.0
Merl (ck)	Good Stab + abs	lowest Lactic Acid results and protein	6.5	Tight cracking- lowest height in biscuit- lowest weight in biscuit.	5.5
Pioneer 25R34	Higher Stab	Lowest abs	6.0	Good SF-best flour to match CK- Good cracking	8.0
Pioneer 25R40	Highest abs		5.0	Good SF- low cracking	7.0
Pioneer 25R47 (ck)		lowest stab	4.5	highest SF of set- good tight cracking	8.2
Bromfield	Highest abs of set	highest stab of set	6.5	Good SF with good cracking very close to ck sample	6.5
Malabar (ck)	high FN	low stab	6.0	Good SF with good tight cracking	6.3
SY Harrison	Low abs and stability		4.5	Excellent SF with great cracking	8.5
Oakes (ck)	High protein, FN which result in a higher absorption and stability		6.5	Best height of the set with a tight cracking	7.5
P04606	High Protein, FN , Abs		7.5	Lower SF due to high pro. with good cracking	6.8
P05247	High Protein, FN,Abs, good stab		8.2	Lower SF due to high pro. with tight cracking	6.5
P05222	Highest Pro and FN but low Lactic Acid value		8.0	Lower SF due to high pro. with low cracking	6.0
INW 1021 (ck)	Low Protein, abs, stab. Good FN and Lactic Acid value		5.0	Best SF of the set due to lower protein. Really nice cracking	7.0

Table 33. The Mennel Milling Company Evaluation and Comments Cont.

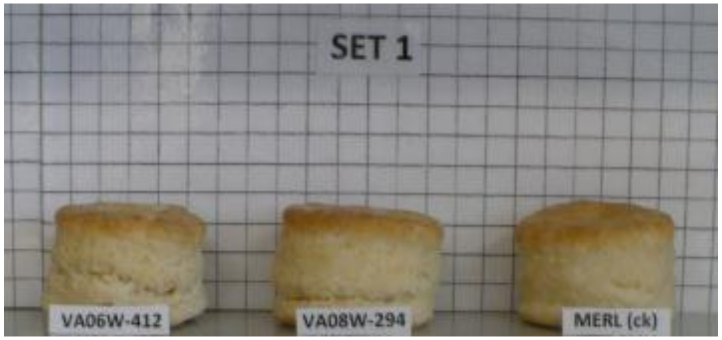
	Aditional Comments Mitigating, Physical/Chemical Properties
VA06W-412	Highest height in Biscuit- dough was dry and bucky
VA08W-294	Dough was dry and bucky in biscuit process
Merl (ck)	Lowest weight in Biscuit- excellent smooth dough
Pioneer 25R34	All doughs in this set was yellow in color in the biscuit process
Pioneer 25R40	But the check sample had the best width and height in Biscuits
Pioneer 25R47 (ck)	
Bromfield	Both dough were yellow in color in the biscuit process
Malabar (ck)	But Broomfield was drier and lumpy in the rolling out process
SY Harrison	Good width with a low height in biscuit
Oakes (ck)	Excellent Height in the biscuit
P04606	All the doughs in this set were yellow in color. The first 3
P05247	samples were bucky in the biscuit process. The Ck sample
P05222	was smooth but had a lower height then the other 3
INW 1021 (ck)	

Table 34. The Mennel Milling Company Cookie Pictures

Table 35. The Mennel Milling Company Cookie Pictures Cont.

Table 36. The Mennel Milling Company Cookie Pictures Cont.

Table 37. The Mennel Milling Company Cookie Pictures Cont.



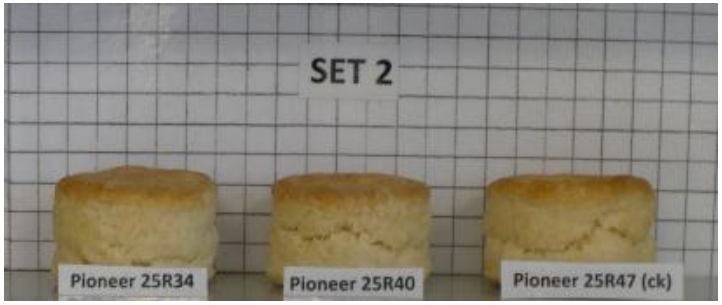
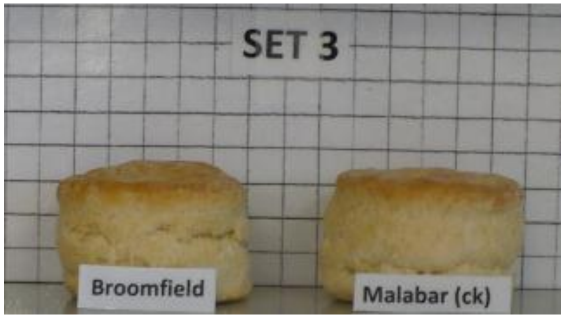


Table 38. The Mennel Milling Company Cookie Pictures Cont.



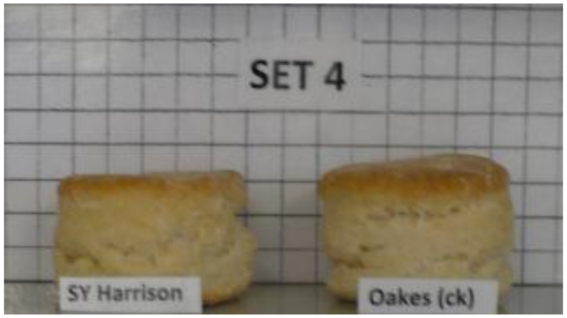
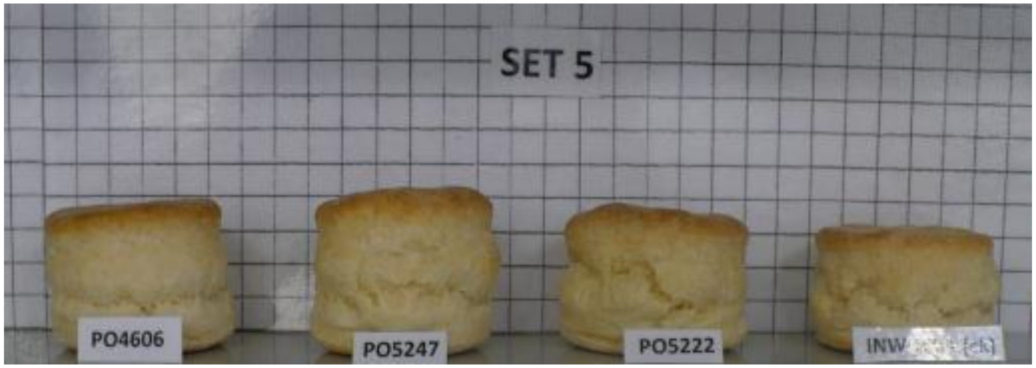


Table 39. The Mennel Milling Company Cookie Pictures Cont.



Siemmer Milling Company

Table 40. Siemmer Milling Company Datasheet: Alveograph

	Alveograph			
Entries	P mm	L mm	P/L Ratio	W (joules)
VA06W-412	58.5	83.7	0.699	144.4
VA08W-294	67.4	60.8	1.109	137.3
Merl (ck)	45.2	51.3	0.881	45.2
Pioneer 25R34	34.5	69.5	0.496	70.8
Pioneer 25R40	59.0	43.3	1.363	99.2
Pioneer 25R47 (ck)	39.8	65.1	0.611	85.5
Bromfield	51.9	54	0.961	82.5
Malabar (ck)	49.2	57.3	0.859	108.5
SY Harrison	38.9	63.6	0.612	81.9
Oakes (ck)	42.1	63.6	0.662	83.5
P04606	50.1	40.9	1.225	63.6
P05247	47.9	58	0.826	87.4
P05222	43.1	52.6	0.819	67.9
INW 1021 (ck)	52.8	61.5	0.859	94.7

Table 41. Siemmer Milling Company Evaluation and Comments

Entry	Aditional Comments Mitigating, Physical/Chemical Properties
VA06W-412	Dough a little stiff. Appears to have some hard wheat tendencies
VA08W-294	Dough- very stiff. Strong flour. Appears to have some hard wheat tendencies.
Merl (ck)	Short lengths- no extensibility.
Pioneer 25R34	low peaks & W- a weaker soft wheat flour
Pioneer 25R40	Dough a little stiff-short lengths - no extensibility
Pioneer 25R47 (ck)	
Bromfield	Short lengths- a little stiff dough
Malabar (ck)	Shorter lengths
SY Harrison	
Oakes (ck)	
P04606	Dough- sticky- no extensibility
P05247	Dough- a little sticky
P05222	Dough - very soft- a little sticky
INW 1021 (ck)	Dough - a little stiff

Syngenta-AgriPro

Table 42. Syngenta-AgriPro Datasheet: Solvent Retention Capacityy and Cookies 10-50D

	Solvent retention capacity					Cookies (10-50D)	
Entries	Water %	Sodium Carb %	Sucrose %	Lactic Acid %		Width (mm)	Score
VA06W-412	58	81	108	112	0.59	16.8	4
VA08W-294	59	84	113	110	0.56	16.9	4
Merl (ck)	58	83	105	92	0.49	17.6	7
Pioneer 25R34	56	76	97	93	0.54	19.0	9
Pioneer 25R40	58	78	100	93	0.52	17.6	6
Pioneer 25R47 (ck)	56	75	86	90	0.56	18.2	9
Bromfield	59	81	107	92	0.49	16.9	5
Malabar (ck)	59	79	98	86	0.48	17.8	8
SY Harrison	54	74	92	86	0.52	18.2	8
Oakes (ck)	57	75	102	90	0.51	17.1	4
P04606	58	79	111	72	0.38	16.3	2
P05247	56	78	113	79	0.41	16.6	3
P05222	57	79	105	64	0.35	16.4	3
INW 1021 (ck)	59	79	106	91	0.49	17.2	7

Table 43. Syngenta-AgriPro Evaluation and Comments

	Analytical Flour Qualities				End Product Performance			
Entry	Likes	Dislikes	Basis	Score	Product	Likes	Dislikes	Score
VA06W-412	LA	H2O, SC,Suc	SRC	4	Sugar snap cookie 10-52.02		Smaller with poor tgrain	4
VA08W-294	LA	H2O, SC,Suc	SRC	4	Sugar snap cookie 10-52.02		Smaller with poor tgrain	4
Merl (ck)		H2O, SC,Suc	SRC	5	Sugar snap cookie 10-52.02	Good Cookie		7
Pioneer 25R34			SRC	7	Sugar snap cookie 10-52.02	Excellent cookie, Nice spread		9
Pioneer 25R40		H2O, Suc	SRC	6	Sugar snap cookie 10-52.02	Good cookie, Nice spread		6
Pioneer 25R47 (ck)	Suc,SC		SRC	8	Sugar snap cookie 10-52.02	Excellent cookie, Nice spread		9
Bromfield		H20,Suc	SRC	4	Sugar snap cookie 10-52.02			5
Malabar (ck)		H2O	SRC	5	Sugar snap cookie 10-52.02	Very good cookie, Nice spread		8
SY Harrison	H2O,SC, Suc		SRC	8	Sugar snap cookie 10-52.02	Very good cookie, Nice spread		8
Oakes (ck)	SC	H2O,?Suc	SRC	6	Sugar snap cookie 10-52.02		Smaller with poor tgrain	4
P04606		H2O,Suc,LA	SRC	4	Sugar snap cookie 10-52.02		Very Small poor cookie	2
P05247		Suc,LA	SRC	4	Sugar snap cookie 10-52.02		Small poor cookie	3
P05222		Suc,LA	SRC	4	Sugar snap cookie 10-52.02		Small poor cookie	3
INW 1021 (ck)	LA	H2O,Suc	SRC	4	Sugar snap cookie 10-52.02	Good Cookie		7

Table 44. Syngenta-AgriPro Evaluation and Comments Cont.

Entry	Aditional Comments Mitigating, Physical/Chemical Properties
VA06W-412	SRC's higher than desired, did not bake as well
VA08W-294	SRC's higher than desired, did not bake as well
Merl (ck)	
Pioneer 25R34	Lower FN, best of set and 2012
Pioneer 25R40	Lower FN, did not perform as well as Chk
Pioneer 25R47 (ck)	Low FN
Bromfield	
Malabar (ck)	Check had better performance than ExpLine
SY Harrison	Peformed better than Chk and overall good quality
Oakes (ck)	
P04606	Poorer SRC and cookie
P05247	Poorer SRC and cookie
P05222	Poorer SRC and cookie
INW 1021 (ck)	Very Low prot and performed better than Explines

Wheat Marketing Center

Table 45. Wheat Marketing Center Datasheet: Sponge Cake

	Sponge Cake Factors			Sponge cake	
Entries	External	Crumb Grain	Texture	Volume (ml)	Total Score
VA06W-412	12	18	12	1202	42
VA08W-294	13	19	21	1244	53
Merl (ck)	12	17	24	1203	53
Pioneer 25R34	13	17	24	1252	54
Pioneer 25R40	12	17	15	1151	44
Pioneer 25R47 (ck)	12	17	21	1255	50
Bromfield	9	17	30	1247	56
Malabar (ck)	12	18	12	1185	42
SY Harrison	9	19	18	1203	46
Oakes (ck)	12	18	18	1183	48
P04606	12	17	21	1260	50
P05247	15	19	15	1243	49
P05222	9	17	15	1168	41
INW 1021 (ck)	12	18	21	1297	51

Table 46. Wheat Marketing Center Evaluation and Comments

	End Product Performance				Aditional Comments
Entry	Product	Likes	Dislikes	Score	Mitigating, Physical/Chemical Properties
VA06W-412	Japanese Sponge Cake	Similar crumb grain to ck	Much harder texture than ck	3	May have made a better sponge cake if the flour protein were 1% lower.
VA08W-294	Japanese Sponge Cake	Better crumb & larger volume than ck		7	May have made a better sponge cake if the flour protein were 1% lower.
Merl (ck)	Japanese Sponge Cake			6	
Pioneer 25R34	Japanese Sponge Cake	Very soft texture, the same volume as ck		7	
Pioneer 25R40	Japanese Sponge Cake		Harder texture and lower volume than ck	3	
Pioneer 25R47 (ck)	Japanese Sponge Cake			5	
Bromfield	Japanese Sponge Cake	Very soft, Higher volume than ck	Slightly worse exterior than ck	7	
Malabar (ck)	Japanese Sponge Cake			3	
SY Harrison	Japanese Sponge Cake	Slightly larger volume than ck	Slightly worse exterior than ck	4	Expect that cake be worse if the flour protein were similar to ck.
Oakes (ck)	Japanese Sponge Cake			5	
P04606	Japanese Sponge Cake	Similar quality cake as ck	Slightly smaller cake than ck	5	May have made a better sponge cake if the flour protein were 1.7% lower.
P05247	Japanese Sponge Cake	Better exterior and crum than ck	Harder texture and lower volume than ck	5	May have made a better sponge cake if the flour protein were 2.7% lower.
P05222	Japanese Sponge Cake		Worst of all	2	May have made a better sponge cake if the flour protein were 3.2% lower.
INW 1021 (ck)	Japanese Sponge Cake			6	

Table 47. USDA-ARS WWQL Datasheet: Solvent Retention Capacity, RVA, and Mixograph

	Solvent retention capacity				RVA	Mixograph	
Entries	Water %	Sodium Carb %	Sucrose %	Lactic Acid %	Peak Time (min)	Water Absorp %	Type
VA06W-412	59.8	84.5	92.6	114.4	178	59.5	6M
VA08W-294	60.5	85.2	94.4	112.8	182	59.5	6M
Merl (ck)	58.5	78.6	88.1	89.2	128	58.5	3M
Pioneer 25R34	54.6	75.3	81.6	92.7	160	57	6M
Pioneer 25R40	58.6	79.5	86.6	94.9	160	56.5	3M
Pioneer 25R47 (ck)	55.6	74.5	81.5	90.7	166	56.5	5M
Bromfield	59.1	81.8	92.2	90.9	131	57	3M
Malabar (ck)	58	81.2	86.4	86.2	183	56.5	7M
SY Harrison	55.6	74.9	82.9	91.8	171	58	8M
Oakes (ck)	57.3	78.8	89.5	96.6	178	59.5	3M
P04606	58.7	82.2	93.5	76.3	195	59.5	2M
P05247	58.6	81	90.2	86.3	177	60.5	1H
P05222	59.3	82.5	92.2	66.7	172	61	1M
INW 1021 (ck)	60.7	81.7	94.1	93.4	202	56.5	3M

Table 48. USDA-ARS WWQL Datasheet Cont.: Sugar-snap Cookie, Sponge Cake, and Alkali Noodle Color Analysis

	Sugar snap cookie	Sponge cake		Alkali noodle color @ 0 Hour			Alkali noodle color @ 24 Hour			
Entries	Diameter (cm)	Volume (ml)	Texture Score	*L**	*a**	*b**	*L**	*a**	*b**	Change in L*
VA06W-412	8.5	1190	21	84.9	-1.6	13.6	71.2	0.8	19.8	13.7
VA08W-294	8.7	1165	20	83.5	-1.5	14.8	70.5	0.8	19.8	13
Merl (ck)	9.1	1230	22	83.5	-1.8	16.5	69.7	1.3	22.5	13.8
Pioneer 25R34	9.0	1270	22	82.3	-2.1	25.4	72.8	0.9	29.3	9.5
Pioneer 25R40	9.0	1240	22	83.1	-1.7	21.2	74	1	26.2	9.1
Pioneer 25R47 (ck)	8.9	1225	21	84.3	-1.9	20.3	76.6	0	24.3	7.7
Bromfield	8.7	1180	20	81.8	-1.6	21.9	68.4	1.3	26.2	13.4
Malabar (ck)	9.1	1180	21	83.9	-1.8	20.3	71.8	0.8	22.4	12.1
SY Harrison	9.0	1240	21	80.1	-0.8	19.2	67	2.6	22.9	13.1
Oakes (ck)	8.4	1185	19	80.5	-1.2	18.3	66.1	1.9	22.5	14.4
P04606	8.3	1200	20	80.8	-1.1	22.5	65.7	2.2	26.9	15.1
P05247	8.3	1220	21	83	-1.5	20.8	67.6	1	26.7	15.4
P05222	8.5	1195	20	79.8	-0.9	21.8	58.5	2.7	24.8	21.3
INW 1021 (ck)	9.0	1220	22	84	-1.7	17.5	74.5	0.8	24.3	9.5

Table 49. USDA-ARS WWQL Evaluation and Comments

	Analytical Flour Qualities				End Product Performance			Additional Comments
Entry	Likes	Dislikes	Basis	Score	Product	Likes	Score	Physical/Chemical Properties
VA06W-412	low protein	High W C S	SRC	3	cookie & cake		3.5	strong gluten type soft
VA08W-294	low protein	High W C S	SRC	3	cookie & cake		4	strong gluten type soft
Merl (ck)	low protein	High W C S	SRC	4	cookie & cake	good cake grain	5.5	
Pioneer 25R34	low protein			5	cookie & cake	good cake grain	6	
Pioneer 25R40	low protein	High W C S	SRC	4	cookie & cake	good cake grain	5.5	
Pioneer 25R47 (ck)	low protein			5	cookie & cake		5	
Bromfield	low protein	High W C S	SRC	3	cookie & cake		4	
Malabar (ck)	low protein	High W C S	SRC	4	cookie & cake		4.5	
SY Harrison	low protein			5	cookie & cake		5	
Oakes (ck)	low protein			4	cookie & cake		3.5	
P04606	low protein	High W C S	SRC	3	cookie & cake		4	
P05247		High W C S	SRC	3	cookie & cake		4	
P05222		High W C S	SRC	3	cookie & cake		3.5	
INW 1021 (ck)	low protein	High W C S	SRC	3	cookie & cake	good cake grain	5.5	

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Table 50. USDA-ARS SWQL Datasheet: Test Weight, Single Kernel Characterization System, and Milling

		SKCS				Milling	
	Test Weight (lb/bu)	Moisture	Diameter	Weight	Hardness	Break	Straight Grade
VA06W-412	64.3	14.0	2.6	40.1	26.5	26.1	71.5
VA08W-294	63.1	14.2	2.6	41.9	34.9	26.6	72.5
Merl (ck)	63.2	14.0	2.6	42.4	29.8	26.6	74.0
Pioneer 25R34	60.8	14.3	2.4	39.8	14.8	28.8	73.5
Pioneer 25R40	60.2	14.1	2.5	42.6	27.5	29.1	74.8
Pioneer 25R47 (ck)	59.6	14.2	2.3	37.1	18.7	30.6	74.1
Bromfield	62.1	14.6	2.2	33.0	33.8	29.5	74.9
Malabar (ck)	58.2	13.8	2.3	31.6	12.2	36.0	75.2
SYHarrison	58.4	14.0	2.3	37.1	10.1	33.7	76.5
Oakes (ck)	61.5	14.3	2.4	34.8	33.8	27.9	75.8
P04606	62	13.7	2.5	36.4	32.6	27.0	74.1
P05247	62.9	14.5	2.6	38.3	35.7	27.5	74.2
P05222	58.9	14.8	2.4	31.7	38.5	26.1	72.6
INW 1021	55.9	13.5	2.5	34.9	5.5	37.4	74.7

Table 51. USDA-ARS SWQL Datasheet Cont.: Primary Flour Analysis and Sovent Retention Capacity

	Primary Flour Analysis							Solvent Retention Capacity				
	Flour Moisture %	Flour Protein %	Flour pH	Falling Number	α-Amylase	Starch Damage	Flour Ash %	Water %	Sodium Carb %	Sucrose %	Lactic Acid %	LA/ SC+S
VA06W-412	13.3	9.0	6.2	332	0.060	4.3	0.519	61.2	87.5	110.3	112.8	0.57
VA08W-294	13.6	9.0	6.2	323	0.059	3.6	0.529	61.7	87.5	113.1	106.9	0.53
Merl (ck)	13.4	8.0	6.2	347	0.050	5.6	0.534	61.3	85.4	103.2	87.9	0.47
Pioneer 25R34	13.1	7.3	6.3	310	0.047	4.4	0.515	57.5	77.4	97.1	93.7	0.54
Pioneer 25R40	13.8	7.4	6.3	315	0.039	4.9	0.532	61.9	83.3	100.2	92.0	0.50
Pioneer 25R47 (ck)	12.9	7.2	6.3	298	0.044	6.3	0.491	58.9	78.4	96.8	92.8	0.53
Bromfield	13.4	7.6	6.3	324	0.049	5.3	0.573	62.4	86.4	105.0	93.9	0.49
Malabar (ck)	13.5	7.1	6.3	359	0.054	4.5	0.581	62.1	84.5	98.9	83.6	0.46
SYHarrison	13.7	7.8	6.2	302	0.065	3.4	0.481	57.4	78.3	95.7	87.7	0.50
Oakes (ck)	13.3	9.0	6.3	344	0.056	4.5	0.497	59.0	81.5	106.4	94.5	0.50
P04606	13.4	9.2	6.3	349	0.035	3.4	0.572	60.8	83.5	113.2	75.3	0.38
P05247	13.1	10.2	6.2	333	0.033	4.6	0.491	58.8	82.6	107.5	83.3	0.44
P05222	13.5	10.9	6.0	341	0.056	4.8	0.701	60.8	84.1	107.1	69.1	0.36
INW 1021	13.1	7.5	6.3	346	0.037	2.3	0.562	60.9	82.1	106.2	90.6	0.48

Table 52. USDA-ARS SWQL Datasheet Cont.: Rapid Visco-Analyzer and Mixograph

	Rapid Visco-Analyzer								Mixograph				
	Peak cP	Trough cP	Break-down cP	Final cP	Setback cP	Peak Time min	Pasting Temp °C	Peak/ Final Ratio	Water Absorp %	Peak Time min	Peak Value %	Peak Width %	Peak Width 7min
VA06W-412	2452	1309	1143	2472	1163	6.03	87.6	0.99	63	3.68	33.39	12.56	7.86
VA08W-294	2551	1396	1156	2616	1221	6.10	87.6	0.98	64	4.54	32.88	10.21	8.26
Merl (ck)	1863	1198	666	2404	1207	6.00	88.1	0.77	61	4.24	33.42	10.89	6.18
Pioneer 25R34	2323	1374	950	2582	1208	5.97	85.1	0.90	58	5.80	28.07	7.44	7.90
Pioneer 25R40	2224	1327	897	2461	1134	6.00	85.9	0.90	63	4.41	23.95	9.03	6.80
Pioneer 25R47 (ck)	2318	1367	951	2577	1210	5.93	84.8	0.90	60	5.85	28.50	9.14	7.93
Bromfield	1911	1083	828	2212	1129	5.87	85.1	0.86	63	4.54	30.05	7.72	5.47
Malabar (ck)	2592	1436	1156	2793	1358	6.07	85.2	0.93	63	3.86	21.01	8.48	5.76
SYHarrison	2189	996	1193	2033	1037	5.80	84.9	1.08	59	5.53	28.03	9.52	8.05
Oakes (ck)	2425	1353	1072	2492	1139	6.03	86.4	0.97	60	3.23	34.11	10.77	6.56
P04606	2534	1602	933	2798	1197	6.27	86.8	0.91	62	2.43	34.23	9.93	2.75
P05247	2547	1603	944	2913	1310	6.23	87.2	0.87	61	2.06	40.28	11.26	2.92
P05222	2185	1388	797	2646	1259	6.20	88.9	0.83	61	1.54	39.49	13.12	2.77
INW 1021	2669	1515	1155	2816	1302	6.13	85.9	0.95	63	6.50	25.11	6.55	6.66

Table 53. USDA-ARS SWQL Datasheet Wire-cut Cookie 10-54 and Sugar-snap

	Wire-cut Evaluation AACC 10-54				Sugar snap	
	Cookie Diameter cm x2	Cookie Stack Ht cm x2	Force g	Distance mm	Diameter cm x2	Top Grain Score
VA06W-412	14.74	2.53	1266	1.90	16.76	4
VA08W-294	14.56	2.62	1208	2.30	16.43	3
Merl (ck)	14.36	2.55	1255	1.48	16.89	5
Pioneer 25R34	15.22	2.34	1359	1.63	17.62	6
Pioneer 25R40	14.66	2.44	1392	1.98	16.93	5
Pioneer 25R47 (ck)	15.42	2.28	1251	1.91	17.99	7
Bromfield	14.33	2.61	1061	3.34	16.75	3
Malabar (ck)	14.78	2.54	1004	2.31	17.22	5
SYHarrison	15.40	2.26	1074	2.50	17.86	5
Oakes (ck)	14.54	2.42	1216	2.48	16.61	2
P04606	14.38	2.62	1483	2.20	16.33	1
P05247	14.54	2.41	1428	2.03	16.49	1
P05222	14.35	2.62	1371	2.40	16.32	1
INW 1021	14.64	2.54	1058	2.56	16.85	4

Table 54. Combined Solvent Retention Capacity: Water

	VA06W-412	VA08W-294	Merl (ck)	Pioneer 25R34	Pioneer 25R40	Pioneer 25R47 (ck)	Bromfield	Malabar (ck)	SYHarrison	Oakes (ck)	P04606	P05247	P05222	INW 1021
ADM	56.0	56.6	56.8	51.8	56.2	52.3	56.2	56.2	52.4	55.0	54.0	54.2	55.2	55.8
ConAgra	57.5	59.4	57.6	53.8	59.5	55.1	58.6	58.7	54.3	56.4	57.5	54.9	55.9	58.8
Kellogg's	56.2	57.0	54.8	52.3	56.3	53.0	56.8	56.2	52.6	53.3	54.6	53.3	55.8	55.6
Mennel	62.0	61.0	59.6	55.8	60.1	56.5	56.9	61.8	59.4	58.5	62.6	58.3	59.2	61.1
Mondelez	57.7	60.0	57.4	54.3	59.3	54.9	59.0	64.8	57.9	56.0	60.3	50.0	54.6	59.9
Syngenta	58.1	59.2	58.1	56.4	57.9	56.4	59.0	59.2	54.5	56.7	58.2	55.9	56.6	58.9
WWQL	59.8	60.5	58.5	54.6	58.6	55.6	59.1	58.0	55.6	57.3	58.7	58.6	59.3	60.7
SWQL	61.2	61.7	61.3	57.5	61.9	58.9	62.4	62.1	57.4	59.0	60.8	58.8	60.8	60.9
Averages	58.6	59.4	58.0	54.6	58.7	55.3	58.5	59.6	55.5	56.5	58.3	55.5	57.2	59.0
StDev	2.2	1.8	1.9	1.9	1.9	2.1	2.0	3.0	2.5	1.8	3.0	3.1	2.3	2.2

Table 55. Combined Solvent Retention Capacity: Sodium Carbonate

	VA06W-412	VA08W-294	Merl (ck)	Pioneer 25R34	Pioneer 25R40	Pioneer 25R47 (ck)	Bromfield	Malabar (ck)	SYHarrison	Oakes (ck)	P04606	P05247	P05222	INW 1021
ADM	84.7	84.5	80.0	70.1	75.4	72.2	83.1	77.9	75.2	77.7	79.0	78.3	78.5	82.6
ConAgra	83.5	86.1	83.2	73.7	79.3	73.8	84.1	81.2	75.9	77.5	82.9	79.5	81.3	81.8
Kellogg's	78.6	79.9	75.6	70.1	75.5	68.9	77.7	75.9	72.1	73.9	77.0	74.7	76.4	76.7
Mennel	86.4	87.7	84.2	79.3	82.1	77.0	84.8	84.0	74.8	68.8	83.8	81.1	85.1	85.1
Mondelez	85.3	88.8	85.9	75.7	81.1	75.4	85.7	85.4	78.8	80.6	84.8	80.9	83.5	82.7
Syngenta	81.4	83.7	83.0	75.6	77.7	75.2	81.3	78.6	74.4	74.8	79.4	78.4	79.0	79.4
WWQL	84.5	85.2	78.6	75.3	79.5	74.5	81.8	81.2	74.9	78.8	82.2	81.0	82.5	81.7
SWQL	87.5	87.5	85.4	77.4	83.3	78.4	86.4	84.5	78.3	81.5	83.5	82.6	84.1	82.1
Averages	84.0	85.4	82.0	74.6	79.2	74.4	83.1	81.1	75.5	76.7	81.6	79.6	81.3	81.5
StDev	2.9	2.8	3.6	3.2	2.9	2.9	2.8	3.4	2.1	4.1	2.8	2.5	3.1	2.5

Table 56. Combined Solvent Retention Capacity: Sucrose

	VA06W-412	VA08W-294	Merl (ck)	Pioneer 25R34	Pioneer 25R40	Pioneer 25R47 (ck)	Bromfield	Malabar (ck)	SYHarrison	Oakes (ck)	P04606	P05247	P05222	INW 1021
ADM	93.2	94.8	88.6	84.8	90.4	80.7	95.7	86.1	82.0	88.4	76.8	92.9	95.6	94.1
ConAgra	111.1	115.4	105.8	96.1	100.9	93.2	108.9	98.5	95.6	105.8	113.8	110.1	108.6	111.1
Kellogg's	101.6	99.2	91.2	82.7	88.9	84.3	95.6	89.3	82.8	92.2	102.0	95.8	94.2	96.0
Mennel	115.6	117.0	105.0	97.0	101.6	95.3	109.0	99.1	96.1	104.7	112.1	111.2	111.1	110.4
Mondelez	114.5	116.4	99.1	97.0	102.6	95.6	103.7	109.1	106.8	103.4	113.4	111.3	108.6	114.2
Syngenta	108.5	113.1	105.5	96.5	100.4	85.6	107.4	98.4	91.8	102.2	111.0	112.9	104.5	106.5
WWQL	92.6	94.4	88.1	81.6	86.6	81.5	92.2	86.4	82.9	89.5	93.5	90.2	92.2	94.1
SWQL	110.3	113.1	103.2	97.1	100.2	96.8	105.0	98.9	95.7	106.4	113.2	107.5	107.1	106.2
Averages	105.9	107.9	98.3	91.6	96.5	89.1	102.2	95.7	91.7	99.1	104.5	104.0	102.7	104.1
StDev	9.1	10.0	7.8	7.2	6.6	6.8	6.7	7.9	8.7	7.7	13.3	9.4	7.5	8.1

Table 57. Combined Solvent Retention Capacity: Lactic Acid

	VA06W-412	VA08W-294	Merl (ck)	Pioneer 25R34	Pioneer 25R40	Pioneer 25R47 (ck)	Bromfield	Malabar (ck)	SYHarrison	Oakes (ck)	P04606	P05247	P05222	INW 1021
ADM	109.9	108.9	87.4	91.5	91.6	92.8	92.4	84.5	89.8	95.6	95.5	84.9	67.5	91.3
ConAgra	118.3	119.1	92.6	96.0	96.6	93.8	96.1	90.2	96.7	102.5	77.6	87.0	66.7	97.1
Kellogg's	110.5	109.5	85.0	90.3	91.9	91.4	88.3	82.9	91.1	97.4	74.8	84.9	64.0	90.0
Mennel	117.8	117.2	92.1	100.5	99.6	98.4	94.1	88.4	97.7	104.6	81.5	93.8	71.3	99.6
Mondelez	116.0	115.5	90.2	93.3	95.8	89.8	96.2	90.3	91.3	92.9	77.0	81.5	66.5	98.3
Syngenta	111.7	109.9	91.9	93.4	93.5	89.8	91.8	85.5	85.8	89.8	71.7	78.6	63.6	90.7
WWQL	114.4	112.8	89.2	92.7	94.9	90.7	90.9	86.2	91.8	96.6	76.3	86.3	66.7	93.4
SWQL	112.8	106.9	87.9	93.7	92.0	92.8	93.9	83.6	87.7	94.5	75.3	83.3	69.1	90.6
Averages	113.9	112.5	89.5	93.9	94.5	92.4	93.0	86.5	91.5	96.7	78.7	85.0	66.9	93.9
StDev	3.2	4.4	2.7	3.1	2.8	2.8	2.7	2.9	4.1	4.9	7.3	4.5	2.5	3.9

Table 58. Combined Overall Acceptability Scores; 9 = Highest, 1 = Poorest

	ADM	ConAgra	Horizon	Mendelez	Mennel	Syngenta	WMC	WWQL	Ave.	StDev.
VA06W-412	5.0	3.0	5.0	2.0	6.0	4.0	3.0	3.5	3.9	1.3
VA08W-294	4.0	3.0	4.0	2.0	5.0	4.0	7.0	4.0	4.1	1.5
Merl (ck)	4.0	3.0	4.0	3.0	5.5	7.0	6.0	5.5	4.8	1.5
Pioneer 25R34	8.0	6.0	7.0	5.0	8.0	9.0	7.0	6.0	7.0	1.3
Pioneer 25R40	6.0	3.0	6.0	2.0	7.0	6.0	3.0	5.5	4.8	1.9
Pioneer 25R47 (ck)	8.0	5.0	8.0	5.0	8.2	9.0	5.0	5.0	6.7	1.8
Bromfield	5.0	3.0	5.0	4.0	6.5	5.0	7.0	4.0	4.9	1.3
Malabar (ck)	5.0	4.0	5.0	4.0	6.3	8.0	3.0	4.5	5.0	1.6
SY Harrison	8.0	6.0	7.0	3.0	8.5	8.0	4.0	5.0	6.2	2.0
Oakes (ck)	5.0	2.0	4.0	3.0	7.5	4.0	5.0	3.5	4.3	1.6
P04606	5.0	2.0	5.0	1.0	6.8	2.0	5.0	4.0	3.9	2.0
P05247	4.0	2.0	4.0	3.0	6.5	3.0	5.0	4.0	3.9	1.4
P05222	4.0	3.0	5.0	1.0	6.0	3.0	2.0	3.5	3.4	1.6
INW 1021 (ck)	6.0	4.0	6.0	4.0	7.0	7.0	6.0	5.5	5.7	1.2

Appendix I. Genotyping for Quality Traits

Genotyping for Quality Traits: WQC
Anne Sturbaum, December, 2012

Genotyping for traits associated with quality, physiology and disease resistance was done at the Soft Wheat Quality Lab and the Regional Small Grains Genotyping Laboratory (RSGGL) in Raleigh, N.C. for 14 varieties: Bromfield, INW 1021, Malabar, Merl, Oakes, Purdue lines P04606, P05222, P05247, Pioneer 25R34, Pioneer 25R40, Pioneer 25R47, SY Harrison, VA06W-412 and VA08W-29. Checks for this group include Malabar, Merl, Oakes, Pioneer 25R47 and INW 1021.

Quality

High molecular weight glutenins, especially the "5+10" allele at *GluD1* and the over-expressed *Bx7* allele at *GluB1,* are useful for selecting favorable milling and baking quality. These alleles correlate with stronger gluten. We report on the *GluA1, GluB1, GluD1* loci and the *γ-gliadin* locus, all involved in selecting for varieties with better dough quality.

Amplification of gene fragments from high molecular weight glutenin genes at the *GluA1* locus, using the marker *umn19*, identified the *Ax2** genotype in Bromfield, INW 1021, Pur05247, Pioneer 25R34, Pioneer 25R40, Pioneer 25R47, SY Harrison, VA06W-412 and VA08W-294 (1, 2). All other entries have the *Ax1* or null alleles.

Primers detecting a 45 base pair insertion specific to the *Bx7* over-expressing allele (*Bx7OE*) indicated *Bx7OE* for INW 1021, Purdue 04606, P05222 and P05247. All other varieties produced a product indicative of the wild type allele at this locus (3).

Primers specific for *GluD1*, *Dx5* (3), generated a PCR product corresponding to the "5+10" genotype in Pioneer 25R40 and VA06W-412 . Bromfield and Malabar tested heterozygous for the "5+10" and "2+12" alleles. All other varieties produced amplification products specific for the "2+12" allele (4).

Low molecular weight glutenins can be predicted by assaying for γ-gliadins due to linkage on chromosomes 3. Allele-specific primers identified the favorable *GliD1.1* allele for γ-gliadin in all varieties (5).

A rye translocation provides resistance to powdery mildew, stem rust, leaf rust and stripe rust. The 1RS/1BR translocation was identified in Merl, P04606, P05222, P05247, VA06W-412 and VA08W-29. Bromfield has the translocation as 1RS/1AL which also confers resistance. These varieties produced an amplification product with scm9F primers specific for rye ω-secalin using the Scm9 marker pair (6, 7).

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 (8).

Physiology

Dwarfing genes were tested using markers specific for *Rht1 (Rht-B1b), Rht2 (RhtD1b)* and *Rht8* (10). All varieties had at least one dwarfing allele. Bromfield, INW 1021, Malabar, P04606, P05222 and P05247 amplified the *Rht1* allele, all others were positive for *Rht2*. Pioneer 25R40 has the *Rht8* allele in combination with *Rht2*.

The semi-dominant *Photperiod-D1a* (*Ppd-D1a*) allele and copy number variations in *Photoperiod-B1a (Ppd-B1a)* genes confer photoperiod insensitivity in wheat, allowing early flowering (11, 15). INW 1021, Merl, Oakes, Pioneer 25R34, Pioneer 25R40, Pioneer 25R47 and SY Harrison were homozygous for *Ppd-D1a* and P0527 was heterozygous at this locus. P05222 and Oakes have the *Ppd-B1a* variants for early flowering. *Ppd-D1a and Ppd-B1a* photoperiod insensitivity is absent in Bromfield, Malabar, P04606, VA06W-412 and VA08W-294.

Disease Resistance

Alleles of the *Vp1B* gene (Viviparous-1), assayed using *Vp1B3* STS marker (9), are associated with tolerance to preharvest sprouting (PHS). Malabar, Oakes, Pioneer 25R34, Pioneer 25R40, Pioneer 25R47 and SY Harrison produced the 569 bp product indicating potential tolerance to PHS. All other WQC varieties amplified the larger product (652 bp), indicating probable susceptibility to PHS.

Markers identifying resistance genes to stem rust (Sr2) and leaf rust (Lr34) were not detected among the varieties.

The presence of a stem rust resistance gene, *Sr36*, is conferred by a translocation from *Triticum timopheevi* and was tested using the marker *wmc477* (12). A 185 base pair amplification product indicates resistance to the stem rust pathogen. The *Sr36* gene and translocation are present in Oakes and P0522 and heterozygous in Merl.

The gene for *Sucrose synthase type 2* (*TaSus2*) is located in the same region chromosomal region (2B) as the *Sr36* gene. The *HapH* (Haplotype High) allele of *Sus2* is associated with improved yield traits, specifically high grain test weight (16). In U.S. wheats, the *HapH* allele is often linked with the *Sr36* allele (17). Mapping studies implicate *HapH* association with favorable Sucrose SRC values and flour yield (Sneller, unpublished). The *HapH* allele for *Sus2* is present and linked to the *Sr36* gene in Oakes and P0522 as detected by a KASP marker (developed at the RSGGL). INW 1021 also has *HapH*, but in this case, the *Sr36* gene is absent.

Resistance to fusarium head blight (FHB) is evaluated using markers associated with QTL on chromosomes 3BS (*FHB-1*) and 5A (Ernie and Ning) (13, 14). P05247 and INW 1021 have favorable resistance alleles for *FHB-1*. P05247, P05222 and Malabar have the 5A Ernie resistance on 3BS. Bromfield has resistance conferred from *Fhb 5A* Ning.

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Table 59. USDA-ARS SWQL: Genotyping for Quality Traits

CULTIVAR	Dwarfing	Photoperiod Insensitivity	HMW GluA1	HMW GluB1 (Bx7 OE)	HMW GluD1	PHS	RyeTL	FHB	Stem Rust	Sucrose Synthase
Bromfield	**Rht-B1b**	WT	**Ax2***	WT	Het	Sus	**1RS:1AL**	**Fhb 5A Ning**	no	Ha
INW_1021	**Rht-B1b**	**Ppd-D1a**	**Ax2***	**OE**	2+12	Sus	no	**Fhb1**	no	**HapH**
Malabar	**Rht-B1b**	WT	Ax1 or null	WT	Het	**Tol**	no	**Fhb 5A Ernie**	no	no
Merl	**Rht-D1b**	**Ppd-D1a**	Ax1 or null	WT	2+12	Sus	**1RS:1BL**	no	**Het Sr36**	no
Oakes	**Rht-D1b**	**Ppd-D1a, Ppd-B1**	Ax1 or null	WT	2+12	**Tol**	no	no	**Sr36**	**HapH**
Pioneer_25R34	**Rht-D1b**	**Ppd-D1a**	**Ax2***	WT	2+12	**Tol**	no	no	no	no
Pioneer_25R40	**Rht-D1b, Rht8**	**Ppd-D1a**	**Ax2***	WT	**5+10**	**Tol**	no	no	no	no
Pioneer_25R47	**Rht-D1b**	**Ppd-D1a**	**Ax2***	WT	2+12	**Tol**	no	no	no	no
Pur04606	**Rht-B1b**	WT	Ax1 or null	**OE**	2+12	Sus	**1RS:1BL**	no	no	no
Pur05222	**Rht-B1b**	**Ppd-B1**	Ax1 or null	**OE**	2+12	Sus	**1RS:1BL**	**Fhb 5A Ernie**	**Sr36**	**HapH**
Pur05247	**Rht-B1b**	**Het -Ppd1a**	**Ax2***	**OE**	2+12	Sus	**1RS:1BL**	**Fhb1, Fhb 5A Ernie**	no	no
SY_Harrison	**Rht-D1b**	**Ppd-D1a**	**Ax2***	WT	2+12	**Tol**	no	no	no	no
VA06W-412	**Rht-D1b**	WT	**Ax2***	WT	**5+10**	Sus	**1RS:1AL**	no	no	no
VA08W-294	**Rht-D1b**	WT	**Ax2***	WT	2+12	Sus	**1RS:1AL**	no	no	no

Appendix II. 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

Nitrogen combustion analysis using 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

Weight 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 showing % soft (A), semi-soft (B), semi-hard (C), and hard (D); SKCS hardness index; SKCS moisture content; SKCS kernel size; and SKCS 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 precede 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. Generally, 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/hour. 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. Finished flour is a blend of the straight grade, breaks, reductions and duster following re-bolting.

The straight grade flour mean volume diameter will be about 130 microns with flour ash content usually between 0.38% and 0.49%. Flour yields will vary between 70% and 78% and are variety-dependent due to milling quality differences and/or grain condition. Recovery of all mill products will usually be 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 NIR using a Unity NIR instrument calibrated by nitrogen combustion analysis using Elementar Nitrogen Analyzer. Units are recorded in % 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 ½ acre field.

Flour protein of 8% to 9% is representative for breeder's samples and SWQL grow-out cultivars. As flour protein increases, the expansive capability of the cookie during the baking process decreases. Flour protein is negatively correlated to cookie diameter ($r=-0.62$, $p<0.0001$) with the cookie shrinking 0.4 cm for every 1% increase in protein content. The effect of flour protein on cookie size is related, in part, to increased water absorption due to greater protein content; however, the amount of cookie shrinkage is greater than that explained by increased water absorption alone.

Protein quality is an evaluation of "elasticity" or gluten strength and is different from protein quantity. A cultivar possessing a low quantity of protein could still exhibit strong gluten strength. Gluten strength is thought to be a desirable characteristic for cracker production. Gluten strength is measured using a mixograph and is graded on a scale of 1-8, with 1 as weakest and 8 as strongest gluten. Evaluation of gluten strength using the mixograph or farinograph is difficult for soft wheat flours that are 8.5% protein and lower. Since the representative protein range for breeders' samples is 8-9%, many of these flours are not adequately evaluated using the mixograph or farinograph methods. The Lactic Acid SRC, which does not require mixing action to assess gluten, tends to provide a better estimate of protein quality for soft wheats. Lactic acid hydrates the native matrix of insoluble polymeric protein (IPP) present in the flour.

Flour Ash, AACC Method 08-01

Basic method, expressed on 14% moisture basis.

Flour Amylase activity, AACC Method 22-06

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

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

Flour Lactic Acid, Sucrose, Water, and Sodium Carbonate Retention Capacities (SRC) results are expressed as %.

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. Water SRC is correlated to Farinograph water absorption but does not directly measure the absorption of the glutenin macropolymer hydration during mixing as does the Farinograph. Water SRC is negatively correlated to flour yield and softness equivalent among flour samples milled on the Quad advanced flour mill ($r=-0.43$ and $r=-0.45$, respectively). 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 arabinoxylans (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. The negative correlation between wire-cut cookie and sucrose SRC values is $r=-0.66$ ($p<0.0001$). Sucrose SRC typically increases in wheat samples with lower flour yield ($r=-0.31$) and lower softness equivalent ($r=-0.23$). The cross hydration of gliadins by sucrose also causes sucrose SRC values to be correlated to flour protein ($r=0.52$) and lactic acid SRC ($r=0.62$). Soft wheat flours for cookies typically have a target of 95% or less when used by the US baking industry for biscuits and crackers. Sucrose SRC values increase by 1% for every 5% increase in lactic acid SRC. 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 is a 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. Sodium carbonate is an effective predictor of milling yield and is negatively correlated to flour yield on the Quad advanced milling system ($r=-0.48$, $p<0.0001$). It also is one of several predictors of cookie diameter ($r=-0.22$, $p<0.0001$). 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. See the above discussion of protein quality in this section for additional details of the lactic acid SRC. 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. The SWQL typically reports a protein-corrected lactic acid SRC value to remove some of the inherent protein fluctuation not due to cultivar genetics. Lactic acid is corrected to 9% protein using the assumption of a 7% increase in lactic acid SRC for every 1% increase in flour protein. On average across 2007 and 2008, the change in lactic acid SRC value was closer to 2% for every 1% protein.

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.

Micro Assay for Flour Alpha Amylase Activity, AACC Method 22-02

The Ceralpha K-CERA (Megazyme) alpha-amylase assay procedure for higher throughput to determine flour alpha-amylase activity in a microwell plate. All reagents, controls and precautions are as described in the Megazyme manual.

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

Two-cookie expressed in cm, cookie top grain expressed in arbitrary units from unacceptable to outstanding, from 1 to 9, respectively.

Diameter and stack height of cookies baked according to this method are measured and used to evaluate flour baking quality. All data reported in this report were produced using the accepted method prior to December, 2008.

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.

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.

The best single predictor of cookie diameter is sucrose SRC. The strong negative correlation of sucrose SRC to cookie diameter ($r=-0.66$, $p<0.0001$) has led to its adoption in lieu of baking cookies for most samples. The best prediction model for cookie diameter among grain samples milled on the Quadrumat advanced system uses a combination of sucrose SRC, softness equivalent, and flour protein (R2=0.61). These three measures are combined into the baking quality score used in Quad Micro milling with the baking quality score favoring lower sucrose SRC and flour protein and greater softness equivalent values.

Cultivars that possess excellent milling properties nearly always produce large diameter cookie spreads. Poor milling cultivars nearly always produce smaller cookie spreads. Cultivars that are very soft in granulation usually produce good cookie spreads.